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(71) Applicant: **Single Buoy Moorings, Inc.**
1723 Marly (CH)

(72) Inventors:
- **Wille, Hein**
  F-06360, Eze (FR)
- **Pollack, Jack**
  98000, Monte-Carlo (MC)

(74) Representative: **van Westenbrugge, Andries**
Nederlandsch Octrooibureau
Postbus 29720
2502 LS Den Haag (NL)

(54) Method for installing an off-shore structure

(57) An off-shore structure is installed in a body of water. The body of water extends above a floor, such as a seabed, and has a water surface. A buoyant pontoon and a top structure are provided separately from each other. The top structure has a deck, a plurality of legs that are connected to the deck, and a jacking system for displacing the legs relative to the deck. The pontoon is submerged below the water surface. The submerged pontoon is connected to the floor with tendons. The top structure is aligned above the submerged pontoon connected to the floor. Then, the legs are jacked-down relative to the deck until the legs abut against the submerged pontoon connected to the floor. Subsequently, the jacked-down legs are attached to the submerged pontoon and the deck is jacked-up relative to the pontoon until the deck is standing above the water surface. A number of risers are installed for providing a fluid communication between the floor and the deck after jacking up the deck above the water surface.

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Description

[0001] The invention relates to a method for installing an off-shore structure in a body of water extending above a floor, such as a seabed, the body of water having a water surface, the method comprising:

- providing a pontoon having buoyancy and a top structure having a deck, a plurality of legs that are connected to the deck, and a jacking system for displacing the legs relative to the deck,
- submerging the pontoon below the water surface,
- connecting the submerged pontoon to the floor with tendons,
- aligning the top structure above the submerged pontoon connected to the floor,
- jacking down the legs relative to the deck until the legs abut against the submerged pontoon connected to the floor,
- attaching the jacked-down legs to the submerged pontoon connected to the floor,
- jacking up the deck relative to the submerged pontoon connected to the floor until the deck is standing above the water surface.

[0002] US2002/0067958 discloses a method for installing a tension leg platform (TLP). A base is maintained in position on the seabed. A buoyant, submerged hull is anchored to the base by tendons. The buoyancy of the hull ensures that the tendons are kept under tension. A jack-up platform has legs which can be raised or lowered. The jack-up platform is mounted so as to be floating directly above the submerged hull. The legs of the jack-up platform are lowered to rest on the hull and then further jacked such that the platform is raised clear of the water surface.

[0003] Flexible or rigid conduits are pre-installed between the base and the submerged hull. The upper ends of these conduits are located at the submerged hull. When the platform is standing above the water surface, transfer lines are lowered from the platform and are attached to the upper ends of the conduits. Thus, the conduits and transfer lines constitute risers for transporting oil, gas, or any other fluid being produced from the seabed to the platform.

[0004] The jack-up platform may be for drilling operations, production operations or a combination of these. When the platform is for drilling operations, it will be difficult to drill well-heads in the seabed and connect them to the pre-installed risers. Furthermore, once the well-heads are drilled in the seabed and connected to the risers, it will be cumbersome to expand the number of well-heads and risers. This leads to limited flexibility during drilling programmes. For example, if the performance of a well during operation turns out to be higher than expected, the costs of increasing the number of risers are relatively high.

[0005] An object of the invention is to provide an improved method for installing an off-shore structure.

[0006] This object is achieved according to the invention in that a number of risers are installed for providing a fluid communication between the floor and at least the pontoon after jacking up the deck above the water surface. Thus, a number of risers are not pre-installed, but installed after the off-shore structure is completed, i.e. after the tendons between the pontoon and the seabed are tensioned due to the buoyancy of the pontoon and the deck is raised clear of the water surface. As a result, the number of risers can easily be expanded during operation.

[0007] It is noted that the risers installed after jacking up the deck above the water surface may extend fully between the floor and the deck. However, it is also possible that transfer lines are already pre-installed between the pontoon and the deck, such as in the form of hard piping. After jacking up the deck above the water surface the fluid communication between the floor and the deck is then established by installing the risers between the floor and the pontoon. These risers are connected to the pre-installed transfer lines at the pontoon.

[0008] For example, the risers comprise steel vertical risers. It is also possible that the risers comprise steel catenary risers (SCR) that are connected to hard piping on the pontoon that leads to the deck. The SCR's would then catenary away from the pontoon.

[0009] It is possible that the method comprises drilling a first group of well heads in the floor after jacking up the deck above the water surface, and wherein subsequently risers are installed for providing a fluid communication between said first group of well heads and the deck. Also, the method may comprise drilling a second group of well heads in the floor after drilling the first group of well heads, wherein subsequently risers are installed for providing a fluid communication between said second group of well heads and the deck.

[0010] According to a drilling programme, a first group of well heads may be drilled. These well heads are connected to the deck by associated risers. If the oil or gas field is performing better than expected, the productivity of the off-shore structure may be increased by drilling a second group of well-heads and connecting these well-heads to the deck by further dedicated risers. Thus, the installation of the off-shore structure continues after it has already been put into service. Instead of continued installation the expansion of the off-shore structure according to the invention may be considered as a method for operating the off-shore structure.

[0011] It is possible that the pontoon is submerged by decreasing its buoyancy, and after connecting the submerged pontoon to the floor with tendons the buoyancy of the pontoon is increased so as to tension the tendons before the legs of the top structure are jacked-down. Prior to receiving the top structure buoyancy is added to the pontoon. For example, when the buoyancy of the pontoon has been decreased by ballasting, it may be increased by deballasting. Alternatively, the pontoon may

have open buoyancy chambers for adjusting the buoyancy of the pontoon. The pontoon may also use a combination of ballasting/deballasting and open buoyancy chambers.

[0012] The buoyancy of the pontoon may be adjusted after the legs of the top structure have been jacked-down and abut against the pontoon. In this case, deballasting and/or buoyancy adjustment is also carried out after the top structure floats over the submerged pontoon and the legs are connected to it.

[0013] It is possible that the buoyancy of the pontoon is adjusted after risers are installed. These adjustments of the buoyancy of the pontoon are made for compensating additional weight of risers. This additional weight occurs when a second group of well heads is drilled and connected to the deck by additional risers, for example, as part of an expanded drilling programme. Also, it may be desired to adjust the buoyancy of the pontoon after displacing large equipment on the deck, such as a drilling rig.

[0014] The pontoon may be submerged below the wave active zone. The wave active zone is the zone adjacent to the water surface in which any buoyant or floating structure is subjected to forces resulting from the waves acting on the structure. Wind forces or or possibly other forces may also act on the structure in the wave active zone. In most circumstances the wave active zone does not extend deeper than 30 meters below the water surface. However, under certain operational conditions the wave active zone may extend to a lesser or greater depth.

[0015] It is possible that the pontoon comprises a hollow column extending substantially vertically along a side of the pontoon, the hollow column having an upper end and a lower end, the upper end extending above the water surface and the lower end being submerged. The column improves stability during lowering the pontoon and also when the pontoon is at its submerged position.

[0016] In this case, drilling may be carried out through the hollow column after the pontoon is submerged and connected to the floor and before the top structure is aligned above the pontoon. If the pontoon and the top structure are separate from each other, they may travel separately from each other to the installation site. Drilling activities may take place through the column of the pontoon before the deck arrives.

[0017] Also, the risers may be guided through the hollow column. When the risers comprise steel vertical risers they may extend through the hollow column. In the case of SCR's they may catenary away from the pontoon. The upper ends of the SCR's are connected to hard piping on the pontoon which is placed within the hollow column and leads to the deck. The column protects the steel vertical risers or the hard piping of the risers against wave impacts and currents.

[0018] It is possible that the lower end of the column is closed. As a result, the column provides additional buoyancy and stability to the pontoon when it is transported to the installation site or during lowering the pontoon to its submerged position.

[0019] It is possible that the pontoon comprises a number of openings that extend through the pontoon, wherein the risers are guided through the openings of the pontoon. In this case, the pontoon has a number of openings, i.e. one or more openings. When the pontoon comprises only one opening for the risers, it may be a central opening or moonpool which, for example, is provided with a riser guiding grid. Also, it is possible that a plurality of openings is provided in the pontoon, each opening being adapted for guiding one or more risers through the pontoon.

