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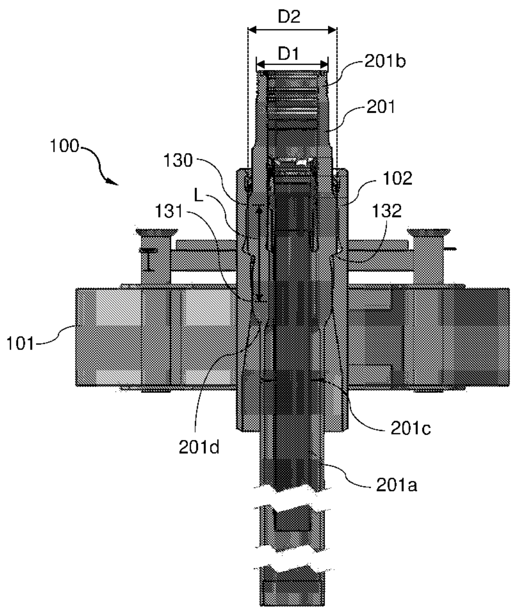

Fig. 23

(57) **Abstract:** A wellhead assembly (100) comprising: a wellhead support structure (101), a high- pressure wellhead housing (201), the wellhead support structure (101) arranged as part of a sea floor foundation (200) and having a receptacle (102) rigidly fixed thereto such that the support structure (101) provides a bending moment restraint on the receptacle (102), wherein the receptacle (102) comprises two vertically spaced, circumferential support faces (130,131), each of the support faces (130,131) providing horizontal support to the high-pressure wellhead housing (201), and wherein the two vertically spaced, circumferential support faces (130,131) in conjunction provide a bending moment restraint on the high-pressure wellhead housing (201) in the receptacle (102). There is also provided a method of establishing a subsea well.

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SUBSEA PETROLEUM WELLHEAD SYSTEMS AND METHODS

The present invention relates to subsea wellhead systems and methods, including but not limited to systems and methods for arranging a high-pressure petroleum well tubular in a sea floor structure.

BACKGROUND

Wellhead systems for subsea petroleum exploration are traditionally known to comprise a wellhead having a wellhead housing secured to a well casing. It also generally has a valve stack, such as a blow out preventer (hereinafter referred to as BOP) or valve tree, located permanently or temporarily on the wellhead, for example during drilling, work-over operations and various phases of the production.

In the design of subsea wellhead support arrangements several factors usually need to be taken into account, for example the capacity to handle loads from the valve stack (such as bending moments and fatigue loads), the interaction with well tubulars (such as a high-pressure casing) during their installation, the interface towards the sea floor for secure foundation and low angular misalignment during installation of the foundation and/or well tubulars, manufacturing efficiencies for the various system components, and other factors.

Publications which may be useful to understand the field of technology include US 2020/0284117 A1; WO 2012/065896 A2; EP 3 102 771 B1; WO 2003/002845 A1; and NO 314320 B1.

Due to the high costs and potentially serious consequences of damage or irregularities in these safety-critical components, there is a continuous need for improved technology for wellhead systems. The present disclosure has the objective to provide such improvements, or at least alternatives to known solutions and techniques.

SUMMARY

In an embodiment, there is provided a wellhead assembly comprising: a wellhead support structure, a high-pressure wellhead housing, the wellhead support structure arranged as part of a sea floor foundation and having a receptacle rigidly fixed thereto such that the support structure provides a bending moment restraint on the receptacle, wherein the receptacle comprises two vertically spaced, circumferential support faces, each of the support faces providing horizontal support to the high-pressure wellhead housing, and wherein the two vertically spaced, circumferential support faces in conjunction provide a bending moment restraint on the high-pressure wellhead housing in the receptacle.

In an embodiment, there is provided a method of establishing a subsea well, the method comprising the steps: (i) installing a wellhead assembly on a sea floor, the wellhead assembly having a wellhead support structure with a pre-installed receptacle rigidly fixed thereto, (ii) running a high-pressure well pipe through the receptacle and into the sea floor, (iii) landing a high-pressure wellhead housing in the receptacle, and (iv) establishing a connection between the high-pressure wellhead housing and the receptacle by bringing two vertically spaced, circumferential support faces in the receptacle adjacent or into contact with the high-pressure wellhead housing, whereby the connection provides a moment restraint on the high-pressure wellhead housing in the receptacle.

Various other embodiments and examples are outlined in the detailed description and claims below, and in the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other characteristics will become clear from the following description of illustrative embodiments, given as non-restrictive examples, with reference to the attached drawings, in which:

Figs 1-4 show a wellhead assembly in a first embodiment.

Figs 5-7 illustrate various embodiments of a wellhead assembly.

Figs 8-9 illustrate a suction anchor sea floor foundation according to an embodiment.

Figs 10-12 illustrate a template sea floor foundation according to an embodiment.

Figs 13-14 illustrate an embodiment having a connection member with two parts.

Fig. 15 illustrates an embodiment having a support member.

Figs 16-18 illustrate features of wellhead assemblies according to further embodiments.

Figs 19a-l illustrate various designs of a connection member and receptacle according to further embodiments.

Fig. 20 illustrates a wellhead assembly having a seal.

Figs 21a-c illustrate an embodiment having a connection member with a thickened portion.

Figs 22a-b illustrate an embodiment having a connection member with through passages.

Fig. 23 illustrates a subsea wellhead assembly according to an example.

Figs 24a-c illustrate connections between a receptacle and a passage being part of a wellhead support structure.

Fig. 25 illustrates a connection between a receptacle and beams being part of a wellhead support structure.

Fig. 26 illustrates a subsea wellhead assembly according to an example.

Figs 27a-b illustrate a connection between a high-pressure wellhead housing and a receptacle using a pre-tensioning lock.

Fig. 28 illustrates a connection between a high-pressure wellhead housing and a receptacle using wedges.

Figs 29a-b illustrate a connection between a high-pressure wellhead housing and a receptacle using locking dogs.

Fig. 30 illustrates a welded connection between a high-pressure wellhead housing and a receptacle.

Fig. 30 illustrates a connection between a high-pressure wellhead housing and a receptacle using a filler material.

Figs 32a-b illustrate a swaged connection between a high-pressure wellhead housing and a receptacle.

Fig. 33a illustrates a receptacle 102 having a lower support face engaging a support member on a well pipe.

Fig. 33b illustrates a wellhead assembly comprising stiffeners.

Figs 34a-c illustrate an example wherein the receptacle is landed in the wellhead support structure and fixed by means of wedges.

DETAILED DESCRIPTION

The following description may use terms such as “horizontal”, “vertical”, “lateral”, “back and forth”, “up and down”, ”upper”, “lower”, “inner”, “outer”, “forward”, “rear”, etc. These terms generally refer to the views and orientations as shown in the drawings and that are associated with a normal use of the invention. The terms are used for the reader’s convenience only and shall not be limiting.

In an embodiment, Figs 1-4 show a wellhead assembly 100 comprising a wellhead support structure 101 arranged as part of a sea floor foundation. The wellhead support structure 101 may comprise a plurality of substantially horizontal or horizontal beams, for example arranged connected to or as part of a template structure and/or a suction anchor foundation (some embodiments being described in further detail below). The support structure 101 defines a passage 103 through which well pipes may extend when the wellhead assembly 100 is complete and in operation. The passage 103 may be defined by a cylindrical wall 103a which makes up part of the support structure 101. Advantageously, the passage 103 may have a circular cross-section in a horizontal plane, however the passage 103 may optionally have a different shape.

A receptacle 102 is arranged at least partly in the passage 103 and fixed to the support structure 101 via a connection member 105. The receptacle 102 is configured to receive and hold a high-pressure wellhead housing 201 (illustrated in Fig. 4 and also discussed in further detail below). The high-pressure wellhead housing 201 will be understood to mean a housing connected to an upper part of a well pipe 201a which extends into a subterranean wellbore and handles internal reservoir or wellbore fluid pressures. The high-pressure wellhead housing 201 and well pipe 201a may thus provide a well barrier and/or be capable of isolating or maintaining a wellbore pressure. A high-pressure wellhead housing 201 may be configured for having a valve tree or blow out preventer fixed thereon. As is common terminology in the art, the high-pressure housing 201 is thus different from a low-pressure pipe, such as a wash out sleeve, tail pipe, conductor casing or the like, which in some wellhead assemblies may be used to guide or support a high-pressure wellhead housing or well pipe 201a but which itself is not design to handle wellbore or reservoir pressures.

The connection member 105 is in this embodiment arranged as an annular disc. The connection member 105 is connected to the receptacle 102 and to the wellhead support structure 101 so as to form a structural support element between these two components. Thereby, the connection member 105 supports the receptacle 102 in the wellhead support structure 101. By appropriate design of the connection member 105, the stiffness or rigidity of the connection between receptacle 102 and the wellhead support structure 101 can be chosen at a desirable level. For example, the connection member 105 may be designed to allow some flexibility of the receptacle 102 relative to the wellhead support structure 101 during installation (a “thin” or “flexible” design of the connection member 105). If it is desirable to allow less relative movement between the wellhead support structure 101 and the receptacle 102, a more rigid connection member design can be chosen (a “thicker” or “stiffer” design). As discussed in further detail below, also the elevation of the connection member 105 compared for example to the wellhead datum, cement level or template frame can be tuned to achieve properties most favourable for the specific case. The connection member 105 may thus be designed with a suitable stiffness or rigidity, e.g. by adjusting the thickness, form factor and/or material choice, to provide desired load transfer properties between the receptacle 102 and the wellhead support structure 101 in a given case. This provides flexibility at the design stage, in that the properties of the connection member 105 can be adjusted without major impact on the other system components. For example, the stiffness can be varied for various angular deflections.

As illustrated in Fig. 4, the receptacle 102 is configured to receive and hold a high-pressure wellhead housing 201. For this purpose, the receptacle 102 may have an internal profile 102c (see Fig. 3) configured for receiving and supporting the high-pressure wellhead housing 201 directly. Particularly, the receptacle 102 may be configured for receiving the high-pressure wellhead housing 201 directly, without any intermediate pipes between the receptacle 102 and the high-pressure wellhead housing 201. This arrangement may be a conductorless setup, i.e. one where no conductor casing (low-pressure pipe) is used outside the high-pressure well pipe. (A tail pipe / sleeve 109 may nevertheless be used in extension of the receptacle 102, e.g. for the first few meters, to penetrate loose soil just below the sea floor and at the top part of the hole in order to provide support and/or to prevent wash-out. The tail pipe 109 may be less than 10 m, less than 5 m or less than 3 m in length, i.e. considerably shorter than a conductor casing.)

Cement ports 112, illustrated in Fig. 3, may optionally be provided in the receptacle 102 and/or in the support structure 101, for example in the part of the support structure 101 which defines the passage 103. Examples of cementing arrangements are described in further detail below.

Fig. 5 shows another embodiment. In this embodiment, the connection member 105 is arranged above the wellhead support structure 101, and is connected to the wellhead support structure 101 via a plurality of structural connectors 110a,b. Similarly, the receptacle 102 is connected to the connection member 105 via a plurality of structural connectors 111a,b.

In any of the embodiments herein, if using such structural connectors between the connection member 105 and the receptacle 102 and/or the wellhead support structure 101, the connection member 105 may be arranged to be spaced from and not in direct contact with the receptacle 102 and/or the wellhead support structure 101. In such a case, the load transfer to or from the connection member 105 may thus proceed entirely through the respective structural connectors.

The structural connectors 110a,b, 111a,b may advantageously comprise brackets engaging an upper and/or a lower surface of the connection member 105. The structural connectors may, for example, be knee plates. The knee plates may advantageously be vertically oriented plates.

Advantageously, in any of the embodiments described herein, four or more structural connectors may be arranged between the connection member 105 and the receptacle 102 and/or four or more structural connectors may be arranged between the connection member 105 and the wellhead support structure 101.

Fig. 6 illustrates another embodiment in which the connection member 105 is connected to the receptacle 102 via structural connectors 111a,b and connected directly to the wellhead support structure 101.

Similarly as for the connection member 105, the structural connectors 110a,b, 111a,b can provide a means of adjusting/tuning the stiffness in various directions through sizing, spacing and/or quantity.

Fig. 7 illustrates another embodiment in which the connection member 105 is connected to the receptacle 102 via structural connectors 111a,b and connected to the wellhead support structure 101 via structural connectors 110a,b, and where the connection member 105 is arranged vertically level with the wellhead support structure 101. Advantageously, arranging the connection member 105 level with the wellhead support structure 101, as also shown in Figs 1-4 and 6 may provide enhanced load transfer and/or manufacturing properties.

Returning now to Figs 1-4, in this embodiment, the connection member 105 forms a continuous structure between the receptacle 102 and the support structure 101 such as to seal the space between the receptacle 102 and the part of the structure 101 which defines the passage 103. Fluid flow through the passage 103 may thereby be prevented. For this purpose the connection member 105 may comprise a disc arranged substantially horizontally or horizontally between an outer surface 102a of the receptacle 102 and the inner surface 103a of the structure 101.

Advantageously, the receptacle 102 has a circular cross-section in a horizontal plane. The disc may be an annular disc arranged about the receptacle 102. Optionally, the components may have another shape, such as square or polygonal.

The connection member 105 may advantageously have a continuous weld towards the outer surface 102a of the receptacle 102 and/or a continuous weld towards the inner surface 103a of the structure 101. Alternatively, the connection member 105 may be fixed to the receptacle 102 and/or the structure 101 at a plurality of spaced locations (such as, for example, in Fig. 7) and wherein one or more seals is/are provided between the connection member 105 and the inner surface 103a and/or between the connection member 105 and the receptacle 102.

Illustrated in Figs 8 and 9, the sea floor foundation 200 may be a suction anchor foundation having an internal volume 202 defined by a top cover 204 and skirt 203.

The skirt 203 may advantageously be a cylindrical skirt extending downwardly from a circular top cover 204. The skirt 203 defines a lower end opening 205 by which the foundation 200 can be driven into a sea floor 206, for example by means of lowering the pressure in the internal volume 202 by means of suction.

Alternatively, as illustrated in Figs 10-12, the sea floor foundation 200 may be a template structure, i.e. a beam structure adapted to support one or more wellheads. The template structure may be arranged on suction foundations, having mud mats for positioning on the sea floor (as illustrated in Fig. 10), on a piled foundation or equivalent. The receptacle(s) 102 may be integrated with the template structure in one or more well bays. As can be seen, the example template structure shown in Fig. 10 comprises six such well bays. Fig. 11 shows one of the well bays in closer detail, while Fig. 12 shows a cross-sectional view of the well bay components.

In any of the embodiments, the wellhead support structure 101 may comprise a plurality of substantially horizontal or horizontal beams. The beams may be part of a well frame or template (as, for example, in Fig. 10) or may be arranged on top of or incorporated into a top section of a suction foundations (as, for example in Figs 8 and 9 or in a template structure having suction foundations).

Referring again to Figs 8 and 9, in some embodiments the receptacle 102 can be sealingly fixed to or integrated within the top cover 204 of the suction anchor foundation. A sealing connection can be made between the outer surface 102a (see Fig. 1) of the receptacle 102 and the connection member 105, between the connection member 105 and the structure 101, and the structure 101 can be fixed to or integrated with the top cover 204 in a sealing manner. In this embodiment, no fluid gaps are present in the passage 103 such that the inner volume 202 can be sealed off for providing suction to install the foundation 200 into the sea floor 206. This could, for example, be done by fixing a pump to the upper opening of the receptacle 102 and using the receptacle 102 as a channel to pump water out of the inner volume 202 for installation, or by sealing off the receptacle 102 and pumping through a dedicated channel, such as a flange for this purpose arranged on the suction anchor foundation, e.g. on the top cover 204.

Such a setup may be used with a single suction anchor foundation, such as that illustrated in Figs 8 and 9, and/or with a template structure having suction foundations and where some of the wells extend through the suction foundations.

Advantageously, in any of the embodiments described herein, the receptacle 102 may have a lower end 102b (see Fig. 1) configured to be positioned above a sea floor 206 when the wellhead assembly 100 is in the installed position, as indicated in Fig. 9. This means that the receptacle 102 is relatively short compared to the height of the foundation 200 or that the receptacle 102 is positioned in an elevated position so as to be spaced from the sea floor 206. The foundation 200 may be arranged as a conductorless wellhead assembly, i.e. without comprising a low-pressure pipe extending into the sea floor 206.

In some embodiments, illustrated in Figs 13 and 14, a wellhead assembly 100 may comprise a connection member 105 having a first part 105a which is fixed to the structure 101 and a second part 105b which is fixed to the receptacle 102, and where the first part 105a and the second part 105b are connected by a weld 105c. The weld 105c is advantageously located between the structure 101 and the receptacle 102 such that the weld 105c is spaced from both the structure 101 and the receptacle 102.

The second part 105b may, for example, be formed partly or fully by a protrusion formed on receptacle 102. The second part 105b may be fixed to the receptacle by a non-welded connection, e.g. the second part 105b may be machined together and monolithically with the receptacle 102, for example in a forging or casting process. Alternatively, the second part 105b can be fixed to the receptacle 102 by a press-fit, threaded, or another type of connection. In this manner, a weld directly in an interface between an outer surface of the receptacle 102 and the connection member 105 (e.g. if the connection member 105 is an annular disc) may be avoided. This can be beneficial to reduce stress concentration hotspots in the welded area, in that the weld is moved outwardly, away from the receptacle 102 and the interface between the receptacle 102 and the connection member 105. This can improve the wellhead assembly’s capability to handle dynamic and/or static loading.

Similarly, the first part 105a may be formed by a protrusion inwardly from the structure 101, for example from an inner surface 103a inwardly towards the receptacle 102. The first part 105a may similarly be formed as part of the structure 101, e.g. as part of the structure component which forms the passage 103.

Alternatively, the first and/or second parts 105a,b may be welded to the structure 101 and receptacle 102, respectively, prior to the weld 105c being made. This can allow the fixing of the first and second parts 105a,b to the structure 101 and receptacle 102, respectively, to be carried out with more accuracy, for example by welding in a workshop prior to the receptacle 102 being fixed to the structure 101 by weld 105c.

The first and second parts 105a,b may advantageously together make up an annular disc which forms the connection member 105.

The weld 105c may be a circumferential weld fixing the first and second parts 105a,b together.

In other embodiments, illustrated in Fig. 15, the wellhead assembly 100 comprises at least one support member 120 arranged to, in conjunction with the connection member 105, provide rotational support for the receptacle 102 from the structure 101. The at least one support member 120 can be configured to, when engaged, provide horizontal support for the receptacle 102 at a vertical elevation which is spaced from the connection member 105. For example, as illustrated in Fig. 15, the connection member 105 and the support member 120 may provide support at two vertically spaced levels so as to prevent any rotation of the receptacle 102 about a horizontal axis. Such rotation may be caused, for example, by a side force or bending moment applied by a valve stack or riser fixed to a wellhead 201 arranged in the receptacle 102. (See, e.g., the above-mentioned WO 2012/065896 A2.) It may be desirable to control the deflection or bending of the receptacle 102, wellhead 201 and the associated well pipes so as to avoid overload and/or fatigue damage to components. By the support member 120, in conjunction with the connection member 105, a bending moment applied on the wellhead 201 and receptacle 102 can be led into, and taken up by, the structure 101.

The support member 120 can, for example, be made up of an annular disc arranged about the receptacle 102. Alternatively, the support member 120 can comprises a plurality of spaced support members, for example brackets or bumpers, arranged about the receptacle 102.

The support member 120 may be fixed to the structure 101 and configured to engage an outer surface 102a of the receptacle 102, as illustrated in Fig. 15. Alternatively, the support member 120 can be fixed to the receptacle 102 and configured to engage the structure 101, for example to engage a surface 103a defining the passage 103.

A gap 121 can be provided between the support member 120 and the receptacle 102 or between the support member 120 and the structure 101 such that he support member 120 is only engaged when the receptacle 102 has an angular deflection. This can be a pre-determined angular deflection, i.e. chosen by design. This may be advantageous to allow some flexibility of the receptacle 102 relative to the structure 101, for example to allow some bending during installation of well pipes, while larger bending moments applied on the wellhead 201 are effectively taken up into the structure 101 when the gap 121 is closed.

Alternatively to having a gap 121, the support member 120 may be permanently in contact with both the receptacle 102 and the structure 101, for example by arranging brackets or an annular ring similarly as for connection member 105.

Illustrated in Figs 16-18 are further optional and advantageous features which can be used in conjunction with the wellhead assemblies according to the embodiments described above.

Fig. 16 illustrates a wellhead assembly 100 similar to that shown in Fig. 4 above. The wellhead assembly 100 may have at least one cement pipe 112a providing a flow channel between an inside of the receptacle 102 and an outside of the passage 103. Three or four cement pipes 112a may, for example, be used. The cement pipe(s) 112a can advantageously extend through the passage 103, for example being arranged radially and/or horizontally through the passage 103. The cement pipe(s) 112a can extend through the inner surface 103a. For this purpose, the cement pipe(s) 112a may be arranged inside the passage 103. Providing the cement pipe(s) 112a inside the passage 103 can give an advantageous design for example in that the pipe(s) 112a are protected by the surrounding structure while the cement outlet is provided at an elevation which permits cement to be provided to a high level, i.e. close to the high-pressure housing 201, if desirable.

