(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 597 854 A1**

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
22.01.2020 Bulletin 2020/04

(21) Application number: **18184631.2**

(22) Date of filing: **20.07.2018**

(51) Int Cl.:
E21B 17/01 *(2006.01)* ***E21B 33/035*** *(2006.01)*
E21B 41/08 *(2006.01)* ***E21B 43/013*** *(2006.01)*
B63B 21/27 *(2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Neodrill AS**
4033 Stavanger (NO)

(72) Inventors:
- **Strand, Harald**
  4339 Ålgård (NO)
- **Mathis, Wolfgang**
  4307 Sandnes (NO)

(74) Representative: **Håmsø Patentbyrå AS**
P.O. Box 171
4301 Sandnes (NO)

(54) ARRANGEMENT FOR SUPPORTING A WELLHEAD

(57) There is described a suction anchor (14) with a device for reducing the load on a wellhead casing (12) from a bending moment (M_w) generated by a horizontal load component (L_h) from a well element (2, 3) arranged over a wellhead (11), the suction anchor having a closed top portion and an open lower portion, the device including a supporting frame (6), integrated into the closed top portion of the suction anchor, connected to an upper portion (12a) of the wellhead casing (12) and projecting outwards from the centre axis of the wellhead casing (12) and being provided with abutments (61) which rest supportingly against the top portion of the suction anchor, at a radial distance from the wellhead casing (12), the supporting frame (6) being arranged to absorb a portion of said bending moment (M_w).

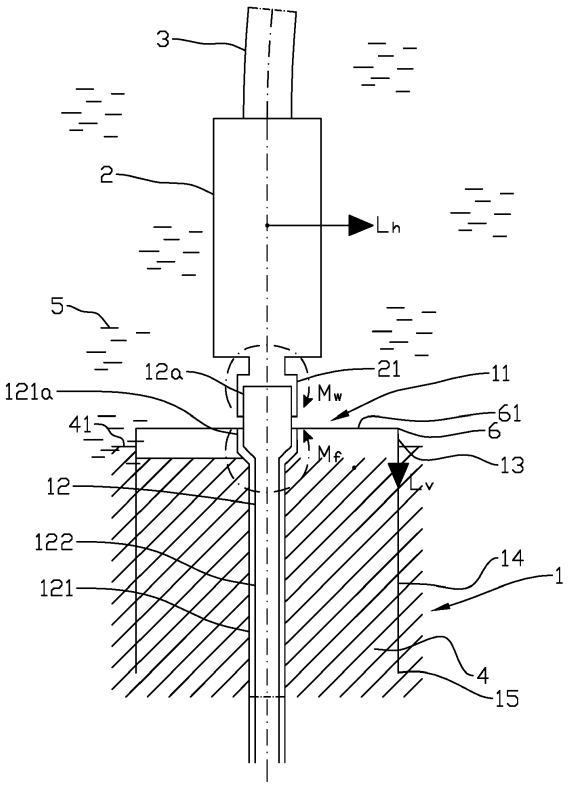

Fig. 4

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Description

[0001] The invention relates to a suction anchor with a device for reducing the strain on a wellhead casing from a bending moment generated by a horizontal load component from a well element arranged over a wellhead.

[0002] As a rule, installing elements on a wellhead, in particular a blowout preventer (BOP), at the top of a wellhead casing which extends down through unconsolidated masses in the sea floor, usually with an upper wellhead-casing portion surrounded by and fixed to a conductor casing, involves a risk of fatiguing the wellhead casing, by the wellhead being subjected to lateral forces so that the wellhead casing is being bent. The lateral load may arise in consequence of drift of a riser extending through the water masses from the wellhead upwards to a surface installation. When a blowout preventer weighs 250-500 tonnes and has a vertical extent of up to 14-16 metres and a horizontal extent of 5-6 metres, such a bending strain will increase in that the load that is resting on the wellhead casing will have its centre of gravity displaced away from the original, vertical centre axis of the wellhead. The problem is described among other things by Dahl Lien: "Methods to Improve Subsea Wellhead Fatigue Life", a project assignment at the Faculty for engineering science and technology, the Institute for petroleum technology and applied geophysics, NTNU, Trondheim, Norway, 2009. The situation may lead to deformation of the wellhead casing and, at worst, fatigue and rupturing. The problems intensify as the safety requirements are being increased, for example illustrated by the fact that while pressure barriers were earlier dimensioned to withstand 5000 psi, the requirements have gradually increased to 15000 psi, and associated valves have gone from 4 to 6 levels. The use of deep-water rigs with heavy subsurface safety equipment at moderate water depths has further intensified the problems. It has been recorded that the wellhead has been subjected to strains of up to 90 % of the critical limit of the wellhead as regards fatigue.

