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EP-A1- 2 603 642
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US-A- 4 010 560
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DESCRIPTION

FIELD OF THE INVENTION

[0001] The invention relates to a subsea grab system comprising a grab device, a hoisting arrangement configured and arranged for suspending and hoisting the grab device from a marine vessel, and a driver configured and arranged for positioning the grab device.

BACKGROUND OF THE INVENTION

[0002] It is known to employ a grab system for subsea excavation and subsea earth or rock moving purposes. Such grab system can, for instance, be used to excavate a trench in the seabed, in which a pipe is laid, which pipe is subsequently buried by earth or rock that had been excavated first. A grab device can be lowered from a ship or another marine vessel using any known type of winch system for lowering the subsea grab device into the sea to the seabed and for raising the grab device again to the marine vessel. At larger depths positioning of the grab device at the seabed becomes more difficult or is even impossible, especially when water currents are present. It is therefore proposed to have a driver arrangement mounted on the grab device which may be operated remotely from the marine vessel. Such a grab system is disclosed in WO 2014/098913 A1.

[0003] However, the driver arrangement adds considerably to the weight of the grab system, leading to a large dynamic load on the hoisting arrangement for suspending, lowering and raising the grab device during movements of the grab device. Having the driver arrangement on the grab device near the digging or excavation process, makes it also more exposed to rising dirt and debris which can be harmful to the system. The driver arrangement further has to be provided at a top part of the grab device, which adds to its length and makes it top-heavy. Such grab device therefore is susceptible of falling over when positioned on the seabed.

SUMMARY OF THE INVENTION

[0004] It is an objective of the invention to provide a subsea grab system that is stable when put on the seabed for excavating material from the seabed.

[0005] It is another or alternative objective of the invention to provide a subsea grab system exerting, during operation, limited dynamic loads on the system itself and the marine vessel.

[0006] At least one of the above objectives is achieved by subsea grab system for activities below a water surface in a marine environment, the subsea grab system comprising

- a grab device;
- a first hoisting arrangement configured for suspending and hoisting the grab device from a marine vessel below the water surface and for positioning the grab device in a vertical direction, the first hoisting arrangement comprising at least one longitudinal suspension element for suspending and hoisting the grab device;
- a driver device comprising a propeller system configured for driving and positioning the driver device in a first horizontal plane below the water surface, the grab system being configured such that, in operation, the grab device is positioned below the driver device, and the driver device being configured for positioning the grab device in a second horizontal plane below the water surface by guiding of the first hoisting arrangement by the driver device and by driving and positioning the driver device in the first horizontal plane; and
- a second hoisting arrangement configured for suspending and hoisting the driver device from the marine vessel below the water surface,

wherein the first and second hoisting arrangements are configured and arranged such that the grab device and the driver device, during operation, are independently suspended from the marine vessel, and

wherein the at least one longitudinal suspension element of the first hoisting arrangement is guided by at least one central opening of the driver device by passing of the at least one longitudinal suspension element through the central opening for guiding the first hoisting arrangement.

[0007] The driver device of the subsea grab system of the present invention is a separate device that is separately suspended and separately hoisted (lowered and raised) from the marine vessel. The grab device and driver device are each separately suspended and hoisted. The capacity of the grab device can be selected independent of the driver device. The driver device is suited for several types and capacities grab systems, which provides additional flexibility. The driver device can be kept in position, especially at a constant height above the seabed, when operating the grab device, leading to less dynamic loads on the system and marine vessel. Some equipment for operation of the grab device can be positioned on the driver device to further reduce weight of the grab device so as to further reduce dynamic loads. The first and second hoisting arrangements and the driver device are configured and arranged such that during operation, the driver device allows positioning of the grab device. The driver device is provided with actuators, such as thrusters to control the horizontal position of the driver device, either remotely or automatically. Independently suspended is intended to mean that the grab device is not suspended via the driver device or vice versa.

[0008] In another practical embodiment the second hoisting arrangement comprises at least one longitudinal suspension element for suspending and hoisting the driver device.

[0009] In yet another practical embodiment the longitudinal suspension element comprises at least one of a cable, a chain and a wire.

