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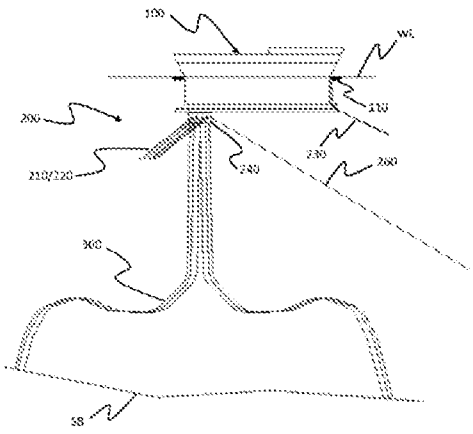
(54) Title **Disconnectable spread mooring system**

(57) Abstract

It is disclosed a disconnectable buoy, a spread mooring system, a floating installation, a computer program, and methods for connecting the floating installation to a seabed and for disconnecting the floating installation for production 5 and/or storage of hydrocarbons using the spread mooring system. The spread mooring system comprises a disconnectable buoy, a first seabed mooring line assembly connected to the disconnectable buoy and the seabed, a second seabed mooring line assembly connected to the disconnectable buoy and the seabed and a third seabed mooring line assembly connectable to the floating 10 installation and the seabed.



FIELD OF THE INVENTION

The present invention generally relates to a mooring system and a method of using same. More specifically, the present invention relates to a spread mooring system for a floating installation for production and/or storage of hydrocarbon, such as a Floating Production Storage and Offloading (FPSO) unit, operating in both shallow and deep water as well as in waters with drifting icebergs where there are drifting icebergs.

BACKGROUND AND PRIOR ART

A Floating Production Storage and Offloading (FPSO) system is a floating facility above or close to an offshore oil and/or gas field to receive, process, store and export hydrocarbons. The system consists of a floater, which may either be a purpose-built installation or a converted tanker, moored at a selected site. The cargo capacity of the installation is used as buffer storage for the produced oil. The process facilities (topsides) and accommodations are installed on the floater. The mooring configuration in FPSOs may be of a spread mooring type or a single point mooring (SPM) system such as a turret. A mooring configuration based on Dynamic Positioning (DP) is also possible but entails high complexity and operational cost and is therefore less preferred. As compared to spread mooring, a turret system is also costly and complex.

WO2019/011407 discloses a FPSO using a spread mooring arrangement that ensures a fixed, non-rotatable floating installation position during hydrocarbon production, to avoid the need of a costly and complex turret assembly and/or dynamic positioning systems (DP).

A spread mooring system is a group of mooring lines distributed over the bow and stern of the floating installation to anchors on the seafloor. The floating installation is positioned in a fixed heading, which is determined by the sea and weather conditions. The symmetrical arrangement of anchors helps to keep the ship on its fixed heading location. The spread mooring system does not allow the floating installation to weathervane, which means to rotate in the horizontal plane due to wind, waves or current. Spread mooring is versatile as it can be used in any water depth, on any floating installation, in an equally spread pattern or a group.

A drawback of the prior art spread mooring systems is that a disconnection of the moored floating installation is time consuming and cumbersome. Typically, a spread moored FPSO must disconnect and lay down one riser at the time until all risers are disconnected and laid down. Then all the anchor lines must be disconnected and laid down one by one. Such disconnections are therefore costly

and commonly not considered acceptable for temporary disconnections. Temporary disconnections may be required when operating in waters where there are drifting icebergs. If a drifting iceberg is on collision course with the FPSO, the FPSO should temporarily disconnect and move out of the way until the drifting iceberg has passed or changed course, then reconnect.

It is thus an objective of the invention to provide a spread mooring system and a method enabling effective disconnection of the moored floating installation such that the cost and operational down time associated with a temporary disconnection can be considered acceptable.

SUMMARY

The invention is set forth in the independent claims and the dependent claims describe certain optional features of the invention.

In particular, the invention concerns a disconnectable buoy for mooring a floating installation for production and/or storage of hydrocarbons to a seabed. The floating installation may be a floating production storage and offloading (FPSO) unit, a floating storage and offloading FSO unit, a floating production unit (FPU) or a floating liquified natural gas (FLNG) unit.

The disconnectable buoy comprises:

- a buoyancy element,
- two coupling structures arranged at a lower end of the disconnectable buoy, i.e. closest to the seabed after installation in the recess, for connecting ends of two seabed mooring line assemblies, wherein the two coupling structures may be configured to allow mooring of the disconnectable buoy, with an angular offset between the two seabed mooring line assemblies, the angular offset is preferably more than 90°,
- a locking arrangement arranged at an upper end of the disconnectable buoy, e.g. a distance less than 20% from the terminal end of the disconnectable buoy's most distal from the seabed relative to the disconnectable buoy's total length, for releasably connecting the disconnectable buoy to a hull of the floating installation, in a non-swivelling manner, i.e. when connected the disconnectable buoy cannot rotate or move relative to the hull, and
- at least one riser guide channel creating a through-going opening extending along the entire length of the disconnectable buoy,

wherein the buoyancy element is configured such that the disconnectable buoy is neutral buoyant at a predetermined depth below a water line after disconnection at

sea, while being connected to the seabed mooring line assemblies and elongated hydrocarbon production equipment, and

wherein the disconnectable buoy has a polygonal horizontal cross-section, e.g. hexagonal or octagonal.

The depth is preferably at least 25 meters. In arctic areas, in particular where there is a risk of drifting icebergs and/or drifting surface ice, the depth is preferably at least 150 meters.

The mooring recess may have a polygonal horizontal cross-section, e.g. hexagonal or octagonal. The disconnectable buoy and the mooring recess preferably have matching horizontal cross-section. In this way the disconnectable buoy is prevented from rotating in the mooring recess.

The coupling structures for connecting different seabed mooring line assemblies are arranged on different sides of the polygon, such that the seabed mooring line assemblies can extend substantially perpendicularly from the side of the disconnectable buoy during mooring while having an angular offset.

The buoyancy element may be a foam-filled cavity of the disconnect buoy. Alternatively the buoyancy element may be filled with air. The buoyancy element may be an external element connected to the disconnectable buoy.

Each coupling structure may comprise a plurality of connections for connecting ends of each mooring line constituting the seabed mooring line assembly.

The locking arrangement may comprise a plurality of locking segments, locking jacks, dogs, latches, collets or a locking ring. The locking arrangement may be configured for remote controlled locking and unlocking.

The invention also concerns a spread mooring system for mooring a floating installation for production and/or storage of hydrocarbons to a seabed in a fixed heading. The floating installation may be a FPSO, a FSO, FPU or a FLNG.

The spread mooring system may comprise

- a disconnectable buoy comprising a buoyancy element, a locking arrangement arranged at an upper end of the disconnectable buoy, e.g. a distance less than 20% from the terminal end of the disconnectable buoy's most distal from the seabed relative to the disconnectable buoy's total length, for releasably connecting the disconnectable buoy within a hull of the floating installation and at least one riser guide channel creating a through-going opening extending along a length of the disconnectable buoy, wherein the at least one riser guide channel allows guiding of elongated hydrocarbon production equipment, such as a riser, an umbilical or a cable, through the disconnectable buoy,

- a first seabed mooring line assembly having first ends connected to a first coupling structure at a lower end of the disconnectable buoy and opposite ends connectable to the seabed,

- a second seabed mooring line assembly having first ends connected to a second coupling structure at a lower end of the disconnectable buoy and opposite ends connectable to the seabed and

- a third seabed mooring line assembly having first ends connectable to a third coupling structure on the installation and opposite ends connectable to the seabed. The third seabed mooring line comprises at least one mooring line.

Each of the first and second seabed mooring line assemblies may comprise at least one mooring line. The at least one mooring line of the first seabed mooring line assembly and the at least one mooring line of the second seabed mooring line assembly may have a relative angular offset of more than 45 degrees, preferably more than 90 degrees.

When connected to the floating installation, the third seabed mooring line will typically have an additional length of mooring line enabling the third seabed mooring line to be paid out at least to a predetermined length, e.g. 100 meters.

The seabed mooring line assemblies may be made of a material making them neutral buoyant when submersed, e.g. polyester.

It is thus achieved a spread mooring system that enables faster disconnection of the spread moored floating installation, as compared to prior art spread mooring systems. This is particularly advantageous in arctic areas where there is a risk of drifting icebergs or drifting surface ice colliding with and thus damaging the floating installation.

It is also achieved a spread mooring system that during disconnect does not require risers, umbilicals and/or cables to be laid down one at the time.

It is also achieved a spread mooring system that during disconnect does not require mooring lines to be laid down one at the time.

It is also achieved a mooring system that is less complex than a turret mooring system.

An advantage of this spread mooring system is that the down time due to connection and disconnection of the mooring system is reduced. This enables the floating installation to be moved to quay for maintenance or upgrades rather than having to performed maintenance offshore. This will reduce the maintenance cost.

An advantage of this spread mooring system is that it is suitable for arctic areas.

An advantage of the spread mooring system is that risers, umbilicals and/or cables are disconnected from the floating installation simultaneously with the mooring lines.

An advantage of this spread mooring system is that the disconnectable buoy can be connected to the floating installation while the connected seabed mooring line assemblies are slack, thus less forces are required as compared to if the seabed mooring line assemblies were tensioned.

An advantage of this spread mooring system is that the system only has two groups of mooring lines connected to the floating installation (the disconnectable buoy and the third seabed mooring line assembly), thus the disconnection time is reduced as compared to systems with three or more groups of mooring lines are connected to the floating installation.

An advantage of this spread mooring system is that the system can be disconnected without paying out any of the seabed mooring line assemblies. This is an advantage in an emergency situation as time can be saved by not having to pay out any of the seabed mooring line assemblies.

An advantage of the spread mooring system is that all processes can be configured for remotely controlled operations, thus making the system suitable for unmanned operations.

The spread mooring system may comprise a retention line having a first end connected to the disconnectable buoy and an opposite end connectable to the seabed.

The disconnectable buoy may preferably have a dedicated coupling structure for the retention line. Alternatively, the retention line may be connected to the first or second coupling structure.

The retention line may be configured to retain the disconnectable buoy within a predetermined horizontal area after disconnecting from the floating installation. This may be controlled by selecting the length of the retention line and/or its connection point to the seabed. The retention line will typically extend in the same direction relative to the disconnectable buoy as the third seabed mooring line assembly.

An advantage of the retention line is that the bending forces acting on the elongated hydrocarbon production equipment can be better controlled and thus reduced when the buoy is not connected to the floating installation.

The spread mooring system may comprise a pick-up line having a first end connected to the disconnectable buoy and an opposite end configured to be accessible in the waterline.

The disconnectable buoy may be configured to be neutral buoyant at a predetermined depth below the water line after disconnection at sea, while being connected to the seabed mooring line assemblies and elongated hydrocarbon production equipment. The depth is preferably at least 25 meters.

The spread mooring system may comprise at least one receiving plate for arrangement in the mooring recess. The receiving plate may be configured to guiding the disconnectable buoy to the hull.

The disconnectable buoy may comprise at least one load transfer plate being configured to transfer loads from the disconnectable buoy to the hull.

The locking arrangement may comprise a plurality of locking segments, locking jacks, dogs, latches, collets or a locking ring. The locking arrangement may be configured for remote controlled connection and disconnection, making it suitable for unmanned operations. The locking arrangement may also be configured for manual operation.

The spread mooring system may comprise a quick connection system for connecting the elongated hydrocarbon production equipment to be held by the disconnectable buoy to a piping or cable system of the floating installation. The quick connect system may be configured for remote controlled connection and disconnection, making it suitable for unmanned operations. The quick connect system may also be configured for manual operation. An alternative to the quick connect system may be manual connection and disconnection of each riser, umbilical and/or cable individually.

The invention also concerns a floating installation comprising a spread mooring system as described herein. The hull comprises a mooring recess extending from a bottom, i.e. most near the seabed, of the hull to a main deck level. The installation further comprises the third coupling structure for connecting the first end of the third seabed mooring line assembly,

The floating installation may have an elongated form comprising a bow portion and an aft portion. The disconnectable buoy may be arranged at either the bow portion or the aft portion, and the third coupling structure may be arranged at the bow portion or the aft portion other than the disconnectable buoy.

The invention also concerns a method for connecting a floating installation, e.g. as described herein, to a seabed.

The method may comprise the steps of:

- Connecting the third seabed mooring line assembly to the third coupling structure on the floating installation.

- Moving the floating installation to a position where the mooring recess is substantially vertically aligned with the disconnectable buoy being submerged below the water line at a certain depth.

- Pulling the disconnectable buoy into the mooring recess, e.g. using a pull-in winch, and releasably connecting the disconnectable buoy in the mooring recess by means of the locking arrangement.

- Pulling in and connecting the elongated hydrocarbon production equipment to the disconnectable buoy. This is preferably performed during installation of the mooring system, i.e. prior to the arrival of the floating installation at the offshore location. However, this can be performed at any time prior to step e).

- Connecting the elongated hydrocarbon production equipment to a piping or cable system of the floating installation.

- Tensioning the third seabed mooring line assembly to a predetermined pretension force, e.g. using a tugger winch.

The invention also concerns a method for disconnecting a disconnectably spread moored floating installation suitable for production and/or storage of hydrocarbons, using a spread mooring system, e.g. as described herein, using a spread mooring system. Such system typically comprises:

- a disconnectable buoy comprising a buoyancy element, a locking arrangement arranged at an upper end of the disconnectable buoy for releasably connecting the disconnectable buoy within a hull of the floating installation, and at least one riser guide channel creating a through-going opening extending along a length of the disconnectable buoy, wherein the at least one riser guide channel allows guiding of elongated hydrocarbon production equipment through the disconnectable buoy,

- a first seabed mooring line assembly having first ends connected to a first coupling structure at a lower end of the disconnectable buoy and opposite ends connected to the seabed,

- a second seabed mooring line assembly having first ends connected to a second coupling structure at a lower end of the disconnectable buoy and opposite ends connected to the seabed, and

– a third seabed mooring line assembly having first ends connected to a third coupling structure on the installation and opposite ends connected to the seabed.

The method may comprise the steps of:

– Disconnecting the elongated hydrocarbon production equipment held by the disconnectable buoy from a piping or cable system of the floating installation.

– Disconnecting the disconnectable buoy from the floating installation.

– Moving the floating installation to a different location within a maximum extend of the third seabed mooring line assembly with the floating installation connected to the third seabed mooring line assembly.

The method may further comprise the initial steps of:

– Paying out the third seabed mooring line assembly.

– Moving the floating installation to a position where the horizontal tension from the first seabed mooring line assembly and the second seabed mooring line assembly is reduced.

When the horizontal tension from the first and second seabed mooring line assemblies are sufficiently reduced, the disconnectable buoy will sink substantially vertically after being disconnected from the floating installation.

The method may further comprise the steps of:

– Disconnecting the third seabed mooring line assembly from the third coupling structure on the floating installation.

– Moving the floating installation to a different location outside the maximum extend of the third seabed mooring line assembly.

