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(54) **LOCKING MECHANISM**

VERRIEGELUNGSMECHANISMUS

MÉCANISME DE VERROUILLAGE

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Description

[0001] The invention relates to well operations, especially in connection with production of hydrocarbons from underground formations. More specifically, the invention relates to a device for heave compensation of equipment on a moving vessel, as disclosed in the preamble of the independent claims.

Background of the invention

[0002] During the recovery of hydrocarbons from wells in underground formations, the operator must sometimes carry out work in the wells. Such work may be maintenance or other technical operations, such as perforating, replacing or reperforating pipes, changing flow regulators, isolating production zones, monitoring production and logging pressure, flow and temperature. A motivating factor for the work is to increase the recovery rate of the well. This work, which is referred to by the collective term 'well intervention', is difficult to perform from conventional surface platforms, especially when subsea wells are involved. It is well known that subsea wells are less maintained than platform wells and hence have lower recovery rates. It is therefore desirable to have systems that are suitable for maintenance of subsea wells.

[0003] A distinction is made between light well intervention and heavy well intervention. Today, light well intervention is carried out with the aid of wireline operations from a ship. Heavy well intervention (which includes the whole spectrum of intervention work) is usually carried out from a special moored, semi-submersible rig that is connected to the wells via a riser (pipe for gas and/or liquid). The special rig fills the gap between the ordinary drilling rigs and the vessels that carry out light well intervention, using wireline operations and has, inter alia, substantially lower costs than an ordinary drilling rig.

[0004] To further optimise costs, it is therefore desirable that such special rigs are of maximum flexibility, such that, for example, in addition to carrying out heavy well intervention they can also carry out light well intervention using wireline-operated tools.

[0005] Known floating intervention rigs have a drilling machine suspended from a tower via a heave compensation system for compensating for wave motions, which may comprise a combined hoisting and compensation cylinder. The tower and the cylinder are mounted on deck. In an ordinary device, the drilling machine is suspended from wires (so-called drill line), which run over guide pulleys at the top of the mast, via reversing pulleys at the top of the cylinder, to a fixed point at the top of the mast. The drilling machine can therefore be hoisted up and down by moving the cylinder, and the cylinder also compensates - within certain tolerances - for the motions of the rig such that the drilling machine is kept as steady as possible when carrying out intervention operations. A combined hoisting and compensation cylinder of this kind is capable of handling large loads, typically in the order of 250 tonnes.

[0006] This device is used, for example, when landing large weights on the seabed or inside the drilling riser, as well as during drilling, and can be operated in passive or active compensation mode when there is a need for greater accuracy and control of the compensation.

[0007] The prior art comprises WO 2007/145503 A1, which describes a device and a method for heave compensation. A mast is mounted on a floating vessel, a first compensation means that is attached via wire means on one side of the mast, and the other end of the wire means is further connected to a second heave compensation means attached to a tool unit for carrying out drilling operations. The second heave compensation means and the tool unit are moved along guide rails in the mast with the aid of dollies/lever arms.

[0008] US 6.000.480 A discloses an arrangement comprising heave drilling, where the arrangement comprises a first frame-like structure which in relation to a floating vessel is mounted for allowing movement at least in the vertical direction in relation to said vessel, as well as devices for providing compensating power between said first frame stucture and said vessel. The arrangement further comprises a second frame-like structure arranged stationary on a deck of the vessel, said first compensated frame-like structure and said second frame-like structure being assembled by means of a further system, allowing compensation of said relative movement between the vessel and said compensated structure, i.e. heave compensation both in relation to said vessel and said first frame structure.

[0009] WO 2007/044924 A2 discloses a rig assist compensation system, the system comprising a motion compensation unit operatively connected to a semi-submersible rig platform having a blow-out prevention (BOP) stack; a hydraulic workover jack rotatably affixed above the BOP stack, wherein the HWO jack includes a through-rotary portion, and a stationary portion; and a hydraulic motion compensator unit, positioned between the HWO jack and the BOP stack. The hydraulic motion compensator unit comprises a base frame having a plurality of base cylinders; an upper frame having a plurality of mating upper cylinders to engage the base cylinders in telescoping fashion, wherein the base frame and the upper frame are slidably connected, and are movable from an extended position and a retracted position.

[0010] There are stringent requirements as regards the ability of the well intervention rig to - very accurately - compensate for the movements of the rig. Heave compensation requirements are often concretised as an ability to compensate weight change, positioning accuracy and speed limitation. In known well intervention rigs, however, the size of the combined hoisting and compensation cylinder, and the friction in the guide pulleys and reversing pulleys make it difficult to satisfy one or more of these requirements. There is therefore a need for a device that is capable of obtaining greater accuracy in heave compensation than is the case with known well intervention rigs. The invention meets this need and has other advantages in addition.

Summary of the invention

[0011] Therefore, a device is provided for heave compensation of a tool unit which is suspended via one or more wire means in a mast mounted on a platform, each wire means at a first end being attached to the mast via an attachment and running via a first heave compensation unit, and each wire means at its other end being attached to a second heave compensation unit that is connected to the tool unit, characterised in that the second heave compensation unit comprises a movable compensation means which at its first end is attached to the wire means and which at its second end is attached to the tool unit, and that the second heave compensation unit comprises a releasable locking means with which the motions of the compensation means can selectively be prevented and allowed.

[0012] In an embodiment, the compensation means is attached to the wire means via a connecting unit and is attached to the tool unit via a link element, the connecting unit and the link element being movable in relation to one another, and where the locking means is movable for selectively and releasably limiting the motions of the connecting unit and the link element in relation to one another.

[0013] In an embodiment, the locking means comprises a locking bolt with a central, narrowed portion and broad shoulder portions at each end of the bolt.

[0014] In an embodiment, the link element comprises a through hole having a first portion and a second portion, the first portion having a larger opening than the second portion. The first portion has a dimension that allows passage of the shoulder portions whilst the second portion has a dimension that does not allow passage of the shoulder portions, but does allow passage of the central portion. In an embodiment, the first portion has a circular cross-section and the second portion is elongate.

[0015] In an embodiment, the wire means runs between the second heave compensation unit and the first heave compensation unit via guide pulleys that are mounted at an upper part of the mast, and run via the first heave compensation unit between the guide pulleys and the attachment in the mast.

[0016] In an embodiment, the first heave compensation unit is connected at a first end to the platform and at a second end is movably attached to said wire means via reversing pulleys and a cylinder.

[0017] In an embodiment, the device comprises locking means with which the movements of the compensation units can selectively be prevented, and the compensation units transfer loads between the tool unit and the wire unit as substantially rigid bodies.

[0018] In an embodiment, the first heave compensation unit functions as an active heave compensator whilst the second heave compensation unit functions as a passive heave compensator.

[0019] In an embodiment, the second heave compensation unit is an integral part of the tool unit. The first and second heave compensation units are preferably hydraulically operated.

[0020] The second heave compensation unit can quickly and simply be installed on any drilling machine, without structural modifications of the drilling machine.

Overview of the figures

[0021] These and other characteristic features of the invention will be elucidated in the following description of preferred, non-limiting embodiments, with reference to the accompanying schematic drawings, wherein:

Figure 1 shows a mast with a compensation system, seen from a side;

Figure 2 shows a mast with the compensation means according to the invention, seen from the front;

Figure 3 shows the mast and the compensation means shown in Figure 2, but from another side;

Figure 4a shows a section of a first embodiment of the invention, seen from a side, where the cylinders in the second heave compensation unit are in a retracted position;

Figure 4b shows the section shown in Figure 4a, seen from the front;

Figure 4c corresponds to Figure 4b, but shows the cylinders in the second heave compensation unit in a fully extended position;

Figure 4d corresponds to Figure 4b, but shows the cylinders in the second heave compensation unit in a mid position;

Figure 5a shows a section of a second embodiment of the invention, seen from a side, where the cylinder in the second heave compensation unit is in a retracted position;

Figure 5b shows the section shown in Figure 5a, seen from the front;

Figure 5c corresponds to Figure 5b, but shows the cylinders in the second heave compensation unit in a fully extended position;

Figure 5d corresponds to Figure 5b, but shows the cylinders in the second heave compensation unit in a mid position;

Figure 6a shows a section of a third embodiment of the invention, seen from a side, where the cylinder in the second heave compensation unit is in a retracted position;

Figure 6b shows the section shown in Figure 6a, seen from the front;

Figures 7a and 7b show the third embodiment of the heave compensation unit in an unlocked state, seen respectively from the front and from a side;

Figures 7c and 7d are an enlarged section of Figures 7a and 7b respectively, and Figure 7e is a sectional view of that shown in Figure 7d;

Figures 8a and 8b shows a locked state, where the motion damper has not been activated;

Figures 8c and 8d are enlarged sections of Figures 8a and 8b respectively, and Figure 8e is a sectional view of that shown in Figure 8d;

Figures 9a and 9b show a state in which it is possible to pull the locking bolt out of the keyhole, and Figure 9c is an enlarged sectional view of that shown in Figure 9b; and

Figures 10a and 10b shows a position for weight reduction by screwing together drilling machine and drill string, a so-called "thread-saver" function, and Figure 10c is an enlarged sectional view of that shown in Figure 10b.

