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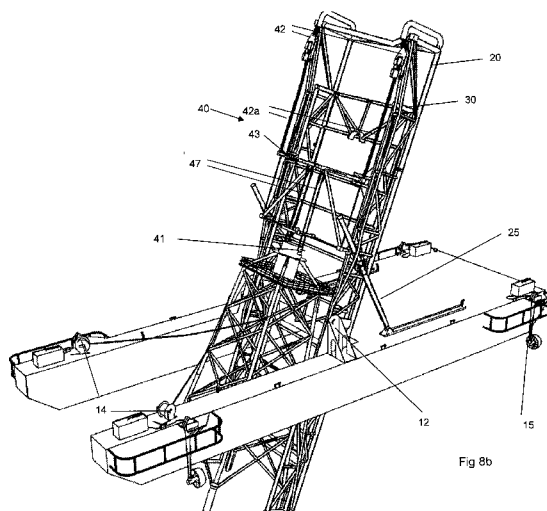
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(54) Title: METHOD AND DEVICE FOR INSTALLATION OF AN ELONGATED OFFSHORE STRUCTURE



(57) Abstract: The present invention relates to a method and device for installation of an offshore elongated offshore structure (2; 6). The device comprises a vessel (10) an outer frame (20) pivotable in relation to the vessel (10) between a substantially horizontal position for transporting the elongated offshore structure (2; 6) to the installation site and a substantially vertical position for installation of the elongated offshore structure (2; 6) at the installation site. A connection device (40) is provided for connection of the elongated offshore structure (2; 6) to the outer frame (20) via a longitudinal actuation device (42). The connection device (40) comprises a first supporting element (41) for providing the elongated offshore structure (2; 6) in a free hanging configuration when the outer frame (20) is in the substantially vertical position. The longitudinal actuation device (42) is provided for lowering the elongated offshore structure (2; 6) towards the seabed when the elongated offshore structure (2; 6) is in the free hanging configuration.

Method and device for installation of an elongated offshore structure

FIELD OF THE INVENTION

The present invention relates to a method and device for installation of an elongated offshore structure. In particular, the present invention relates to a method and device for installation of an offshore wind turbine device or a foundation of an offshore wind turbine device.

BACKGROUND OF THE INVENTION

Several concepts and designs exist for offshore wind turbine devices. Basically, a wind turbine device comprises a tower device with a nacelle and rotor blades provided in a first end thereof and a foundation provided in a second end thereof. Offshore wind turbine devices may have a floating foundation anchored to the seabed or a foundation fixed to the seabed.

The installation of offshore wind turbine devices is a vulnerable operation until the foundation is anchored or fixed sufficiently to the seabed. Often, a considerable time window with good weather forecasts is needed before the operation can begin.

The object of the invention is to provide an efficient device and method for installation of offshore wind turbine devices such that a shorter time window is needed. Moreover, it is an object that the method and device contribute to a reduced exposure to weather conditions during installation. One further object is that the method and device allows the wind turbine device to be assembled on a land based facility before transportation to the installation site. Of course, the object is also to provide a method and device for decommissioning and transportation of similar structures from sea to land.

It is also an object to provide an efficient device and method for installation of other elongated offshore structures.

SUMMARY OF THE INVENTION

The object of the invention is to provide a device for installation of an elongated offshore structure, where the device comprises:

- a vessel;
- an outer frame pivotable in relation to the vessel between a substantially horizontal position for transporting the elongated offshore structure to the installation site and a substantially vertical position for installation of the elongated offshore structure at the installation site;
- a connection device for connection of the elongated offshore structure to the outer frame via a longitudinal actuation device;

where the connection device comprises a first supporting element for providing the elongated offshore structure in a free hanging configuration when the outer frame is in the substantially vertical position, and where the longitudinal actuation device is provided for lowering the elongated offshore structure towards the seabed when the an elongated offshore structure is in the free hanging configuration.

In one aspect, the elongated offshore structure is a wind turbine device comprising a tower device with a nacelle and at least one rotor blade provided in a first end thereof and a foundation provided in a second end thereof. Hence, in this aspect, the invention relates to a device for installation of an offshore wind turbine device, where the wind turbine device comprises a tower device with a nacelle and at least one rotor blade provided in a first end thereof and a foundation provided in a second end thereof, where the device comprises:

- a vessel;
 - an outer frame pivotable in relation to the vessel between a substantially horizontal position for transporting the wind turbine device to the installation site and a substantially vertical position for installation of the wind turbine device at the installation site;
 - a connection device for connection of the wind turbine device to the outer frame via a longitudinal actuation device;
- where the connection device comprises a first supporting element for providing the wind turbine device in a free hanging configuration when the outer frame is in the substantially vertical position, and where the longitudinal actuation device is provided for lowering the wind turbine device towards the seabed when the wind turbine device is in the free hanging configuration.

In one aspect, the connection device comprises a cross bar slidingly arranged in relation to the outer frame by means of the longitudinal actuation device.

In one aspect, the first supporting element is connected to the cross bar.

In one aspect, the connection device comprises a second supporting element for releasable connection of the elongated offshore structure or wind turbine device in relation to the outer frame.

In one aspect, an inner frame is provided inside the outer frame, where the inner frame comprising a first supporting device for supporting the elongated offshore structure or wind turbine device in the substantially horizontal position during transportation to the installation site.

In one aspect, the inner frame comprises a cross bar supporting device for supporting the cross bar in relation to the inner frame.

In one aspect, the cross bar supporting device is configured to release the support of the cross bar in the substantially vertical position.

In one aspect, the inner frame is displaceable in a longitudinal direction with respect to the outer frame.

- 5 In one aspect, the longitudinal actuation device is pivotably mounted to the outer frame.

In one aspect, control devices are provided to control the orientation of the elongated offshore structure or wind turbine device in the free hanging configuration.

- 10 In one aspect, a locking device is provided for locking the inner frame to the outer frame.

The invention also relates to a method for installation of an offshore elongated offshore structure, where the method comprises:

- 15 - connecting the elongated offshore structure to an outer frame via a longitudinal actuation device, where the outer frame is pivotable in relation to a vessel;
- transporting the elongated offshore structure to the installation site in a substantially horizontal position;
- 20 - pivoting the outer frame to a substantially vertical position at the installation site;
- providing the elongated offshore structure in a free hanging configuration via the longitudinal actuation device when the outer frame is in the substantially vertical position;
- 25 - lowering the elongated offshore structure towards the seabed by means of the longitudinal actuation device when the elongated offshore structure is in the free hanging configuration.

- In one aspect, the elongated offshore structure is a wind turbine device comprising a tower device with a nacelle and at least one rotor blade provided in a first end thereof and a foundation provided in a second end thereof. Hence, in this aspect, the invention relates to a method for installation of an offshore wind turbine device, where the wind turbine device comprises a tower device with a nacelle and at least one rotor blade provided in a first end thereof and a foundation provided in a second end thereof, where the method comprises:
- 30

- 35 - connecting the wind turbine device to an outer frame via a longitudinal actuation device, where the outer frame is pivotable in relation to a vessel;
- transporting the wind turbine device to the installation site in a substantially horizontal position;
- pivoting the outer frame to a substantially vertical position at the installation

site;

- providing the wind turbine device in a free hanging configuration via the longitudinal actuation device when the outer frame is in the substantially vertical position;
- 5 - lowering the wind turbine device towards the seabed by means of the longitudinal actuation device when the wind turbine device is in the free hanging configuration.

10 In one aspect the method is comprising the step of providing the connection device with a cross bar slidably arranged in relation to the outer frame by means of the longitudinal actuation device.

In one aspect the method is comprising the step of connecting the first supporting element to the cross bar.

15 In one aspect the method is comprising the step of providing the connection device with a second supporting element for releasably connecting the elongated offshore structure or wind turbine device in relation to the outer frame.

In one aspect the method is comprising the step of providing an inner frame inside the outer frame, where the inner frame comprising a first supporting device for supporting the elongated offshore structure or wind turbine device in the substantially horizontal position during transportation to the installation site.

20 In one aspect the method is comprising the step of providing the inner frame with a cross bar supporting device for supporting the cross bar in relation to the inner frame.

25 In one aspect the method is comprising the step of configuring the cross bar supporting device to release the support of the cross bar in the substantially vertical position.

In one aspect the method is comprising the step of displacing the inner frame in a longitudinal direction with respect to the outer frame.

30 In one aspect the method is comprising the step of controlling the orientation of the elongated offshore structure or wind turbine device in the free hanging configuration.

In one aspect the method is comprising the step of locking the inner frame to the outer frame.

DETAILED DESCRIPTION

35 Embodiments of the invention will now be described in detail with reference to the enclosed drawings, where:

Fig. 1 illustrates a perspective view of a vessel;

Fig. 2 illustrates a perspective view of a first or outer frame;

Fig. 3 illustrates a perspective view of a second or inner frame;

Fig. 4a and fig. 4b illustrate a perspective view of parts of a connection device in closed and open position respectively;

Fig. 4c illustrates a perspective view of the connection device from below;

Fig. 5a illustrates a partial perspective view of the vessel, the inner frame and the outer frame assembled;

Fig. 5b and fig. 5c illustrate an enlarged perspective view of the locking device for locking the inner frame to the outer frame in open and closed position respectively;

Fig. 6a illustrates a partial top view of fig. 5a;

Fig. 6b illustrates a partial front view of the embodiment of fig. 5a;

Fig. 7a illustrates how the wind turbine device is supported on the inner frame on a land based facility;

Fig. 7b illustrates how the inner frame is pulled into the second frame of the vessel;

Fig. 7c illustrates the transportation to the installation site;

Fig. 7d illustrates a side view of the arrival at the installation site;

Fig. 7e and fig. 7f illustrate a side view and perspective view of the pivoting of the second frame in relation to the vessel respectively;

Fig. 7g – 7n illustrate the further steps of the installation procedure;

Fig. 8a – 8e illustrate a third embodiment of the invention;

Fig. 9a – 9e illustrate a fourth embodiment of the invention

25 First embodiment

A first embodiment of a device 1 for installation or decommissioning of an offshore wind turbine device 2 will now be described in detail. First, it is referred to fig. 7a. Here it is shown that the offshore wind turbine device comprises a tower device 3 with a nacelle 4 and at least one rotor blade 5 provided in a first end thereof and a foundation 6 provided in a second end thereof. The wind turbine device is

considered known for a skilled person and will not be described here in detail. It should be noted that the present invention might be utilized for both floating wind turbine devices anchored to the seabed and wind turbine devices for fixation to the seabed. The foundation 6 may typically be a jacket foundation, a mono pile
5 foundation, a tripod foundation, a gravity foundation, a suction anchor foundation, etc.