[0010] In an embodiment the grab device comprises an actuation cylinder, especially an hydraulic or pneumatic cylinder, for actuating the grab device, especially for actuating a grab of the grab device.

[0011] Advantageously, a pump for actuating the actuation cylinder is provided on the driver device, which both reduces the weight of the grab device and reduces risk of damaging the pump since it is, in operation, located at a distance from the grab device.

[0012] In a further advantageous embodiment a winch for a hose is provided on the driver device, the hose connecting the actuation cylinder and the pump so as to, during operation, keep the hose taut. Keeping the hose taut reduces any risk of entanglement of the hose and damage thereof.

[0013] In a preferred embodiment one or more buoyancy floaters are connected to the first hoisting arrangement such as to, during operation, keep part of the first hoisting arrangement between driver device, especially between a top part of the driver device, and the grab device taut. Such embodiment reduced the risk of the first hoisting arrangement becoming entangled with the driver device or second hoisting arrangement, or that the first hoisting arrangement interferes with the grab device, especially when the grab of the grab device is placed on the seabed.

[0014] In a practical embodiment one or more buoyancy floaters are connected to the at least one longitudinal suspension element of the first hoisting arrangement such as to, during operation, keep part of the at least one longitudinal suspension element of the first hoisting arrangement between driver device, especially between a top part of the driver device, and the grab device taut.

[0015] In a preferred embodiment the one or more buoyancy floaters are connected to the first hoisting arrangement, especially the at least one longitudinal suspension element of the first hoisting arrangement, such as to, during operation, remain above the driver device. Such embodiment effectively provides that the first hoisting arrangement between driver device and grab device remains taut.

[0016] Advantageously, the grab system comprises a heave compensator, especially a passive heave compensator, for the grab device. Having the heave compensator reduces any peak loads on the system due to its use and due to any movements of the marine vessel, for instance due to waves at the sea surface.

[0017] Preferably, the passive heave compensator is arranged on the grab device and the first hoisting arrangement is connected to the passive heave compensator, which provides the optimum location to compensate for any peak loads.

[0018] In another aspect the invention provides for a marine vessel comprising such grab system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Further features and advantages of the invention will become apparent from the description of the invention by way of non-limiting and non-exclusive embodiments. These embodiments are not to be construed as limiting the scope of protection. The person skilled in the art will realize that other alternatives and equivalent embodiments of the invention can be conceived and reduced to practice without departing from the scope of the present invention. Embodiments of the invention will be described with reference to the accompanying drawings, in which like or same reference symbols denote like, same or corresponding parts, and in which

Figure 1 shows an embodiment of a subsea grab system according to the invention suspended from a marine vessel;

Figure 2 shows a detailed view on the subsea part of the grab system of figure 1 in a state when being lowered towards the seabed;

Figure 3 shows a detailed view on the subsea part of the grab system of figure 1 in a state when having been lowered to and being supported by the seabed;

Figure 4 shows a detailed view on the subsea part of the grab system of figure 1 in a state when just having excavated earth form and being pulled from the seabed;and

Figure 5 shows a detailed view on the subsea part of the grab system of figure 1 in a state when being lifted away from the seabed after having excavated earth from the seabed.

DETAILED DESCRIPTION OF EMBODIMENTS

[0020] Figure 1 shows a marine vessel 10 on which a subsea grab system 100 according to the invention is provided. Winches 122, 142 of first and second hoisting arrangements 120, 140 are arranged on the vessel and are configured for lowering a subsea part of the grab system 100 through a moon pool type opening 11 in the marine vessel. The subsea part of the subsea grab system 100 can be lowered towards the seabed SB at a depth SD of, for instance, several hundred meters below the sea surface. A ship is shown in figure 1, but any type of marine vessel can be employed.

