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(54) MULTISTAGE LIFTING SYSTEM AND METHOD

(57) A lifting system (200, 200’) for vertically lifting a load (300, 300’) in two stages, the system (200, 200’) comprising: a first rope (210, 210’) for connecting to the load (300, 300’) to be lifted; a first rope pulling mechanism (230, 230’) configured to selectively pull the first rope (210, 210’) in and selectively hold the first rope (210, 210’); a vertically moveable sheave (220, 220’); and a sheave lifting apparatus (400, 400’) configured to lift the vertically moveable sheave (220, 220’); wherein in use the first rope (210, 210’) passes over the vertically moveable sheave (220, 220’) between the first rope pulling mechanism (230, 230’) and the load (300, 300’); such that in use the first rope pulling mechanism (230, 230’) can be used to lift the load (300, 300’) in a first stage by pulling the first rope (210, 210’) in, and then hold the first rope (210, 210’) such that the sheave lifting apparatus (400, 400) can lift the vertically moveable sheave (220, 220’) to spool the first rope (210, 210’) over the vertically moveable sheave (220, 220’), thereby lifting the load (300, 300’) in a second stage.

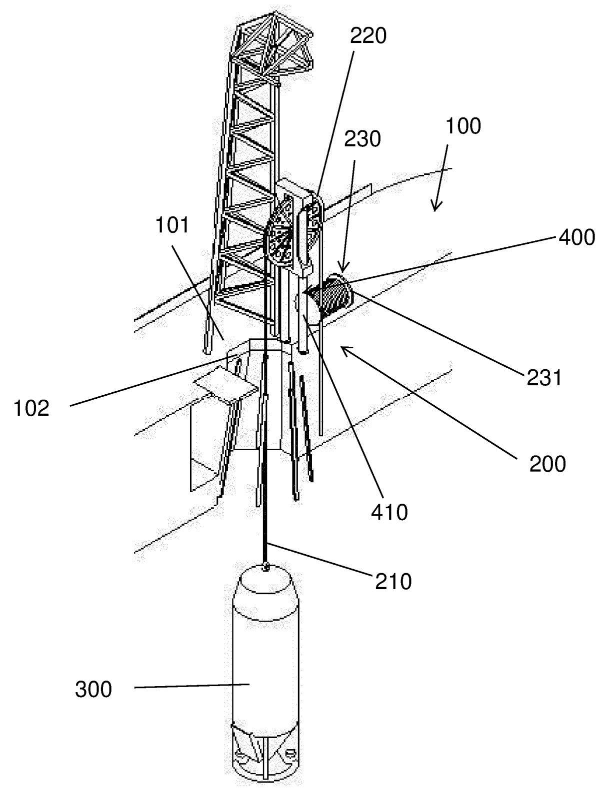

Fig. 3

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Description

FIELD

[0001] The present invention relates to a lifting system for performing lifting operations. More specifically, the present invention relates to a system and method for performing efficient lifting of subsea infrastructure while it is fully submerged, through the splash zone and into the air and the other way around, from the air, through the splash zone and into a fully submerged position.

BACKGROUND

[0002] In many different industries, subsea infrastructure needs to be lowered from a vessel to the seabed during installation of the infrastructure and lifted from the seabed to the vessel for maintenance and servicing when required. This is particularly prevalent in the offshore oil and gas industry, where myriad equipment is regularly transported from vessel to seabed and vice versa.

[0003] There are many terms used in the art to generally identify the infrastructure which may be passed from vessel to seabed. In the present description, it is not important what the particular infrastructure is, therefore throughout the present description, reference will be made to a "load" which may be any of myriad components, systems or devices which are required to be lowered or lifted to or from the seabed.

[0004] When lowering or lifting a load to or from the seabed, the load can be viewed as being lifted through three main zones. The establishment of three zones is based on the possibility to demarcate each zone based on the forces the load experiences in that zone, as will now be explained.

[0005] Throughout the present description, the uppermost zone is referred to as the "air zone", where the load is lifted or lowered through air only. The middle zone is referred to as the "splash zone", where the load passes from the air to the water. In calm sea states, the splash zone may not be problematic and may not impart significant dynamic forces on the load. However, in moderate and higher sea states, significant dynamic forces may be imparted on the load in this zone as the load splashes through the constantly rising and falling waves. The lower zone is referred to as the "subsea" zone, where the load is entirely submerged in water. In the subsea zone, the weight of the load is counteracted by the buoyancy of the load. In this connection, the lifting force required in the subsea zone is typically much less than in the air zone or the splash zone. It will be understood that the reduction in effective weight, by the buoyancy of the load counteracting the weight, will depend greatly on the density of the load being lifted or lowered. For example, steel loads will create a low buoyancy force, whereas concrete loads will create a higher buoyancy force.

[0006] Typically, to lower and lift loads to and from the seabed, wire rope winches are often provided. The winches are provided with crane booms, hoisting towers, A-frames or other arrangement to provide a system whereby loads can be lowered or lifted to or from the seabed.

[0007] One such application in which loads are lifted and lowered from the seabed is deep sea mining. In deep sea mining, minerals and deposits from the seabed are retrieved to a vessel by lifting a container from the seabed to the vessel. Typically, the containers carrying the minerals have a very high buoyancy when being lifted through the water.

[0008] The winch provided must be sufficiently capable of lifting the load through the subsea zone, as well as through the splash zone and air zone. In this connection, it must be rated to the highest lifting requirements of the three zones through which it will perform the lift. Therefore, the winch is typically oversized for the subsea zone, where the force required to lift is typically much less than in the splash zone and air zone.

[0009] Using an oversized winch is inefficient. The winch may lift the load slower through the subsea zone than could be performed with a winch or lower lifting rating.

[0010] Offshore and subsea operations are extremely expensive. There is a constant strive for efficiency of operations to reduce costs. It is therefore highly desirable to improve the efficiency of lifting operations.

[0011] The invention has for its object to remedy or to reduce at least one of the drawbacks of the prior art, or at least provide a useful alternative to the prior art.

[0012] The object is achieved through features, which are specified in the description below and in the claims that follow.

SUMMARY

[0013] According to a first aspect of the invention, there is provided a lifting system for vertically lifting a load in two stages, the system comprising: a first rope for connecting to the load to be lifted; a first rope pulling mechanism configured to selectively pull the rope in and selectively hold the first rope; a vertically moveable sheave; and a sheave lifting apparatus configured to lift the vertically moveable sheave; wherein in use the first rope passes over the vertically moveable sheave between the first rope pulling mechanism and the load; such that in use the first rope pulling mechanism can be used to lift the load in a first stage by pulling the first rope in, and then hold the first rope such that the sheave lifting apparatus can lift the vertically moveable sheave to spool the first rope over the vertically moveable sheave, thereby lifting the load in a second stage.

[0014] The first stage may be a lift through water. The second stage may be a lift through air.

[0015] The first rope pulling mechanism may be a first winch. The first winch may comprise a first brake for selectively holding the first rope.

[0016] The sheave lifting apparatus may have a higher lifting capacity than the first rope pulling mechanism.

[0017] The first rope pulling mechanism may have a higher operating speed than the sheave lifting apparatus.

[0018] The sheave lifting apparatus may comprise a hydraulic cylinder arrangement.

[0019] The sheave lifting apparatus may be configured to push against a deck of a vessel to provide lifting of the sheave in use.

[0020] The sheave lifting apparatus may comprise a second rope for connecting to the vertically moveable sheave; and a second rope pulling mechanism; wherein the second rope pulling mechanism is configured to: selectively hold the second rope and selectively pull the second rope in, such that in use the second rope pulling mechanism can be used to hold the second rope such that the vertically moveable sheave cannot move vertically downwards so that the first rope pulling mechanism can pull the first rope in over the vertically moveable sheave in the first stage; and selectively pull in the second rope thereby lifting the vertically moveable sheave and the load in the second stage.

[0021] The second rope pulling mechanism may be a second winch. The second winch may comprise a second brake for selectively holding the second rope.

[0022] The second rope pulling mechanism and the first rope pulling mechanism may be configured to be driven by the same driveshaft in use.

[0023] According to a second aspect of the invention, there is provided a method of vertically lifting a load in two stages, the method comprising the steps of: providing a lifting system according to the first aspect of the invention; passing the first rope over the vertically moveable sheave; connecting the first rope to a load to be lifted; pulling the first rope in with the first rope pulling mechanism to lift the load in a first stage; holding the first rope with the first rope pulling mechanism; and lifting the vertically moveable sheave with the sheave lifting apparatus; thereby spooling the rope over the vertically moveable sheave and lifting the load in a second stage.

[0024] The step of pulling the first rope in a first stage may be performed at a higher speed than the step of lifting the vertically moveable sheave in the second stage.

[0025] The step of pulling the first rope in with the first rope pulling mechanism may comprise pulling the rope over the vertically moveable sheave.