The invention also concerns a method for reconnecting a disconnectable spread moored floating installation for production and/or storage of hydrocarbons, using a spread mooring system comprising:

– a disconnectable buoy comprising

  - a buoyancy element,

  - a locking arrangement arranged at an upper end of the disconnectable buoy for releasably connecting the disconnectable buoy within a hull of the floating installation, and

  - at least one riser guide channel creating a through-going opening extending along a length of the disconnectable buoy, wherein the at least one riser guide channel allows guiding of elongated hydrocarbon production equipment through the disconnectable buoy,

- a first seabed mooring line assembly having first ends connected to a first coupling structure at a lower end of the disconnectable buoy and opposite ends connected to the seabed,

- a second seabed mooring line assembly having first ends connected to a second coupling structure at a lower end of the disconnectable buoy and opposite ends connected to the seabed, and

- a third seabed mooring line assembly having first ends connectable to a third coupling structure on the installation and opposite ends connected to the seabed,

wherein each of the first and second seabed mooring line assemblies comprises at least one line,
the method may further comprise the steps of:

- Moving the floating installation to a position where the mooring recess is substantially vertically aligned with the disconnectable buoy being submerged below the water line at a certain depth.

- Pulling the disconnectable buoy into the mooring recess and releasably connecting the disconnectable buoy in the mooring recess by means of the locking arrangement.

- Connecting the elongated hydrocarbon production equipment to a piping or cable system of the floating installation.

- Tensioning the third seabed mooring line assembly to a predetermined pretension force.

The method may further comprise the steps of:

- Returning the floating installation within a maximum extend of the third seabed mooring line assembly.

- Connecting the third seabed mooring line assembly to the third coupling structure on the floating installation.

- Moving the floating installation to a position where the mooring recess is substantially vertically aligned with the disconnectable buoy being submerged below the water line at a certain depth.

- Pulling the disconnectable buoy into the mooring recess and releasably connecting the disconnectable buoy in the mooring recess by means of the locking arrangement.

- Connecting the elongated hydrocarbon production equipment to a piping or cables system of the floating installation.

– Tensioning the third seabed mooring line assembly to a predetermined pretension force.

The invention also relates to a method for avoiding drifting obstacles. The method may comprise the steps of disconnecting and reconnecting a floating installation as described herein.

The invention also concerns a computer program comprising instructions which, when the program is executed by a computer installed onboard a floating installation configured for remote controlled operation, e.g. as described herein, causes the computer to execute the steps of anyone of the methods described herein.

A FLNG unit is conceptually similar to the FPSO. The difference being that the hydrocarbon mixture from the well is predominantly gas and that the process facility's purpose is to separate, clean and liquefy the gas for storage in dedicated cryogenic tanks within the hull. Offloading of the liquefied gas is done towards trading gas (LNG) vessels.

The application is equally relevant for similar purpose units such as a FSO, a FPU, a FLNG, a FPSO or equivalent spread moored units, i.e. offshore units that are not weathervaning.

BRIEF DESCRIPTION OF THE DRAWINGS

Following drawings are appended to facilitate the understanding of the invention. The drawings show embodiments of the invention, which will now be described by way of example only, where:

Fig. 1 is a side view of a floating installation moored by means of a spread mooring system according to the invention;

Fig. 2a and Fig. 2b are side views of a floating installation connected and disconnected respectively from the disconnectable buoy of the spread mooring system according to the invention;

Fig. 3A shows view from aft of the disconnectable buoy connected to the mooring recess of the floating installation, wherein the floating installation is shown as a cross-section; and Fig. 3B shows a vertical cross-section of the disconnectable buoy connected to the mooring recess of the floating installation;

Fig. 4A shows view from aft of the disconnectable buoy 240 connected to the mooring recess 120 of the floating installation 100, wherein the floating installation 100 is shown as a cross-section; and Fig. 4B shows a vertical cross-section of the

disconnectable buoy 240 connected to the mooring recess 120 of the floating installation 100;

Fig. 5A shows a top view of the disconnectable buoy 240; Fig. 5B shows a side view of the disconnectable buoy 240; and Fig. 5C shows a bottom view of the disconnectable buoy 240;

Fig. 6A shows a top view of the disconnectable buoy 240; Fig. 6B shows a side view of the disconnectable buoy 240; and Fig. 6C shows a bottom view of the disconnectable buoy 240;

Fig. 7 shows a top view of the floating installation 100 with the spread mooring system 200 installed;

Fig. 8A and Fig. 8B respectively show a top view and a bottom view of a part of the floating installation 100 in which the mooring recess 120 is arranged;

Fig. 9 shows a vertical cross-section of the disconnectable buoy 240 locked in the mooring recess 120;

Fig. 10A shows a detail view from Fig. 9 of the locking arrangement 241 in a locked position; Fig. 10B shows a detail view from Fig. 9 of the locking arrangement 241 in a partially locked/unlocked position; and Fig. 10C shows a detail view from Fig. 9 of the locking arrangement 241 in an unlocked position; and

Fig. 11A – Fig. 16B show a temporary disconnect sequence from a side view and a top view, with Figs. 11A, 12A, 13A, 14A, 15A and 16A showing the side views and Figs. 11B, 12B, 13B, 14B, 15B and 16B showing the top views.

DETAILED DESCRIPTION

In the following, embodiments of the invention will be discussed in more detail with reference to the appended drawings. It should be understood, however, that the drawings are not intended to limit the invention to the subject-matter depicted in the drawings.

Fig. 1 shows a side view of a floating installation 100 moored to the seabed *SB* at an offshore location. The floating installation 100 may be suitable for production and/or storage of hydrocarbons, e.g. a FPSO, a FSO, a FPU, a FLNG, and the offshore location may be at an arctic oil field.

In Fig. 1 the floating installation 100 is moored by means of a spread mooring system 200. The spread mooring system 200 anchors the floating installation 100 to the seabed *SB* such that the floating installation 100 has a fixed heading, i.e. not weathervaning.

The spread mooring system 200 comprises at least a first seabed mooring line assembly 210, a second seabed mooring line assembly 220 and a third seabed mooring line assembly 230. When the floating installation 100 is moored for operation, the three seabed mooring line assemblies 210,220,230 will extend away from the floating installation 100 in different directions. The third seabed mooring line 230 will typically extend in a substantially forward direction relative to the floating installation 100, while the first and second seabed mooring line assemblies 210,220 typically will extend in the substantially opposite direction relative to the floating installation 100, i.e. in a backwards direction.

When seen from a top view, as illustrated in Fig. 7, the first seabed mooring line assembly 210 and the second seabed mooring line assembly 220 have a first horizontal angular offset α_1. In Fig.7 this first angular offset α_1 is approximately 120°. The second seabed mooring line assembly 220 and the third seabed mooring line assembly 230 have a second horizontal angular offset α_2. In Fig.7 this second angular offset α_2 is approximately 120°. The first seabed mooring line assembly 210 and the third seabed mooring line assembly 230 have a third horizontal angular offset α_3. In Fig.7 this third angular offset α_3 is approximately 120°. The three seabed mooring line assemblies 210,220,230 thus have an equal angular offset in Fig. 7. The three angular offsets $\alpha_1,\alpha_2,\alpha_3$ do not have to be equal. As an example, the second and third horizontal angular offsets α_2,α_3 may be equal, e.g. 135° each while the first horizontal angular offset α_1 is 90°.

Fig. 1 also shows that the mooring system 200 comprises a disconnectable buoy 240. The disconnectable buoy 240 is configured for connection to the floating installation 100. Additionally, the disconnectable buoy 240 is configured for connection of the first and second seabed mooring line assemblies 210,220. For example, the disconnectable buoy 240 may comprise a first coupling structure 243a for connection of the first seabed mooring line assembly 210 and a second coupling structure 243b for connection of the second seabed mooring line assembly 220. Hence, the first and second seabed mooring line assemblies 210,220 may be indirectly connected to the floating installation 100 via the disconnectable buoy 240. The floating installation 100 may have a third coupling structure 110 for connection of the third seabed mooring line assembly 230. Hence, the third seabed mooring line assembly 230 may be connected directly to the floating installation 100. When connected to the floating installation 100, the third seabed mooring line 230 will typically have an additional length of mooring line enabling the third seabed mooring line 230 to be paid out at least a predetermined length, e.g. 100 meters.

The third coupling structure 110 will typically comprise fairleads located close to a bottom section, i.e. nearest to the seabed *SB*, of the hull 130, mooring winches

located at deck level and chain lockers. The third coupling structure 110 may be configured for remote operation and thus be suitable for unmanned operations.

As seen in Fig. 1, the disconnectable buoy 240 may be configured to hold elongated hydrocarbon production equipment 300 such as one or several risers, umbilical, cables or similar extending from the seabed *SB* to the sea surface, i.e. close to the water line *WL*. The elongated hydrocarbon production equipment 300 is preferably of a flexible type in order to allow some movement of the buoy 240 relative to the connection point of the elongated hydrocarbon production equipment 300 on the seabed *SB*.

The spread mooring system 200 may comprise a retention line 260. The retention line 260 can be connected to the buoy 240 in order to keep it within a predetermined area when not connected to the floating installation 100. The retention line typically has a first end connected to the disconnectable buoy 240 and an opposite end connected to the seabed *SB*. The retention line 260 will typically extend in substantially the same direction as the third seabed mooring line assembly 230, i.e. in the substantially opposite direction of the first and second seabed mooring line assemblies 210,220. The predetermined area can be selected by the length of the retention line 260 and/or its point of connection to the seabed *SB*.

Fig. 2A and Fig. 2B show view from aft of the disconnectable buoy 240 connected to and disconnected from the floating installation 100, respectively. The view of Figs. 2A and 2B are perpendicular on the view of Fig. 1.

In Fig. 2A, the disconnectable buoy 240 is connected to a mooring recess 120 in a hull 130 of the floating installation 100. The mooring recess 120 and the third coupling structure 110 are typically arranged in opposite ends of the floating installation 100. The third coupling structure 110 is preferably arranged in a forward end of the floating installation 100. The mooring recess 120 is preferably arranged in an aft end of the floating installation 100. The mooring recess 120 is extending from the bottom, i.e. the part nearest to the seabed *SB*, of the hull 130 and up to the main deck level.

In Fig. 2B the disconnectable buoy 240 has been disconnected from the floating installation 100 or it has not yet been connected to the floating installation 100. The disconnectable buoy 240 is then in an idle position. The disconnectable buoy 240 is neutral buoyant at a depth *D* below the waterline *WL*. The depth *D* may be selected such that a drifting iceberg can have a temporary position vertically aligned with the submersed disconnectable buoy 240 without risk of striking the disconnectable buoy 240. Depths of 150 meters or more are generally considered safe. A depth of 25 meters may be sufficient in areas without the risk of drifting icebergs. In such case the floating installation 100 may e.g. be disconnected because it is moved to shore for maintenance.

To achieve neutral buoyancy at a predetermined depth D, the disconnectable buoy 240 comprises a buoyancy element 242. The buoyancy element 242 may be enclosed by dry compartments, e.g. air-filled, or compartments filled with buoyancy foam. Foam segments may also be placed outside the enclosed part of the disconnectable buoy 240. The buoyancy of the buoyancy element 424 may be calculated based on the predetermined depth D and the net downward forces applied on the disconnectable buoy 240 e.g. by the first and second seabed mooring line assemblies and the elongated hydrocarbon production equipment 300. The seabed mooring line assemblies 210,220,230 may be neutral in water, e.g. if made of polyester.

Fig. 3A shows view from aft of the disconnectable buoy 240 connected to the mooring recess 120 of the floating installation 100, wherein the floating installation 100 is shown as a cross-section. Fig. 3B shows a vertical cross-section of the disconnectable buoy 240 connected to the mooring recess 120 of the floating installation 100.

The disconnectable buoy 240 is locked in place in the mooring recess 120 by means of a locking arrangement 241. A part of the locking arrangement 241 may be arranged in an upper end 240b of the buoy 240 and a second part of the locking arrangement 241, configured for locking engagement with the first part, may be arranged in the mooring recess 120. The locking arrangements are illustrated in more detail in Fig. 9 and Figs. 10A-C.

The mooring recess 120 comprises at least one receiving plate 121. The receiving plate 121 is may be arranged in the mooring recess 120. The receiving plates 121 have a substantially vertical part suitable for guiding the upper end 240b of the disconnectable buoy 240 in the mooring recess 120.

The locking arrangement 241 will, when the two parts of the locking arrangement 241 are engaged, firmly lock the disconnectable buoy 240 in the mooring recess 120. The locking arrangement 241 may preferably be arranged at an elevation above the loaded water line WL_L, as illustrated in Fig. 3A. This arrangement will allow both connection and disconnection of the disconnectable buoy 240 to be made in a dry area. Alternatively, the locking arrangement 241 may be arranged at a low ballast draft elevation, i.e. a substantially unloaded waterline WL_U, as illustrated in Fig. 4A. The disconnectable buoy 240 has a longitudinal length L. The longitudinal length L may be adjusted relative to the arrangement of the locking arrangement 241 in the mooring recess 120. The longitudinal length L of the disconnectable buoy 240 will typically be longer when the locking arrangement 241 is arranged at an elevation above the loaded water line WL_L as compared to when the locking arrangement is arranged at a low ballast draft elevation WL_U.

The first coupling structure 243a and the second coupling structure 243b are arranged in a lower end 240a of the disconnectable buoy 240. The lower end 240a of the disconnectable buoy 240 may preferably extend below the bottom part of the hull 130 when the disconnectable buoy 240 is locked in the mooring recess 120 such that the first and second mooring line assemblies are not interfered by the hull 130. In this way the first and second seabed mooring line assemblies 210,220 can freely rotate in both the vertical and the horizontal direction. The disconnectable buoy 240 may not comprise any arrangements for tensioning at the coupling structure 243a,243b. All tensioning and later re-tensioning of the spread mooring system 200 can be done by means of the mooring winches arranged on the floating installation 100.

The disconnectable buoy 240 may comprise one or several load transfer plates 245. The load transfer plate 245 has sufficient strength to transfer forces from the spread mooring system 200 into the hull 130 structure of the floating installation 100. The load transfer plate 245 may be arranged in the upper end 240b and/or the lower end 240a of the disconnectable buoy 240. The load transfer plate 245 may substantially extend the horizontal circumference of the disconnectable buoy 240.

Fig. 4A shows a side view of the disconnectable buoy 240 connected to the mooring recess 120 of the floating installation 100, wherein the floating installation 100 is shown as a cross-section. Fig. 4B shows a vertical cross-section of the disconnectable buoy 240 connected to the mooring recess 120 of the floating installation 100.

The only difference between Figs. 4A-B and 3A-B is that the disconnectable buoy 240 has a shorter longitudinal length L in Figs. 4A-B as compared to Figs. 3A-B. When connected to similar hulls 130, the length L will affect the elevation of the locking arrangement 241.

Fig. 5A shows a top view of the disconnectable buoy 240. Fig. 5B shows a side view of the disconnectable buoy 240. Fig. 5C shows a bottom view of the disconnectable buoy 240.

Figs. 5A-C illustrate how the disconnectable buoy 240 may be provided with riser guide channels 244. The riser guide channels 244 are oriented in the longitudinal direction of the disconnectable buoy 240. The riser guide channels 244 are configured to receive and hold elongated hydrocarbon production equipment 300, such as risers, umbilicals and cables. The lower end of the guide channel 244 may have connections for bending restrictors. The upper end of the guide channel 244 located above the upper end 240b of the disconnectable buoy 240 may have arrangements for hang-off for the elongated hydrocarbon production equipment 300.