Illustrated in Figs 16 and 18, the receptacle 102 can be fixed to a tail pipe 109 arranged in extension of the receptacle 102. The receptacle 102 can, for example, be fixed to the tail pipe 109 by a welded connection. The tail pipe 109 can be a pipe configured for extending into a soil layer at the sea floor, similar to tail pipes known in the art. The tail pipe 109 can, for example, be less than 10m in length, less than 5m in length, or less than 3m in length. In this manner, the tail pipe 109 can prevent the top section of the borehole from collapsing and provide stability in the top section of the borehole, just below the wellhead assembly 100 and in the uppermost sea floor soil layers.

Alternatively, the receptacle 102 can be configured not to extend into a soil layer and/or not being connected to a tail pipe 109. In such embodiments, the receptacle 102 is thus provided above the sea floor. This is illustrated in Fig. 17. (See also Fig. 9.) If no tail pipe 109 is used, or no tail pipe connected to the receptacle 102 is used, the manufacturing of the receptacle 102 may be simplified, in that for example no welded connection to a separate pipe is required on the lowermost part of the receptacle 102.

In any of the embodiments described herein, the receptacle 102 can be a monolithically formed metal structure, i.e. an elongate structure machined or formed monolithically in one piece without any internal welds or connections. The receptacle 102 thus ends at the weld to a tail pipe 109, if applicable.

In embodiments where no tail pipe 109 extending from (and fixed to) the receptacle 102 is used, there may consequently be no need for any welded connection to the receptacle 102 apart from any weld required to the connection member 105, if applicable.

In other embodiments, illustrated in Fig. 17, a tail pipe 109' can be arranged in extension of the passage 103 and configured for extending into a soil layer. The tail pipe 109' may be a similar tail pipe as described above in relation to tail pipe 109. Advantageously, the tail pipe 109' is provided in extension of the inner surface 103a. The tail pipe 109 and the inner surface 103a may provide an enclosed or semi-enclosed volume which may be configured for partly or fully hold cement.

The tail pipe 109' may comprise a frusto-conical connection section 109'' extending between the passage 103 and the tail pipe 109' and connecting these. The frusto-conical connection section 109'' may advantageously extend between the inner surface 103a and the tail pipe 109'. The frusto-conical section 109'' may have a successively reducing diameter and cross-sectional area such as to connect a larger-diameter passage 103 with a smaller diameter tail pipe 109'. (Where “larger” and “smaller” refer to the relative diameters between these two components.)

A cementing volume can in this manner be defined by the tail pipe 109' and/or the frusto-conical connection section 109'' about a well pipe 201a extending downwardly from the high-pressure wellhead housing 201. The passage 103 may additionally form part of the cementing volume.

In other embodiments, illustrated in Figs 16 and 18, the connection member 105 is fixed to the receptacle 102 at a lower part of the receptacle 102. By “lower part” is meant the vertically lower part in relation to the receptacle’s vertical extension (i.e., height) as shown in the figures and as in the ordinary, installed orientation. Particularly, the connection member 105) can advantageously be fixed to the receptacle 102 at a lower half thereof or at a lowermost 30% of the receptacle 102, or at a lowermost 20% of the receptacle 102. (All seen in relation to the receptacle’s vertical extension, i.e., height.)

Alternatively, or additionally, the part of the receptacle 102 which extends below the connection member 105 can be configured to make up less than 30% of the longitudinal length of the receptacle 102, less than 20% of the longitudinal length of the receptacle 102, or less than 10% of the longitudinal length of the receptacle 102.

Figs 19a-l illustrate further embodiments and alternative configurations for the receptacle 102 and the connection member 105.

Fig. 20 illustrates another embodiment, wherein the wellhead assembly 100 comprises a seal 128 between the outer surface 102a (see Fig. 1) of the receptacle 102 and the inner surface 103a (see Fig. 1) of the structure 101 such as to prevent fluid flow through the passage 103 (see Fig. 1) between the receptacle 102 and the support structure 101. In such an embodiment, sealing of the passage 103 can be provided without for example the connection member 105 itself providing a sealing function. The seal 128 may, for example, be a rubber gasket. The seal 128 may, for example, be arranged to withstand pressures of up to 10-15 bar.

The seal 128 may, as illustrated in Fig. 20, be arranged on opposite sides of the connection member 105. Alternatively, the seal 128 may be arranged only on one side of the connection member 105, for example on the underside of the connection member 105. The position of the connection member 105 in the passage 103 can be designed for this purpose, i.e. to provide sufficient space for the seal 128. A layout such as that illustrated in Figs 19k or 19l may, for example, be beneficial.

The connection member 105 may, as described above, comprise a disc or equivalent. Alternatively, the connection member 105 may be in the form of an annular plate of a different shape, such as a polygonal plate. The polygonal plate may, for example, be an octagonal plate.

Alternatively, the connection member 105 may be in the form of a support structure having a plurality of radially extending support struts arranged horizontally or substantially horizontally between the receptacle 102 and the structure 101. This may, for example, be in the form of a spoked wheel type arrangement. Such an arrangement is illustrated in Fig. 22b, which shows a top view of the connection member 105 according to such an embodiment. A plurality of support struts 105e are arranged radially outwardly from the receptacle 102 and form the connection between the receptacle 102 and the structure 101. The support struts 105e may be circumferentially disposed about the receptacle 102 and spaced such as to form passages 106 between them. The connection member 105 may or may not have an outer, circumferential rim 105f in this configuration.

In an alternative embodiment, illustrated in Fig. 22a, the connection member 105 may comprise through passages 106 machined or otherwise formed in the connection member 105. This may, for example, be holes extending through the connection member 105, for example, where the connection member 105 is an annular disc, a plurality of holes extending through the annular disc, as illustrated.

The embodiments in Figs 22a and 22b can, for example, be beneficial to optimise material usage and to allow control of the mechanical properties of the connection member 105. For example, the stiffness of the connection member 105 may be adjusted or “tuned” based on e.g. the thickness of the support struts 105e, their position or quantity. The size, number, shape and/or positioning of the through passages 106 may be chosen with the same purpose.

Illustrated in Figs 21a and 21b, the connection member 105 may advantageously comprise a thickened portion 105d at the interface towards the receptacle 102. The thickened portion 105d may be formed integrally with the connection member 105, for example machined monolithically in the same piece. This can provide enhanced load handling properties in the connection member 105, for example improved load distribution when subjected to bending moment loads.

Illustrated in Fig. 21c, the receptacle 102 may comprises at least one stop member 107,108 defining a stop face arranged to prevent longitudinal movement of the connection member 105 relative to the receptacle 102. The stop member 108 may, for example, be a protrusion or structural feature fixed to or integrated with the receptacle 102 in order to define the longitudinal position of the connection member 105 in relation to the receptacle 102. The stop member 107 may, for example, be a lock ring which can be positioned on the receptacle 102 after arranging the connection member 105 on the receptacle 102 to lock the connection member 105 in the correct position. The connection member 105 may, for example, be arranged on the receptacle 102 by press fit or shrink fit, and subsequently the lock ring placed for securing the components and prevent relative motion between them.

According to embodiments described herein, advantages for example in relation to reduced manufacturing complexity and manufacturing cost while maintaining the required structural strength can be realized. For example, the embodiments described herein may allow for a simplified cementing arrangement, for example reduced number of penetrations, without negatively affecting structural reliability. In some embodiments, the cost and complexity for manufacturing the receptacle 102 can be reduced. Embodiments described herein may, alternatively or additionally, be employed to provide enhanced control of the load distribution in the system during operation, for example better handling of bending moment loads. This can, for example, give improved safety margins in “worst case” extreme load conditions, and/or for handling long-term fatigue loads. Such improved control at the design stage can, in turn, allow for cost reductions in terms of material thicknesses, manufacturing tolerances, or the like. Improved weld access for components, such as cement handling components, can similarly give reduced manufacturing cost.

Advantageously, assemblies as described herein can provide greater design flexibility according to projected requirements and loads for a given installation. As described above, the design of the connection member 105 may be adapted according to design requirements, for example in view of its thickness and material properties. The size (e.g. the diameter or width) of the passage 103 may also be adjusted during the design process, in order to use a larger or smaller connection member 105, as may be desirable in a given application.

In any of the embodiments described herein, the connection member 105 may be an annular disc. This may, for example, provide advantages in load distribution between the receptacle 102 and the support structure 101.

Figure 23 illustrates another example of a subsea wellhead assembly 100. The assembly 100 in this example comprises a wellhead support structure 101 arranged as part of a sea floor foundation 200. The sea floor foundation 200 may be sea floor foundations as in the examples described above. The support structure 101 has a receptacle 102 rigidly fixed thereto, where the receptacle 102 is configured to receive and hold a high-pressure wellhead housing 201. As above, the high-pressure wellhead housing 201 has a high-pressure well pipe 201a connected thereto and extending downwardly into the sea floor.

Similarly as shown in Fig. 3 and described above, the receptacle 102 has an internal profile 102c (not indicated by reference numeral in Fig. 23) configured for receiving and supporting the high-pressure wellhead housing 201. The receptacle 102 is configured for receiving the high-pressure wellhead housing 201 directly, without any intermediate pipes between the receptacle 102 and the high-pressure wellhead housing 201, in a so-called “conductorless” arrangement.

In this example, the receptacle 102 is fixed to and supported by the support structure 101 such that the support structure 101 provides a moment restraint for the receptacle 102. By a moment-restrained connection, a rigid connection is meant whereby the support structure 101 prevents rotation of the receptacle 102 about a horizontal axis relative to the support structure 101. By means of the rigid connection, the support structure 101 thus acts a moment restraint, such that the receptacle 102 cannot rotate freely about a horizontal axis, for example if/when subjected to bending moment loads from a BOP via the high-pressure wellhead housing 201. A bending moment applied by the BOP is such a case would then be transferred to the structure 101. Such a rigid connection can for example be arranged to provide substantially the same rigidity as the rest of the support structure 101, which may, for example, be H-beams.

In the example shown in Fig. 23, the receptacle 102 is fixed to beams making up the structure 101. The beams are horizontally arranged, and may for example be a template structure comprising multiple beams, as illustrated in Fig. 10. Alternatively, the beams may be part of a support structure 101 arranged on a suction anchor foundation for example as shown in Fig. 8. The receptacle 102 is fixed to the beams for example by welding into the beams.

Alternatively, for the purpose of creating a moment-restrained connection to the receptacle 102, the support structure 101 can define a vertical passage 103, for example similarly as described above, and the vertical passage 103 prevent rotation of the receptacle 102 about a horizontal axis.

The receptacle 102 can be fixed to the support structure 101 by for example a shrink fit connection, a clamped connection, a bolted connection, or a welded connection for this purpose. Fig. 24a illustrates an example wherein the receptacle 102 is connected to a passage 103 which is part of the support structure 101 by means of shrink fit, i.e. wherein the receptacle 102 is inserted into the passage 103 at material temperature differences and with small tolerances, and where on equalisation of the material temperatures the passage 103 engages the receptacle 102 by shrink fit.

Fig. 24b illustrates a bolted connection, where the receptacle 102 has a flange 102d which is bolted to the support structure 101, for example at the passage 103. Fig. 24c illustrates a welded connection wherein the receptacle 102 is arranged in the passage 103 and then welded to the receptacle 103 and/or to a different part of the support structure 101. In the examples shown in Figs 24b and 24c, the support structure 101 need not necessarily comprise a “close fit” passage 103 exactly as shown, as the receptacle 102 could alternatively be bolted or welded to the support structure 101 in a different manner.

The receptacle 102 can be arranged in the passage 103 to a close fit tolerance, for example where a clearance or tolerance between an outer cylindrical surface of the receptacle 102 and an inner cylindrical surface of the passage 103 is less than 1 mm, less than 0.5 mm, or less than 0.2 mm. The receptacle 102 can advantageously be arranged in the passage 103 with zero clearance between the receptacle 102 and the passage 103.

Alternatively, a moment-restrained connection between the receptacle 102 and the support structure 101 can be realised similarly as illustrated in Fig. 15 above. Advantageously, a small or zero clearance/tolerance of the gap 121 is provided to provide an efficient bending moment restraint between the receptacle 102 and the support structure 101. Alternatively, such a rigid, moment-restrained connection can also be obtained by providing the examples above with a stiff connection member 105.

Fig. 25 illustrates an example where the wellhead support structure 101 comprises a plurality of substantially horizontal or horizontal beams and the receptacle 102 is rigidly fixed on top of the beams. The receptacle 102 may, for example, be welded or bolted to the beams / support structure 101, thereby creating a rigid connection between the receptacle 102 and the support structure 101.

Referring now again to Fig. 23, in an example the receptacle 102 may comprise two vertically spaced, circumferential support faces 130,131 at an inner face thereof, interfacing the high-pressure wellhead housing 201. Each of the support faces 130,131 is configured for providing horizontal support to the high-pressure wellhead housing 201. The two support faces 130,131 in conjunction provide a moment restraint on the high-pressure wellhead housing 201 in the receptacle 102, i.e. prevents rotation of the high-pressure wellhead housing 201 about a horizontal axis. This is illustrated in Fig. 26, which shows a similar arrangement as in Fig. 23. A bending moment load (or horizontal force generating a bending moment load) applied to the high-pressure wellhead housing 201 by for example a BOP arranged thereon (illustrated by the curved arrow at the top in Fig. 26) may thus be effectively transferred into the support structure 101, in that the support faces 130,131 provide two vertically spaced reaction forces which provides a moment restraint on the high-pressure wellhead housing 201. This can reduce the loads on the well pipe 201a, for example material tension in weaker points of the pipe 201a or housing 201, such as in a weld 201c (known as the girth weld) located at the lower end of the housing 201 and/or in a transition section 201d of the housing 201 where the material thicknesses and/or diameters are reduced or transitions into a different cross-sectional profile.

The receptacle 102 and the high-pressure wellhead housing 201 can be machined and arranged such as to allow the high-pressure wellhead housing 201 to land in the receptacle 102 with low clearances between the support faces 130,131 and the respective outer circumferential surface of the high-pressure wellhead housing 201. Such tolerances/clearances may for example be in the order of 1 mm, less than 0.5 mm, or less than 0.2 mm.

The circumferential support faces 130,131 may each be vertical. Optionally, one or both of the support faces 130,131 may be arranged with an angle, such as a to provide a shoulder onto which the high-pressure wellhead housing 201 can land, and be supported both vertically and horizontally. Advantageously, in such an arrangement with an angled support face 130,131, the other of the support faces 130,131 is vertical.

The receptacle 102 may comprise a landing shoulder 132 (see Fig. 23) configured for providing vertical support to the high-pressure wellhead housing 201. The landing shoulder 132 may be independent of the support faces 130,131. In the example illustrated in Fig. 23, the landing shoulder 132 is arranged between two vertically spaced, circumferential support faces 130,131.

In this example, the upper circumferential support face 130 has a diameter which is larger than that of the lower circumferential support face 131.

Advantageously, the vertical distance between the support faces 130,131 is larger than an outer diameter D1 of a connector part 201b of the high-pressure wellhead housing 201. The vertical distance between the support faces 130,131 may be larger than a maximum or largest outer diameter D2 of the high-pressure wellhead housing 201.

Advantageously, arrangements according to the examples shown in relation to Fig. 23 can simplify installation, particularly installation of a conductorless wellhead assembly, while ensuring good load handling properties, for example for handling fatigue loads, loads on the assembly during installation or other operations, or accidental loads.

In other examples, the wellhead assembly 100 is arranged to rigidly fix the high-pressure wellhead housing 201 to the receptacle 102 with zero clearance between the high-pressure wellhead housing 201 and the receptacle 102. By a rigid fixation, a connection is meant which prevents relative movement between the high-pressure wellhead housing 201 and the receptacle 102, and such that the receptacle 102 prevents rotation of the high-pressure wellhead housing 201 about a horizontal axis. The receptacle 102 thus provides a moment restraint on the high-pressure wellhead housing 201, whereby the zero clearance effects an immediate transfer of bending moment applied to the high-pressure wellhead housing 201 into the structure 101.

Providing the assembly 100 with a rigidly fixed connection between the high-pressure wellhead housing 201 and the receptacle 102 which can be established after installation of the high-pressure wellhead housing 201 can provide the advantage of easier installation, in that the gaps/clearances between the high-pressure wellhead housing 201 and the receptacle 102 can be held sufficiently large to ensure reliable/undisturbed installation of the well pipe 201a and housing 201. This may, for example, be an advantage in cases where there is an angular misalignment of the sea floor foundation 200 relative to the vertical.

Illustrated in Fig. 25, a pre-tensioning lock 140 fixing the high-pressure wellhead housing 201 in or on the receptacle 102 can be applied for this purpose. The pre-tensioning lock 140 may, for example, be such a lock described in the abovementioned WO 2003/002845 A1. In such a case, the pre-tensioning lock 140 can be a rigid lock mechanism 140a operable to engage an outside of the high-pressure wellhead housing 201 and the receptacle 102 to rigidly fix the high-pressure wellhead housing 201 in or to the receptacle 102 with a clearance-free connection.

In one example, illustrated in Figs 27a and 27b, the pre-tensioning lock 140 is a clamp 140b. The clamp 140b can advantageously be arranged to engage an outside surface of both the high-pressure wellhead housing 201 and the receptacle 103. The high-pressure wellhead housing 201 can be configured to land on a shoulder of the receptacle 103 and the clamp 140b can be operable to provide a force urging the high-pressure wellhead housing 201 towards the shoulder to provide a rigid fixation. The shoulder could advantageously be of a “ball joint style” design, to allow good contact at any misalignment.

The pre-tensioning lock 140 may be one or more wedges. An example of such an arrangement is illustrated in Fig. 28. In this example, to close the gaps/clearances after landing of the high-pressure wellhead housing 201, a set of wedges 151,152 are used. The wedges 151,152 are disengaged during installation of the structure 101 and high-pressure wellhead housing 201. The wedges 151,152 can be held in place by a retainer ring 153 allowing free passage of the high-pressure wellhead housing 201 to its landed position in the receptacle 103. Grooves can for example be machined in the receptacle 103 and/or on the high-pressure wellhead housing 201 to guide the wedges 151,152. After landing of the high-pressure wellhead housing 201 in the receptacle 103, the wedges 151,152 can be released from the retainer ring 153 and either (a) are permitted to slide downward and into position due to gravity, or (b) lowered using a mechanism. In this example, both upper and lower wedges are illustrated, being arranged vertically spaced, however the skilled reader will understand that wedges may be used at only one vertical elevation. A second contact point, for example an inclined shoulder, may provide a second contact which together with the wedge provide a vertically spaced pair of forces operable to create a moment restraint and to provide immediate bending moment transfer from the high-pressure wellhead housing 201 into the structure 101. The geometry of the wedges 151,152 can advantageously be made such that they induce self-locking. As the wedges 151,152 are allowed to move in place or forced in place, a clearance-free contact is created between the high-pressure wellhead housing 201 and the receptacle 103. As can be seen from Fig. 28, in this example the wedges 151,152 are operable to move vertically into place.

In another example, the pre-tensioning lock 140 may be a plurality of locking dogs. This is illustrated schematically in Figs 29a and 29b, where a plurality (for example, three) locking dogs 140d are provided in the receptacle 102. Actuators 140e are provided and operable to activate the locking dogs 140d by urging them into engagement with the high-pressure wellhead housing 201. The locking dogs 140d may be positioned at one vertical level, as illustrated, or at more than one vertical level, such as two vertically spaced sets of locking dogs 140d. In the example illustrated in Fig. 29a, the high-pressure wellhead housing 201 engages the receptacle 102 at engagement faces 140f, for example several, spaced engagement faces about the inner circumference of the receptacle 102 or a continuous circumferential engagement face about the inner circumference of the receptacle 102. The engagement face(s) 140f may be a vertical face or a slightly angled face, such as a shoulder on which the high-pressure wellhead housing 201 can land. Locking dogs 140d (illustrated schematically in Fig. 29a) is provided at a vertically lower position for engagement with the high-pressure wellhead housing 201.

Once landed, the actuators 140e can be engaged to force the locking dogs 140d into engagement with the high-pressure wellhead housing 201. This closes the gaps and provides a clearance-free fixation of the high-pressure wellhead housing 201 in the receptacle 102. The actuators 140e can, for example, be actuated by a remotely operated vehicle (ROV) having an appropriate torque tool for operating the actuators 140e and moving the locking dogs 140d.

In this example, the pre-tensioning lock 140 thus provides a horizontal activation towards the high-pressure wellhead housing 201.

