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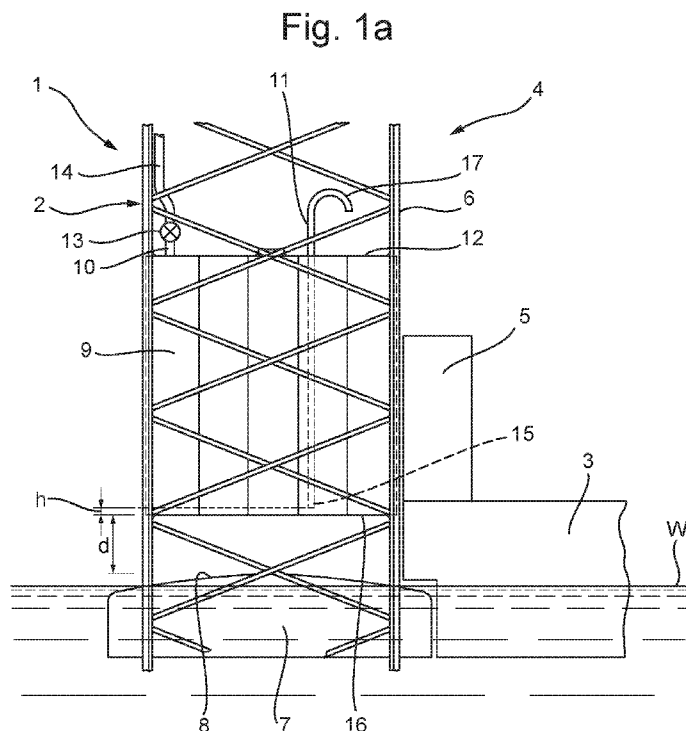
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- (54) Title: JACK-UP PLATFORM; LEG FOR A JACK-UP PLATFORM; METHOD FOR INSTALLING A JACK-UP PLAT-  
FORM



(57) Abstract: Jack-up leg comprising a lower end provided with a supporting device and provided with a leg jacking part arranged to cooperate with a hull jacking part, wherein the lower end of the leg further is provided with an equalizing pressure tank, wherein the tank comprises a top plate and a bottom plate and the tank is provided with at least one air line for allowing air in and/or out of the tank arranged near the top plate and with at least one equalizing line for allowing water in and/or out of the tank of which a first end is arranged near the bottom plate.

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GW, KM, ML, MR, NE, SN, TD, TG).

Title: Jack-up platform; Leg for a jack-up platform; method for installing a jack-up platform

5        Field of the invention

The invention relates to jack-up platforms comprising a hull and at least one leg adjustable with respect to the hull.

Background

10        Jack-up platforms, such as jack-up rigs and self elevating vessels, are widely known and typically used offshore for installation and/or maintenance work. The jack-up platform is temporarily installed at a certain offshore location and can be displaced between subsequent offshore locations. Thereto, the jack-up platform comprises a hull and at least one  
15        adjustable leg. Typically, a jack-up platform can comprise three, four or even six legs. The legs are adjustable between a floating condition and an elevated condition. In the floating condition, the legs are fully retracted and the hull is floating, the legs extend substantially above the hull. In the elevated condition, the legs are lowered with a lower end of the legs on or in  
20        the seabed, the legs are substantially below the hull and the hull is elevated with respect to the water surface. In an intermediate condition, the installation condition, the legs are lowered to engage the seabed, while the hull is still on the water surface. After preloading the hull is being raised above the water surface until the elevated condition is reached.

25        In the floating condition, jack-up platforms have to fulfil the requirements to intact and damaged stability as dictated by different Regulatory Bodies. This loading condition is essentially defined by the draft or displacement in combination with the vertical center of gravity (VCG). With increasing draft, the allowable vertical center of gravity (AVCG) is  
30        decreasing, as it becomes more and more difficult to satisfy the stability

criteria, due to lesser reserve buoyancy which is available when the platform is floating at a deeper draft.

In many cases it appears difficult to satisfy all stability criteria, for the actual loading condition in which the jack-up platform is floating: in  
5 present practice, jack-ups that have their legs fully retracted, may in some cases not fulfil the criterion that the vertical center of gravity is below the allowable vertical center of gravity ( $VCG < AVCG$ ). This means that either the amount of variable load carried should be reduced which gives lesser draft and thus an increased allowable vertical center of gravity ( $AVCG$ ), or  
10 the legs have to be lowered over some distance which results in a lower vertical center of gravity ( $VCG$ ). Both measures are undesirable from an operational point of view.

When the jack-up platform is at the required location, the legs will be lowered with respect to the hull to place the lower ends of the legs on or in  
15 the seabed. Typically, the legs are at their lower end provided with a supporting device, such as a spud can or footing which typically is a foundation designed to spread the leg load to the seabed.. Such a supporting device may penetrate the seabed. During lowering, the motions of the platform due to environmental conditions can cause the legs to move at  
20 considerable speed, depending on the length of the leg. This can result in considerable impact as the leg strikes the ocean floor.

In the elevated condition, jack-up platforms have to withstand severe storm conditions, resisting the combined action of waves, current and wind. Under the influence of these loads, amplified by the jack-up's dynamic  
25 response, the jack-up legs may exert high loads on the seabed. These loads can be significantly greater than the static loads exerted by the legs on the seabed. To ascertain that the seabed will not be overloaded in this storm condition, jack-up rigs are preloaded during installation. In the preload condition, the load in the legs is significantly increased above the static leg  
30 load. This can be done by temporarily taking in large quantities of water

ballast. Alternatively, for jack-ups with more than three legs, the load on one diagonal pair of legs can be significantly increased by slightly lifting the other diagonal pair of legs. The amount of generated preload may however not be sufficient to create sufficient margin between static leg loads and leg  
5 loads during severe storm, in which case the jack-up would not be allowed to install at the determined site.

When the soil is relatively soft, the lower part of a leg may be embedded into the seabed, resulting in soil disturbance around the leg. Soil is pushed down and to the sides of the spudcan, creating a hole in the  
10 seabed. The walls of this hole will collapse thus creating infill, which is soil piling up on top of the spudcan. Further, soil that is pushed away during penetration of the leg into the seabed flows around the spudcan, creating back flow. This back flow increases infill and soil disturbance. Infill increases the load on the spudcan and therefore reduces the allowable leg  
15 load. Soil disturbance is undesirable when close to the pile foundation of a jacket.

There is a need to increase the margin between the static leg loads and the dynamic leg loads, preferably without jeopardizing the operational conditions too much.

20 The present invention is intended to resolve at least one of the abovementioned drawbacks, preferably by a single device which can be adjusted to the condition, floating or elevated, of the jack-up platform.

#### Summary of the invention:

25 The invention relates to a jack-up leg and a jack-up platform comprising a hull and at least one jack-up leg that is adjustable with respect to the hull. According to the invention, the jack-up leg comprises a lower end provided with a supporting device and a leg jacking part arranged to cooperate with a hull jacking part, wherein the lower end of the leg further  
30 is provided with an equalizing pressure tank, wherein the tank comprises a

top plate and a bottom plate and the tank is provided with at least one air line for allowing air in and/or out of the tank arranged near the top plate and with at least one equalizing line for allowing water in and/or out of the tank of which a first end is arranged near the bottom plate.

- 5           Typically, a jack-up platform comprising a hull and at least one jack-up leg comprises a jacking device for moving the jack-up leg up- and/or downwards along the hull. The jacking device comprise a leg jacking part on the jack-up leg and a hull jacking part on the hull, wherein the leg jacking part and the hull jacking part cooperate for moving the leg along the hull.
- 10       The leg jacking part can be embodied as a rack on a chord or as a series of holes on a rail or as an other embodiment. The hull jacking part cooperates with the leg jacking part and can comprise a driven gear cooperating with a rack or as a driven pin cooperating with the holes. Jacking devices are well known and are not elaborated further. The leg jacking part typically extends
- 15       over the length of the leg, while the hull jacking part typically is provided on the hull.

Preferably, the bottom plate of the tank is located at a distance above a top side of the supporting device.

- By providing an equalizing pressure tank at the lower end of the leg,
- 20       loading conditions on the leg can be adjusted and as such, the margin for dynamic loading on the leg, e.g. during severe storm conditions, can be increased.

- The air line provides for allowing air in and/or out of the tank, which both allows for a venting mode as for a pressurizing mode in which
- 25       compressed air is supplied through the air line.

- Additionally, due to the gap between the bottom plate of the tank and the top side of the supporting device, in particular with soft soil, soil disturbance can be reduced due to the possibility of soil back flow in the gap between the tank and the supporting device. Reducing soil disturbance can
- 30       be important in particular with soft soil and may allow the jack-up platform

to be positioned more near to an existing offshore structure, thereby the working radius of the jack-up platform may be increased.

Also, due to the gap between the bottom of the tank and the top side of the supporting device, flow may be possible over the supporting device,  
5 e.g. when the supporting device is not fully penetrating in the sea bottom. Thus, an increased flow around the supporting device near the seabed may be avoided, as this may result in an increase scour rate, the scour rate may therefore be reduced.