[0020] It is possible that the tendons have lower ends and upper ends, the upper ends being provided with buoyancy members that can be removed, and wherein the lower ends are connected to the floor before submerging the pontoon, and wherein the buoyancy members are removed from the upper ends after submerging the pontoon and connecting the upper ends to the submerged pontoon. In this case, the tendons are installed prior to the arrival of the pontoon. The upper ends of the pre-installed tendons are provided with buoyancy members to keep the tendons in a vertical position.

[0021] It is noted that the installation of the pontoon may be carried out in various ways. For example, the upper ends of the tendons may be attached to the pontoon while it is still at the water surface, after which the pontoon with the tendons are lowered together. Then, the lower ends of the tendons may be connected to the floor. Alternatively, the pontoon may be lowered to its submerged position, after which the lower ends of the tendons are connected to the floor and once all lower ends are anchored the upper ends of the tendons are connected to the submerged pontoon. As a further example, the upper ends of the tendons may be connected to the submerged pontoon before connecting the lower ends to the floor.

[0022] The invention also relates to an off-shore structure installed by a method as described above.

[0023] Furthermore, the invention relates to a method for operating an off-shore structure in a body of water extending above a floor, such as a seabed, the body of water having a water surface, the off-shore structure comprising:

- a submerged pontoon connected to the floor with tendons that are under tension due to the buoyancy of the pontoon,
- a top structure having a deck that is standing above the water surface, a plurality of legs that are connected between the deck and the submerged pontoon, and
- a number of risers for providing a fluid communication between a first group of drilled well heads in the floor and at least the pontoon. These risers may extend to the pontoon or to the deck. According to the invention the method comprises drilling a second

group of well heads and installing a number of risers for providing a fluid communication between the second group of drilled well heads in the floor and at least the pontoon. The risers associated with the second group of drilled well heads may be installed between the floor and the pontoon or the deck.

[0024] The invention will now be described, merely by way of examples, with reference to the accompanying drawing.

[0025] Figure 1a, 1b, 1c show various embodiments of the pontoon and the top structure being towed to an installation site.

[0026] Figure 2a, 2b, 2c, 2d show the pontoons depicted in figures 1a, 1b, 1c being lowered and connected to the seabed by tendons.

[0027] Figure 3 shows that the buoyancy of the pontoon is increased for tensioning the tendons.

[0028] Figure 4 shows the legs of the top structure being jacked-down to the pontoon.

[0029] Figure 5 shows drilling activities from the deck of the top structure.

[0030] Figure 6 shows that risers are guided from the deck through the pontoon guides and to the seabed.

[0031] Figure 7a, 7b, 7c show that drilling takes place through the substantially vertical column of a side of the pontoon depicted in figure 1c.

[0032] Figure 8 shows an operational off-shore structure with SCR's connected to a pontoon depicted figure 1c.

[0033] The figures show schematically several variations of a method for installing an off-shore structure, in particular a tension leg platform (TLP), in a body of water 3. The body of water 3 is usually an open sea, but other bodies of water are not excluded. The sea 3 has a water surface 4 and a seabed 5. A wave active zone 6 extends under the water surface 4.

[0034] Figure 1a shows a self-floating pontoon 7 being towed by a tug boat 11 to an installation site. A top structure 9 is towed separately from the pontoon 7 by another tugboat 12 to the installation site. Thus, before installing the off-shore structure the pontoon 7 and the top structure 9 are separate from each other, and the pontoon 7 and the top structure 9 travel separately from each other to the installation site.

[0035] The top structure 9 is provided with a jack-up deck or platform 18 and a plurality of legs 20. Although truss-like legs 20 are shown in figure 1a, the legs may be constructed in a different manner, e.g. as cylindrical legs. The legs 20 are connected to the deck 18 so that they can be raised or lowered relative to the deck 20 by a jacking system (not shown). For example, the jacking system comprises electric jacks, hydraulic jacks, winches and/or other means. While under tow the legs 20 are raised so as not to drag in the water. The top structure 9 comprises topsides that are placed on the deck 18. Although various installations and equipment are provided on the deck 18, figure 1a only shows a drilling rig 22.

[0036] The self-floating pontoon 7 comprises closed buoyancy chambers and/or open buoyancy chambers (not shown). The pontoon 7 has leg receiving and locking devices 14. In the exemplary embodiment shown in figure 1a the leg receiving and locking devices are formed by cavities 14, in which the legs 20 of the top structure 9 can be stabbed. This pontoon 7 has riser openings 16 that are adapted for guiding risers through the pontoon 7. The risers are installed through the openings 16 in a later phase of the procedure for installing the TLP, as will be described below.

[0037] Figure 1b shows a top structure 9 that has no buoyancy and is not self-floating. It is transported on an installation vessel or lift-up barge. Figure 1b also shows a second embodiment of the pontoon 7, which is provided with buoyant columns 24. As a result of the buoyant columns 24 the centre of gravity will be below the centre of buoyancy when the pontoon is being lowered. The buoyant columns 24 improve the stability of the pontoon 7 during its descent. The pontoon 7 shown in figure 1b is provided with a central opening or moonpool 26 which can be provided with a riser grid (not shown). The risers can be installed through the riser grid and maintained in position relative to each other. As will be described below the risers are installed in a later phase of the TLP installation procedure.

[0038] Figure 1c shows a preferred embodiment of the pontoon 7, which comprises a hollow column 28 extending substantially vertically at a side of the pontoon 7. The column 28 is able to protect drill strings and/or hard fluid transfer piping that can be provided within the column 28. The column 28 has an upper end 29 and a lower end 30. The upper end 29 protrudes above the water surface 4, whereas the lower end 30 can be submerged in the water 3 while being towed to the installation site. The lower end 30 of the column 28 can be closed which provides additional buoyancy and stability to the pontoon when it travels to the installation site and/or during the lowering of the pontoon 7. The buoyancy of column 28 helps to control the descent of the pontoon 7 during the lowering operation. Temporary buoyancy elements may be added to stabilize the pontoon during transport or descent. These temporary buoyancy elements can be removed when desired, e.g. after the pontoon has arrived at the installation site. Of course, the pontoon 7 having the column 28 may also be towed to the installation site floating on the water surface (not shown).

[0039] Any combination of pontoon 7 and top structure 9 shown in figures 1a, 1b, 1c is possible as well.

[0040] Figures 2a-2d show various ways of lowering of the pontoon 7 at the installation site and connecting the pontoon 7 to the seabed 5 by tendons 32. In figure 2a and 2c the tendons 32 are installed before the arrival of the pontoon 7. The pre-installed tendons 32 have upper ends 33 and lower ends 34. The lower ends 34 are attached to to the seabed 5. The upper ends 33 are provided with temporary buoyancy elements 35 to maintain the tendons 32 in a vertical position.

[0041] The buoyancy of the pontoon 7 is decreased, for example by ballasting. As a result, the pontoon 7 is lowered to a submerged position under the wave active zone. Thus, the submerged pontoon 7 is normally located at least 30 meters below the water surface, such as deeper than 50 meters or at a depth of 100 meters or more. Once the pontoon 7 is at the desired depth the upper ends 33 of the tendons 32 are secured to the pontoon 7 and additional buoyancy is added to the pontoon 7. An ROV or other device may be used in the process. Then, the temporary buoyancy elements 35 may be removed.

[0042] Alternatively, the upper ends 33 of the tendons 32 are attached to the pontoon 7 when it is still at the water surface 4 (see figure 2b). Then, the pontoon 7 with the tendons 32 are lowered together and the lower ends 34 of the tendons 32 are attached to the seabed 5, such as in anchoring piles 31 that are pre-installed in the seabed 5.