It should be noted that the present invention may be used for installation or decommissioning of only some parts of the offshore wind turbine device, for example only the foundation 6, i.e. without the tower device 3, nacelle 4 and rotor
10 blade 5.

It should also be noted that the present invention may be used for installation or decommissioning of other elongated offshore structures, for example jacket foundations for oil and gas facilities, etc.

The device 1 comprises a vessel 10. The vessel 10 of the present embodiment is a
15 barge intended to be towed to the installation site by means of a towing vessel 8 (see fig. 7c). Alternatively, the vessel 10 may be self-propelled by means of propulsion means etc. In the present embodiment, the vessel 10 comprises a main hull structure 10a with a main deck, and two parallel protruding hull elements 10b, 10c where a slot 11 is provided between the two parallel protruding “catamaran-
20 like” hull elements 10b, 10c. The slot 11 is provided for submerging the foundation 6 into the sea between the two parallel protruding hull elements 10b, 10c. Hence, the vessel 10 as shown in fig. 1 is substantially U-shaped when viewed from above.

In fig. 1 and 2 a longitudinal direction is indicated by line X-X. The longitudinal direction is in the description below used to indicate the longitudinal direction of
25 the wind turbine device 2, more specifically to the tower device 3, when it is provided in a horizontal position on the device 1.

It is now referred to fig. 2, where the first or outer frame 20 is illustrated. The outer frame 20 comprises a first outer frame element 20a, a second outer frame element 20b and a third outer frame element 20c, where the second and third outer frame
30 elements 20b, 20c are fixed perpendicular to the first outer frame element 20a as shown in fig. 2. It should be noted that the width W_o of the outer frame 20 is less than the distance between the two hull elements 10b, 10c of the vessel.

The device 1 further comprises a pivoting system for pivoting the outer frame 20 in relation to the vessel 10. In the present embodiment, the pivoting system comprises
35 pivoting pins 12 provided on the vessel 10 and pivoting openings 21 provided in the second and third outer frame elements 20b, 20c, provided for receiving the pivoting pins 12. Consequently, the outer frame 20 may be pivoted with respect to the axis I-I indicated in fig. 1 and 2, perpendicular to the longitudinal axis X-X. The pivoting

system further comprises a pivotal actuation device 25 fixed between the outer frame 20 and the vessel 10. In the present embodiment the pivotal actuating device 25 comprises one hydraulic cylinder device connected to the each of the second and third outer frame elements 20b and 20c, where the piston of the hydraulic cylinder devices is fixed to lugs 13 of the vessel.

The device 1 further comprises a connection device 40 for connection of the wind turbine device 2 to the outer frame 20 by means of a longitudinal actuation device 42. The longitudinal actuation device 42 is provided for moving the wind turbine device 2 in its longitudinal direction. In the present embodiment the longitudinal actuation device 42 comprises a hydraulic cylinder device connected to the end of each of the second and third outer frame elements 20b, 20c as illustrated in fig. 2. The connection device 40 comprises a first supporting element 41 which may be fixed to the piston of the hydraulic cylinder devices by means of connection elements 47. The first supporting element 41 is in the present embodiment a supporting ring fixed around the tower device 3. The connection elements 47 may be flexible connection elements such as chains, wires, cables etc. Alternatively, the connection elements 47 may be rods connected to the pistons and/or first supporting element 41 by means of articulated joints etc.

The purpose of the connection elements 47 and the other elements of the connection device 40 is to provide the wind turbine device 2 in a free hanging configuration when the outer frame 20 is in the substantially vertical position. The free hanging configuration allows an easy orientation of the foundation 6 of the wind turbine device with respect to the seabed or with respect to anchoring devices (not shown) at the installation site. The longitudinal actuation device 42 is provided for lowering the wind turbine device 2 towards the seabed when the wind turbine device 2 is in the free hanging configuration.

The weight of the wind turbine device 2 is in the vertical position carried by the outer frame 20 via the first supporting element 41, the connection elements 47 and the longitudinal actuation device 42.

Consequently, by actuating the pivotal actuation device 25, the outer frame 20 may be pivoted in relation to the vessel with an angle α between 0 and ca 100° (as indicated in fig. 7j). Here it can be seen that the outer frame 20 is pivotable in relation to the vessel 10 between a substantially horizontal position for transporting the wind turbine device 2 to the installation site and a substantially vertical position for installation of the wind turbine device 2 at the installation site.

In the embodiment described above, the free hanging configuration may be achieved when the pivotation of the outer frame 20 is substantially perpendicular to the vessel (i.e. angle $\alpha \approx 90^\circ$), i.e. the position shown in fig. 7g. In this position, the orientation of the foundation 6 may be limited due to its contact with the outer

frame 20. Hence, by increasing the pivotation of the outer frame 20 further, for example to a position where the angle α is $95 - 100^\circ$ (fig. 7j), the possibilities for orientation of the wind turbine device 2 increases.

5 The longitudinal actuation device 42 may be pivotably mounted to the outer frame 20. In this way, the distance between the outer frame 20 and the wind turbine device 2 is increasing further when the angle α is increased to more than 90° .

10 For performing the orientation, the vessel 10 may comprises control devices 14 (fig. 1), for example winches or similar, for controlling the orientation of the wind turbine device 2 in the free hanging configuration. In the present embodiment, there is one winch in each end of the protruding hull elements 10b, 10c, connected to the foundation 6 by means of wires. The control devices 14 may be used to rotate the wind turbine device around its longitudinal axis by using one of the winches, or by pulling the foundation 6 away from the outer frame 20 by using both of the winches.

15 Alternatively, a dynamically positioned vessel may help with the orientation of the wind turbine device 2. Moreover, if the wind turbine device 2 is being anchored to the seabed, orientation may be performed by slackening or tightening the anchoring wires. In yet an alternative, the vessel 10 itself may be self-propelled and dynamically positioned to orient the wind turbine device 2 correctly.

20 The use of the first embodiment described above will now be described. In a first step the wind turbine device 2 is connected to the outer frame 20 via the longitudinal actuation device 42, where the outer frame 20 is pivotable in relation to a vessel 10. The wind turbine device 2 is transported to the installation site in a substantially horizontal position, i.e. substantially parallel to the vessel 10. At the installation site the outer frame 20 is pivoted to a substantially vertical position, thereby providing that the wind turbine device 2 is in a free hanging configuration via the longitudinal actuation device 42 when the outer frame 20 is in the substantially vertical position. In the free hanging configuration, the wind turbine device may be lowered towards the seabed by means of the longitudinal actuation device 42.

30 Thereafter, the foundation 6 of the wind turbine device is fixed to the seabed or anchored to the seabed by means of anchoring devices. In the present embodiment, a seabed supporting frame 9 has been preinstalled on, and is fixed to, the seabed. The seabed supporting frame 9 is assumed known for a skilled person. Consequently, the foundation of the wind turbine device only has to be lowered
35 down into the seabed supporting frame 9 before fixing the seabed supporting frame to the foundation of the wind turbine device. This represents a very efficient way of installing an offshore wind turbine device, since no interaction with the seabed itself is necessary.

In the embodiment described above, the connection elements 47 are connected directly between the first supporting element 41 and the longitudinal actuation device 42. It should be noted that it would be possible to use only one connection element and one hydraulic cylinder as the longitudinal actuation device 42. A free hanging configuration would still be achieved between the wires of the control devices 14 and the only one connection element 47.

Second embodiment

A second embodiment will now be described. In the second embodiment, the connection device 40 comprises a cross bar 43 slidably arranged in relation to the outer frame 20 by means of the longitudinal actuation device 42. The cross bar 43 is showed in detail in fig. 4a and 4b. Each end 44 of the cross bar comprises different connection interfaces: a first connection interface 44a for supporting the cross bar 43 between the second and third outer frame elements 20b, 20c in the horizontal position, i.e. for bearing the cross bar against the upper edges of the second and third outer frame elements 20b, 20c in the horizontal position; a second connection interface 44b for connection to the longitudinal actuation device 42, for example lugs for connection to the piston of the longitudinal actuation device 42; and a third connection interface 44c, for example lugs, for connection to the connection elements 47. In the present embodiment the longitudinal actuation device 42 comprises two hydraulic cylinders. Moreover, there are two connection elements 47, connected between the first supporting element 41 and the cross bar 43, i.e. to each of the third connection interfaces 44c of the cross bar 43.

The connection device 40 may comprise a second supporting element 45 for releasable connection of the wind turbine device 2 in relation to the outer frame 20 (fig. 4a, 4b). In the present embodiment, the second supporting element 45 comprises two locking arms 45a pivotably connected to the cross bar 43, where the locking arms 45a may be opened and closed by means of hydraulic cylinders 46. Hence, the tower device 3 of the wind turbine device 2 may be releasably locked to the cross bar 43. It should be noted that the hydraulic cylinders 46 in the present embodiment is not provided for carrying the weight of the wind turbine device when in the vertical position, they are only locking the tower device 3 with respect to transverse movement of the tower device, not axial movement. The connection device 40 also comprises a rear protruding pin 48 as shown in fig. 4c. It is now referred to fig. 3 and fig. 5a-c and fig. 6a-b. The device 1 according to the second embodiment may comprise an inner or second frame 30 provided inside the outer frame 20. The inner frame comprises a first inner frame element 30a, a second inner frame element 30b and a third inner frame element 30c, where the second and third inner frame elements 30b, 30c are fixed perpendicular to the first inner frame element 30a as shown in fig. 2. It should be noted that the width W_i of the inner frame 30 is less than the distance between the second and third outer frame

elements 20b, 20c of the outer frame 20. As shown in fig. 5a, the inner frame 30 may be located inside the outer frame 20.