Further, due to the gap between the tank and the supporting device,  
10 the supporting device can be accessible when the leg is retracted and the jack-up platform is in floating condition, which may be beneficial for inspection, maintenance and/repair.

By providing at least one air line for allowing air in and/or out of the tank arranged near the top plate and with at least one equalizing line for  
15 allowing water in and/or out of the tank of which an inlet is arranged near the bottom plate, the tank may fulfil different functions in the different loading conditions of the jack-up platform. The tank can be partly or fully filled with water and/or air. Via the air line compressed air can be submitted to the tank as to push the water out of the tank. The air line can  
20 also be used for venting the tank. Due to the equalizer line, having a first end arranged near the bottom plate, the pressure at the bottom of the tank inside the tank is about the same as the pressure at the bottom of the tank outside the tank, i.e. the pressure is equalized as the air pushes the water out, or when the tank is filled with water.

25 The equalizer line can be provided as an equalizing pipe having a first end near the bottom plate inside the tank and having outlet second end above the top plate outside the tank or the equalizing line can be arranged as a valve in the bottom plate of the tank wherein then the valve opening may be considered as the first end. Advantageously, the outlet of the  
30 equalizing pipe remains above the soil level in case the lower end of the leg

is embedded in the sea bed. As such the pressure at the bottom of the tank can be 'equalized'. When the equalizing line is embodied as a bottom valve, there may or may not be a second end. For example, when there is a piping connected to the valve, further reaching downward, or e.g. an elbow piping, or even a piping reaching upward, the free end of such piping may be considered as the second end of the equalizing line as bottom valve. A valve opening can be considered the first end of the equalizing line.

The tank may also be provided with a drain valve in the bottom plate of the tank, such that, when the leg is retracted, the water can flow out of the tank without requiring pumping. In an embodiment, the equalizing bottom valve and the drain valve may be a single valve in the bottom plate of the tank.

In case of the tank having multiple compartments or a segmented tank, each of the compartments or segments can have its own at least one air line and at least one equalizer line. Alternatively, the multiple compartments or segments can be in fluid communication with each other and the tank may be provided with the at least one air line and at least one equalizer line. The number and/or arrangements of compartments and/or segments in the tank can vary.

By providing the equalizing pressure tank, the survivability of the jack-up platform may be increased due to an increase of the dynamic load capacity of the jack-up leg. The equalizing pressure tank can be filled with water for preloading of the leg. Typically, in the elevated condition of the jack-up platform with a lowered leg, the static load on the seabed may be reduced by filling the equalizing pressure tank with air, creating more margin for dynamic leg loads. The outlet of the equalizing line may remain open in this elevated condition of the jack-up platform, while the tank is being filled with air. The air then pushes or has pushed the water out through the equalizing line.

In an embodiment, when for example severe environmental conditions e.g. storm conditions can be expected, the static load on the seabed may be temporarily reduced by filling the equalizing pressure tank with air and thus more margin for dynamic leg loads can be created. For  
5 example, compressed air can be supplied via the air line to expel the water out of the tank via the equalizing line.

The tank can be fitted inside the chords and bracings of the jack-up leg. The tank can also be integrated as a structural part of the leg, e.g. plating instead of bracings can be provided at the tank location. Also, the  
10 tank may extend outside of the circumference of the leg structure or may have compartments outside of the chords and bracings.

According to the invention, the jack-up leg is provided at a lower end thereof with a tank having at least one compartment, wherein the tank is arranged to be filled with water and/or compressed air. To that end, an air  
15 line and an equalizer line, which may be embodied as one or more valves, may be provided on the tank. The filled condition of the tank depends on the loading condition of the jack-up platform.

The invention also relates to a jack-up leg for engagement with a jack-up platform wherein the jack-up leg at its lower end is provided with at  
20 least one tank that is arranged for filling with water and/or compressed air depending on the loading condition of the jack-up platform.

The invention also relates to a method to adjust the load on the jack-up leg.

Further the invention relates to a tank arranged to be mounted to a  
25 leg of jack-up platform.

The invention also relates to a method of installing a jack-up platform comprising such a leg with a compartment.

An embodiment of the invention of the equalizing pressure tank is the Equalized Pressure Compartment (EPC), consisting of one or multiple  
30 compartments fitted in the lower part of the jack-up legs, which has an air

line and an equalizer line, which can be embodied as a valve connection at its top and its bottom respectively, enabling the tank to fulfil different functions in the different loading conditions of the jack-up:

- Floating condition: the tank is acting as a stability tank of the jack-up, providing significant reserve buoyancy when at larger heeling angles of the jack-up. This additional reserve buoyancy is a large contributor to the stability in the floating condition. In order to perform the function as a stability tank, the equalizing line bottom-valve of the compartment is kept closed, while the air line valve at the top is open, to act as a vent line. The tank internal is almost or completely empty (fully drained).
- Preload condition: the equalizing bottom valve of the compartment is opened, right before the start of leg lowering for installation of the jack-up at the site. The tank is thus gradually flooded with seawater, while getting more and more submerged through the leg-lowering operation. The air in the tank is being pushed out of the open air line top-valve, by the water entering through the equalizing bottom-valve. The tank is kept freely flooded with seawater during the preload condition, to maximize the leg loads that are exerted on the seabed during preloading.
- Elevated condition: the air line top-valve of the compartment is closed right after finishing of the preloading, e.g. by ROV or remote. The equalizing bottom-valve remains open to the sea. The tank is now being filled with compressed air, which is provided by the rig's air systems. The sea water is being pushed out through the open equalizing bottom-valve, until the tank is almost fully filled with compressed air. The static load on the seabed is thus significantly reduced, creating more margin for dynamic leg loads during e.g. storm condition, before the allowable leg load is reached, wherein the allowable leg load is directly dependent on the generated preload.
- Departure condition: the air line top valve of the tank is opened to allow the compressed air to escape, and the tank is thus being re-filled with

sea water. This free flooded condition will be kept during the whole leg retraction operation. When the jack-up legs are almost fully retracted, the compartment will be raised gradually out of the water, allowing the water inside the tank to drain: air can enter the tank from the opened air line top valve, while the water is gradually draining through the open equalizing bottom valve and/or drain valve. Once the legs are fully retracted the bottom-plating of the compartment is completely above the surrounding sea level, which means that the tank is fully self-draining, with no active pumping systems required. Directly after draining of the tank is completed, the bottom valve and/or drain valve of the compartment is closed, so the tank will now function as stability tank during the floating condition of the jack-up (see “floating condition”).

As explained above (“elevated condition”), the tank is in open connection to the sea at its bottom, which means that the pressure at the bottom of the tank is at any moment equalized with the pressure of the surrounding sea water. At the top of the tank the pressure difference is limited to a water column equal to the height of the tank: this is caused by the difference in specific gravity of the air inside the tank and the specific gravity of the water surrounding the tank. Due to this limited pressure difference, the compartment can be fabricated as a stiffened flat plated tank, as is customary in normal shipbuilding practice. This flat plated tank can be an integral part of the leg structure, thus taking part in the transfer of the global loads V, H, M in the leg, or it can be a separate tank connected to the leg structure, thus only transferring the buoyancy forces of the tank to the leg. Both alternatives are understood to fall within the scope of the present invention as defined by the claims.

The tank can be a multiple segmented tank, e.g. for reasons of redundancy. This provides a subdivision whereby loss of buoyancy is mitigated, in case one of the segmented compartments would fail to perform its function. Each of the segments will be outfitted with its own top and

bottom valve. The number of segments can vary, and is not essential to the invention.

The bottom-plating of the tank is positioned at some distance above the top-plating of the supporting device e.g. spudcan, in order to:

- 5           • Fully self-drain when the legs are retracted: bottom-plating of the compartment is above the level of the sea water in floating condition and legs fully retracted.
- Allow current to maintain its flow over the spudcan in the elevated condition with non-penetrating spudcan: thus avoiding increased flow
- 10       around the spudcan near the seabed, which would result in increased scour rate.
- Allow back-flow of soil when the spudcan is penetrating in soft soil, thereby reducing the distance over which the soil will be disturbed during penetration of the spudcan.
- 15       • Provide accessibility of the spud can in retracted condition.

As explained previously, the jack-up legs may be fully retracted in the floating condition. In this case the tank can be above the water level, and is acting as a stability tank: providing reserve buoyancy at heeling angles of

20   the jack-up. The legs may be however be lowered over some distance, such that the tank is fully or partially in the water, for special floating conditions like “ocean tow” or transit. In this way the vertical center of gravity is decreased, which may be necessary due to the more stringent stability criteria for such “ocean tow” condition. The effect will be that the tank can

25   be partly immersed. It will thus provide buoyancy to the jack-up platform in the even keel condition. This will reduce the draft of the jack-up platform, and thereby increase the allowable vertical center of gravity. The stability function of the tank is thus still the same, regardless of any amount of partial immersion.