Fig. 30 illustrates another example of providing a clearance-free connection between the high-pressure wellhead housing 201 and the receptacle 102. In this example, the high-pressure wellhead housing 201 is fixed by welding to the receptacle 102 after landing. A method of achieving such welding (e.g. cold welding) of the high-pressure wellhead housing 201 towards the receptacle 102 is to introduce high contact stresses during installation (e.g. at the contact points indicated in Fig. 30 at 140g). This welding can be further strengthened by applying a rotational movement (indicated at 140h) of the high-pressure wellhead housing 201 while maintaining high contact stresses of the high-pressure wellhead housing 201 towards the receptacle 102. The use of high alloy materials on both the high-pressure wellhead housing 201 and on the receptacle 102 can increase the effect of cold welding. By means of the welding, a rigid connection is obtained between the high-pressure wellhead housing 201 and on the receptacle 102, such as to provide for immediate bending moment transfer.

Fig. 31 illustrates another example, wherein a clearance-free connection is provided between the high-pressure wellhead housing 201 and the receptacle 201 by means of a filler material such as grouting, epoxy or cement injected into to the space (e.g., the void, annulus or gap, such as the space indicated at 140i in Fig. 31) between the high-pressure wellhead housing 201 and the receptacle 103. A method of closing this space between the high-pressure wellhead housing 201 and the receptacle 103 is by providing a dedicated access point into the space. This access point can be used to fill the space with the filler material after landing the high-pressure wellhead 201 in the receptacle 103. Preferably, the filler material is a material which can harden in the space, into a substantially non-compressible state. As the filler material hardens, a clearance-free, rigid connection between the high-pressure wellhead housing 201 and the receptacle 102 is provided at multiple points or continuously over a vertical distance, thus allowing load to be efficiently transferred from the high-pressure wellhead housing 201 to the receptacle 102 and thus into the structure 101.

Figs 32a and 32b illustrate another example, wherein a clearance-free connection is provided between the high-pressure wellhead housing 201 and the receptacle 201 by creating a physical contact with no gaps between the high-pressure wellhead housing 201 and the receptacle 102. This can be achieved by altering the dimensions of the high-pressure wellhead housing 201, the receptacle 102 or both through a cold forging process.

Fig. 32a illustrates one option of achieving this, wherein a swage tool 149 is used to seal off a part of the interior volume of the high-pressure wellhead housing 201, creating a closed volume 146 between an upper seal 148 and a lower seal 147. The volume 146 is then pressurized to a level where the material of the high-pressure wellhead housing 201 is yielding outwardly such that it comes into contact with the receptacle 102 and elastically deforms the receptacle 102 outwardly. The high-pressure wellhead housing 201 is deformed such that it plastically deforms outwardly in order that gaps between the high-pressure wellhead housing 201 and the receptacle 102 are closed by the elastically deformed receptacle 102. Advantageously, prepared grooves or profiles can be included on the high-pressure wellhead housing 201 and/or the receptacle 102 to increase load transfer capability in terms of vertical loads, shear forces and/or bending moment loads after forging.

Fig. 32b illustrates an alternative method following the same principles as described in relation to Fig. 32a, but where the swage tool 149 is arranged about the receptacle 102 and the high-pressure wellhead housing 201 to engage an outer surface of the receptacle 102. In this example, the receptacle 102 is forged/swaged inwardly and plastically deformed into fixed, clearance-free engagement with the high-pressure wellhead housing 201. Similarly as above, prepared grooves or profiles can be included on the high-pressure wellhead housing 201 and/or the receptacle 102 to increase load transfer capability in terms of vertical loads, shear forces and/or bending moment loads after forging.

Fig. 33a illustrates another example where receptacle 102 comprises a lower support face 134 and the well pipe 201a comprises a support member 133 arranged to engage the lower support face 134 with a small or zero clearance. The support member 133 may, for example, be a larger cross-section feature such as a machined/forged extension pipe or a separate part such as a ring firmly connected to the well pipe 201a (e.g., bolted, welded, shrink fit or by another method). The example shown in Fig. 33a can thus provide a larger distance between the vertically spaced contacts between the high-pressure wellhead housing 201 and the receptacle 102 in the moment restraint, thereby improved performance for example with a lesser reliance on small clearances.

Fig. 33b illustrates another example. In this example, the wellhead assembly further comprises a plurality of stiffeners 137,138. The stiffeners can provide a reduction in stress in the lower part of the high-pressure wellhead housing 201, in the well pipe 201a, and/or in the weld 201c. The stiffeners may for example be a plurality of stiffener plates 137, illustrated on the left hand side in Fig. 33b, disposed about the high-pressure wellhead housing 201 and the well pipe 201a. The stiffener plates 137 are fixed to both the high-pressure wellhead housing 201 and to the well pipe 201a, and span the weld 201c. The stiffener plates 137 can advantageously be arranged to extend radially outwardly from the housing 201 and pipe 201a for best structural support. The wellhead assembly may, for example, comprise four, six, eight or more stiffener plates 137.

Alternatively, or additionally, the assembly may comprise a support member 133 as described in relation to Fig. 33a above and a plurality of bars 138 fixed to the high-pressure wellhead housing 201 and to the support member 133, spanning the weld 201c. This is illustrated on the right hand side of Fig. 33b. The wellhead assembly may, for example, comprise four, six, eight or more bars 138. The bars 138 may be preloaded to offer increased stiffness.

The stiffener plates 137 and/or bars 138 can contribute to take parts of the loads away from the weld 201c and/or stiffen sections of the high-pressure wellhead housing 201 and the well pipe 201a.

Optionally, a circular sleeve may be used as an alternative to the stiffener plates 137 or bars 138.

Figs 34a-c shows an alternative example wherein the receptacle 102 is landed subsequent to installing the wellhead assembly 100 with the wellhead support structure 101. In this example, the receptacle is run and rigidly fixed to the wellhead support structure 101 after the wellhead support structure 101 is positioned on the sea floor. The high-pressure wellhead housing 201 with the high-pressure well pipe 201a is subsequently run and landed in the receptacle 102, and a connection between the high-pressure wellhead housing 201 and the receptacle 102 established. The high-pressure wellhead housing 201 is not shown in Figs 34a-c, however it may have a design similar to any of the examples described above and may be installed similarly as described in the examples above.

The receptacle 102 in this example may be a conductor housing having a conductor casing attached thereto, extending into the sea floor. Alternatively, only a receptacle 102 can be installed, having no conductor casing or other pipe extending from the receptacle 102 into the sea floor.

The receptacle 102 may in this example be fixed to the wellhead support structure 101 in the same manner as the high-pressure wellhead housing 201 is fixed to the receptacle 102 in the examples above. In Figs 34a-c, the receptacle 102 is fixed to the wellhead support structure 101 by bringing a plurality of wedges 154 into engagement between the receptacle 102 and the wellhead support structure 101 for rigidly fixing the receptacle 102 to the wellhead support structure 101. The wedges 154 establish two vertically spaced contacts, such as to provide a moment restraint on the receptacle 102.

Alternatively, the receptacle 102 can be fixed to the wellhead support structure 101 by means of: a pre-tensioning lock fixing the receptacle 102 to the wellhead support structure 101; a clamp clamping the receptacle 102 to the wellhead support structure 101; a forged or swaged connection between the receptacle 102 and the wellhead support structure 101; a rigid lock mechanism 140a between the receptacle 102 and the wellhead support structure 101 for rigidly fixing the receptacle 102 to the wellhead support structure 101; a welded connection between the receptacle 102 and the wellhead support structure 101; or providing a filler material into a space between the receptacle 102 and the wellhead support structure 101.

In any of the embodiments and examples described herein, the receptacle 102 may be of elongate, tubular form and fixed to the support structure 101, such that the receptacle 102 is configured to receive the high-pressure wellhead housing 201 at least partially therein.

By a clearance-free connection or a clearance-free moment restraint in the above description, a connection is meant which provides a moment restraint in which no gap closing before bending moment transfer occurs. While the skilled reader will understand that in conventional wellhead systems, a clearance-free connection may be provided by the high-pressure wellhead housing landing and resting e.g. on a shoulder in the support structure, according to the present disclosure a clearance-free connection or clearance-free moment restraint requires no bending or rotation of the components to close any gaps before bending moment transfer occurs. Alternatively, in some examples a moment restrained is provided after a gap or clearance has been closed between the high-pressure wellhead housing 201 and the receptacle 102, for example in an arrangement as shown in Fig. 23.

Examples described here can thus provide enhanced load handling capability, whereby an increased lifetime can be achieved for the high-pressure wellhead housing 201, the well pipe 201a, and/or other components, while ensuring good installation capability in a subsea environment. In a clearance-free moment restraint, immediate support against for example small fatigue loads can be achieved. In the examples not having a clearance-free moment restraint, enhanced load transfer can be obtained by e.g. improved bending moment restraint and load paths.

All the examples described herein may be particularly suitable for a conductorless wellhead assembly, i.e. wherein no low-pressure pipe or intermediate pipe is run or set between the receptacle 102 and the high-pressure wellhead housing 201.

The invention is not limited by the embodiments described above; reference should be had to the appended claims. The following numbered clauses outline further embodiments and inventive aspects according to the present disclosure:

1. A wellhead assembly (100) comprising:
   a wellhead support structure (101) arranged as part of a sea floor foundation (200), the support structure (101) defining a passage (103), and
   a receptacle (102) arranged at least partly in the passage (103) and fixed to the support structure (101) via a connection member (105).
2. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) comprises an annular plate, particularly wherein the connection member (105) comprises an annular disc or polygonal plate.
3. A wellhead assembly (100) according to any preceding clause, wherein the annular plate has a plurality of first structural connectors (110a,b) to the wellhead support structure (101).
4. A wellhead assembly (100) according to any preceding clause, wherein the annular plate has a plurality of second structural connectors (111a,b) to the receptacle (102).

5. A wellhead assembly (100) according to any preceding clause, wherein the first and/or second structural connectors (110a,b,111a,b) comprises brackets engaging an upper and/or a lower surface of the annular plate.
6. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) forms a continuous structure between the receptacle (102) and the support structure (101) such as to prevent fluid flow through the passage (103) between the receptacle (102) and the support structure (101).
7. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) comprises a plate arranged substantially horizontally or horizontally between an outer surface (102a) of the receptacle (102) and an inner surface (103a) of the structure (101), the inner surface (103a) defining the passage (103).
8. A wellhead assembly (100) according to any preceding clause, wherein the outer surface (102a) of the receptacle (102) has a circular cross-section in a horizontal plane.
9. A wellhead assembly (100) according to any preceding clause, wherein the passage (103) has a circular cross-section in a horizontal plane.
10. A wellhead assembly (100) according to any preceding clause, wherein the passage (103) is defined by a cylindrical wall (103a) which is part of the support structure (101).
11. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) is arranged in the passage (103).
12. A wellhead assembly (100) according to any preceding clause, wherein the plate is an annular plate, particularly wherein the plate is an annular disc.
13. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) is configured to receive and hold a high-pressure wellhead housing (201).
14. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) has an internal profile (102c) configured for receiving and supporting a high-pressure wellhead housing (201).
15. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) is configured for receiving a high-pressure wellhead housing (201) directly, without any intermediate pipes between the receptacle (102) and the high-pressure wellhead housing (201).

16. A wellhead assembly (100) according to any preceding clause, comprising the high-pressure wellhead housing (201) supported in the receptacle (102).
17. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) has a continuous weld towards the outer surface (102a) of the receptacle (102).
18. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) has a continuous weld towards the inner surface (103a) of the structure (101).
19. A wellhead assembly (100) according to any preceding clause, wherein the passage (103) between the receptacle (102) and the support structure (101) is sealed, particularly wherein fluid flow through the passage (103) between the receptacle (102) and the support structure (101) is prevented.
20. A wellhead assembly (100) according to any preceding clause, the assembly comprising a seal between the connection member (105) and the outer surface (102a) of the receptacle (102) and between the connection member (105) and the inner surface (103a) of the structure (101) such as to prevent fluid flow through the passage (103) between the receptacle (102) and the support structure (101).
21. A wellhead assembly (100) according to any preceding clause, the assembly comprising a seal (128) between the outer surface (102a) of the receptacle (102) and the inner surface (103a) of the structure (101) such as to prevent fluid flow through the passage (103) between the receptacle (102) and the support structure (101).
22. A wellhead assembly (100) according to any preceding clause, wherein the sea floor foundation (200) is a suction anchor foundation having an internal volume (202) defined by a top cover (204) and skirt (203), the skirt (203) defining a lower end opening (205),
and wherein the receptacle (102) is sealingly fixed to or integrated within the top cover (204).
23. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) has a lower end (102b) configured to be positioned above a sea floor (206) when the wellhead assembly (100) is in the installed position.
24. A wellhead assembly (100) according to any preceding clause, wherein the assembly (100) is a conductorless wellhead assembly.

25. A wellhead assembly (100) according to any preceding clause, wherein the wellhead support structure (101) comprises a plurality of substantially horizontal or horizontal beams.
26. A wellhead assembly (100) according to any preceding clause, wherein the beams are arranged onto the top cover (204) or integrated into the top cover (204).
27. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) is arranged vertically level with the beams.
28. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) comprises a first part (105a), the first part being fixed to the structure (101), and a second part (105b), the second part being fixed to the receptacle (102),
and wherein the first part (105a) and the second part (105b) are connected by a weld (105c).
29. A wellhead assembly (100) according to any preceding clause, wherein the weld (105c) is located between the structure (101) and the receptacle (102) such that the weld (105c) is spaced from both the structure (101) and the receptacle (102).
30. A wellhead assembly (100) according to any preceding clause, wherein the first part (105a) is fixed to the structure (101) by a non-welded connection.
31. A wellhead assembly (100) according to any preceding clause, wherein the second part (105b) is fixed to the receptacle (102) by a non-welded connection.
32. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) is an annular plate, such as an annular disc, formed by the first and second parts (105a,b).
33. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) is an annular plate, such as an annular disc, and the weld (105c) is a circumferential weld fixing the first and second parts (105a,b) together.
34. A wellhead assembly (100) according to any preceding clause, further comprising at least one support member (120) arranged to, in conjunction with the connection member (105), provide rotational support for the receptacle (102) from the structure (101).

35. A wellhead assembly (100) according to any preceding clause, wherein the at least one support member (120) is configured to, when engaged, provide horizontal support for the receptacle (102) at a vertical elevation which is spaced from the connection member (105).
36. A wellhead assembly (100) according to any preceding clause, wherein the support member (120) is:
    fixed to the structure (101) and configured to engage an outer surface (102a) of the receptacle (102), or
    wherein the support member (120) is fixed to the receptacle (102) and configured to engage the structure (101), for example a surface (103a) defining the passage 103.
37. A wellhead assembly (100) according to any preceding clause, wherein a gap (121) is provided between the support member (120) and the receptacle (102) or between the support member (120) and the structure (101) such as to engage the support member (120) only when the receptacle (102) has an angular deflection.
38. A wellhead assembly (100) according to any preceding clause, wherein the support member (120):
    is an annular plate, such as an annular disc, arranged about the receptacle (102), or
    comprises a plurality of spaced support members arranged about the receptacle (102).
39. A wellhead assembly (100) according to any preceding clause, further comprising at least one cement pipe (112a), the cement pipe (112a) providing a flow channel between an inside of the receptacle (102) and an outside of the passage (103).
40. A wellhead assembly (100) according to any preceding clause, wherein the at least one cement pipe (112a) extends through the passage (103), optionally wherein the at least one cement pipe (112a) extends radially and/or horizontally through the passage (103).
41. A wellhead assembly (100) according to any preceding clause, wherein the at least one cement pipe (112a) extends through the inner surface (103a).
42. A wellhead assembly (100) according to any preceding clause, wherein the at least one cement pipe (112a) is arranged inside the passage (103).

43. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) is fixed to a tail pipe (109) arranged in extension of the receptacle (102).
44. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) is fixed to the tail pipe (109) by a welded or threaded connection.
45. A wellhead assembly (100) according to any preceding clause, wherein the tail pipe (109) is a pipe configured for extending into a soil layer and/or the tail pipe (109) is less than 10m in length, less than 5m in length, or less than 3m in length.
46. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) is not configured to extend into a soil layer and/or is not connected to a tail pipe (109).
47. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) is a monolithically formed metal structure which is not connected to any pipe extending longitudinally in extension of the receptacle (102), particularly wherein the receptacle (102) is not welded to any pipe extending longitudinally in extension of the receptacle (102), such as a tail pipe (109).
48. A wellhead assembly (100) according to any preceding clause, further comprising a tail pipe (109’) arranged in extension of the passage (103) and configured for extending into a soil layer.
49. A wellhead assembly (100) according to any preceding clause, wherein the tail pipe (109’) is provided in extension of the inner surface (103a).
50. A wellhead assembly (100) according to any preceding clause, wherein the tail pipe (109’) comprises a frusto-conical connection section (109’’) extending between the passage (103) and the tail pipe (109’), particularly wherein the frusto-conical connection section (109’’) extends between the inner surface (103a) and the tail pipe (109’).
51. A wellhead assembly (100) according to any preceding clause, wherein the tail pipe (109’) and/or the frusto-conical connection section (109’’) defines a cementing volume about a well pipe (201a) extending downwardly from the high-pressure wellhead housing (201).
52. A wellhead assembly (100) according to any preceding clause, wherein the passage (103) forms part of the cementing volume.

53. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) is fixed to the receptacle (102) at a lower part of the receptacle (102), particularly wherein the connection member (105) is fixed to the receptacle (102) at a lower half of the receptacle (102), at a lowermost 30% of the receptacle (102), or at a lowermost 20% of the receptacle (102).
54. A wellhead assembly (100) according to any preceding clause, wherein a part of the receptacle (102) extending below the connection member (105) makes up less than 30% of the longitudinal length of the receptacle (102), less than 20% of the longitudinal length of the receptacle (102), or less than 10% of the longitudinal length of the receptacle (102).
55. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) comprises a thickened portion (105d) at the interface towards the receptacle (102).
56. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) comprises at least one stop member (107,108) defining a stop face arranged to prevent longitudinal movement of the connection member (105) relative to the receptacle (102).
57. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) comprises a plurality of through passages (106).
58. A wellhead assembly (100) according to any preceding clause, wherein the connection member (105) comprises a plurality of radially extending support struts (105e) connecting the receptacle (102) and the structure (101).
59. A wellhead assembly (100) according to any preceding clause, wherein the radially extending support struts (105e) are circumferentially disposed about the receptacle (102).

60. A wellhead assembly (100) comprising:
a wellhead support structure (101) arranged as part of a sea floor foundation (200), the support structure (101) having a receptacle (102) rigidly fixed thereto, the receptacle (102) being configured to receive and hold a high-pressure wellhead housing (201).
61. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) has an internal profile (102c) configured for receiving and supporting the high-pressure wellhead housing (201).

62. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) is configured for receiving the high-pressure wellhead housing (201) directly, without any intermediate pipes between the receptacle (102) and the high-pressure wellhead housing (201).
63. A wellhead assembly (100) according to any preceding clause, comprising the high-pressure wellhead housing (201) supported in the receptacle (102).
64. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) is fixed to and supported by the support structure (101), particularly such that the support structure (101) provides a bending moment restraint on the receptacle (102) and prevents rotation of the receptacle (102) about a horizontal axis.
65. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) is fixed to the support structure (101) by:
    - a shrink fit connection,
    - a clamped connection,
    - a bolted connection, or
    - a welded connection.
66. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) is fixed to the support structure (101) by a plurality of wedges (154).
67. A wellhead assembly (100) according to the preceding clause, wherein the wedges establish vertically spaced contacts between the receptacle (102) and the support structure (101) whereby the support structure (101) provides a bending moment restraint on the receptacle (102) and prevents rotation of the receptacle (102) about a horizontal axis.
68. A wellhead assembly (100) according to any preceding clause, wherein the support structure (101) defines a vertical passage (103) and the vertical passage (103) prevents rotation of the receptacle (102) about a horizontal axis.
69. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) is arranged in the passage (103) to a close fit tolerance, particularly wherein a clearance between an outer cylindrical surface of the receptacle (102) and an inner cylindrical surface of the passage (103) is less than 1 mm, less than 0.5 mm, or less than 0.2 mm.

70. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) is arranged in the passage (103) with zero clearance between the receptacle (102) and the passage (103).
71. A wellhead assembly (100) according to any preceding clause, wherein the wellhead support structure (101) comprises a plurality of substantially horizontal or horizontal beams and the receptacle (102) is rigidly fixed on top of the beams or horizontally aligned with the beams and wherein the beams are fixed to outer surfaces of the receptacle (102).
72. A wellhead assembly (100) according to any preceding clause, wherein the wellhead assembly is a wellhead assembly (100) according to any of clauses 1-59 having a passage (103), and the receptacle (102) is arranged at least partly in the passage (103) and fixed to the support structure (101) via the connection member (105).
73. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) comprises two vertically spaced, circumferential support faces (130,131), each of the support faces (130,131) configured for providing horizontal support to the high-pressure wellhead housing (201), particularly wherein the two vertically spaced, circumferential support faces (130,131) in conjunction provide a bending moment restraint on the high-pressure wellhead housing (201) in the receptacle (102).
74. A wellhead assembly (100) according to any preceding clause, wherein each of the circumferential support faces (130,131) is vertical.
75. A wellhead assembly (100) according to any preceding clause, wherein the circumferential support faces (130,131) are both arranged:
    - above a weld (201c) interconnecting the high-pressure wellhead housing (201) to a high-pressure well pipe (201a), and/or
    - above a transition section (201d) in the high-pressure wellhead housing (201), the transition section (201d) being a section in which the material thickness of the high-pressure wellhead housing (201) is reduced to a thickness substantially the same as that of the high-pressure well pipe (201a).
76. A wellhead assembly (100) according to any preceding clause, wherein the vertical distance between the support faces (130,131) is larger than an outer diameter (D1) of a connector part (201b) of the high-pressure wellhead housing (201), larger than a maximum or largest outer diameter (D2) of the

high-pressure wellhead housing (201), and/or larger than twice the outer diameter (D1) of the connector part (201b).