[0026] According to a third aspect of the invention, there is provided a lifting and lowering system for vertically lifting or lowering a load in two stages, the system comprising: a first rope for connecting to the load to be lifted or lowered; a first rope pulling mechanism configured to: selectively pull the first rope in; selectively controllably feed the first rope out; and selectively hold the first rope; a vertically moveable sheave; and a sheave lifting apparatus configured to lift and lower the vertically moveable sheave; wherein in use the first rope passes over the vertically moveable sheave between the first rope pulling mechanism and the load; such that in use the first rope pulling mechanism can be used to: lift the load in a first stage by pulling the first rope in, and then hold the first rope such that the sheave lifting apparatus can lift the vertically moveable sheave to spool the first rope over the vertically moveable sheave, thereby lifting the load in a second stage; or hold the first rope in a second stage such that the sheave lifting apparatus can lower the vertically moveable sheave to spool the first rope over the vertically moveable sheave thereby lowering the load, and then feed the rope out to lower the load in a first stage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] An embodiment of the invention will now be described with reference to the following drawings, in which:

Figure 1 shows a lifting system performing a lifting operation with a load in the subsea zone;
Figures 2 and 3 show alternative views of the lifting operation shown in Figure 1;
Figures 4 and 5 show the lifting operation shown in Figure 1 with the load in the splash zone; and
Figure 6 shows the lifting operation shown in Figure 1 with the load in the air zone;
Figure 7 shows an alternative lifting system performing a lifting operation with a load in the subsea zone;
Figure 8 shows an alternative views of the lifting operation shown in Figure 7;
Figures 9 and 10 show the lifting operation shown in Figure 7 with the load in the splash zone; and
Figure 11 shows the lifting operation shown in Figure 1 with the load in the air zone.

[0028] For clarity reasons, some elements may in some of the figures be without reference numerals. A person skilled in the art will understand that the figures are just principal drawings. The relative proportions of individual elements may also be distorted.

DETAILED DESCRIPTION OF THE DRAWINGS

[0029] Figure 1 shows a vessel 100 for supporting offshore operations. In the presently described example, the vessel 100 is a boat, however it will be understood that in other examples the vessel 100 may be a semi-submersible structure, a rig, a jack-up structure, a wind turbine or any other structure regardless of whether it is fixed or floating. The vessel 100 comprises a deck 101 and a centrally located moonpool 102 which is a portal through which the sea below the vessel 100 may be accessed from the central area of the deck 101. The vessel 100 is supporting a subsea lifting operation in that it is hosting a lifting system 200 conveniently located around and over the moonpool 102.

[0030] It will be understood that in other examples the lifting system 200 may be positioned at another location, such as near the edges of the vessel 100, and need not access the sea via the moonpool 102, although this is the most convenient location when a moonpool 102 is provided.

[0031] The lifting system 200 is configured to provide lifting of a load 300 through two stages of a lift. As previously discussed, lifting a load 300 from the seabed (not shown) to the vessel 100 involves lifting the load 300 through three zones: a subsea zone, a splash zone and an air zone. Throughout the present description, reference is made to the two stages of the lift and the three zones, so clarification of the definition of stages and zones is now provided.

[0032] The load 300 is shown in Figures 1-3 in the subsea zone, in Figures 4 and 5 in the splash zone and in Figure 6 in the air zone. The water below the vessel 100 is not shown in the drawings, however a person skilled in the art will be familiar with the terms subsea zone, splash zone and air zone.

[0033] In the subsea zone, the load 300 passes through water, such as sea or fjord. The effective weight of the load 300 is reduced because of an upward buoyancy force on the load 300, therefore it is easier to lift or lower the load 300 in the subsea zone than in air. Reference to "easier" is intended to mean that a lower force is required to lift or lower the load in water than in air. Therefore, the lifting capacity of the equipment needed is lower for lifting the same load in water than in air.

[0034] In the splash zone (Figures 4 and 5) the load 300 passes from the water to the air. In calm sea states, the splash zone may not be problematic and may not impart significant dynamic forces on the load. In fact, in very calm sea states, there may be very little impact on the load 300 as it transitions from the subsea zone to the air zone via the splash zone. However, in moderate and higher sea states, significant dynamic forces may be imparted on the load 300 in this zone as the load 300 splashes through the constantly rising and falling waves, as the load 300 exits the water.

[0035] In some regions, such as the North Sea and the Norwegian Sea, it can be common to experience moderate and high sea states, especially at particular times of year, such as in winter. Often, the lifting system used in offshore operations must be rated to well above its expected operational limits, therefore in these regions the lifting system must be rated to withstand severe loads.

[0036] In the air zone (Figure 6), the load 300 passes through air to deliver the load 300 to the deck 101 of the vessel 100. The effective weight of the load 300 is greater than when the load 300 is submerged in water in the subsea zone, because of the lack of upward buoyancy force on the load 300 in the air zone. Therefore, it is more difficult to lift or lower the load 300 in the air zone than in the subsea zone. Reference to "more difficult" is intended to mean that a higher force is required to lift or lower the load in air than in water. Therefore, the lifting capacity of the equipment needed is greater for lifting the same load in air than in water.

[0037] Referring again to Figure 1, the main components of the lifting system 200 are now described. The lifting system 200 is shown in an assembled state in Figure 1 and comprises a rope 210 connected to the load 300 to be lifted. It will be understood that the lifting system 200 may often be provided in a disassembled state, since the rope 210 may be used for other operations on the vessel 100 when a lifting operation using the lifting system 200 is not being performed.

[0038] Still referring to Figure 1, from the connection at the uppermost point on the load 300, the rope 210 passes through the moonpool 102 to a sheave 220. The sheave 220 has an axis of rotation about which it can turn in use. The sheave 220 is arranged with the axis of rotation in the horizontal plane such that the rope 210 can run through the sheave 220 in use. In the presently described example, it can be seen that the rope 210 enters the sheave 220 vertically on the non-load side of the sheave 220. It will be understood that in other examples, the rope 210 may enter the sheave 220 horizontally, or at an angle to the horizontal. At the non-load side of the sheave 220, the rope 210 is connected to a winch 230. The winch 230 is configured to selectively pull the rope 210 in in use. The winch 230 gathers pulled in rope in a first spool 231 to conveniently store the pulled in rope 210 such that it does not clutter the deck 101. The winch 230 also comprises a brake (not shown the Figures) to selectively hold the rope 210. In this connection, the winch 230 can be used to reel in the rope 210 and, when required, apply the brake to hold the rope 210 such that the load 300 can be supported and hang from the rope 210, the purpose of which will be explained later. It will be appreciated that in other examples not presently described there may be a series of other spools, pulleys, sheaves or other rope guidance equipment provided depending on the specific configuration.

[0039] Still referring to Figure 1, the sheave 220 is arranged in a vertically moveable fashion. In this connection, in the presently described example, the sheave 220 is mounted in a moveable frame 400. The moveable frame 400 comprises an 'A-frame' structure with the sheave 220 mounted in an upper portion of the 'A-frame'. It will be understood that other types or shapes of structures may be provided. The moveable frame 400 is a lifting apparatus configured to lift the vertically moveable sheave 220 in use, as will be explained in more detail later. In the example shown in Figures 1 to 6, the moveable frame 400 comprises hydraulic cylinders 410 which are arranged to telescope to lift the sheave 220 vertically when required. In this connection, the hydraulic cylinders 410 are arranged to push on the deck 101 to provide lifting of the sheave 220. In this way, the lifting force required is transferred to the large and stable deck 101 of the vessel 100 such that a high lifting force can be provided.

[0040] Therefore, it can be seen that the lifting system 200 comprises two means by which the load 300 can be lifted. The first is by means of the winch 230 pulling in the rope 210, and the second is by means of the hydraulic cylinders 410 lifting the sheave 220 vertically. When the sheave 220 is lifted vertically, it is required that the brake of the winch 230 is applied such that the winch 230 cannot spool out rope to allow the sheave 220 to be raised. Said another way, when the brake is applied and the sheave 220 is lifted, the length of rope between the winch 230 and the load 300 does not change. If the length of rope were to be allowed to increase, i.e. if the winch 230 was allowed to reel out more rope, lifting the sheave 220 vertically would not lift the load 300 and instead would simply reel out more rope from the winch 230. Therefore, applying the brake in the winch 230 to not allow further rope 210 to be reeled out causes the load 300 to be lifted when the sheave 220 is lifted vertically by the hydraulic cylinders 410, as will now be explained in more detail.

[0041] A complete lift of the load 300 from a subsea location to air is now described with reference to Figures 1 to 6. As previously explained, in Figures 1 to 3, the load 300 is fully submerged in water, i.e. it is in the subsea zone. Figure 1 provides a perspective view from above the lifting system 200. Figure 2 shows an end view of the vessel 100 and lifting system 200. Figure 3 shows a cutaway view through the vessel 100 so the main components of the lifting system 200 can be seen.

[0042] Although the load 300 is shown close to the vessel 100 for illustration purposes, it will be understood that the load 300 may be picked up from the seabed (not shown) which may be several thousand meters below sea level, i.e. below the vessel 100. It does not matter if the load 300 is picked up from the seabed, or another piece of equipment or fixed or floating infrastructure. After the rope 210 is connected to the load 300, the load 300 is lifted through the water by the rope 210 being pulled in by the winch 230. A certain lifting force is required to lift the load 300 through the water. When the load 300 reaches the splash zone (as shown in Figures 4 and 5) and then continues through the air (as shown in Figure 6), a higher lifting force is required to lift the load 300.

[0043] Typically, lower capacity lifting equipment can operate at a higher speed than higher capacity lifting equipment. Therefore, it is inefficient to provide lifting through the water using the high-capacity lifting equipment which is needed to lift the load 300 through the splash and air zones. This inefficiency becomes even greater when operating in deep or ultra-deep water, because the lift through the water then takes up a far greater proportion of the total lifting time to lift the load 300 through all three zones.

[0044] Therefore, once the rope 210 has been sufficiently reeled in by the winch 230 such that the load 300 has been lifted to the splash zone (as shown in Figures 4 and 5), the brake of the winch 230 is applied and the rope 210 is held by the winch 230. The sheave 220 is then lifted by the moveable frame 400 by means of the aforementioned hydraulic cylinders 410. This provides a higher lifting capacity to lift the load 300 through the splash zone and the air zone such that the load 300 can be lifted on to the deck 101.