[0003] From the prior art describing solutions to the problem of fatiguing the wellhead casing which forms the foundation for wellhead elements, the inventor's own suction foundation (Conductor Anchor Node = CAN) may be mentioned, disclosed in NO patent No. 313340, included in its entirety herein by reference, in principle providing a larger contact surface between the upper part of the conductor casing and the surrounding seabed mass, the diameter of the suction foundation typically being approximately 6 metres, whereas the diameter of the conductor casing is in the range of 0.75-0.90 m (30-36 inches). CAN therefore provides significant lateral support to the conductor and thereby to the wellhead/wellhead casing therein.

[0004] It is also known (Dahl Lien 2009, see above) to use mooring lines extending at outward and downward angles from an upper portion of a wellhead installation to the seabed where the moorings are secured to anchors.

[0005] From NO 305179, a suction anchor enclosing an upper portion of a conductor casing and parts of a wellhead is known. To the wellhead, a frame is connected, arranged to carry a swivel device for the horizontal connection of a riser *et cetera,* the frame resting on separate suction anchors placed at a distance from the former suction anchor.

[0006] From the applicant's own NO patent 331978 (and the corresponding WO publication 2011162616 A1), a stabilizing device for a wellhead with the upper portion of a wellhead casing projecting up above a seabed is known, in which a wellhead valve which projects up from the upper portion of the wellhead casing is completely or partially supported on the suction foundation by several supporting elements being arranged between the wellhead valve and the suction foundation.

[0007] US2006162933A1 discloses a system and a method of establishing a subsea exploration and production system, in which a well casing, projecting up from a seabed where a well is to be stablished, is provided with a buoyancy body arranged at a distance above the seabed. The buoyancy body is stabilized by means of adjustable stabilizing elements, which are anchored to the seabed at a distance from the well casing.

[0008] US2010/0212916 A1 is disclosing a stabilizer for a wellhead, comprising: a ground engaging support structure having lateral dimensions suitable for laterally stabilizing the wellhead; wellhead stabilizer elements disposed within the ground engaging support structure, the wellhead stabilizer elements having wellhead abutting faces spaced to laterally cage the wellhead to restrict lateral movement of the wellhead while permitting the wellhead to move in a vertical direction. The wellhead may include various wellhead components, including for example casing bowls, spools, blowout preventers, and other suitable components. The portion of wellhead that is laterally caged need not be circular in cross-section, but may be a suitable geometry.

[0009] To try to meet the constantly increasing challenges when it comes to avoiding fatigue fracturing of the wellhead, the dimension of the wellhead casing has gradually been increased, the diameter having increased from 30 inches to 36 inches and further to 42 inches, with a wall thickness that has increased from 1 inch all the way up to 2 inches.

[0010] In the further description, the term "wellhead valve" covers both a blowout preventer (BOP) alone and also a combination of a blowout preventer and other valve types (for example production valves), and other valve types or combinations of valve types alone, said wellhead valve being arranged on a wellhead on an end portion of a wellhead casing projecting above a seabed.

[0011] As mentioned above, suction anchors have been known to provide significant lateral support to conductors such as disclosed in the above-mentioned NO 313340, which corresponds to US 6692194. The applicant's own WO 2016/085348 on the other hand, discloses a supporting frame provided on a suction anchor,

where the supporting frame also transfers a significant portion of bending moment exerted on the wellhead, directly or indirectly, from the wellhead to the suction anchor. A disadvantage of the supporting frame disclosed in WO 2016/085348 is that the frame itself needs to have a certain height, typically around 1 meter, in order to create a force pair that may handle the high loads in question. This leads to a higher stick-up requiring a correspondingly large trawl protection.

[0012] The invention has for its object to remedy or reduce at least one of the drawbacks of the prior art or at least provide a useful alternative to the prior art.

[0013] The object is achieved through the features, which are specified in the description below and in the claims that follow.

[0014] The applicant has realised that the above-mentioned drawback of the high stick-up may be avoided by partially or fully embedding the supporting frame into a top portion of the suction anchor.