[0043] Figure 2d shows another alternative, wherein the pontoon 7 is lowered to its submerged position. The lower ends 34 of the tendons 32 are connected to the seabed 5, e.g. by stabbing the lower ends 34 in anchoring piles 31 pre-installed in the seabed 5 using an ROV. Once all lower ends 34 of the tendons 32 are attached, the upper ends 33 of the tendons 32 are connected to the submerged pontoon 7.

[0044] Of course, the ways of submerging the pontoon and connecting the submerged pontoon to the seabed with tendons as shown in figures 2a-2d may be applied to any pontoon 7. The pontoons 7 shown in figures 2a-2d may be constructed as any pontoon according to figure 1a, 1b or 1c. For example, figure 2b may be combined with a pontoon having a column 28.

[0045] Figure 3 shows the pontoon 7 connected to the seabed 5 by the tendons 32. The buoyancy of the pontoon 7 is now increased, for example by de-ballasting the pontoon 7. As a result the tendons 32 are tensioned to a greater extent. Next, the top structure 9 is aligned above the submerged pontoon 7, e.g. by a float-over procedure.

[0046] As shown in figure 4 the legs 20 are jacked-down relative to the deck 18 into the leg receiving and locking devices 14 of the pontoon 7. Before jacking down the legs 20, the buoyancy of the pontoon 7 is checked and adjusted so that the tendons 32 will have the correct tension when the pontoon 7 supports the top structure 9. After the legs 20 are secured into the leg receiving and locking devices and the pontoon 7 supports the full weight of the top structure 9, the deck 18 can be jacked-up so as to be standing above the water surface 4. The submerged pontoon 7 attached to the seabed 5 by the tensioned tendons 32 and the top structure 9 resting on the pontoon 7 with the legs 20 constitute a completed TLP.

[0047] The installation of the completed TLP is now expanded as shown in figures 5 and 6. In figure 5 drilling is performed from the deck 18. Then, risers 37 are connected between the deck 18 and the seabed 5 (see figure 6). The risers 37 may extend through the openings 16 of the pontoon 7. Normally the risers 37 are guided from the deck 18 through the pontoon 7. After installing the risers 37 the buoyancy of the pontoon 7 is adjusted again. This adjustment compensates the addition of weight of the risers 37 and/or displacement of large equipment, such as the drilling rig 22 on the deck 18.

[0048] Figures 7a, 7b, 7c show that drilling may be carried out through the hollow column 28 of the pontoon shown in figure 1c. The drilling activities may take place from a drilling rig 39 that can be displaced horizontally on the deck 18 (see figure 7a). Alternatively, it is possible to drill through the hollow column 28 from a semi-sub drilling derrick 40. In figure 7b the derrick 40 is temporarily placed next to the submerged pontoon 7 that is connected to the seabed 5, but without the top structure being installed. Figure 7c shows drilling from the derrick 40 when it is placed next to a completed TLP, i.e. when the top structure 9 has been installed on the pontoon 7.

[0049] Figure 7c illustrates that it is possible that the TLP is temporarily displaced by the derrick 40 and/or using a tug boat so that wells can be drilled vertically under the TLP. This drilling and work-over technology can also be performed for the TLP structures shown in figures 5, 6, 7a and 7b.

[0050] Also in the embodiment of the pontoon 7 having a hollow column 28 the risers 37 are installed after the TLP has been completed. The risers 37 may be constructed in various ways. The risers 37 may be rigid vertical risers, for example made of steel, composite materials or any combination thereof, or steel catenary risers that are connected to the pontoon 7 and the deck 18 (see figure 8). In the case of steel catenary risers they can be attached to the pontoon 7 and catenary away from the pontoon 7 towards the seabed 5.

[0051] The steel catenary risers 37 are coupled to hard piping 38 on the pontoon 7 and within the hollow column 28. The hard piping 38 leads to topside equipment placed on the deck 18. The hard piping 38 within the hollow column 28 is protected in the wave active zone 6 against wave impacts and currents. If the column 28 is closed at its lower end the interior of the column 28 forms a substantially dry environment for the hard piping 38. Also the column 28 gives access to the pontoon 7 for inspection and maintenance.

[0052] When an oil field performs better than expected, the TLP can be expanded in a relatively simple manner. Also after the TLP has been put into service, it is straightforward to carry out additional drilling and install additional risers. After installing additional risers the buoyancy of the pontoon is adjusted again.

[0053] It is noted that the buoyancy of the pontoon 7 can be adjusted in various ways - this applies to all stages of the installation method. As mentioned above, the buoyancy of the pontoon 7 can be decreased and increased by ballasting and de-ballasting, respectively. However, it is also possible to adjust the buoyancy of the pontoon using open buoyancy chambers. This can be done via equipment placed on the deck or via the tug or installation vessel.

[0054] It should be understood that the term "tendon" is used broadly for any member for connecting the pontoon to the seabed, such as wires, cables, tethers, pipes, riser pipes, chains or other, such that they are under tension due to the buoyancy of the pontoon. The tendons can be made of steel, polyester or any other suitable material.

[0055] The invention is not limited to the examples described above. The skilled person may derive various modifications of the installation method and the resulting off-shore structure that are within the scope of the invention.

Claims

1. Method for installing an off-shore structure (1) in a body of water (3) extending above a floor (5), such as a seabed, the body of water (3) having a water surface (4), the method comprising:

   - providing a pontoon (7) having buoyancy and a top structure (9) having a deck (18), a plurality of legs (20) that are connected to the deck (18), and a jacking system for displacing the legs (20) relative to the deck (18),
   - submerging the pontoon (7) below the water surface (4),
   - connecting the submerged pontoon (7) to the floor (5) with tendons (32),
   - aligning the top structure (9) above the submerged pontoon (7) connected to the floor (5),
   - jacking down the legs (20) relative to the deck (18) until the legs (20) abut against the submerged pontoon (7) connected to the floor (5),
   - attaching the jacked-down legs (20) to the submerged pontoon (7) connected to the floor (5),
   - jacking up the deck (18) relative to the submerged pontoon (7) connected to the floor (5) until the deck (18) is standing above the water surface (4),

   characterized in that a number of risers (37) are installed for providing a fluid communication between the floor (5) and at least the pontoon (7) after jacking up the deck (18) above the water surface (4).

2. Method according to claim 1, wherein the method comprises drilling a first group of well heads in the floor (5) after jacking up the deck (18) above the water surface (4), and wherein subsequently risers (37) are installed for providing a fluid communication between said first group of well heads and the deck (18).

3. Method according to claim 2, wherein the method comprises drilling a second group of well heads in the floor (5) after drilling the first group of well heads, wherein subsequently risers (37) are installed for providing a fluid communication between said second group of well heads and the deck (18).

4. Method according to one of the preceding claims, wherein the pontoon (7) is submerged by decreasing its buoyancy, and after connecting the submerged pontoon (7) to the floor (5) with tendons (32) the buoyancy of the pontoon (7) is increased so as to tension the tendons (32) before the legs (20) of the top structure (9) are jacked-down.

5. Method according to claim 4, wherein the buoyancy of the pontoon (7) is adjusted after the legs (20) of the top structure (9) have been jacked-down and abut against the pontoon (7).

6. Method according to one of the preceding claims, wherein the buoyancy of the pontoon (7) is adjusted after risers (37) are installed.

7. Method according to one of the preceding claims, wherein the pontoon (7) is submerged below the wave active zone (6).

8. Method according to one of the preceding claims, wherein the pontoon (7) comprises a hollow column (28) extending substantially vertically along a side of the pontoon (7), the hollow column (28) having an upper end (29) and a lower end (30), the upper end (29) extending above the water surface (4) and the lower end (30) being submerged.

9. Method according to claim 8, wherein drilling is carried out through the hollow column (28) after the pontoon (7) is submerged and connected to the floor (5) and before the top structure (9) is aligned above the pontoon (7).

10. Method according to claim 9, wherein the risers (37) are guided through the hollow column (28).

11. Method according to one of the claim 8-10, wherein the lower end (30) of the column (28) is closed.

12. Method according to one of the claim 8-11, wherein the pontoon (7) is submerged to a depth such that the lower end (30) of the column (28) is located below the wave active zone (6).