Description of preferred embodiments

[0022] Figure 1 shows a mast 1 located on a deck 2, for example, on an intervention rig or drilling rig (not shown). An active heave compensation cylinder 7 and accumulator 8 and a combined hoisting and heave compensation cylinder 4 are mounted on the deck 2. The heave compensation cylinder 4 is equipped at its upper end with reversing pulleys 5 for hoisting wires 6. It is usual to have four or six parallel running hoisting wires.

[0023] With reference to Figure 2, the combined hoisting and heave compensation cylinder 4 has a length of stroke d, where the cylinder rod 12 is in a fully extended position. The fully retracted and extended positions, respectively, of the reversing pulleys are indicated by the reference numerals 5 and 5'.

[0024] In the illustrated embodiments, the mast is constructed of a lattice structure in a known way, and will therefore not be described in more detail here. Similarly, the heave compensation units are driven by fluid reservoirs, regulating valves and systems, gas tanks and hydraulic power units. These components are well known to the skilled person and are therefore not referred to in more detail here.

[0025] The mast is equipped with guide rails 9 for a drilling machine 11 in a known way. Furthermore, with reference to Figures 2 and 3, the wires 6 are connected to the upper part of the mast via an anchorage 10. The wires 6 run from the anchorage 10 via the reversing pulleys 5 on the cylinder rod 12 of the combined hoisting and heave compensation cylinder 4, onward via guide pulleys 3 at the top of the mast and then down to a compensator 20, which is connected to the drilling machine 11. Figure 2 shows the combined drilling machine 11 and compensator 20 in a lower position against the deck 2, whilst these units in Figure 3 are raised slightly from the deck.

[0026] Three embodiments of the compensator are described below.

<u>First embodiment:</u>

[0027] Referring to Figures 4a-d, the compensator 20 comprises two cylinders 22a,b that are directly connected between the drilling machine 11 and the connecting link 24 of the hoisting wires. The hoisting wires (not shown in Figures 4a-c) are connected to the connecting link 24 via suitable attachments 25. Figure 4a further shows a dolly 21 attached to the drilling machine 11 for engagement with the tower guide rail as described above.

[0028] The cylinders 22a,b are equipped with a lock 23 with which the cylinders can be locked in the retracted position when the system is not in use. The load from the drilling machine 11 is transferred to the lifting wires via the cylinders 22a,b and the connecting link 24.

[0029] Figures 4 a,b show the cylinders 22a,b in a retracted position, Figure 4c shows the cylinders 22a,b in a fully extended position, whilst Figure 4d shows the cylinders 22a,b in a mid position. The reference numeral 26 indicates the respective cylinder rods of the cylinders.

[0030] Fluid reservoirs and control units for the heave compensation cylinders 22a,b are in accordance with the prior art and are therefore not discussed in more detail here.

<u>Second embodiment:</u>

[0031] Referring to Figures 5a-d, the compensator 20' comprises one cylinder 27 which is connected between the drilling machine 11 (via a link 29) and a connecting link 28 for the hoisting wires (only attachments 25 for the wires are shown in Figures 5b-d). Figure 5a further shows a dolly 21 attached to the drilling machine 11, for engagement with the tower guide rail as described above.

[0032] The cylinder 27 is equipped with lock 23 with which the cylinders can be locked in collapsed position when the compensator 20' is not in use. The load from the drilling machine 11 is transferred to the hoisting wires via the cylinder 27 and the connecting link 28.

[0033] The figures 5a,b show the cylinder 27 in a retracted position, Figure 5c shows the cylinder 27 in a fully extended position, whilst Figure 5d shows the cylinder 27 in a mid position. The reference numeral 26 indicates the cylinder rod of the cylinder. Fluid reservoirs and control units for the heave compensation cylinder 27 are in accordance with the prior art and are therefore not discussed in more detail here.

Third embodiment:

[0034] With reference to Figures 6a to 10c, the compensator 20" comprises one compensator cylinder 31 (also referred to as a motion damper) that is mounted to a connecting piece 32 for the hoisting wires. Figures 6a and 6b further show a dolly 21 attached to the drilling machine 11, for engagement with the tower guide rail as described above. On the connecting piece 32 there is mounted a lock 30 (which, for example, is hydraulically operated via an actuator 86) that is capable of connecting together the connecting piece 32 and the below-lying link element 33 from which the drilling machine 11 is suspended. The lock 30 bears all load when it is in the locked position and the compensator 20" is not in use, such that the load from the drilling machine 11 is transferred to the hoisting wires via the link element 33, the hydraulically operated lock 30 and the connecting piece 32. Figures 6a,b show such a locked position, in which the cylinder 31 is in a retracted position and is inactive.

[0035] Fluid reservoirs and control units for the compensation cylinder 31 are in accordance with the prior art and are therefore not discussed in more detail here.

[0036] Figures 7a to 10c are further illustrations of the compensator cylinder 31, the connecting piece 32, the link element 33 and the connection between these components in different configurations.

[0037] The connecting piece 32, to which the compensator cylinder 31 and the wires 6 are fastened, comprise two plate elements 32a,b arranged spaced apart and fastened together by means of upper bolts 81 and lower bolts 83. The lock 30, with its hydraulic actuating mechanism, is also attached to the connecting piece (hydraulic connecting lines are not shown, as they are prior art). The lock 30 comprises a housing 30' with a locking bolt 87, a locking bolt cylinder 88 and a position sensor 89 for the locking bolt. The locking bolt 87 has a central narrowed portion 87b, and broad portions (flanges) 87a at each end.

[0038] In this illustrated embodiment, the link element 33 also has a plate form, and is disposed between the plate elements 32a,b of the connecting piece in such a way as to be movable. The cylinder rod 26 of the compensator cylinder 31 (whose housing is fastened to the connecting piece) is secured to the link element 33 via a fastening bolt 84. The link element 33 is provided with a through "keyhole" 82, which is adapted for receiving the locking bolt 87. The keyhole 82 is elongate and has a lower portion 82a that has a larger opening than the above-lying, slightly narrower portion 82b of the keyhole.

[0039] The broad end portions 87a of the locking bolt 87 have a cross-sectional dimension that allows passage through the lower, broad portion 82a of the keyhole and into the respective support holes 37 in the side plates 32a,b, but does not allow passage through the above-lying portion 82b. The central, narrowed portion 87b of the locking bolt has a cross-sectional dimension that allows movement of the locking bolt up and down in the keyhole, also in the slightly narrower portion 82b.

[0040] Figures 7a-e show an unlocked state. The locking bolt 87 has been fully withdrawn from the keyhole 82 in the link element 33, thereby allowing the link element 33 to move between the two side plates 32a,b in the connecting piece 32. The link element 33, which is connected to the compensator cylinder 31 via the cylinder rod 26, can move between a lower position (as shown) and an upper position, limited by, respectively, the upper shoulders 85 and lower shoulders 90 and the lower (stop) bolts 83. The figures show that when the link element 33 is in the full lower position, it will rest on the two lower bolts 83 via the shoulders 85, which will prevent the drilling machine from falling if the compensator cylinder 31 should fail. When the cylinder stroke is reduced to about half stroke (compared with that shown in Figures 7a-d), the system will be in the position for motion damping.

[0041] Figures 8a-e show a locked stated wherein the motion damper 31 is not in use. The system is locked, such that all load passes through the locking bolt without affecting the motion damper. The load is suspended from the drilling machine (not shown) and is transferred to the link element 33. The link element 33 is suspended from the locking bolt 87 that is seated in holes in the side plates 32a,b of the connecting piece 32. From the locking bolt 87, the load passes through these two side plates up to the upper bolts 81, which connect the hoisting wires to the connecting piece 32. This is a normal configuration of the suspension system for drilling and lifting/lowering the drill string.