Further, during installation of the jack-up platform, the at least one tank provided on the jack-up leg may provide for additional dampening and/or may reduce the relative motions of the jack-up platform. The position of the tank on the lower end of the leg may result in a dampening effect on roll and/or pitch during installation, due to the added mass or inertia and/or increased drag. This may reduce the impact forces when the leg end touches the seabed. Further, the position of the tank on the lower leg end may reduce horizontal loads on the tank and thus on the jack-up leg when the jack-up leg is in elevated condition and the tank is then near the sea bottom, since waves and other environmental motion have less influence at larger depth. To further reduce the effect of horizontal loads on the tank, the height of the tank can be optimized with respect to the volume required.

In addition, the at least one compartment at the lower end of the leg may provide a barrier against infill of the lower leg end, e.g. due to sand or mud or other substances.

#### Detailed description of the invention

The invention will further be elucidated on the basis of exemplary embodiments which are represented in a drawing. The exemplary embodiments are given by way of non-limitative illustration.

In the drawing:

Figure 1a: shows an embodiment of the equalizing pressure tank at a jack-up leg in floating condition with the jack-up leg fully retracted with an equalizer pipe as equalizing line;

Figure 1b: shows an alternative embodiment of the equalizing pressure tank at a jack-up leg in floating condition with the jack-up leg fully retracted; with a bottom valve as equalizing line;

Figure 2: shows the embodiment of figure 1a/1b with the jack-up leg in floating condition and somewhat lowered;

Figure 3: shows the embodiment of figure 1a/1b with the jack-up leg in elevated condition, with a non-penetrated supporting device;

Figure 4: shows the embodiment of figure 1a/1b with the jack-up leg in elevated condition with a penetrated supporting device allowing back-  
5 fill of soil over the penetrated supporting device;

Figure 5 shows a further embodiment of the equalizing pressure tank;

Figure 6 shows a sequence of installation and departure;

Figure 7 shows a schematic cross-section showing a multi-  
10 segmented tank; and

Figure 8 shows an embodiment of discrete level control in the tank. It is noted that the figures are only schematic representations of embodiments of the invention that are given by way of non-limiting example.

15 Figure 1a shows a schematic representation of a jack-up leg 1, in particular of the lower end 2 thereof. Further, schematically, the hull 3 of the jack-up platform 4 and the hull jacking part 5 are represented. Typically, a jack-up platform 4 comprises a hull 3 and at least one jack-up leg 1. The jack-up leg 1 is provided with a leg jacking part 6, e.g. one or  
20 more racks along achord of the leg 1. The leg jacking part 6 and the hull jacking part 5 cooperate in a known manner as a jacking device and will not be further explained.

The hull 3 and jack-up leg 1 are in figure 1a shown in the floating condition, i.e. the hull 3 is floating in the water up to the water surface W,  
25 and the jack-up leg 1 is almost fully retracted.

The leg 1 is here a truss-type leg having chords and braces. Alternatively a cylindrical leg may be provided. The leg 1 can be of a triangular or a square cross-section. A jack-up platform can have three, four or sometimes more legs.

The lower end 2 of the leg 1 is provided with a supporting device 7, typically a spud can. Spud cans are well known supporting devices for jack-up platforms and will not be elaborated here. It is understood that instead of a spud can, also other supporting devices or even anchoring devices may be  
5 used.

At the lower end 2, at a distance  $d$  above a top side 8 of the spud can 7, an equalizing pressure tank 9 is provided. The equalizing pressure tank 9 is here schematically represented but can be embodied as a separate structure which can be fitted to the lower leg end 2, or as an integral  
10 structure to the leg 1. Many variants are possible. The equalizing pressure tank 9 has an air line 10 and an equalizing line 11. The air line 10 is here provided at a top plate 12 of the tank 9, and can be provided with a valve 13 which can be connected with a compressed air supply 14. Typically, the compressed air supply 14 is connected to the pressurized air circuit of the  
15 jack-up platform 4. Valve 13 can also be situated at an upper part of the leg which remains above water in elevated condition.

When a bottom valve or drain valve 11b is provided as equalizing line 11, as in figure 1b, the tank 9 is fully self-draining when in the floating condition as the bottom plate 16 is above the water level  $W$  and the drain  
20 valve would be above the water level as well. Self-draining of the tank 9 is advantageous as the tank 9 can be emptied without requiring actively pumping. Typically, the distance  $d$  depends on various parameters, such as the height of the hull to have the bottom plate above the water level when the leg is fully elevated, such as the soil quality for determining allowable  
25 soil back flow, such as structural requirements of the lower leg end with the tank provided, etc. In another embodiment, both an equalizing pipe 11a and a drain valve 11b may be provided. In a further embodiment, two equalizing pipes 11a may be provided for redundancy in case one of the equalizing pipes may fail. For example, figure 5 shows such an alternative embodiment  
30 with two equalizing pipes 11a, a drain valve 11b and an air line 10. Here,

the valve 13 of the air line 10 is above the water level W. Many variants on the configuration are possible.

Further, the equalizing pressure tank 9 is provided with an equalizing line 11 which is in figure 1a embodied as an equalizing pipe 11a  
5 having a first end 15 near a bottom plate 16 inside of the tank 9 and having a second end 17 outside and above the top plate 12 of the tank 9.

Alternatively and/or additionally, a valve 11b can be provided in the bottom plate 16 of the tank 9, as shown in figure 1b. Such a valve 11b can then function as a drain valve and/or as an equalizing valve.

10 The first end 15 of the equalizing pipe 11a is here located at a distance h above the bottom plate 16 of the tank 9. This distance h may determine the minimum amount of water in the tank, in the absence of a drain valve, and thus may determine the static load on the leg.

Here, with the leg 1 in floating condition, the tank 9 is functioning as  
15 a buoyancy tank filled with air. In the floating condition as shown in figure 1a, the tank 9 is entirely above the water level W and is fully drained, i.e. filled with air. The tank 9 is now acting as a stability tank of the jack-up platform 4, providing reserve buoyancy at larger heeling angles of the jack-up platform 4 during floating. This additional reserve buoyancy can be a  
20 large contributor to the stability of the jack-up platform 4 in the floating condition.

In order to perform the function as a stability tank, if a bottom valve or drain valve is provided, the bottom-valve or drain valve of the tank 9 is kept closed. The equalizer line 11 is open and can be used to vent the tank 9.  
25 The air line top valve 13 is closed and a pressure sensor can be used to monitor air pressure changes in the tank 9, with an unpredicted change indicating a failure of the tank 9.

In the floating condition, the legs may also be lowered over some distance, for special floating conditions like "ocean tow" or transit. This is  
30 shown in figure 2, wherein the spud can 7 is now immersed in the water. In

this way the vertical center of gravity is decreased, which may be required in view of more stringent stability criteria for such an “ocean tow” condition. The tank 9 is here partly immersed and may thus provide buoyancy to the jack-up platform 4 in this floating condition. This may reduce the draft of the jack-up platform 4, and thereby increasing the allowable vertical center of gravity (AVCG). The stability function of the tank 9 is therefore similar for the condition of figure 1a or for the condition of figure 2, regardless of any amount of partial immersion. In the floating condition shown in figure 2, the second top end 17 of the equalizer pipe 11 still is above the water line W, in order to vent the tank 9, in intact as well as damaged condition of the hull.

Figure 3 shows a schematic representation of the lower end 2 of the jack-up leg 1 in the elevated condition, the spud can 7 is, at least partly, penetrating the sea bottom S and the hull of the jack-up platform is on or above the water level and thus not visible in this figure 3.

Due to the first end of the equalizing line 11 being near the bottom of the tank 9, when the tank 9 is filled with air, the pressure difference over the height H of the tank 9 is limited to a water column equal to the height H of the tank 9. This is caused by the difference in specific gravity of the air inside the tank 9 and the specific gravity of the water surrounding the tank 9. Due to this limited pressure difference, the tank 9 can be fabricated as a stiffened flat plated tank 9, as is customary in normal shipbuilding practice.

Due to the gap d between the bottom plate 16 and the top side 8 of the spud can 7, current can flow through the gap, thus avoiding an increased flow around the spud can near the sea bed. Such an increased flow typically may result in an increased scour rate of the sea bed around the spud can, and this may be limited by providing the gap.

Figure 4 shows schematically the lower end 2 of the jack-up leg 1 in the elevated condition of the jack-up platform 4 with the spud can 7 now fully penetrated in the soil of the sea bottom S. Also, the tank 9 is partly

below the sea bed level. Due to the gap provided by the distance  $d$  between the bottom plate 16 of the tank 9 and the top side 8 of the spud can 7, back flow of soil can be allowed in the gap. This can be advantageous, in particular with soft soil, since the disturbance of the soil around the leg 1  
5 can be reduced, which may allow the jack-up platform 4 to be positioned closer to an existing offshore structure, which may give operational advantages to the operation on the jack-up platform 4. This is in particular contrary to the prior art, where lower end leg structures either allow infill and backflow, often leading to additional weight on the spud can thereby  
10 reducing the dynamic load margin of the leg, or are typically designed to prevent infill and backflow, leading to soil disturbance. Here, the design can be such that infill is at least largely prevented but back flow is at least partly allowed to reduce soil disturbance.