[0021] The first hoisting arrangement or system 120 comprises longitudinal suspension elements in the form of chains 121 from which a grab device 110 is suspended though the moon pool 11 into the water W below the sea surface and below the marine vessel. The chains 121 can be unwound from and wound onto the winches 122 on the vessel for lowering and raising, respectively, the grab device 110. Alternatively, cables, wires or any other suitable

means can be used in the first hoisting system. The second hoisting arrangement or system 140 comprises longitudinal suspension elements in the form of cables 141 from which a driver device 130 is suspended through the moon pool 11 into the water W below the marine vessel. The cables 141 can be unwound from and wound onto the winches 142 on the vessel for lowering and raising, respectively, the driver device 130. Alternatively, chains, wires or any other suitable means can be used in the second hoisting system. Hoisting by the first and second hoisting arrangements is done in a coordinated fashion for raising and lowering the grab and driver devices 120, 130. It is required that the grab and driver devices remain within a predetermined distance range from one another, the grab device below the driver device, in the embodiment shown.

[0022] The subsea part of an embodiment of the grab system of the invention is shown in more detail in the figures 2 to 5. Figure 2 shows the subsea part when being lowered towards the seabed SB by the chains 121 of the first hoisting system. The grab device 110 comprises a grab having two grab parts 112 that can be opened and closed. Opening and closing of the grab is actuated by hydraulic (or pneumatic) cylinders 112. However, any other suitable actuator or means for opening and closing the grab can be employed as well. A heave compensator 150 is mounted in the top part of the grab device, which will be described further below.

[0023] The chains 121 of the first hoisting arrangement 120 associated with the grab device 110 are passed through and guided by the driver device 130, which during operation is above the grab device 110. The chains can move freely through the driver device. The driver device comprises a frame or housing 131 that is suspended from the cables 141 of the second hoisting arrangement 140. A propeller system 132 is arranged on the frame 131 and comprises propellers that are driven by motors. The propeller system is to be understood as any system that allows propelling (moving) the driver device. The propeller system is configured for driving and positioning the driver device in a first horizontal plane along the seabed and below the water surface. The driver device may also be referred to as remotely operated vehicle or ROV since its positioning is, generally, remotely operated from the marine vessel 10. The propellers shown in the figures act in a direction perpendicular to the plane of the drawing. Further propellers are present, but not shown, which act in a direction parallel to the plane of the drawing. The driver device 130 is positioned along the seabed SB using the propeller system 132. Since the chains 121 from which the grab device is suspended are guided through an opening 135 in the driver device, the grab device 110 is positioned in a second horizontal plane and along the seabed as well through positioning of the driver device. The second horizontal plane associated with the grab device is below the first horizontal plane associated with the driver device. The grab device is positioned in the vertical direction by the first hoisting arrangement associated with the grab device.

[0024] A foundation plate 134 is mounted in a top part of the central opening 135 of the driver device. The individual chains 121 are guided in smaller openings in the foundation plate, which openings are further provided with roller bearings for improved guidance of the chains 121. A winch 115 is provided on the foundation platform 134 and is employed for winding and

unwinding hoses running towards and connected to the actuation cylinders 112 of the grab device 110. The hoses are further connected to pumps 114 provided on the driver device. The actuation cylinders 112 are actuated by driving the pumps 114 so as to pump hydraulic fluid towards and away from the actuation cylinders 112, which causes the shells of the grab to open and close. The winch 115 keeps the hoses running towards the grab device 110 taut. During operation, which is especially depicted in figure 3, the driver device is at some safe operational height H_o above the seabed SB and grab device 110 to keep any debris from excavation away from the driver device and equipment and components mounted on the driver device. Actual heights and distances H , H_o and D may vary according to the actual equipment employment and circumstances. A protection cover 136 is provided over the foundation plate 134 and winch 115. An umbilical cord 170 is connected in between vessel 10 and driver device for controlling the various components and equipment on the driver device and to provide power thereto.

[0025] Figure 3 shows a state of the subsea part of the subsea grab system 100 when having been lowered to and resting on the seabed SB. The driver device is at an operational height H_o above the grab device and fully suspended from the cables 141 of the second hoisting arrangement. The weight of the grab device 110 is actually not being suspended from its chains 121 of the first hoisting arrangement, since the grab device is supported by the seabed. This will cause slack in the chains 121. Buoyancy floaters 160 are attached to the chains 121 at a position that will remain above the driver device 130 during operation. The set of buoyancy floaters 160 provide an upwards force to the chains 121 below the elements 160 and keep that part of the chains 121 taut so as not to interfere and become entangled with equipment and components of the driver device or the grab device. The slack is therefore present in chain parts 121A above the buoyancy floaters 160.