5 The inner frame 30 is displaceable in a longitudinal direction with respect to the outer frame 20. The inner frame 30 may for example comprise roller devices, skid pads or wheels for rolling into the outer frame 20. This will be described more in detail below. Moreover, a locking device 60 may be provided for locking the inner frame 20 to the outer frame 30. In fig. 5b and 5c one example of such a locking device is illustrated. The locking device comprises a toothed bar fixed to the inner frame and a movable locking arm fixed to the outer frame for locking to the toothed bar. In the open position, the inner frame may be moved in relation to the outer frame, and in the locked position this movement is prevented. It should be noted that the outer frame 20 may comprise one such locking device 60 on each side.

15 As shown in fig. 3, the inner frame comprises first supporting devices 31, 32, for supporting the wind turbine device 2 in the substantially horizontal position during transportation to the installation site. The first supporting devices 31, 32 may comprise a substantially semi-circular surface adapted to receive the tower device 3, where the substantially semi-circular surfaces are fixed to the first inner frame element 30a, the second inner frame element 30b and the third inner frame element 30c by means of supporting bars. It should be noted that the inner frame may comprise only one of the respective first supporting devices 31 or 32, or no such supporting devices at all. It should also be mentioned that the foundation 6 of the wind turbine device 2 will normally be bearing against or supported by the inner frame 30.

25 The inner frame 30 may also comprise a cross bar supporting device 33 for supporting the cross bar 43 in relation to the inner frame 30. In the present embodiment, the cross bar supporting device 33 comprises an opening for receiving the rear protruding pin 48 of the connection device 40. The cross bar supporting device 33 is configured to release the support of the cross bar 43 in the substantially vertical position. When the pivotation of the outer frame reaches an angle of 90° or more, the rear protruding pin 48 is no longer supported by the cross bar supporting device 33, and consequently, the abovementioned free hanging configuration is achieved. The cross bar 43 may now be lowered (and if necessary raised) in relation to the inner frame 30. Please note that the inner frame 30 should be locked to the outer frame before pivoting the outer frame in relation to the vessel.

35 The method for installation of the wind turbine device 2 by means of the second embodiment will now be described. As described above, a seabed supporting frame 9 has been preinstalled on, and is fixed to, the seabed.

It is now referred to fig. 7a, where the inner frame 30 is separated from the outer frame 20 and the vessel 10. The inner frame 30 is here movable on rails on a pier.

As shown, the wind turbine device is supported in a horizontal position on the inner frame 30. More specifically, the foundation 6 is supported directly on the inner frame element 30a and the tower device 3 is supported on the first supporting devices 31, 32.

5 Moreover, parts of the connection device 40 is here connected to the inner frame 30, i.e. the cross bar supporting device 33 is supporting the cross bar 43 in relation to the inner frame 30 since the rear protruding pin 48 is inserted into the opening of the cross bar supporting device 33. Moreover, the first supporting element 41 is connected around the tower device 3 and is connected to the cross bar 43 via the
10 connection elements 47. Moreover, the second supporting element 45 of the connection device is connected to the tower device.

In fig. 7a and 7b, the inner frame 30 with the connection device 40 is run onto or into the outer frame 20. This can be performed by using the longitudinal actuation devices 42, for example connected to the inner frame 30 by means of chains or
15 similar (shown in fig. 7a), and stepwise pulling the inner frame towards the outer frame. Alternatively, a separate vehicle etc may be used to push the inner frame and the connection device 40 into or onto the outer frame 20.

The inner frame 30 may now also be locked to the outer frame 20 by means of the locking device 60, however this is strictly not necessary. Moreover, the cross bar 43
20 is being connected to the longitudinal actuating devices 42 via the connection interface 44b.

The device 1 is now transported to the installation site with the wind turbine device 2 in the substantially horizontal position. In fig. 7c it is shown that a towing vessel 8 is used.

25 Fig. 7d illustrates the situation on the installation site, with the seabed supporting frame 9 provided on the seabed. Note the wires 14a connected between the control devices 14 and the foundation 6.

In fig. 7e and 7f the outer frame 20 is pivoted in relation to the vessel 10 by means of the pivotal actuation devices 25.

30 In fig. 7g and 7h, the outer frame 20 has reached a substantially vertical position. If necessary, the locking device 60 could have been unlocked for adjusting the inner frame 30 with respect to the outer frame 20 in the horizontal position or before the outer frame 20 reaches the vertical position. This could for example be performed to avoid that the foundation 6 crashes into the seabed during the pivotation.

35 As described above, the wind turbine device is supported by the connection device 40 in relation to the outer frame. Due the cross bar 43 and its support in the supporting device 33 of the inner frame 30, the inner frame is also supported with

respect to the outer frame. Hence, the locking device 60 is not necessary for supporting the inner frame with respect to the outer frame as long as the rear protruding pin 48 of the cross bar 43 is supported by the supporting device. This would be the case for pivotation angles between 0° and 90°.

- 5 When the pivotation angle exceeds 90°, the protruding pin 48 will exit from the supporting device 33. Before that happens, the inner frame should be locked to the outer frame by means of the locking device 60.

Hence, by pivoting the outer frame 30 further, for example to the position shown in fig. 7i and 7k, the cross bar 43 is released from the cross bar supporting device 33
10 of the inner frame, since the longitudinal actuation devices 42 are pivotably mounted to the outer frame 20 as described above. Hence, the weight of the wind turbine device provides that the longitudinal actuation devices 42 are hanging downwardly from the outer frame. Consequently, the wind turbine device is in a substantially vertical position, even though the outer frame is pivoted to an angle
15 more than 90°.

The wind turbine device is now in a free hanging configuration and may be lowered towards the seabed by means of the longitudinal actuation device 42 (fig. 7j and 7l). The positioning of the wind turbine device may be performed by moving the vessel with respect to the seabed.

- 20 The tower device may now be released from the cross bar 43 by opening the second supporting element 45. Now, the control device 14 may control the orientation of the foundation with respect to the seabed supporting frame 9 by means of the wires 14a before the foundation is lowered further onto the seabed supporting frame 9.

The foundation is then fixed to the seabed supporting frame 9, and the connection
25 device 40 is released from the wind turbine device allowing the vessel 10 with the outer and inner frames 30, 20 to leave the now installed wind turbine device.

For retrieval or de-commissioning of offshore wind turbine devices, the reverse procedure may be utilized.

Third embodiment

- 30 A third embodiment is shown in fig. 8a – 8e. The same reference numbers are used as in the embodiments described above, and will therefore not be described in detail herein.

In fig. 8a it is shown that the device according to the invention is used to install a foundation 6 of a wind turbine device 2, i.e. the tower device 3 with a nacelle 4 and
35 rotor blade(s) 5 are installed on the foundation 6 in a subsequent operation by means of a similar or a different installation vessel. It should also be noted that in

this embodiment, there might be no supporting frame 9 on the seabed, since the foundation 6 comprises suction anchor foundations 6a.

5 The vessel 10 is in this embodiment comprising propulsion means 15. In the present embodiment, these propulsion means 15 may be elevated to the position of fig. 8a during transportation, and may be lowered to the position of fig. 8b for positioning and orienting the vessel at the installation site.

In this embodiment, the device comprises a vessel 10, a first or outer frame 20 and a second or inner frame 30 pivotable in relation to the vessel as described above.

10 The pivotal actuation device 25 for pivoting the outer frame 20 in relation to the vessel is in this embodiment comprising a hydraulic actuator connected to the outer frame 20 and is comprising a climbing beam device in contact with the vessel 10, as shown in fig. 8b.

15 The connection device 40 of the present embodiment comprises a first supporting element 41 connected to the top end of the foundation 6. A cross bar 43 and a connection element 47 is provided for connecting the first supporting element 41 to the outer frame 20 via the longitudinal actuation device 42 and for supporting the connection device 40 to the inner frame 30. See fig. 8b and 8c.

20 The longitudinal actuation device 42 here comprises a chain climbing device with a chain 42a. The present embodiment comprises two such longitudinal actuation devices 42, as shown in fig. 8b.

25 The free hanging configuration is shown in fig. 8c. Here, it is shown that the first supporting element 41 is hanging freely with respect to the inner and outer frame 20, 30, i.e. it is no longer supported by the inner and outer frames. The longitudinal actuation device 42 can now be used to lowering the foundation 6 towards the seabed, while the control devices 14 can be used to control the orientation of the foundation 6 with respect to the seabed together with the propulsion devices 15.

Fourth embodiment

30 A second alternative embodiment is shown in fig. 9a – 9e. The same reference numbers are used as in the embodiments described above, and will therefore not be described in detail herein.

35 In fig. 9a it is shown that the device according to the invention is used to install a foundation 6 of a wind turbine device 2, i.e. the tower device 3 with a nacelle 4 and rotor blade(s) 5 are installed on the foundation 6 in a subsequent operation by means of a similar or a different installation vessel. It should also be noted that in this embodiment, there is no supporting frame 9 on the seabed, the foundation 6 comprises suction anchor foundations 6a.

In this embodiment, the device comprises a vessel 10 and first or outer frame 20 pivotable in relation to the vessel. Hence, in this embodiment, there is no second or inner frame 30.

5 In this embodiment, the centre of gravity of the foundation 6 is provided over the slot 11 of the vessel 10, i.e. to the left of the pivotal pins 12 defining the pivotal axis I-I in fig. 9b. Consequently, an alternative pivotal actuation device 25 may be used. In the present embodiment, the pivotal actuation device 25 comprises two winches, each provided on the respective protruding hull structures 10b, 10c. A wire of the winches is connected to the lower part of the foundation 6. Hence, when the
10 winches are releasing their wires, the foundation 6 and outer frame 20 will rotate due to the weight of the foundation 6 to its substantial vertical position shown in fig. 9c.