[0042] Figures 9a-c show a state in which the lower link element 33 has been lifted up to a maximum height in the keyhole 82, such that the locking bolt shoulders 87a and the broad portion 82a of the keyhole are aligned with one another. This is the only position in which it is possible to pull the locking bolt 87 out of the keyhole 82. The locking bolt is moved (pulled) horizontally by means of a cylinder 88 equipped with a stroke sensor 89 such that there is control of whether the bolt is in lockable engagement with the keyhole or not. This lifting of the link element 33 is done with the aid of the compensator cylinder 31. As described above, Figures 9a-c also show that the lower dimension (diameter) of the keyhole is so great that the locking bolt can be moved horizontally through the keyhole. In the upper, narrower part of the keyhole, it is not possible to move the locking bolt in a horizontal direction owing to the shoulders having increased diameter at the ends. However, the locking bolt is free to be moved vertically in the keyhole, throughout the length of the keyhole. The sectional view in Figure 9c shows the locking bolt half out of engagement. It can be seen that the locking bolt has a shoulder 87a with a larger diameter at both ends than the diameter of the central portion 87b. The diameter of the shoulders fits in the supporting holes 37 of the connecting piece 32 and the lower part 82a of the keyhole in the link element.

[0043] Figures 10a-c shows a state in which the locking bolt 87 is locked, but the damping cylinder 31 (not shown in Figures 10a-c) is actuated with a small stroke such that the locking bolt is roughly in the middle of the keyhole 82. This is a position for weight reduction on screwing together the drilling machine and the drill string, a so-called "thread-saver" function.

[0044] The task of the compensator 21" is to hold tool that has been lowered into the well in an accurate position without subjecting equipment installed in the well to weights greater than typically +/- 500 kg whilst the main heave compensation is in progress with the aid of the combined hoisting and heave compensation cylinder 4, with associated accumulator tanks and other necessary, known equipment (not shown). The compensator 21" with compensation cylinder 31 takes the "peaks" of the damping from the main compensator 4.

[0045] The compensator 21" may thus have at least the following two functions:

a) Damping/minimising vertical motion and controlling/minimising load against components inside the well from tools that may be lowered down into it; and
b) Reducing the load between the shaft of the drilling machine and the top of the drill pipe when they are to be screwed together (thread-saver).

[0046] Although the compensator 21" is described here as being made up of a lower link element 33 that is movably arranged between the two side plates 32a,b of the connecting piece 32, the invention should not be limited to such designs, as a variant may be an inverted configuration where the lower link element has two side plates and the connecting piece comprises one element that is movably arranged therebetween. The invention should also not be limited to plate-shaped elements.

<u>Features common to the embodiments:</u>

[0047] The combined hoisting and heave compensation cylinder 4 and associated components (in the following also referred to as Stage 1) are used when landing large loads on the seabed or inside the drilling riser, and during drilling. In such situations, the compensator 20; 20'; 20" is not necessarily in use, i.e., the cylinders are locked via their respective locking mechanisms 23; 30.

[0048] For heave compensation, Stage 1 can be operated in passive compensation mode or in active compensation mode.

[0049] In situations where greater accuracy and control of the compensation are required, as for example, during well intervention, Stage 1 will be operated in active compensation mode. Stage 1 will therefore be able to achieve heave compensation down to a certain minimum level.

[0050] The compensator 20; 20'; 20" (in the following also referred to as Stage 2) is used together with Stage 1 in order to further increase sensitivity and accuracy, and to ensure that the power of the drilling machine does not exceed a defined minimum value. Stage 2 then functions as a passive heave compensator. The compensator in Stage 2, which may have a relatively short stroke length, is constructed such that the cylinder piston is held stationary until loaded with a predefined weight. When such a predefined weight has been reached, the compensator in Stage 2 will compensate by either retracting or extending the cylinder rod 26.

[0051] Examples of situations in which the need for a Stage 2 is present include landing of lighter equipment within the casing and subsea safety valves.

[0052] A two-stage heave compensator of this kind can thus - very accurately - compensate for the motions of the rig. Within given operational parameters (e.g., max heave motion of rig), Stage 1 and Stage 2 in combination can compensate for a relatively small weight change and obtain major positioning accuracy at a limited speed. As mentioned above, a combined hoisting and compensation cylinder can typically handle loads of the order of 250 tonnes. In such a connection, a relatively small weight change may be of the order of ± 500 kg, and the positioning accuracy can be of the order of ± 10 cm.

[0053] Stage 1 can handle large loads and most of the heave. The compensator 20; 20'; 20" (Stage 2) is however substantially smaller than Stage 1 and thus generates less packing friction. In addition, the compensator in Stage 2 is located on top of the drilling machine 11 such that it does not take with it other friction than that in the compensator 20; 20'; 20", and possibly some from the well.

[0054] The compensator 20; 20'; 20" is thus able to reduce the load amplitude from Stage 1 to a load oscillation that is within the requirement for weight change compensation.

[0055] The device according to the invention functions in this way as a two-stage heave compensator, where the combined hoisting and heave compensation cylinder 4 (Stage 1) handles the large loads, whilst the compensator 20; 20'; 20" (Stage 2, which has better sensitivity and greater accuracy) is able to compensate for loads that are smaller than Stage 1 is adapted to compensate for.

[0056] In an embodiment, the load for which the compensator 20; 20'; 20" is designed to compensate may be of the order of 8-10% of the load capacity of the hoisting system.

[0057] It will be appreciated that the device for heave compensation can be used for purposes other than well intervention.

[0058] The numerical values in the description above have been included to illustrate the application of the invention, and should not be regarded as a limitation of the invention.

Claims

1. A device for heave compensation of a tool unit (11) that is suspended via one or more wire means (6) from a mast (1) mounted on a platform (2), each wire means at a first end being attached to the mast via an attachment (10) and running via a first heave compensation unit (4, 5, 12), and each wire means (6) at its second end being attached to a second heave compensation unit (20; 20'; 20") that is connected to the tool unit,
characterised in that
the second heave compensation unit (20'; 20") comprises a movable compensation means (31) which at its first end is attached to the wire means (6) and which at its second end is attached to the tool unit (11), and that the second heave compensation unit comprises a releasable a locking means (30) with which the motions of the compensation means (31) can be selectively prevented and allowed.

2. A device as disclosed in claim 1, wherein the compensation means (31) is attached to a wire means (6) via a connecting unit (32) and is attached to the tool unit (11) via a link element (33), and wherein the connecting unit (32) and the link element (33) are movable in relation to one another, and wherein the locking means (30) is movable for selectively and releasably limiting the motions of the connecting unit (32) and the link element (33) in relation to one another.

3. A device as disclosed in claim 2, wherein the locking means (30) comprises a locking bolt (87) with a central, narrowed portion (87b) and broad shoulder portions (87a) at each end of the bolt.

4. A device as disclosed in claim 2 or claim 3, wherein the link element (33) comprises a through hole (82) with a first portion (82a) and a second portion (82b), the first portion having a larger opening than the second portion.

5. A device according to claim 4, wherein the first portion (82a) has a dimension that allows passage of the shoulder portions (87a) whilst the second portion (82b) has a dimension that does not allow passage of the shoulder portions but does allow passage of the central portion (87b).

6. A device according to claim 4 or claim 5, wherein the first portion (82a) has a circular cross section and the second portion (82b) is elongate.

7. A device as disclosed in claim 1, wherein said wire means between the second heave compensation unit and the first heave compensation unit runs via guide pulleys (3) which are mounted at an upper portion of the mast, and run via the first heave compensation unit between the guide pulleys and the attachment in the mast.

8. A device as disclosed in claim 1 or claim 2, wherein the first heave compensation unit is connected at a first end to the platform and at a second end is movably attached to said wire means via reversing pulleys (5) and a cylinder (4, 12).

9. A device as disclosed in any one of the preceding claims, comprising locking means (23) with which the motions of the compensation units (22a,b; 27) can selectively be prevented and the compensation units transfer loads between the tool unit and the wire means as substantially rigid bodies.

10. A device as disclosed in any one of the preceding claims, wherein the first heave compensation unit (4, 5, 12) functions as an active heave compensator whilst the second heave compensation unit (20; 20'; 20") functions as a passive heave compensator.