[0045] The winch 230 has a higher operating speed but lower lifting capacity than the lower operating speed but higher lifting capacity hydraulic cylinders 410. Therefore, the method can optimise the lifting operation by providing a fast lift in a first stage where a lowering lifting capacity is required, and then providing a higher lifting capacity only in a second stage where a higher lifting capacity is required.

[0046] It will be understood that, although the presently described example discusses lifting of the load 300, the operation may be performed in reverse to lower the load 300 from the air zone, through the splash zone and the subsea zone.

[0047] In the present description, the load 300 is lifted through a first stage comprising the subsea zone and a second stage comprising the splash zone and the air zone where greater lifting capacity is required. It will be understood that in other lifting operations the limits of the first stage and second stage may be different. That is to say, for example only, the lifting system 200 may be used in a closed environment, such as an indoor environment, where a splash zone is not present. Reference is also made to the aforementioned calm sea state where a splash zone may be minimal or not present. In these cases, the first stage may comprise a lift through the water and the second stage may comprise a lift through air only. There is a plurality of other applications whereby a higher lifting capacity is required in a second stage of a lift compared to in a first stage of the lift. For the sake of brevity, only the subsea lifting operation comprising the three zones has been described.

[0048] Figure 7 shows a vessel 100' for supporting offshore operations. As in the example described in Figures 1 to 6, the vessel 100' is a boat, however it will be understood that in other examples the vessel 100' may be a semi-submersible structure, a rig, a jack-up structure, a wind turbine or any other structure regardless of whether it is fixed or floating. The vessel 100' comprises a deck 101' and a centrally located moonpool 102' which is a portal through which the sea below the vessel 100' may be accessed from the central area of the deck 101'. The vessel 100' is supporting a subsea lifting operation in that it is hosting a lifting system 200' conveniently located around and over the moonpool 102'.

[0049] The lifting system 200' may be positioned at another location on the vessel 100' in other examples, such as near the edges of the vessel 100' and need not access the sea via the moonpool 102', although this is the most convenient location when a moonpool 102' is provided.

[0050] The lifting system 200' is configured to provide lifting of a load 300' through two stages of a lift. As previously discussed, lifting a load 300' from the seabed (not shown) to the vessel 100' involves lifting the load 300' through three zones: a subsea zone, a splash zone and an air zone.

[0051] The load 300' is shown in Figures 7 and 8 in the subsea zone, in Figures 9 and 10 in the splash zone and in Figure 11 in the air zone.

[0052] Referring again to Figure 7, the main components of the lifting system 200' are now described. The lifting system 200' is shown in an assembled state in Figure 7 and comprises a first rope 210' connected to the load 300' to be lifted. It will be understood that the lifting system 200' may often be provided in a disassembled state, since the first rope 210' may be used for other operations on the vessel 100' when a lifting operation using the lifting system 200' is not being performed.

[0053] Still referring to Figure 7, from the connection at the uppermost point on the load 300', the first rope 210' passes through the moonpool 102' to a sheave 220'. The sheave 220' has an axis of rotation about which it can turn in use. The sheave 220' is arranged with the axis of rotation in the horizontal plane such that the first rope 210' can run through the sheave 220' in use.

[0054] In the presently described example, it can be seen that the first rope 210' enters the sheave 220' vertically on the non-load side of the sheave 220'. It will be understood that in other examples, the first rope 210' may enter the sheave 220' horizontally, or at an angle to the horizontal. At the non-load side of the sheave 220', the first rope 210' is connected to a first winch 230'. The first winch 230' is configured to selectively pull the first rope 210' in use. The first winch 230' gathers pulled in rope in a second spool 231' to conveniently store the pulled in first rope 210' such that it does not clutter the deck 101'. The first winch 230' also comprises a brake (not shown the Figures) to selectively hold the first rope 210'. In this connection, the first winch 230' can be used to reel in the first rope 210' and, when required, apply the brake to hold the first rope 210' such that the load 300' can be supported and hang from the first rope 210', as in the previously described example in Figures 1 to 6. It will be appreciated that in other examples not presently described there may be a series of other spools, pulleys, sheaves or other rope guidance equipment provided depending on the specific configuration.

[0055] Still referring to Figure 7, the sheave 220' is arranged in a vertically moveable fashion. In this connection, in the presently described example, the sheave 220' is mounted in a rectangular moveable frame 400'. It will be understood that other types or shapes of structures may be provided. The moveable frame 400' is a lifting apparatus configured to lift the vertically moveable sheave 220' in use, as will be explained in more detail later.

[0056] The lifting system 200' further comprises a second rope 410' connected to the moveable frame 400'. Again, it will be understood that the lifting system 200' may often be provided in a disassembled state, since the second rope 410' may be used for other operations on the vessel 100' when a lifting operation using the lifting system 200' is not being performed.

[0057] The second rope 410' is connected at the uppermost point on the moveable frame 400' and runs to a second winch 230'B. The first 230' and second 230'B winches may be driven by independent drive shafts, or may share a drive shaft. Where the first 230' and second 230'B winches share a drive shaft, they may each be configured to selectively be engaged and disengaged from the shared drive shaft.

[0058] The second rope 410' passes over a support structure 103' between the moveable frame 400' and the second winch 230'B.

[0059] The second rope 410' is arranged vertically above the moveable frame 400' before it passes over the support structure 103' and changes direction, as can be seen in Figure 7.

[0060] The second winch 230'B is configured to selectively pull the second rope 410' in use. The second winch 230'B gathers pulled in second rope 410' in a second spool 231'B to conveniently store the pulled in second rope 410' such that it does not clutter the deck 101'. The second winch 230'B also comprises a brake (not shown the Figures) to selectively hold the second rope 410'. In this connection, the second winch 230'B can be used to reel in the second rope 410' and, when required, apply the brake to hold the second rope 410' such that the moveable frame 400' can be supported and hang from the second rope 410'. It will be appreciated that in other examples not presently described there may be a series of other spools, pulleys, sheaves or other rope guidance equipment provided depending on the specific configuration.

[0061] Therefore, it can be seen that the lifting system 200' comprises two means by which the load 300' can be lifted. The first is by means of the first winch 230' pulling in the first rope 210', and the second is by means of the second winch 230'B pulling in the second rope 410'. When the sheave 220' is lifted vertically by the second rope 410' lifting the moveable frame 400' which carries the sheave 200', it is required that the brake of the first winch 230' is applied such that the first winch 230' cannot spool out the first rope 210' to allow the sheave 220' to be raised. Said another way, when the brake is applied and the sheave 220' is lifted, the length of rope between the first winch 230' and the load 300' does not change. If the length of rope were to be allowed to increase, i.e. if the first winch 230' was allowed to reel out more rope, lifting the sheave 220' vertically would not lift the load 300' and instead would simply reel out more rope from the first winch 230'. Therefore, applying the brake in the first winch 230' to not allow further first rope 210' to be reeled out causes the load 300' to be lifted when the sheave 220' is lifted vertically by the second rope 410' and the second winch 230'B, as will now be explained in more detail.

[0062] A complete lift of the load 300' from a subsea location to air is now described with reference to Figures 7 to 11. As previously explained, in Figures 7 and 8, the load 300' is fully submerged in water, i.e. it is in the subsea zone. Figure 7 provides a perspective view from above the lifting system 200'. Figure 8 shows a cut-away view through the vessel 100' so the main components of the lifting system 200' can be seen.

[0063] Although the load 300' is shown close to the vessel 100' for illustration purposes, it will be understood that the load 300' may be picked up from the seabed (not shown) which may be several thousand meters below sea level, i.e. below the vessel 100'. It does not matter if the load 300' is picked up from the seabed, or another piece of equipment or fixed or floating infrastructure. After the first rope 210' is connected to the load 300', the load 300' is lifted through the water by the first rope 210' being pulled in by the first winch 230'. A certain lifting force is required to lift the load 300' through the water. When the load 300' reaches the splash zone (as shown in Figures 9 and 10) and then continues through the air (as shown in Figure 11), a higher lifting force is required to lift the load 300'.

[0064] Once the first rope 210' has been sufficiently reeled in by the first winch 230' such that the load 300' has been lifted to the splash zone (as shown in Figures 9 and 10), the brake of the first winch 230' is applied and the first rope 210' is held by the first winch 230'. The sheave 220' is then lifted by the moveable frame 400' by means of the aforementioned second rope 410' and second winch 230'B. This provides a higher lifting capacity to lift the load 300' through the splash zone and the air zone such that the load 300' can be lifted on to the deck 101'.

[0065] The first winch 230' has a higher operating speed but lower lifting capacity than the lower operating speed but higher lifting capacity second winch 230'B. Therefore, the method can optimise the lifting operation by providing a fast lift in a first stage where a lowering lifting capacity is required, and then providing a higher lifting capacity only in a second stage where a higher lifting capacity is required.

[0066] It will be understood that in examples where the first 230' and second 230'B winches may share a drive shaft to which they are selectively connectable, they may each be configured to provide different lifting capacities and operating speeds by utilising different gearing ratios, for example.

[0067] It will be understood that, as with the example described in Figures 1 to 6, although the present description discusses lifting of the load 300', the operation may be performed in reverse to lower the load 300' from the air zone, through the splash zone and the subsea zone.