13. Method according to one of the preceding claims, wherein the pontoon (7) comprises a number of openings (16) that extend through the pontoon (7), wherein the risers (37) are guided through the openings (16) of the pontoon (7).

14. Method according to one of the preceding claims, wherein the tendons (32) have lower ends (34) and

upper ends (33), the upper ends (33) being provided with buoyancy members (35) that can be removed, and wherein the lower ends (34) are connected to the floor (5) before submerging the pontoon (7), and wherein the buoyancy members (35) are removed from the upper ends (33) after submerging the pontoon (7) and connecting the upper ends (33) to the submerged pontoon (7).

15. Off-shore structure (1) installed by a method according to one of the preceding claims.

16. Method for operating an off-shore structure (1) in a body of water (3) extending above a floor (5), such as a seabed, the body of water (3) having a water surface (4), the off-shore structure (1) comprising:

- a submerged pontoon (7) connected to the floor (5) with tendons (32) that are under tension due to the buoyancy of the pontoon (7),
- a top structure (9) having a deck (18) that is standing above the water surface (4), a plurality of legs (20) that are connected between the deck (18) and the submerged pontoon (7), and
- a number of risers (37) for providing a fluid communication between a first group of drilled well heads in the floor (5) and at least the pontoon (7),

characterized in that the method comprises drilling a second group of well heads and installing a number of risers (37) for providing a fluid communication between the second group of drilled well heads in the floor (5) and at least the pontoon (7).