When the disconnectable buoy 240 is locked in the mooring recess 120, as illustrated in Figs. 3A and 4A, the elongated hydrocarbon production equipment 300

can be connected to a piping or cable system of the floating installation 100. All connections are made as "direct" connections, i.e. no swivel arrangements are required. The connections may for risers be standard flange connections. Alternative connections allowing shorter time for the disconnect operation may also be used, such as multi quick coupler stab plates. The connections may also be configured for remotely controlled connection and disconnection, e.g. by being hydraulically or electrically operable and connected to a control system, and thus be suitable for unmanned operations.

The position of the connection point of the elongated hydrocarbon production equipment 300 and the piping or cable system of the floating installation 100 can preferable be located at an elevation above the loaded water line WL_L, as illustrated in Fig. 3A. This location will allow both the connection and the disconnection of the piping or cable system to be made in a dry area. If the position of the connection point of the elongated hydrocarbon production equipment 300 and the piping or cables system of the floating installation 100 is located at a low ballast draft elevation WL_U, as illustrated in Fig. 4A, remotely operated connection and disconnection may be required.

Fig. 6A shows a top view of the disconnectable buoy 240. Fig. 6B shows a side view of the disconnectable buoy 240. Fig. 6C shows a bottom view of the disconnectable buoy 240.

The only difference between Figs. 6A-C and 5A-C is that the disconnectable buoy 240 has a shorter longitudinal length L in Figs. 6A-C as compared to Figs. 5A-C.

The disconnectable buoy 240 may have a circular horizontal cross-section, or as illustrated in Figs. 5A and 5C, a polygonal horizontal cross-section, and in particular a hexagonal horizontal cross-section. The horizontal cross-section may also taper towards the upper end 240b of the disconnectable buoy 240. The first coupling structure 243a and the second coupling structure 243b may be arranged at different sides of the polygon, such that when the first and second seabed mooring line assemblies 210,220 are connected to respective coupling structures 243a,243b they can extend perpendicular to the respective sides of the polygon while having a first horizontally angular offset α_1. The number of sides of the polygonal horizontal cross-section or an uneven angular spacing of the sides of the horizontal polygonal cross-section may be used to set a desired value of the first horizontally angular offset α_1.

Fig. 8A and Fig. 8B, respectively, show a top view and a bottom view of a part of the floating installation 100 in which the mooring recess 120 is arranged.

The lower end of the mooring recess 120 may comprise a backing support 123. The upper end of the mooring recess 120 may comprise a support deck 122.

The mooring recess 120 may as illustrated in Figs. 8A and 8B, have a polygonal horizontal cross-section, and in particular a hexagonal horizontal cross-section. The horizontal cross-section may also taper towards the upper end of the mooring recess 120. The horizontal cross-section of the mooring recess 120 may match the horizontal cross-section of the disconnectable buoy 240.

Fig. 7 shows a top view of the floating installation 100 with the spread mooring system 200 installed. In Fig. 7 it is illustrated how the horizontal cross-section of the mooring recess 120 matches the horizontal cross-sections of the disconnectable buoy 240. In this case the horizontal polygonal cross-section is an octagon.

The disconnectable buoy 240 may be pulled into the mooring recess 120 by means of a winch arranged on the floating installation 100, preferably positioned near or above the mooring recess 120. The force required to pull in the disconnectable buoy 240 will be relatively low due to the buoyancy element 242. By paying out the third seabed mooring line assembly 230 before pulling in the disconnectable buoy 240, all seabed mooring line assemblies 210,220,230 are slack and therefore do not apply significant forces to the disconnectable buoy 240. The disconnectable buoy 240 may comprise a pick-up line 250 for pulling the disconnectable buoy 240 into the mooring recess 120. The pick-up line 250 may be configured to extend from the disconnectable buoy 240 when submersed at the predetermined depth D at which it is neutral buoyant to the waterline WL.

Fig. 7 shows how a plurality of locking arrangements 241 may be distributed across the periphery of the mooring recess 120 and the disconnectable buoy 240.

Fig. 9 shows a vertical cross-section of the disconnectable buoy 240 locked in the mooring recess 120. In this example the locking arrangement 241 is a locking jack. Other alternatives may be locking segments, dogs, latches, collets or a locking ring. These locking arrangements 241 may be configured for remote operation and thus be suitable for unmanned operations.

Fig. 10A shows a detail view from Fig. 9 of the locking arrangement 241 in a locked position. Fig. 10B shows a detail view from Fig. 9 of the locking arrangement 241 in a partially locked/unlocked position. Fig. 10C shows a detail view from Fig. 9 of the locking arrangement 241 in an unlocked position.

The locking arrangement 241 has a first part arranged in the upper end 240b of the disconnectable buoy 240 and a second part arranged in the mooring recess 120, also in part or fully illustrated in Figs. 3A, 4A, 5B, 6B, 9. In the example of the locking jack, the part arranged on the disconnectable buoy 240 is static and the part arranged in the mooring recess 120 is movable. When the two parts are aligned, the second part can be moved into engagement with the first part to lock the disconnectable buoy 240 in the mooring recess 120. The second part is then

mechanically preventing relative vertical movement of the first part. Due to the matching horizontal cross-sections of the mooring recess 120 and the disconnectable buoy 240, horizontal movement of the first part of the locking arrangement 241 relative to the second part is prevented. When the mooring recess 120 and the disconnectable buoy 240 are upwardly tapered, it is sufficient that the locking arrangement prevents relative vertical movement in the downwards direction, i.e. towards the seabed *SB*. The tapering shape of the mooring recess 120 and disconnectable buoy 240 will prevent further relative vertical movement in the upwards direction.

When the locking arrangement 241 is unlocked, the disconnectable buoy 240 will fall downwards out of the mooring recess 120 and sink towards the seabed *SB* until it reaches a predetermined depth *D* below the waterline *WL* at which it is neutral buoyant, e.g. at 150 meters.

Fig. 11A – Fig. 16B show a temporary disconnect sequence from a side view and a top view. Figs. 11A, 12A, 13A, 14A, 15A and 16A showing the side views and Figs. 11B, 12B, 13B, 14B, 15B and 16B showing the top views.

In Fig. 11A and Fig. 11B the floating installation 100 is moored with the spread mooring system 200. The first, second and third seabed mooring line assemblies 210,220,230 are tensioned. The disconnectable buoy 240 is locked in the mooring recess 120. Elongated hydrocarbon production equipment 300 is connected to the floating installation 100. The floating installation can thus be operational.

In Fig. 12A the third seabed mooring line assembly 230 has been paid out such that the tension is reduced in the first, second and third seabed mooring line assemblies 210,220,230. To further reduce the horizontal tension from the first and second seabed mooring line assemblies 210,220, the floating installation 100 can be moved in a direction towards the first and second seabed mooring line assemblies 210,220. The floating installation 100 can be moved by one or several tugs 400, as illustrated in Fig. 12B. The floating installation 100 may also comprise its own propulsion system. This could enable remote control of the floating installation 100 and also make it suitable for unmanned operations.

Before the disconnectable buoy 240 can be unlocked from the mooring recess 120 and thus disconnected from the floating installation 100, the production of hydrocarbons must be stopped. The elongated hydrocarbon production equipment 300 can then be disconnected from the piping and/or cable system of the floating installation 100.

The floating installation 100 is now ready for quick release of the disconnectable buoy 240. The floating installation 100 is now prepared to disconnect quickly if

required, e.g. due to drifting icebergs. At the same time the floating installation 100 can quickly return to operation if the need for disconnect is no longer present.

In the event of a sudden need for disconnection of the disconnectable buoy 240, this may be performed without paying out the third seabed mooring line assembly 230. However, the first and second seabed mooring line assemblies 210,220 will still be tensioned and thus possibly pull the disconnectable buoy 240 away from the floating installation 100.

In Fig. 13A the disconnectable buoy 240 has been disconnected from the floating installation 100 and has sunk to a depth *D* below the waterline *WL*. The third seabed mooring line assembly 230 is still connected to the third coupling structure 110 on the floating installation 100. The first and second seabed mooring line assemblies 210,220 are still connected to the first and second coupling structure 243a,243b on the disconnectable buoy 240.

A retention line 260 may be connected to the disconnectable buoy 240 to prevent horizontal movement of the disconnectable buoy 240 caused by the first and second seabed mooring line assemblies 210,220. The disconnectable buoy 240 will then stay within a predetermined horizontal area. This will prevent excessive bending of the elongated hydrocarbon production equipment 300.

Fig. 13A shows how a pick-up line 250 may be connected to the disconnectable buoy 240. The pick-up line 250 will facilitate re-connection of the disconnectable buoy 240 to the floating installation 100. The pick-up line 250 may also provide visual confirmation of the position of the submerged disconnectable buoy 240.

In Fig. 14A the disconnectable buoy 240 has been submerged and abandoned by the floating installation 100. A drifting iceberg can then be vertically aligned with the disconnectable buoy 240 without colliding.

In Fig. 14B it is illustrated that the floating installation 100 has been moved in a horizontal direction away from the position of the disconnectable buoy 240. The floating installation 100 can in this way also be moved out of the way of a drifting iceberg. The floating installation 100 is still connected to the third seabed mooring line assembly 230. The horizontal movement of the floating installation 100 is therefore limited by the third seabed mooring line assembly 230. By paying out the third seabed mooring line assembly 230, the horizontal movement of the floating installation 100 can be increased. The movement of the floating installation 100 will typically be a rotation with the position on the seabed *SB* where the third seabed mooring line assembly 230 is connected as pivoting point. The movement of the floating installation 100 is illustrated with a tug 400; however, the floating installation may alternatively comprise its own propulsion system.

If the floating installation 100 must be moved beyond the reach of the third seabed mooring line assembly 230, the third seabed mooring line assembly 230 can be disconnected from the floating installation 100. This is not illustrated in the drawings.

In Fig. 15A and Fig. 15B the re-connection of the disconnectable buoy 240 to the floating installation 100 has been initiated. In these figures the third seabed mooring line assembly 230 is connected to the third coupling structure 110 on the floating installation 100. The third seabed mooring line assembly 230 has not been tensioned.

If the third seabed mooring line assembly 230 is not connected to the floating installation 100, it should be connected prior to the connection of the disconnectable buoy 240. In these figures the elongated hydrocarbon production equipment 300 is connected to the disconnectable buoy 240. In Fig. 15A the floating installation 100 is positioned in substantially vertical alignment with the submersed disconnectable buoy 240. In Fig. 15B it is illustrated how the floating installation 100 is moved into position with a tug 400.

When positioned substantially in vertical alignment with the disconnectable buoy 240 the floating installation 100 may engage the pick-up line 250. Pulling the disconnectable buoy 240 into the mooring recess 120 may be done by means of a winch arranged onboard the floating installation 100.

In Fig. 16A the disconnectable buoy 240 has been re-connected with the floating installation 100. After connection of the disconnectable buoy 240 to the floating installation 100, the tug 400 is no longer needed and can be disconnected from the floating installation 100 as illustrated in Fig. 16B.

When the disconnectable buoy 240 has been re-connected to the floating installation 100, the third seabed mooring line assembly 230 can be tensioned to a predetermined pretension. Tensioning of the third seabed mooring line assembly 230 may be performed by means of a winch. The first and second seabed mooring line assemblies 210,220 are tightened as a result of the tightening of the third seabed mooring line assembly 230.

When the disconnectable buoy 240 has been re-connected to the floating installation 100, the elongated hydrocarbon production equipment 300 can be re-connected to the piping or cable system of the floating installation 100. This can be performed prior or after tensioning of the third seabed mooring line assembly 230.

Fig. 16A and Fig. 16B show the floating installation 100 re-connected and moored with the spread mooring system 200.

The initial connection to the spread mooring system 200 and mooring of the floating installation 100 will require the same steps as a re-connection. In addition, the initial connection and mooring requires the elongated hydrocarbon production equipment 300 to be connected to the disconnectable buoy 240. This can be performed prior to the arrival of the floating installation 100 at the offshore location, such that when the disconnectable buoy 240 is pulled into and locked in the mooring recess 120, the elongated hydrocarbon production equipment 300 is already connected to the disconnectable buoy 240. The elongated hydrocarbon production equipment 300 may be connected to the disconnectable buoy 240 when locked in the mooring recess 120.

Before the initial connection to the spread mooring system 200 and mooring of the floating installation 100, the spread mooring system 200 is preferably installed at the offshore location prior to the arrival of the floating installation 100. This involves: connecting the first seabed mooring line assembly 210 to the seabed *SB* and the disconnectable buoy 240; connecting the second seabed mooring line assembly 220 to the seabed *SB* and the disconnectable buoy 240; and connecting the third seabed mooring line assembly 210 to the seabed *SB*.

The pick-up line 250 and the retention line 260 may preferably be connected to the disconnectable buoy 240 prior to the arrival of the floating installation 100 at the offshore location.

Any winch used with the spread mooring system 200 may be configured for remotely operation and thus be suitable for unmanned operations.

REFERENCE NUMERALS

100 – Floating installation

110 – Third coupling structure (on the installation)

120 – Mooring recess

121 – Receiving plate

122 – Support deck

123 – Backing support

130 – Hull

200 – Mooring system

210 – First seabed mooring line assembly

220 – Second seabed mooring line assembly

230 – Third seabed mooring line assembly

240 – Disconnectable buoy

240a – Lower end of buoy

240b – Upper end of buoy

241 – Locking arrangement / structural connector / connector hub

242 – Buoyancy element

243a – First coupling structure (on the disconnectable buoy)

243b – Second coupling structure (on the disconnectable buoy)

244 – Riser guide channel

245 – Load transfer plate

250 – Pick-up line

260 – Retention line

300 – Elongated hydrocarbon production equipment

400 – Tug

WL – Waterline

WL_L – Waterline, when the floating installation is loaded

WL_U – Waterline, when the floating installation is unloaded

SB – Seabed

L – length of buoy

D – depth of buoy below the waterline

α_1 – angular offset between the first and the second seabed mooring line assemblies

α_2 – angular offset between the second and the third seabed mooring line assemblies

α_3 – angular offset between the third and the first seabed mooring line assemblies

CLAIMS

1. A disconnectable buoy (240) for mooring a floating installation (100) for production and/or storage of hydrocarbons to a seabed (*SB*),
wherein the disconnectable buoy (240) comprises:
   - a buoyancy element (242),
   - two coupling structures (243a,243b) arranged at a lower end (240a) of the disconnectable buoy (240) for connecting ends of two seabed mooring line assemblies (210,220), wherein the two coupling structures (243a,243b) are configured to allow mooring of the disconnectable buoy (240) with an angular offset (α_1) between the two seabed mooring line assemblies (210,220),
   - a locking arrangement (241) arranged at an upper end (240b) of the disconnectable buoy (240) for releasably connecting the disconnectable buoy (240) to a hull (130) of the floating installation (100), in a non-swivelling manner, and
   - at least one riser guide channel (244) creating a through-going opening extending along the entire length of the disconnectable buoy (240),

   wherein the buoyancy element (242) is configured such that the disconnectable buoy (240) is neutral buoyant at a depth (*D*) below a water line (*WL*) of at least 25 meters after disconnection at sea, while connected to the seabed mooring line assemblies (210,220) and elongated hydrocarbon production equipment (300), and
   wherein the disconnectable buoy (240) has a polygonal horizontal cross-section.

