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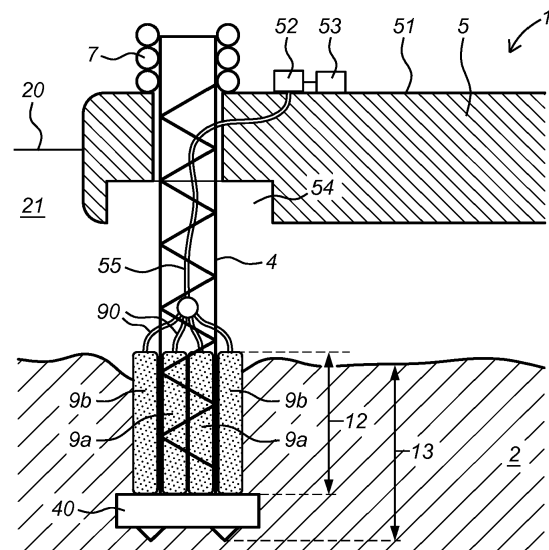
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(54) **JACK-UP VESSEL AND METHOD FOR POSITIONING THE VESSEL ON AN UNDERWATER BOTTOM**

(57) A jack-up vessel is described comprising a horizontal work deck and a number of legs for supporting the work deck on an underwater bottom. A lower end of the legs comprises an enlarged foot section adapted to engage or penetrate an underwater bottom, and the legs are provided with at least one closable container for a compressed medium, the container being positioned above the foot section. A method for positioning the jack-up vessel on an underwater bottom is also described. In such method, the at least one container prevents that underwater bottom material adheres to a lower portion of the legs, thereby facilitating retrieval of the legs from the the underwater bottom.

Fig. 4A



Description

FIELD OF THE INVENTION

[0001] The invention relates to a jack-up vessel comprising a horizontal work deck and a number of legs for supporting the work deck on an underwater bottom. A lower end of the legs comprises an enlarged foot section, adapted to engage or penetrate the underwater bottom, and each leg is actuated by a jacking mechanism to elevate the work deck above a water surface. The invention also relates to a method that positions a jack-up vessel on an underwater bottom and substantially prevents settlement/eases the removal of underwater bottom material from the legs and top side of the foot sections.

BACKGROUND OF THE INVENTION

[0002] A jack-up vessel, platform or rig comprises a horizontal work deck and at least three legs connected to the work deck. Such a vessel can sail to an offshore position while the legs are held in a docking position close to the work deck of the vessel. The vessel is anchored to the underwater bottom by bringing the legs to a lowered support position in which an enlarged foot section provided at a lower end of the legs engages or penetrates the underwater bottom. A hydraulic or electric system is provided to elevate the work deck upon the legs to a position above a water surface. The work deck can then be used as a stable platform to perform a number of tasks such as oil well drilling, mining, construction and maintenance of offshore wind turbines, bridges, and jetty or other constructions.

[0003] The underwater bottom in many cases comprises a relatively soft material such as mud, silt, clay, sedimentary material or other known soft material that adheres to the leg lower end portion and/or on top of the foot section. Upon retrieval of the legs from the underwater bottom, the additional weight of the adhered materials requires higher pulling forces, and the remaining sediments reduce the amount of payload of the jack-up vessel when floating. To be able to retract the legs into their docking positions close to the work deck and avoid any jamming, the adhered materials need to be removed, for instance by divers. This is a time-consuming operation and removing the adhered material may take several days, in particular in high cohesive soil.

[0004] It is an aim of the invention to provide a jack-up vessel that can efficiently be positioned on an underwater bottom as well as retrieved from it.

BRIEF SUMMARY OF THE INVENTION

[0005] The invention thereto provides a jack-up vessel according to claim 1. The jack-up vessel in accordance with the invention comprises a horizontal work deck and a number of legs for supporting the work deck on an underwater bottom, whereby a lower end of the legs com-

prises an enlarged foot section adapted to engage or penetrate an underwater bottom, whereby the legs are provided with at least one closable container for a compressed medium, and the container is positioned above the foot section. A pressurized container prevents accumulation of underwater bottom material along the legs, within the legs and/or on top of the foot section of the legs, before, during and/or after penetration of the legs into the underwater bottom.

[0006] The jack-up vessel may be positioned on an underwater bottom by a method comprising lowering the legs from a docking position close to a horizontal work deck of the jack-up vessel to a support position in which an enlarged foot section provided at a lower end of the legs engages or penetrates the underwater bottom, whereby the legs are provided with at least one closable container for a compressed medium, and the container is positioned above the foot section. An enlarged foot section is also referred to in the art as a spud can or a mud mat.

[0007] A suitable container is adapted to at least partly prevent accumulation of underwater bottom material at a lower end portion of the legs. Although the shape of a container may vary, an embodiment of the jack-up vessel according to the invention comprises one or more containers, wherein the at least one container extends along a leg and is positioned within a virtual cylinder having the foot section as base. Such a container effectively shields a volume around the leg from bottom material ingress, said volume being particularly apt to receive such material. The at least one container in this embodiment preferably forms an elongated body, a longitudinal axis whereof extends substantially parallel to a longitudinal axis of the leg.

[0008] The extension along a leg of the at least one container can also be chosen within a large range. In a useful embodiment of the jack-up vessel according to the invention, the at least one container extends along a leg over a distance at least equal to the penetration depth of the leg in the underwater bottom. The penetration depth of a leg may be anticipated before positioning the jack-up vessel on the underwater bottom by determining relevant properties of the bottom material, such as its cohesiveness, strength, etc.. A container in this embodiment will extend up to and possibly beyond the bottom surface when a leg has penetrated to a stable depth. This prevents accumulation of underwater bottom material along the leg substantially over its complete penetrated length.

[0009] A particularly useful embodiment of the invention provides a jack-up vessel wherein the at least one container is made of a flexible material and the container is inflatable with the medium between an empty and an inflated state. This allows changing the volume of the container at will, depending on the particular stage of operation of the jack-up vessel and its legs, for instance whether the vessel is sailing, or stationary in a jacked-up state, or whether the legs are in their docking position,

or in their lowered support position, and so on.

[0010] The at least one container may be pressurized before mounting the container on the legs. A more practical embodiment of the invention provides a jack-up vessel that further comprises inflating and/or deflating means for bringing the at least one container to a state between the empty and the inflated state. The inflating and/or deflating means in a useful embodiment comprise a source of compressed medium and a medium inlet provided on the at least one container in medium communication with the source. A suitable source of compressed medium would be a compressor pump, provided on the work deck, that pumps medium from a medium reservoir to an inlet of the at least one container, for instance through hoses connecting the source with the inlet. The source (pump) may also be provided on each container in order to draw in medium, for instance surrounding water. Another source may comprise a number of medium jet nozzles, provided on a leg, in particular on a top side of a foot section. Each source may be electrically connected with a suitable controlling device provided on the work deck. A container is preferably also equipped with a remote controlled pressure gage and/or valve to maintain the desired pressure within the container. The pressure gage/valve may be integrated in the compressor pump.

[0011] A useful embodiment of the jack-up vessel employs inflating and/or deflating means that are adapted to change the pressure inside the at least one container with the level of submersion of the at least one container. A container preferably needs to keep its inflated volume when a leg (and the container) is lowered under water towards the underwater bottom. This embodiment allows adjusting the internal pressure of the container to the surrounding water pressure, which obviously increases with submersion level (or water depth). Although internal pressure may be varied within a large range, internal pressures may vary between 1-200 bar for instance.

[0012] The at least one container is also instrumental in removing bottom material that may have accumulated around the leg. An embodiment of the jack-up vessel wherein a surface of the at least one container is non-sticking, more preferably is provided with a non-stick coating layer, facilitates such removal and also prevents accumulation further. One skilled in the art is familiar with suitable non-sticking materials, for instance polyolefin materials (PE, PP), silicone and other rubbers, as well as fluor polymers, such as PTFE (Teflon®).