[0026] The number and actual configuration of the buoyancy floaters 160 can be selected dependent on actual circumstances. They may comprise blocks of material having an effective density that is considerably smaller than the density of (sea) water. Each floater 160 can comprise individual block shaped elements that are kept together by mounting plates and connecting rods. Mounting eyes at the end of the mounting rods can be used to connect the buoyancy floaters by further chains, cables or wires to the chains 121 of the hoisting arrangement 120. The buoyancy floaters 160 are connected to the chains 121 at a fixed distance D above the grab device, which allows the driver device to be positioned at a required operational height above the seabed SB and grab device.

[0027] Figure 4 shows a state of the subsea part of the subsea grab system 100 when just having excavated earth from the seabed and being pulled up from the seabed. This will cause a peak load on the system. The seabed may further exert some suction force on the grab system, which will further add to the peak load. It is seen that the parts 121A of the chains 121 above the buoyancy floaters is pulled taut. Figure 4 further shows that the heave compensator is in an extended state to compensate and smooth out any peak loads, which will be explained further below.

[0028] Figures 3 and 4 appear largely identical. Figure 3 shows a state in which the grab device is actually not suspended from the first hoisting arrangement 120 and in which there is slack in the chains 121 of the first hoisting arrangement. However, figure 4 shows a state in which the grab device is being pulled from the sea bed SB. An upwards force is exerted on the grab device by the chains 121 of the first hoisting arrangement, but the grab device 110 has not yet become released from the seabed. The chain parts 121A above the buoyancy floaters 160 have been pulled taut. This may give rise to large forces in the chains 121 and on the marine vessel 10 and the grab device, which will even more so the case when the marine vessel is moving up and down on waves at the sea surface. To smoothen such forces a heave compensator 150 is provided on the grab device 110. The heave compensator 150 of the embodiment shown is of the passive type comprising shock absorbing cylinders to absorb forces. Such (passive) heave compensators are known as such and will not be further described. They generally have a damped-spring like behavior.

[0029] Figure 5 shows a state of the subsea part of the subsea grab system 100 after excavation of earth from the seabed SB. The grab device 110 has been raised from the seabed and the grab is closed to contain the earth excavated. It is shown that the chains 121 of the first hoisting arrangement pulling the grab device 110 upwards have been pulled taut above the buoyancy floaters 160. The grab device is fully suspended from the hoisting arrangement 120.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO2014098913A1 [0002]

P a t e n t k r a v

1. Undervandsgribesystem (100) til aktiviteter under en vandoverflade i et havmiljø, hvilket undervandsgribesystem omfatter

- 5 - en gribeindretning (110);
- en første hejseanordning (120), der er indrettet til at ophænge og hejse gribeindretningen fra et marinefartøj (10) under vandoverfladen og til positionering af gribeindretningen i en vertikal retning, hvor den første hejseanordning (120) omfatter mindst et langsgående ophængningsselement (121) til ophængning og hejsning af gribeindretningen (110); og
10 - en drivindretning (130) omfattende et propelsystem (132), der er indrettet til at drive og positionere drivindretningen i et første horisontalt plan under vandoverfladen, hvor gribesystemet er indrettet således, at gribeindretningen (110) under drift er positioneret under drivindretningen (130), og drivindretningen er indrettet til at positionere gribeindretningen (110) i et andet horisontalt plan under vandoverfladen ved at føre den første hejseanordning ved hjælp af drivindretningen og ved at drive og positionere drivindretningen i et første horisontalt plan;

kendetegnet ved at undervandsgribesystemet endvidere omfatter

- 20 - en anden hejseanordning (140), der er indrettet til at ophænge og hejse drivindretningen fra marinefartøjet under vandoverfladen, hvor den første og anden hejseanordning (120, 140) er indrettet og anbragt således, at gribeindretningen (110) og drivindretningen (130) under drift uafhængigt er ophængt fra marinefartøjet (10), og
25 hvor det mindst ene langsgående ophængningsselement (121) af den første hejseanordning (120) føres af mindst en central åbning (135) af drivindretningen (130) ved at lede det mindst ene langsgående ophængningsselement gennem den centrale åbning med henblik på at føre den første hejseanordning (120).