The connection device 40 of the present embodiment comprises a first supporting element 41 connected to the top end of the foundation 6. The connection element 41
15 is connected to the outer frame 20 via the longitudinal actuation device 42. The foundation 6 is supported directly against the outer frame 20 in the horizontal position, i.e. there is no cross bar 43 and connection elements 47.

The longitudinal actuation device 42 here comprises a chain climbing device with a chain 42a. The chain 42a is connected directly to the first supporting element 41.
20 The present embodiment comprises one such longitudinal actuation device 42, as shown in fig. 9b.

The free hanging configuration is shown in fig. 9c. Here, it is shown that the first supporting element 41 is hanging freely with respect to the outer frame 20 and the first supporting element 41 and the foundation 6 are no longer supported by the
25 outer frame 20. The longitudinal actuation device 42 can now be used to lowering the foundation 6 towards the seabed, while the control devices 14 can be used to control the orientation of the foundation 6 with respect to the seabed.

It should also be noted that the first supporting device 41 may comprise one element 41a connected to the connection device 40 and one element 41b connected to the
30 foundation 6 or wind turbine device 2. The elements 41a and 41b are connected to each other when foundation 6 is connected to the connection device 40, but is separated from each other when disconnecting the foundation from the connection device 40. This is for example indicated in fig. 8e.

Other alternative embodiments

35 It should be noted that the vessel 10 may have many other suitable designs and configurations than the one illustrated in fig. 1. For example is the length of the vessel shorter than the length of the wind turbine device 2, but the invention is not limited to such embodiments.

CLAIMS

1. Device for installation of an elongated offshore structure (2; 6), where the device comprises:
 - a vessel (10);
 - 5 - an outer frame (20) pivotable in relation to the vessel (10) between a substantially horizontal position for transporting the elongated offshore structure (2; 6) to the installation site and a substantially vertical position for installation of the elongated offshore structure (2; 6) at the installation site;
 - a connection device (40) for connection of the elongated offshore structure
 - 10 (2; 6) to the outer frame (20) via a longitudinal actuation device (42);where the connection device (40) comprises a first supporting element (41) for providing the elongated offshore structure (2; 6) in a free hanging configuration when the outer frame (20) is in the substantially vertical position, and where the longitudinal actuation device (42) is provided for lowering the elongated offshore
- 15 structure (2; 6) towards the seabed when the an elongated offshore structure (2; 6) is in the free hanging configuration.
2. Device according to claim 1, where the elongated offshore structure (2; 6) is a wind turbine device (2) comprising a tower device (3) with a nacelle (4) and at least one rotor blade (5) provided in a first end thereof and a foundation (6) provided in a
- 20 second end thereof.
3. Device according to claim 1, where the connection device (40) comprises a cross bar (43) slidably arranged in relation to the outer frame (20) by means of the longitudinal actuation device (42).
4. Device according to claim 3, where the first supporting element (41) is connected
- 25 to the cross bar (43).
5. Device according to claim 3, where the connection device (40) comprises a second supporting element (45) for releasable connection of the elongated offshore structure (2; 6) in relation to the outer frame (20).
6. Device according to claim 1, where an inner frame (30) is provided inside the
- 30 outer frame (20), where the inner frame comprising a first supporting device (31, 32) for supporting the elongated offshore structure (2; 6) in the substantially horizontal position during transportation to the installation site.
7. Device according to claim 6, where the inner frame (30) comprises a cross bar supporting device (33) for supporting the cross bar (43) in relation to the inner
- 35 frame (30).

8. Device according to claim 7, where the cross bar supporting device (33) is configured to release the support of the cross bar (43) in the substantially vertical position.
9. Device according to claim 6, where the inner frame (30) is displaceable in a longitudinal direction with respect to the outer frame (20).
10. Device according to claim 1, where the longitudinal actuation device (42) is pivotably mounted to the outer frame (20).
11. Device according to claim 1, where control devices (14) are provided to control the orientation of the elongated offshore structure (2; 6) in the free hanging configuration.
12. Device according to claim 5, where a locking device (60) is provided for locking the inner frame (30) to the outer frame (20).
13. Method for installation of an offshore elongated offshore structure (2; 6), where the method comprises:
- connecting the elongated offshore structure (2; 6) to an outer frame (20) via a longitudinal actuation device (42), where the outer frame (20) is pivotable in relation to a vessel (10);
 - transporting the elongated offshore structure (2; 6) to the installation site in a substantially horizontal position;
 - pivoting the outer frame (20) to a substantially vertical position at the installation site;
 - providing the elongated offshore structure (2; 6) in a free hanging configuration via the longitudinal actuation device (42) when the outer frame (20) is in the substantially vertical position;
 - lowering the elongated offshore structure (2; 6) towards the seabed by means of the longitudinal actuation device (42) when the elongated offshore structure (2; 6) is in the free hanging configuration.
14. Method according to claim 13, where the elongated offshore structure (2; 6) is a wind turbine device (2) comprising a tower device (3) with a nacelle (4) and at least one rotor blade (5) provided in a first end thereof and a foundation (6) provided in a second end thereof.
15. Method according to claim 13, further comprising the step of providing the connection device (40) with a cross bar (43) slidably arranged in relation to the outer frame (20) by means of the longitudinal actuation device (42).
16. Method according to claim 13, further comprising the step of connecting the first supporting element (41) to the cross bar (43).

17. Method according to claim 13, further comprising the step of providing the connection device (40) with a second supporting element (45) for releasably connecting the elongated offshore structure (2; 6) in relation to the outer frame (20).
- 5 18. Method according to claim 13, further comprising the step of providing an inner frame (30) inside the outer frame (20), where the inner frame comprising a first supporting device (31, 32) for supporting the elongated offshore structure (2; 6) in the substantially horizontal position during transportation to the installation site.
- 10 19. Method according to claim 18, further comprising the step of providing the inner frame (30) with a cross bar supporting device (33) for supporting the cross bar (43) in relation to the inner frame (30).
20. Method according to claim 19, further comprising the step of configuring the cross bar supporting device (33) to release the support of the cross bar (43) in the substantially vertical position.
- 15 21. Method according to claim 13, further comprising the step of displacing the inner frame (30) in a longitudinal direction with respect to the outer frame (20).
22. Method according to claim 13, further comprising the step of controlling the orientation of the elongated offshore structure (2; 6) in the free hanging configuration.
- 20 23. Method according to claim 18, further comprising the step of locking the inner frame (30) to the outer frame (20).