2. A spread mooring system (200) for mooring a floating installation (100) for production and/or storage of hydrocarbons to a seabed (*SB*) in a fixed heading,
wherein the spread mooring system (200) comprises:
   - a disconnectable buoy (240) comprising
     - a buoyancy element (242),
     - a locking arrangement (241) arranged at an upper end (240b) of the disconnectable buoy (240) for releasably connecting the disconnectable buoy (240) within a hull (130) of the floating installation (100), and
     - at least one riser guide channel (244) creating a through-going opening extending along a length (*L*) of the disconnectable buoy (240), wherein the at least one riser guide channel (244) allows guiding of elongated hydrocarbon production equipment (300) through the disconnectable buoy (240),

- a first seabed mooring line assembly (210) having first ends connected to a first coupling structure (243a) at a lower end (240a) of the disconnectable buoy (240) and opposite ends connectable to the seabed (SB),
- a second seabed mooring line assembly (220) having first ends connected to a second coupling structure (243b) at a lower end (240a) of the disconnectable buoy (240) and opposite ends connectable to the seabed (SB), and
- a third seabed mooring line assembly 230 having first ends connectable to a third coupling structure (110) on the floating installation (100) and opposite ends connectable to the seabed (SB),

wherein each of the first and second seabed mooring line assemblies (210,220) comprises at least one mooring line, and wherein the at least one mooring line of the first seabed mooring line assembly (210) and the at least one mooring line of the second seabed mooring line assembly (220) have a relative angular offset (α_1) of more than 45 degrees.

3. The spread mooring system (200) according to claim 2, wherein the spread mooring system (200) comprises:
   - a retention line (260) having a first end connected to the disconnectable buoy (240) and an opposite end connectable to the seabed (*SB*),

   wherein the retention line (260) is configured to retain the disconnectable buoy (240) within a predetermined horizontal area after disconnecting from the floating installation (100).

4. The spread mooring system according to any one of claims 2-3, wherein the disconnectable buoy (240) is configured to be neutral buoyant at a depth (*D*) below the water line (*WL*) of at least 25 meters after disconnection at sea, while connected to the seabed mooring line assemblies (210,220) and an elongated hydrocarbon production equipment (300).

5. The spread mooring system according to claim 2-4, wherein the spread mooring system (200) comprises:
   - at least one receiving plate (121) for arrangement in the mooring recess (120), the receiving plate (121) being configured to guiding the disconnectable buoy (240) in the recess (120).

6. The spread mooring system according to claim 2-5, wherein the disconnectable buoy (240) comprises:

- at least one load transfer plate (245) being configured to transfer loads from the disconnectable buoy (240) to the hull (130).

7. The spread mooring system according to any one of claim 2-6, wherein the locking arrangement (241) comprises a plurality of locking segments, locking jacks, dogs, latches, collets or a locking ring.

8. The spread mooring system according to any one of claims 2-7, wherein the spread mooring system comprises:
   - a quick connection/disconnection system for connecting the elongated hydrocarbon production equipment (300) to be held by the disconnectable buoy (240) to a piping or cable system of the floating installation (100).

9. A floating installation (100) comprising:
   - a spread mooring system (200) according to any one of claims 2-8,
   - the hull (130) comprising a mooring recess (120) extending from a bottom of the hull (130) to a main deck level, and
   - the third coupling structure (110) for connecting the first end of the third seabed mooring line assembly (230),

   wherein the floating installation (100) has an elongated form comprising a bow portion and an aft portion, wherein the disconnectable buoy (240) is arranged at either the bow portion or the aft portion, and the third coupling structure (110) is arranged at the bow portion or the aft portion other than the disconnectable buoy (240).

10. A method for connecting a floating installation (100) in accordance with claim 15 to a seabed (*SB*), wherein the method comprises the steps of:
   - connecting the third seabed mooring line assembly (230) to the third coupling structure (110) on the floating installation (100),
   - moving the floating installation (100) to a position where the mooring recess (120) is vertically aligned with the disconnectable buoy (240) being submerged below the water line (*WL*) at a depth (*D*),
   - pulling the disconnectable buoy (240) into the mooring recess (120) and releasably connecting the disconnectable buoy (240) in the mooring recess (120) by means of the locking arrangement (241),
   - pulling in and connecting the elongated hydrocarbon production equipment (300) to the disconnectable buoy (240),
   - connecting the elongated hydrocarbon production equipment (300) to a piping or cable system of the floating installation (100) and

- tensioning the third seabed mooring line assembly (230) to a predetermined pretension force.

11. A method for disconnecting a disconnectable spread moored floating installation (100) for production and/or storage of hydrocarbons, using a spread mooring system (200) comprising:
    - a disconnectable buoy (240) comprising:
        - a buoyancy element (242),
        - a locking arrangement (241) arranged at an upper end (240b) of the disconnectable buoy (240) for releasably connecting the disconnectable buoy (240) within a hull (130) of the floating installation (100), and
        - at least one riser guide channel (244) creating a through-going opening extending along a length (L) of the disconnectable buoy (240), wherein the at least one riser guide channel (244) allows guiding of elongated hydrocarbon production equipment (300) through the disconnectable buoy (240),
    - a first seabed mooring line assembly (210) having first ends connected to a first coupling structure (243a) at a lower end (240a) of the disconnectable buoy (240) and opposite ends connected to the seabed (SB),
    - a second seabed mooring line assembly (220) having first ends connected to a second coupling structure (243b) at a lower end (240a) of the disconnectable buoy (240) and opposite ends connected to the seabed (SB), and
    - a third seabed mooring line assembly (230) having first ends connected to a third coupling structure (110) on the installation (100) and opposite ends connected to the seabed (SB),

    wherein each of the first and second seabed mooring line assemblies (210,220) comprises at least one line,
    wherein the method comprises the steps of:
    - disconnecting the elongated hydrocarbon production equipment (300) held by the disconnectable buoy (240) from a piping or cable system of the floating installation (100),
    - disconnecting the disconnectable buoy (240) from the floating installation (100), and
    - moving the floating installation (100) to a different location within a maximum extend of the third seabed mooring line assembly (230) with the floating installation (100).

12. The method according to claim 11,

wherein the method further comprises the initial steps of:

- paying out the third seabed mooring line assembly (230) and
- moving the floating installation (100) to a position where the horizontal tension from the first seabed mooring line assembly (210) and the second seabed mooring line assembly (220) is reduced.

13. The method according to claim 12,
wherein the method further comprises the steps of:

- disconnecting the third seabed mooring line assembly (230) from the third coupling structure (110) on the floating installation (100) and
- moving the floating installation (100) to a different location outside a maximum extend of the third seabed mooring line assembly (230).

14. A method for reconnection a disconnectable spread moored floating installation (100) for production and/or storage of hydrocarbons, using a spread mooring system (200) comprising:

- a disconnectable buoy (240) comprising:
  - a buoyancy element (242),
  - a locking arrangement (241) arranged at an upper end (240b) of the disconnectable buoy (240) for releasably connecting the disconnectable buoy (240) within a hull (130) of the floating installation (100), and
  - at least one riser guide channel (244) creating a through-going opening extending along a length (L) of the disconnectable buoy (240), wherein the at least one riser guide channel (244) allows guiding of elongated hydrocarbon production equipment (300) through the disconnectable buoy (240),
- a first seabed mooring line assembly (210) having first ends connected to a first coupling structure (243a) at a lower end (240a) of the disconnectable buoy (240) and opposite ends connected to the seabed (SB),
- a second seabed mooring line assembly (220) having first ends connected to a second coupling structure (243b) at a lower end (240a) of the disconnectable buoy (240) and opposite ends connected to the seabed (SB), and
- a third seabed mooring line assembly (230) having first ends connectable to a third coupling structure (110) on the installation (100) and opposite ends connected to the seabed (SB),

wherein each of the first and second seabed mooring line assemblies (210,220) comprises at least one line,
wherein the method further comprises the steps of:

- moving the floating installation (100) to a position where the mooring recess (120) is vertically aligned with the disconnectable buoy (240) being submersed below the water line (*WL*) at a depth (*D*),
- pulling the disconnectable buoy (240) into the mooring recess (120) and releasably connecting the disconnectable buoy (240) in the mooring recess (120) by means of the locking arrangement (241),
- connecting the elongated hydrocarbon production equipment (300) to a piping or cables system of the floating installation (100) and
- tensioning the third seabed mooring line assembly (230) to a predetermined pretension force.

15. The method according to claim 14,
wherein the method further comprises the steps of:

- returning the floating installation (100) within a maximum extend of the third seabed mooring line assembly (230),
- connecting the third seabed mooring line assembly (230) to the third coupling structure (110) on the floating installation (100),
- moving the floating installation (100) to a position where the mooring recess (120) is vertically aligned with the disconnectable buoy (240) being submersed below the water line (*WL*) at a depth (*D*),
- pulling the disconnectable buoy (240) into the mooring recess (120) and releasably connecting the disconnectable buoy (240) in the mooring recess (120) by means of the locking arrangement (241),
- connecting the elongated hydrocarbon production equipment (300) to a piping or cables system of the floating installation (100) and
- tensioning the third seabed mooring line assembly (230) to a predetermined pretension force.