Claims

1. A lifting system (200, 200') for vertically lifting a load (300, 300') in two stages, the system (200, 200') comprising:

   a first rope (210, 210') for connecting to the load (300, 300') to be lifted;
   a first rope pulling mechanism (230, 230') configured to selectively pull the first rope (210, 210') in and selectively hold the first rope (210, 210');
   a vertically moveable sheave (220, 220'); and
   a sheave lifting apparatus (400, 400') configured to lift the vertically moveable sheave (220, 220');
   wherein in use the first rope (210, 210') passes over the vertically moveable sheave (220, 220') between the first rope pulling mechanism (230, 230') and the load (300, 300');
   such that in use the first rope pulling mechanism (230, 230') can be used to lift the load (300, 300') in a first stage by pulling the first rope (210, 210') in, and then hold the first rope (210, 210') such that the sheave lifting apparatus (400, 400) can lift the vertically moveable sheave (220, 220') to spool the first rope (210, 210') over the vertically moveable sheave (220, 220'), thereby lifting the load (300, 300') in a second stage.

2. The lifting system (200, 200') according to claim 1, wherein the first stage is a lift through water and the second stage is a lift through air.

3. The lifting system (200, 200') according to claim 1 or 2, wherein the first rope pulling mechanism (230, 230') is a first winch comprising a first brake for selectively holding the first rope.

4. The lifting system (200, 200') according to any preceding claim, wherein the sheave lifting apparatus (400, 400') has a higher lifting capacity than the first rope pulling mechanism (230, 230').

5. The lifting system (200, 200') according to any preceding claim, wherein the first rope pulling mechanism (230, 230') has a higher operating speed than the sheave lifting apparatus (400, 400').

6. The lifting system (200) according to any preceding claim, wherein the sheave lifting apparatus (400) comprises a hydraulic cylinder arrangement (410).

7. The lifting system (200) according to any preceding claim, wherein the sheave lifting apparatus (400) is configured to push against a deck (101) of a vessel (100) to provide lifting of the sheave (220) in use.

8. The lifting system (200') according to any of claims 1 to 5, wherein

   the sheave lifting apparatus (400') comprises:

   a second rope (410') for connecting to the vertically moveable sheave (220'); and
   a second rope pulling mechanism (230'B);

   wherein the second rope pulling mechanism (230'B) is configured to:

   selectively hold the second rope (410') and selectively pull the second rope (410') in, such that in use the second rope pulling mechanism (230'B) can be used to hold the second rope (410') such that the vertically moveable sheave (220') cannot move vertically downwards so that the first rope pulling mechanism (230') can pull the first rope (210') in over the vertically moveable sheave (220') in the first stage; and

selectively pull in the second rope (410') thereby lifting the vertically moveable sheave (220') and the load (300') in the second stage.

9. The lifting system (200') according to claim 9, wherein the second rope pulling mechanism (230'B) is a second winch comprising a second brake for selectively holding the second rope (410').

10. The lifting system (200') according to claim 8 or 9, wherein the second rope pulling mechanism (230'B) and the first rope pulling mechanism are configured to be driven by the same driveshaft in use.

11. A method of vertically lifting a load (300, 300') in two stages, the method comprising the steps of:

providing a lifting system (200, 200') according to any of claims 1 to 10;
passing the first rope (210, 210') over the vertically moveable sheave (220, 220');
connecting the first rope (210, 210') to a load (300, 300') to be lifted;
pulling the first rope (210, 210') in with the first rope pulling mechanism (230, 230') to lift the load (300, 300') in a first stage;
holding the first rope (210, 210') with the first rope pulling mechanism (230, 230');
and lifting the vertically moveable sheave (220, 220') with the sheave lifting apparatus (400, 400');

thereby spooling the first rope (210, 210') over the vertically moveable sheave (220, 220') and lifting the load (300, 300') in a second stage.

12. The method according to claim 11, wherein the step of pulling the first rope (210, 210') in a first stage is performed at a higher speed than the step of lifting the vertically moveable sheave (220, 220') in the second stage.

13. The method according to claim 11 or 12, wherein the step of pulling the first rope (210, 210') in with the first rope pulling mechanism (230, 230') comprises pulling the first rope (210, 210') over the vertically moveable sheave (220, 220').

14. A lifting and lowering system (200, 200') for vertically lifting or lowering a load (300, 300') in two stages, the system (200, 200') comprising:

a first rope (210, 210') for connecting to the load (300, 300') to be lifted or lowered;
a first rope pulling mechanism (230, 230') configured to:

selectively pull the first rope (210, 210') in;
selectively controllably feed the first rope (210, 210') out; and
selectively hold the first rope (210, 210');

a vertically moveable sheave (220, 220'); and
a sheave lifting apparatus (400, 400') configured to lift and lower the vertically moveable sheave (220, 220');
wherein in use the first rope (210, 210') passes over the vertically moveable sheave (220, 220') between the first rope pulling mechanism (230, 230') and the load (300, 300');
such that in use the first rope pulling mechanism (230, 230') can be used to:

lift the load (300,300') in a first stage by pulling the first rope (210, 210') in, and then hold the first rope (210, 210') such that the sheave lifting apparatus (400, 400') can lift the vertically moveable sheave (220, 220') to spool the first rope (210, 210') over the vertically moveable sheave (220, 220'), thereby lifting the load (300, 300') in a second stage; or

hold the first rope (210, 210') in a second stage such that the sheave lifting apparatus (400, 400') can lower the vertically moveable sheave (220, 220') to spool the first rope (210, 210') over the vertically moveable sheave (220, 220') thereby lowering the load (300, 300'), and then feed the rope (210, 210') out to lower the load (300, 300') in a first stage.