77. A wellhead assembly (100) according to any preceding clause, wherein the upper circumferential support face (130) has a diameter which is larger than that of the lower circumferential support face (131).
78. A wellhead assembly (100) according to any preceding clause, wherein the receptacle (102) comprises a landing shoulder (132) configured for providing vertical support to the high-pressure wellhead housing (201).
79. A wellhead assembly (100) according to any preceding clause, wherein the landing shoulder (132) is arranged between two vertically spaced, circumferential support faces (130,131).
80. A wellhead assembly (100) according to any preceding clause, wherein the high-pressure wellhead housing (201) is arranged in the receptacle (102) with zero clearance between the high-pressure wellhead housing (201) and the receptacle (102).
81. A wellhead assembly (100) according to any preceding clause, wherein the high-pressure wellhead housing (201) is rigidly fixed in the receptacle (102), particularly wherein the receptacle (102) provides a bending moment restraint on the high-pressure wellhead housing (201) and/or the receptacle (102) prevents rotation of the high-pressure wellhead housing (201) about a horizontal axis.
82. A wellhead assembly (100) according to any preceding clause, comprising a pre-tensioning lock (140) fixing the high-pressure wellhead housing (201) in or on the receptacle (102).
83. A wellhead assembly (100) according to any preceding clause, wherein the pre-tensioning lock (140) is a rigid lock mechanism (140a) operable to engage an outside of the high-pressure wellhead housing (201) and the receptacle (102) to rigidly fix the high-pressure wellhead housing (201) in or to the receptacle (102).
84. A wellhead assembly (100) according to any preceding clause, wherein the pre-tensioning lock (140) is a clamp (140b).
85. A wellhead assembly (100) according to any preceding clause, wherein the high-pressure wellhead housing (201) is configured to land on a shoulder of the receptacle (103) and the clamp (140b) is operable to provide a force urging the high-pressure wellhead housing (201) towards the shoulder.

86. A wellhead assembly (100) according to any preceding clause, wherein the pre-tensioning lock (140) is one or more locking members, for example where the pre-tensioning lock (140) is at least one vertically movable wedge (151,152) operable to engage an outside surface of the high-pressure wellhead housing (201) and an inner surface of the receptacle (103) when the high-pressure wellhead housing (201) is landed in the receptacle (103) or where the pre-tensioning lock (140) is at least one horizontally movable locking dog operable to engage the high-pressure wellhead housing (201) when the high-pressure wellhead housing (201) is landed in the receptacle (103).
87. A wellhead assembly (100) according to any preceding clause, wherein the connection between the support structure (101) and the receptacle (102) and between the receptacle (102) and the high-pressure wellhead housing (201) provide a moment restraint on the high-pressure wellhead housing (201) such that a bending moment applied to the high-pressure wellhead housing (201) is counteracted by the support structure (101).
88. A method of establishing a subsea well, the method comprising the steps:
    (i) installing a wellhead assembly (100) on a sea floor, the wellhead assembly (100) having a wellhead support structure (101) with a pre-installed receptacle (102) fixed, such as rigidly fixed, thereto,
    (ii) running a high-pressure well pipe (201a) through the receptacle (102) and into the sea floor,
    (iii) landing a high-pressure wellhead housing (201) in the receptacle (102), and
    (iv) establishing a connection between the high-pressure wellhead housing (201) and the receptacle (102), whereby the connection provides a moment restraint of the high-pressure wellhead housing (201) in the receptacle (102).
89. The method of any preceding clause, wherein step (iv) comprises bringing two vertically spaced, circumferential support faces (130,131) in the receptacle (102) adjacent or into contact with the high-pressure wellhead housing (201).
90. The method of any preceding clause, wherein step (iii) comprises landing the high-pressure wellhead housing (201) on a shoulder (132) in the receptacle (102).

91. The method of any preceding clause, wherein the shoulder (132) is arranged between the two vertically spaced, circumferential support faces (130,131).
92. The method of any preceding clause, wherein step (iv) comprises establishing a clearance-free moment restraint on the high-pressure wellhead housing (201) from the receptacle (102).
93. The method of any preceding clause, wherein step (iv) comprises activating a pre-tensioning lock (140) fixing the high-pressure wellhead housing (201) in or on the receptacle (102).
94. The method of any preceding clause, wherein step (iv) comprises:
    - clamping the high-pressure wellhead housing (201) to the receptacle (102),
    - bringing or forcing at least one wedge or locking dog into engagement with the receptacle (102) and the high-pressure wellhead housing (201) to establish the connection,
    - forging or swaging the high-pressure wellhead housing (201) into engagement with the receptacle (102),
    - forging or swaging the receptacle (102) into engagement with the high-pressure wellhead housing (201),
    - activating a rigid lock mechanism (140a) to establish the connection,
    - welding the high-pressure wellhead housing (201) to the receptacle (102), or
    - providing a filler material into a space between the high-pressure wellhead housing (201) and the receptacle (102).
95. The method of any preceding clause, wherein step (iii) comprises landing the high-pressure wellhead housing (201) directly in the receptacle (102) without an intermediate low-pressure pipe or pipe housing therebetween.
96. A method of establishing a subsea well, the method comprising the steps:
    (i) installing a wellhead assembly (100) on a sea floor, the wellhead assembly (100) having a wellhead support structure (101),
    (ii) running a receptacle (102) and rigidly fixing the receptacle (102) to the wellhead support structure (101),
    (iii) running a high-pressure well pipe (201a) through the receptacle (102) and into the sea floor,
    (iv) landing a high-pressure wellhead housing (201) in the receptacle (102), and

(v) establishing a connection between the high-pressure wellhead housing (201) and the receptacle (102), whereby the connection provides a moment restraint of the high-pressure wellhead housing (201) in the receptacle (102).

97. The method of any preceding clause, wherein the receptacle is a conductor housing having a conductor casing attached thereto and step (ii) comprises running the conductor casing into the sea floor prior to landing the receptacle

98. The method of any preceding clause, wherein the receptacle has no pipe attached thereto which extends into the sea floor.

99. The method of any preceding clause, wherein step (v) comprises bringing two vertically spaced, circumferential support faces (130,131) in the receptacle (102) adjacent or into contact with the high-pressure wellhead housing (201).

100. The method of any preceding clause, wherein step (iv) comprises landing the high-pressure wellhead housing (201) on a shoulder (132) in the receptacle (102).

101. The method of any preceding clause, wherein the shoulder (132) is arranged between the two vertically spaced, circumferential support faces (130,131).

102. The method of any preceding clause, wherein step (v) comprises establishing a clearance-free moment restraint on the high-pressure wellhead housing (201) from the receptacle (102).

103. The method of any preceding clause, wherein step (v) comprises activating a pre-tensioning lock (140) fixing the high-pressure wellhead housing (201) in or on the receptacle (102).

104. The method of any preceding clause, wherein step (v) comprises:

- clamping the high-pressure wellhead housing (201) to the receptacle (102),
- bringing or forcing at least one wedge or locking dog into engagement with the receptacle (102) and the high-pressure wellhead housing (201) to establish the connection,
- forging or swaging the high-pressure wellhead housing (201) into engagement with the receptacle (102),
- forging or swaging the receptacle (102) into engagement with the high-pressure wellhead housing (201),

- activating a rigid lock mechanism (140a) to establish the connection,
- welding the high-pressure wellhead housing (201) to the receptacle (102), or
- providing a filler material into a space between the high-pressure wellhead housing (201) and the receptacle (102).

105. The method of any preceding clause, wherein step (ii) comprises:

- clamping the receptacle (102) to the wellhead support structure (101),
- bringing or forcing at least one wedge (154) or locking dog into engagement with the receptacle (102) and the wellhead support structure (101) for rigidly fixing the receptacle (102) to the wellhead support structure (101),
- forging or swaging the receptacle (102) into engagement with the wellhead support structure (101),
- activating a rigid lock mechanism (140a) between the receptacle (102) and the wellhead support structure (101) for rigidly fixing the receptacle (102) to the wellhead support structure (101),
- welding the receptacle (102) to the wellhead support structure (101), or
- providing a filler material into a space between the receptacle (102) and the wellhead support structure (101).

CLAIMS

1. A wellhead assembly (100) comprising:
   a wellhead support structure (101),
   a high-pressure wellhead housing (201),
   the wellhead support structure (101) arranged as part of a sea floor foundation (200) and having a receptacle (102) rigidly fixed thereto such that the support structure (101) provides a bending moment restraint on the receptacle (102),
   wherein the receptacle (102) comprises two vertically spaced, circumferential support faces (130,131), each of the support faces (130,131) providing horizontal support to the high-pressure wellhead housing (201), and wherein the two vertically spaced, circumferential support faces (130,131) in conjunction provide a bending moment restraint on the high-pressure wellhead housing (201) in the receptacle (102).

2. A wellhead assembly (100) according to claim 1, wherein the receptacle (102) holds the high-pressure wellhead housing (201) directly, without any intermediate pipes between the receptacle (102) and the high-pressure wellhead housing (201).

3. A wellhead assembly (100) according to any preceding claim, wherein a vertical distance between the support faces (130,131) is larger than an outer diameter (D1) of a connector part (201b) of the high-pressure wellhead housing (201), larger than a largest outer diameter (D2) of the high-pressure wellhead housing (201), and/or larger than twice the outer diameter (D1) of the connector part (201b).

4. A wellhead assembly (100) according to any preceding claim, wherein the uppermost circumferential support face (130) has a diameter which is larger than that of the lowermost circumferential support face (131).

5. A wellhead assembly (100) according to any preceding claim, wherein the receptacle (102) comprises a landing shoulder (132) providing vertical support to the high-pressure wellhead housing (201).

6. A wellhead assembly (100) according to claim 5, wherein the landing shoulder (132) is arranged between two vertically spaced, circumferential support faces (130,131).

7. A method of establishing a subsea well, the method comprising the steps:
   (i) installing a wellhead assembly (100) on a sea floor, the wellhead assembly (100) having a wellhead support structure (101) with a pre-installed receptacle (102) rigidly fixed thereto,
   (ii) running a high-pressure well pipe (201a) through the receptacle (102) and into the sea floor,
   (iii) landing a high-pressure wellhead housing (201) in the receptacle (102), and
   (iv) establishing a connection between the high-pressure wellhead housing (201) and the receptacle (102) by bringing two vertically spaced, circumferential support faces (130,131) in the receptacle (102) adjacent or into contact with the high-pressure wellhead housing (201), whereby the connection provides a moment restraint on the high-pressure wellhead housing (201) in the receptacle (102).

8. The method of claim 7, wherein step (iii) comprises landing the high-pressure wellhead housing (201) on a shoulder (132) in the receptacle (102).

9. The method of claim 8, wherein the shoulder (132) is arranged between the two vertically spaced, circumferential support faces (130,131).

10. The method of any of claims 7-9, wherein step (iii) comprises landing the high-pressure wellhead housing (201) directly in the receptacle (102) without an intermediate low-pressure pipe or pipe housing therebetween.