Due to the presence of the tank at the lower end 2 of the jack-up leg 1,  
15 infill in the lower end of the leg may be reduced, which may facilitate removal of the leg 1 out of the soil  $S$  when the jack-up platform 4 is departing. In an embodiment, in case soil disturbance is less of an issue, some or all of the side plating of the tank 9 may be connected to or extended to the spud can to at least partly shield the gap between the tank 9 and the  
20 spud can 7 from soil infill thus further reducing the static load of the jack-up leg on the seabed, while the bottom plate remains at a distance  $d$  from the top side of the spud can. With the bottom plate of the tank still spaced from the spudcan, the tank may still be selfdraining when the jack up platform is in floating condition, for example by providing sufficient outlets through the  
25 side plating.

Figure 6 shows a typical floating, installation and departure cycle of the equalizing pressure tank 9. This is a typical cycle, so other phases or modes can of course be possible. Figure 6 shows schematically the equalizing pressure tank 9 with two equalizing pipes 11a, a drain valve 11b

and an air line 10. For reasons of simplicity, the leg structure, hull structure and supporting structure have been omitted here.

In phase 1, the equalizing pressure tank 9 is in floating condition, partially immersed in water, which is a similar condition as described in  
5 figure 2. The drain valve 11b is closed and the tank 9 is filled with air acting as a buoyancy tank. On site, phase 2, the legs are being lowered. The drain valve 11b remains closed, and during leg lowering water can enter the tank 9 via the equalizing pipes 11a. Approaching the sea bottom, the water entering the tank 9 pushes air out through the air line 10 when the valve 13  
10 is opened or increases air pressure in the tank when valve 13 is closed.

The tank 9 may now add to stability during lowering and may reduce impact of the leg when hitting the sea bottom. When installed, the leg is being preloaded, phase 3. To that end, the tank is preferably fully filled with water as to increase the static load on the leg. In phase 4, the tank 9 can be  
15 partially penetrating the sea bed. In installation condition, water is being pushed out of the tank through the equalizer pipes 11a by compressed air entering the tank via the air line 10. In phase 4 the static load of the leg is maximally reduced to increase the dynamic load margin of the leg. This way, the jack-up platform may remain on site in harsh condition where it  
20 otherwise would have had to sail off. This may significantly increase the operational window of the jack-up platform and reduce operational costs. In phase 5 the jack-up platform is in elevated condition. The water level in the tank may vary due to wave action and the open connection with the surrounding water via the equalizer lines. When departing, phase 6, the  
25 tank can be fully or partially emptied to reduce the loads on the spud can and to retract more easily from the soil. Air present in the tank may expand during lifting of the leg. During lifting of the leg, the tank may be refilled with water via the equalizer pipes 11a. Once the tank is above the water level, phase 7, the tank can be drained via the bottom valve 11b to empty.

During installation of the jack-up platform 4, each drain valve 11b remains closed while the equalizer pipes 11a is open. The equalizer pipe advantageously has no valves and provides for fluid communication between the inside of the tank and the surroundings. .. The tank 9 is thus gradually  
5 flooded with seawater, while getting more and more submerged through the leg-lowering operation. When the top valve 13 in the air line 10 is opened, the air in the tank is pushed out of through the air line 10 by the water entering through the equalizer pipe 11a. When the top valve 13 in the air line 10 is closed, water entering the tank increases the air pressure inside  
10 the tank, continuously creating equilibrium. This means that when leg lowering is temporarily stopped, the inflow of water may also stop. A pressure sensor can be used to monitor the air pressure change, with an unpredicted change indicating malfunctioning of the equalizing pipes 11a.

In case the tank has no equalizer pipe 11a but a bottom valve 11b  
15 only, the bottom valve 11b of the tank 9 is opened, right before the start of leg lowering for installation of the jack-up platform 4 at the offshore site.

The tank 9 is freely flooded and filled with seawater during the preloading condition, with the top valve 13 in the air line 10 open, to maximize the leg loads that are exerted on the seabed during preloading.

20 In the elevated condition of the jack-up platform 4 the top-valve 13 of tank 9, or each segment or compartment of the tank 9, is closed right after finishing of the preloading. The top valve 13 is preferably situated at the top of the leg 1 remaining above the waterline. In case the top valve 13 would be directly on the top plate 12 of the tank 9, and thus submerged, an ROV can  
25 be used or remote control can be used to operate the valve.

In a preferred embodiment, the tank having equalizing pipes 11a, the drain valve 11b remains closed and the equalizer pipe 11a remains open to the sea during installed or elevated condition. In case the tank 9 has no equalizer pipe 11a but a bottom valve 11b only, the bottom valve of (each  
30 segment or compartment of) the tank 9 remains open to the sea during

installed or elevated condition. Advantageously, the bottom valve is provided with additional piping with a first end connected to the bottom valve and a second end reaching well above the seabed when the leg penetrates the seabed to prevent the bottom valve from being clogged by soil or being stuck in the sea bed..

After preloading, the top valve 13 can be connected to the air system of the jack-up platform, switching from venting mode to supplying mode in which compressed air is supplied to the tank. Each segment or compartment of the tank 9 can be filled with compressed air through the air line 10. The sea water is being pushed out through the equalizer pipe 11a or bottom valve 11b, until the tank 9 is almost fully filled with compressed air. A predetermined volume of water may remain in the tank 9 under equalized pressure. The resulting allowable leg load is directly dependent on the difference between actual leg load and the generated preload.

After supplying the compressed air, the top valve 13 may be closed. A pressure sensor can be used to monitor the air pressure during the elevated condition, with unpredicted pressure change indicating failure of the compartment.

In the departure condition of the jack-up platform, the top valve 13 of the air line 10, in venting mode, of the tank 9, or each segment or compartment, can be opened to allow the compressed air to escape, and the tank 9 can thus be re-filled with sea water via the bottom valve 11b or equalizing pipe 11a. This free flooded condition typically may be kept during the whole leg retraction operation.

It is also possible to retract a leg with one or more or all compartments air filled, thus with the top valve closed. This may reduce the required pulling load during retraction, which is especially advantageous during extraction from the soil. After breaking free from the soil the air filled compartments can be flooded in order to reduce instability caused by buoyant forces on the lower parts of the leg during retraction.

When the legs are almost fully retracted, the tank will be raised gradually out of the water, allowing the water inside the tank to drain: air can enter the tank 9 from the opened top valve 13 and/or equalizer pipe 11a of which the second end 17 is above the water line, while the water can  
5 gradually be draining through the open bottom or now opened drain valve 11b.

Once the legs are fully retracted, the bottom-plating of the tank 9 is completely above the water level, which means that the tank is fully self-draining, with no active pumping systems required. After draining of the  
10 tank is completed, the bottom valve or drain valve of each compartment can be closed. The tank 9 can now function as stability tank during the floating condition of the jack-up platform.

In an embodiment, the tank 9 can be provided of multiple segments and/or multiple compartments, as e.g. shown in the cross-section of a tank 9  
15 figure 7. In figure 7, the triangular tank 9, integrally to the leg structure, is divided into six compartments extending along the longitudinal direction of the leg. In an embodiment, the multiple compartments can be in fluid communication with each other, for which a configuration with an air line and at least one equalizing line suffices. In another embodiment, at least  
20 two of the compartments can be separate from each other, each requiring an air line and an equalizing line. It may be understood that, where in the context of this description the tank is mentioned, there can also be referred to one or more compartments of the tank.

As discussed above, the amount of water or air in the tank 9 can be  
25 varied, depending on the loading condition, e.g. the tank is preferably filled with water during preloading and is preferably filled with air during elevated condition. However, since the volume of water inside the tank is part of the static load of the leg on the seabed, it may be desirable to vary the water volume in the tank 9 for more and/or various conditions to further

optimize the load conditions of the leg. Thereto, level control or volume control of the water level in the tank may be provided.

The tank 9 is intended to maximize the margin between preload and actual static leg load to optimize the dynamic load caused e.g. by severe environmental conditions or by additional temporary load on the jack-up platform such as heavy hoisting or cantilever activity. When there is sufficient margin to the allowable leg load, depending on the site specific conditions, more water in the tank can improve the stability of the jack-up platform in elevated condition.

The water volume of a tank 9 with one or multiple segments or compartments can be controlled when each of the compartments having a known volume is equipped with an individual air line 10, equalizer pipe 11a and/or drain or bottom valve 11b. The load contributed by the tank 9 to the leg load can be controlled by using the air line top valves 13 to vent air from a compartment, or supply compressed air to a compartment in order to have a desired number of air filled and water filled compartments. As the volume of each compartment is known, this enables volume control of the tank 9, and thus optimizing of the load in various conditions.