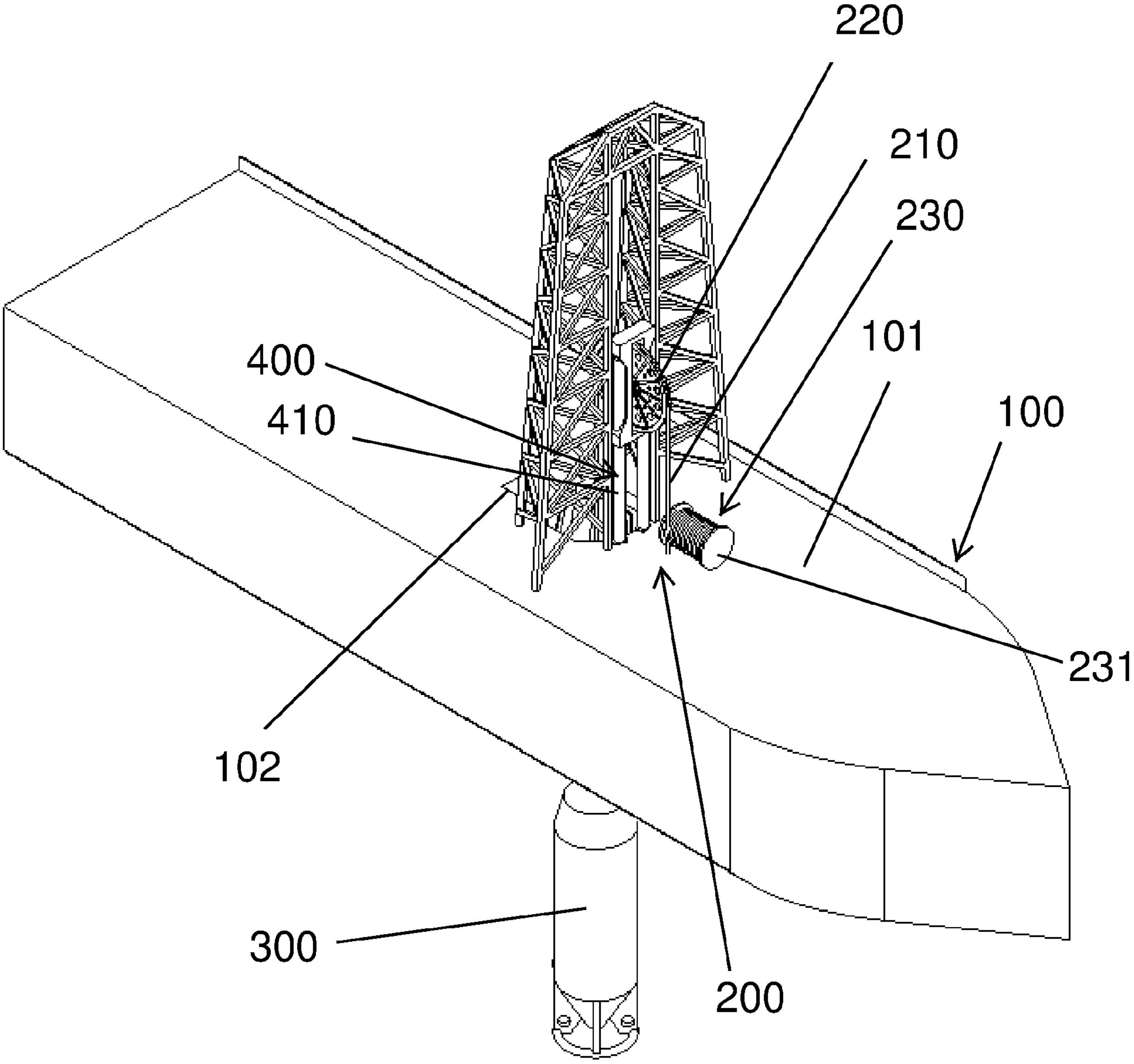

Fig. 1

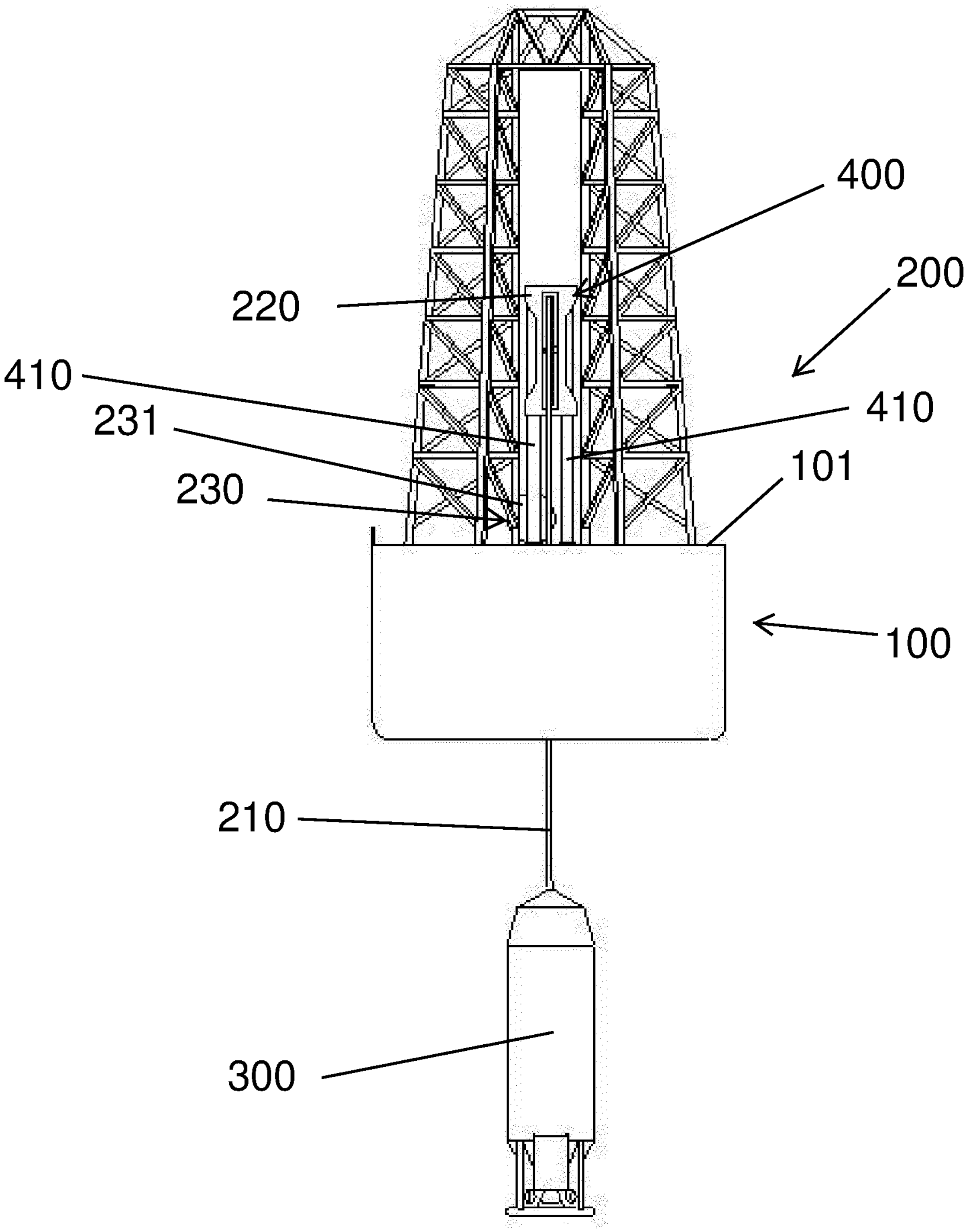

Fig. 2

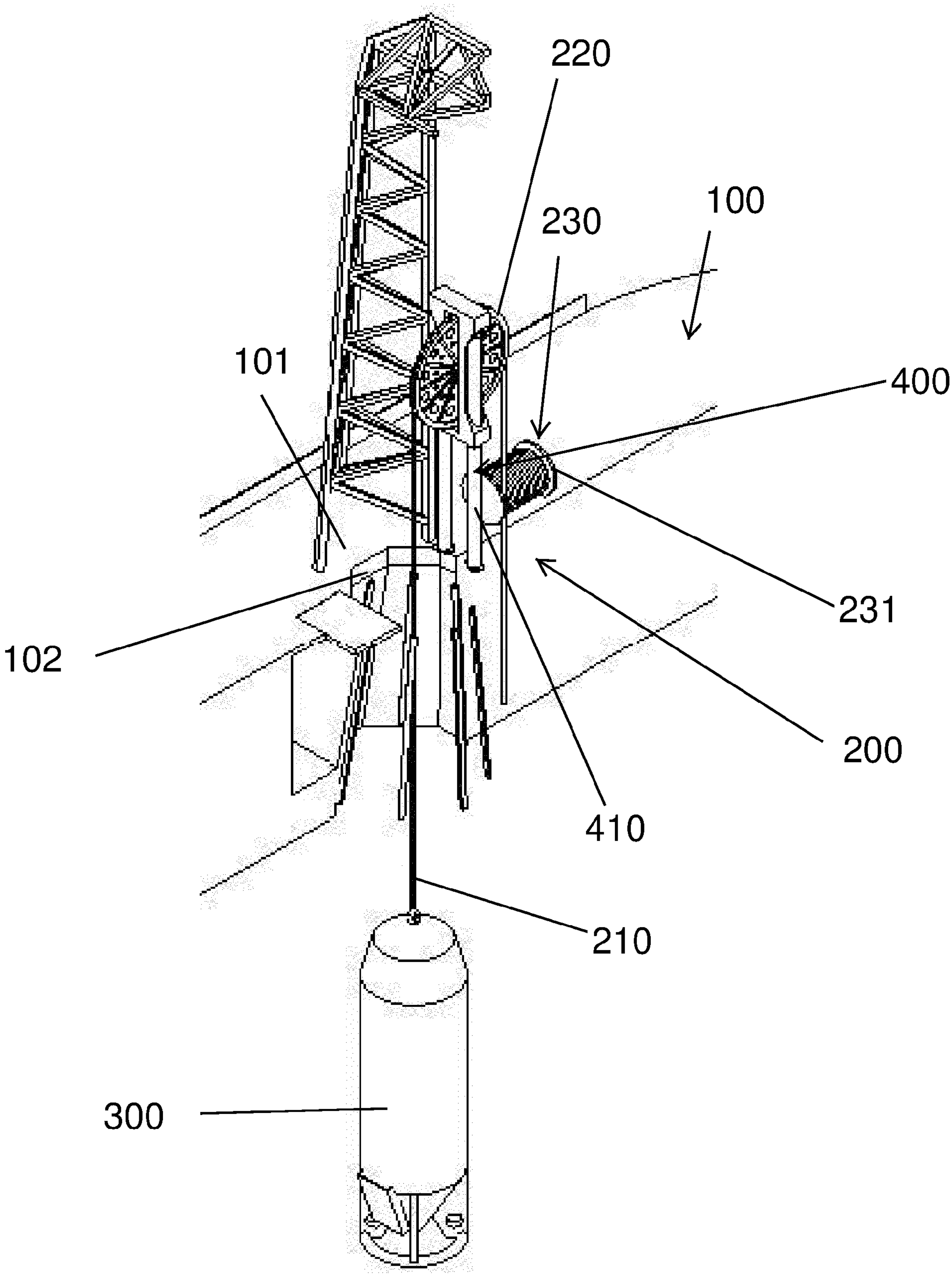

Fig. 3

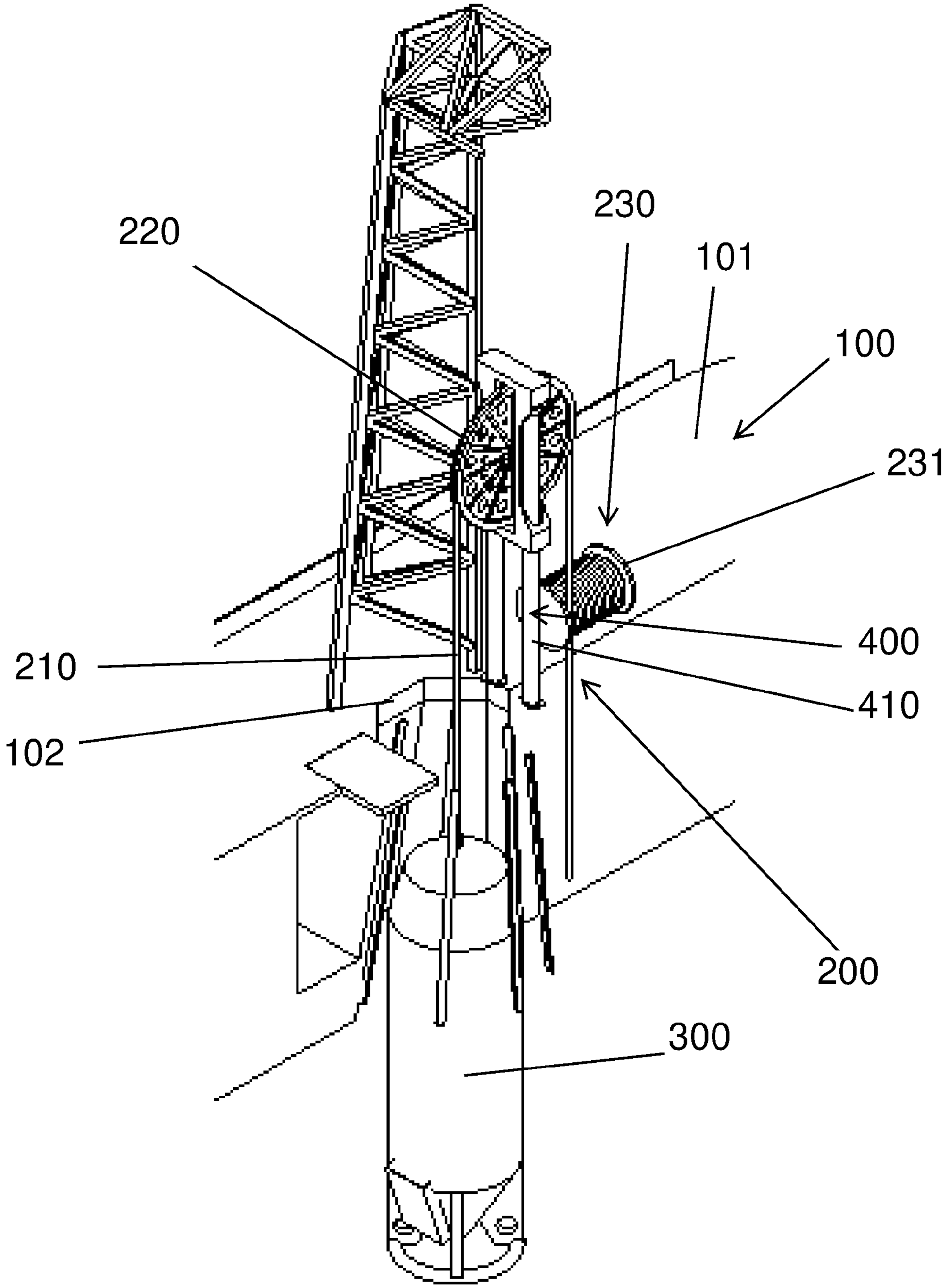