30

2. Gribesystem ifølge det foregående krav, hvor den anden hejseanordning omfatter mindst et langsgående ophængningsselement (141) til ophængning og hejsning af gribeindretningen (130).

35

3. Gribesystem ifølge et hvilket som helst af de foregående krav, hvor det langsgående ophængningsselement omfatter mindst et kabel, en kæde (121)

og en wire (141).

5 **4.** Gribesystem ifølge et hvilket som helst af de foregående krav, hvor gribeindretningen (110) omfatter en aktiveringscylinder (112), især en hydraulisk eller pneumatisk cylinder, til aktivering af gribeindretningen, eventuelt til aktivering af en grab (111) af gribeindretningen.

10 **5.** Gribesystem ifølge det foregående krav, hvor der er tilvejebragt en pumpe (114) til aktivering af aktiveringscylinderen (112) på drivindretningen (130).

15 **6.** Gribesystem ifølge det foregående krav, hvor der er tilvejebragt et spil (115) til en slange (113) på drivindretningen (130), hvor slangen forbinder aktiveringscylinderen (112) og pumpen (114), således at slangen holdes spændt under drift.

20 **7.** Gribesystem ifølge et hvilket som helst af de foregående krav, hvor en eller flere opdriftsflydere (160) er forbundet med den første hejseanordning (120), således at en del af den første hejseanordning mellem drivindretningen (130), eventuelt mellem en øvre del af drivindretningen, og gribeindretningen (110) holdes spændt under drift.

25 **8.** Gribesystem ifølge et hvilket som helst af de foregående krav, hvor en eller flere opdriftsflydere (160) er forbundet med det mindst ene langsgående ophængningselement (121) af den første hejseanordning (120), således at en del af det mindst ene langsgående ophængningselement (121) af den første hejseanordning mellem drivindretningen (130), eventuelt mellem en øvre del af drivindretningen, og gribeindretningen (110) holdes spændt under drift.

30 **9.** Gribesystem ifølge et hvilket som helst af kravene 7 og 8, hvor den ene eller de flere opdriftsflydere (160) er forbundet med den første hejseanordning (120), eventuelt det mindst ene langsgående ophængningselement (121) af den første hejseanordning, således at den/de under drift forbliver over drivindretningen (130).

10. Gribesystem ifølge et hvilket som helst af de foregående krav, hvor gribesystemet omfatter en heave-kompensator, eventuelt en passiv heave-kompensator (150), til gribeindretningen (110).

5 **11.** Gribesystem ifølge det foregående krav, hvor den passive heave-kompensator (150) er anbragt på gribeindretningen (110), og den første hejseanordning (120) er forbundet med den passive heave-kompensator.

10 **12.** Marinefartøj omfattende gribesystemet (100) ifølge et hvilket som helst af de foregående krav.

13. Undervandsgribefremgangsmåde til aktiviteter under en vandoverflade i et havmiljø, hvilken undervandsgribefremgangsmåde omfatter

- at anvende et undervandsgribesystem omfattende
- 15 - en gribeindretning (110);
- en første hejseanordning (120) til ophængning og hejsning af gribeindretningen fra et marinefartøj (10) under vandoverfladen og til positionering af gribeindretningen i en vertikal retning, hvor den første hejseanordning (120) omfatter mindst et langsgående ophængningselement (121) til ophængning og hejsning af gribeindretningen (110); og
- 20 - at anvende en drivindretning (130) omfattende et propelsystem (132) til drivning og positionering af drivindretningen i et første horisontalt plan under vandoverfladen, således, at gribeindretningen (110) er positioneret under drivindretningen (130), til at positionere gribeindretningen (110) i et andet horisontalt plan under vandoverfladen ved at føre den første hejseanordning ved hjælp af drivindretningen og ved at drive og positionere drivindretningen i et første horisontalt plan; **kendetegnet ved at** undervandsgribefremgangsmåden endvidere omfatter
- 25 - at anvende en anden hejseanordning (140) til ophængning og hejsning af drivindretningen fra marinefartøjet under vandoverfladen,
- 30 hvor gribeindretningen (110) og drivindretningen (130) uafhængigt er ophængt af den første og anden hejseanordning (120, 140) fra marinefartøjet (10), og hvor det mindst ene langsgående ophængningselement (121) af den første hejseanordning (120) føres af mindst en central åbning (135) af drivindretning-

gen (130) ved at lede det mindst ene langsgående ophængningselement gennem den centrale åbning med henblik på at føre den første hejseanordning (120).