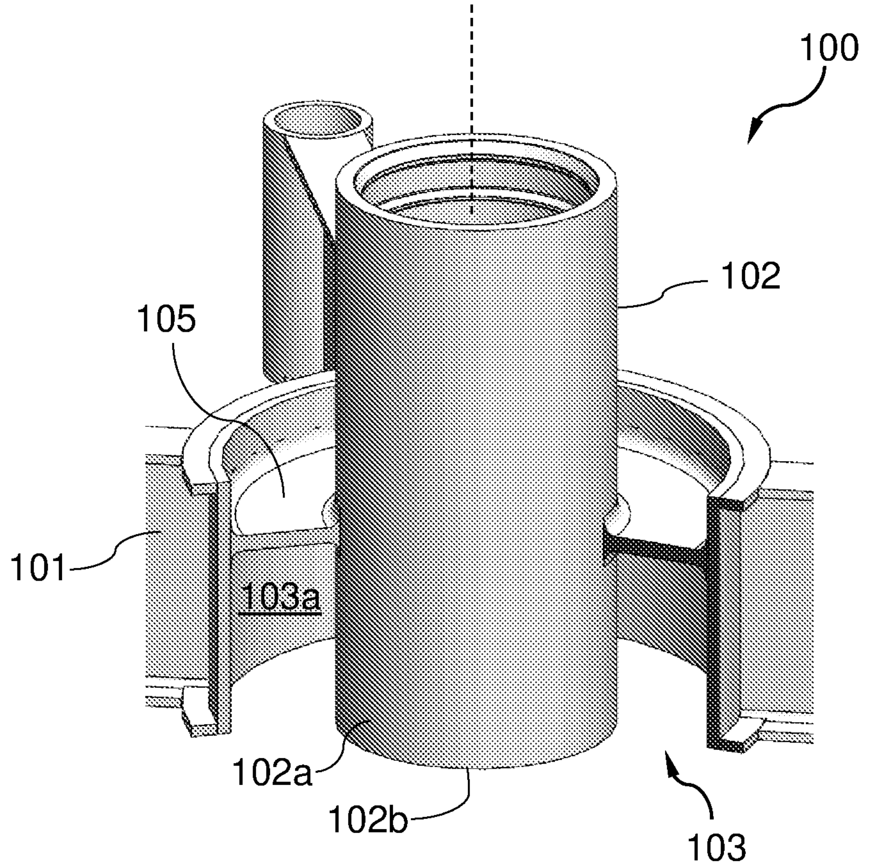

Fig. 1

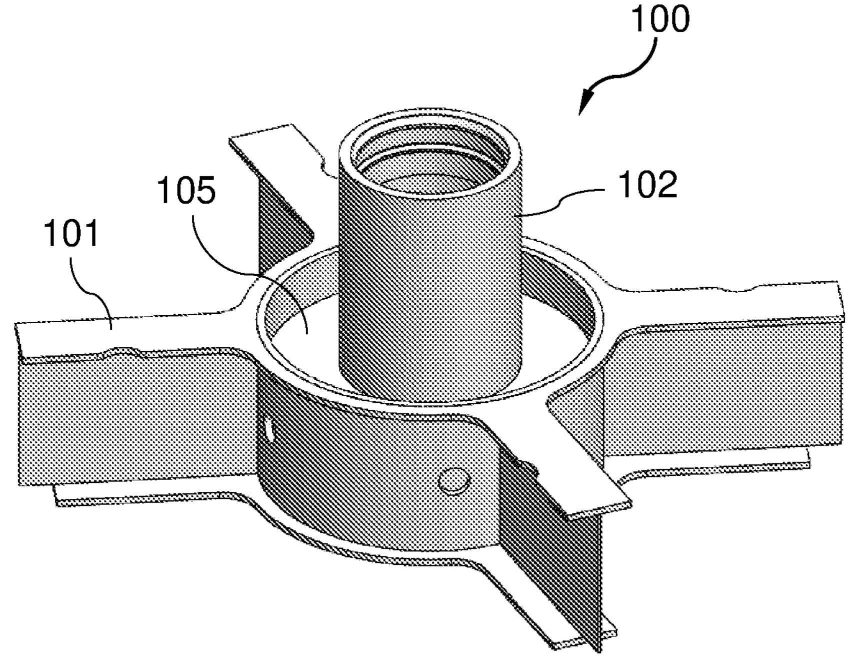

Fig. 2

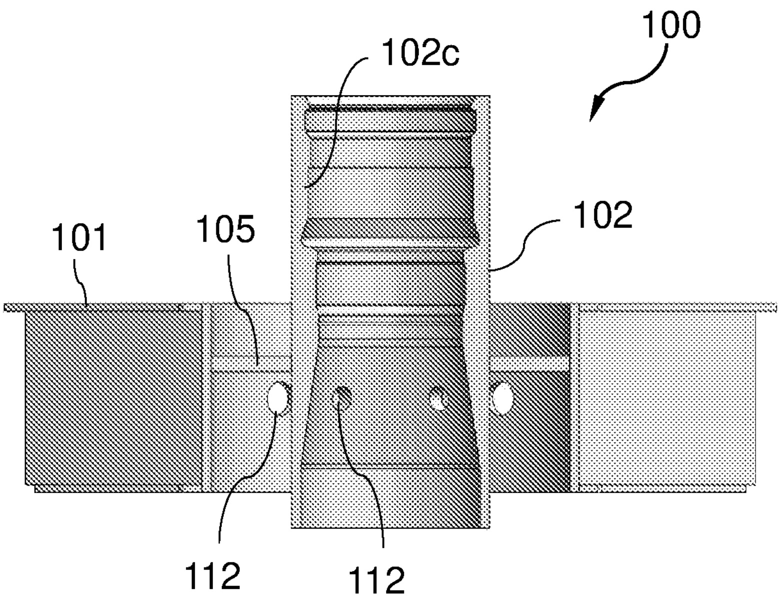

Fig. 3

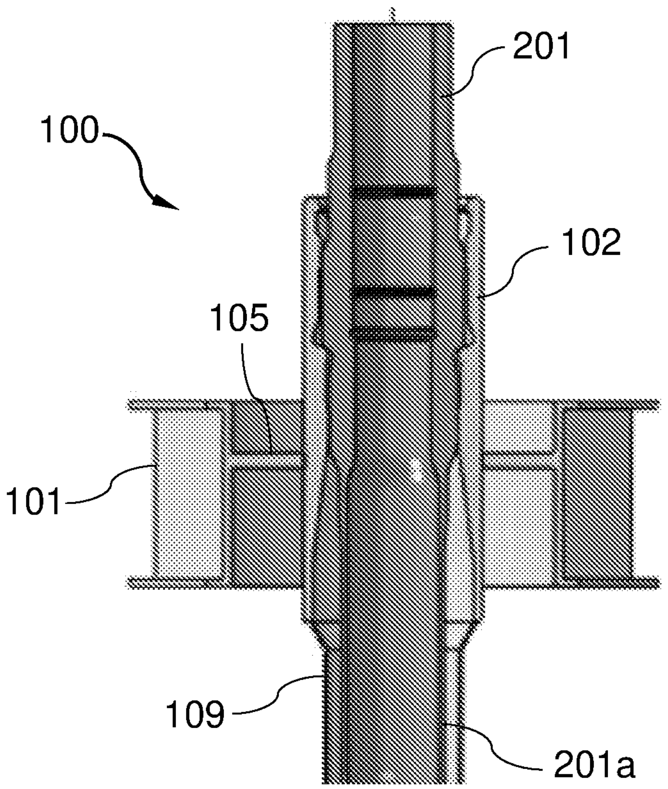

Fig. 4

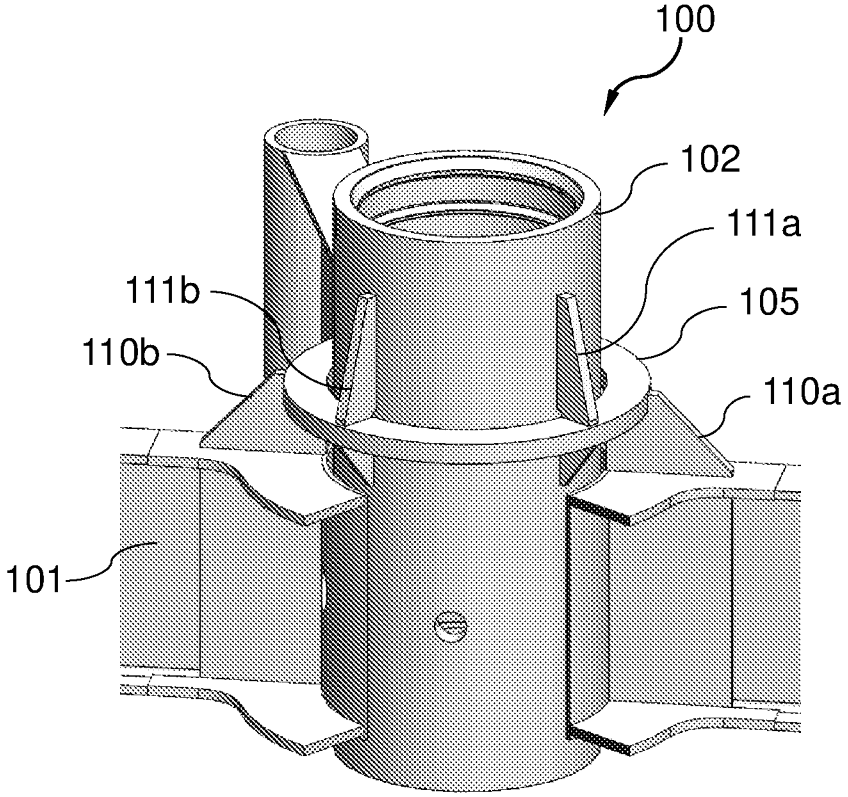

Fig. 5

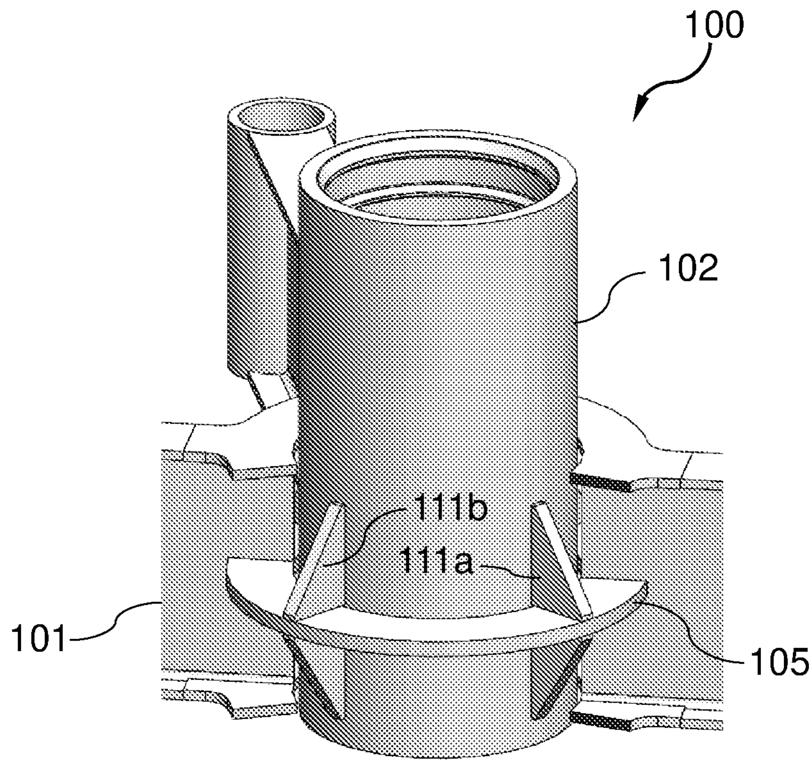

Fig. 6

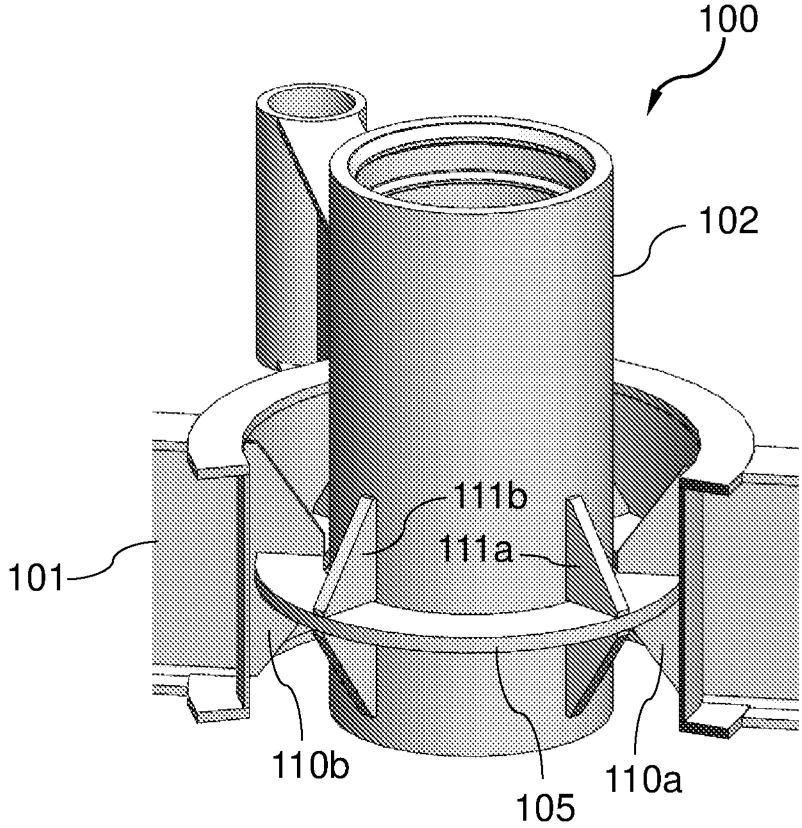

Fig. 7

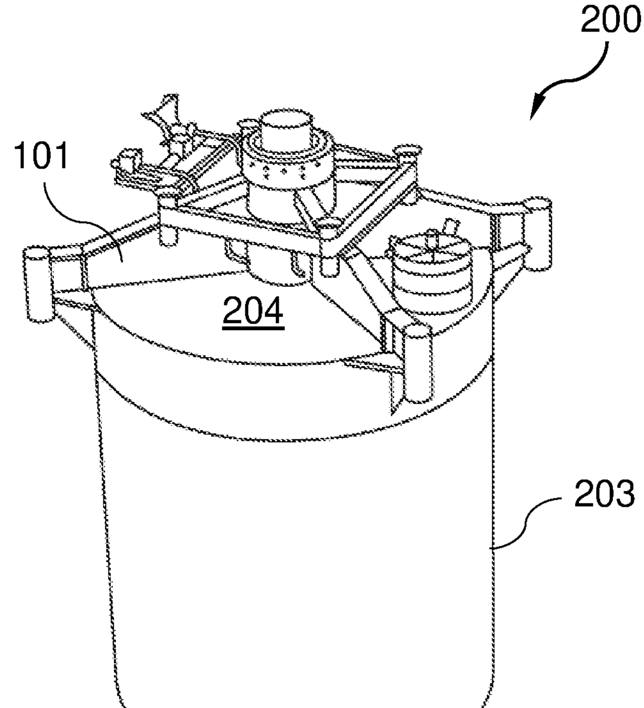

Fig. 8

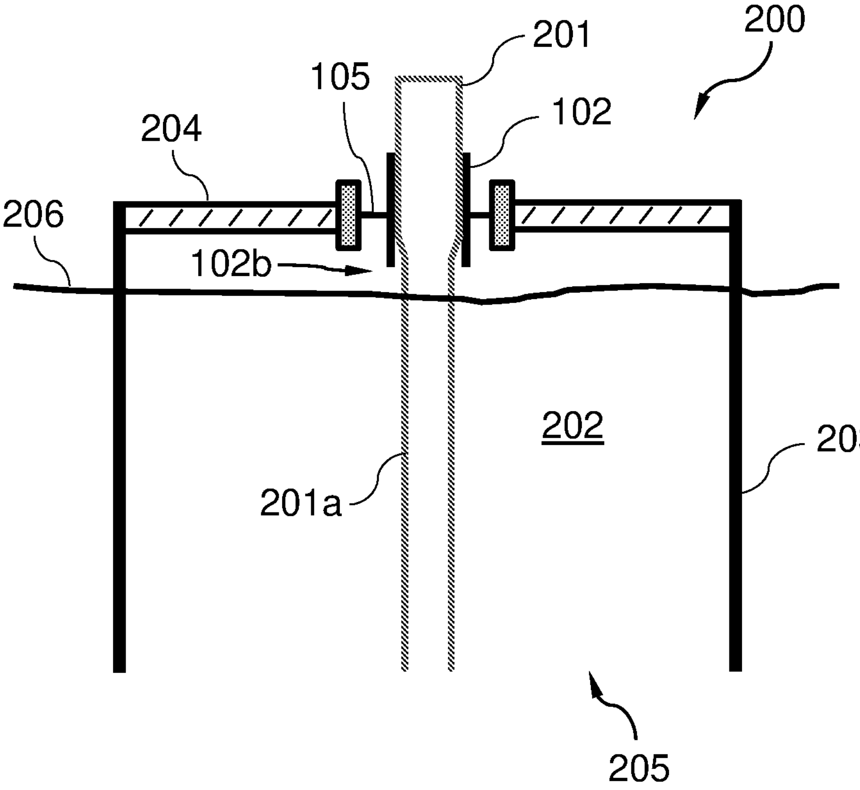

Fig. 9

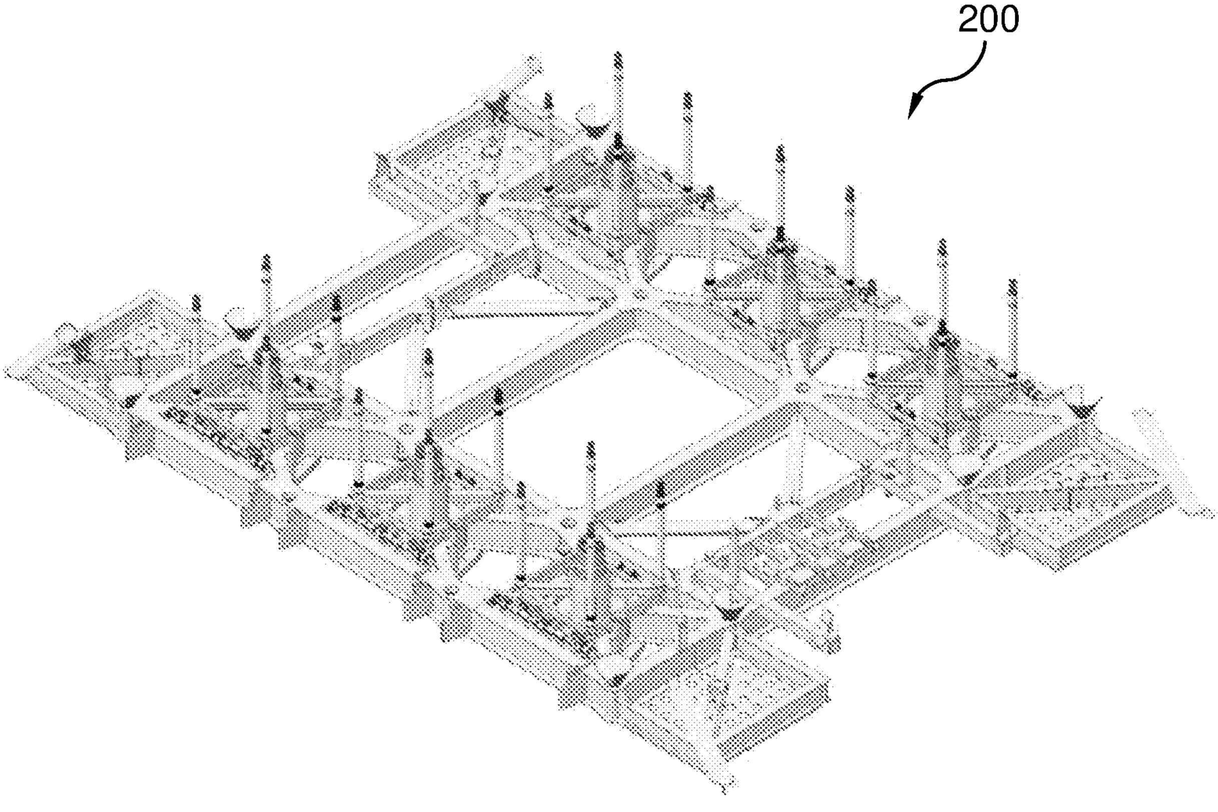

Fig. 10

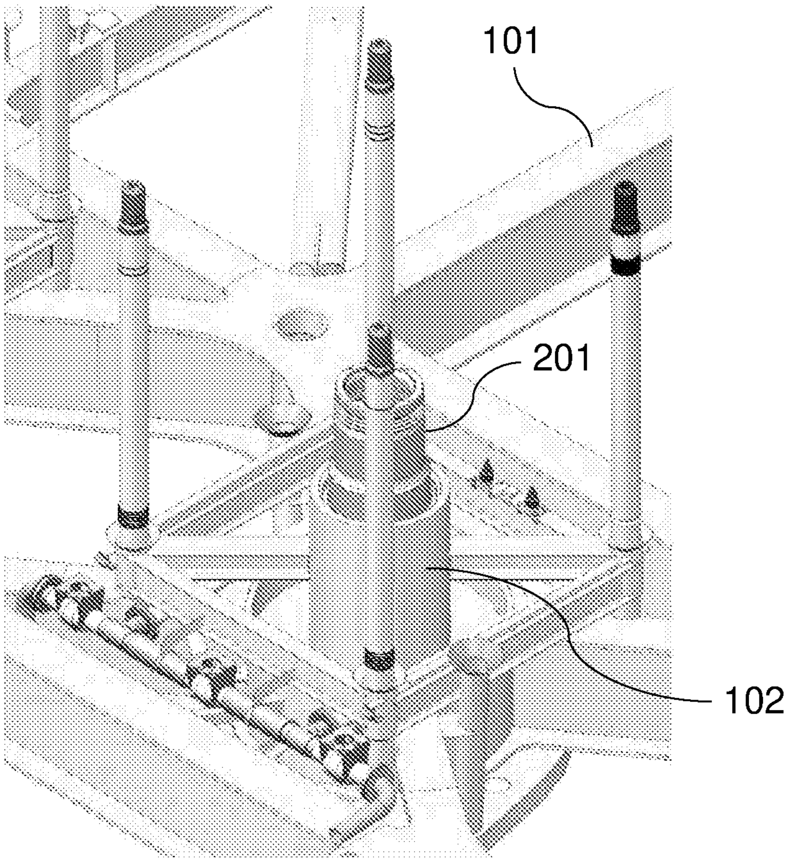

Fig. 11

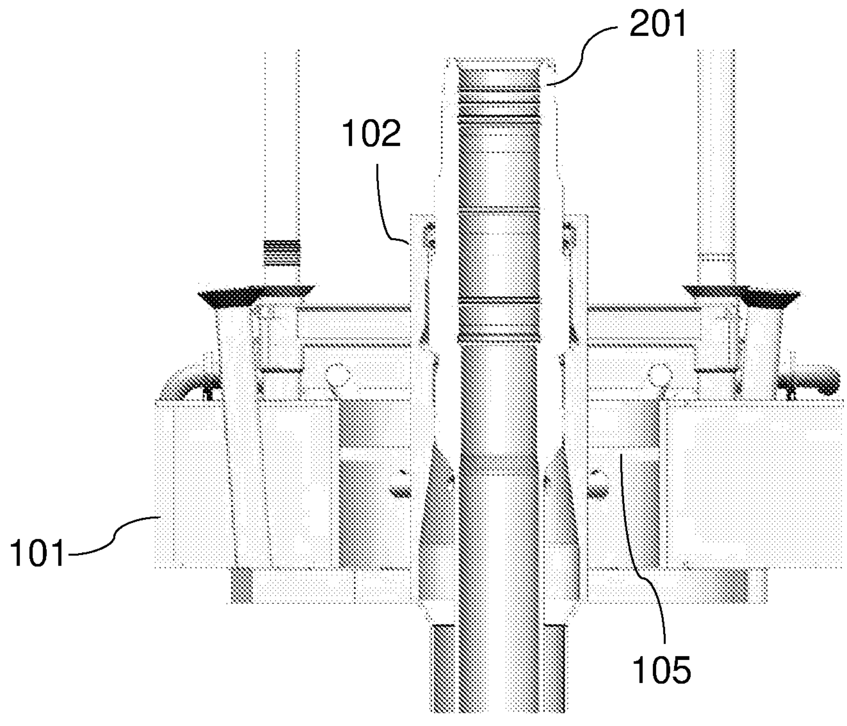

Fig. 12

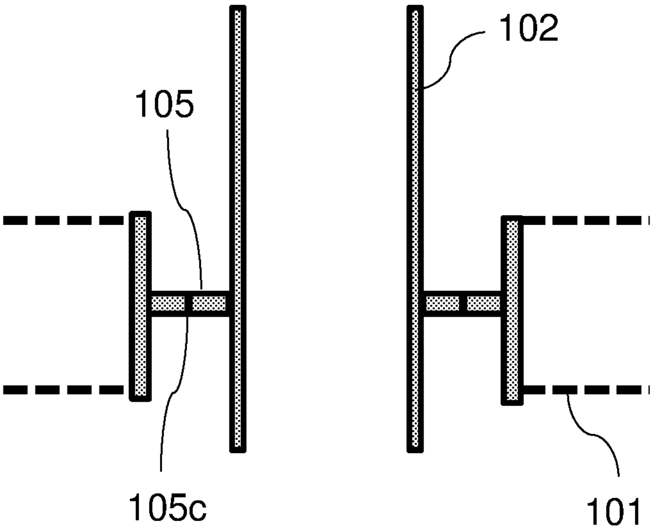

Fig. 13

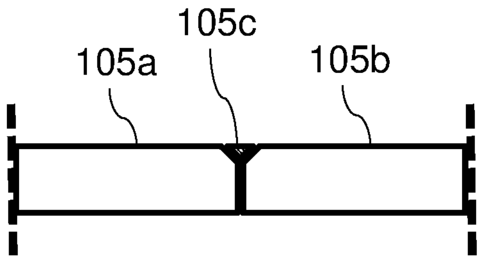

Fig. 14

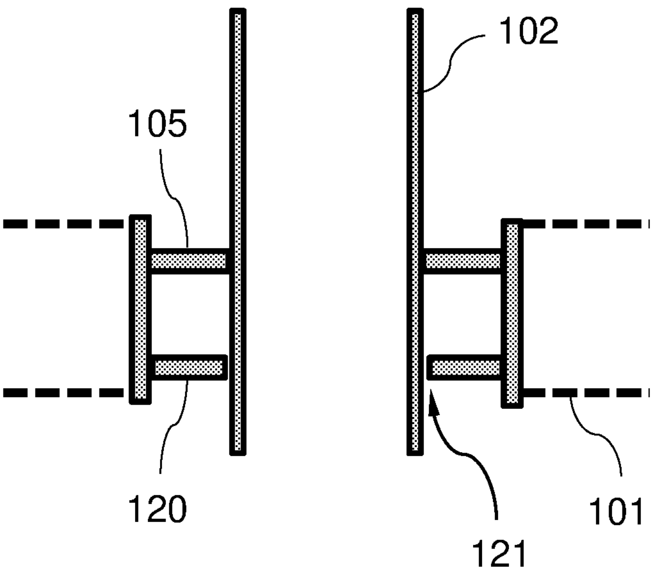

Fig. 15

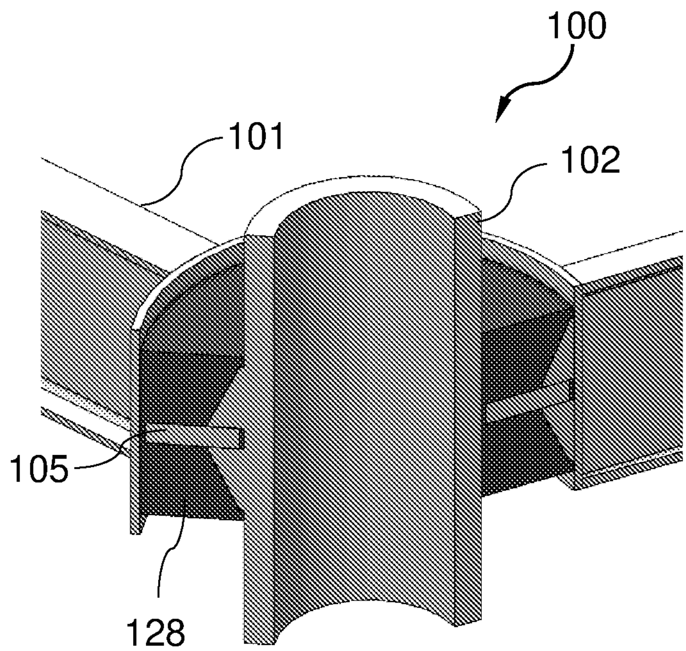