[0013] A suitable medium for the container(s) may be selected according to the circumstances. In a preferred embodiment, the medium comprises air, water, or another high density substantially non-compressible fluid. Surrounding water as medium is particularly preferred.

[0014] The at least one container may be connected (semi-)permanently to the legs of the jack-up vessel. Another embodiment provides a jack-up vessel wherein the at least one container is removably connected to a leg. The (temporary or removable) connection may be achieved with well known means, such as by riveting,

welding, jointing, tying, roping, and so on.

[0015] The legs of the jack-up platform may be any leg known in the art, such as solid legs provided at a lower end with spud cans. In particular for larger depths, a jack-up vessel wherein the legs are truss-shaped may be the leg of choice. In such an embodiment, at least one container is preferably positioned inside the truss, i.e. inside an outermost contour of a (horizontal) cross-section of the truss.

[0016] In another embodiment, a jack-up vessel is provided wherein the legs are truss-shaped and at least one container is positioned outside the truss, i.e. an outermost contour of a (horizontal) cross-section of the truss. In such embodiment, a jack-up vessel wherein the at least one container positioned outside the truss is made of a flexible material and the container is inflatable with the medium between an empty and an inflated state is preferred.

[0017] In order to further improve shedding of bottom material that accumulated along a leg, an embodiment is provided that further comprises vibratory means for bringing the at least one container in vibration. Preferred vibratory means comprise hydraulic impulse means, for instance means for pulsing the output pressure of the compressor pump that inflates the at least one container.

[0018] The invention further relates to a closable container for a compressed medium for use in a jack-up vessel comprising a horizontal work deck and a number of legs for supporting the work deck on an underwater bottom, whereby a lower end of the legs comprises an enlarged foot section (or can) adapted to engage or penetrate an underwater bottom, and whereby the closable container is provided on the legs above the foot section.

[0019] The invention further relates to a leg for supporting a horizontal work deck of a jack-up vessel on an underwater bottom, whereby a lower end of the leg comprises an enlarged foot section, adapted to engage or penetrate the underwater bottom, the leg being provided with at least one closable container for a compressed medium, the container being positioned above the foot section.

[0020] The invention finally relates to a method for positioning a jack-up vessel on an underwater bottom, the method comprising lowering a number of legs from a docking position close to a horizontal work deck of the jack-up vessel to a support position in which an enlarged foot section (or can) provided at a lower end of the legs engages or penetrates the underwater bottom, whereby the legs are provided with at least one closable container for a compressed medium, and the container is positioned above the foot section. Preferred embodiments of the method are described in the enclosed dependent claims and relate to embodiments wherein the at least one container is made of a flexible material and the container is inflated with the medium and/or deflated between an empty and an inflated state; wherein the pressure inside the at least one container is changed with the level of submersion of the at least one container; wherein

the medium comprises air or water, preferably surrounding water; and wherein a leg is penetrated in the underwater bottom to a penetration depth about equal to an extension of the at least one container along the leg.

[0021] In an embodiment wherein the legs are truss-shaped and at least one container is positioned inside the truss, the at least one container positioned inside the truss is preferably in an inflated state during lowering of the legs. Such inside containers when filled with pressurized water have about neutral buoyancy when submerged. The inside container(s) are preferably kept in this state to effectively shield an inside volume of the truss legs against ingress of bottom material. Inflated inside containers further do not substantially hinder the movement of the truss legs, in particular their penetration in the underwater bottom since the inside containers are confined within a leg outer cross-sectional contour.

[0022] In a particularly useful embodiment of the method, wherein the legs are truss-shaped and wherein at least one container is positioned outside the truss, the at least one container positioned outside the truss is inflated prior to penetrating in the underwater bottom. This further reduces the amount of bottom material that may adhere to the leg.

[0023] The jack-up platform may be disconnected from the underwater bottom after it has performed its operations at an offshore site. Thereto a method is provided that further comprises raising the legs from a support position in which an enlarged foot section (or can) provided at a lower end of the legs engages or penetrates the underwater bottom to a docking position close to the horizontal work deck of the jack-up vessel.

[0024] In a preferred embodiment of the method at least one container is deflated while the leg is still penetrated in the underwater bottom. This allows pulling the leg from the underwater bottom with less force. In retrieving the legs from the bottom, bottom material may accumulate on top of the (partly) deflated container(s), but the amount is reduced, due to the presence of optional containers and/or containers that are still inflated and occupy volume.

[0025] To shed or shake off underwater bottom material efficiently, the method according to an embodiment provides that the at least one container that has been deflated is inflated again after it has left the underwater bottom. This process is further facilitated by an embodiment wherein the at least one container is brought in vibration.

[0026] In a further embodiment of the method according to the invention at least one container and preferably each container is deflated before the legs enter their docking position. The jack-up vessel is able to sail to another offshore site when each leg is in its docking position. The invention allows positioning a jack-up vessel on an underwater bottom and disconnecting the vessel from an underwater bottom in a lesser amount of time than known in the art.

BRIEF DESCRIPTION OF DRAWINGS

[0027] The invention will now be elucidated with reference to the following figures, without however being limited thereto. In the figures:

Fig. 1 is a schematic perspective view of a jack-up vessel according to an embodiment of the invention; Fig. 2A is a schematic side view of a jack-up vessel according to the state of the art in a jacked-up position;

Fig. 2B is a schematic side view of a jack-up vessel according to the state of the art in a floating position; Fig. 3A is a schematic top view of a truss leg according to an embodiment of the invention;

Fig. 3B is a schematic side view of the truss leg according to the embodiment shown in figure 3A;

Fig. 4A is a schematic side view of a jack-up vessel according to an embodiment of the invention in a jacked-up position;

Fig. 4B is a schematic side view of a jack-up vessel according to an embodiment of the invention in a floating position;

Fig. 5A is a schematic side view of a jack-up vessel according to the embodiment shown in figure 4 in a jacked-up position;

Fig. 5B is a schematic side view of a jack-up vessel according to the embodiment shown in figure 4 in a floating position;

Fig. 6A is a schematic side view of a jack-up vessel according to the embodiment shown in figure 4 in a floating position;

Fig. 6B is a schematic side view of a jack-up vessel according to the embodiment shown in figure 4 in a sailing position;

Fig. 7 is a schematic side view of a jack-up vessel according to an embodiment of the invention in a floating position; and

Fig. 8 finally shows a schematic side view of a truss leg according to another embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0028] Referring to figure 1, a jack-up vessel 1 is shown for placing an object 3 on an underwater bottom 2 or for performing other offshore operations. The jack-up vessel 1 comprises a hull 5 such that it can navigate autonomously through thrusters 8 to an offshore location, where it can be positioned and connected to the underwater bottom 2 by lowering a number of truss legs (or spud poles) 4 onto the underwater bottom 2. The legs 4 may for this purpose be moved from a docking position 54 (see also figures 2A and 2B) provided in the hull 5 towards the underwater bottom 2 by means of a rack and pinion system 7 such that the legs 4 engage or even penetrate the underwater bottom 2. The hull 5 of jack-up vessel 1 is then fixed relative to the underwater bottom 2 but may

still be floating, as shown in figure 2A for instance. The hull 5 may also be raised further out of the water, as shown in figure 1, such that a work deck 51 of the hull 5 is situated meters above the water surface 20. The truss legs 4 are at a lower end provided with enlarged foot sections 40 (also referred to as mud mats) to prevent the legs 4 from penetrating into the underwater bottom 2 too far. On the work deck 51 of hull 5 are provided several objects 3 to be placed, as well as a crane 6, pivotable about pivot 60. The work deck 51 of hull 5 further comprises a gripping construction 10 configured to engage an object 3 suspended from crane 6.