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Fig. 1

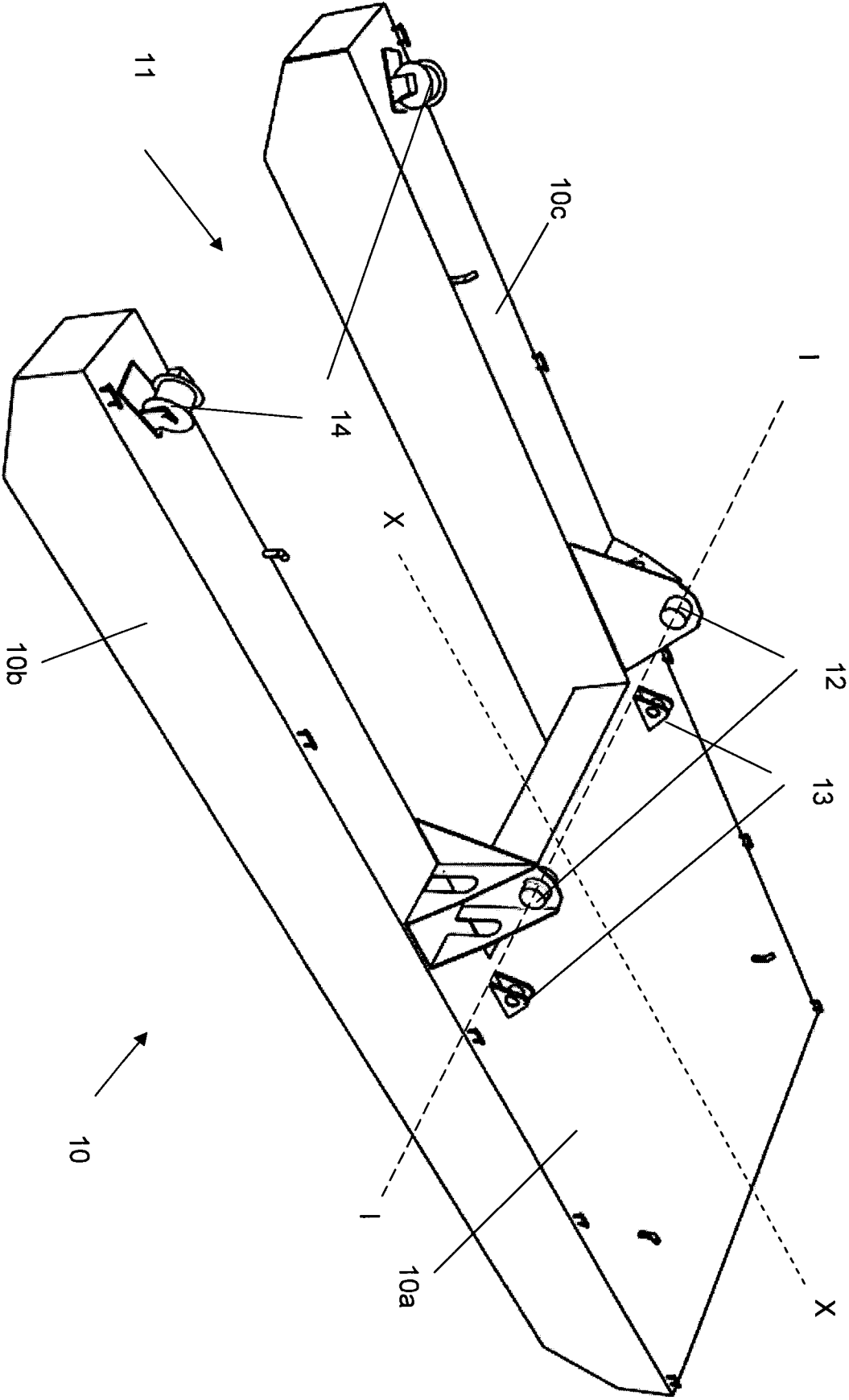


Fig. 2

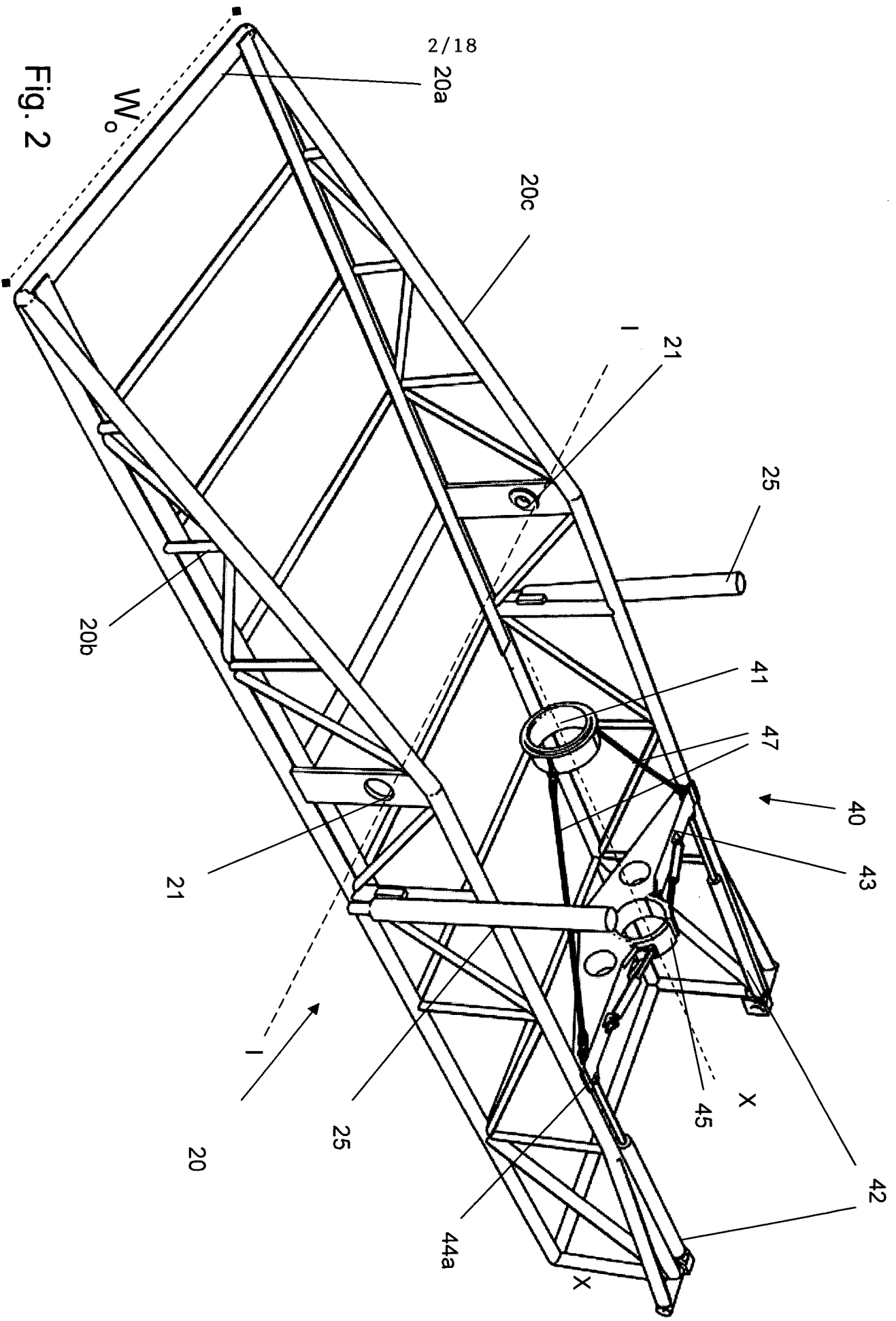