Fig. 20

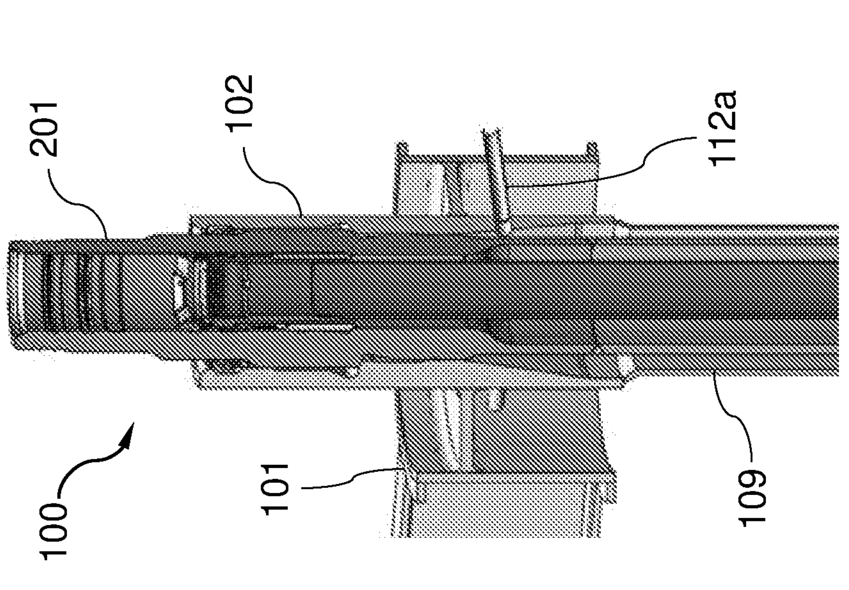

Fig. 16

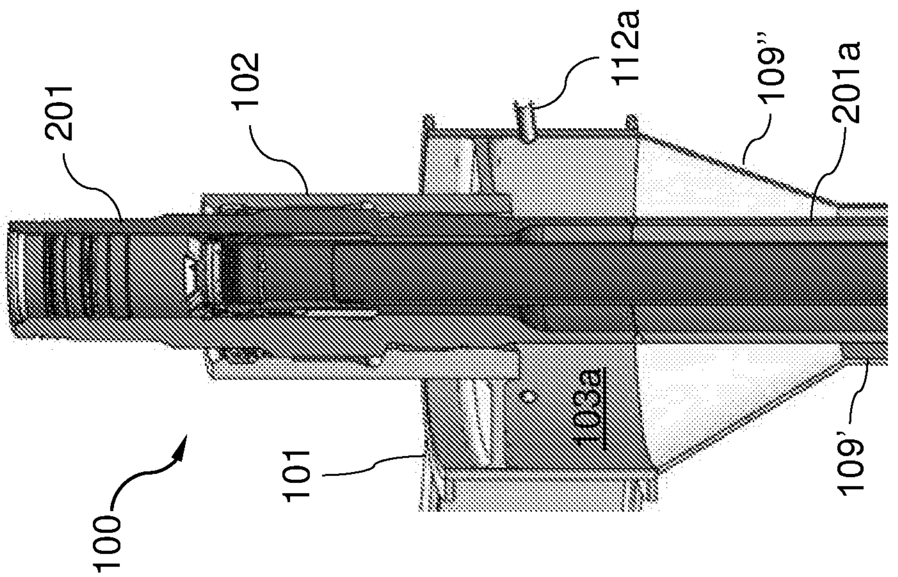

Fig. 17

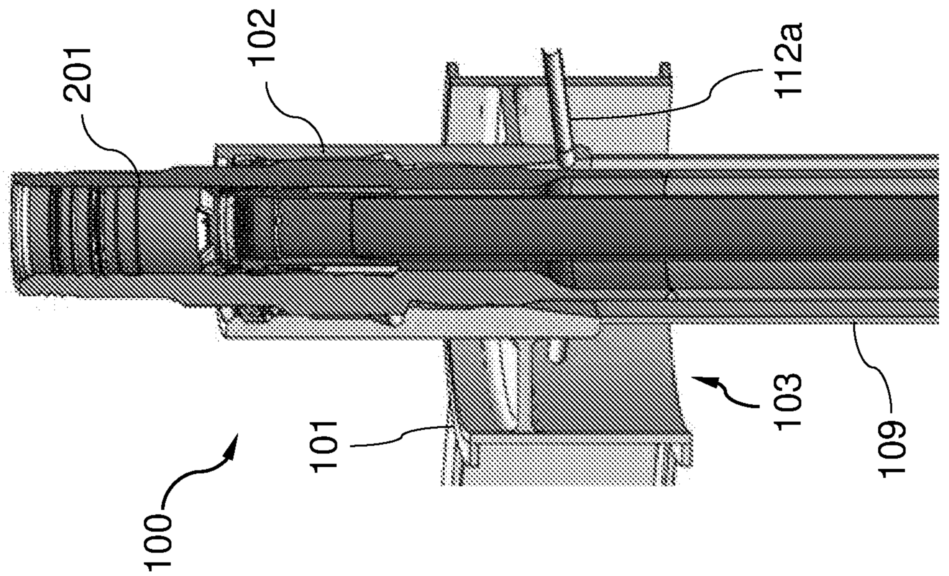

Fig. 18

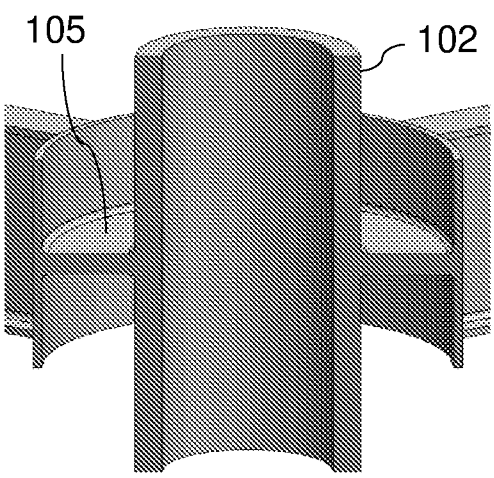

Fig. 19a

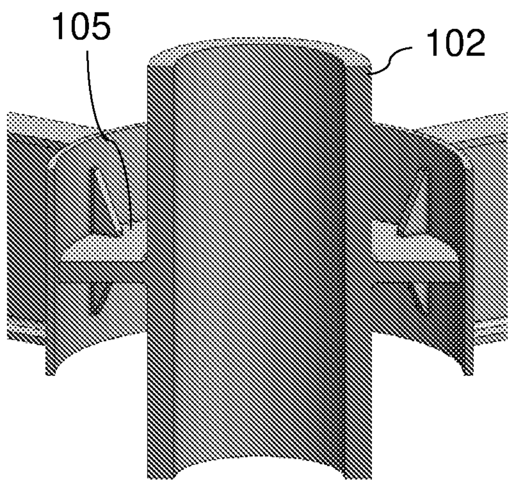

Fig. 19b

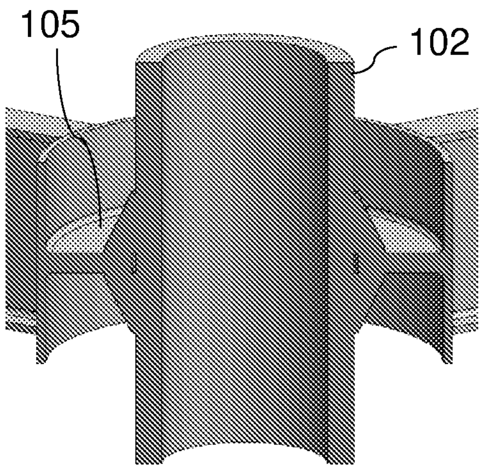

Fig. 19c

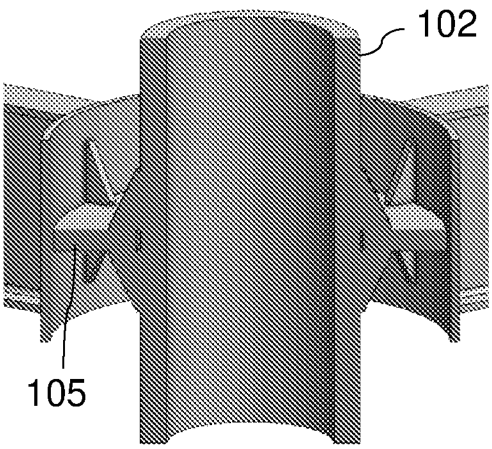

Fig. 19d

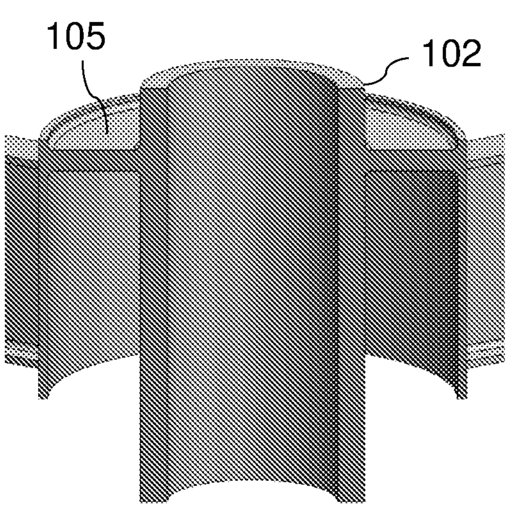

Fig. 19e

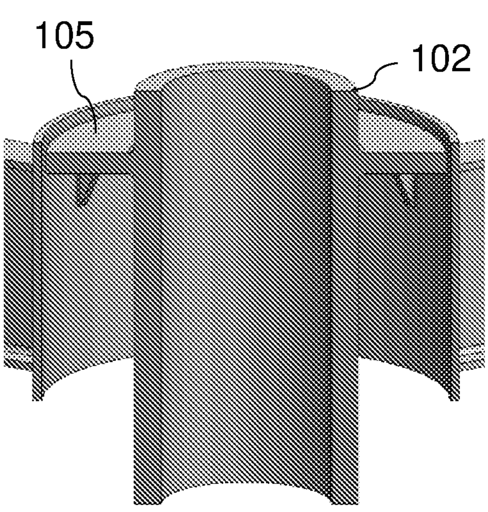

Fig. 19f

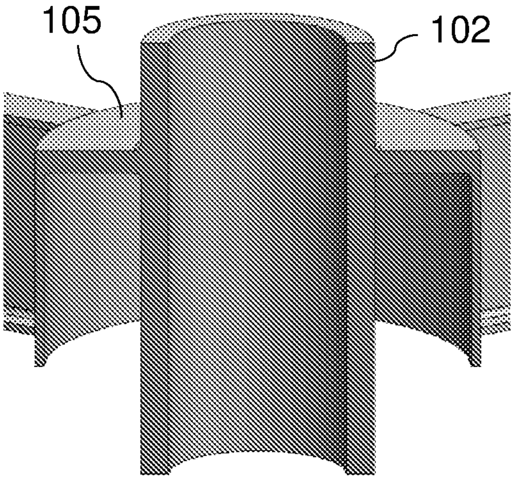

Fig. 19g

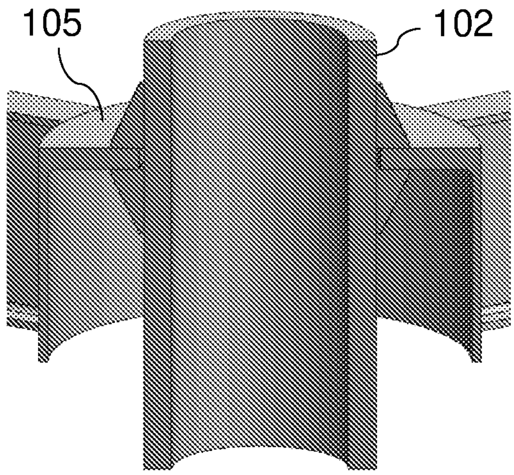

Fig. 19h

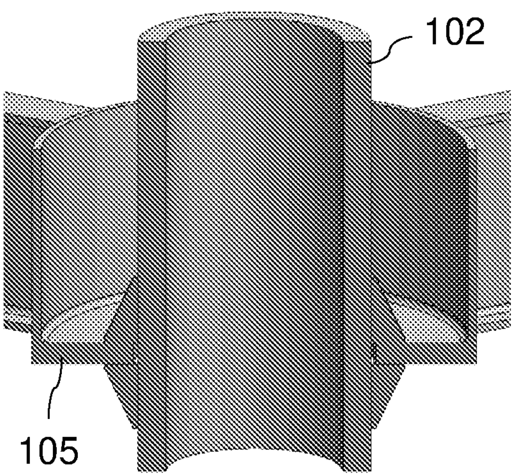

Fig. 19i

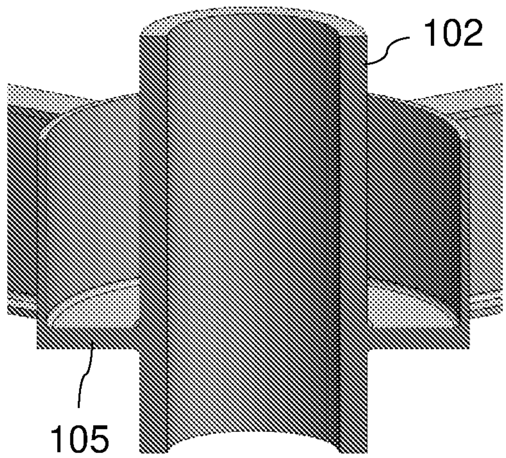

Fig. 19j

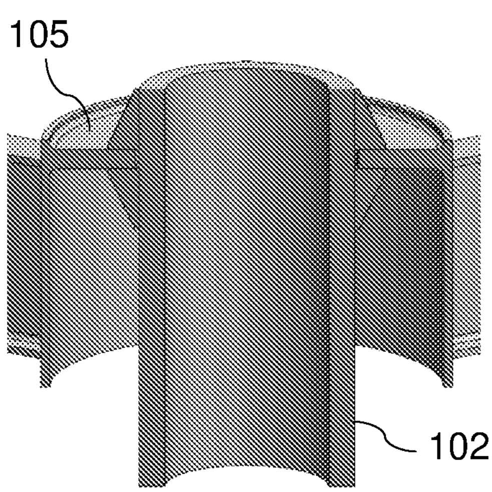

Fig. 19k

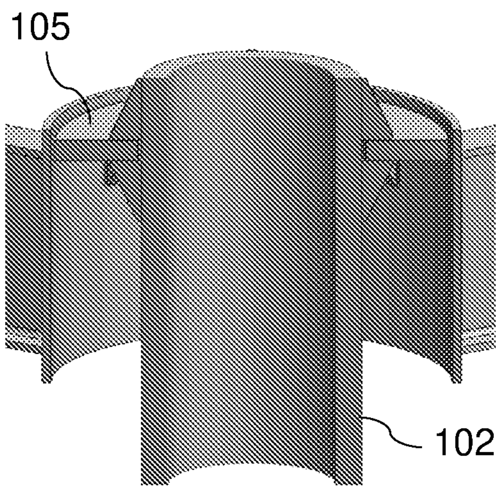

Fig. 19l