Patentansprüche

1. Vorrichtung zur Hubkompensation von einer Werkzeugeinheit (11), welche über ein oder mehrere Draht-Mittel (6) von einem Mast (1), welcher auf einer Plattform (2) eingerichtet ist, aufgehängt ist, wobei jedes Draht-Mittel mit seinem ersten Ende über ein Befestigungselement (10) am Mast angebracht ist und über eine erste Hubkompensationseinheit (4, 5, 12) verläuft, und wobei jedes Draht-Mittel (6) mit seinem zweiten Ende an einer zweiten Hubkompensationseinheit (20; 20'; 20"), welche mit der Werkzeugeinheit verbunden ist, angebracht ist,
dadurch gekennzeichnet, dass
die zweite Hubkompensationseinheit (20'; 20") ein bewegbares Kompensationsmittel (31) umfasst, welches an seinem ersten Ende an dem Draht-Mittel (6) angebracht ist und welches an seinem zweiten Ende an der Werkzeugeinheit (11) angebracht ist, und wobei die zweite Hubkompensationseinheit ein lösbares Verriegelungsmittel (30) umfasst, durch welches die Bewegungen des Kompensationsmittels (31) selektiv unterbunden und zugelassen werden können.

2. Vorrichtung nach Anspruch 1, bei welcher das Kompensationsmittel (31) über eine Verbindungseinheit (32) an einem Draht-Mittel (6) angebracht ist und über ein Verbindungselement (33) an der Werkzeugeinheit (11) angebracht ist, und wobei die Verbindungseinheit (32) und das Verbindungsmittel (33) in Relation zueinander bewegbar sind, und wobei das Verriegelungselement (30) zur selektiven und lösbaren Einschränkung der Bewegungen zwischen

der Verbindungseinheit (32) und dem Verbindungselement (33) in Relation zueinander bewegbar ist.

3. Vorrichtung nach Anspruch 2, bei welcher das Verriegelungsmittel (30) einen Verriegelungsbolzen (87) mit einem mittig verengten Abschnitt (87b) und breiten Schulterabschnitten (87a) an jedem Ende von dem Bolzen umfasst.

4. Vorrichtung nach Anspruch 2 oder 3, bei welcher das Verbindungselement (33) ein Durchgangsloch (82) mit einem ersten Abschnitt (82a) und einem zweiten Abschnitt (82b) umfasst, wobei der erste Abschnitt eine größere Öffnung hat als der zweite Abschnitt.

5. Vorrichtung nach Anspruch 4, bei welcher der erste Abschnitt (82a) Abmessungen hat, welche die Durchführung von den Schulterabschnitten (87a) zulässt, während der zweite Abschnitt (82b) Abmessungen hat, welche die Durchführung von den Schulterabschnitten nicht zulassen jedoch die Durchführung des Mittenabschnitts (87b) zulassen.

6. Vorrichtung nach Anspruch 4 oder 5, bei welcher der erste Abschnitt (82a) einen kreisförmigen Querschnitt hat und der zweite Abschnitt (82b) langgestreckt ist.

7. Vorrichtung nach Anspruch 1, bei welcher das Draht-Mittel zwischen der zweiten Hubkompensationseinheit und der ersten Hubkompensationseinheit über Führungsrollen (3), welche an einem oberen Abschnitt von dem Mast eingerichtet sind, verläuft, und über die erste Hubkompensationseinheit zwischen den Führungsrollen und dem Befestigungselement im Mast verläuft.

8. Vorrichtung nach Anspruch1 oder 2, bei welcher die erste Hubkompensationseinheit an einem ersten Ende mit der Plattform verbunden ist und an einem zweiten Ende über Umkehrrollen (5) und einem Zylinder (4, 12) bewegbar an dem Draht-Mittel angebracht ist.

9. Vorrichtung nach einem der vorhergehenden Ansprüche, umfassend ein Verriegelungsmittel (23), mit welchem die Bewegungen der Kompensationseinheiten (22a, b; 27) selektiv unterbunden werden können, und wobei die Kompensationseinheiten Lasten zwischen der Werkzeugeinheit und dem Draht-Mittel als im Wesentlichen starre Körper überführen.

10. Vorrichtung nach einem der vorhergehenden Ansprüche, bei welcher die erste Hubkompensationseinheit (4, 5, 12) als ein aktiver Hubkompensator wirkt, während die zweite Hubkompensationseinheit (20; 20'; 20") als ein passiver Hubkompensator wirkt.

Revendications

1. Dispositif de compensation de tangage d'une unité d'outil (11) qui est suspendue via un ou plusieurs moyens de fil métallique (6) à un mât (1) monté sur une plateforme (2), chaque moyen de fil métallique, au niveau d'une première extrémité, étant fixé au mât via une fixation (10) et s'étendant, via une première unité de compensation de tangage (4, 5, 12), et chaque moyen de fil métallique (6), au niveau de sa seconde extrémité, étant fixé à une seconde unité de compensation de tangage (20 ; 20' ; 20") qui est raccordée à l'unité d'outil,
caractérisé en ce que
la seconde unité de compensation de tangage (20' ; 20") comprend un moyen de compensation mobile (31) qui, au niveau de sa première extrémité, est fixé au moyen de fil métallique (6) et qui, au niveau de sa seconde extrémité, est fixé à l'unité d'outil (11), et **en ce que** la seconde unité de compensation de tangage comprend un moyen de verrouillage (30) amovible avec lequel les mouvements du moyen de compensation (31) peuvent être sélectivement empêchés et autorisés.

2. Dispositif selon la revendication 1, dans lequel le moyen de compensation (31) est fixé à un moyen de fil métallique (6) via une unité de raccordement (32) et est fixé à l'unité d'outil (11) via un élément de liaison (33), et dans lequel l'unité de raccordement (32) et l'élément de liaison (33) sont mobiles l'un par rapport à l'autre, et dans lequel le moyen de verrouillage (30) est mobile pour limiter, de manière sélective et séparable, les mouvements de l'unité de raccordement (32) et de l'élément de liaison (33) l'un par rapport à l'autre.

3. Dispositif selon la revendication 2, dans lequel le moyen de verrouillage (30) comprend un boulon de verrouillage (87) avec une partie centrale étroite (87b) et de larges parties d'épaulement (87a) au niveau de chaque extrémité du boulon.

4. Dispositif selon la revendication 2 ou la revendication 3, dans lequel l'élément de liaison (33) comprend un trou débouchant (82) avec une première partie (82a) et une seconde partie (82b), la première partie ayant une plus grande ouverture que la seconde partie.

5. Dispositif selon la revendication 4, dans lequel la première partie (82a) a une dimension qui permet le passage des parties d'épaulement (87a) alors que la seconde partie (82b) a une dimension qui ne permet pas le passage des parties d'épaulement mais permet le passage de la partie centrale (87b).

6. Dispositif selon la revendication 4 ou la revendication 5, dans lequel la première partie (82a) a une section transversale circulaire et la seconde partie (82b) est allongée.

7. Dispositif selon la revendication 1, dans lequel ledit moyen de fil métallique, entre la seconde unité de compensation de tangage et la première unité de compensation de tangage, s'étend via des poulies de guidage (3) qui sont montées au niveau d'une partie supérieure du mât, et s'étendent via la première unité de compensation de tangage entre les poulies de guidage et la fixation dans le mât.

8. Dispositif selon la revendication 1 ou la revendication 2, dans lequel la première unité de compensation de tangage est raccordée, au niveau d'une première extrémité, à la plateforme et au niveau d'une seconde extrémité, est fixée de manière mobile audit moyen de fil métallique via des poulies d'inversion (5) et d'un cylindre (4, 12).

9. Dispositif selon l'une quelconque des revendications précédentes, comprenant un moyen de verrouillage (23) avec lequel les mouvements des unités de compensation (22a, b ; 27) peuvent être sélectivement empêchés, et les unités de compensation transfèrent les charges entre l'unité d'outil et le moyen de fil métallique sous forme de corps sensiblement rigides.

10. Dispositif selon l'une quelconque des revendications précédentes, dans lequel la première unité de compensation de tangage (4, 5, 12) fonctionne comme un compensateur de tangage actif alors que la seconde unité de compensation de tangage (20 ; 20' ; 20") fonctionne comme un compensateur de tangage passif.