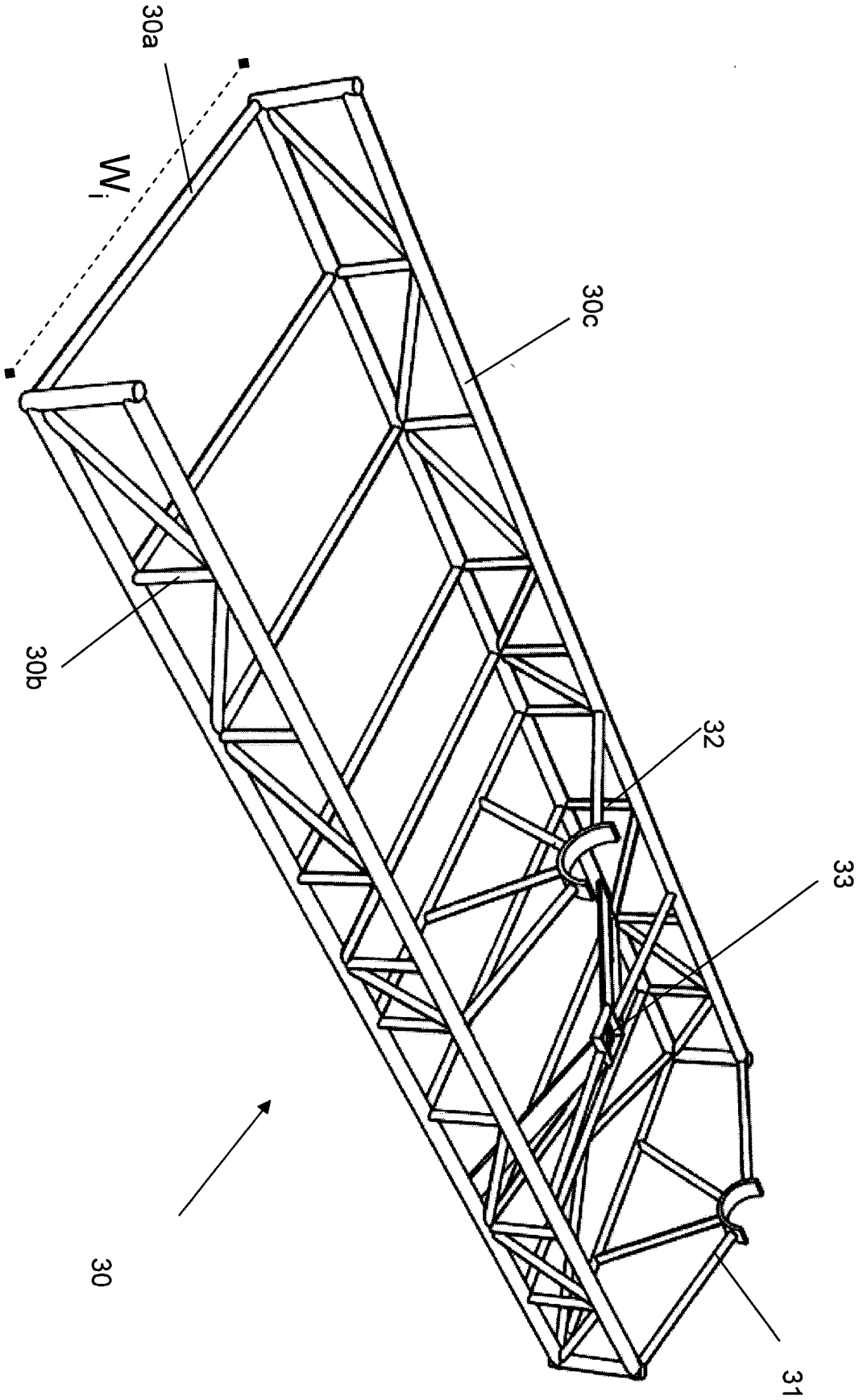
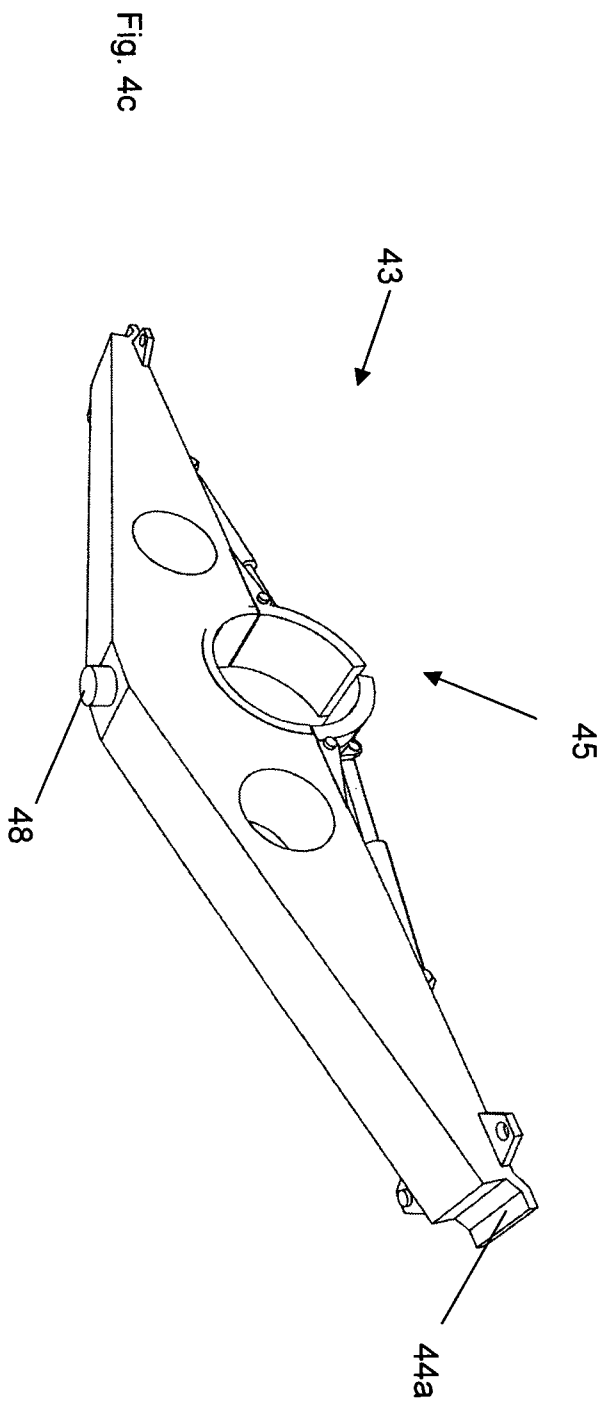
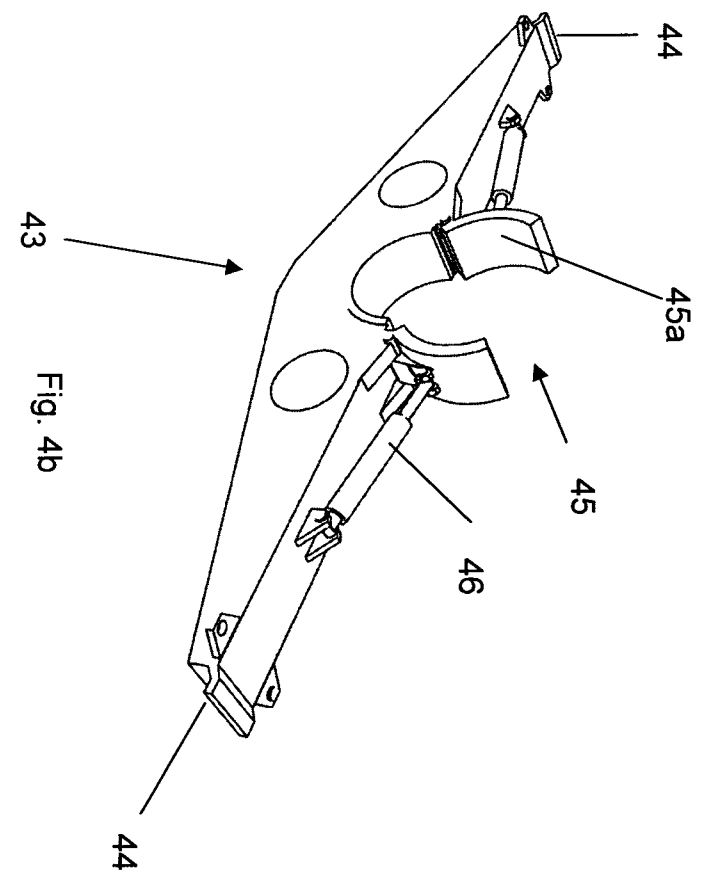
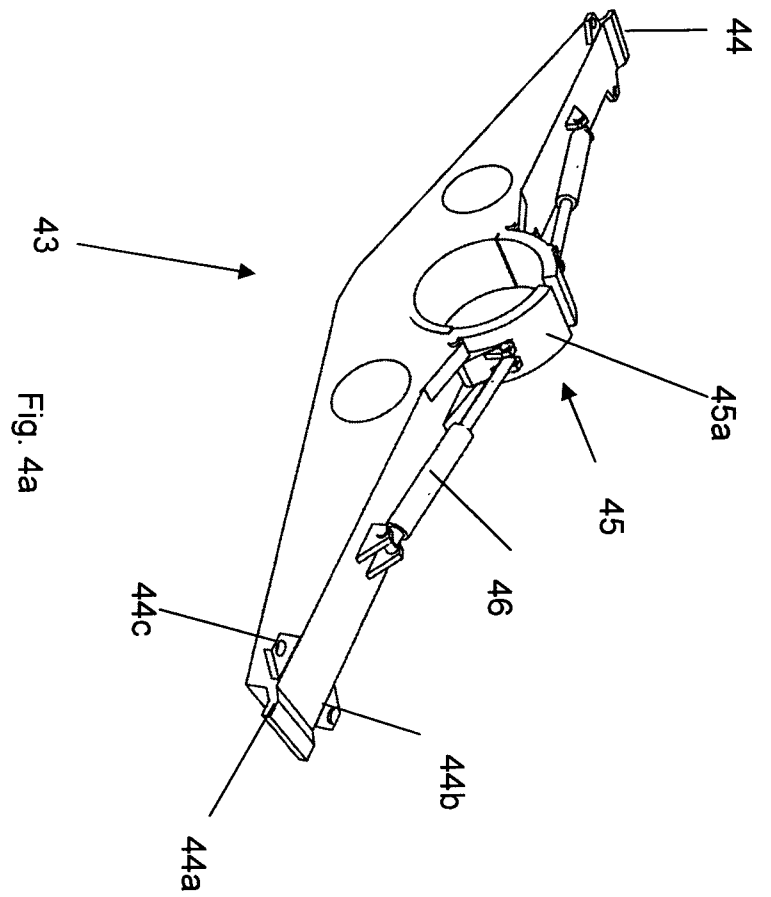