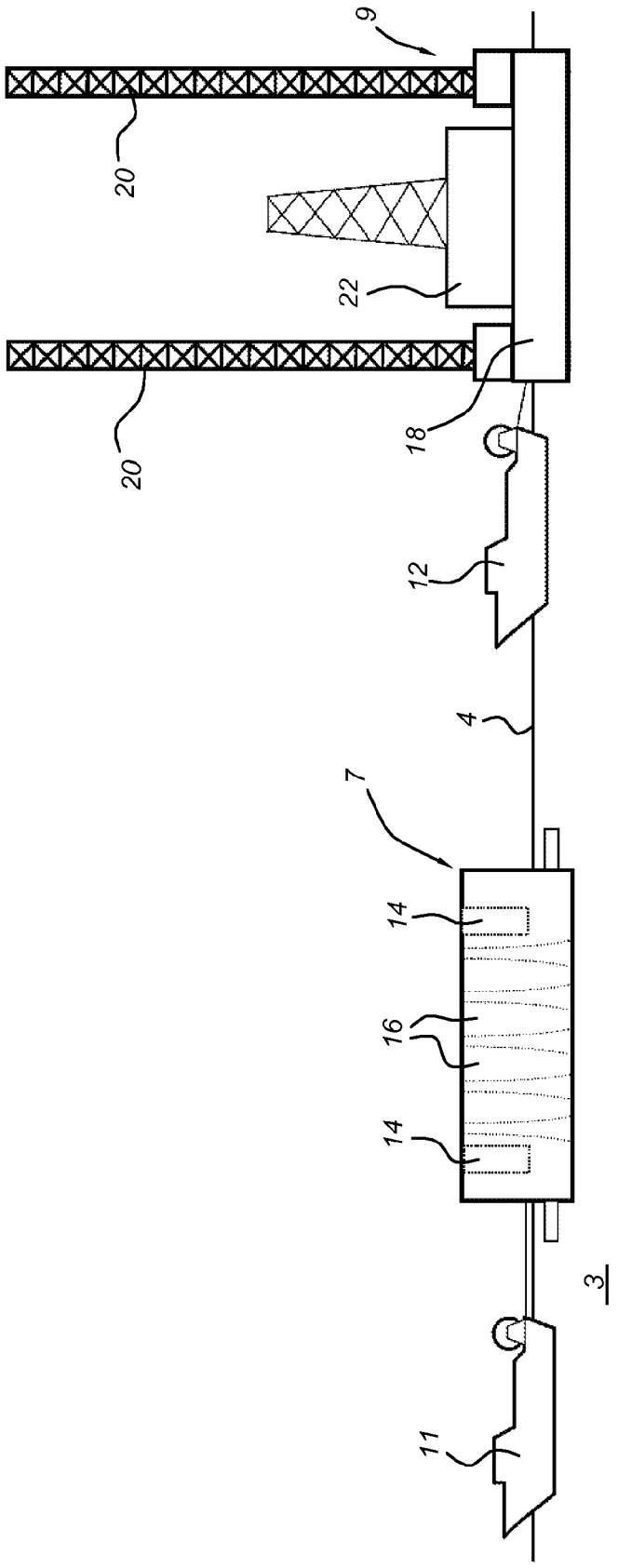


Fig 1a

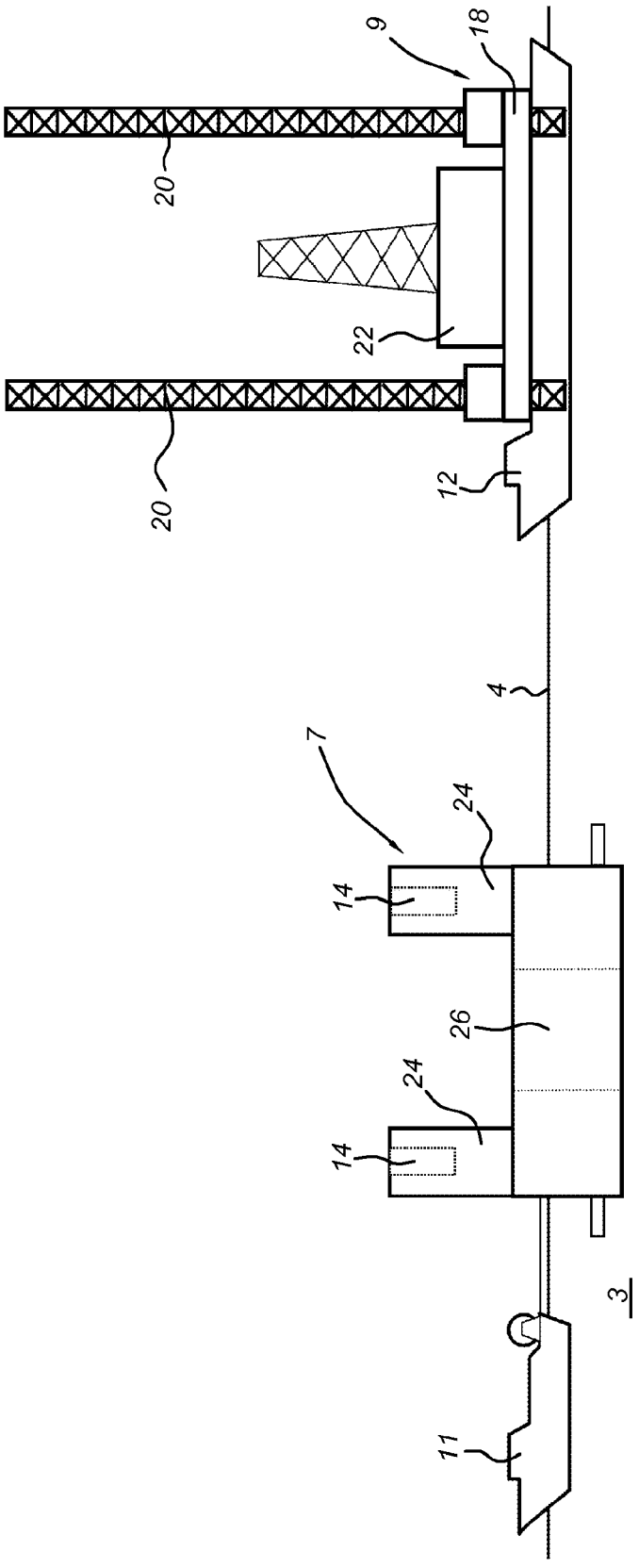


Fig 1b

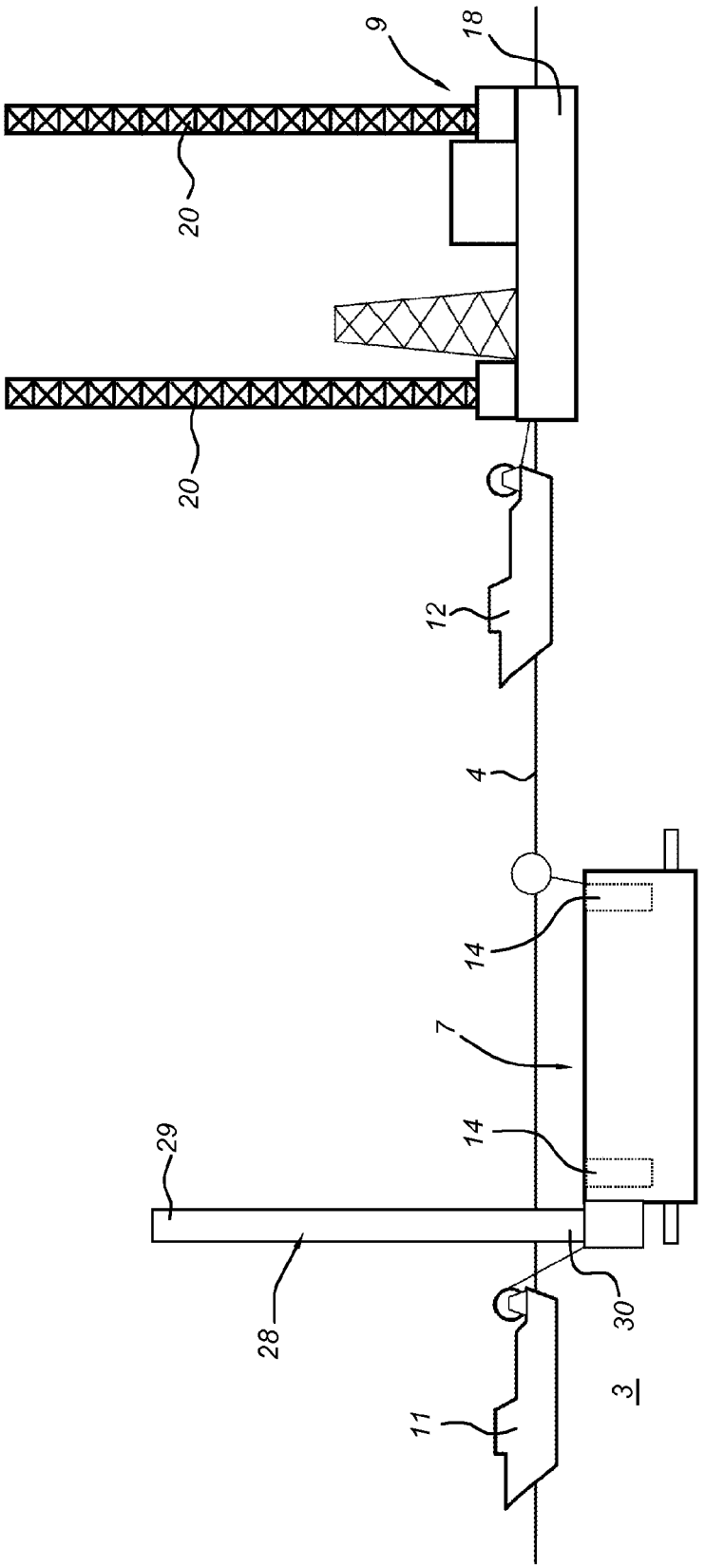


Fig 1c

Fig 2a