[0015] The invention provides a suction anchor including a device for reducing the risk of fatigue in a wellhead without increasing the pipe dimension, that is to say the pipe-wall thickness, the pipe diameter or the material quality, of the wellhead casing projecting up above the seabed and forming the wellhead, and without intervening in valves and so on mounted on the wellhead and while avoiding a large stickup from the suction anchor The invention relates to a suction anchor having a supporting frame integrated into a top portion of the suction anchor that rests on a seabed, the supporting frame being rigidly connected, directly or indirectly, to the wellhead casing to absorb a substantial portion of a bending moment applied to the wellhead casing by a horizontal load component. Calculations show that the bending stresses on the wellhead casing can be reduced considerably by the supporting frame absorbing a substantial part of the load caused by horizontal load components affecting the wellhead. Such horizontal load components may, for example, be caused by a connected riser being bent out sideways, for example because of sea currents. Studies have shown that bending stresses on the wellhead casing can be reduced to a range of 5-25 % of the total torque by the supporting frame relieving the wellhead casing. The material stresses in the wellhead casing will thereby be reduced correspondingly and, with a view to fatigue, the lifetime of the wellhead casing will increase. With a conservatively estimated effect by which the load on the wellhead casing is reduced to 10 %, the supporting frame taking 90 % of the load, the stresses in the wellhead casing will be reduced to 10 %, which results in an increase in the estimated lifetime of the wellhead casing by 1000 times seen in relation to fatigue.

[0016] The invention is defined by the independent claim. The dependent claims define advantageous embodiments of the invention.

[0017] The invention relates, more specifically, to a suction anchor with a device for reducing the strain on a wellhead casing from a bending moment generated by a horizontal load component from a well element arranged over a wellhead, wherein the device includes a supporting frame being integrated with the top portion of the suction anchor and connected, directly or indirectly, to an upper portion of the wellhead casing and projecting outwards from the centre axis of the wellhead casing and being provided with abutments resting in a supporting manner against the top portion of the suction anchor at a radial distance from the wellhead casing, the supporting frame being arranged to absorb a portion of said bending moment.

[0018] The supporting frame may include a well-casing extension adapted for connection to the wellhead casing. The advantage of this is that the wellhead casing can thereby be protected from bending stresses from drilling operations during the establishing of the well, as, in this phase, the bending moment from a blowout valve and other elements temporarily installed over the wellhead subject only the supporting frame and the well-casing extension to strain, and this is removed after the drilling operations have been carried out, and the well casing is possibly provided with a new supporting frame connected directly to the wellhead casing.

[0019] The ratio of the bending moment absorbed by the supporting frame to the bending moment applied to the wellhead casing may be at least 1:2, alternatively at least 3:4, alternatively at least 9:10.

[0020] The connection between the supporting frame and the wellhead casing, possibly between the supporting frame and the well-casing extension may preferable be formed as a zero-clearance connection. An advantage of this is that any bending moment applied will, in the main, be absorbed immediately by the supporting frame.

[0021] The supporting frame may include a coupling formed as a sleeve enclosing a portion of the wellhead casing or the well-casing extension, by a press fit. The sleeve may have been shrunk around a portion of the wellhead casing or the well-casing extension. An advantage of this is that the connection can be machined with moderate requirements of tolerance, and the shrinking may be provided by heat development during the welding-together of the sleeve and the projecting elements of the supporting frame.

[0022] In a preferred embodiment, the so-called low-pressure housing may be integrated with the supporting frame of the suction anchor for optimal load transfer. The high-pressure housing/wellhead may be connected inside the low-pressure housing, The low pressure housing may be a standard 30" or 36" housing and the high-pressure housing may be a standard 18 3/4" housing. The bending moment exerted on the wellhead will be transferred into a vertical force pair that is directly transmitted into the suction anchor and further into ground. The well equipment below the supporting frame will not be exposed to significant loads and enables the use of small diameter dimensions. Basis for this transfer of forces is the stiffness relation between the supporting frame and the equipment below the supporting frame in the well. If

the stiffness would be equal, the load sharing would be 50/50. Beneficial for this case is that the piping (e.g. conductor) below the supporting frame is intended to be of small diameter and therefore has a low stiffness. This way, most of, and in principle almost all, the bending moment may be transferred through the supporting frame. This is also beneficial for fatigue lifetime as stresses in the material will be very small. The connection between the supporting frame and the wellhead, via the low-pressure housing, is preferably zero clearance.