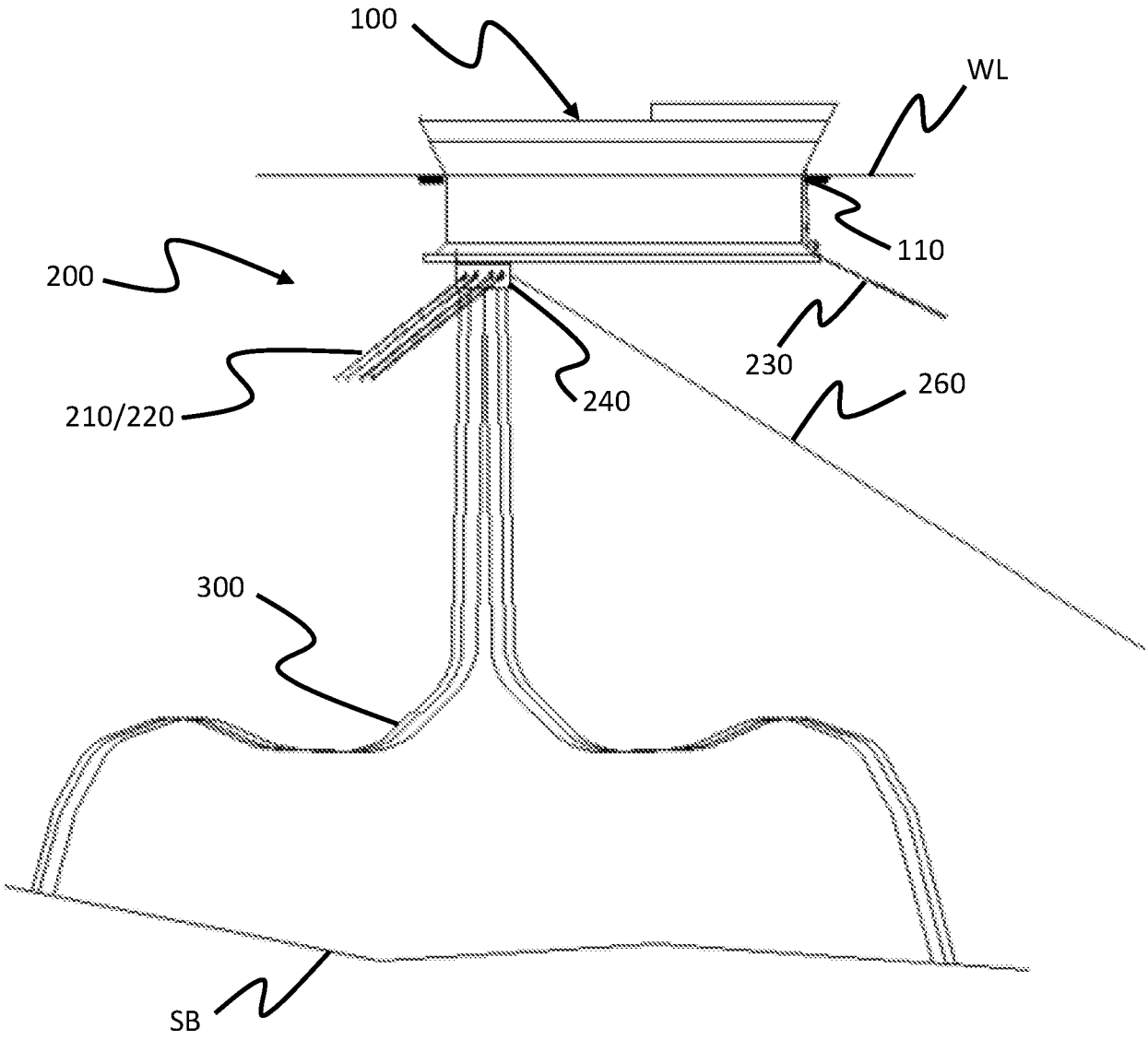


Fig. 1

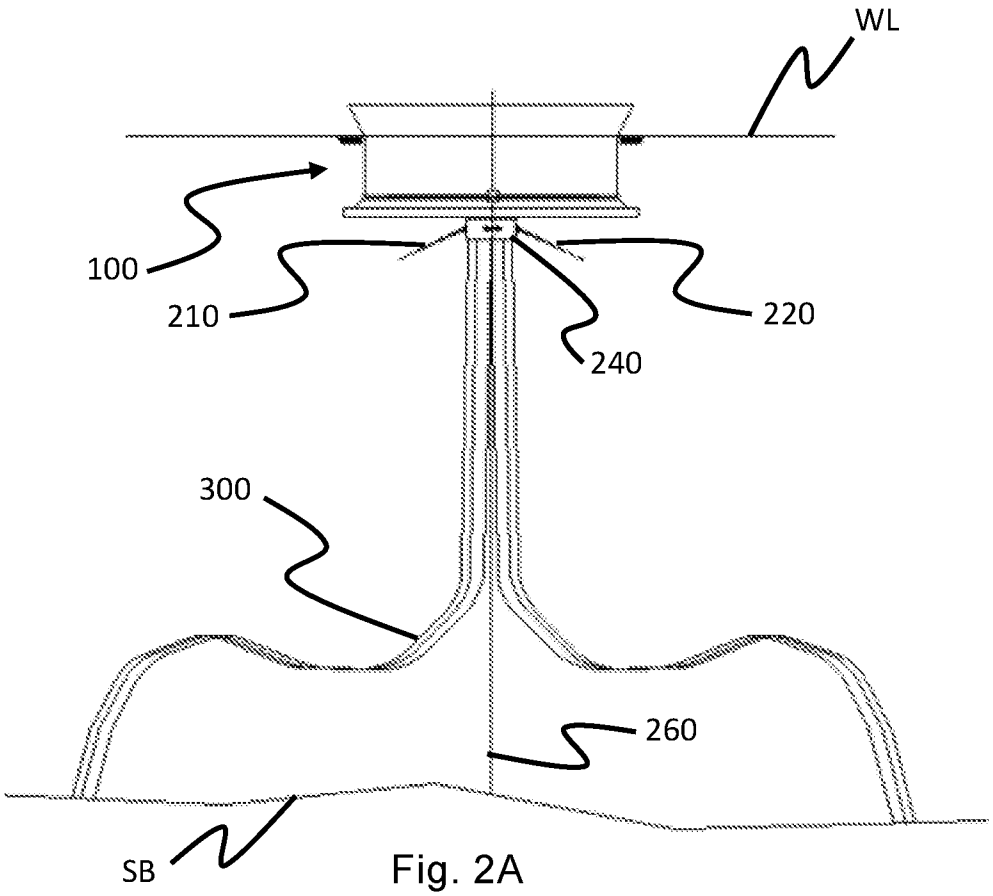

WL
100
210
220
240
300
260
SB

Fig. 2A

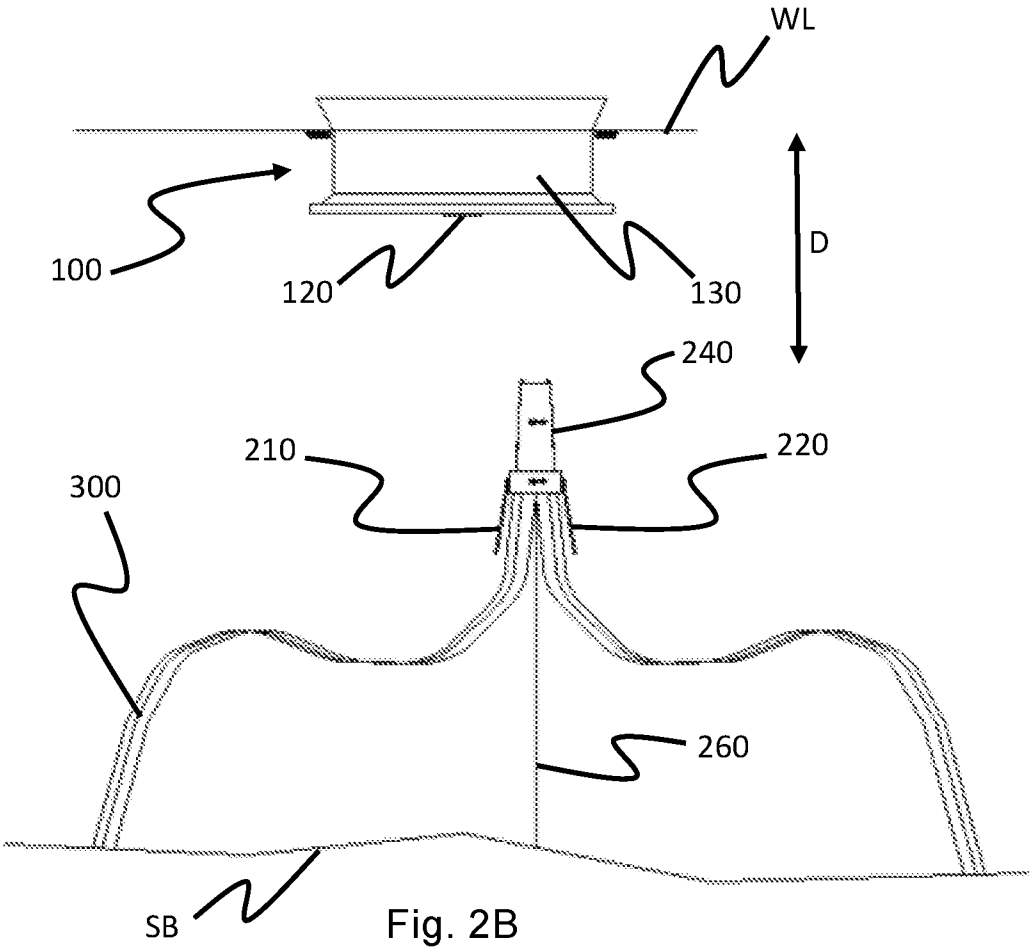

WL
100
120
130
D
240
210
220
300
260
SB

Fig. 2B

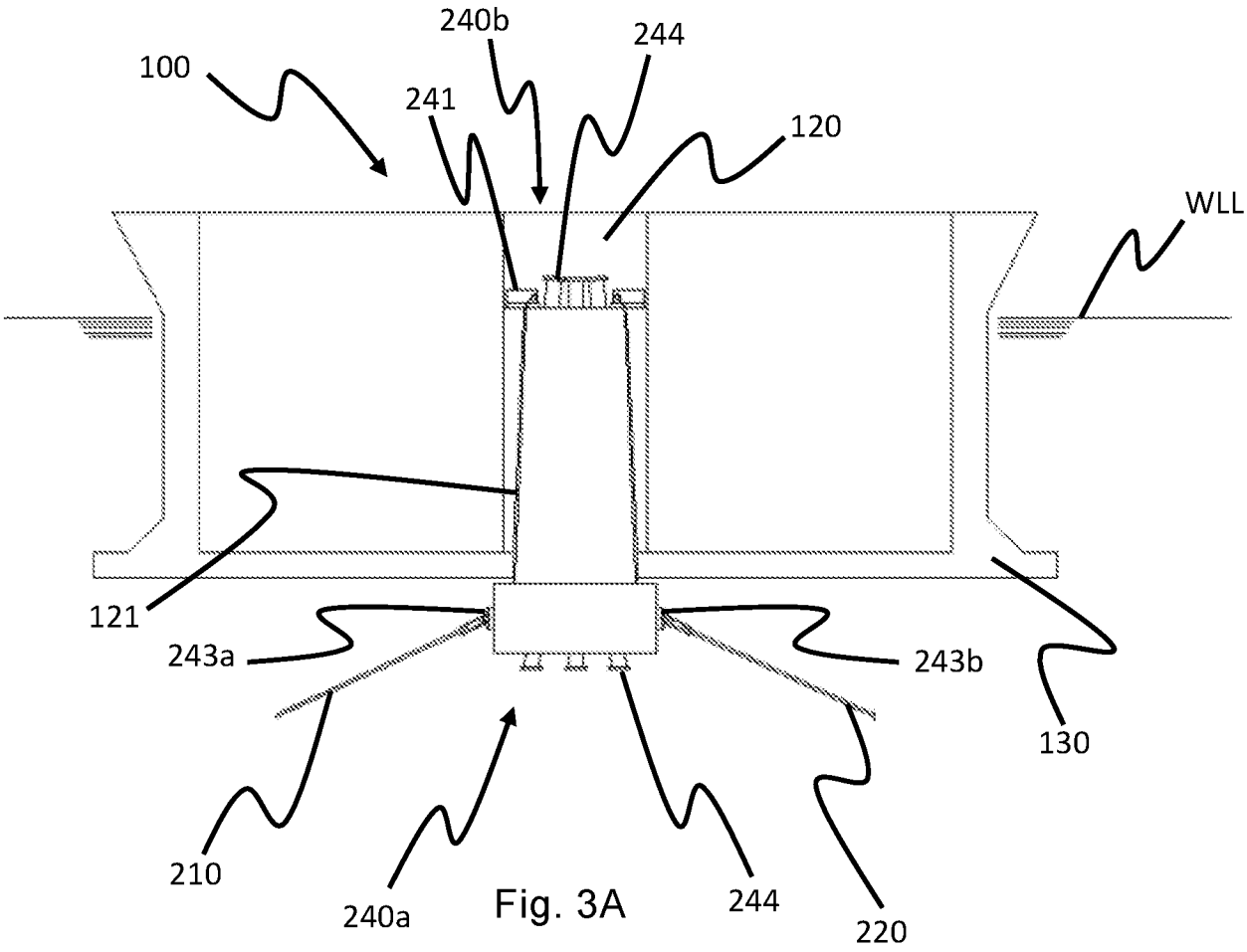

100
240b
244
241
120
WLL
121
243a
243b
130
210
240a
244
220

Fig. 3A

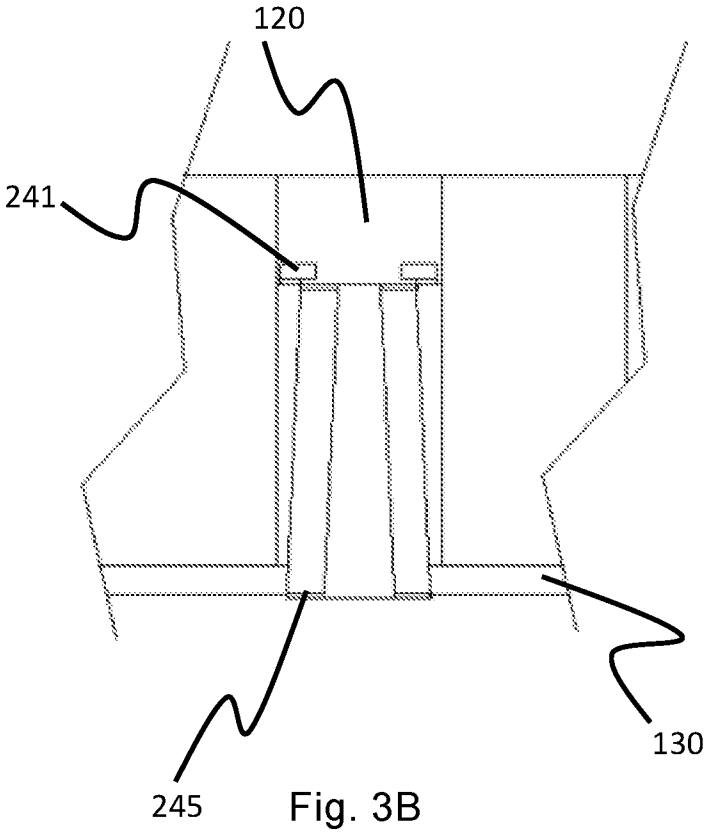

120
241
130
245

Fig. 3B

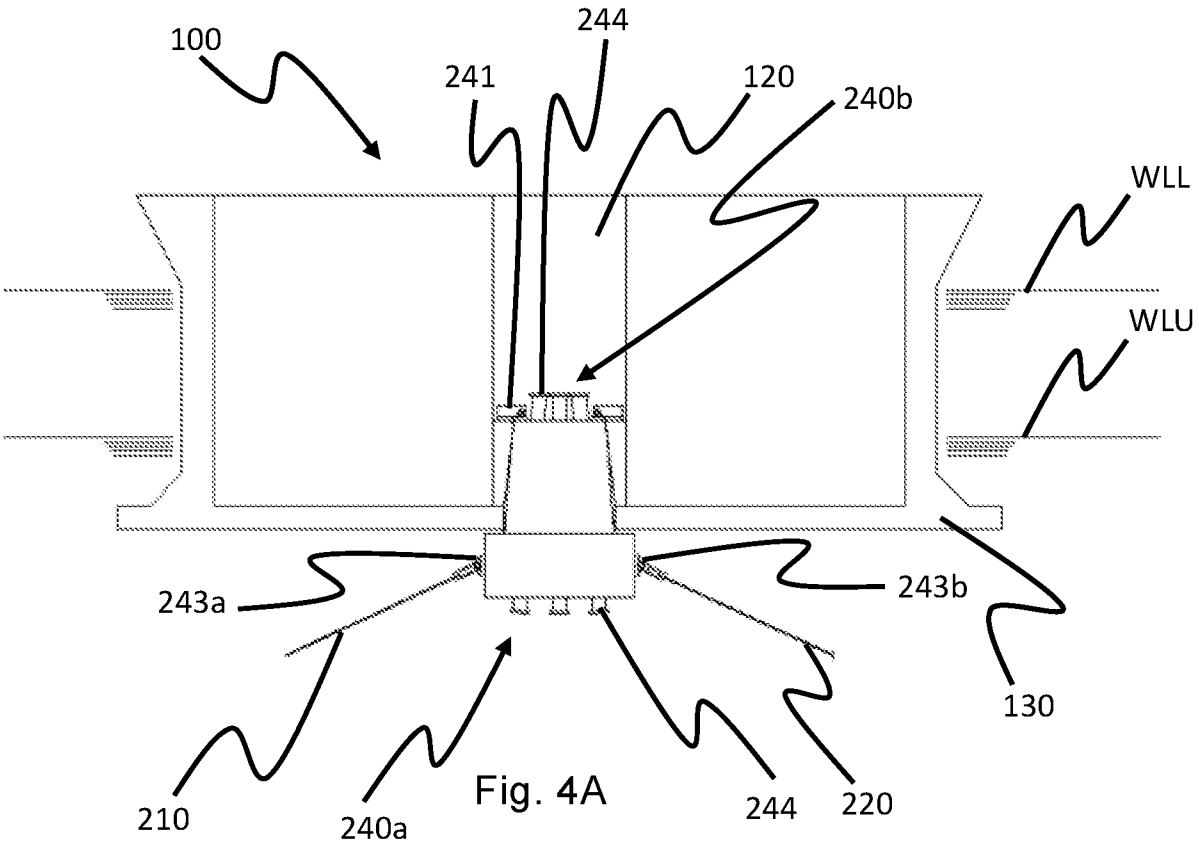

100
241