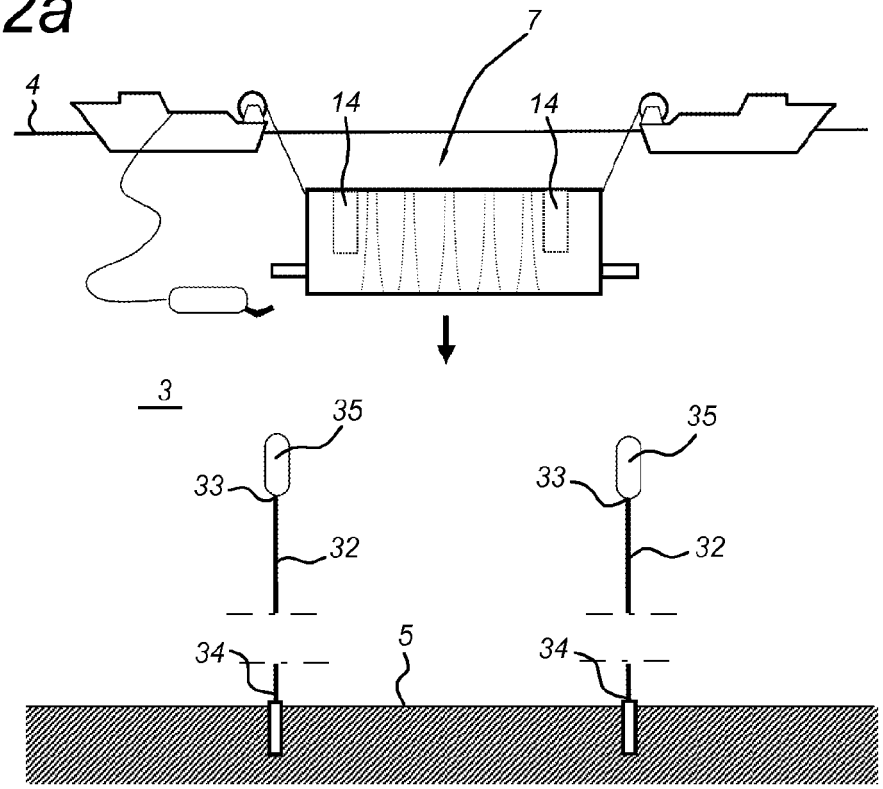


Fig 2b

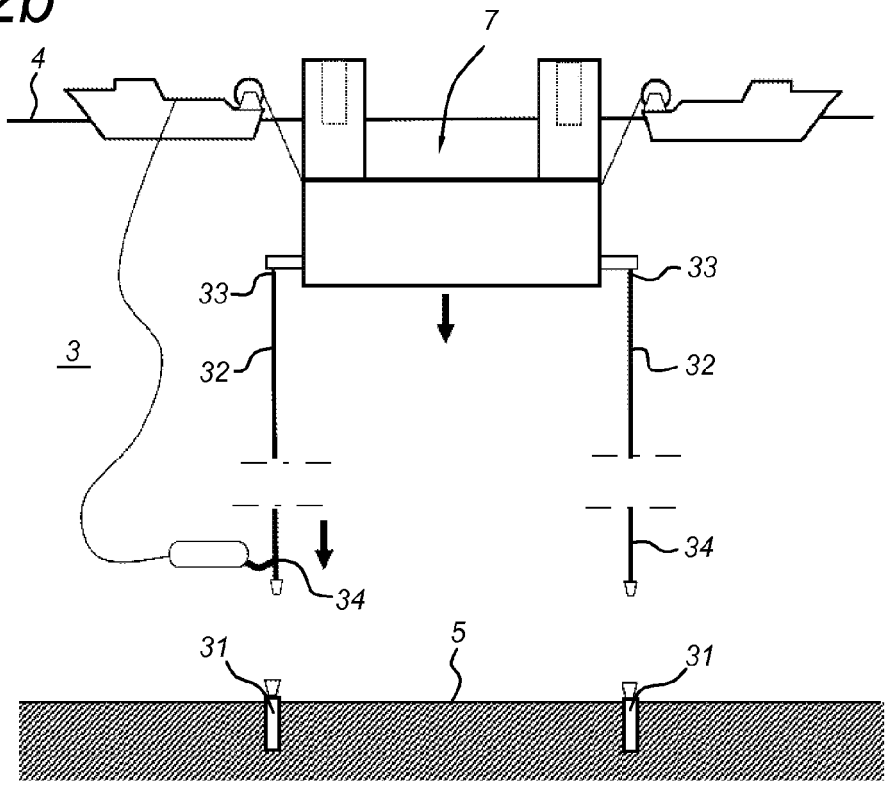


Fig 2c

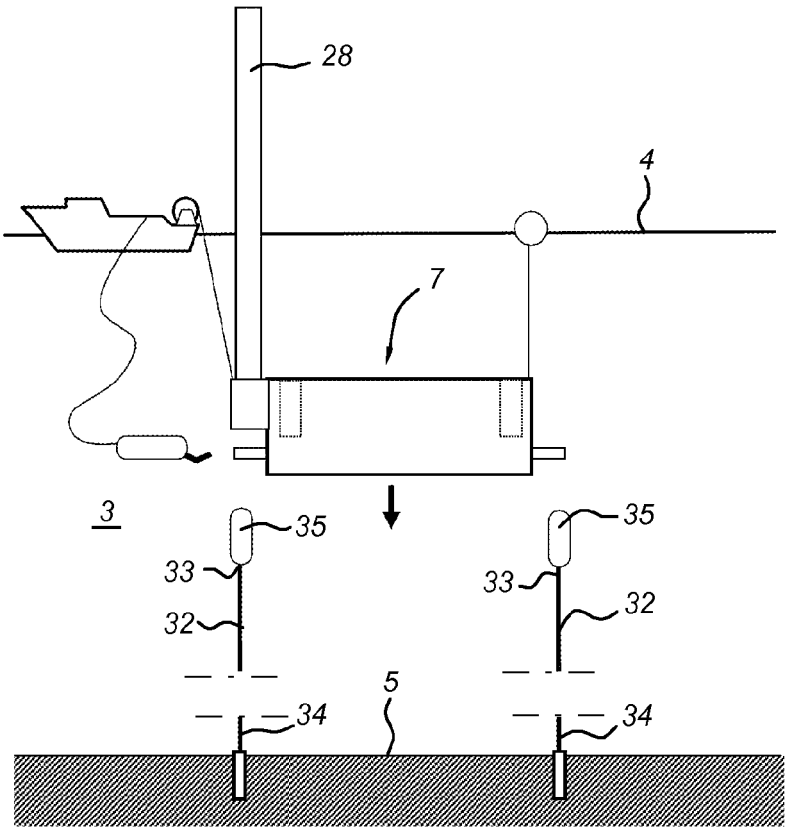
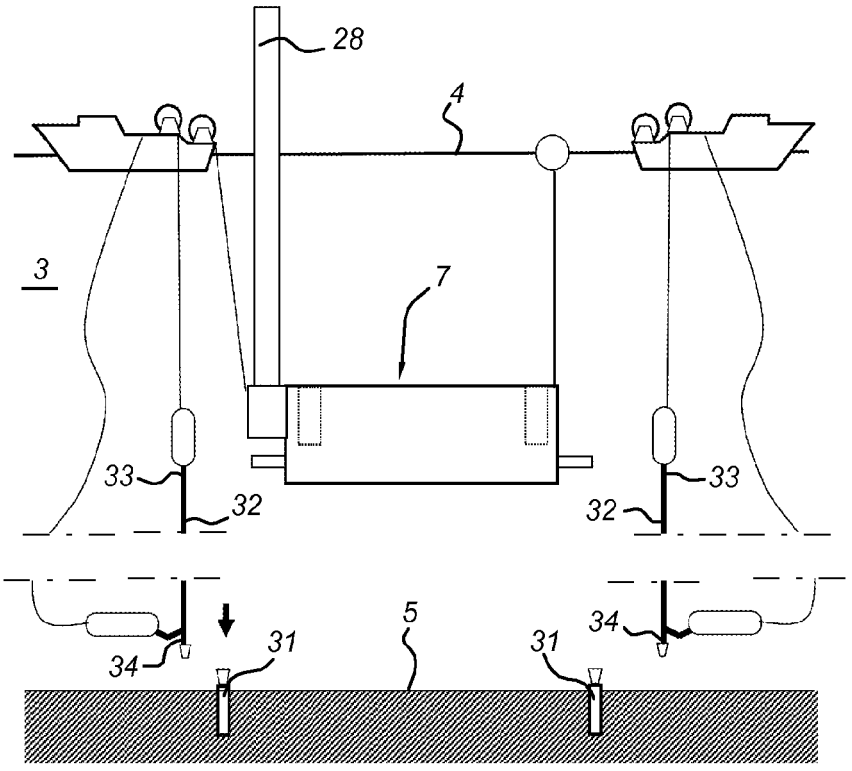