Fig. 2

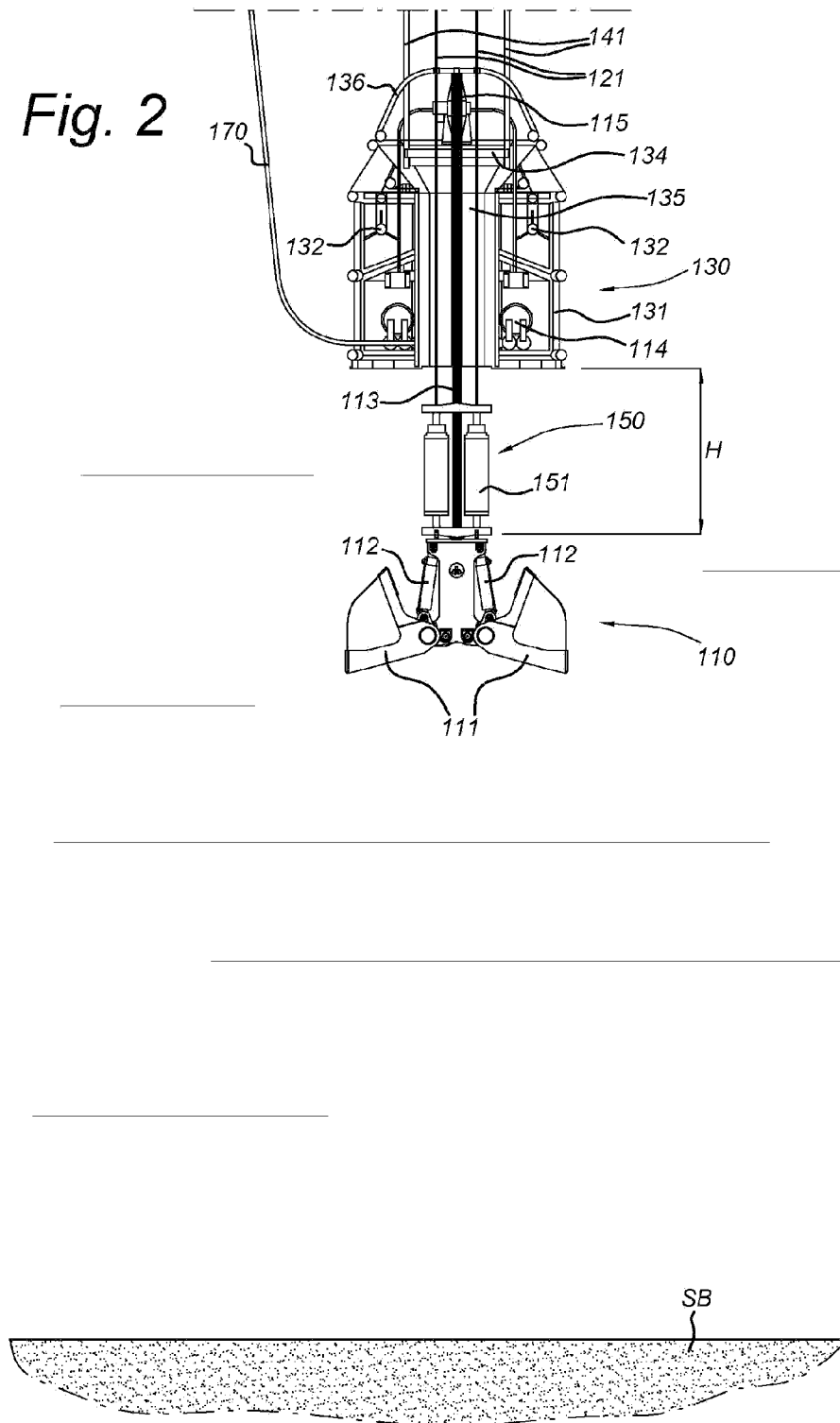