[0029] It should be noted that the configuration of figure 1 is given for illustrative purposes only and any other jack-up vessel 1 having legs 4 and employed for any other purpose may be used in the present invention.

[0030] The underwater bottom 2 in many cases comprises a relatively soft material such as mud, silt, clay, sedimentary material or other known soft material that may adhere to a lower portion of each leg 4, and/or may accumulate on top of the foot section 40 as a mass 2adh. Referring to figure 2A and upon retrieval of the legs 4 from the underwater bottom 2 by moving the legs 4 in the upward direction 19, the additional weight of the adhered materials 2adh may require higher pulling forces, and further may hinder retracting the legs 4 into their docking positions 54 close to the work deck 51. According to the state of the art, the adhered materials 2adh are removed, for instance by divers, which is a time-consuming operation.

[0031] A jack-up vessel 1 according to an embodiment of the invention is partly shown in figures 4A and 4B. The truss legs 4 are at a lower portion provided with a plurality of closable containers 9. As also shown in figures 3A and 3B, the truss legs 4 are triangular in cross-section, and the containers 9 comprise a first set of containers 9a positioned inside the truss. Indeed, a cross-section of the truss leg 4 is built from outer steel members 4b, between which extend a number of inner truss members 4a that together delimit four triangular subspaces 4c. The inside containers 9a are each contained within a substantially vertical cylinder having one of the subspaces 4c as base plane. According to the embodiment shown, the containers 9 further comprise a second set of containers 9b positioned outside the truss. Indeed, the outside containers 9b are positioned within a virtual cylinder having the extended foot section as base and outside a substantially vertical cylinder having the triangular cross-section of the leg 4 as base plane. The containers 9 extend vertically along a leg 4 over a distance 12 at least equal to the penetration depth of the leg 4 in the underwater bottom 2.

[0032] The containers 9 are positioned above the foot section 4 and are made of a flexible material, such as rubber, and they can be inflated with for instance compressed air or (surrounding) water between an empty state, as for instance shown in figure 5A for the outer containers 9b, and an inflated state, as shown in figure 5A for the inside containers 9a. Jack-up vessel 1 is there-

to provided with inflating and/or deflating means for bringing the containers 9 to a state between the empty and the inflated state. As shown in figures 4A and 4B, suitable means comprise a compressor pump 52, provided on the work deck 51. The compressor pump 52 pumps water from the surrounding sea 21 to an inlet 90 of the containers 9, for instance through hoses 55 connecting the compressor 52 with the inlets 90. A controlling device 53 provided on the work deck 51 may regulate the pressure inside each container 9 through remote control of pressure gages and/or valves provided on the containers 9, in order to maintain the desired pressure within the containers 9, and for instance change the pressure inside the containers 9 with the submersed depth of the containers 9.

[0033] The surface of the containers 9 may be coated with a non-stick coating layer, for instance based on a fluorinated polymer, such as PTFE. The containers are removably connected to members (4a, 4b) of the truss leg 4, for instance by tying.

[0034] The containers 9 are used to advantage when positioning and disconnecting the jack-up vessel 1 on and from the underwater bottom 2. Positioning the jack-up vessel 1 on the underwater bottom 2 involves lowering each truss leg 4 from its docking position 54 to a support position, shown in figures 4A and 5A, in which the enlarged foot section 40 of each truss leg 4 has penetrated the underwater bottom 2 over a stable distance 13. During lowering of the legs 4 and penetrating the underwater bottom 2, the containers 9a positioned inside the truss leg 4 are in an inflated state, as shown in figures 4A and 5A. This prevents bottom material from entering the inside volumes 4c of the truss legs 4. The outside containers 9b are preferably also in an inflated state, see figure 4A. The height 12 of the containers 9 is chosen such that the legs 4 stably penetrate to a penetration depth 13 which is about equal to the extensional height 12 of the containers 9 along the legs 4. This prevents bottom material accumulation on top of the containers 9.

[0035] When the legs 4 need to be retracted from the bottom 2 to free the jack-up vessel 1 from the bottom, each truss leg 4 is raised from its support position in which the foot section 40 engages or is embedded in the underwater bottom 2 to its docking position 54. A first embodiment is shown in figure 4B in which the outside containers 9b remain in an inflated state during raising of the truss legs 4. This considerably reduces the amount of bottom material 2adh adhered to the foot section 40 and other parts of the legs 4, such as the containers 9. This facilitates removing the truss legs 4 from the bottom 2.

[0036] A second embodiment is shown in figures 5A and 5B in which the inside containers 9a remain in an inflated state during raising of the truss legs 4. The outside containers 9b however are deflated while the legs 4 are still penetrated in the underwater bottom, see figure 5A. This facilitates removing the truss legs 4 and foot sections 40 from the bottom 2, this however having the drawback of a slightly increased amount of bottom ma-

terial 2adh adhered to the foot section 40 and other parts of the legs 4, as shown in figure 5B. This additional amount of bottom material 2adh is relatively easy removed from the legs 4 by a further step of the method wherein the outer containers 9b that were deflated are inflated again to a partly or fully inflated state after the containers 9b have left the underwater bottom 2. This method step, shown in figure 6A, effectively shakes off adhered underwater bottom material 2adh. Preferably, the containers 9b are simultaneously brought in vibration 15 by pulsating the inner pressure of the containers 9b, as schematically shown by hydraulic impulse means.

[0037] A last step, shown in figure 6B involves jacking up the legs 4 further until they can be accommodated inside the docking positions 54. The outside containers 9b are deflated before entering their docking position 54.

[0038] As shown in figure 7, the inside containers 9a and/or the outside containers 9b may be provided with pressure valves 56 for releasing excess pressure from within the containers 9. Stacking a plurality of smaller containers (9a-1, 9a-2,..., 9a-8) inside a truss leg 4, as shown in figure 8, may be beneficial in terms of flexibility.

Claims

1. Jack-up vessel comprising a horizontal work deck and a number of legs for supporting the work deck on an underwater bottom, whereby a lower end of the legs comprises an enlarged foot section adapted to penetrate an underwater bottom over a penetration depth of the legs, whereby the legs are provided with at least one closable container for a compressed medium, whereby the at least one container is positioned above the foot section within a virtual cylinder having the foot section as base, and extends along a leg.
2. Jack-up vessel according to claim, wherein the at least one container extends along a leg over a distance at least equal to the penetration depth of the leg in the underwater bottom.
3. Jack-up vessel according to any one of the preceding claims, wherein the at least one container is made of a flexible material and the container is inflatable with the medium between an empty and an inflated state.
4. Jack-up vessel according to claim 3, further comprising inflating and/or deflating means for bringing the at least one container to a state between the empty and the inflated state.
5. Jack-up vessel according to claim 4, wherein the inflating and/or deflating means comprise a source of compressed medium and a medium inlet provided on the at least one container in medium communi-

cation with the source.

6. Jack-up vessel according to claim 4 or 5, wherein the inflating and/or deflating means are adapted to change the pressure inside the at least one container with the level of submersion of the at least one container.
7. Jack-up vessel according to any one of the preceding claims, wherein a surface of the at least one container is non-sticking, more preferably is provided with a non-stick coating layer.
8. Jack-up vessel according to any one of the preceding claims, wherein the medium comprises air or water, preferably surrounding water.
9. Jack-up vessel according to any one of the preceding claims, wherein the at least one container is removably connected to a leg.
10. Jack-up vessel according to any one of the preceding claims, wherein the legs are truss-shaped and at least one container is positioned inside the truss.
11. Jack-up vessel according to any one of the preceding claims, wherein the legs are truss-shaped and at least one container is positioned outside the truss.
12. Jack-up vessel according to claim 10 or 11, wherein the at least one container positioned outside the truss is made of a flexible material and the container is inflatable with the medium between an empty and an inflated state.
13. Jack-up vessel according to any one of the preceding claims, further comprising vibratory means for bringing the at least one container in vibration.
14. Method for positioning a jack-up vessel on an underwater bottom, the method comprising lowering a number of legs from a docking position close to a horizontal work deck of the jack-up vessel to a support position in which an enlarged foot section provided at a lower end of the legs penetrates the underwater bottom over a penetration depth of the leg, whereby the legs are provided with at least one closable container for a compressed medium, and the container is positioned above the foot section within a virtual cylinder having the foot section as base, and extending along a leg, whereby the closable container is inflated to prevent accumulation of underwater bottom material on top of the foot section of the legs.
15. Method according to claim 14, wherein the at least one container is made of a flexible material and the container is inflated with the medium and/or deflated between an empty and an inflated state.