244
120
240b
WLL
WLU
243a
243b
130
210
240a
244
220

Fig. 4A

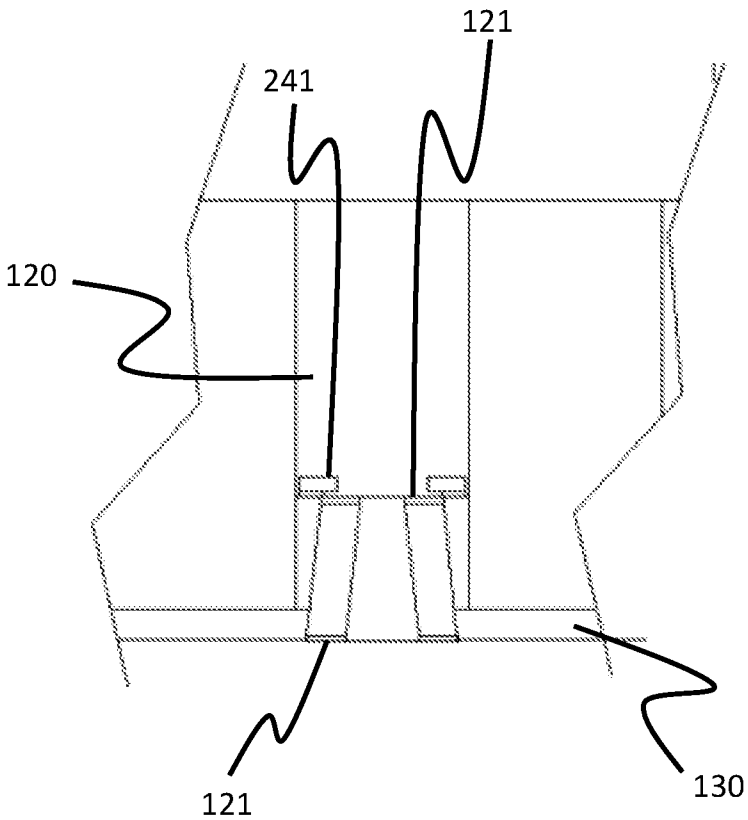

121
241
120
121
130

Fig. 4B

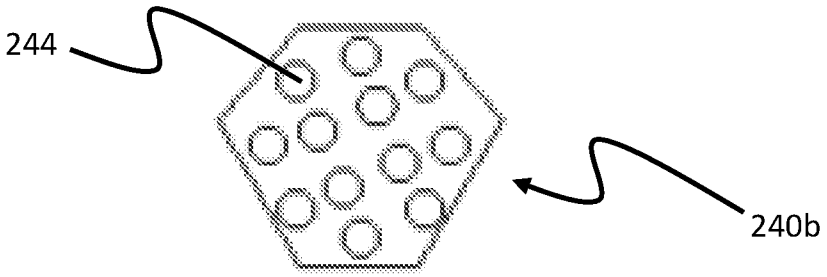


Fig. 5A

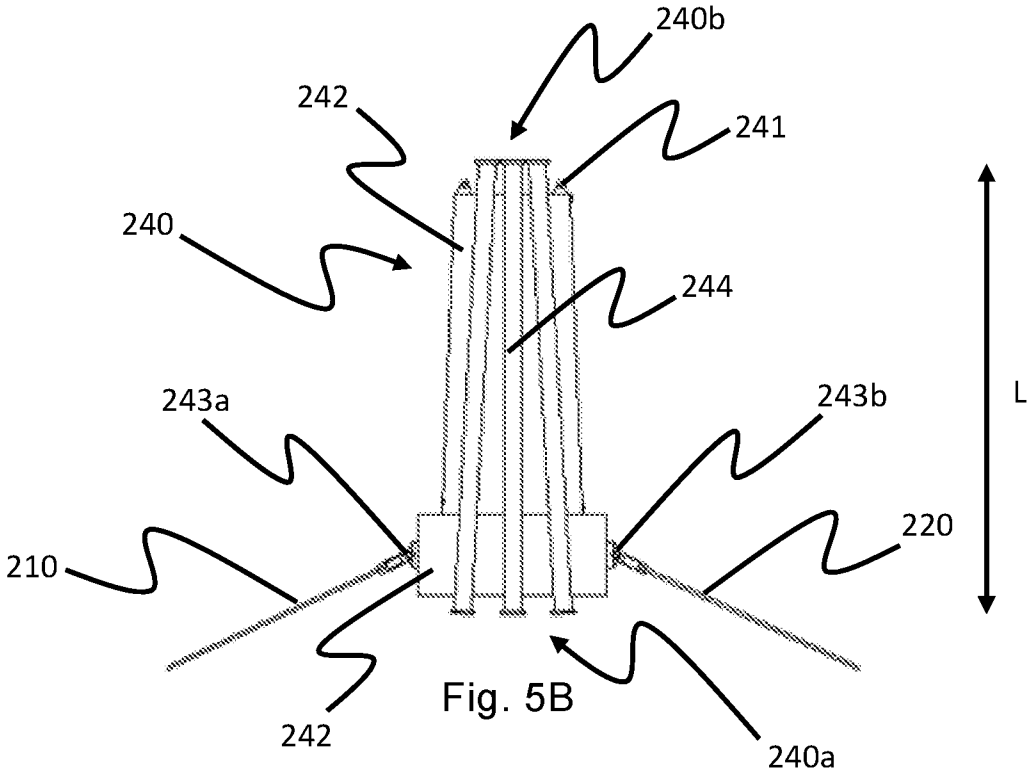


Fig. 5B

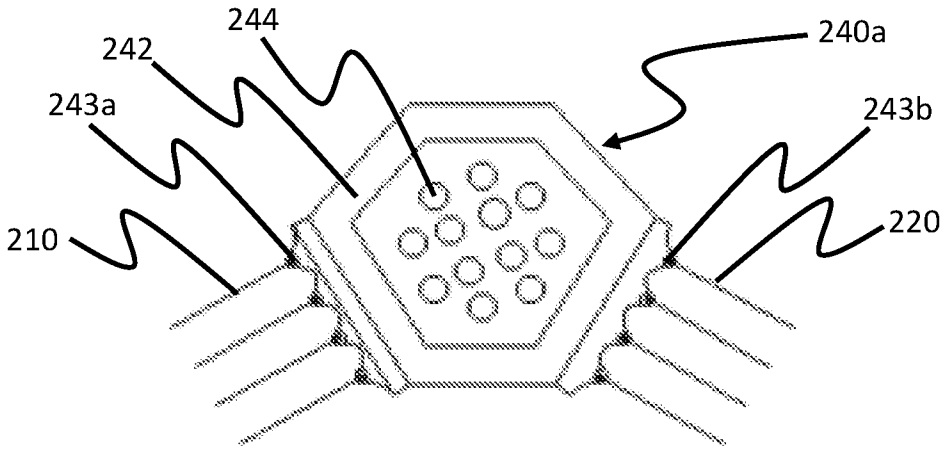


Fig. 5C

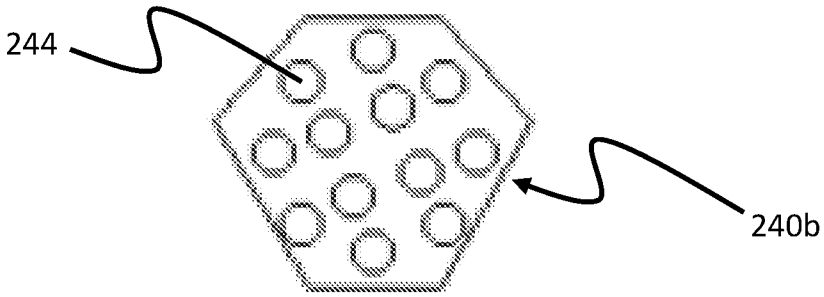


Fig. 6A

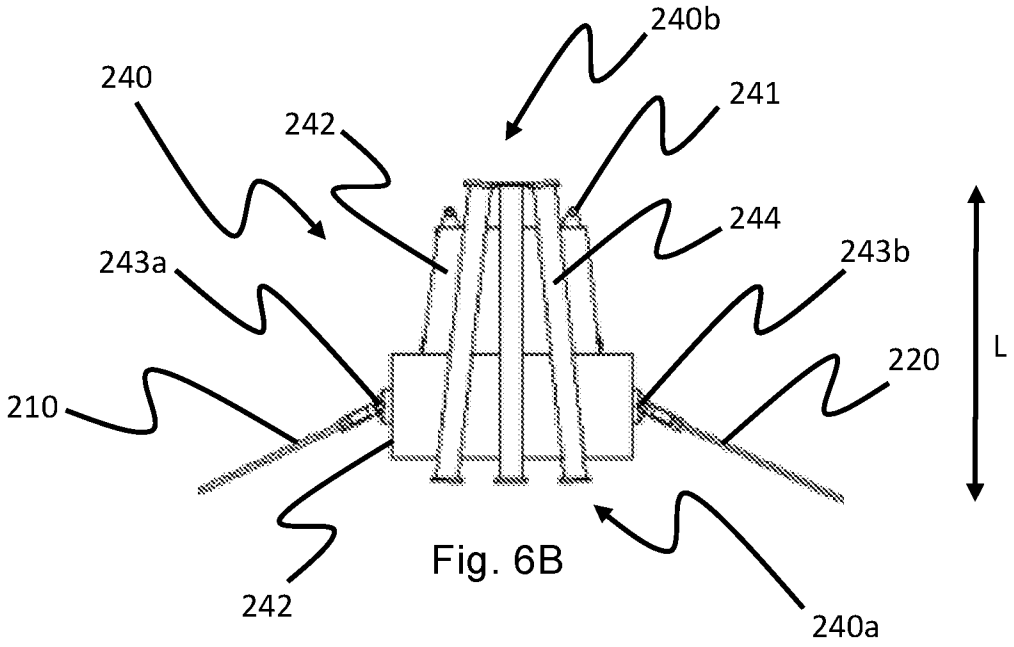


Fig. 6B

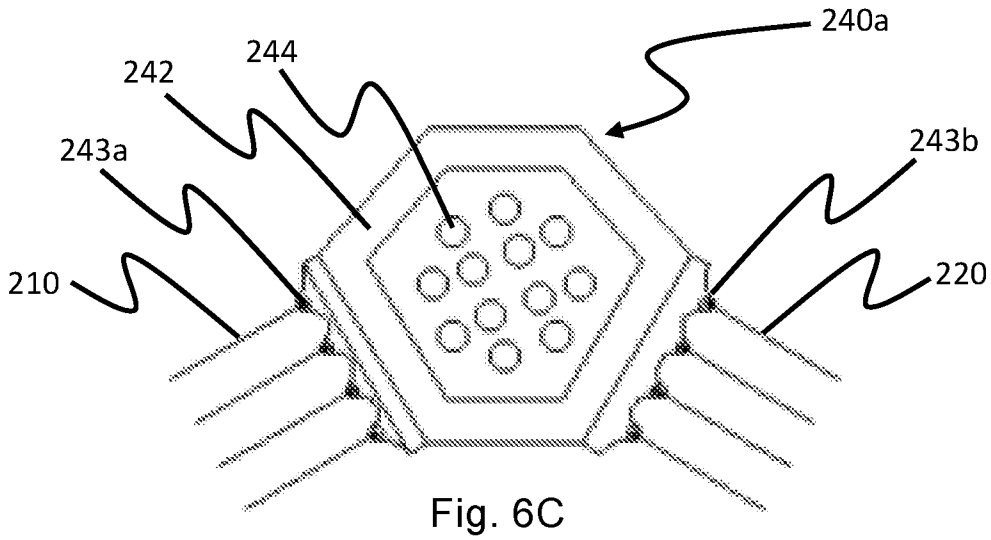


Fig. 6C