In another embodiment, the equalizer pipe 11a of one or more compartments is adjustable in height, such that the distance  $h$  between first end 17 of equalizer pipe 11a and the bottom plate 16 of the compartment or tank 9 can be adjusted. The complete equalizer pipe 11a may for example be moved by known linear displacement means, possibly driven by the already available pneumatic power. Also, the equalizer pipe or parts thereof may be extendible or retractable by linear or rotational displacement. This may enable level control per compartment, as the distance  $h$  may define the minimum amount of water that can remain in the tank with closed drain valve or without drain valve. As the height  $h$  can be known, the volume of water in the compartment or tank can be known, resulting in volume control per compartment or per tank.

Alternatively, several equalizer pipes with different lengths may be fitted to one or more compartments, as shown in figure 8. In figure 8 an embodiment of a tank 9 is shown having three equalizer pipes 11a1, 11a2, 11a3, of which the first ends 17 are respectively at a height h1, h2 and h3 above the bottom plate 16 of the tank 9. The equalizer pipes preferably are provided with a valve 20<sup>1</sup>, 20<sup>2</sup>, 20<sup>3</sup>, such that the equalizer pipe 11a1, 11a2, 11a3 having the required height can be opened. This embodiment is preferred because it has discrete known levels and there are no moving parts.

With one of the compartments fitted with an adjustable equalizer pipe 11a or several equalizer pipes of different length 11a1, 11a2, 11a3, the level of water in that compartment or tank 9 can be controlled. The volume of water in the tank 9 can now be controlled more precisely by combining full and empty compartments as well as one or more partly filled compartments.

Advantageously, the tank 9 can be provided with pressure sensors. A pressure sensor, for example in the air line 10 between the valve 13 and the top plate 12 or in a compartment of the tank can be used to monitor air pressure during operations and detect a pressure change indicating for example leakage, structural damage or a clogged equalizing line.

Pressure sensors can also be used to measure the water level in a compartment. The air pressure directly relates to the water level inside the compartment at a given submerged water depth. When retracting calculated pressure of water level from the air pressure, the result returns the pressure of the level inside the tank.

$$P_{AtmosphericAir} + P_{WaterDepth} - P_{compressedAir} = P_{water} \rightarrow WaterLevel$$

This method has several drawbacks which may influence accuracy of measurement. First of all, the water depth needs to be known accurately. Additionally, the temperature differences of the sea water influence the

density and thereby the pressure of the water column. Further, during wave motion, the pressure inside the tank lags behind outside pressure changes.

Using a secondary pressure measurement near the bottom 16 of the compartment or tank 9 may resolve one or more of these inaccuracies. The pressure of the bottom sensor can then retracted from the measured pressure of the air pressure.

$$P_{AtmosphericAir+WaterDepth} - P_{compressedAir} = P_{water} \rightarrow WaterLevel$$

The resulting difference divided by the density of the water returns the value of the water level inside the compartment.

10 With the legs being adjustable, the common practice of wired signals to the control room may require complex equipment for reeling and/or unreeling of the wire during adjustment of the leg. Alternatively, wireless arrangements can be used for wireless communication between the pressure sensors and control rooms on the jack-up platform or remote. For example, several receivers may be positioned on the jack-up platform to avoid shadow zones due to different leg positions and to assure signal reliability.

In an embodiment, such a pressure differential measurement system can be arranged with a pressure sensor for the dry part of a compartment (top, compressed air) and a pressure sensor for the wet part of a compartment (bottom, water). For signal communication, this system can be arranged with a wired connection between submerged pressure sensors and a wireless transmitter, wherein the wireless transmitter can be located on the leg above water level to transmit to multiple receivers on the jack-up.

When a jack-up platform is moved from one offshore site to another, 25 the site specific conditions typically are different. The tank 9 can be used to optimize the margin between preload and actual static leg load, but the full capacity of the tank which may be required for a first site may not always be optimal for a second site. Volume control and/or level control can be used to optimize the site specific load case, resulting in sufficient margin between actual and allowed leg load as well as a reliable stability of the jack-up. 30

Also, installing the jack-up on site may require a specific adjustment of the tank load capacity. During the elevated condition dynamic control may be advantageous. When heavy hoisting or cantilever operations may be executed on the jack-up platform, this may result in temporary additional  
5 leg loads. Also, severe weather conditions may lead to significant additional dynamic environmental loads on the legs. In such cases the volume and/or level control on the tank can be used to compensate for these additional load by temporarily adjusting the water volume of the tank per leg.

Typically, a control system is provided to control the water and/or air  
10 volume in the tank. The control system can comprise an input module for receiving site specific conditions or expected loading specific conditions as input. Then, in a control module, the required water volume in the compartments and/or tank can be determined which can be outputted to the valves or adjustment units on the respective air lines and/or equalizing  
15 pipes. Control of the volume of the compartments and/or tank can be done in a discrete mode for site or environmental specific conditions, or can be done continuously or dynamically following regular or continuous input from jack-up operational conditions and/or environmental conditions.

Various modifications, variations, and alternatives are possible, as  
20 well as various combinations of the features described. The specifications, drawings and examples are, accordingly, to be regarded in an illustrative sense rather than in a restrictive sense.

For example, in the figures a truss-type leg is shown. However, a tank or compartment can be equally well be provided on other types of legs, such  
25 as a closed cylindrical type of leg. Also, the tank or compartment is shown as being inside of the leg, but can be located at other positions on the leg as well, for example outside or at one side or surrounding the leg etc. Many variants are possible.

Also, the compartment can be embodied in various ways. For  
30 example, the compartment can be provided as a tank that is mounted to the

leg. Or the compartment can be provided as a part of the leg, or may be integrated to the leg, for example by using plate material between the leg chords, thereby possibly replacing some of the trusses at that location and/or using plate material to cover the bottom and/or top of the compartment. The  
5 tank or compartment can have any suitable shape.

Furthermore, the valve connection is being described as a top valve at the top and a bottom valve at the bottom of the compartment. However, alternative locations are also possible, for example at a side of the compartment. Advantageously, the top valve is at an upper end of the  
10 compartment, e.g. at the top or at an upper side. Advantageously, the bottom valve is at a lower end of the compartment, e.g. at the bottom or at a lower side.

One or more compartments can be provided, which may be advantageous that when one compartment fails, other compartments still  
15 may be available for use.

For the purpose of clarity and a concise description features are described herein as part of the same or separate embodiments, however, it will be appreciated that the scope of the invention may include  
embodiments having combinations of all or some of the features described.

20 The word 'comprising' does not exclude the presence of other features or steps than those listed in a claim. Furthermore, the words 'a' and 'an' shall not be construed as limited to 'only one', but instead are used to mean 'at least one', and do not exclude a plurality. The mere fact that certain features are recited does not indicate that a combination of these features  
25 cannot be used to an advantage.

Many variants will be apparent to the person skilled in the art. All variants are understood to be comprised within the scope of the invention.

Claims

1. Jack-up leg comprising a lower end provided with a supporting  
5 device and provided with a leg jacking part arranged to cooperate with a hull jacking part, wherein the lower end of the leg further is provided with an equalizing pressure tank, wherein the tank comprises a top plate and a bottom plate and the tank is provided with at least one air line for allowing air in and/or out of the tank arranged near the top plate and with at least  
10 one equalizing line for allowing water in and/or out of the tank of which a first end is arranged near the bottom plate.
2. Jack-up leg according to claim 1, wherein the bottom plate of the tank is located at a distance above a top side of the supporting device.  
15
3. Jack-up leg according to claim 1 or 2, wherein the tank comprises at least one compartment.
4. Jack-up leg according to claim 3, wherein for the compartments  
20 that are in fluid communication with each other at least one air line and at least one equalizing line is provided and/or for the compartments that are separate at least one air line and at least one equalizing line per compartment is provided.
- 25 5. Jack-up leg according to any of the preceding claims, wherein the tank further comprises a drain valve in the bottom plate of the tank.
6. Jack-up leg according to any of the preceding claims, wherein the equalizing line is arranged as an equalizing pipe having a first end near the  
30 bottom plate inside the tank and having a second end outlet above the top

plate outside the tank or wherein the equalizing line is arranged as a valve in the bottom plate of the tank.

7. Jack-up leg according to any of the preceding claims, further  
5 comprising a second equalizing line for redundancy.

8. Jack-up leg according to any of the preceding claims, wherein the tank further comprises a load control system to control the water level in at least one compartment of the tank to adjust the load contribution of the  
10 tank to the leg load.

9. Jack-up leg according to claim 8 referring to claim 6, wherein the load control system comprises at least one adjustable equalizing pipe wherein the equalizing pipe is adjustable such that the distance of the first  
15 end with respect to the bottom plate is variable.

10. Jack-up leg according to claim 8 referring to claim 6, wherein the load control system comprises at least two equalizing pipes having first end at mutually different distances from the bottom plate inside the tank.  
20

11. Jack-up leg according to any of claims 8 – 10, further comprising a pressure sensor in at least one of a compartment of the tank to measure the water level in the said compartment.