16. Method according to claim 15, wherein the pressure inside the at least one container is changed with the level of submersion of the at least one container.

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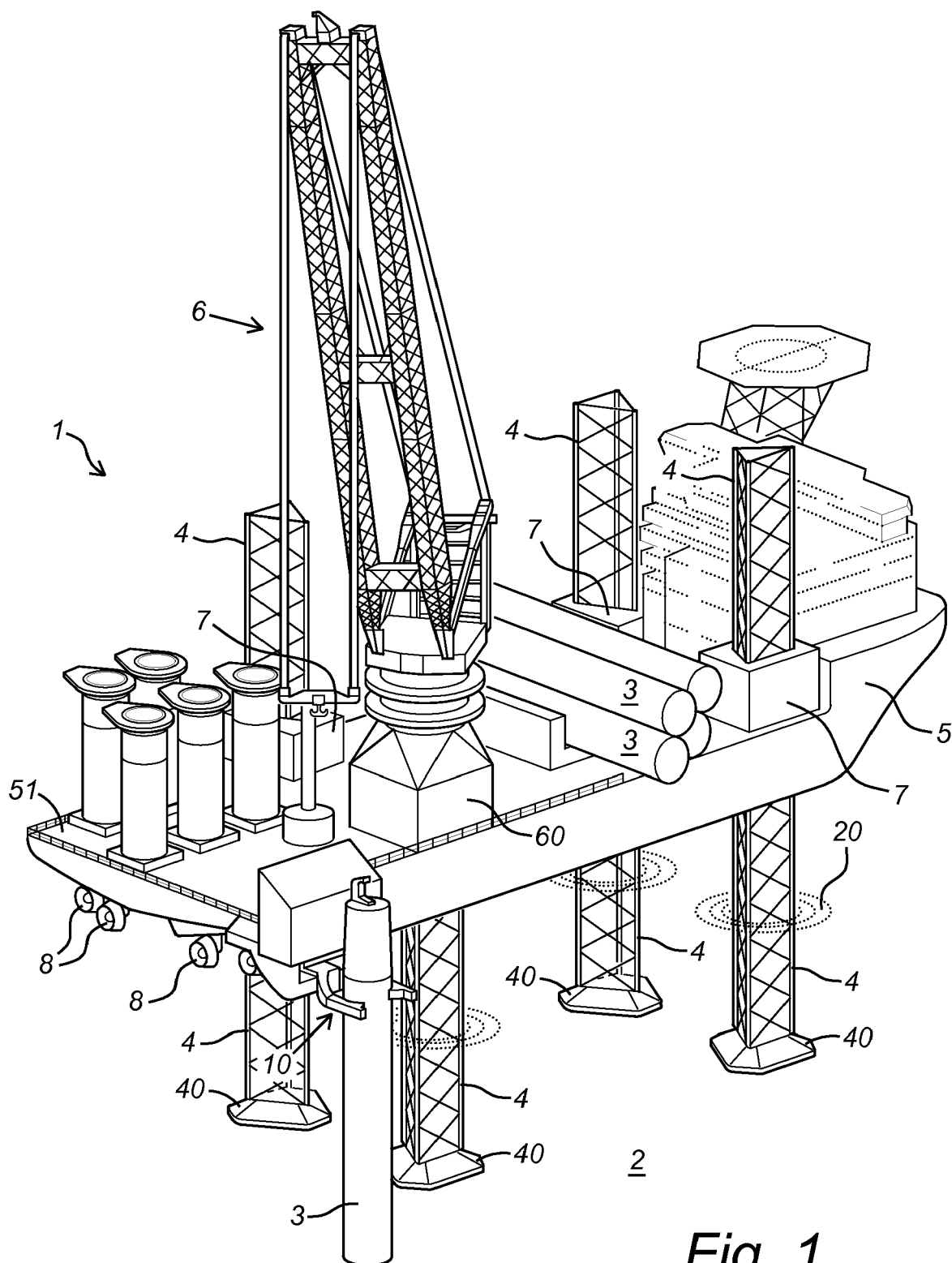


Fig. 1

Fig. 2B

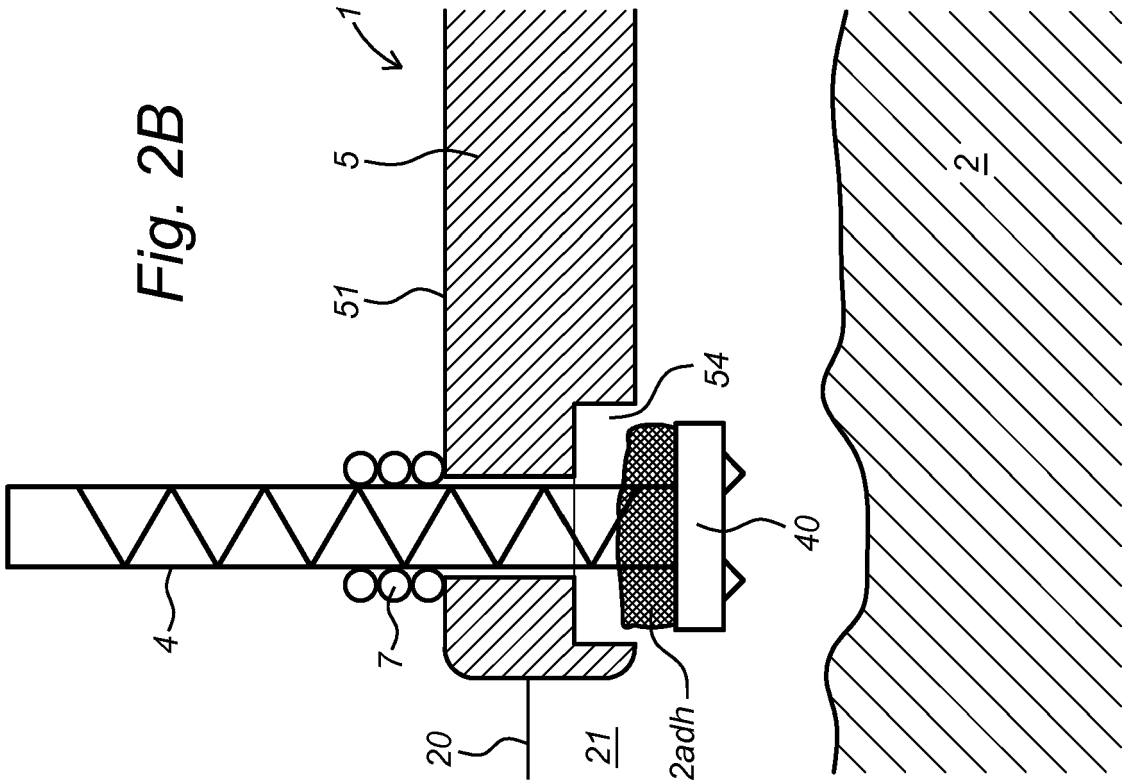
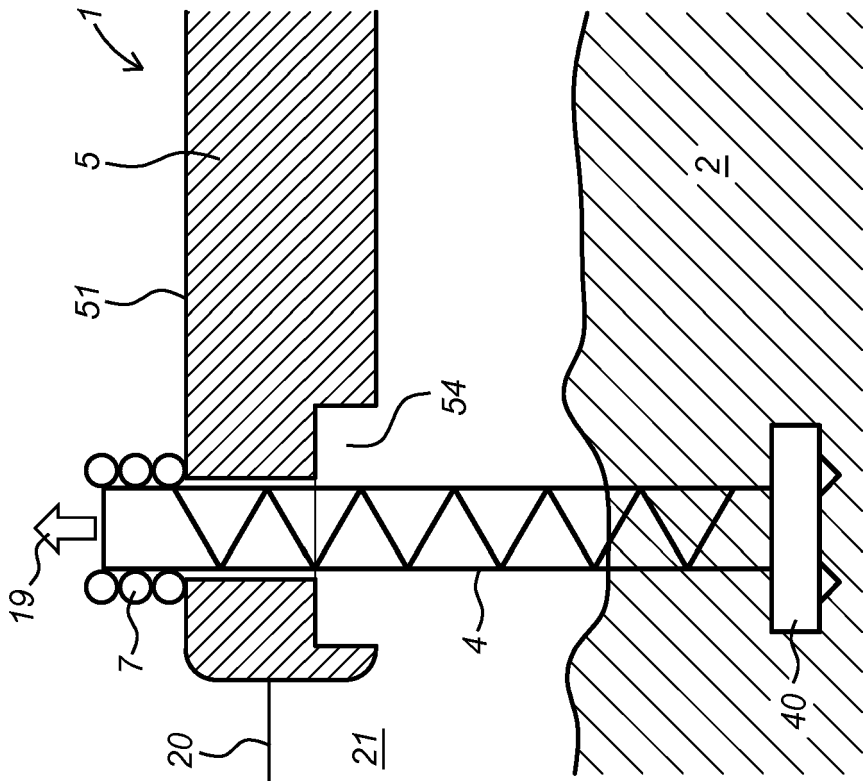