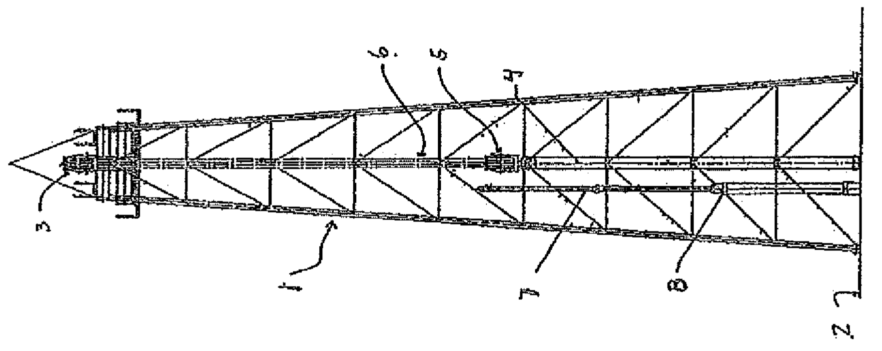

FIG. 1

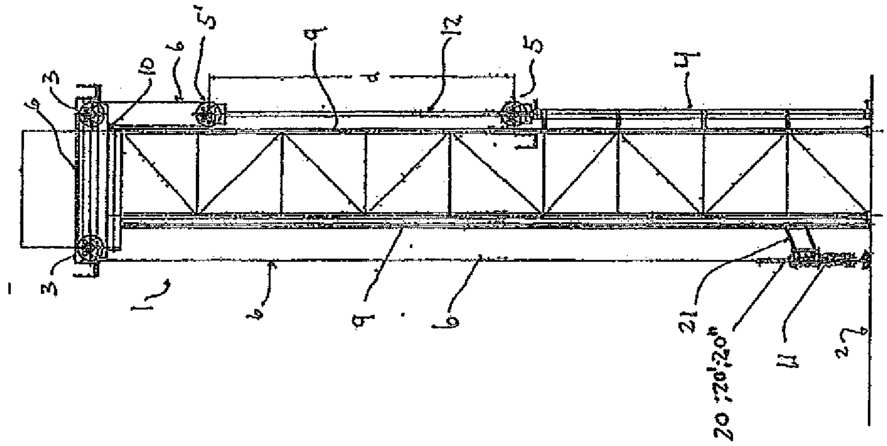

FIG. 2

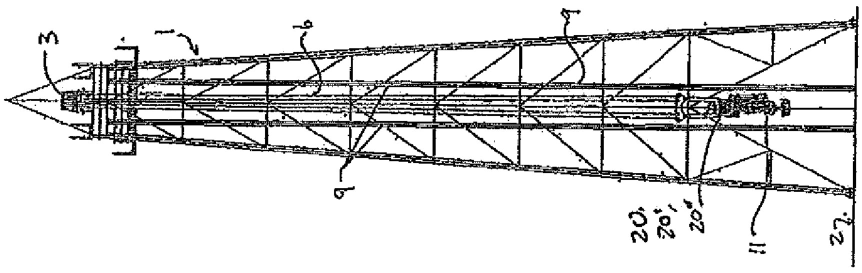

FIG. 3

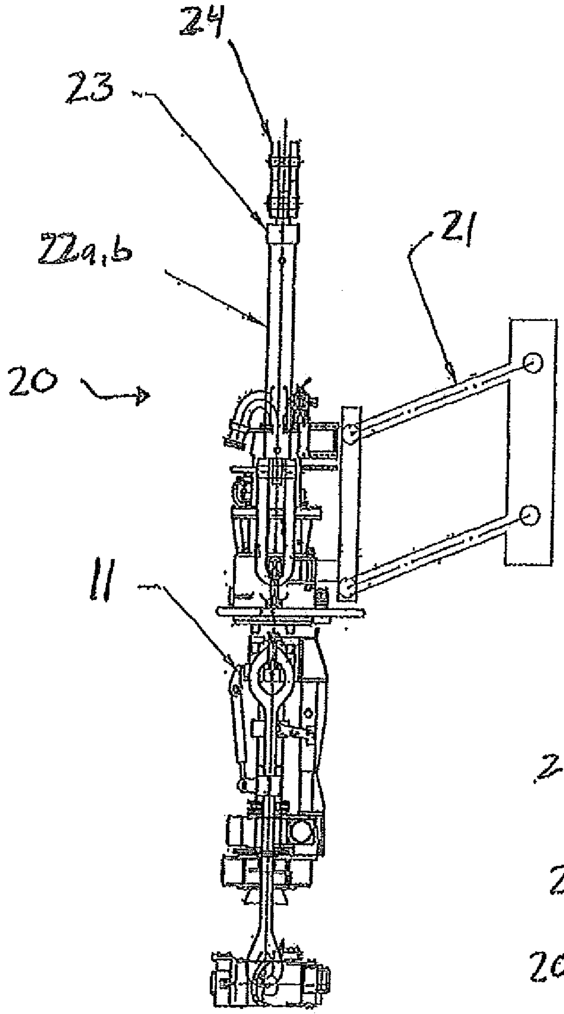

FIG. 4a

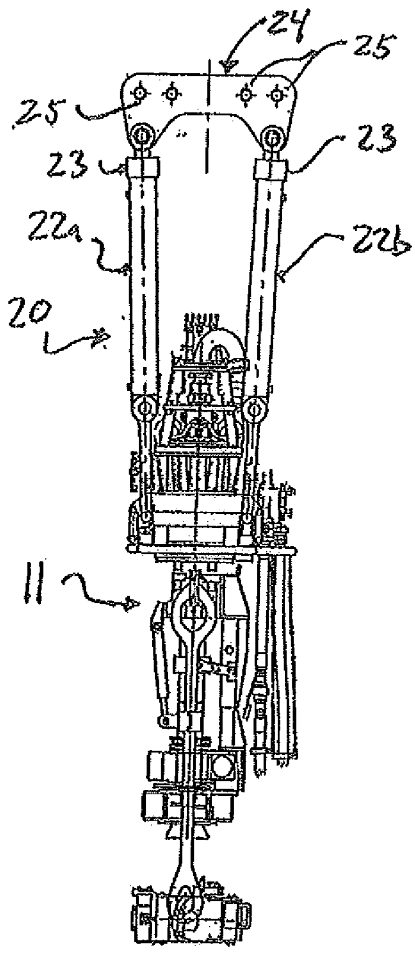

FIG. 4b

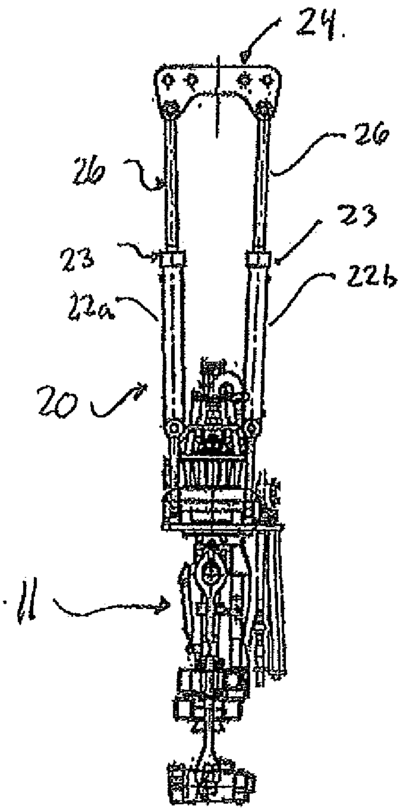

FIG. 4c

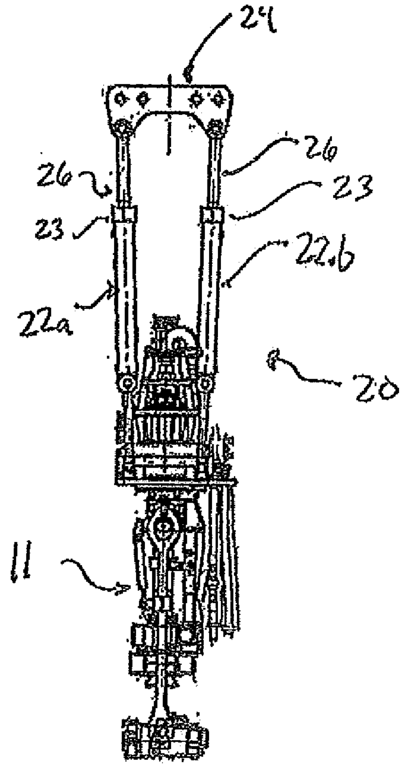

FIG. 4d

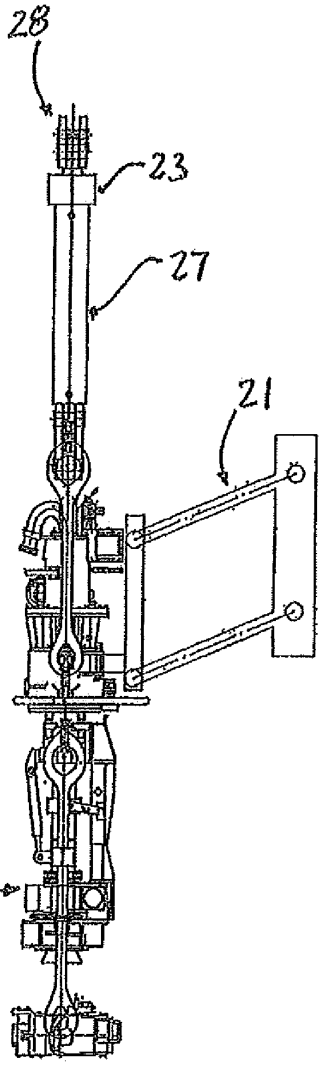