[0023] In what follows, an example of preferred embodiments is described, which is visualized in the accompanying drawings, in which:

Figure 1 shows a principle drawing of a suction anchor and wellhead according to the prior art provided with a supporting frame directly connected to an upper portion of a wellhead casing;

Figure 2 shows, in a highly simplified manner, the elements that absorb load when a wellhead is subjected to a bending moment from a horizontal load component;

Figure 3 shows another principle drawing of a suction anchor and wellhead according to the prior art provided with a supporting frame connected to an upper portion of a well-head casing via a well-casing extension integrated in the supporting frame; and

Figure 4 shows a suction anchor and wellhead according to the present invention with supporting frame integrated into the top portion of the suction anchor.

[0024] The drawings discussed in the following are drawn in a simplified and highly schematic manner, and various features shown therein are not necessarily drawn to scale. Like reference numerals refer to identical or similar features in the drawings.

[0025] Reference is first made to figure 1 showing a suction anchor 14 according to the prior art as disclosed in the above-referenced WO2016/085348. The suction anchor is formed with a closed upper portion (13) and an open lower portion (15). A subsea well 1 extends downwards in an underground 4 under a water mass 5. A wellhead 11 is arranged immediately above a seabed 41, an upper portion 12a of a wellhead casing 12 projecting up from the seabed and forming the wellhead 11 in which one or more wellhead elements 2 are arranged, such as a Christmas tree or blowout preventer (also referred to as a BOP), a wellhead connector 21 connecting the wellhead elements 2 to the wellhead casing 12. From the wellhead element 2, at least a marine riser 3 extends up through the water mass 5 to a surface installation (not shown). The riser 3 is shown as being deflected in order to indicate a situation in which the wellhead 11 is subjected to a horizontal load component L_h which subjects the wellhead casing 12 to a bending moment M_w. The deflection of the riser 3 may be due to currents in the water mass 5 or the position of the surface installation not shown. Currents in the water mass 5 may also subject the wellhead element 2 to a horizontal load component L_h, and skewed distribution of the mass of the wellhead element 2 will also subject the wellhead 11 to a horizontal load component L_h.

[0026] The wellhead casing 12 is shown here as a casing 122 extending up through a so-called conductor casing 121 which bounds the well 1 in a manner known *per se* towards the unconsolidated masses in the upper part of the base 4. An upper portion 12a of the wellhead casing 12 is rising from an upper portion 121a of the conductor casing 121. The upper portion 12a of the wellhead casing is often also referred to as the wellhead or the high-pressure housing. Similarly, the upper portion 121a of the conductor casing 121 is often referred to as the low-pressure housing. It should also be noted that in the industry, the combined low-pressure and high-pressure housings have also been known to be referred to as the wellhead.

[0027] Connected to the upper portion 12a of the wellhead casing 12, there is a supporting frame 6 which projects radially outwards from the wellhead casing 12 and is provided with several abutments 61 resting in a supporting manner against the top portion 13 of the suction anchor 14, the suction anchor 14 shown schematically here as an element which is embedded into the seabed 41. The wellhead casing 12 and the supporting frame 6 are connected to each other in a way that makes it possible for the supporting frame 6 to absorb a bending moment M_f as a reaction to the horizontal load component L_h from the wellhead element 2 subjecting the wellhead casing 12 to said bending moment M_w. In one embodiment a coupling 62 may be arranged in such a way that the wellhead casing 12 is allowed a certain deflection before hitting the supporting frame 6 and the further load being substantially absorbed by the supporting frame 6. The design of the coupling 62 and the dimensioning of the supporting frame 6 can thereby be used to control how great a load the wellhead casing 12 may be subjected to. However, in preferred embodiments there is zero radial clearance between the wellhead and the supporting frame 6. Calculations carried out by the applicant and other instances have shown that the supporting frame 6 may absorb 75 to 95 % of the strain caused by said horizontal load component L_h.

[0028] To ensure a greatest possible relief of the wellhead casing 12, the coupling 62 may be formed as a sleeve 621 surrounding a portion of the wellhead casing 12 without radial clearance. This may be achieved by shrinking the sleeve 621.

[0029] The supporting frame 6 according to figure 1 is suitable for permanent installation on the wellhead 11.

[0030] Reference is now made to figure 3, in which the supporting frame 6 is provided with a well-casing exten-

sion 63 which is adapted for insertion between the wellhead casing 12 and the wellhead element 2. Thereby the supporting frame 6 can be installed without any intervention into the wellhead casing 12. This embodiment is well suited for temporary installation, for example while drilling is in progress, indicated here by a drill string 7 extending from a surface installation not shown and through the wellhead 11. The well-casing extension 63 also works as a protection of the wellhead 11 during the temporary installation of wellhead elements 2 or the insertion or withdrawal of drilling equipment.