Fig. 2A



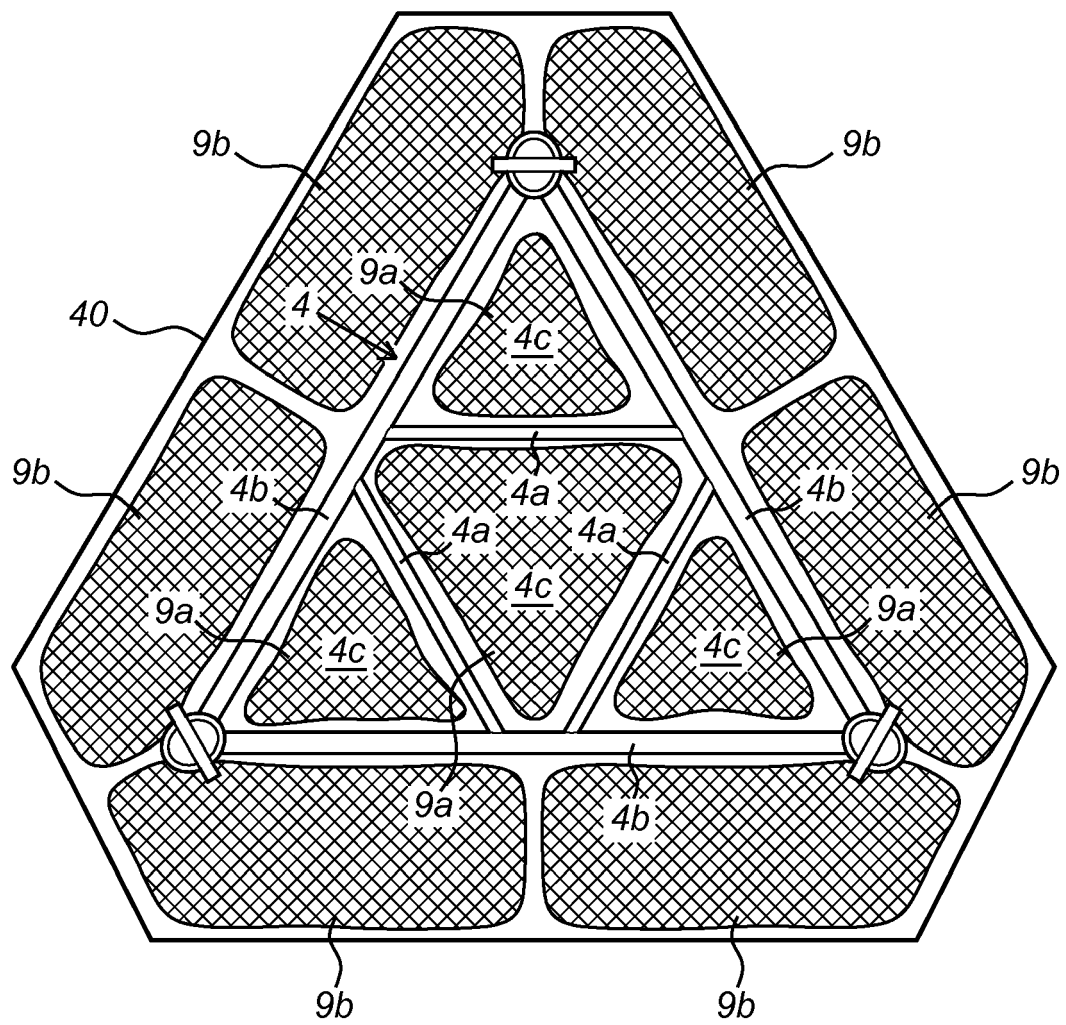


Fig. 3A

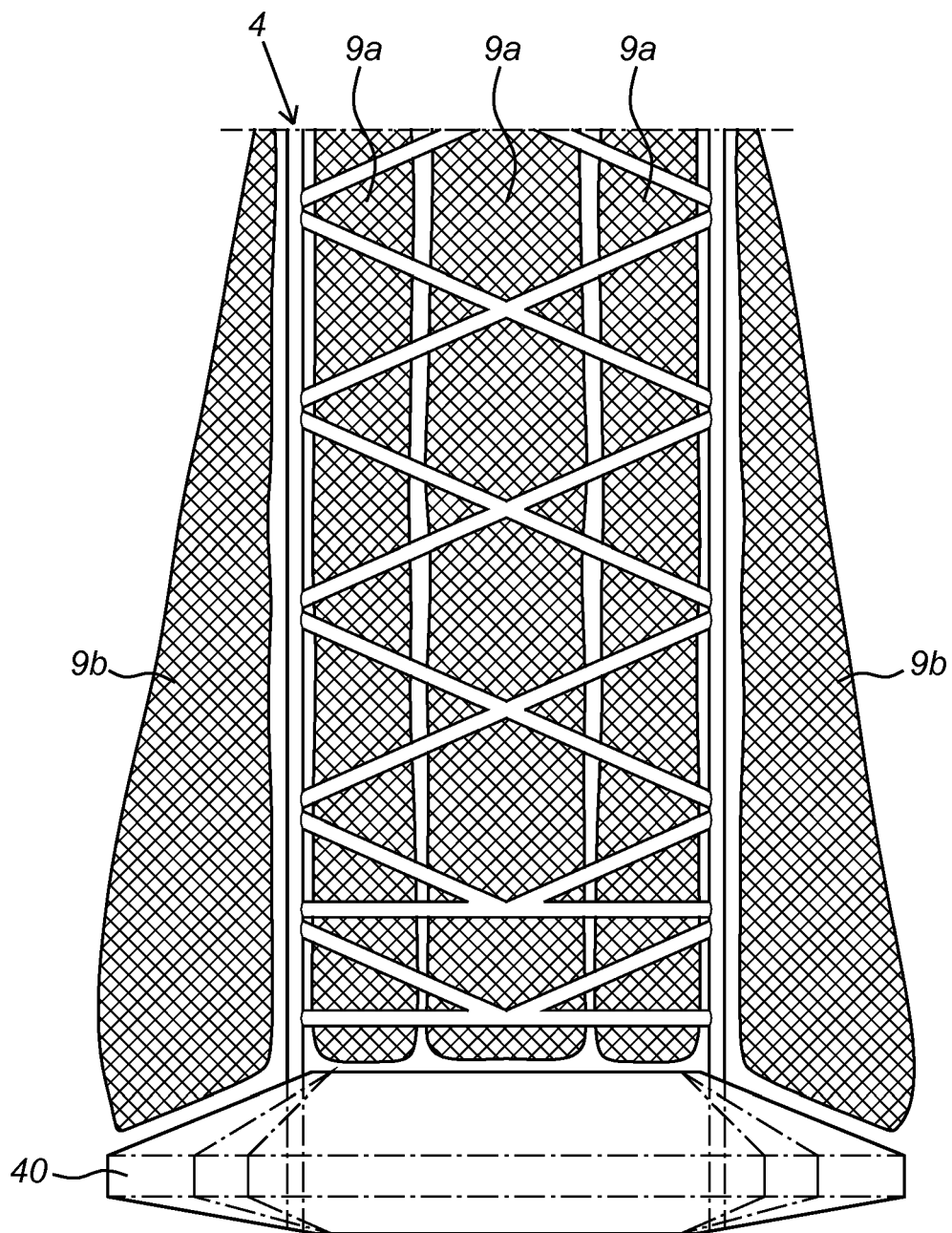