Fig. 3

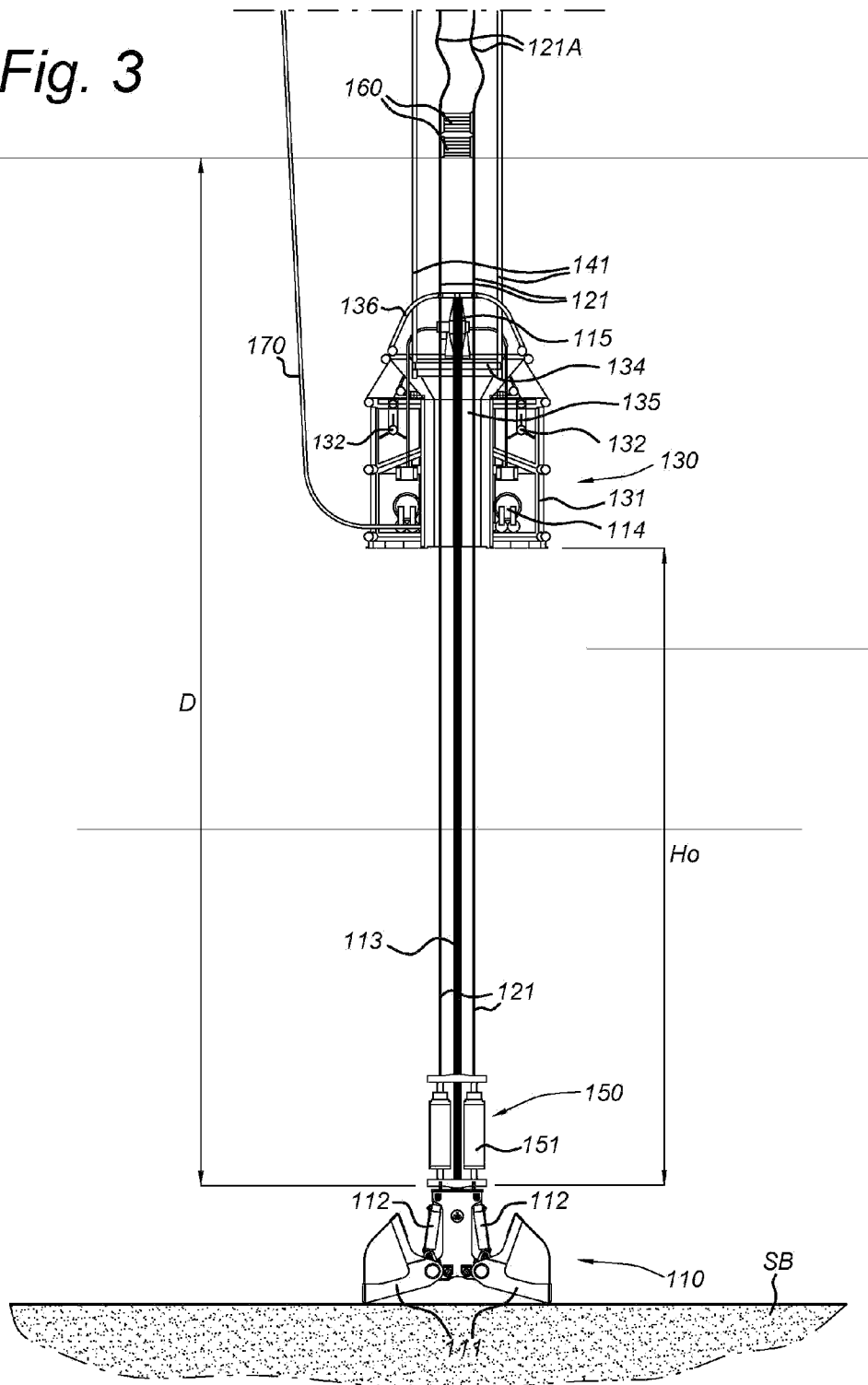


Fig. 4