Fig 2d



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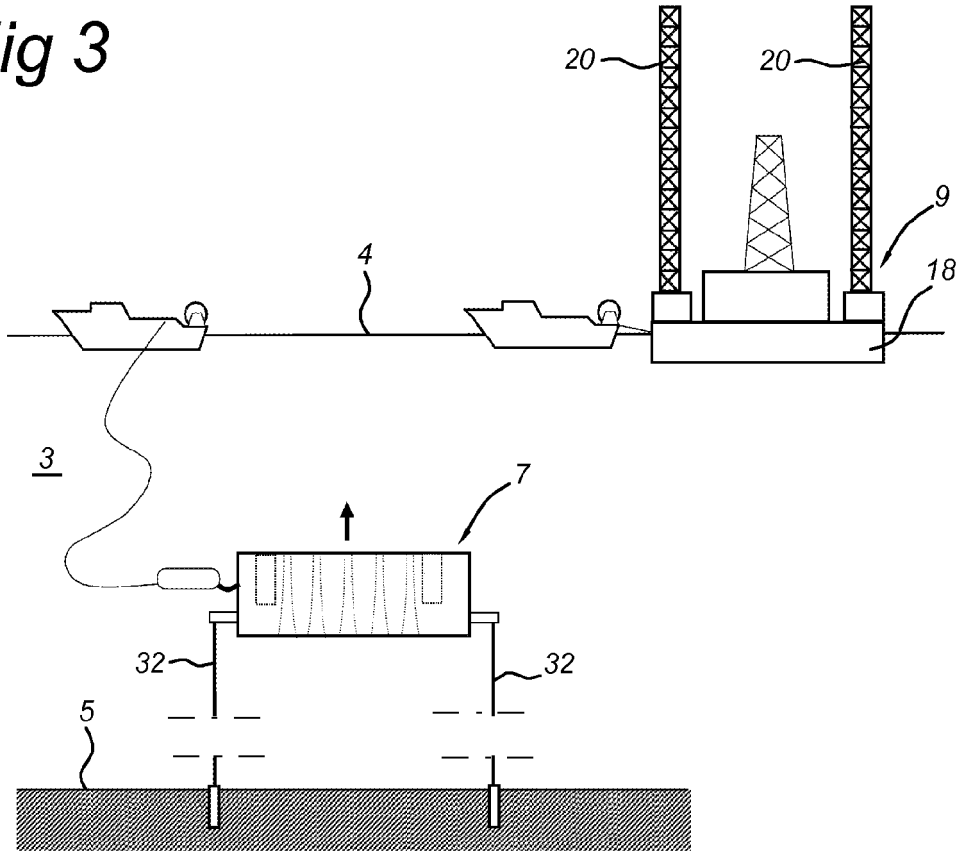
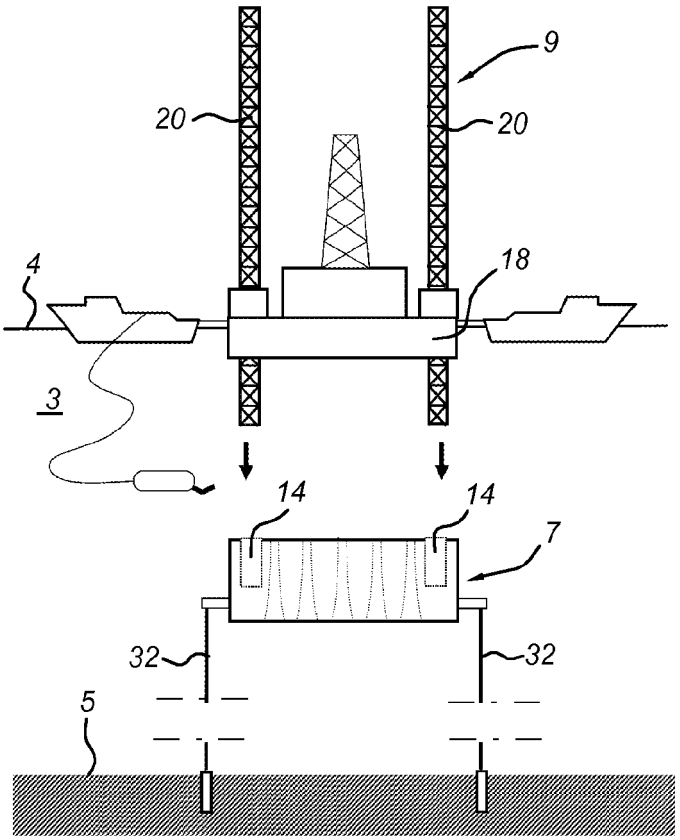