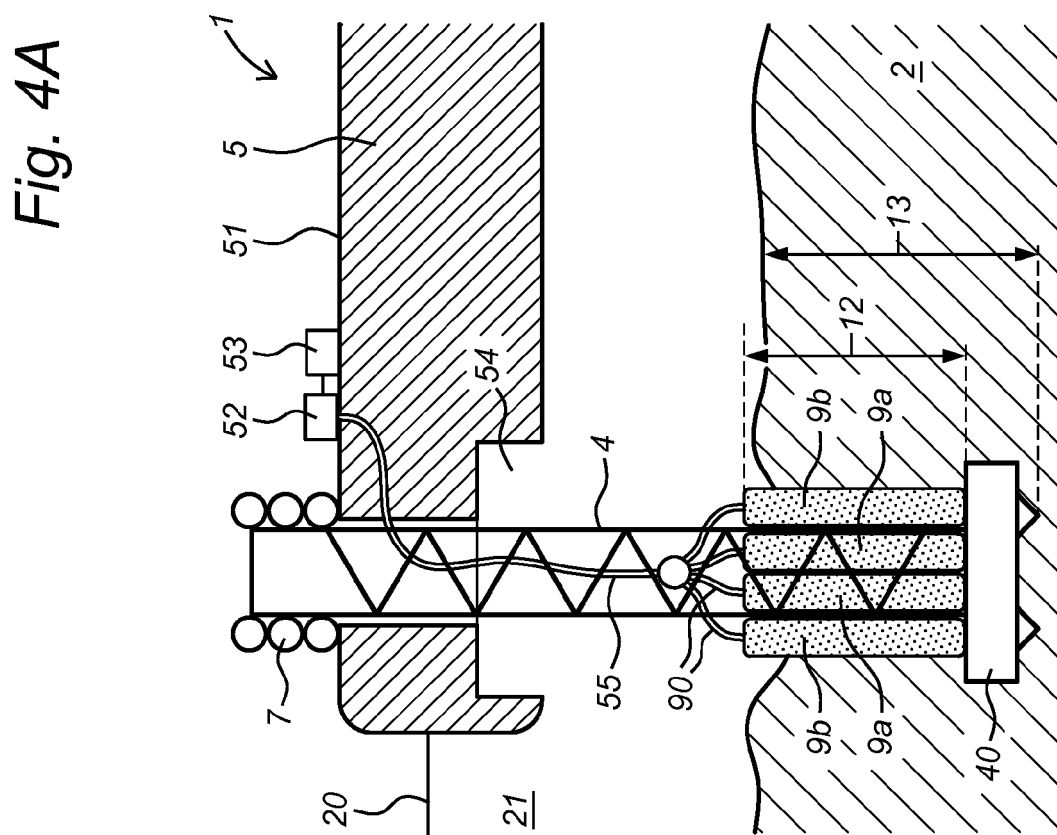
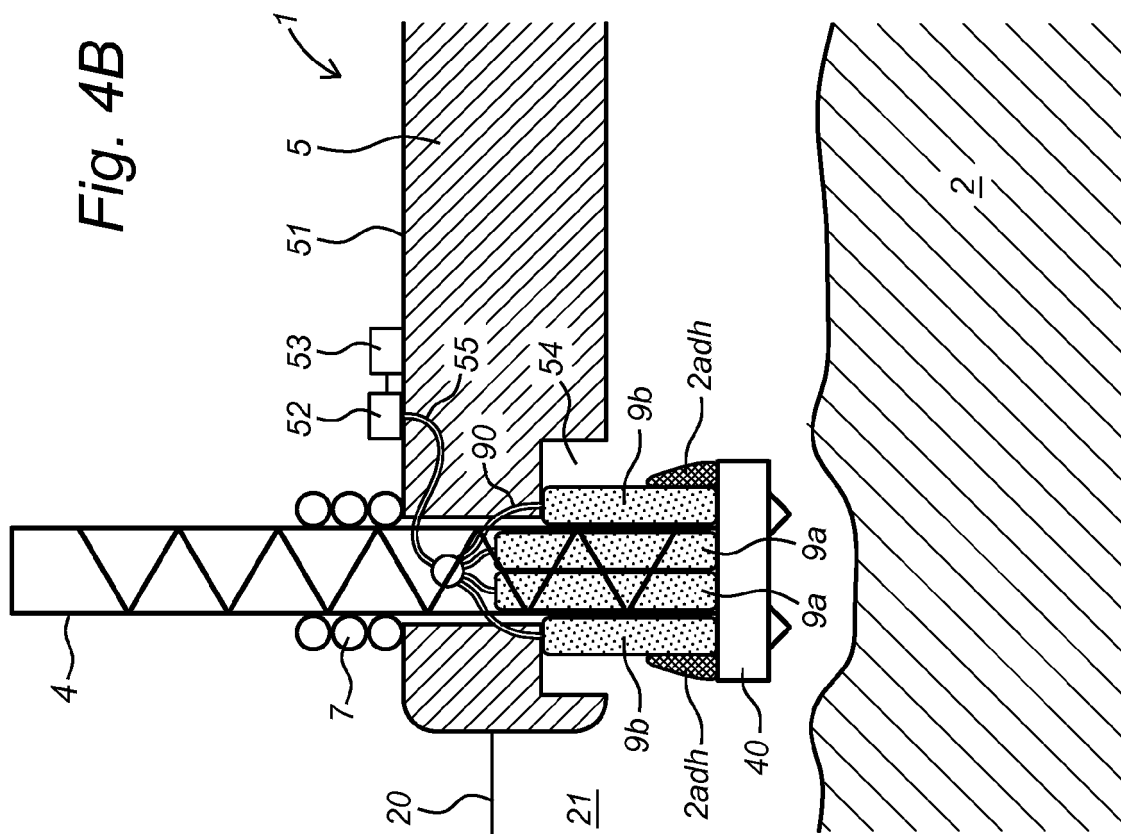