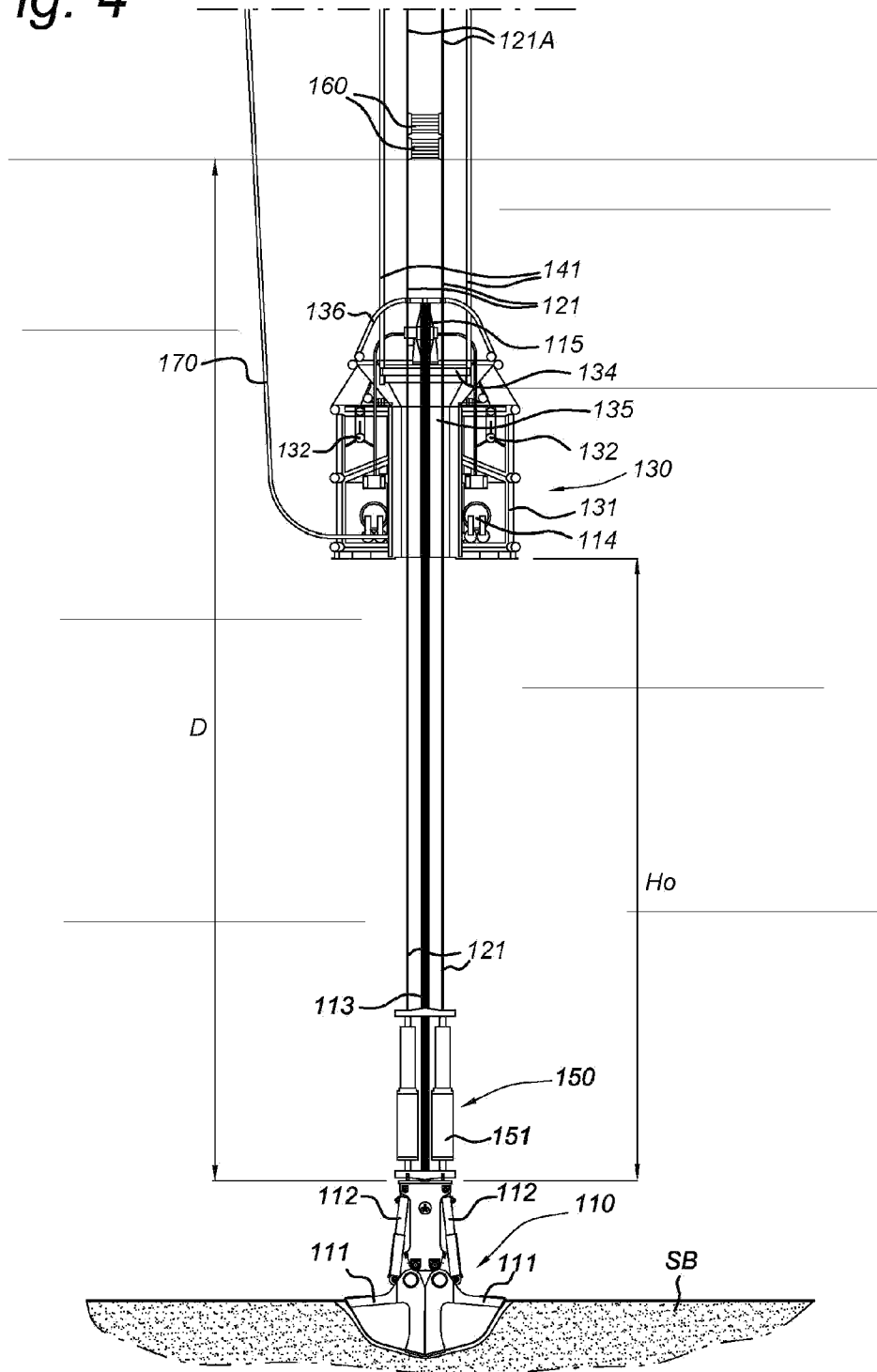


Fig. 5