FIG. 5a

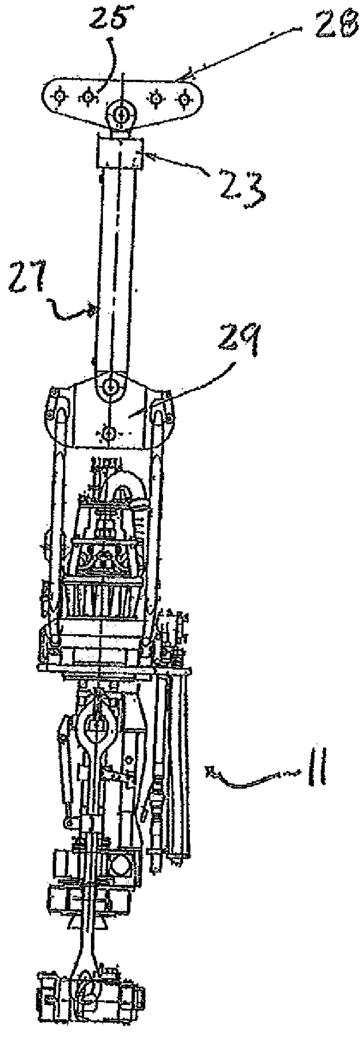

FIG. 5b

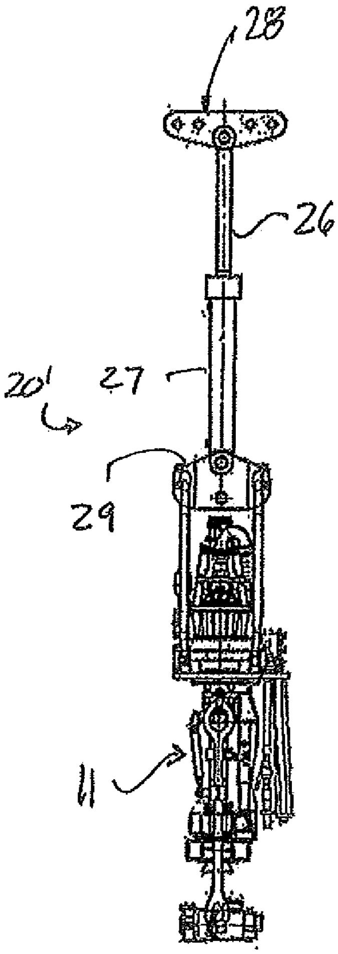

Fig. 5c

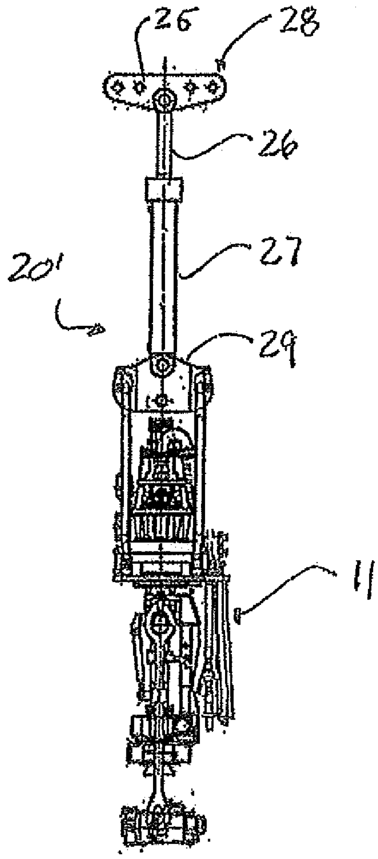

Fig. 5d

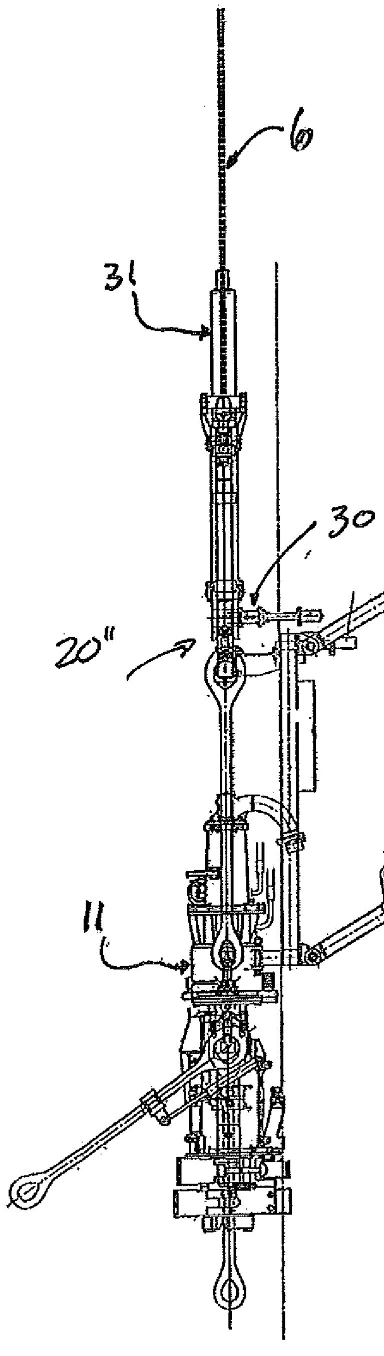

FIG. 6a

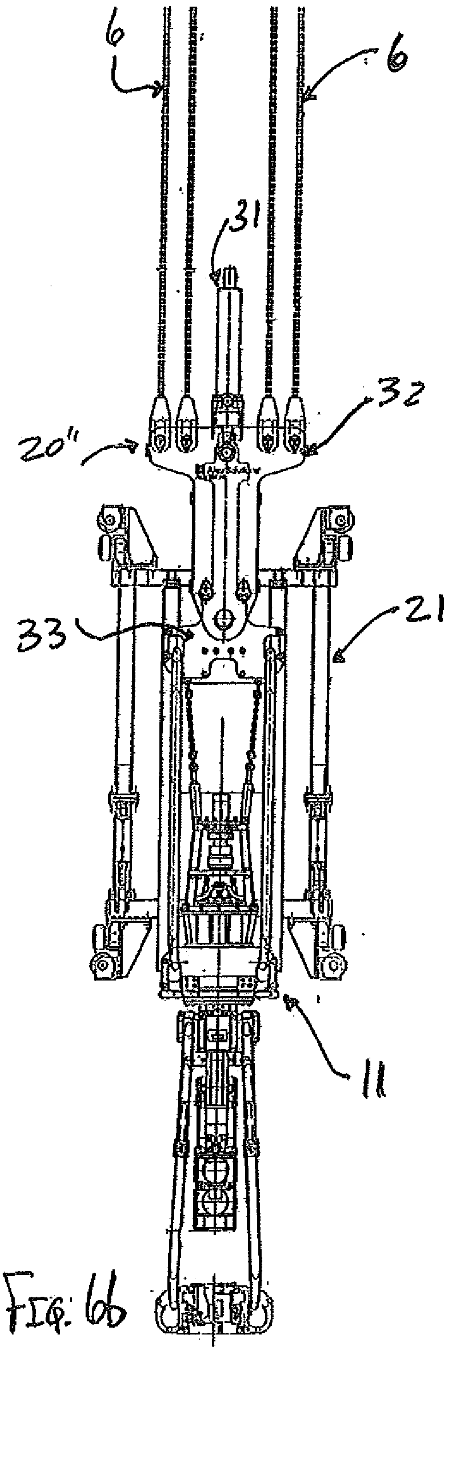

FIG. 6b

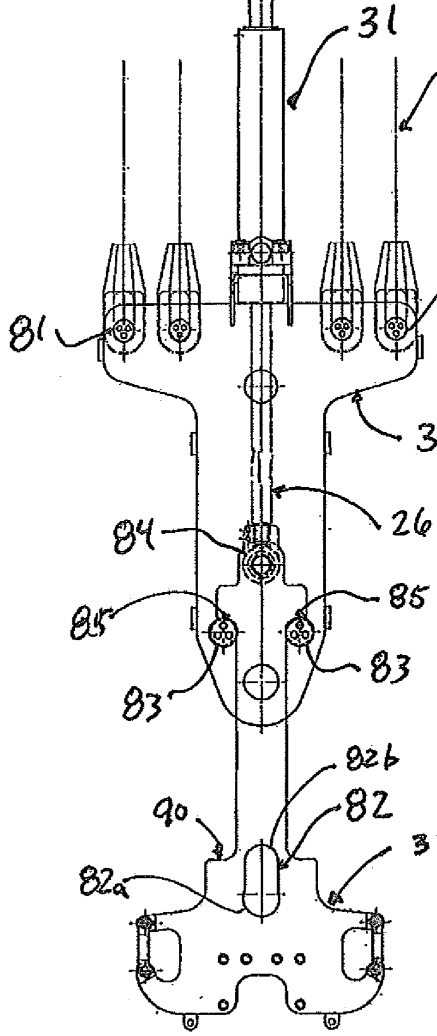
31
6
81
81
32
26
84
85
85
83
83
82b
90
82
33
82a