Fig. 3B



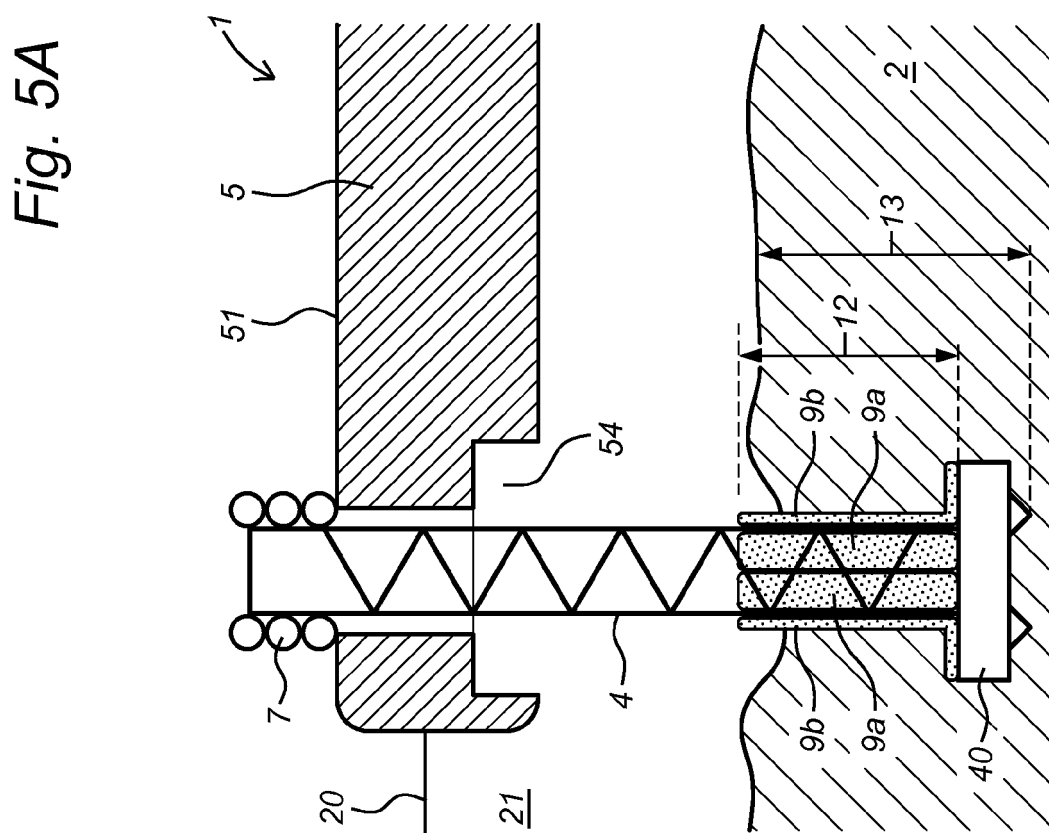
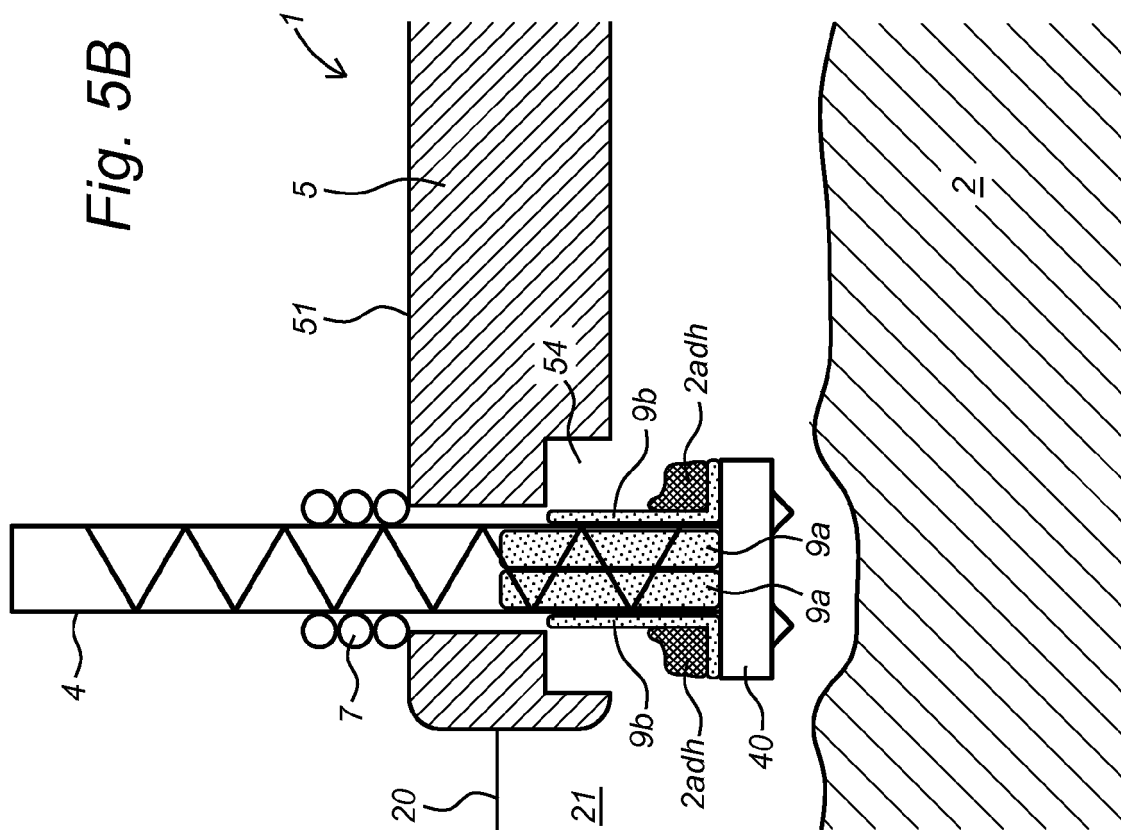