25 12. Jack-up leg according to claim 8, further comprising a second pressure sensor located near the bottom plate inside the compartment, additionally to a pressure sensor located near the top plate in the compartment.

30 13. Jack-up platform comprising a hull and at least three adjustable legs, wherein each leg is provided as a jack-up leg according to any of the

claims 1 – 12 and wherein for each leg a hull jacking part is provided that cooperates with the leg jacking part of the respective leg.

14. Jack-up platform according to claim 13, wherein the bottom plate  
5 of the equalizing pressure tanks of the respective legs is above the water level to allow self-draining of the tanks when the legs are retracted for the jack-up platform to be in floating condition.

15. Jack-up platform according to claim 13 or 14, wherein the  
10 equalizing pressure tank provides for additional stability of the jack-up platform when the jack-up platform is in floating condition.

16. Method to adjust the load on a jack-up leg of a jack-up platform,  
comprising:  
15 - providing an equalizing pressure tank at a lower end of the jack-up leg above a supporting device wherein the tank comprises a top plate and a bottom plate and the tank is provided with at least one air line for allowing air in and/or out of the tank arranged near the top plate and with at least one equalizing line for allowing water in and/or out of the tank of which an  
20 inlet is arranged near the bottom plate, - adjusting the water level inside the equalizing pressure tank depending on the loading condition of the jack-up leg.

17. Method according to claim 16, wherein the water level is adjusted  
25 by supplying pressurized air to the tank.

18. Equalizing pressure tank with one or more compartments  
arranged for mounting at a lower end of a jack-up leg, wherein the tank  
comprises a top plate and a bottom plate and the tank is provided with at  
30 least one air line for allowing air in and/or out of the tank arranged near the top plate and with at least one equalizing line for allowing water in and/or

out of the tank of which a first end is arranged near the bottom plate, wherein the bottom plate of the tank, when mounted on the jack-up leg, is located at a distance above a top side of a supporting device provided at the lower end of the jack-up leg.

5

19. Method for installing a jack-up platform comprising:

- providing an equalizing pressure tank at a lower end of the jack-up leg above a supporting device wherein the tank comprises a top plate and a bottom plate and the tank is provided with at least one air line for allowing  
10 air in and/or out of the tank arranged near the top plate and with at least one equalizing line for allowing water in and/or out of the tank of which a first end is arranged near the bottom plate
- at the determined offshore site, lowering the jack-up legs from the floating condition to an installed condition in which the jack-up legs are engaged to  
15 the sea bottom, while the hull remains floated, wherein during lowering the tank is gradually flooded due to the open equalizer line;
- jacking the hull upward along the jack-up legs from the installed condition to the elevated condition;
- preloading the jack-up legs with the tank filled with water;
- 20 - filling the tank with air depending on the required loading margin.