Fig. 3





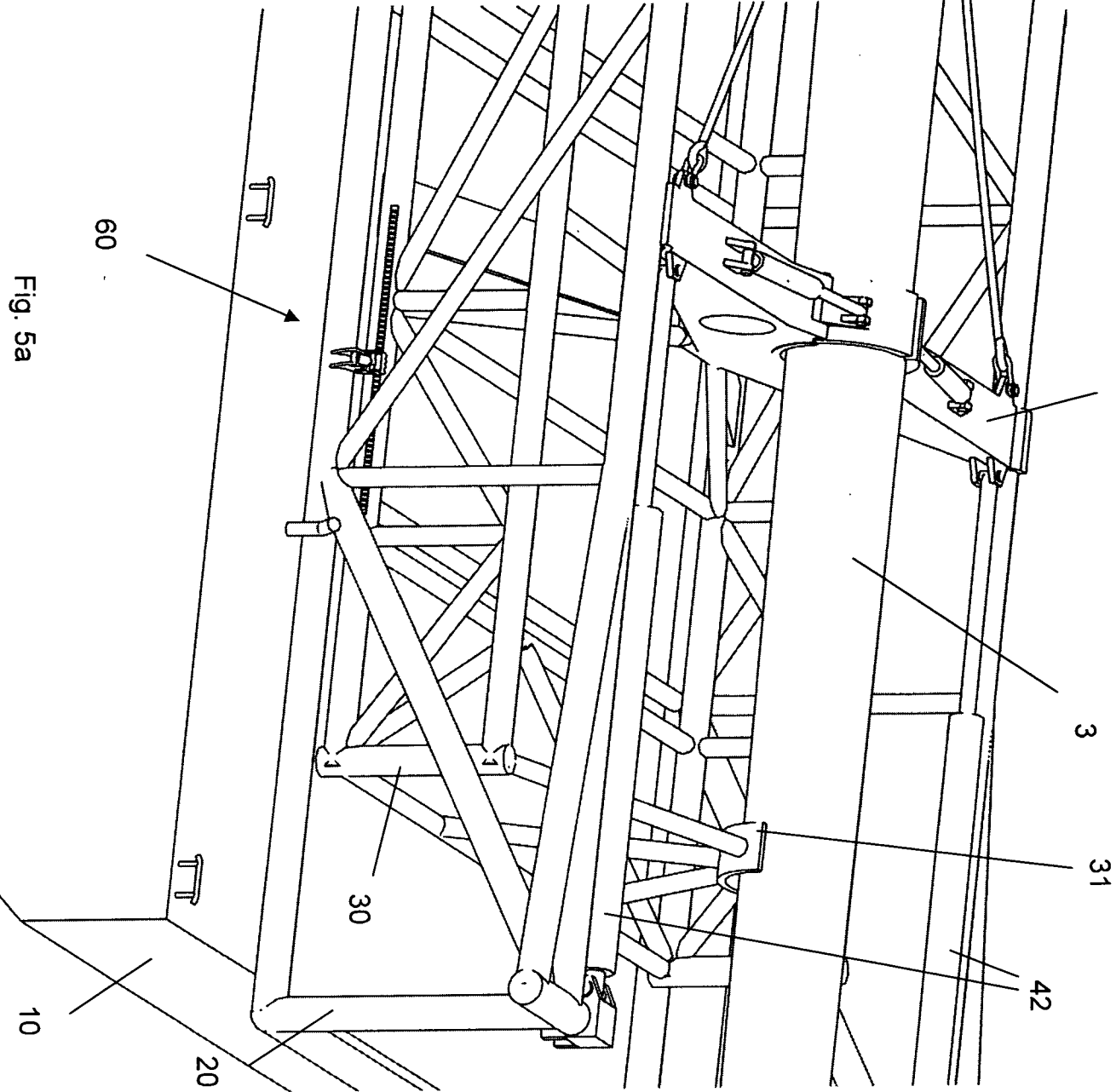


Fig. 5a

60

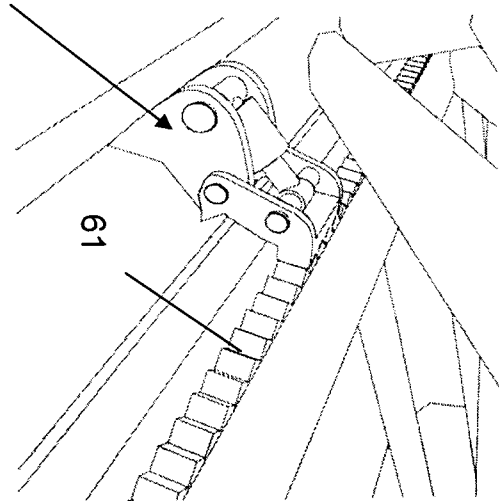


Fig. 5c

60

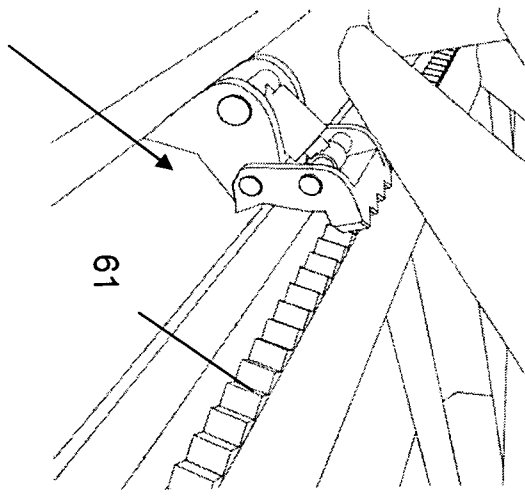


Fig. 5b

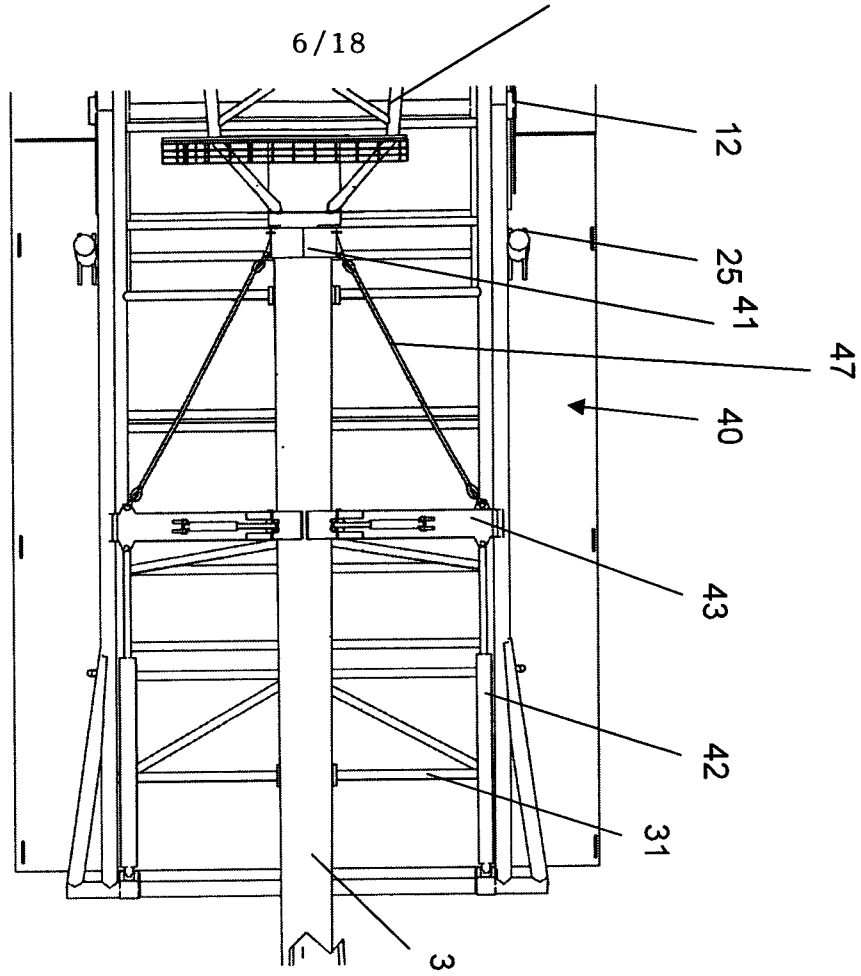


Fig. 6a

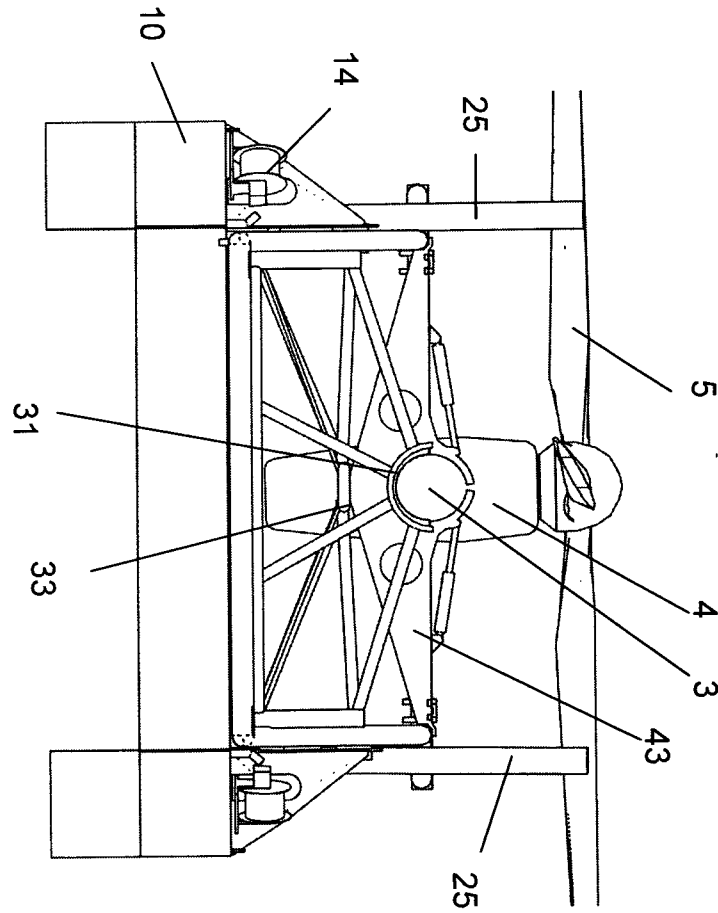


Fig. 6b