Fig. 4

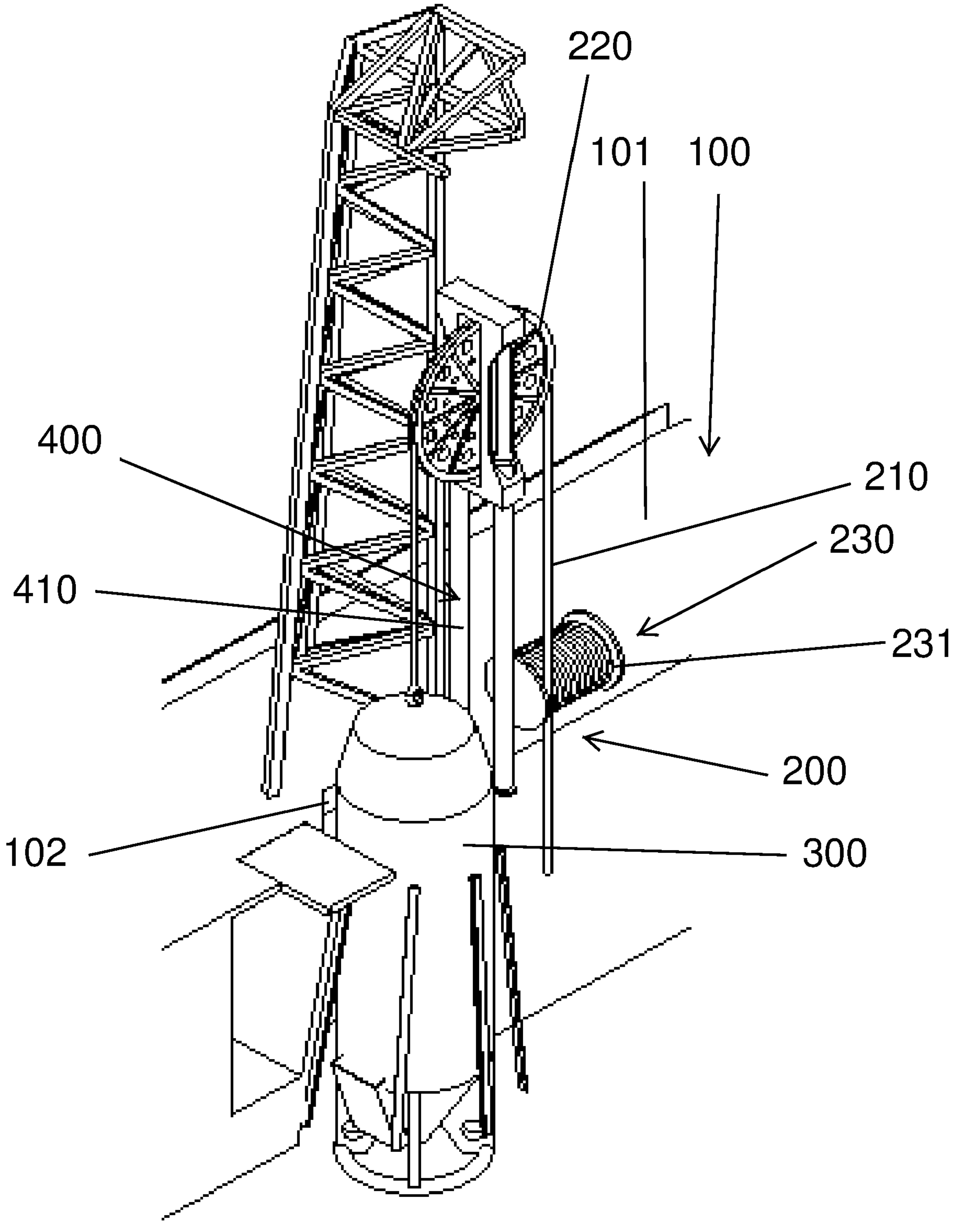

Fig. 5

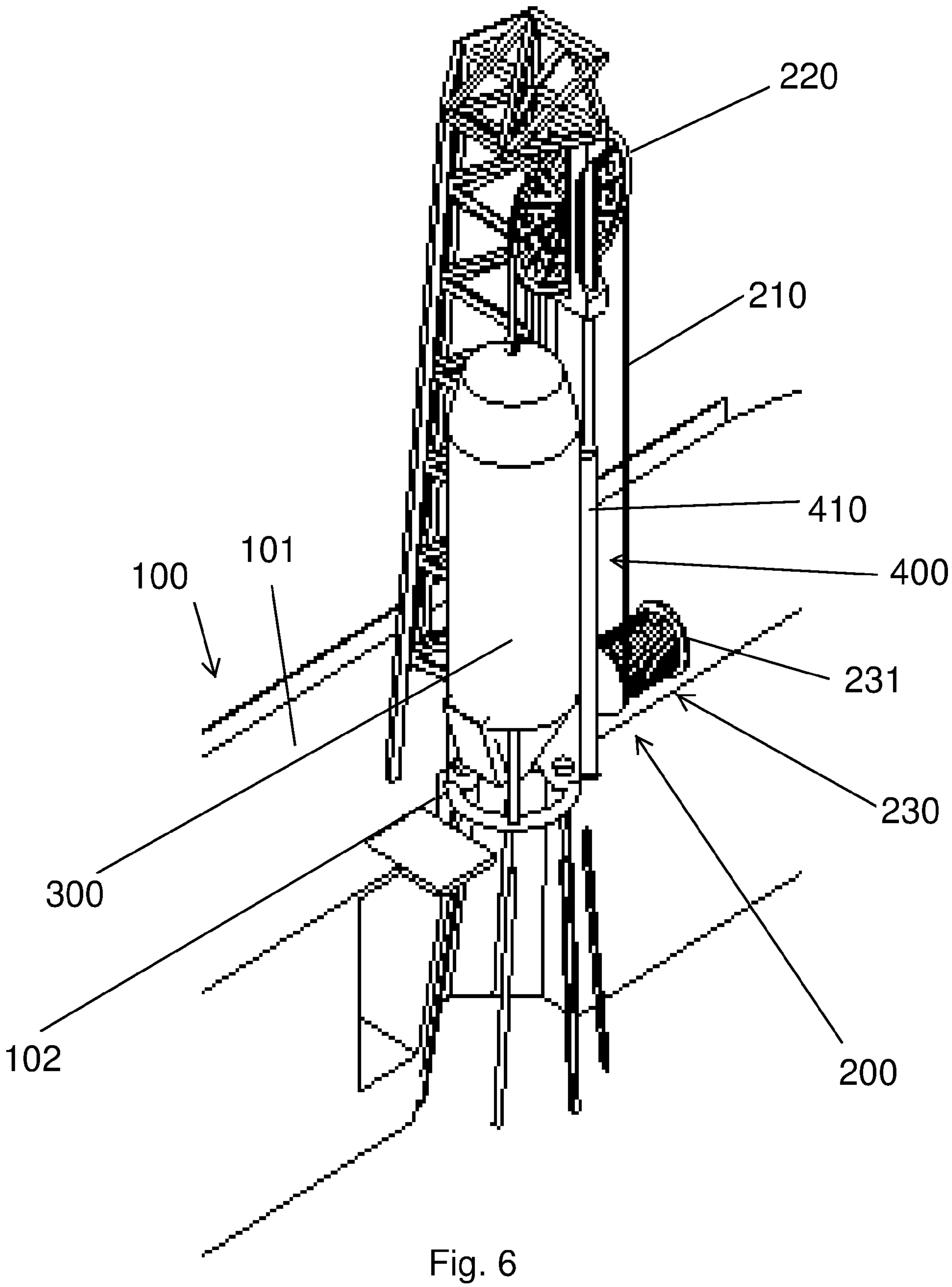

Fig. 6

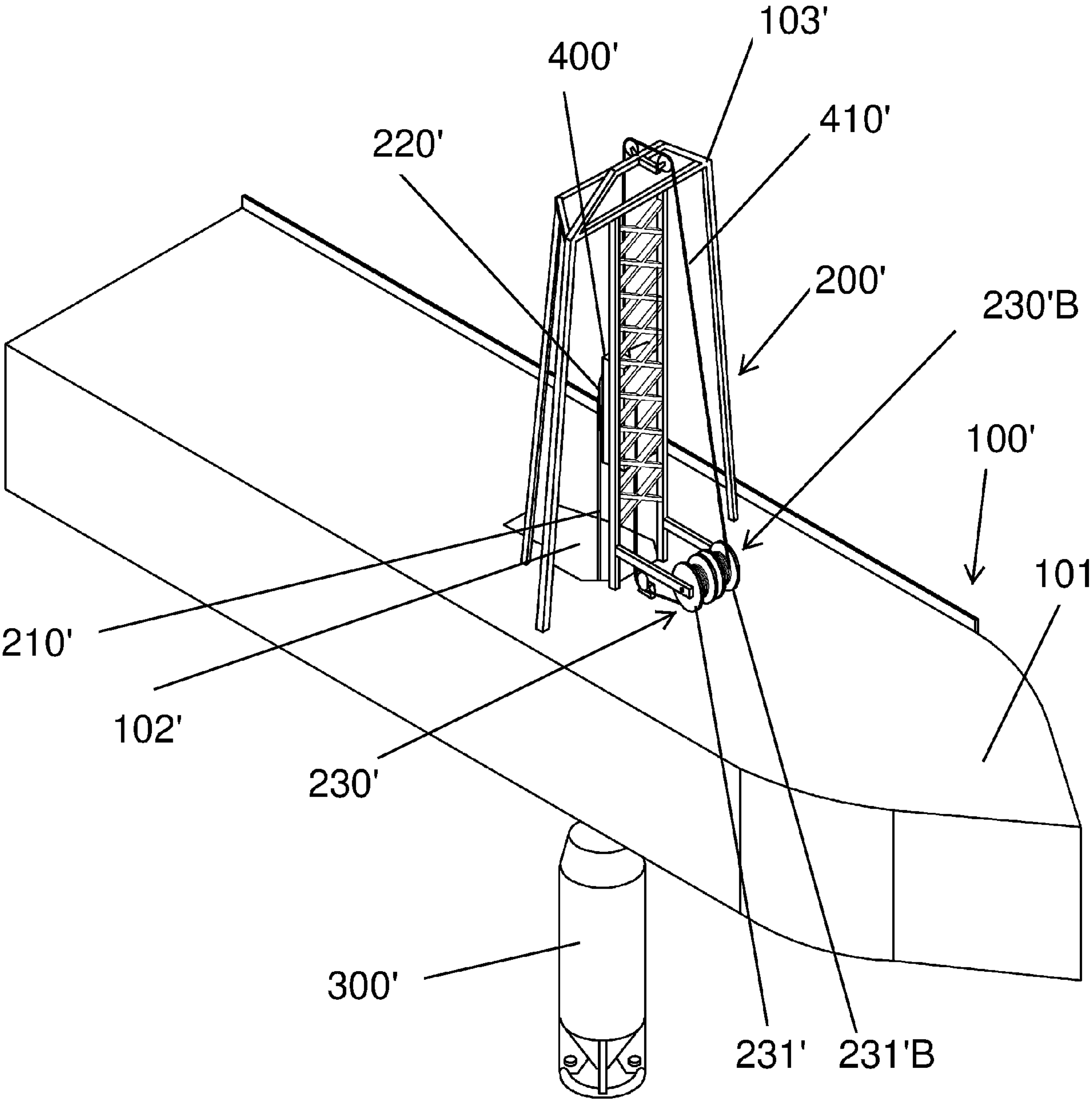

Fig. 7

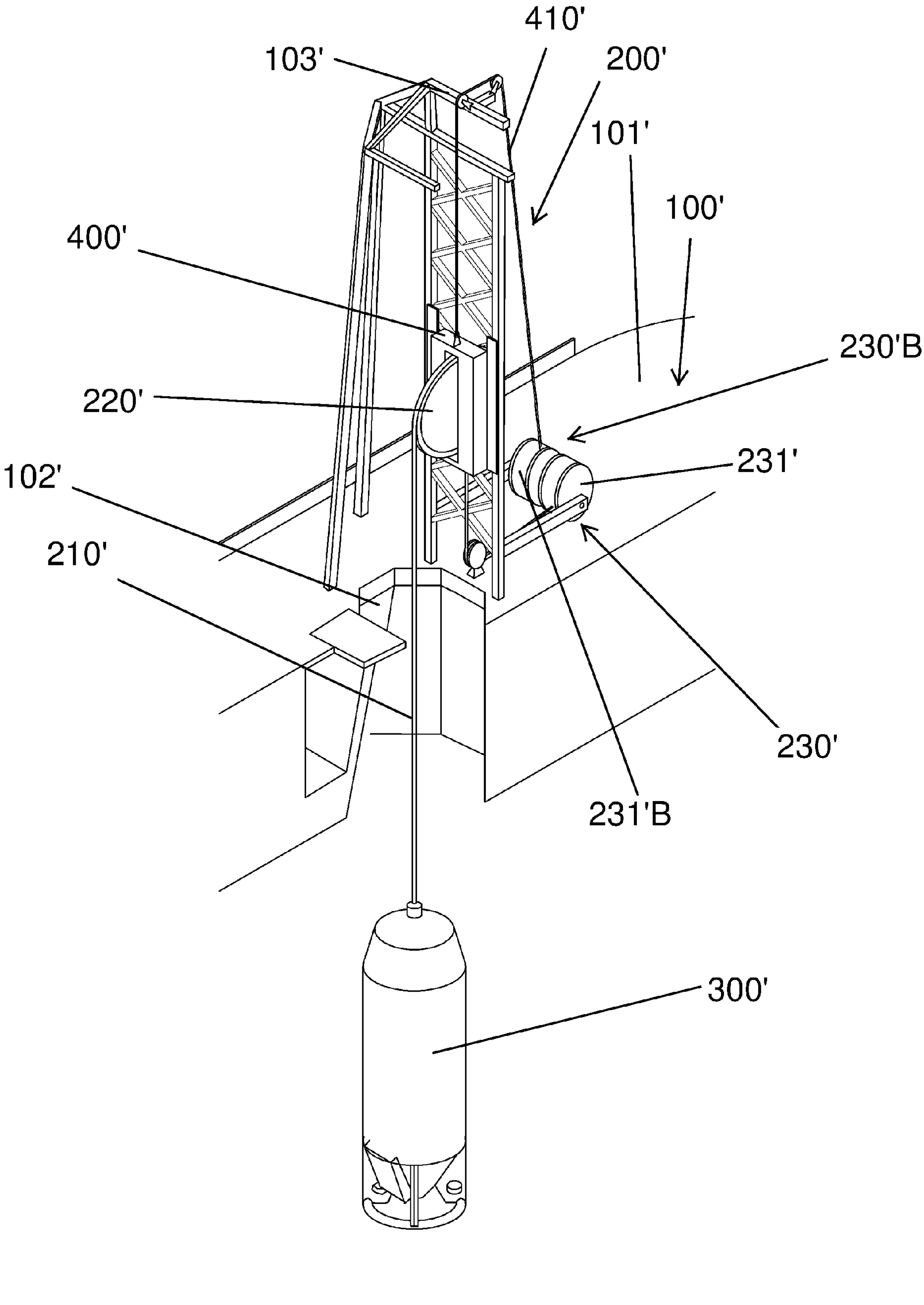