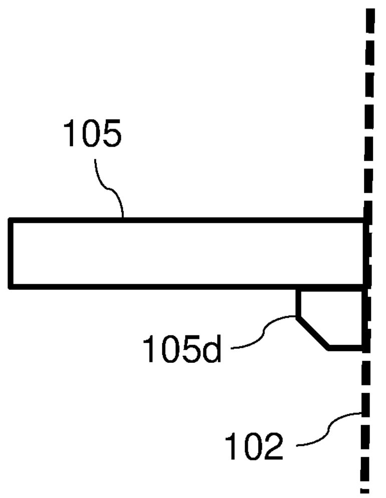

Fig. 21a

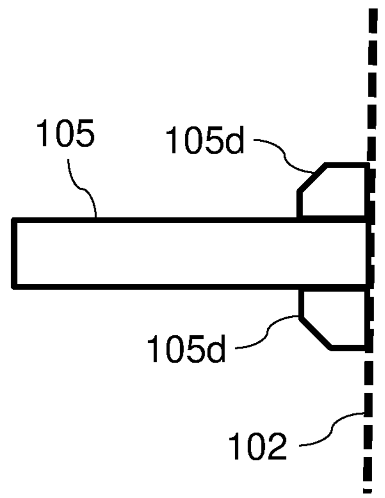

Fig. 21b

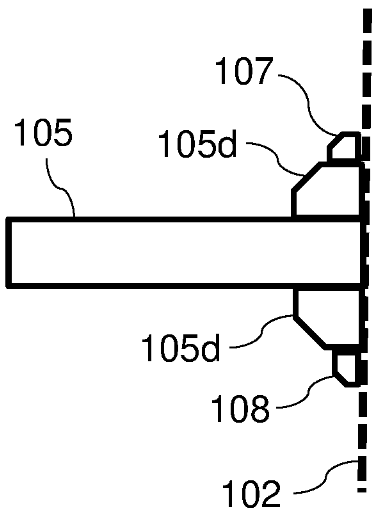

Fig. 21c

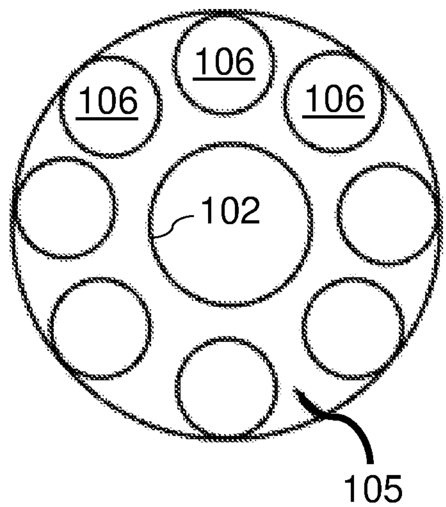

Fig. 22a

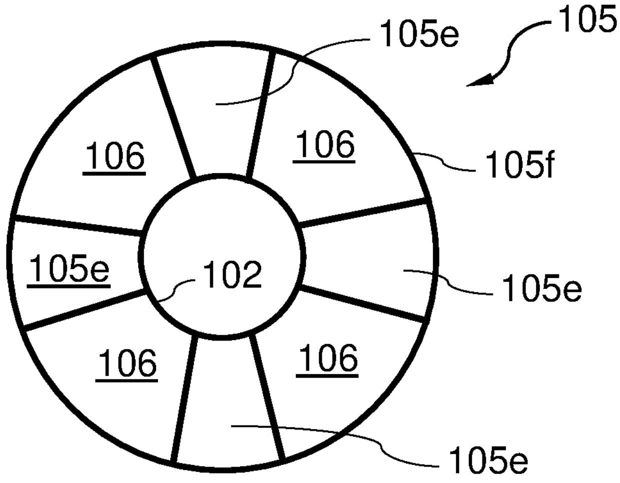

Fig. 22b

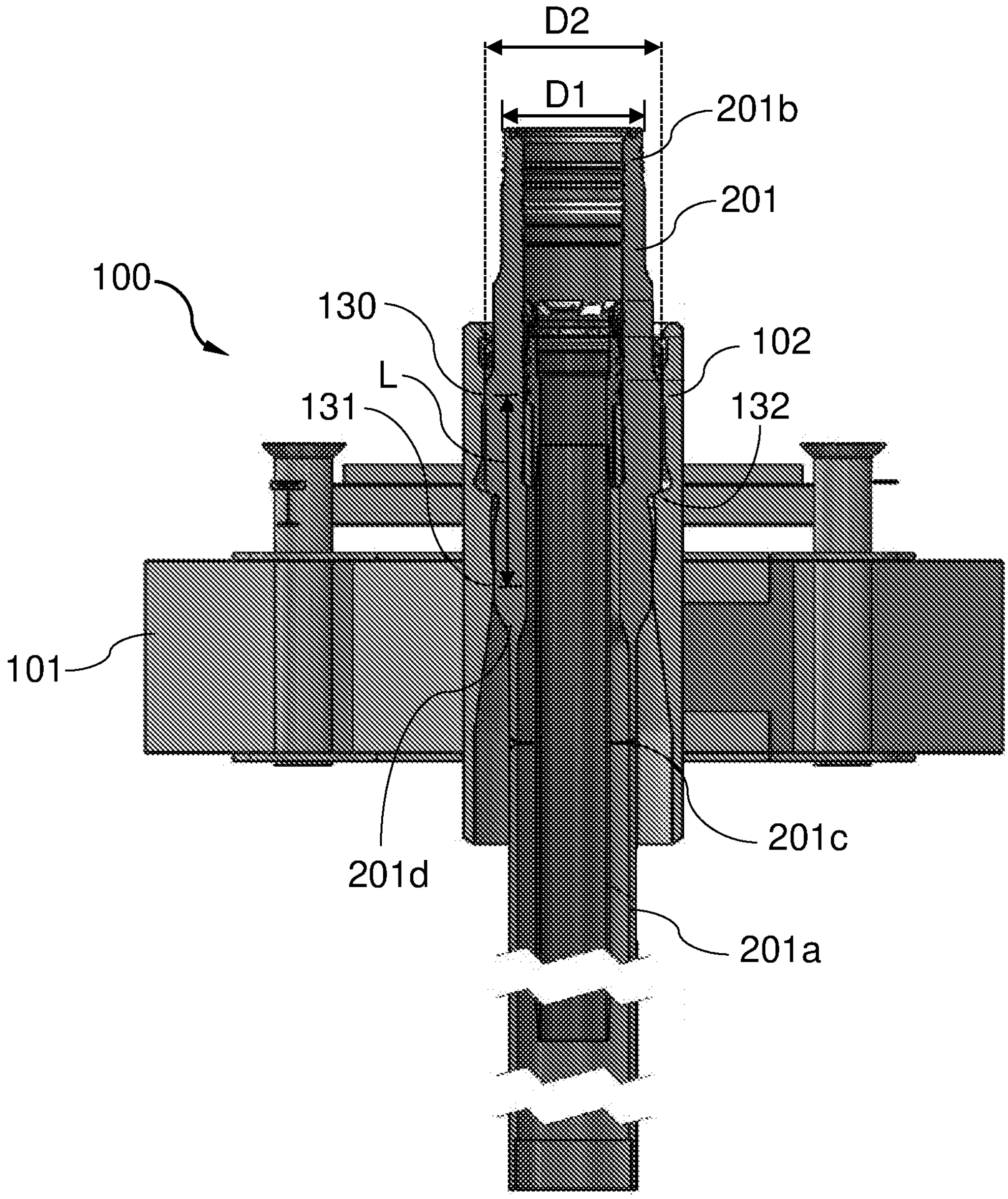

Fig. 23

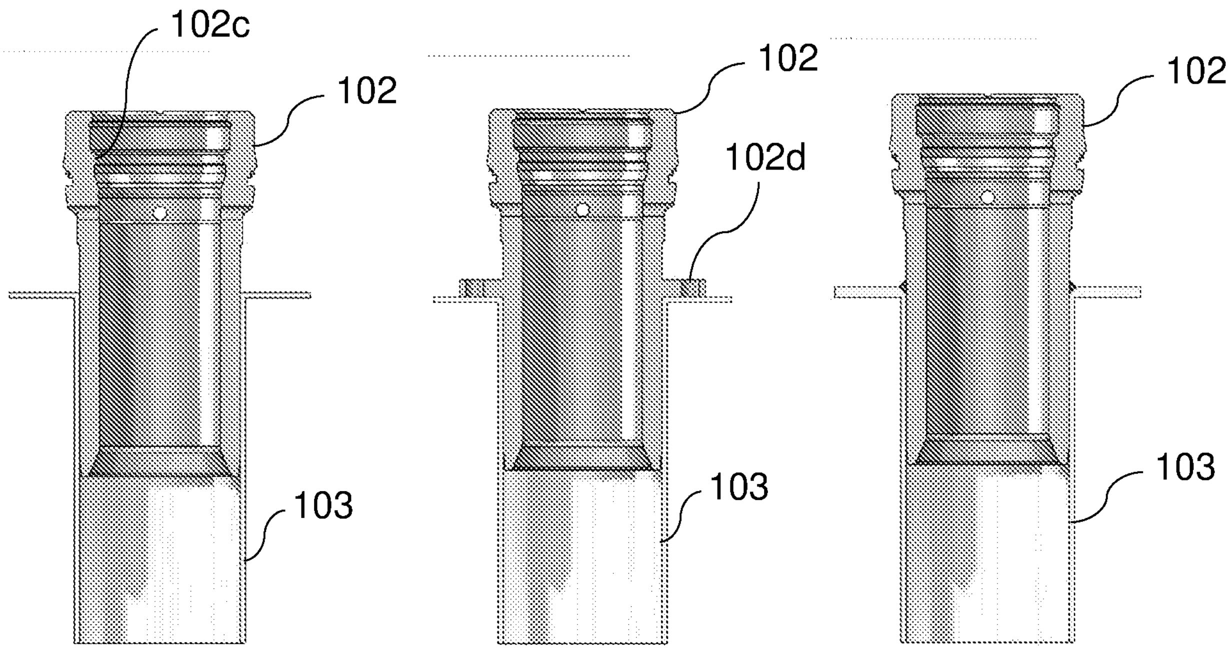

Fig. 24a Fig. 24b Fig. 24c

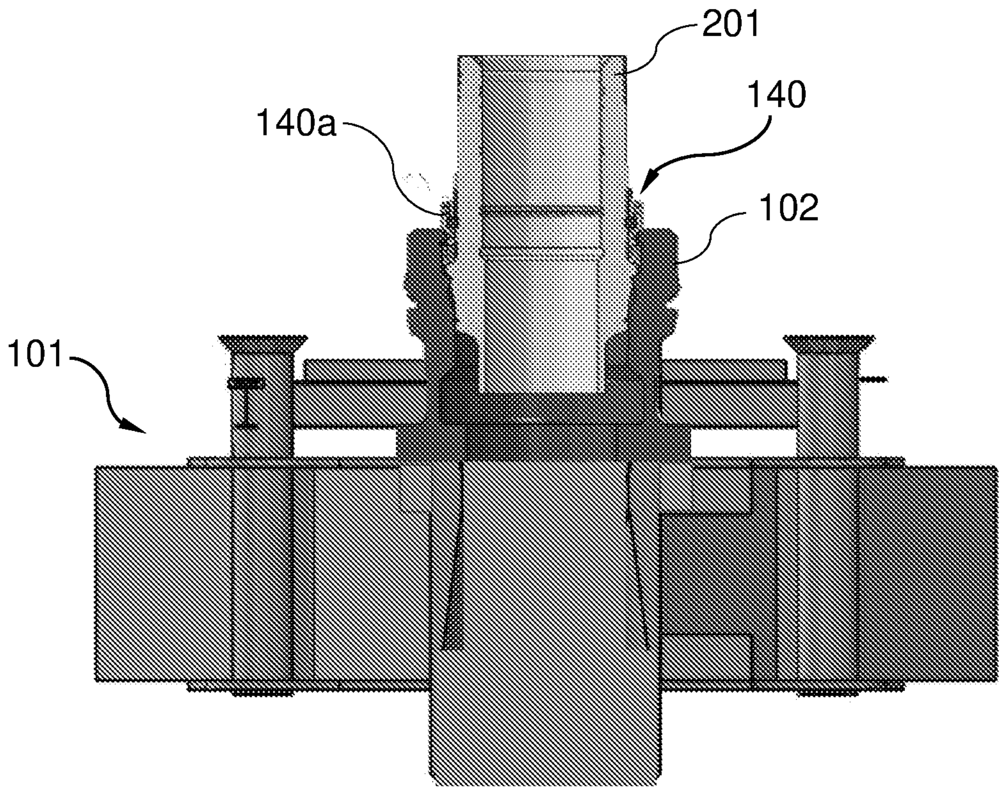

Fig. 25

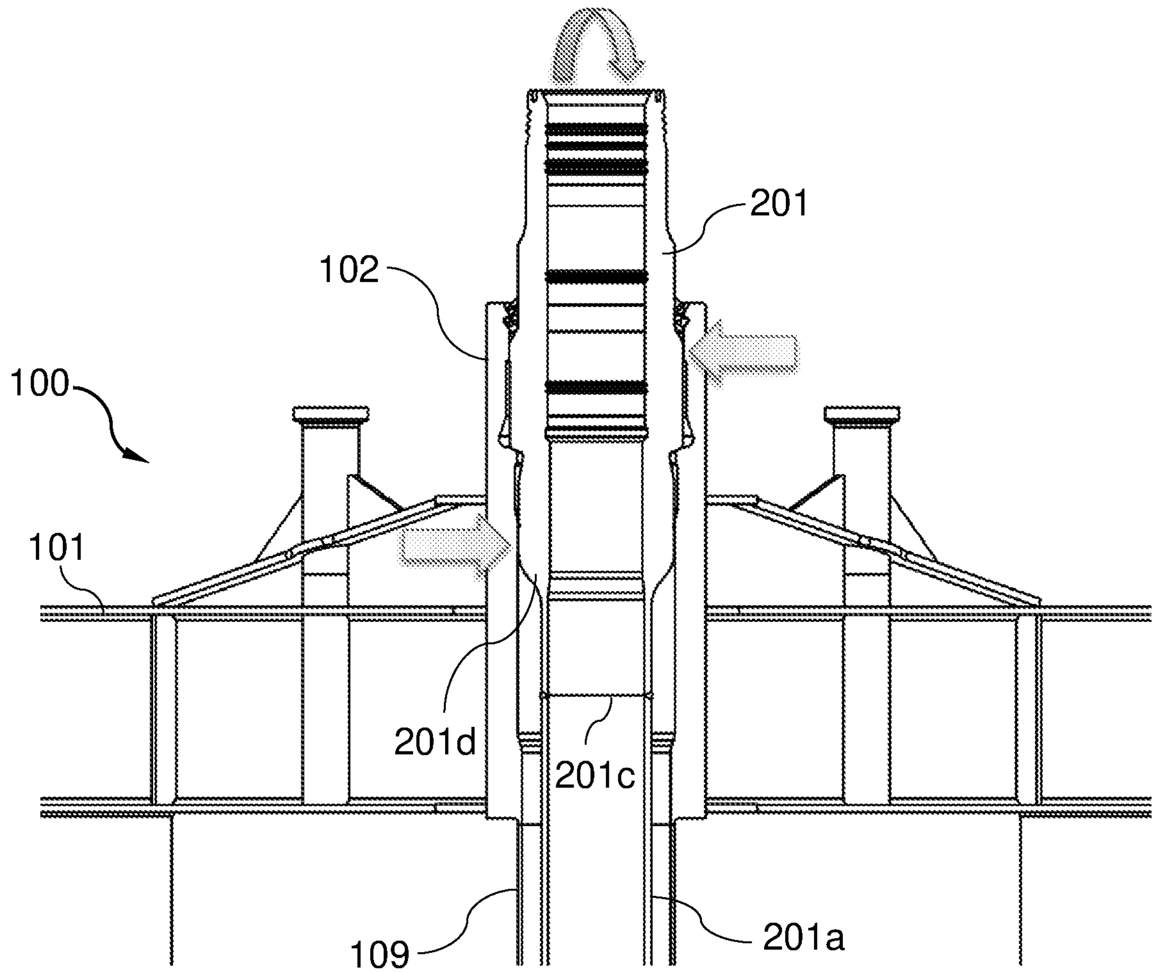

Fig. 26

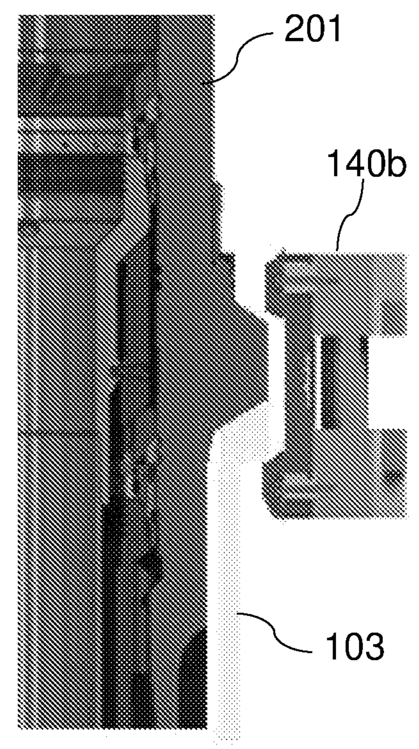

Fig. 27a

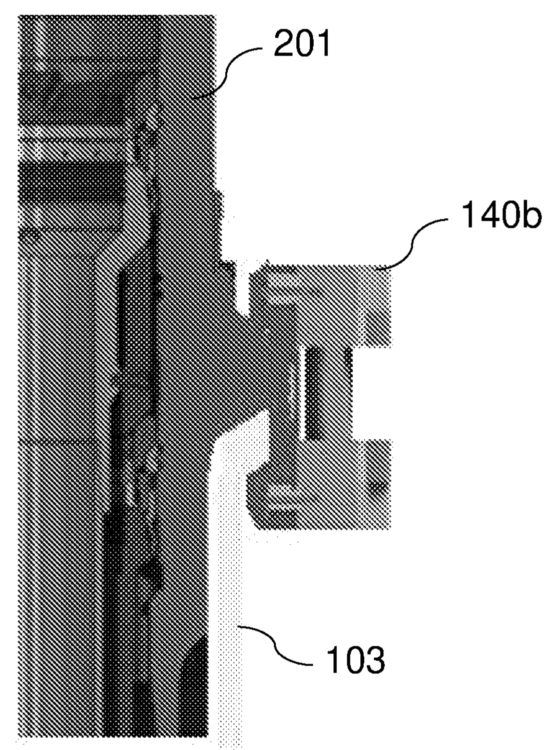

Fig. 27b

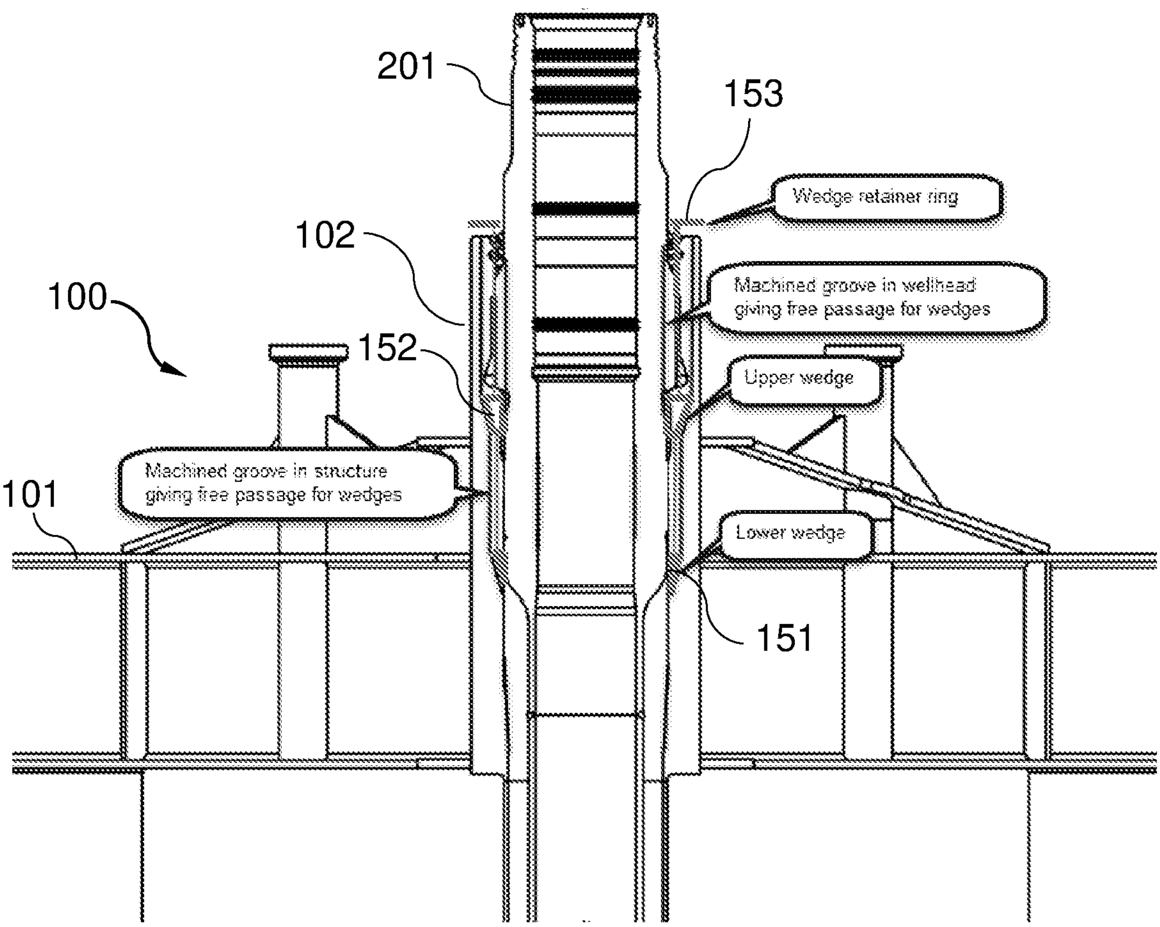
201
153
Wedge retainer ring
102
Machined groove in wellhead giving free passage for wedges
100
152
Upper wedge
Machined groove in structure giving free passage for wedges
101
Lower wedge
151