[0031] Figure 2 shows the statics of the supporting frame 6 in principle, the statics being representative for the supporting frames 6 shown in each of the figures 1, 3 and 4. Solid, oblique connecting lines between horizontal and vertical lines indicate that the connection is rigid. Fig. 4 shows a suction anchor 14 with a device according to the present invention. In the shown embodiment, the supporting frame 6 is fully embedded into the top portion 13 of the suction anchor 14, significantly reducing the stick-up and thereby the need for a large trawl protection structure. The principle for transfer of bending moment is the same as for the suction anchors shown in figures 1 and 3. For simplicity, the connection between the upper portion of the conductor 121a and the supporting frame 6 is shown without any coupling 62. However, a coupling may well be present between the supporting frame 6 and the upper portion of the conductor 121a in order to ensure a zero clearance radial gap connection. The closed upper portion 13 of suction anchor 14 may be located at the upper end, lower end or anywhere in between of the upper and lower ends of the support structure 6.

[0032] When the supporting frame 6 is mounted on the wellhead 11 and the wellhead 11 is subjected to a bending moment M_w generated by a horizontal load component L_n from above-lying elements 2, 3, the supporting frame 6 is subjected to a vertical load L_v which is transmitted to the seabed 41 at a distance from the centre axis of the wellhead casing 12 through the abutment of the supporting frame 6 against the base. Depending on the amount of play the coupling 62 between the supporting frame 6 and the wellhead casing 12 allows and how great a bending stiffness the wellhead casing 12 and the supporting frame 6 exhibit, the portion of the applied bending moment M_w absorbed by the supporting frame, that is to say M_f/M_w, M_f being the bending moment absorbed by the supporting frame 6, will vary. Calculations show that it is quite possible to dimension the supporting frame 6 to enable absorption of at least 9/10 of the bending moment M_w applied.

[0033] It should be noted that all the above-mentioned embodiments illustrate the invention, but do not limit it, and persons skilled in the art may construct many alternative embodiments without departing from the scope of the dependent claims. In the claims, reference numbers in brackets should not be regarded as restrictive. The use of the verb "to comprise" and its different forms does not exclude the presence of elements or steps that are not mentioned in the claims. The indefinite article "a" or "an" before an element does not exclude the presence of several such elements.

[0034] The fact that some features are stated in mutually different dependent claims does not indicate that a combination of these features cannot be used with advantage.

Claims

1. A suction anchor (14) with a device for reducing the load on a wellhead casing (12) from a bending moment (M_w) generated by a horizontal load component (L_h) from a well element (2, 3) arranged over a wellhead (11), the suction anchor having a closed top portion and an open lower portion, the device including a supporting frame (6), integrated into the closed top portion of the suction anchor, connected to an upper portion (12a) of the wellhead casing (12) and projecting outwards from the centre axis of the wellhead casing (12) and being provided with abutments (61) which rest supportingly against the top portion of the suction anchor, at a radial distance from the wellhead casing (12), the supporting frame (6) being arranged to absorb a portion of said bending moment (M_w).

2. The suction anchor according to claim 1, wherein the supporting frame (6) comprises a well-casing extension (63) adapted for connection to the wellhead casing (12).

3. The suction anchor according to claim 1, wherein the ratio of the bending moment (Mf) absorbed in the supporting frame (6) to the bending moment (M_w) applied to the wellhead casing (12) is at least 1:2.

4. The suction anchor according to claim 3, wherein the ratio of the bending moment (Mf) absorbed by the supporting frame (6) to the bending moment (M_w) applied to the wellhead casing (12) is at least 3:4.

5. The suction anchor according to claim 4, wherein the ratio of the bending moment (Mf) absorbed in the supporting frame (6) to the bending moment (M_w) applied to the wellhead casing (12) is at least 9:10.

6. The suction anchor according to claim 1 or 2, wherein the connection between the supporting frame (6) and the wellhead casing (12), possibly between the supporting frame (6) and the well-casing extension (63) is formed as a zero-clearance connection.

7. The suction anchor according to claim 6, wherein the supporting frame (6) comprises a coupling (62) formed as a sleeve (621) which encloses a portion

of the wellhead casing (12) with a press fit.

8. The suction anchor according to claim 6, wherein the supporting frame (6) comprises a coupling (62) formed as a sleeve (621) which encloses a portion of the well-casing extension (63) with a press fit.

9. The suction anchor according to claim 6, wherein the supporting frame (6) comprises a coupling (62) formed as a sleeve (621) which has been shrunk around a portion of the wellhead casing (12).