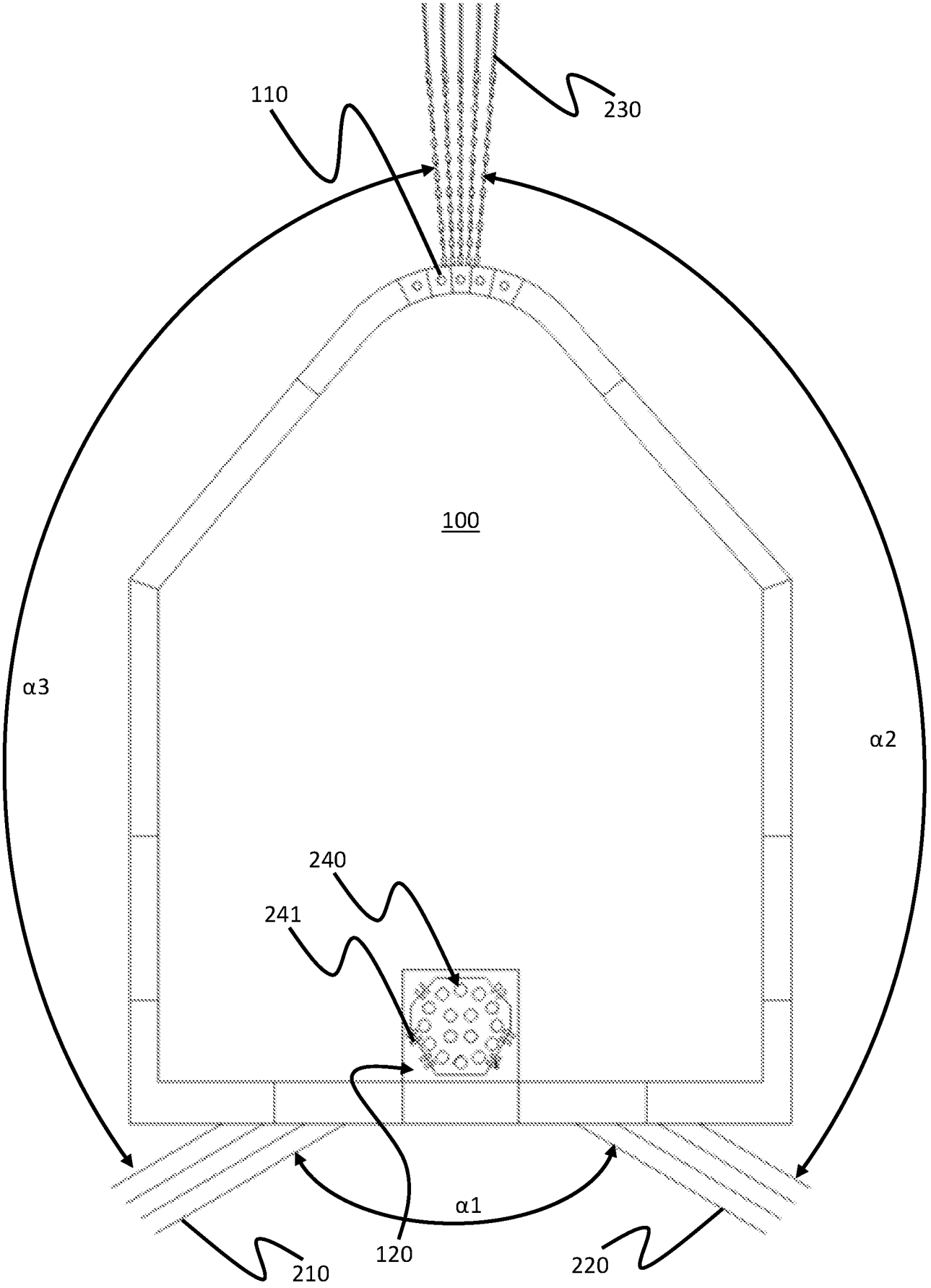


Fig. 7

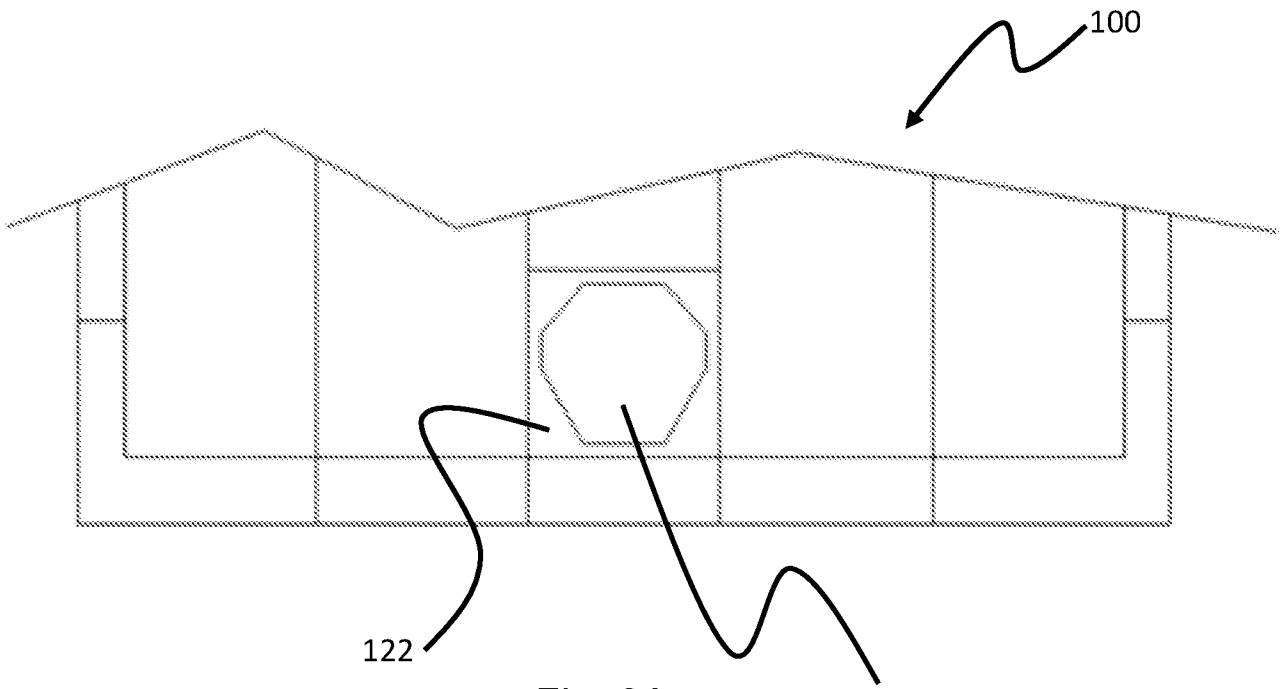


Fig. 8A

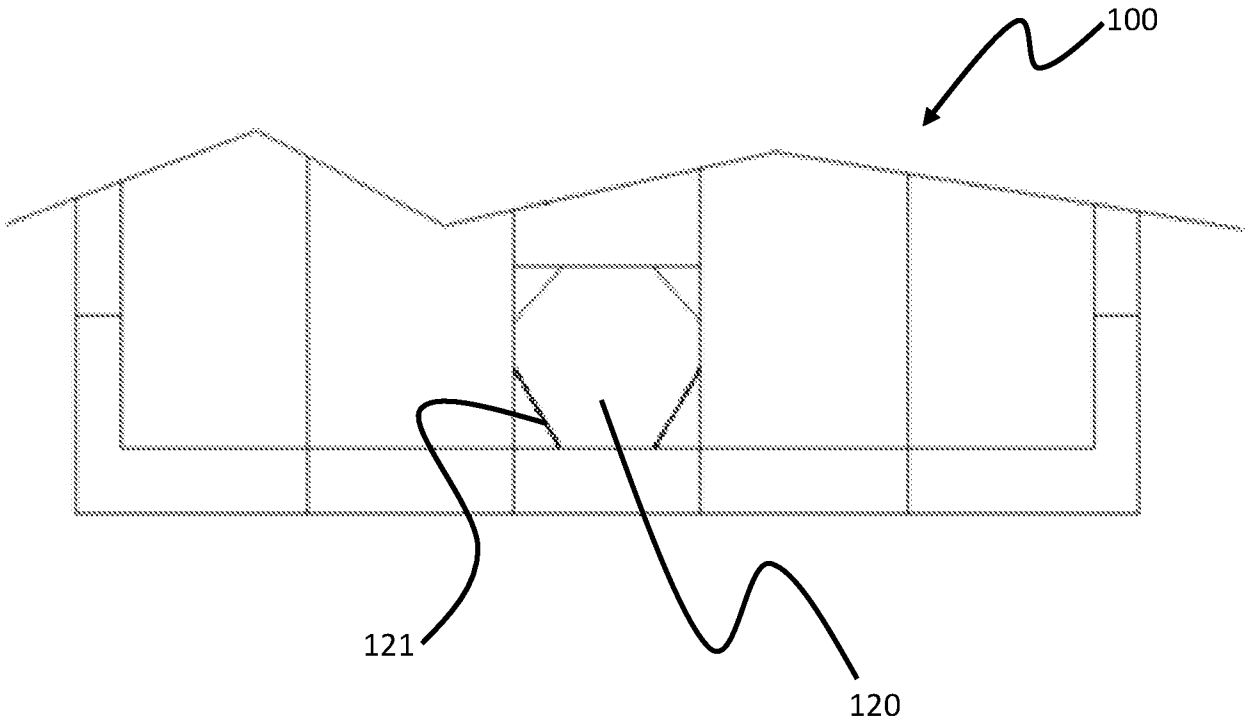


Fig. 8B

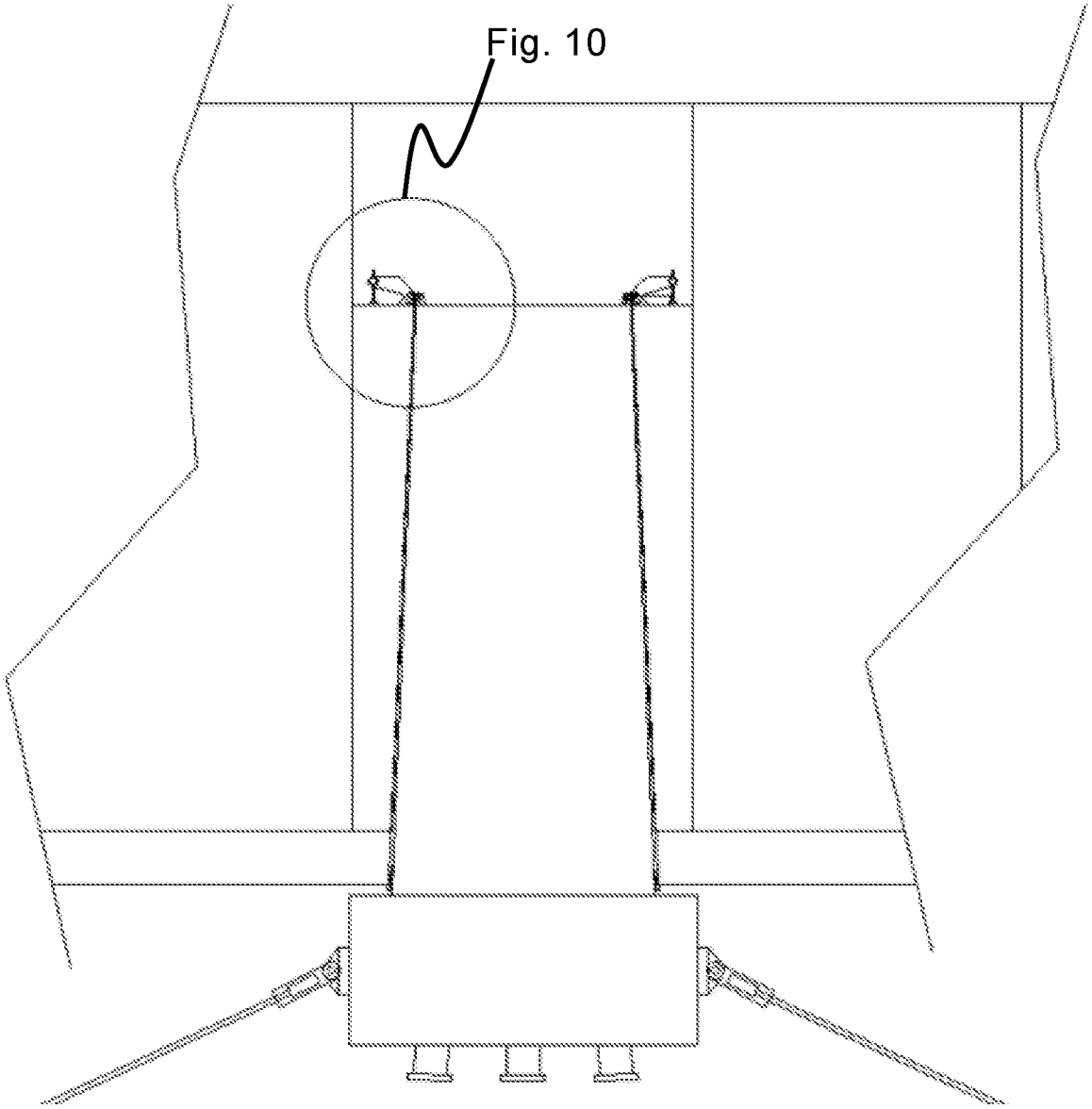


Fig. 9

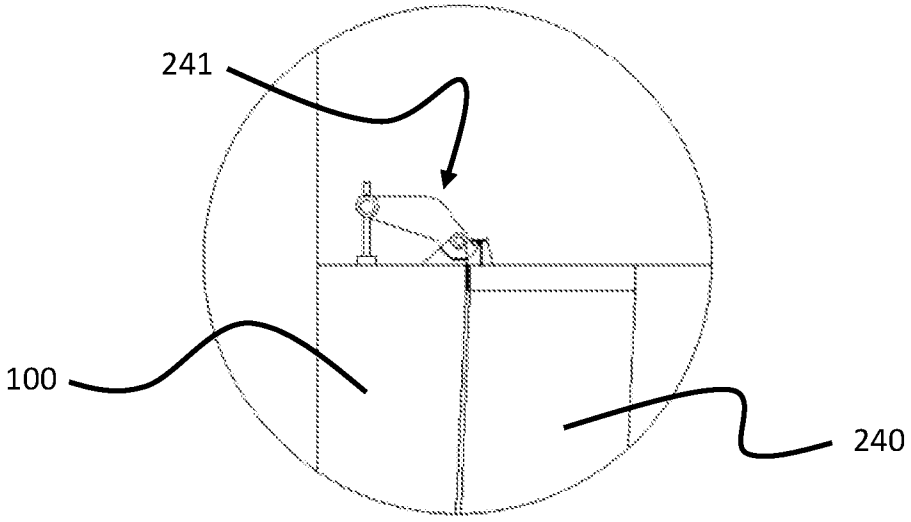


Fig. 10A

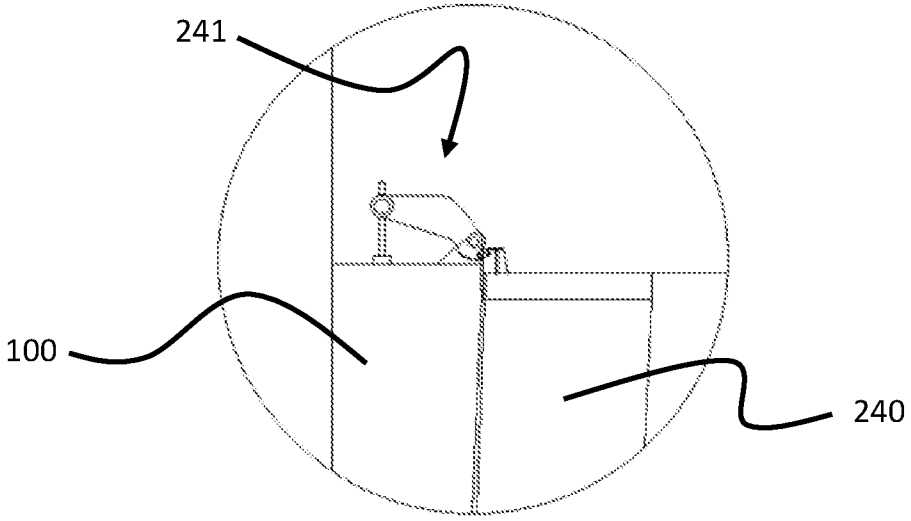


Fig. 10B

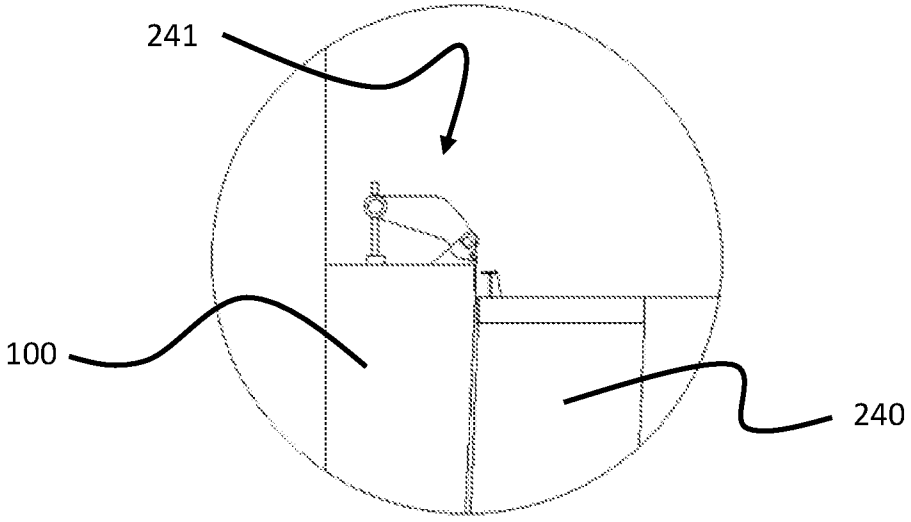


Fig. 10C

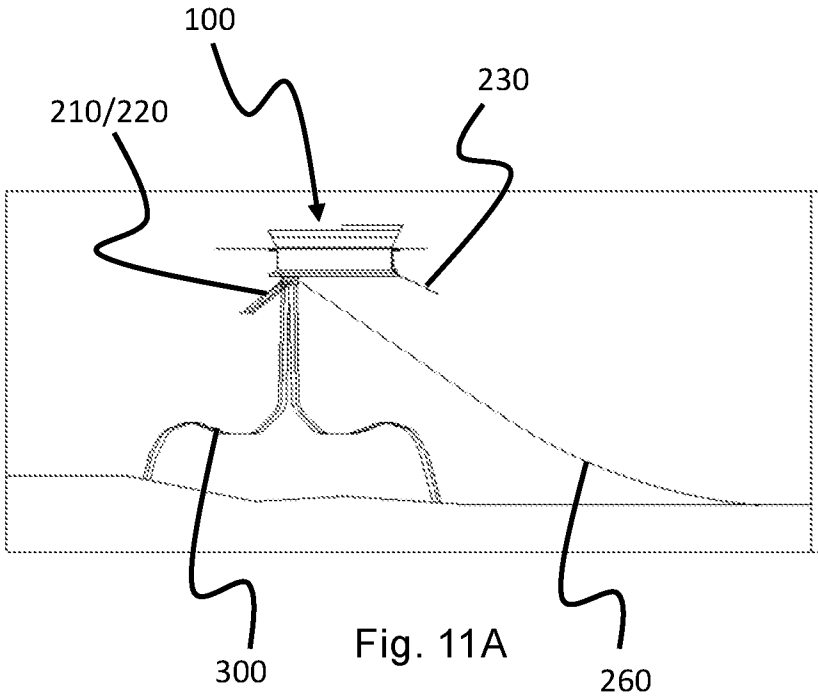


Fig. 11A

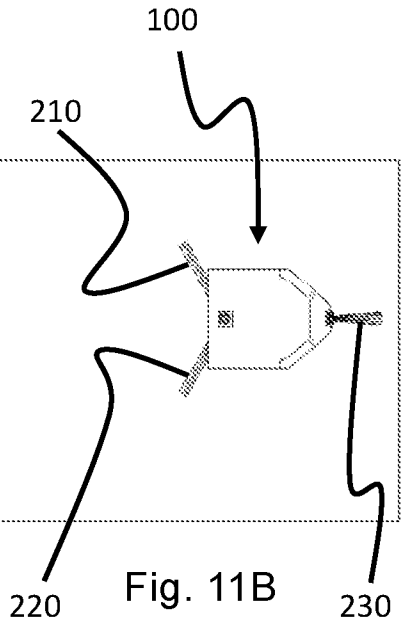