Fig. 28

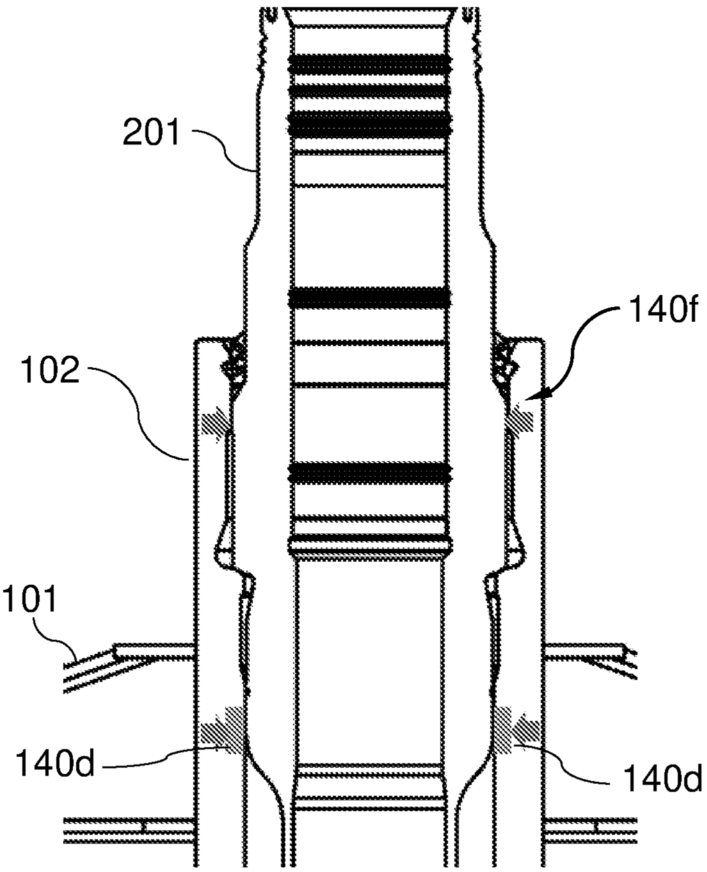

Fig. 29a

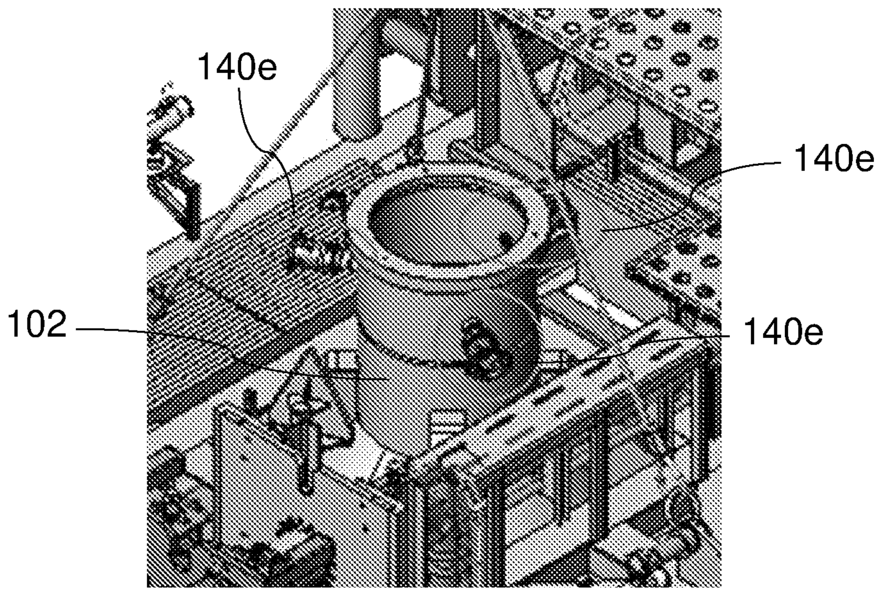

Fig. 29b

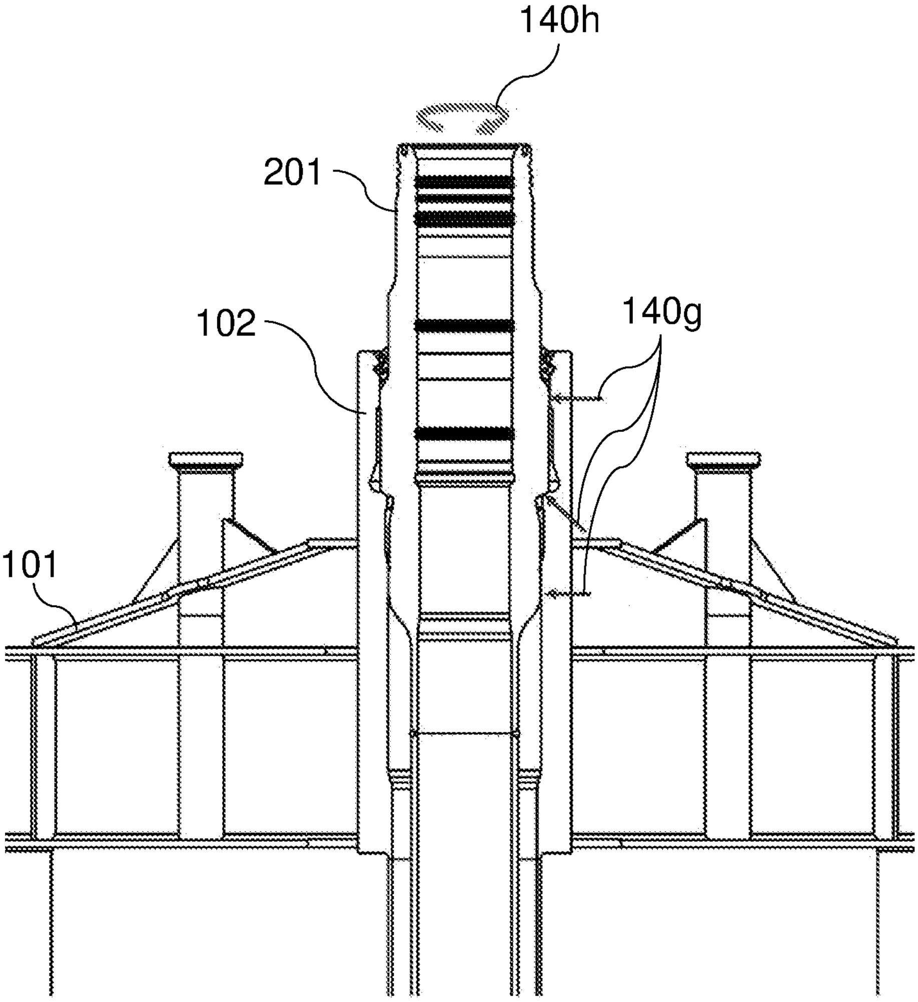

Fig. 30

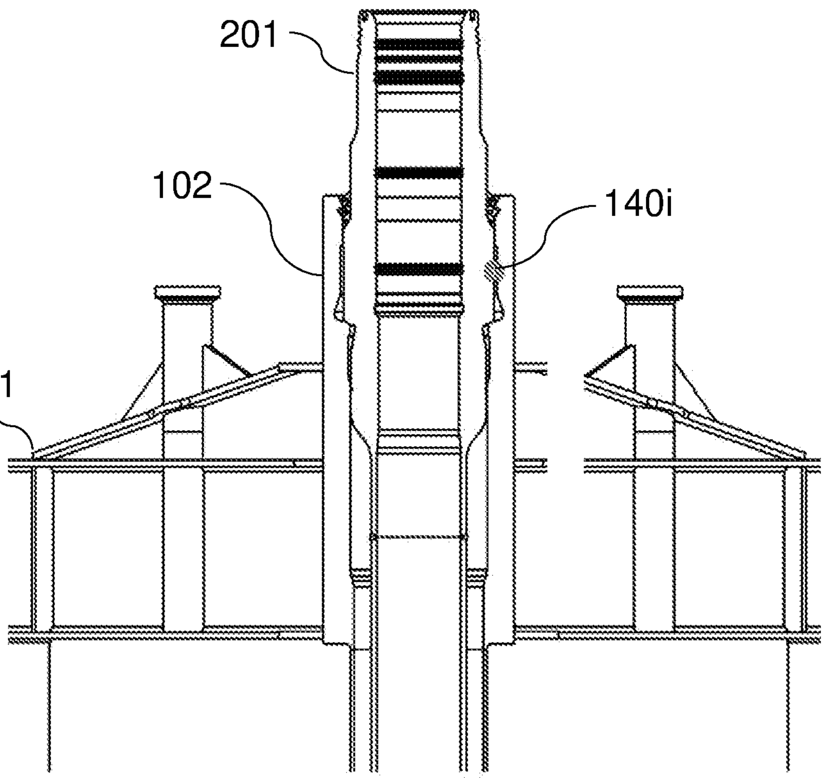

Fig. 31

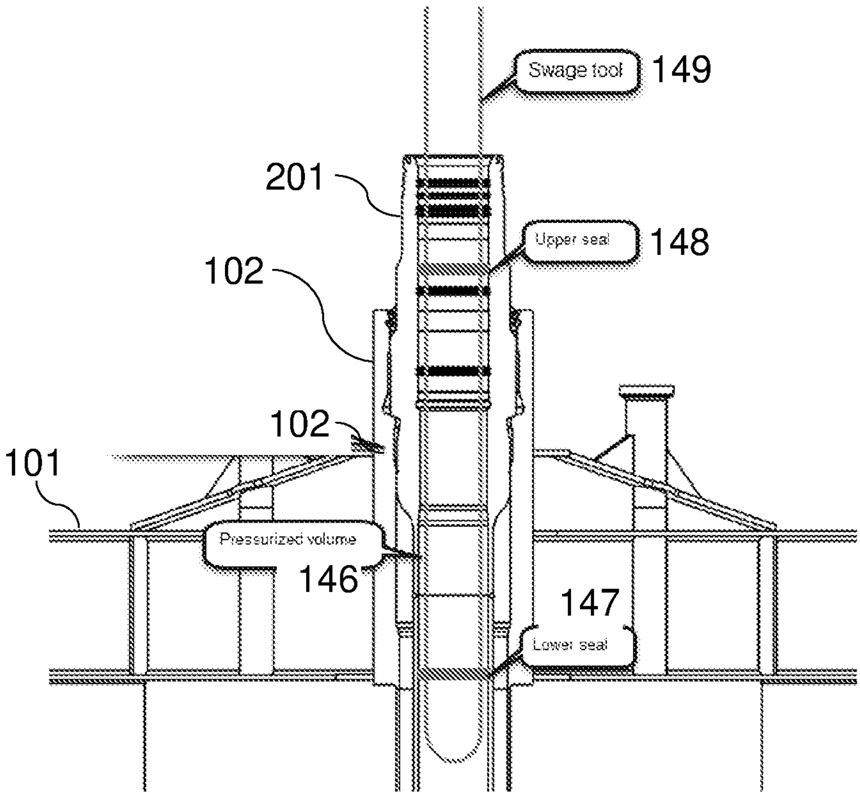

Fig. 32a

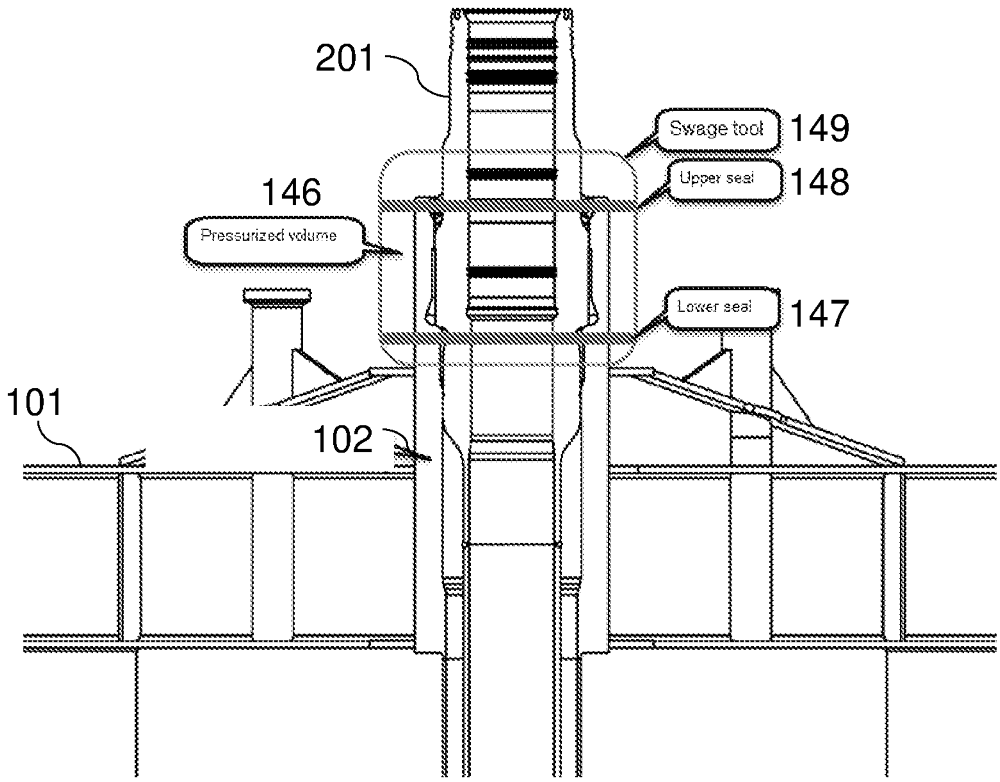

Fig. 32b

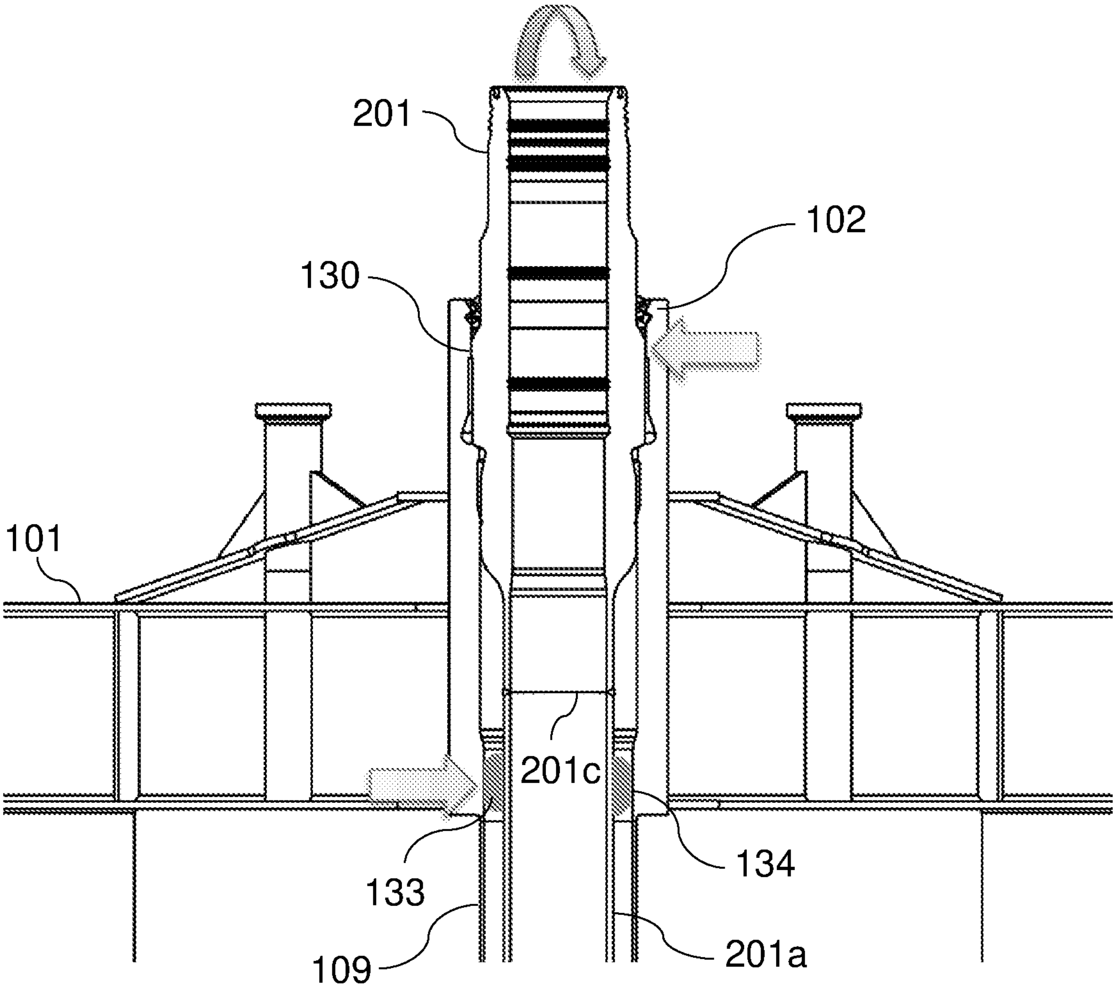

Fig. 33a

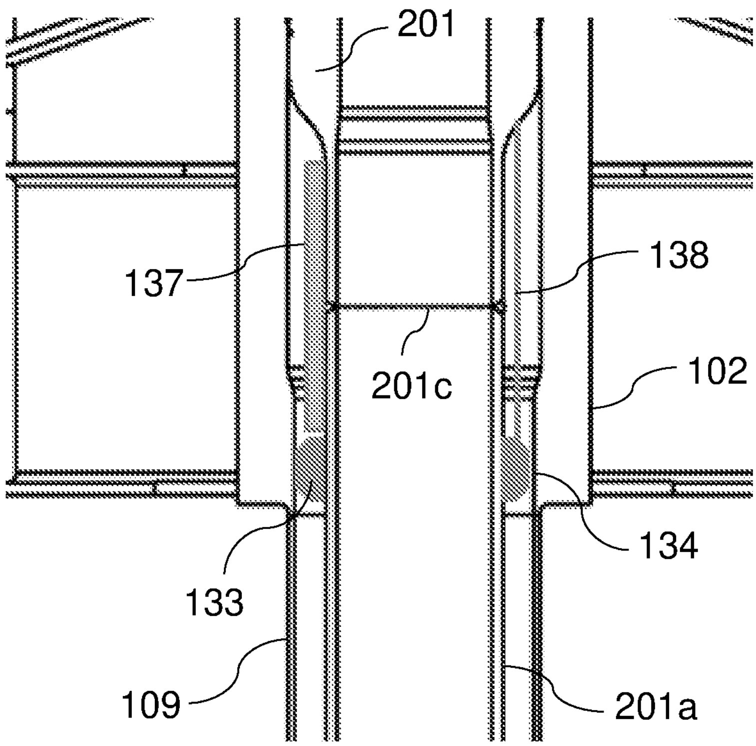

Fig. 33b

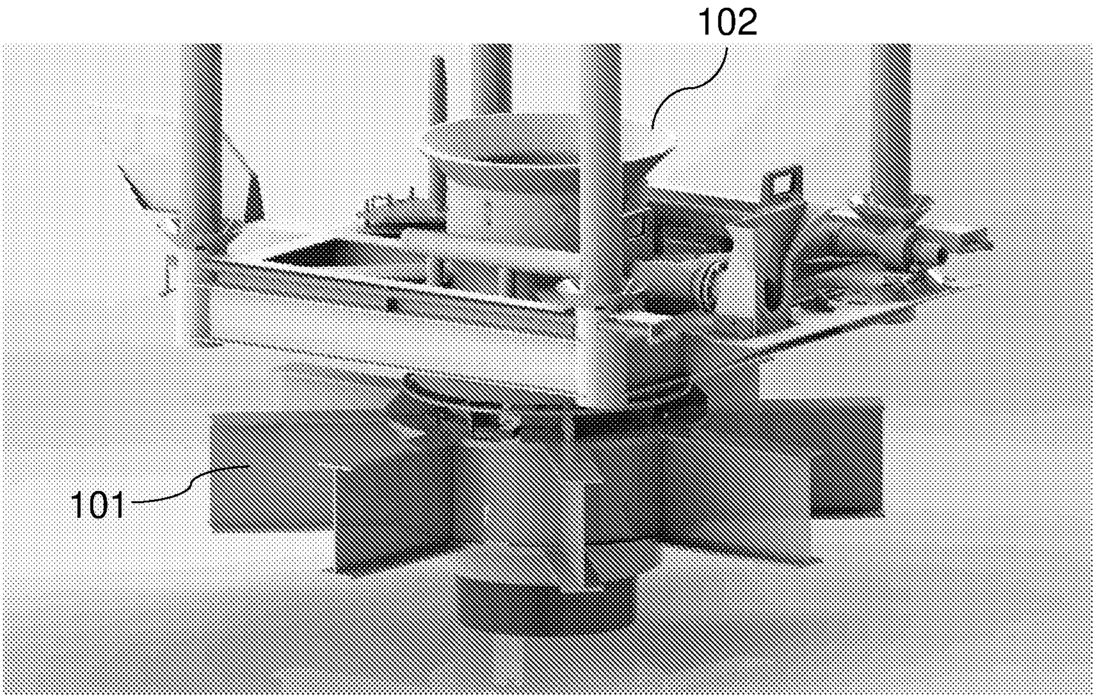

Fig. 34a

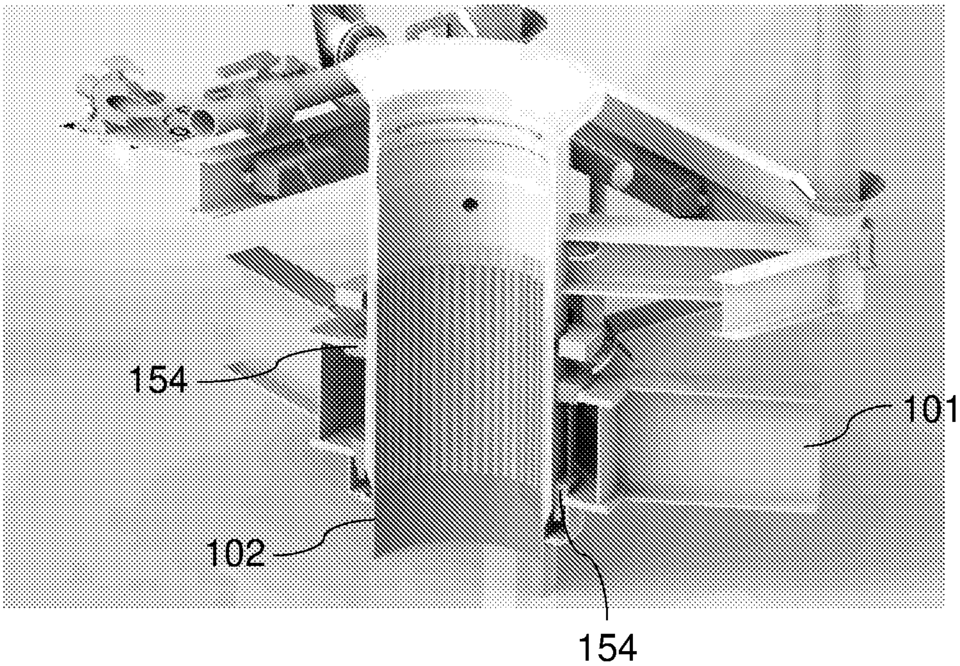

Fig. 34b

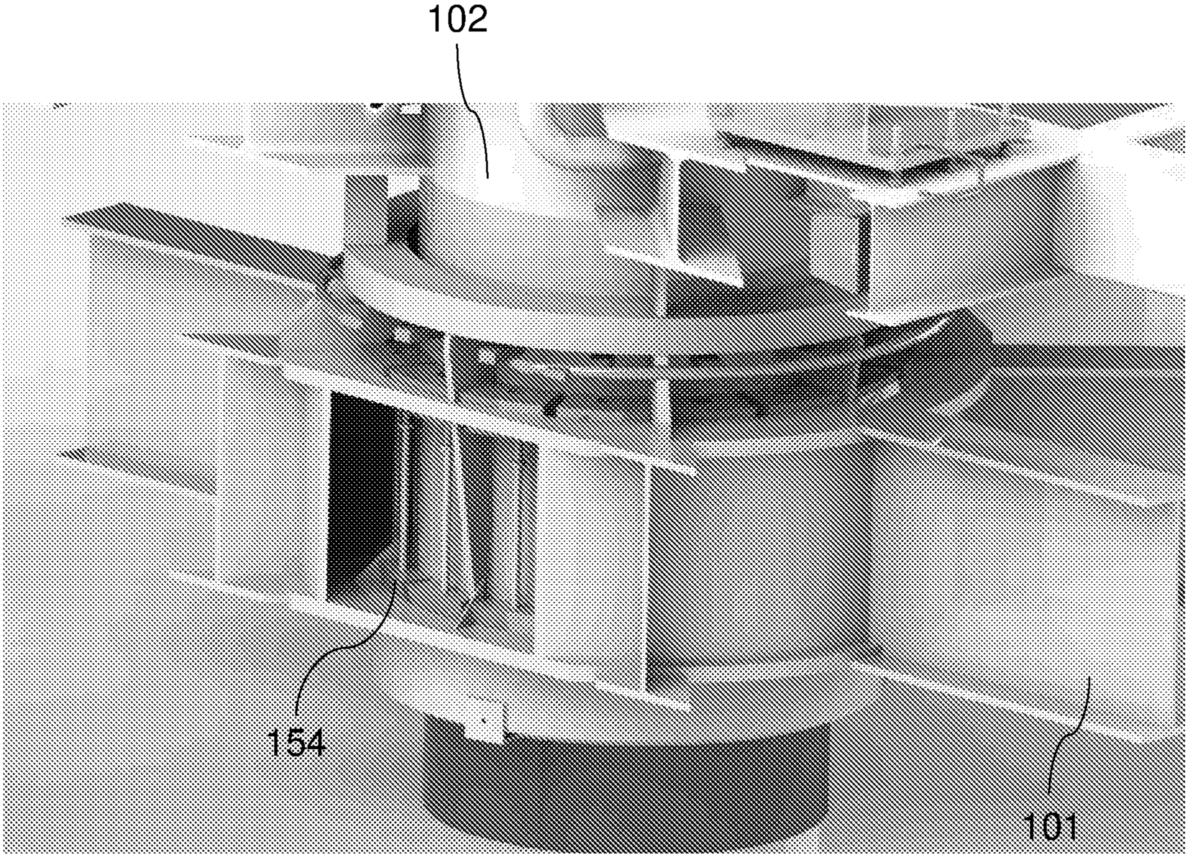

Fig. 34c

INTERNATIONAL SEARCH REPORT

International application No
PCT/NO2022/050135

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B33/035
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 2020/198735 A1 (REINÅS LORENTS [NO] ET AL) 25 June 2020 (2020-06-25) abstract figures 1-3 paragraphs [0011] - [0012], [0048] - [0051] -----	1-4,7
X	US 2019/162038 A1 (REINÅS LORENTS [NO] ET AL) 30 May 2019 (2019-05-30) abstract figures 7-9 paragraph [0161] -----	1-10
X	US 2019/128084 A1 (OSEN PER [NO] ET AL) 2 May 2019 (2019-05-02) abstract figures 3-4 -----	1,7

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 September 2022	30/09/2022

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Ing, James

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NO2022/050135

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