Fig. 8

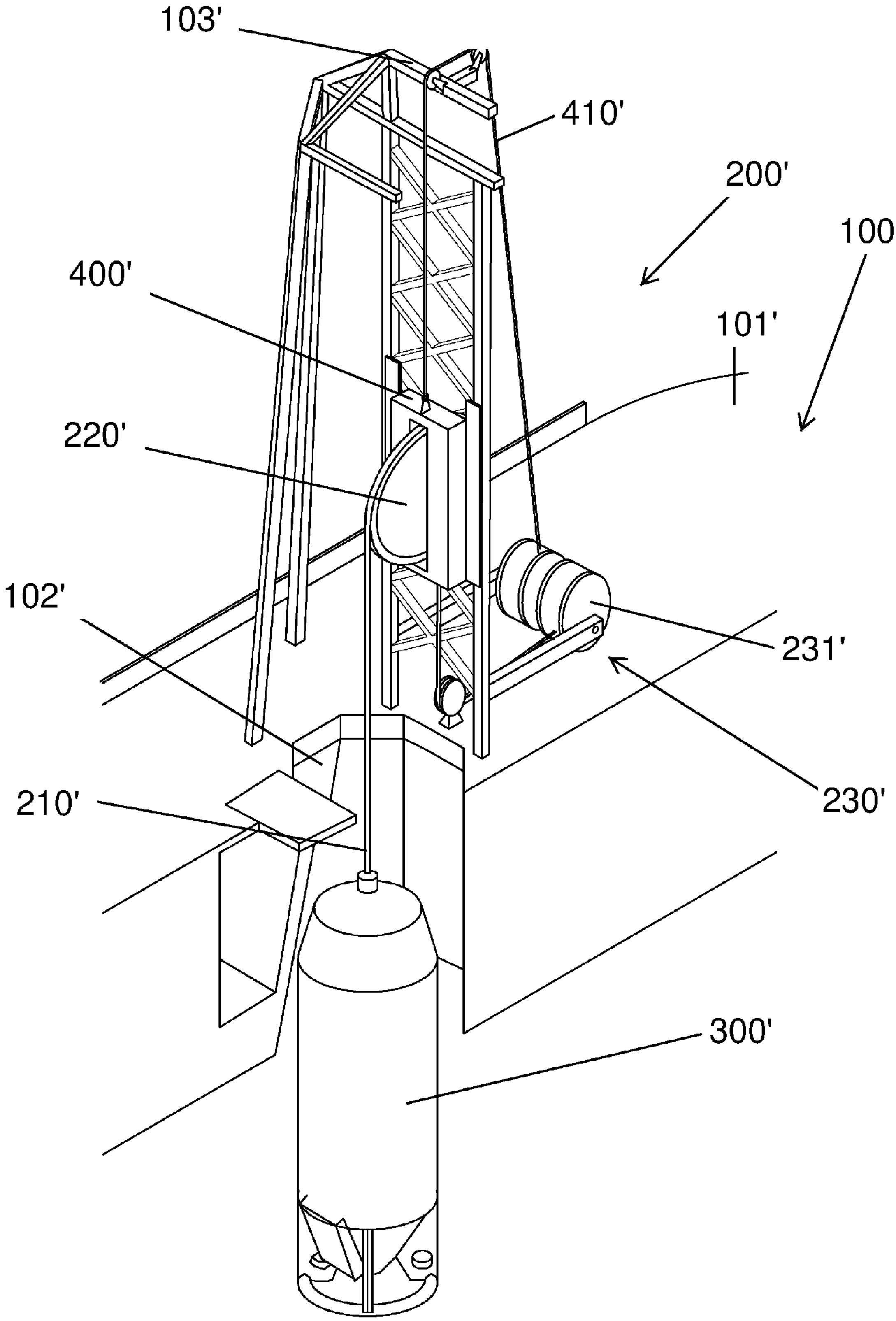

Fig. 9

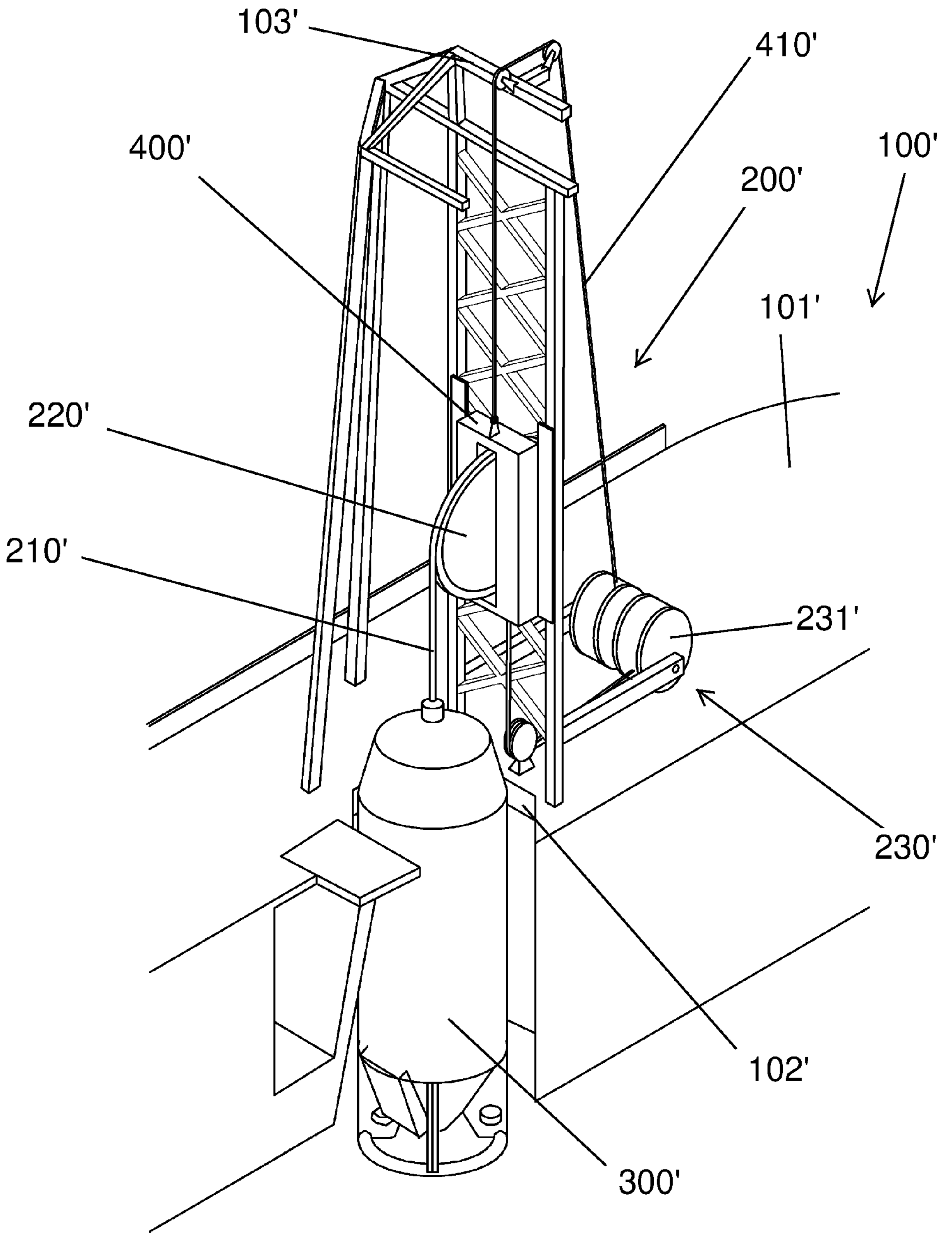

Fig. 10

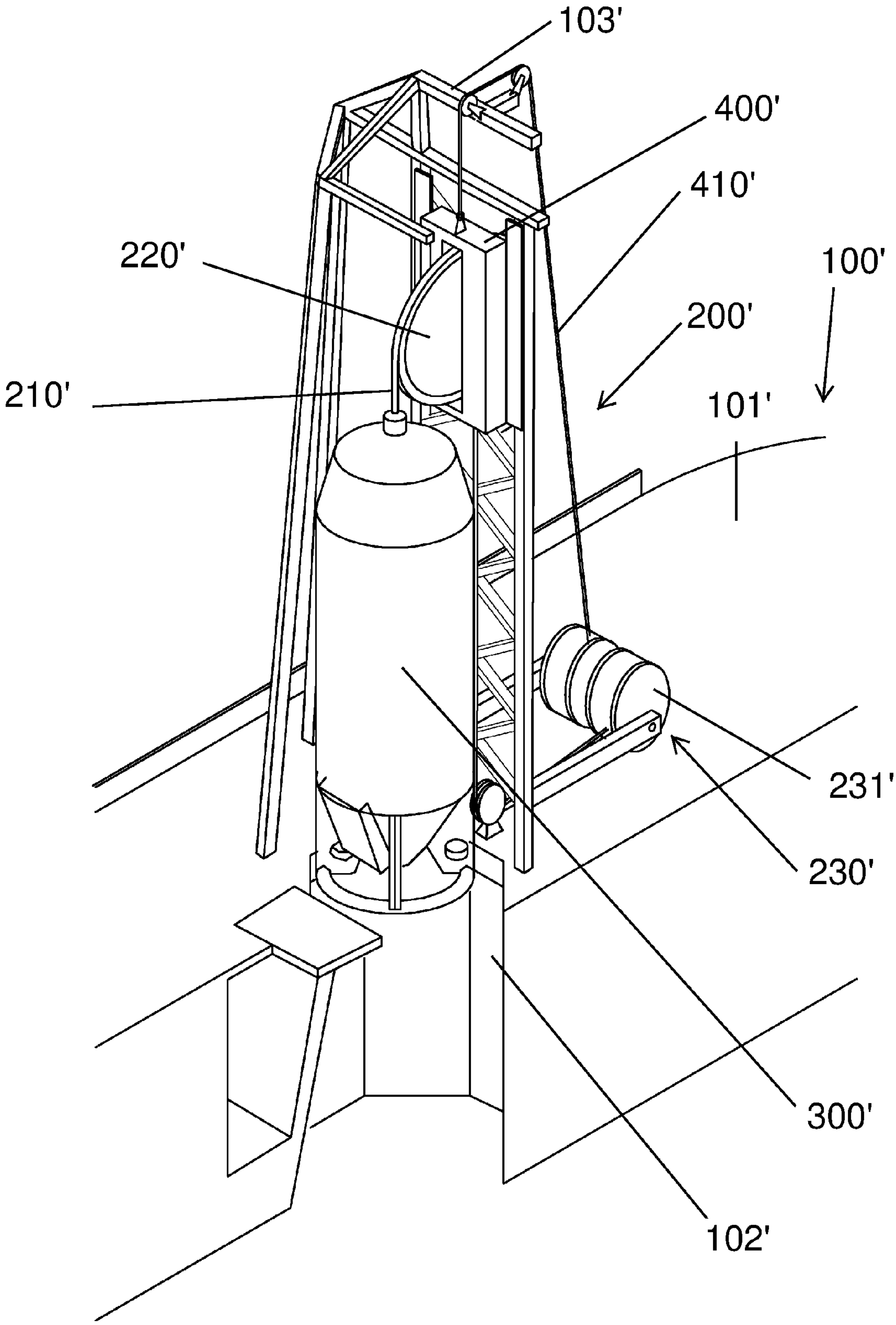

Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 22 21 5908

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	5 June 2023	Popescu, Alexandru

CATEGORY OF CITED DOCUMENTS

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