Fig. 11B

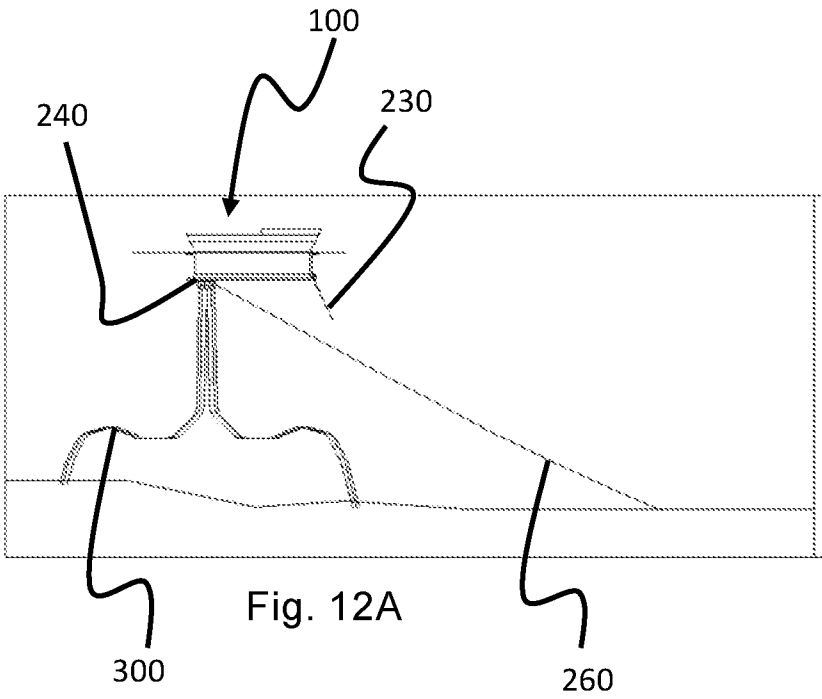


Fig. 12A

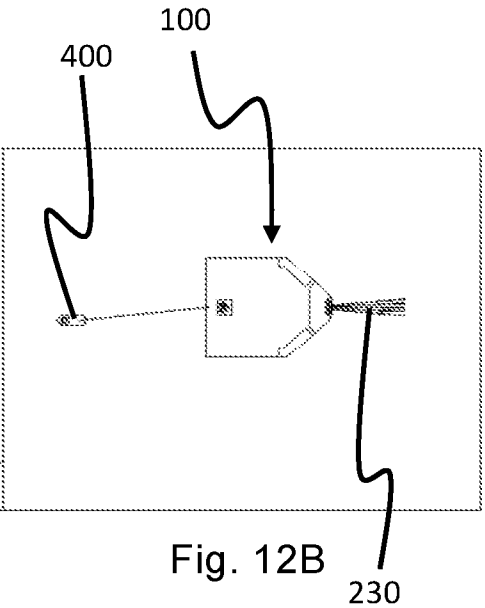


Fig. 12B

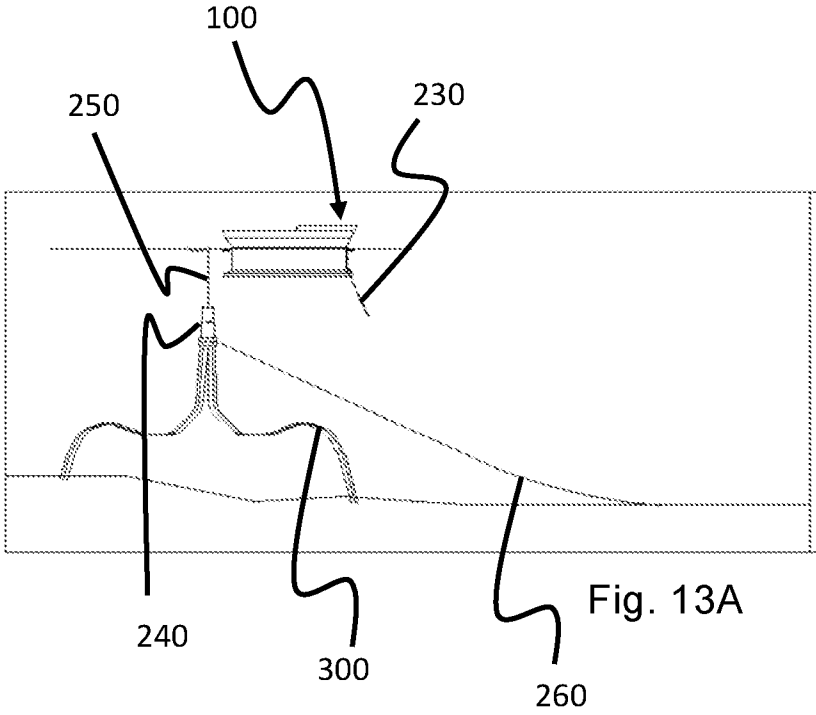


Fig. 13A

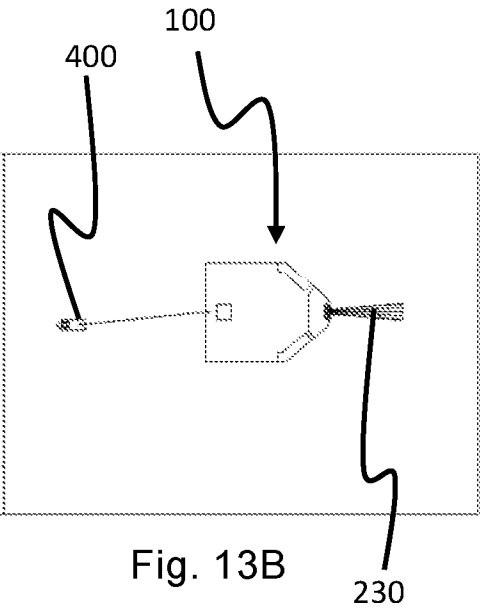


Fig. 13B

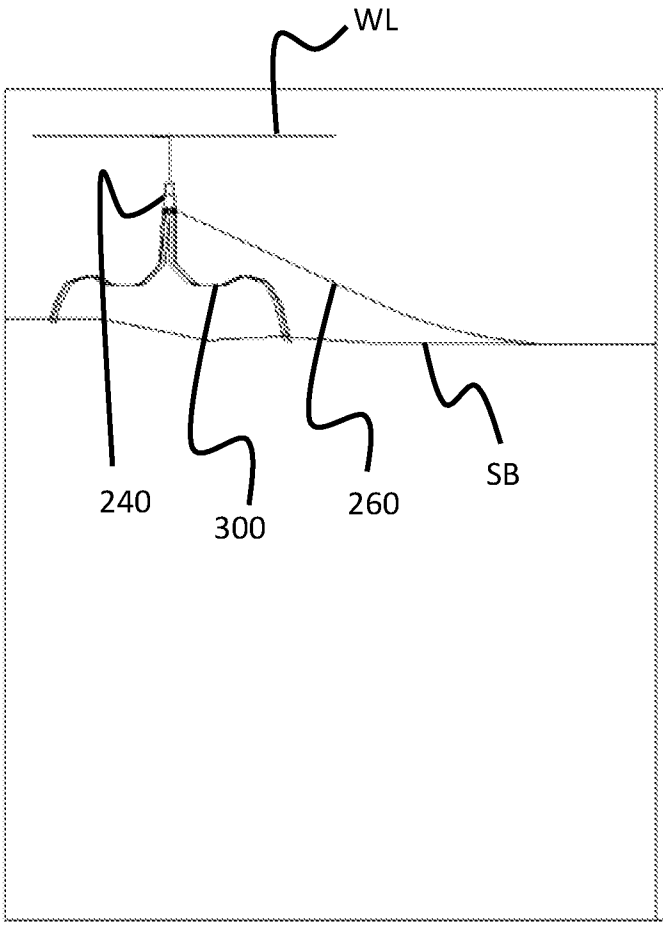


Fig. 14A

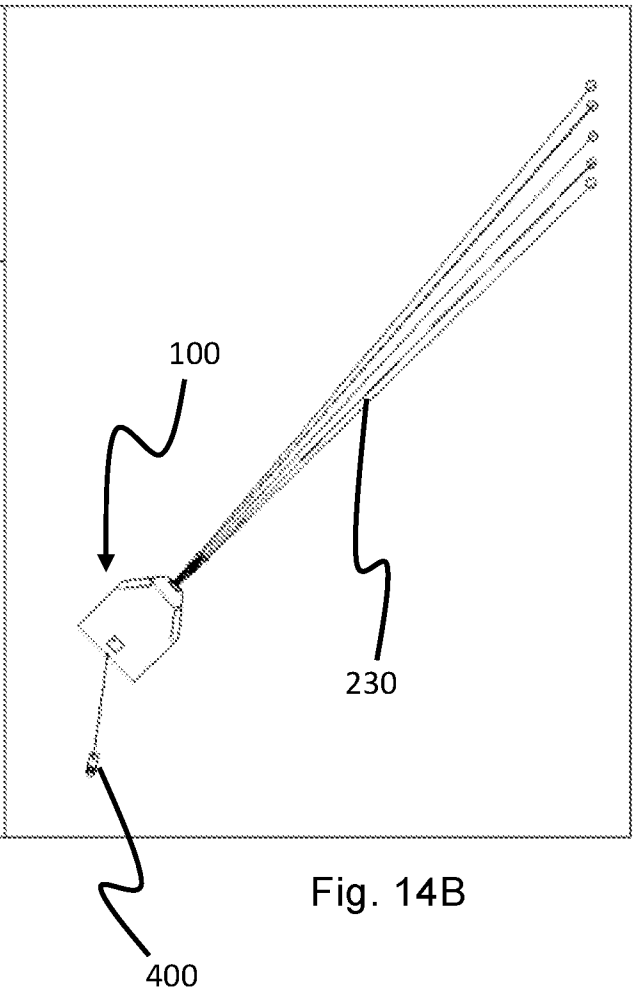


Fig. 14B

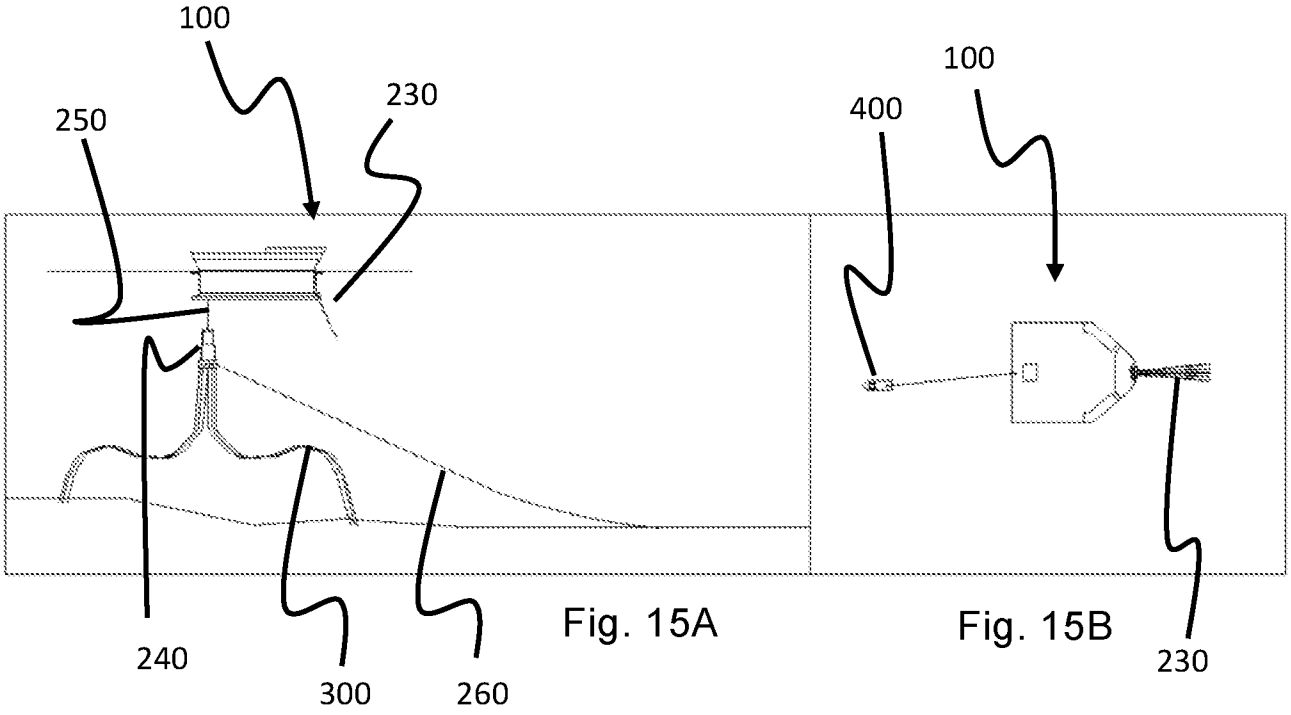


Fig. 15A

Fig. 15B

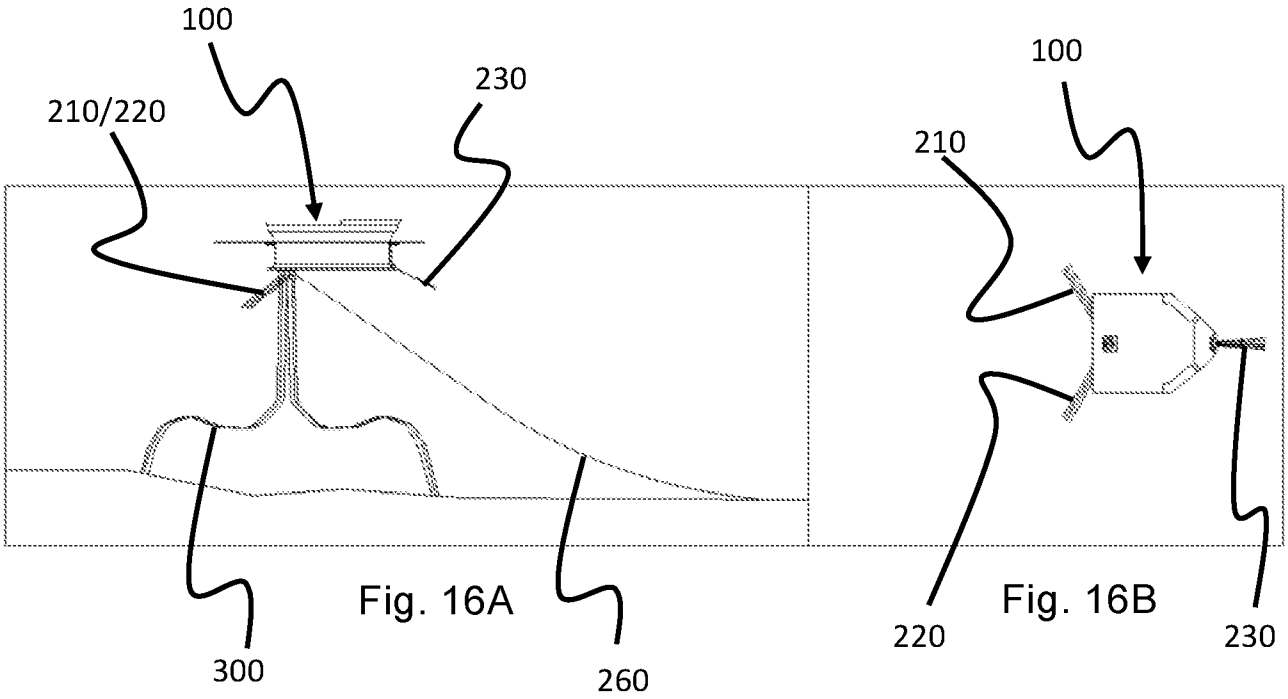


Fig. 16A

Fig. 16B