10. The suction anchor according to claim 6, wherein the supporting frame (6) comprises a coupling (62) formed as a sleeve (621) which has been shrunk around a portion of the well-casing extension (63).

11. The suction anchor according to any of the preceding claims, wherein a low-pressure housing is integrated into said supporting frame (6).

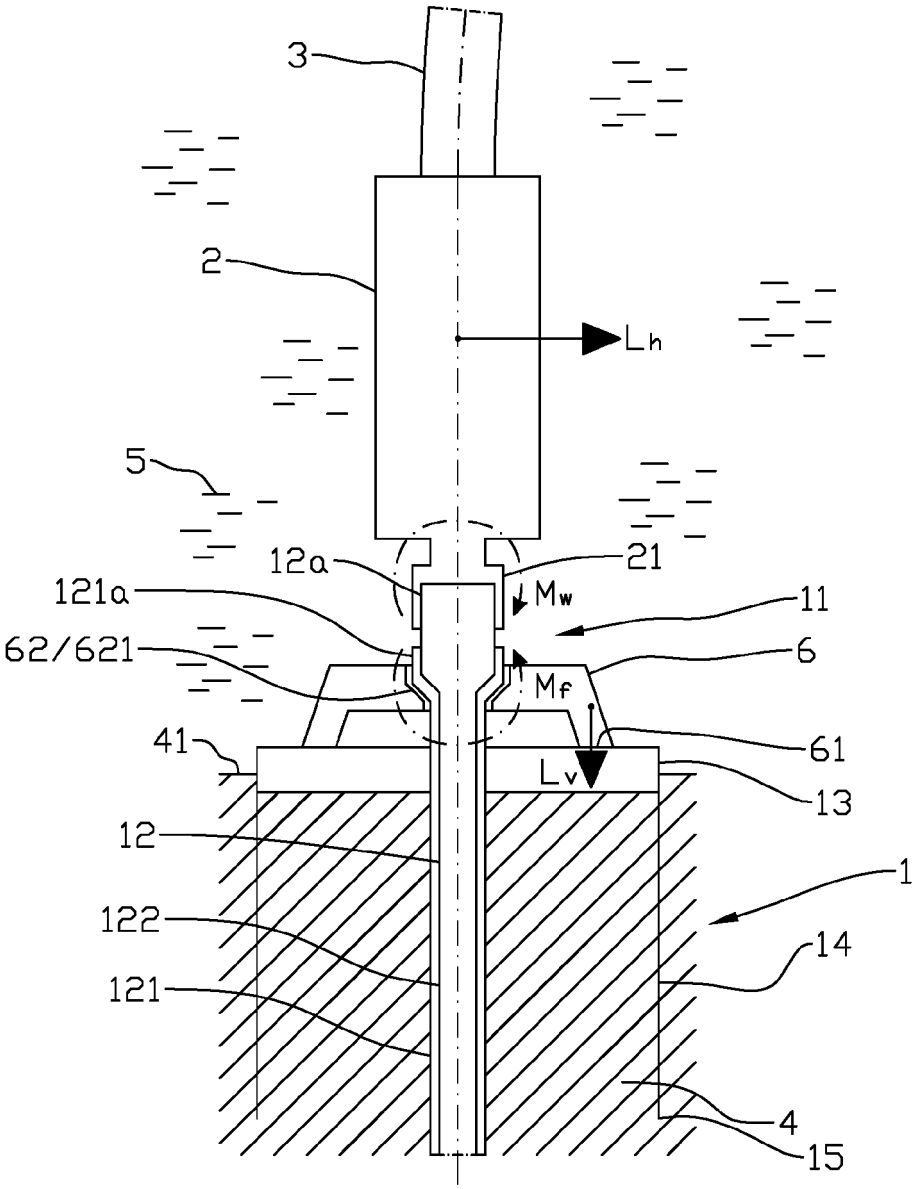
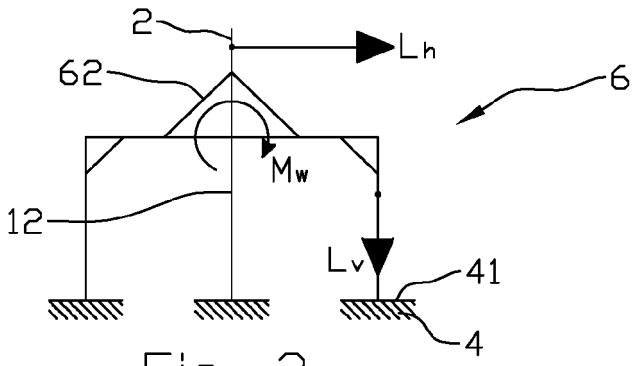