Fig. 6B

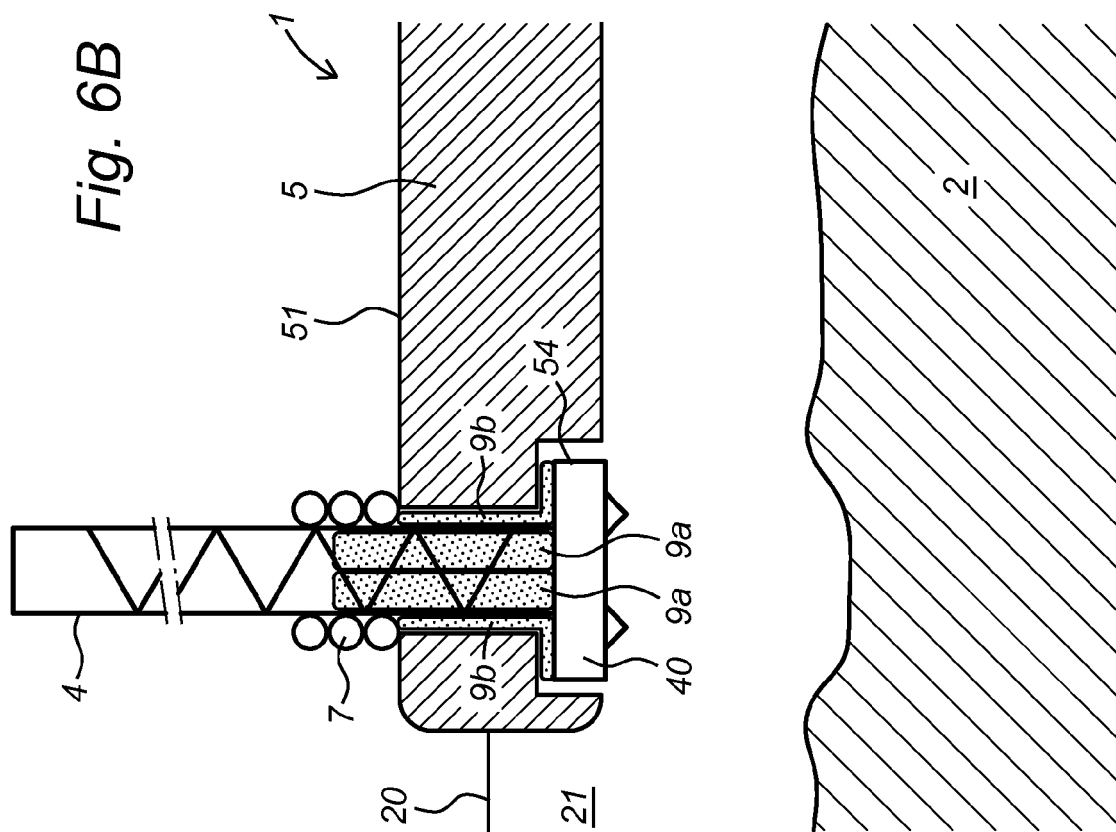
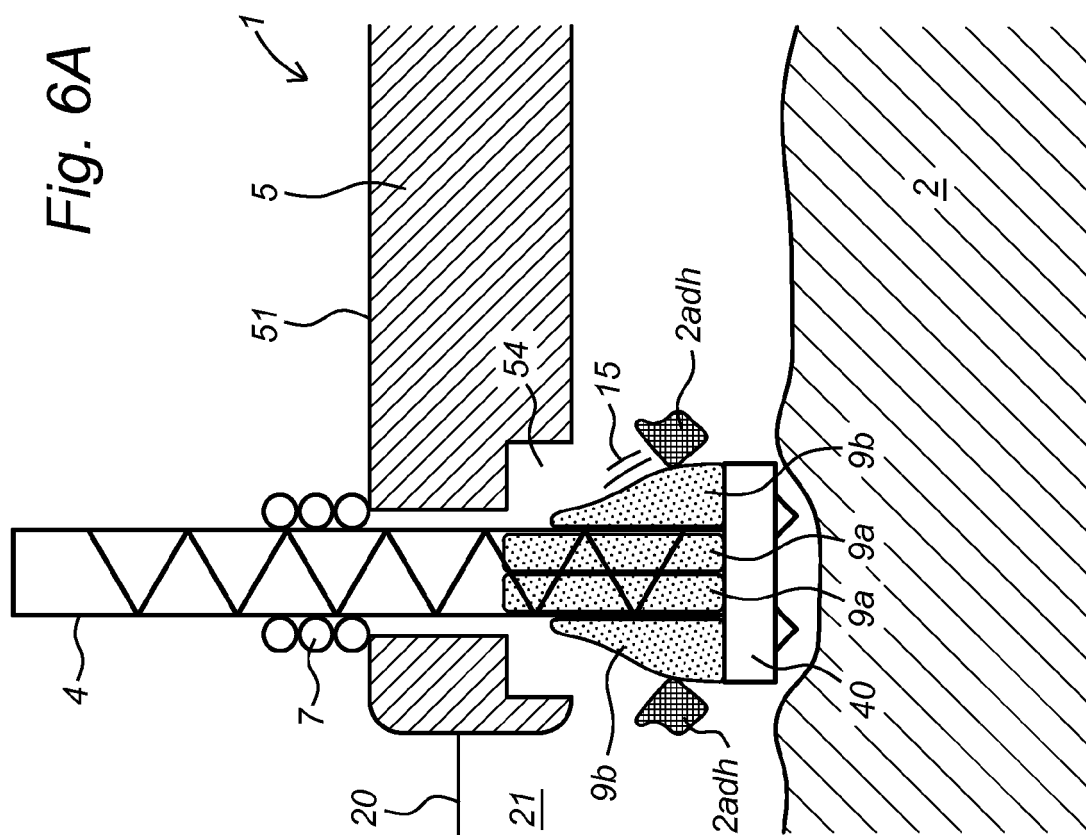


Fig. 6A



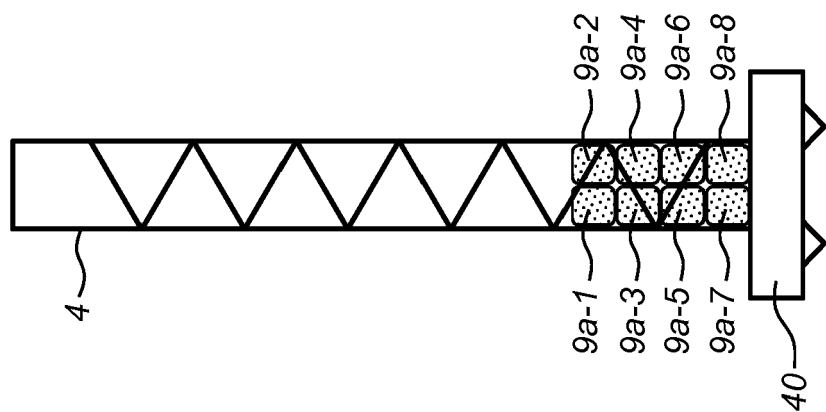


Fig. 8

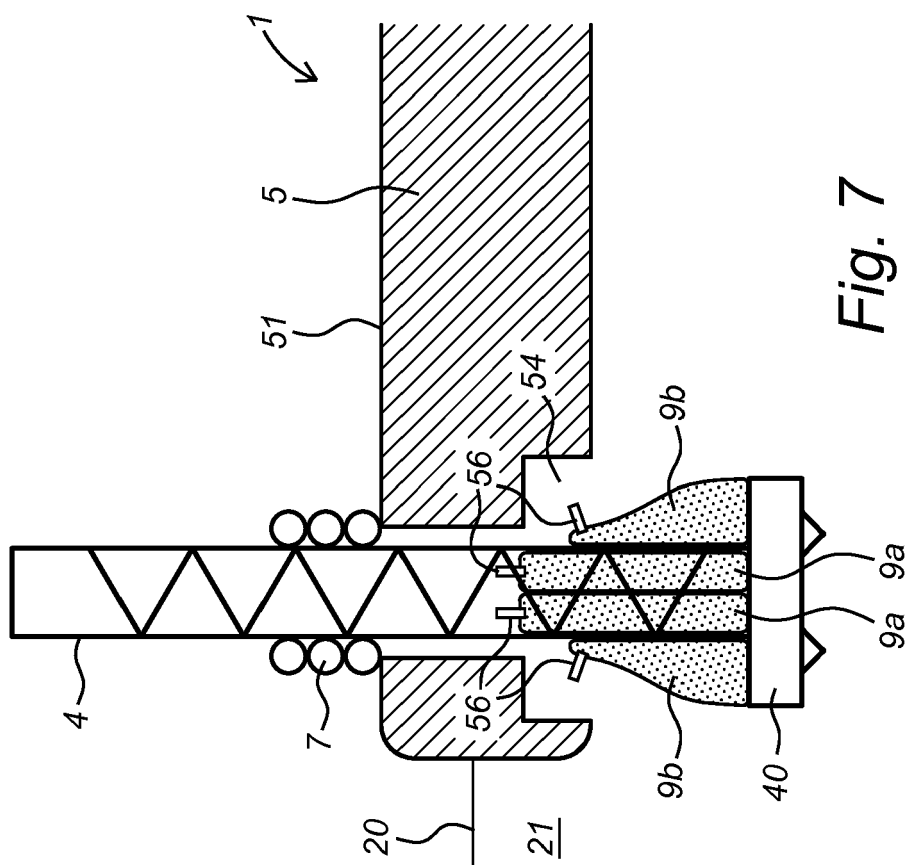


Fig. 7



EUROPEAN SEARCH REPORT

Application Number
EP 17 15 2283

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 18 May 2017	Examiner Zuurveld, Gerben
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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