Fig 4



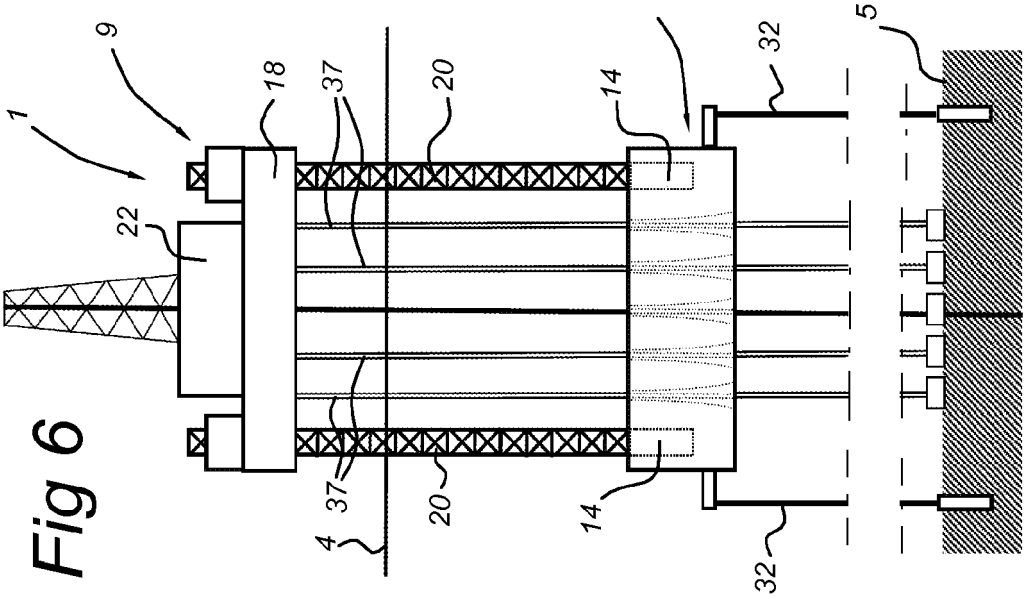


Fig 6

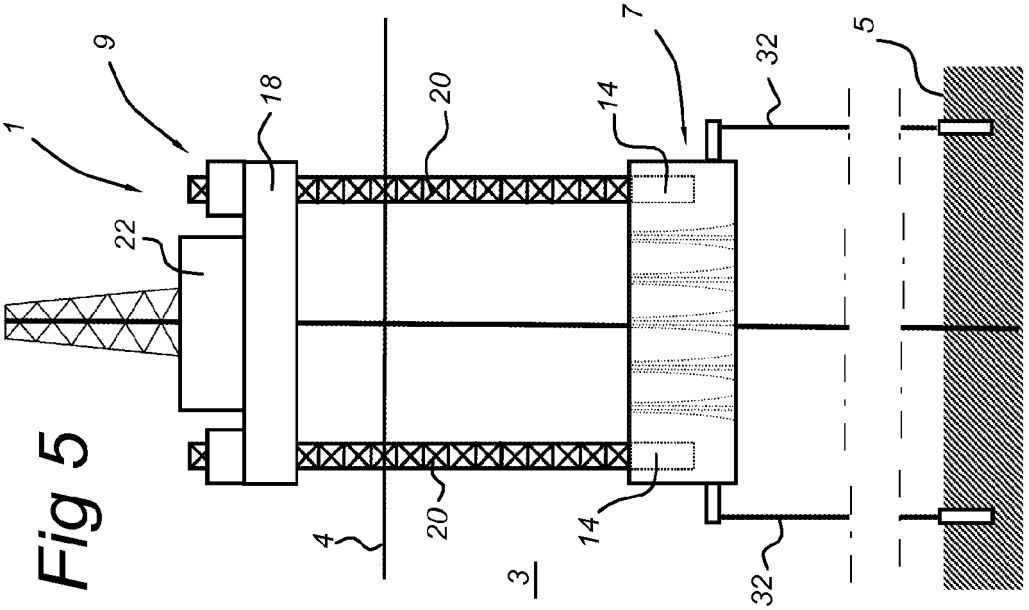


Fig 5

Fig 7a

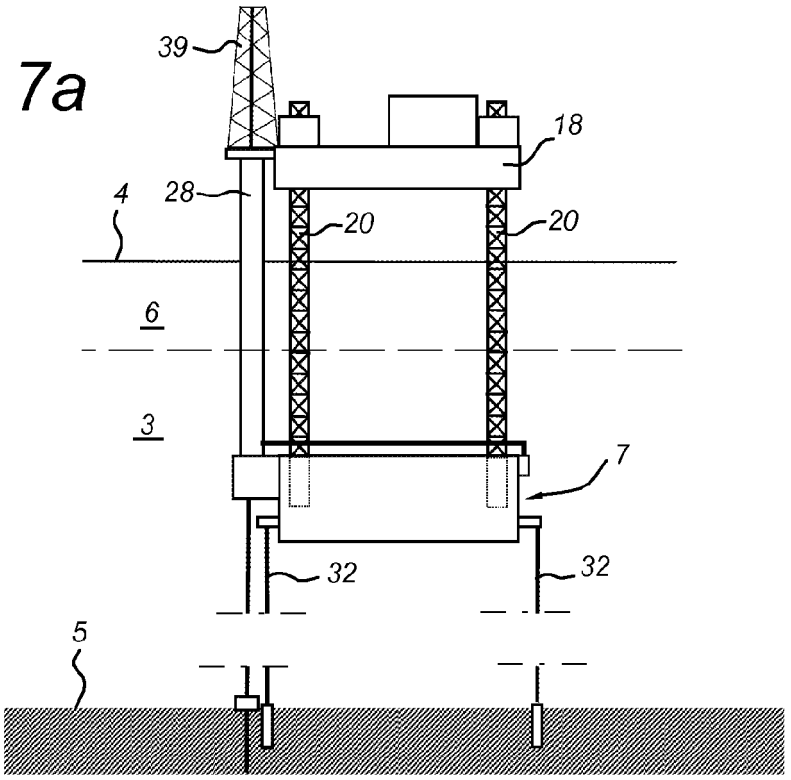


Fig 7b

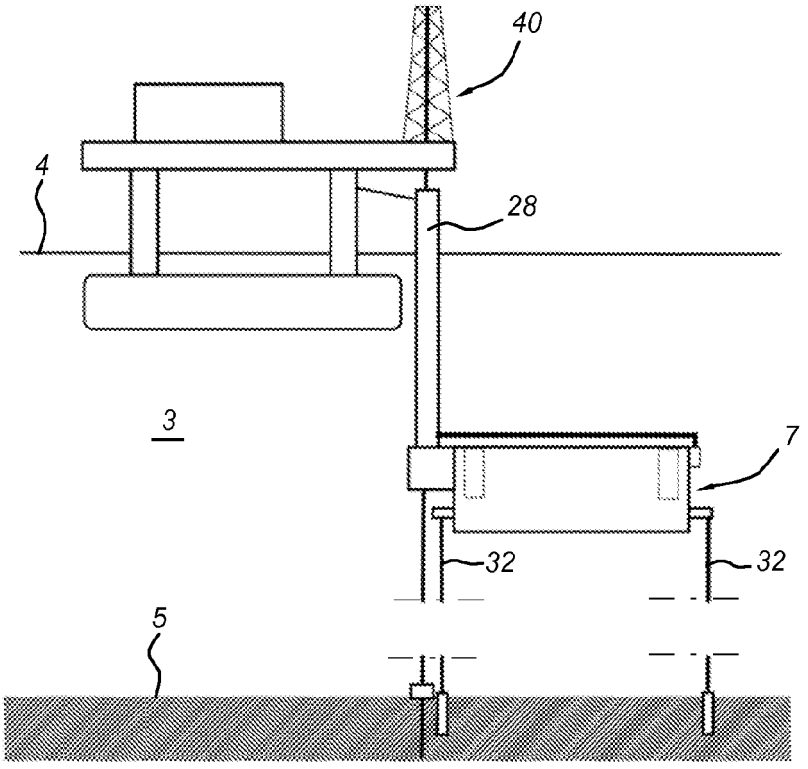


Fig 7c

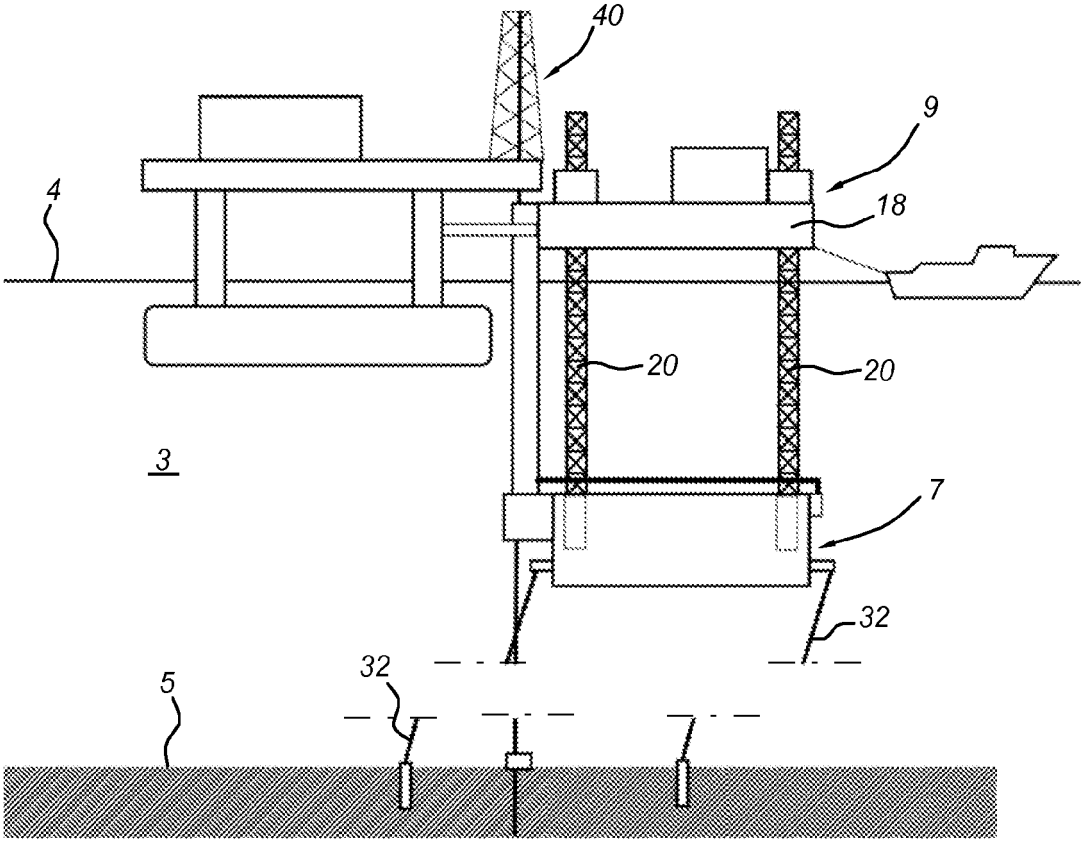
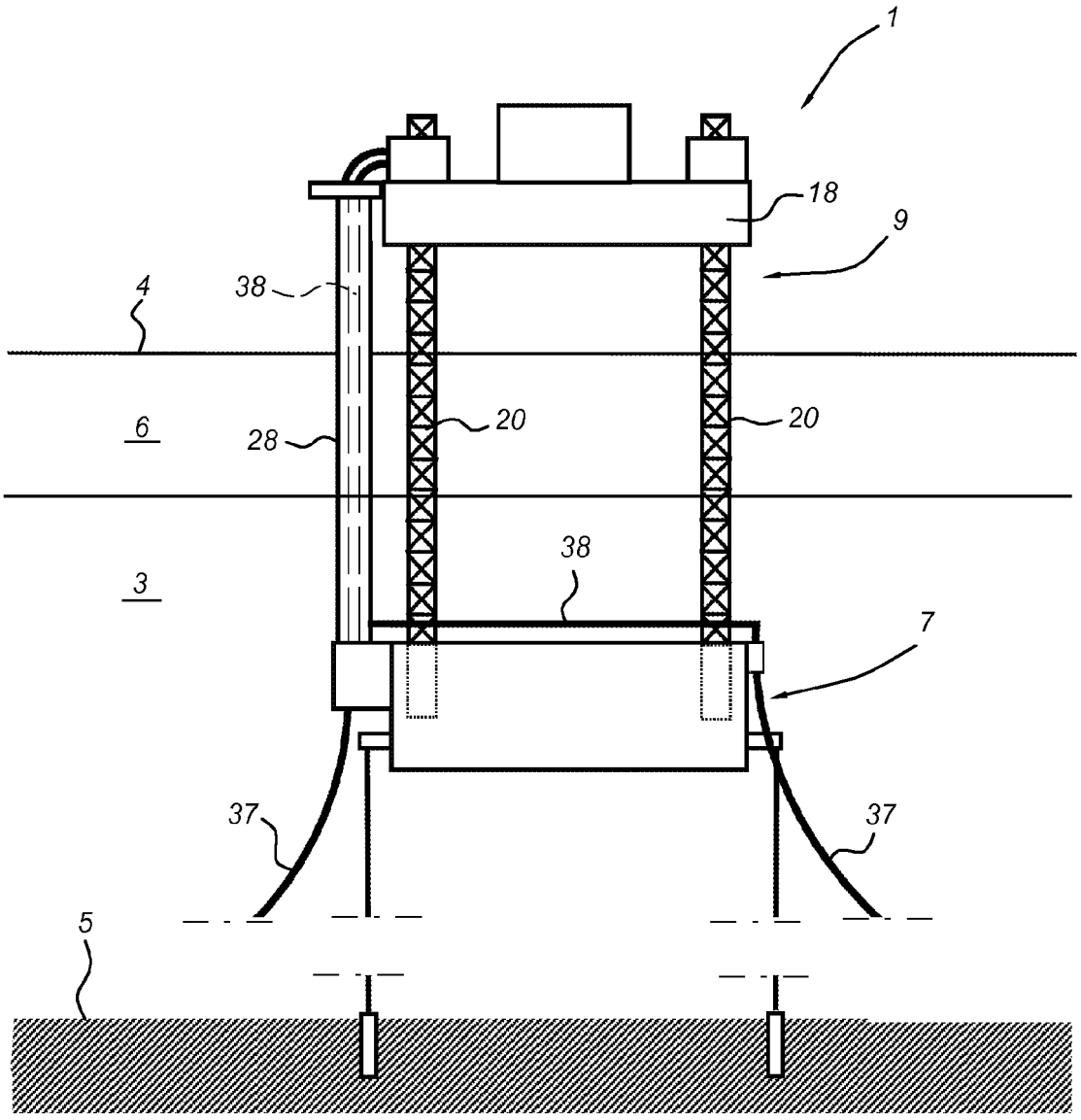


Fig 8



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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	20 November 2007	Nicol, Yann

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