3
2
Lh
5
12a
21
121a
Mw
11
62/621
6
Mf
41
61
Lv
13
12
1
122
14
121
4
15

Fig. 1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Lh
62
6
Mw
12
Lv
41
4

Fig. 2

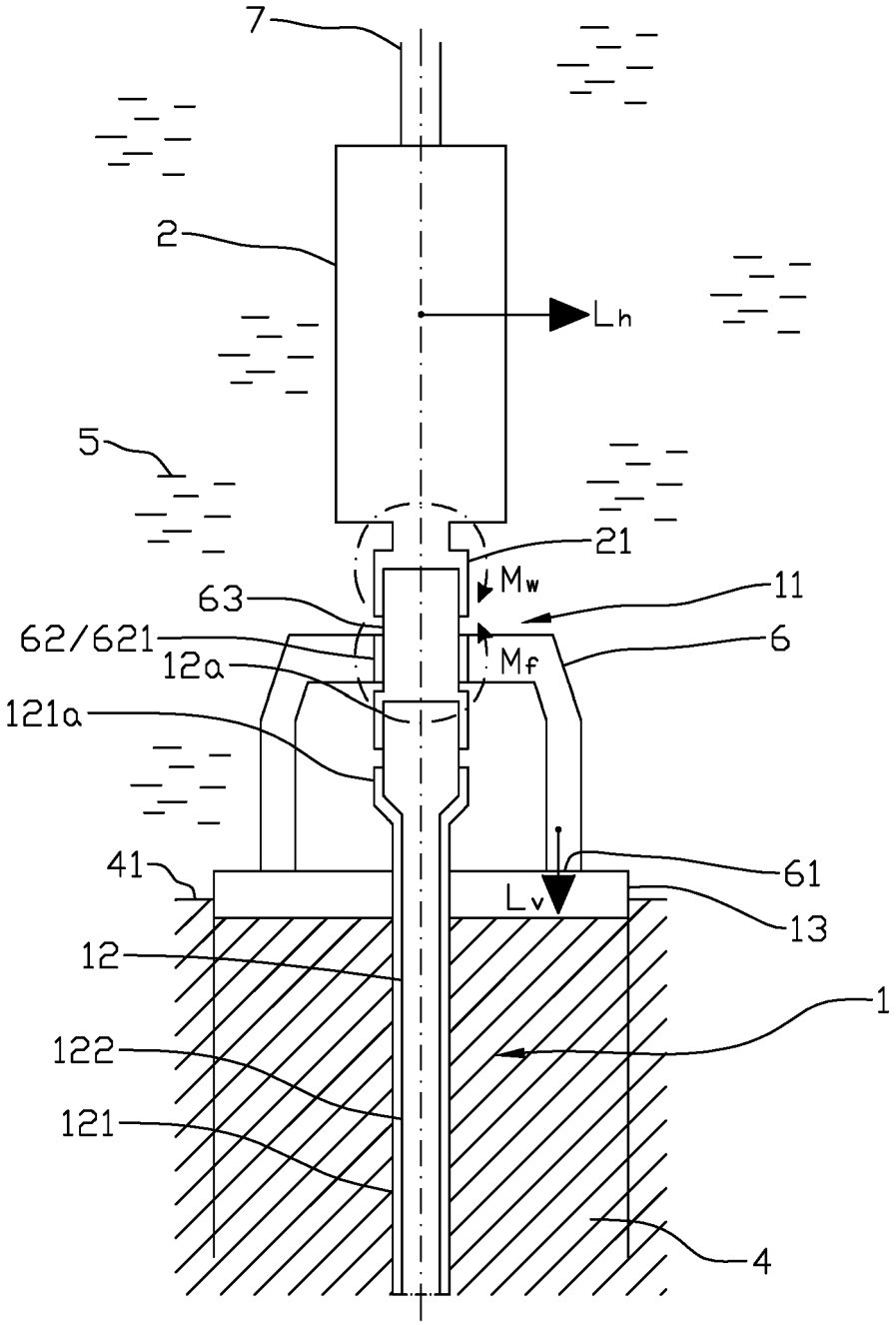

Fig. 3

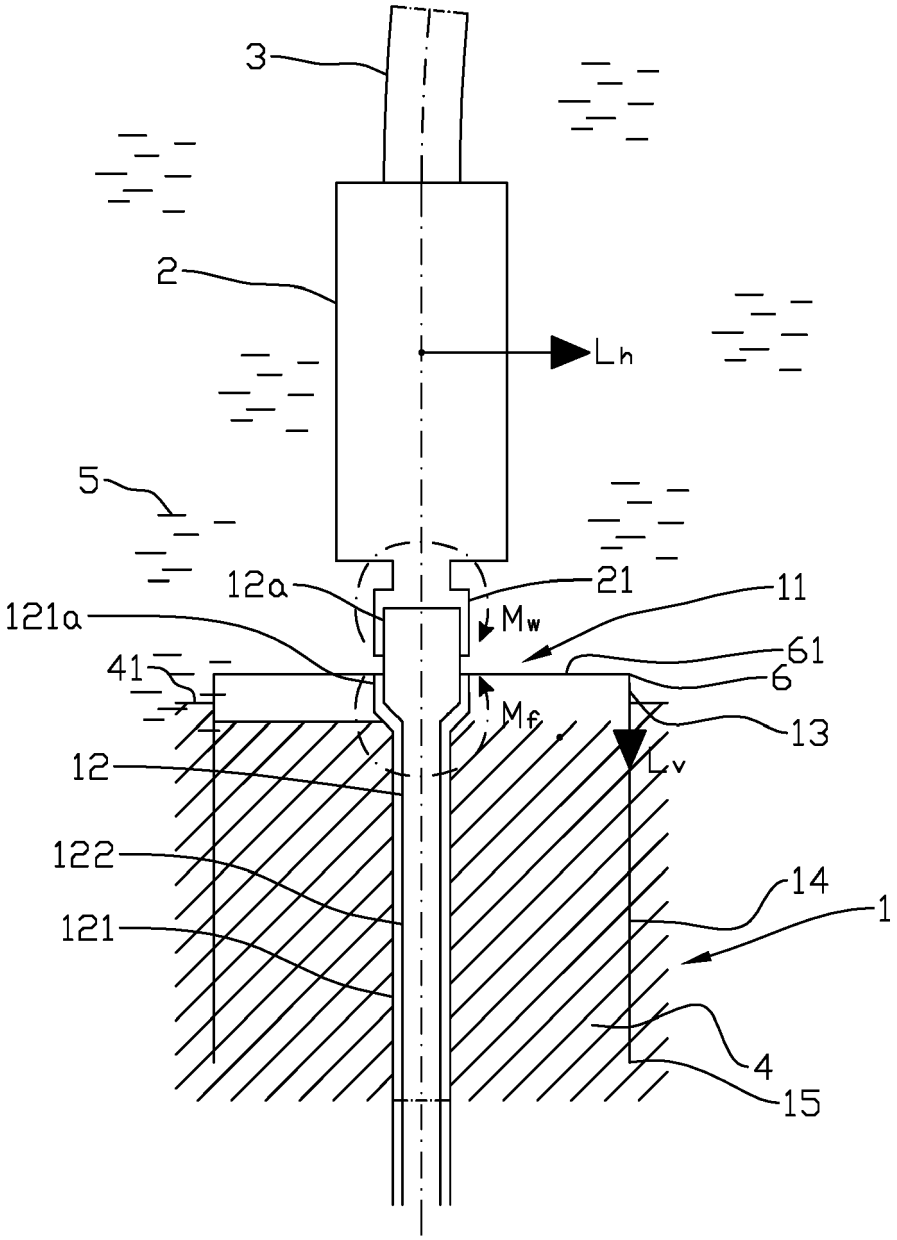

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 18 18 4631

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	WO 2016/085348 A1 (NEODRILL AS [NO]) 2 June 2016 (2016-06-02) * abstract; figures 1-3 *	1-11	INV. E21B17/01 E21B33/035 E21B41/08
A	WO 2017/155415 A1 (STATOIL PETROLEUM AS [NO]) 14 September 2017 (2017-09-14) * page 25, line 27 - page 27, line 32; figures 5,6 *	1-11	E21B43/013 B63B21/27

TECHNICAL FIELDS SEARCHED (IPC)

E21B
B63B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	2 January 2019	Strømmen, Henrik

CATEGORY OF CITED DOCUMENTS

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02-01-2019

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- NO 305179 **[0005]**
- NO 331978 **[0006]**
- WO 2011162616 A1 **[0006]**
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- US 20100212916 A1 **[0008]**
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