FIG. 7a

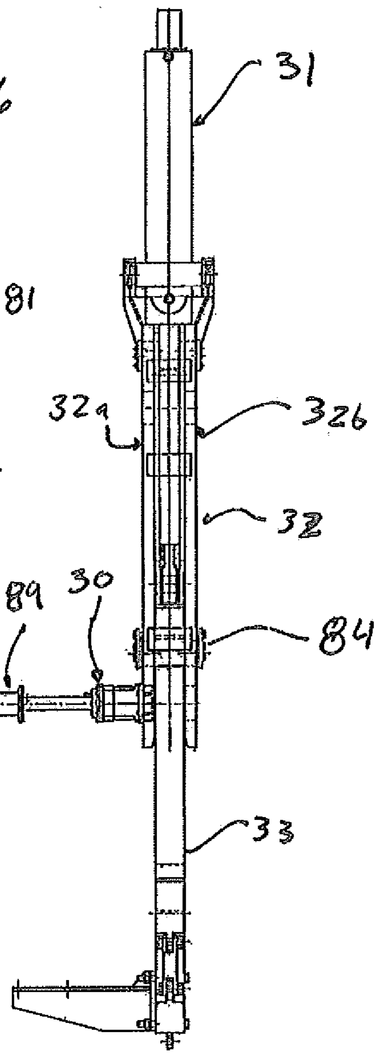
31
32a
32b
32
89
30
84
33

FIG. 7b

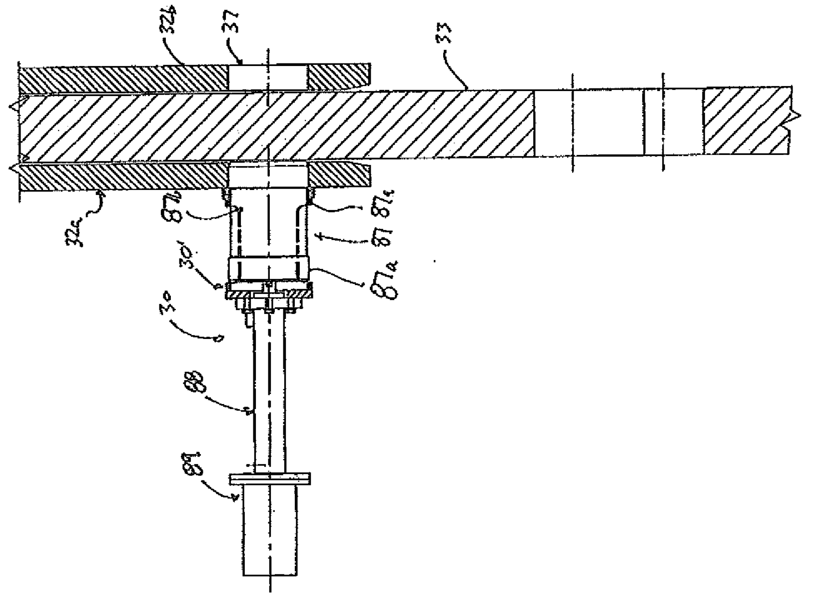

FIG. 7e

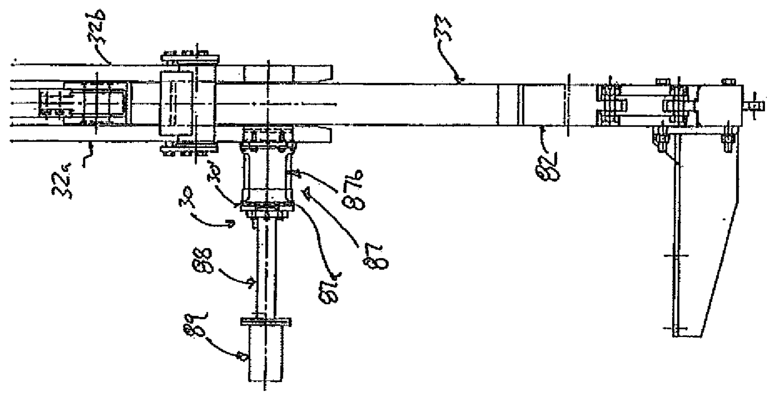

FIG. 7d

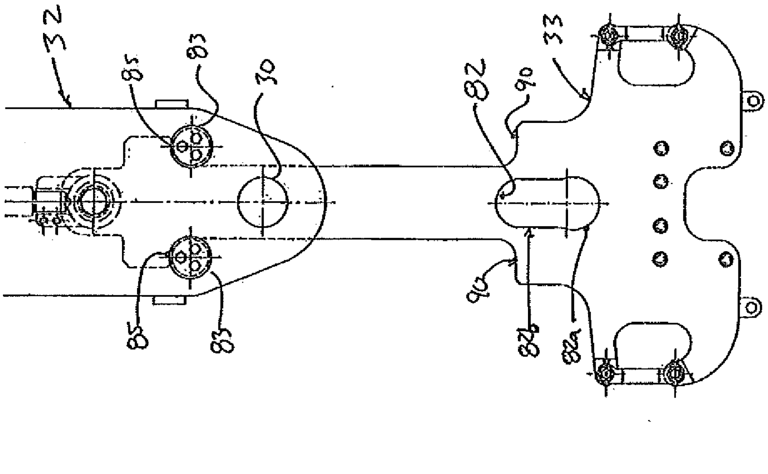

FIG. 7c

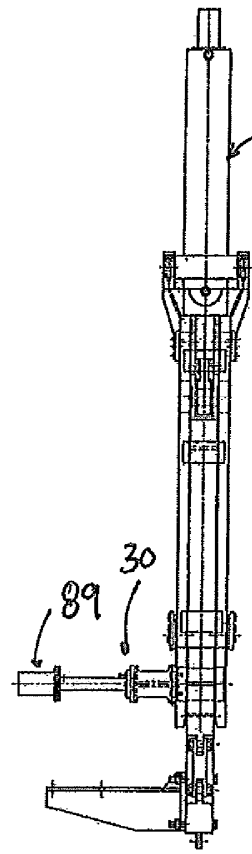

FIG. 8a

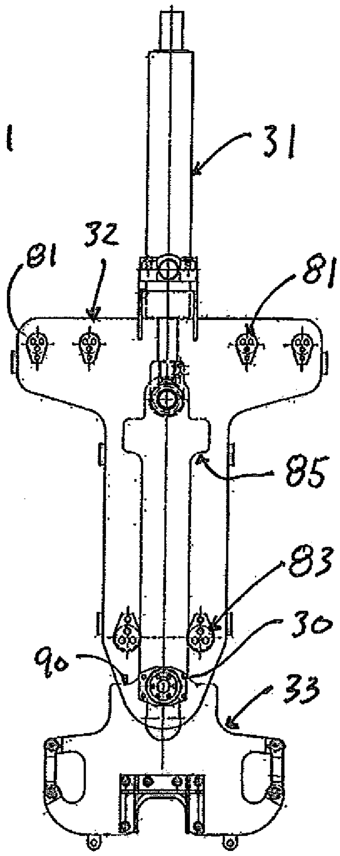

FIG. 8b

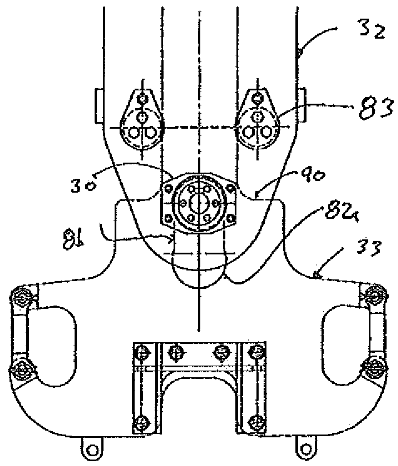

FIG. 8c

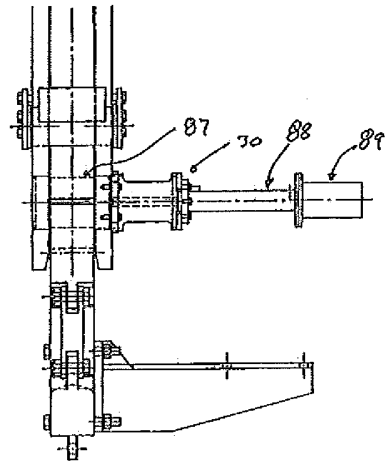

FIG. 8d

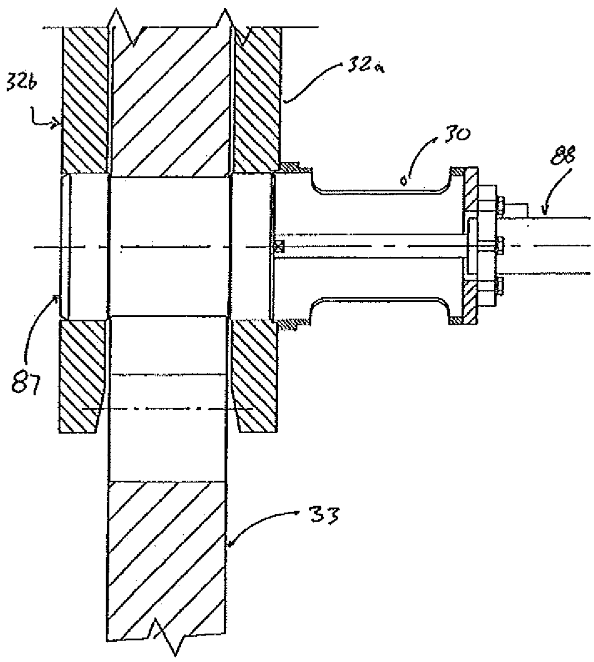