Fig. 2

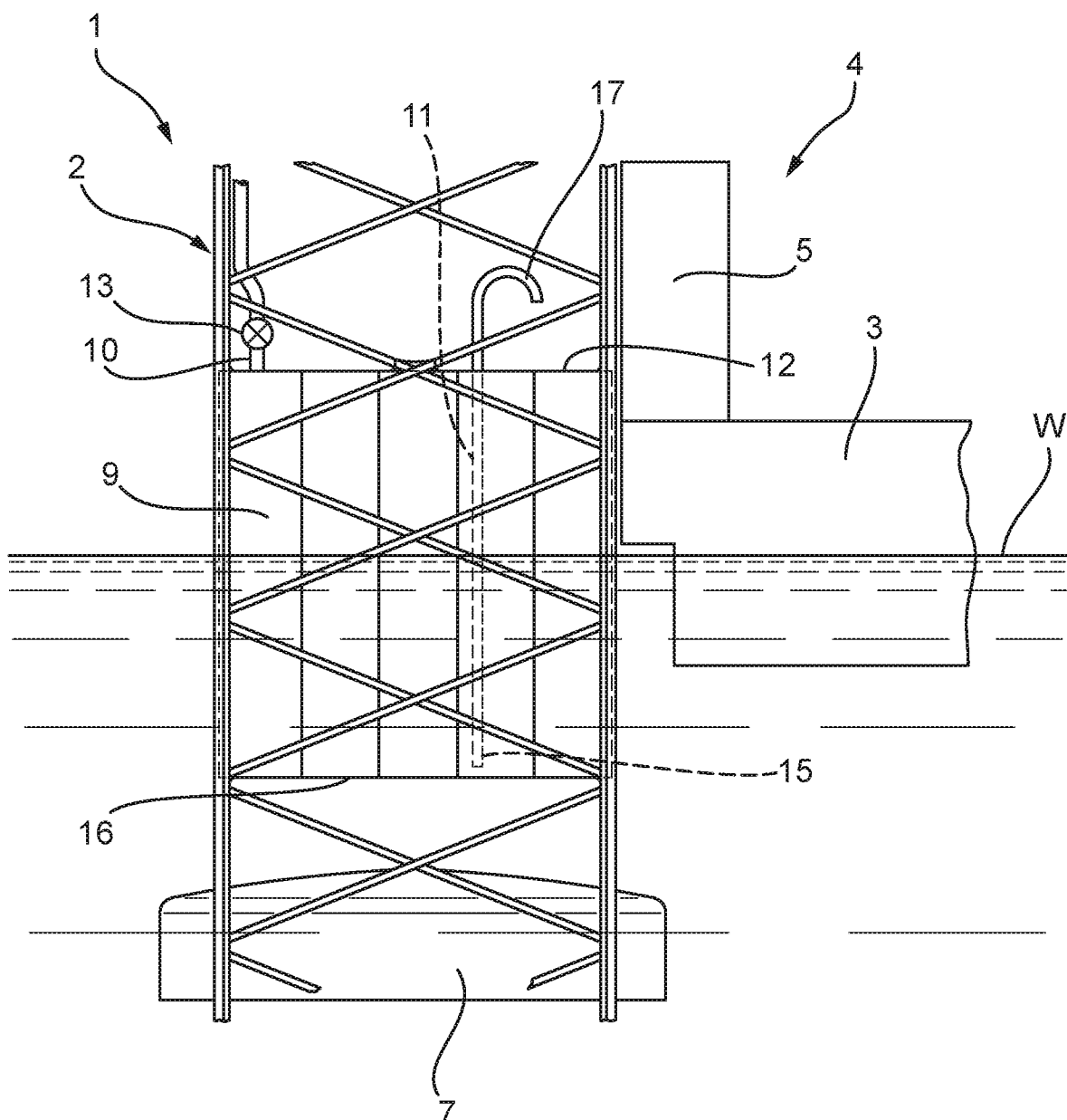


Fig. 3

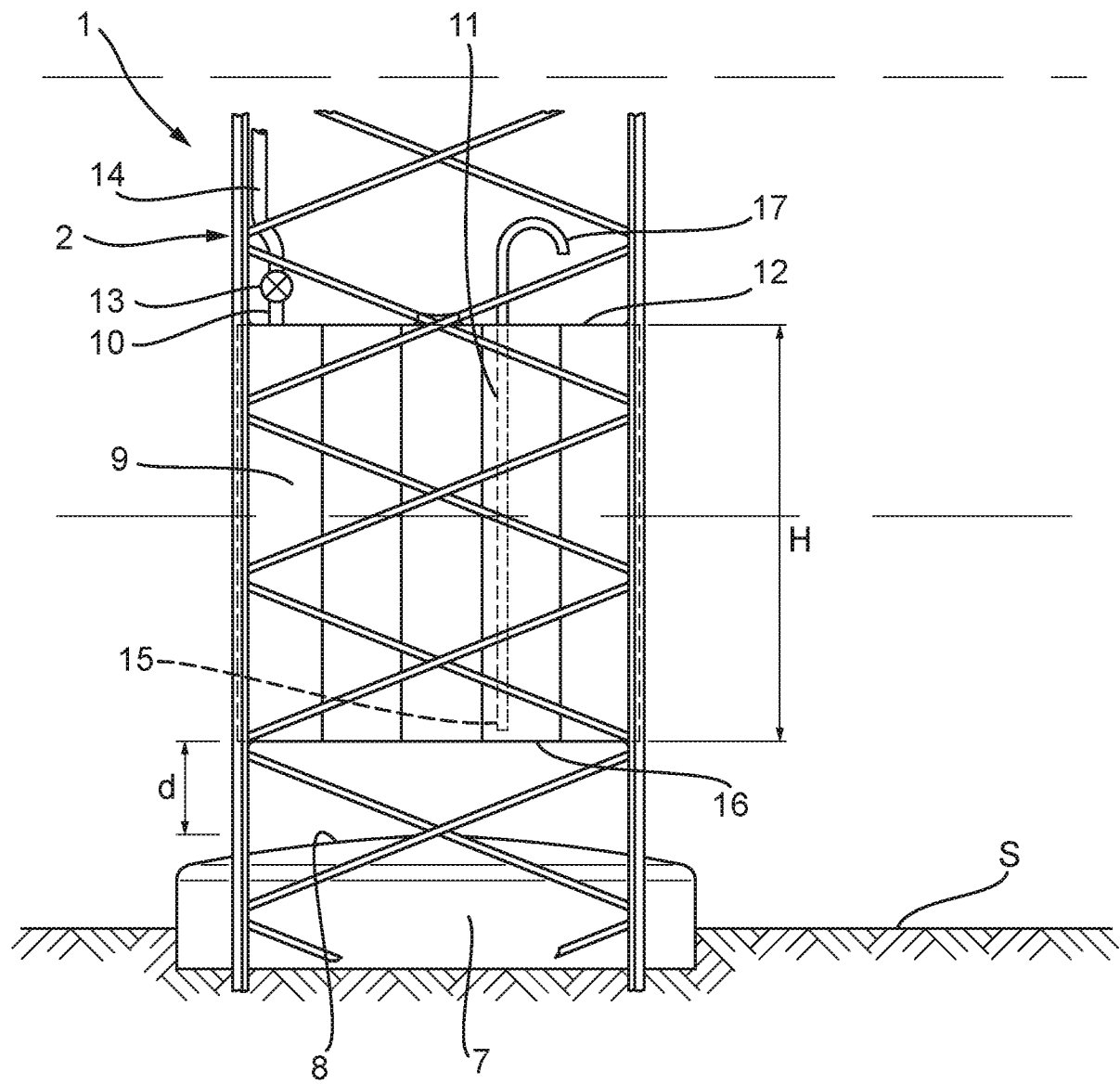


Fig. 4

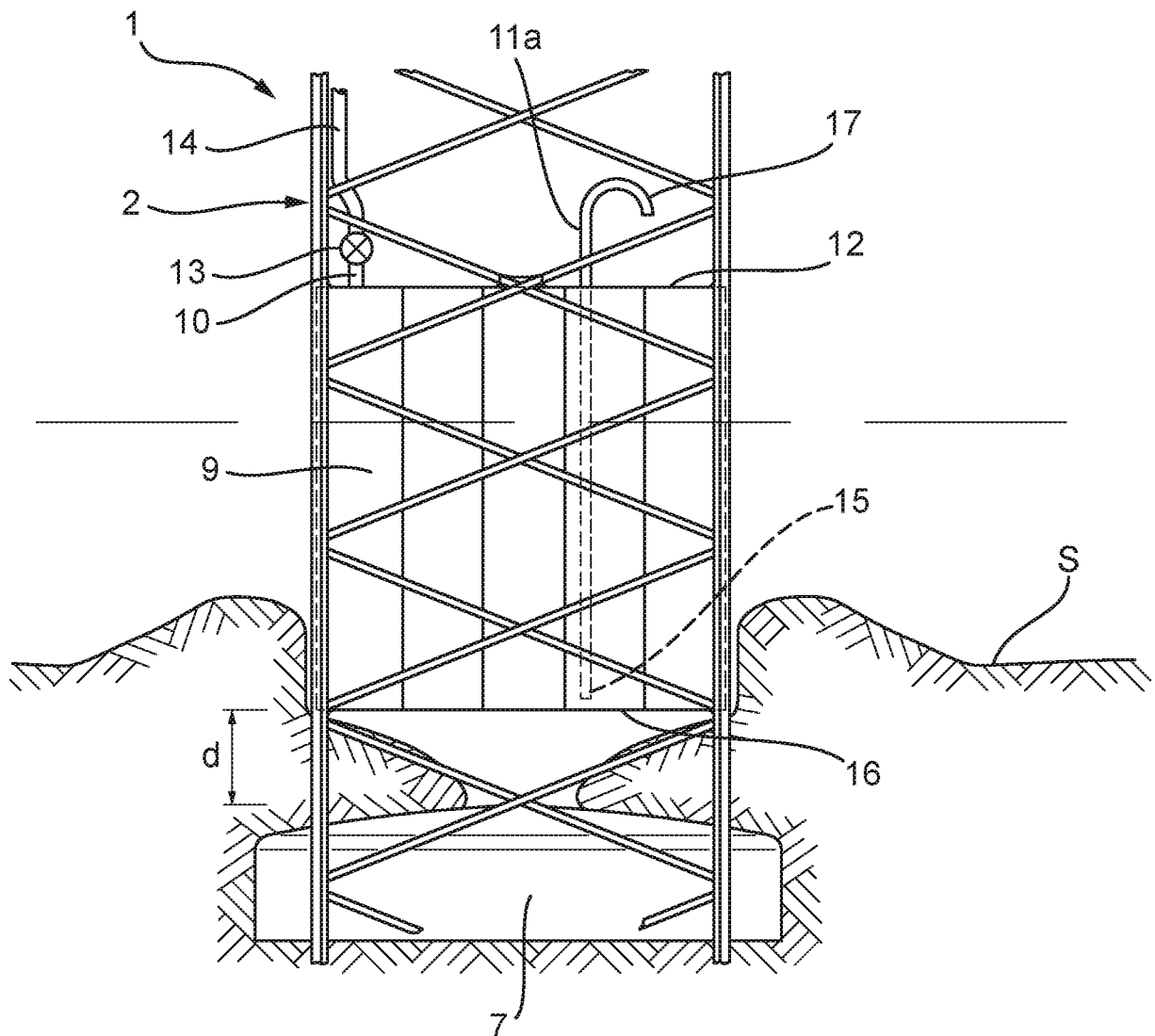


Fig. 5

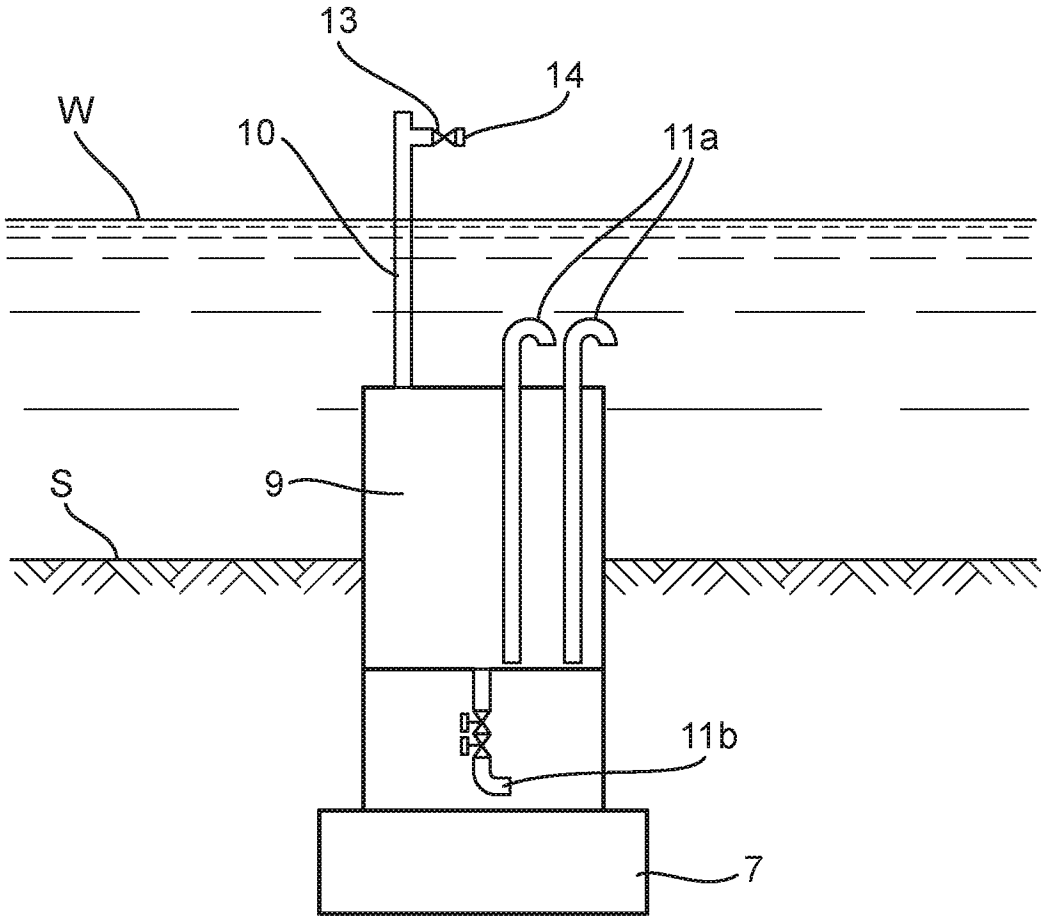


Fig. 6

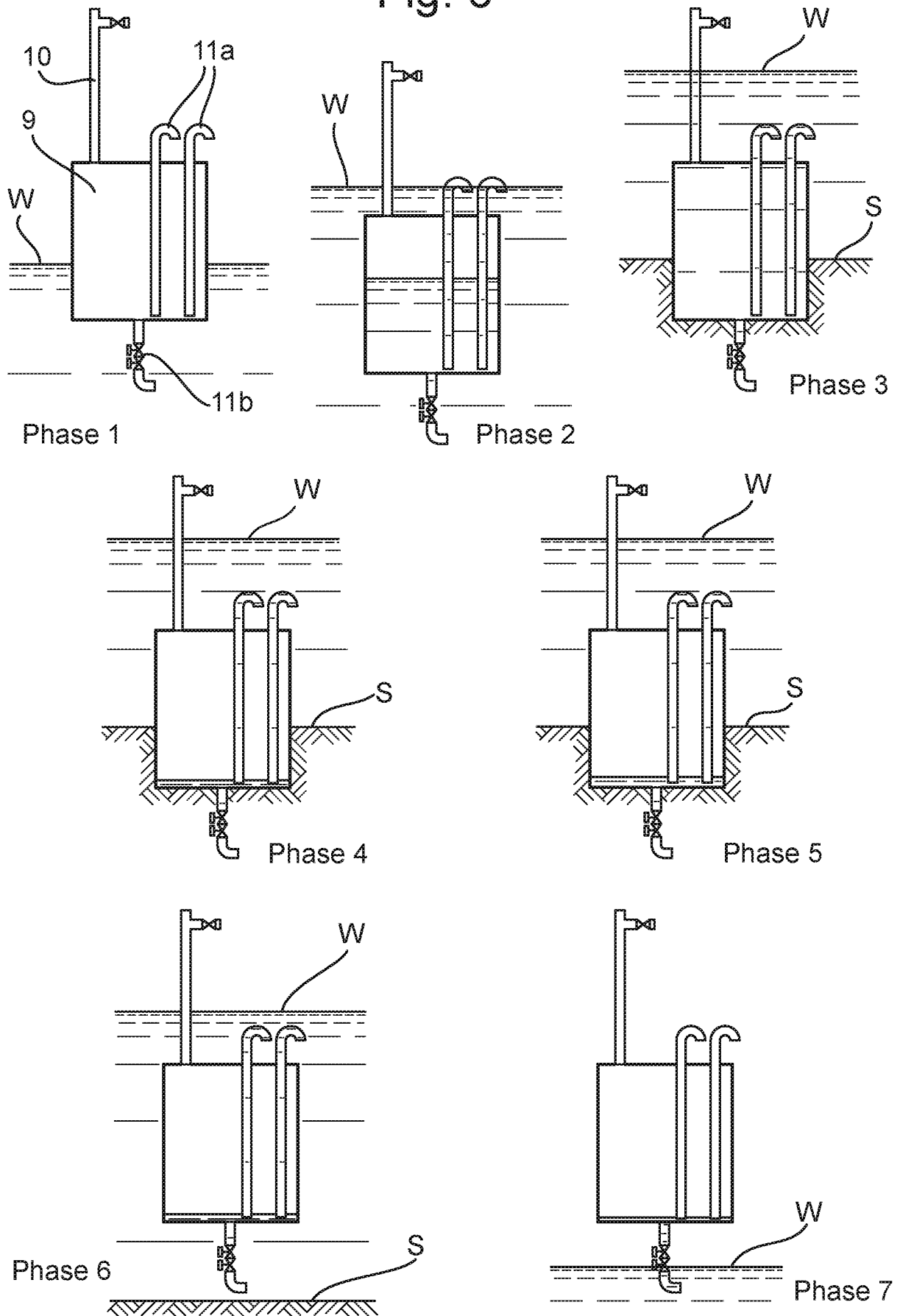


Fig. 7

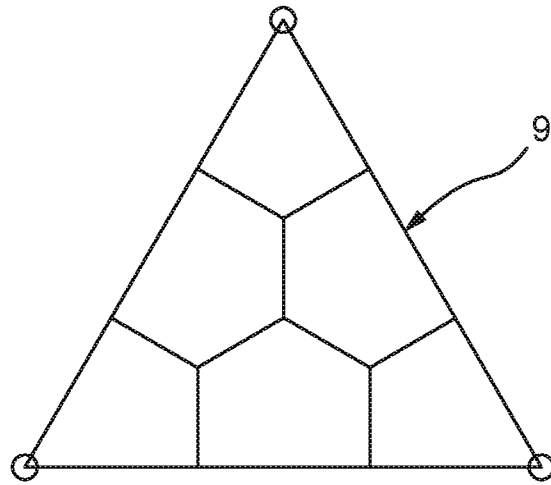
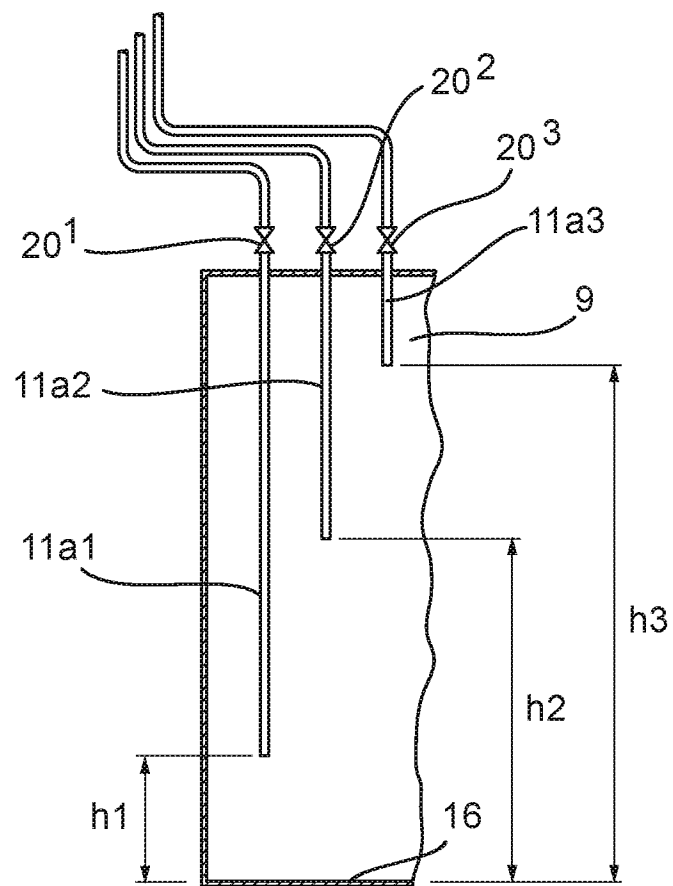


Fig. 8



## INTERNATIONAL SEARCH REPORT

International application No  
PCT/NL2016/050181

## A. CLASSIFICATION OF SUBJECT MATTER

INV. E02B17/00 E02B17/02 B63B35/44  
ADD.

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

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E02B B63B

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

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

EPO-Internal, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                           | Relevant to claim No. |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | US 3 797 256 A (GIBLON R)<br>19 March 1974 (1974-03-19)<br>column 13, line 61 - column 15, line 20;<br>figures 11-17<br>-----                | 1-19                  |
| X         | WO 2011/116254 A2 (NAT OILWELL VARCO LP<br>[US]) 22 September 2011 (2011-09-22)<br>paragraph [0038] - paragraph [0039];<br>figure 3<br>----- | 1,13,16,<br>18,19     |
| X         | WO 2013/064327 A1 (AKER MH AS [NO])<br>10 May 2013 (2013-05-10)<br>page 4, line 16 - page 6, line 13; figures<br>1-14<br>-----               | 1,13,16,<br>18,19     |



Further documents are listed in the continuation of Box C.



See patent family annex.

## \* Special categories of cited documents :

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Date of the actual completion of the international search

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/NL2016/050181

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date         |
|-------------------------------------------|---------------------|----------------------------|-----------------------------|
| US 3797256                                | A                   | 19-03-1974                 | BE 804607 A1 07-03-1974     |
|                                           |                     |                            | DE 2345274 A1 21-03-1974    |
|                                           |                     |                            | ES 418566 A1 01-09-1976     |
|                                           |                     |                            | FR 2199038 A1 05-04-1974    |
|                                           |                     |                            | GB 1446751 A 18-08-1976     |
|                                           |                     |                            | IT 994202 B 20-10-1975      |
|                                           |                     |                            | JP S4968501 A 03-07-1974    |
|                                           |                     |                            | JP S5911008 B2 13-03-1984   |
|                                           |                     |                            | NL 7312471 A 12-03-1974     |
|                                           |                     |                            | NO 142456 B 12-05-1980      |
|                                           |                     |                            | US 3797256 A 19-03-1974     |
| WO 2011116254                             | A2                  | 22-09-2011                 | EP 2547829 A2 23-01-2013    |
|                                           |                     |                            | US 2013189038 A1 25-07-2013 |
|                                           |                     |                            | WO 2011116254 A2 22-09-2011 |
| WO 2013064327                             | A1                  | 10-05-2013                 | EP 2776633 A1 17-09-2014    |
|                                           |                     |                            | NO 333631 B1 29-07-2013     |
|                                           |                     |                            | WO 2013064327 A1 10-05-2013 |