FIG. 8e

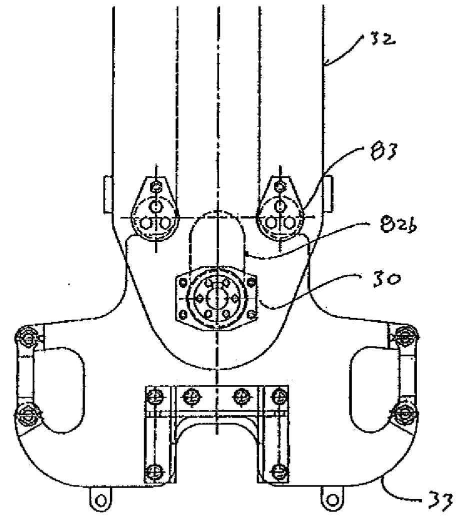

FIG. 9a

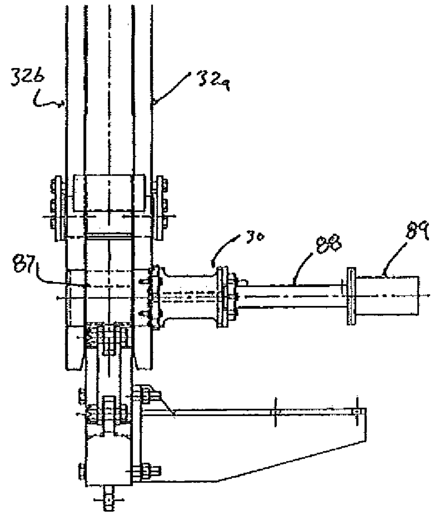

FIG. 9b

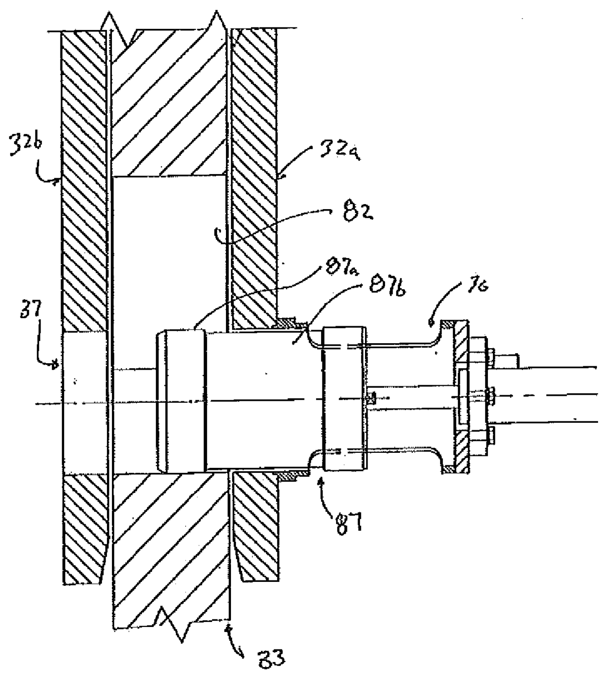

FIG. 9c

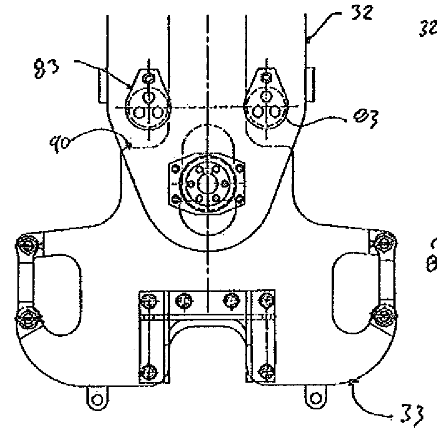

Fig. 10a

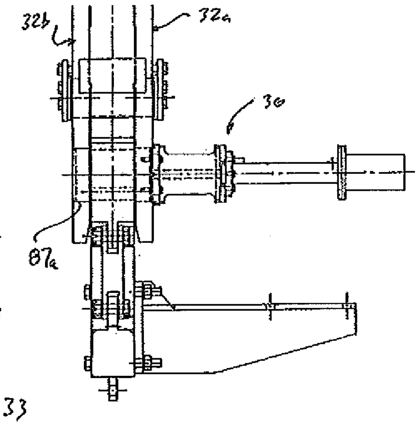

Fig. 10b

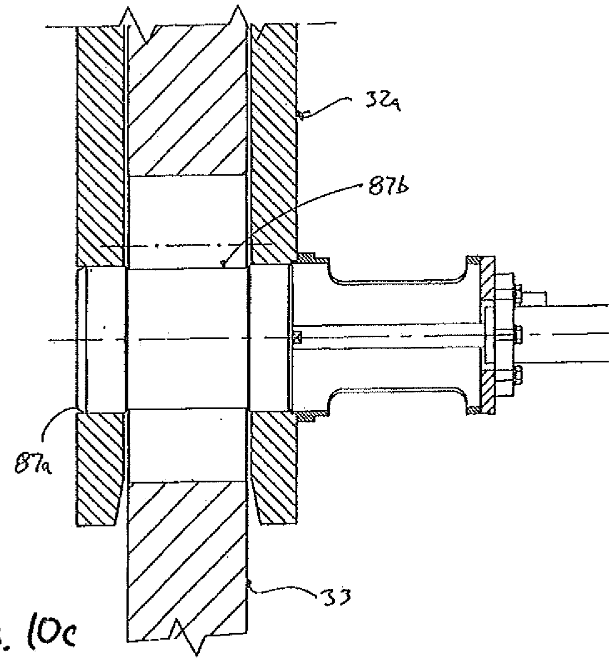

Fig. 10c

REFERENCES CITED IN THE DESCRIPTION

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- US 6000480 A **[0008]**
- WO 2007044924 A2 **[0009]**