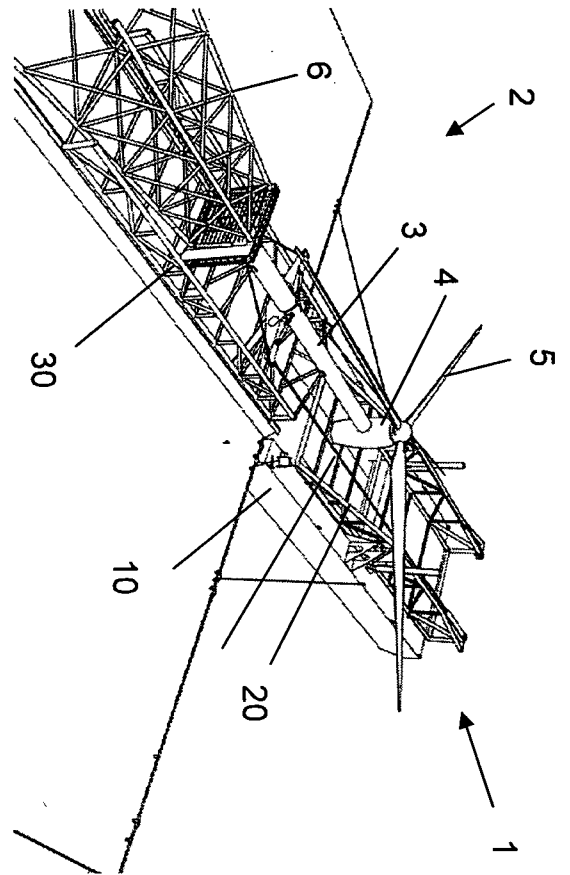


Fig. 7a

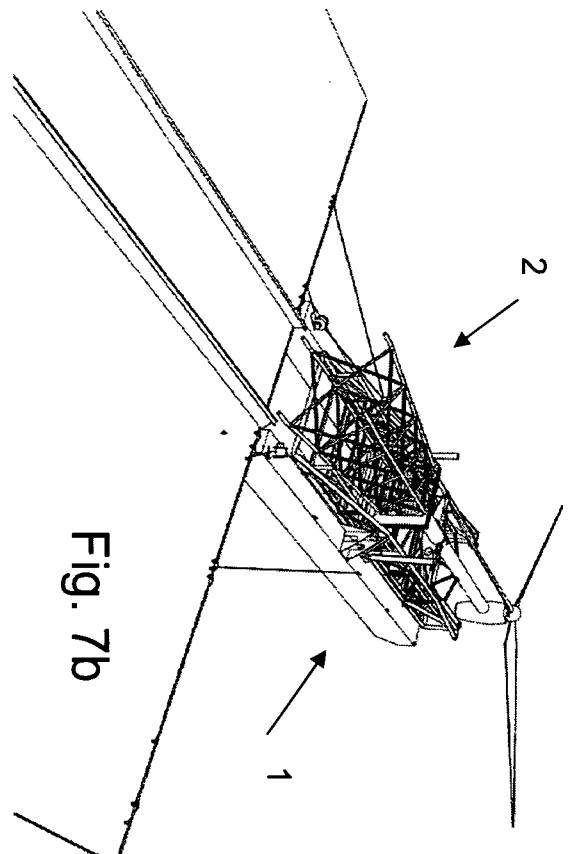


Fig. 7b

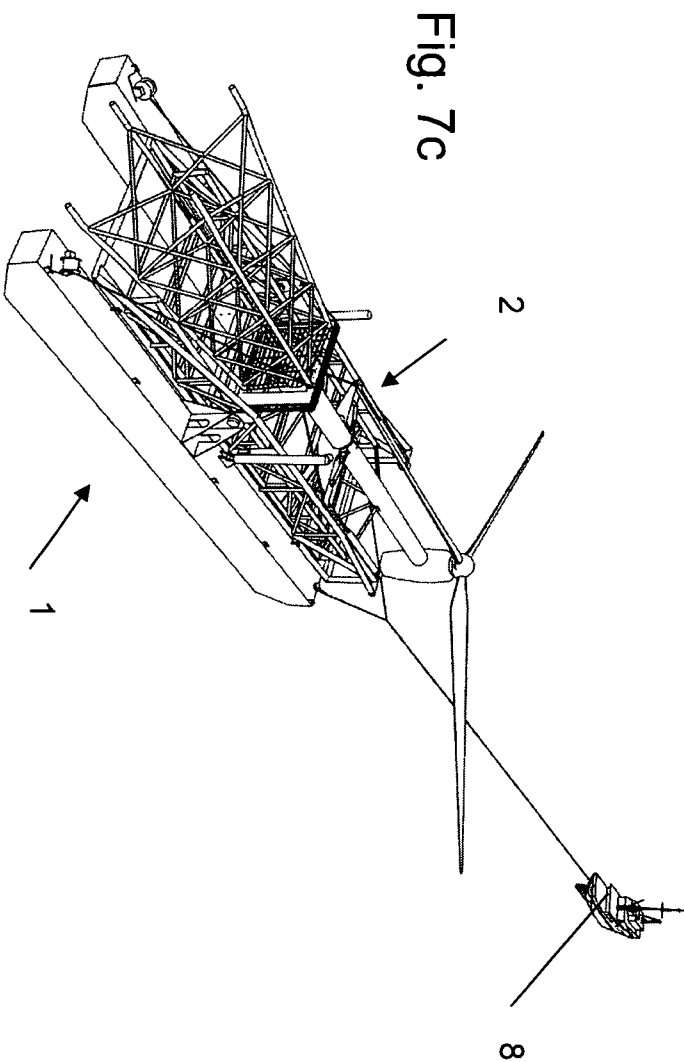


Fig. 7c

Fig. 7d

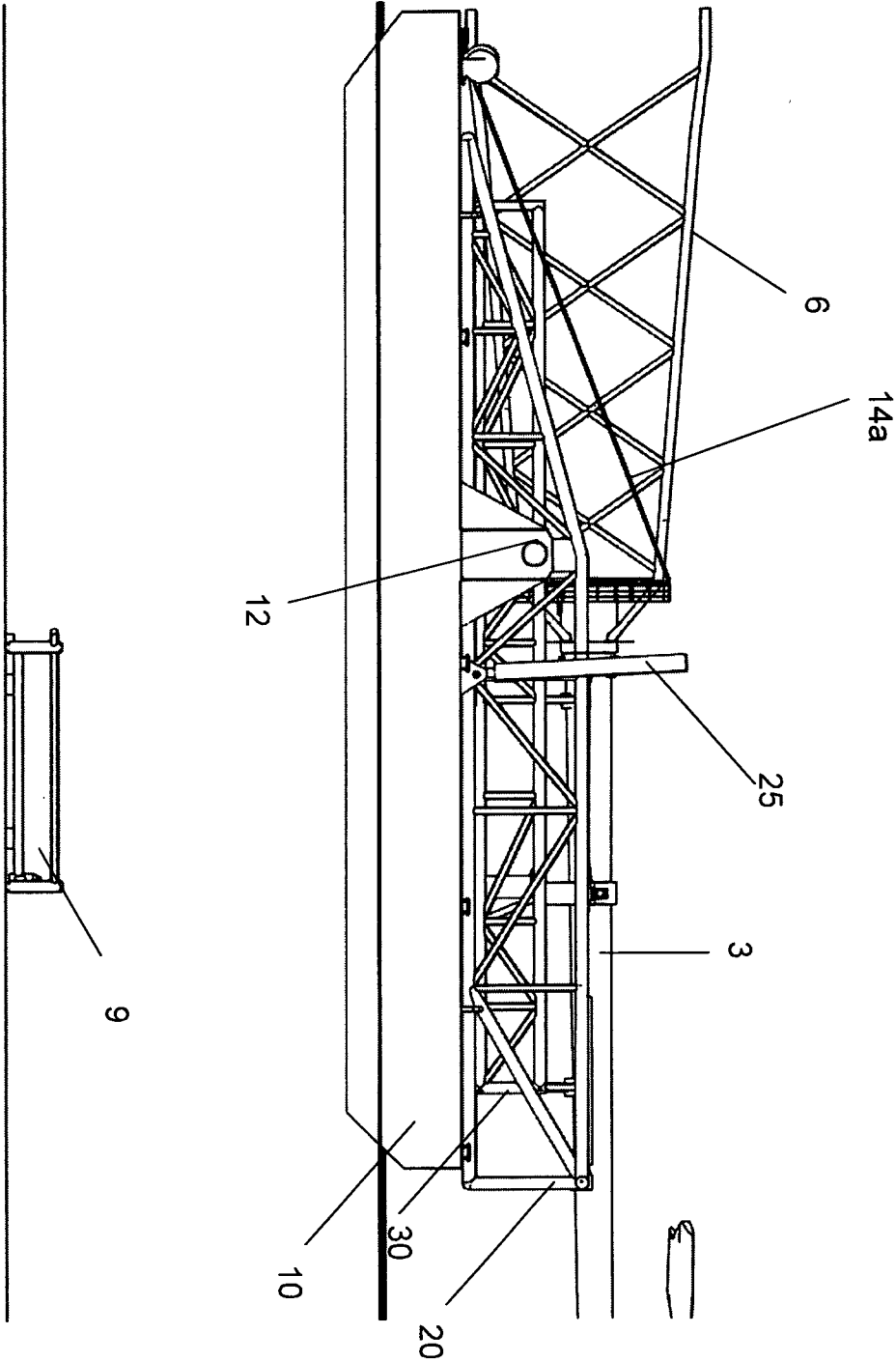


Fig. 7e

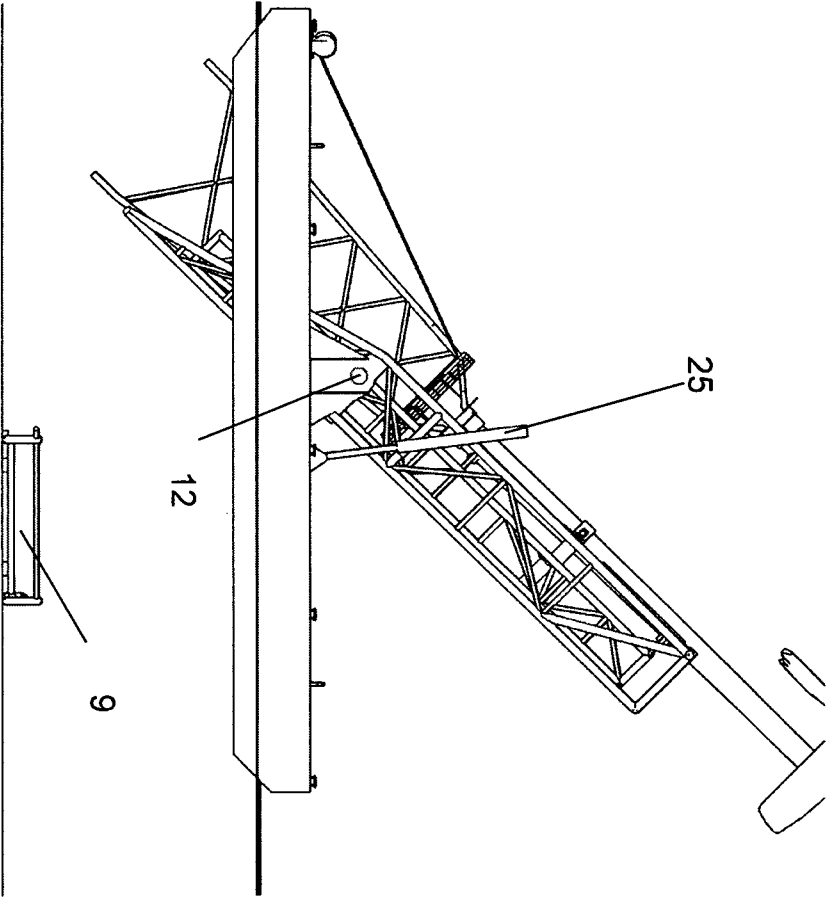
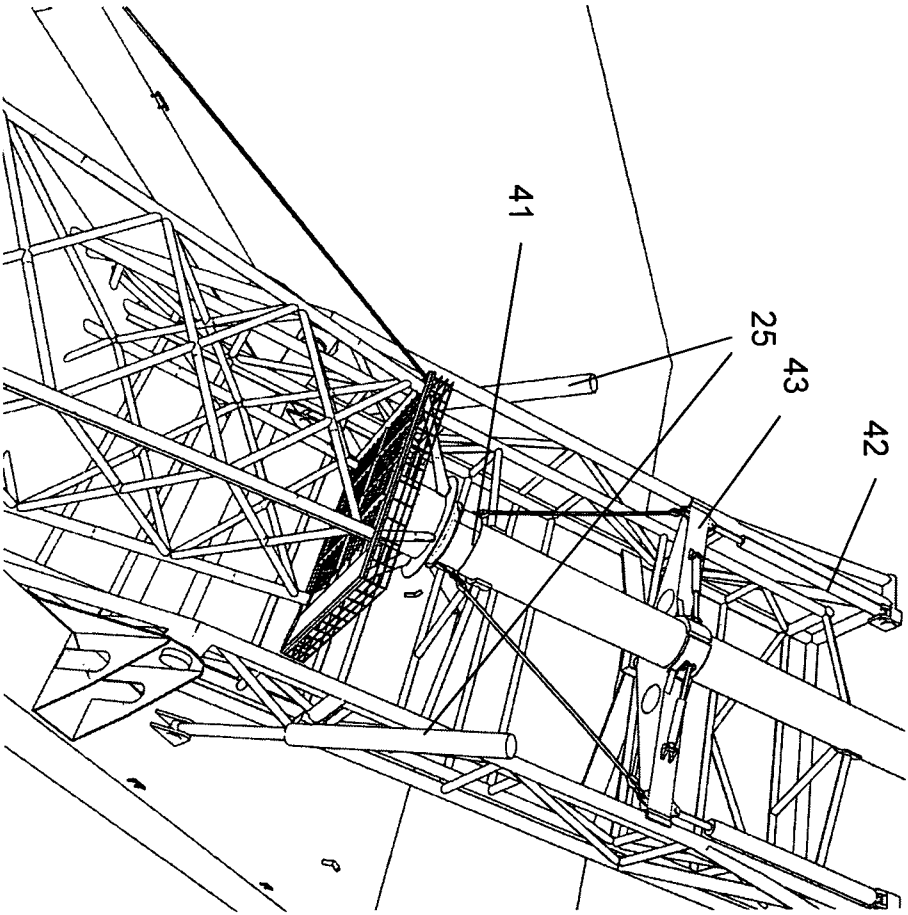
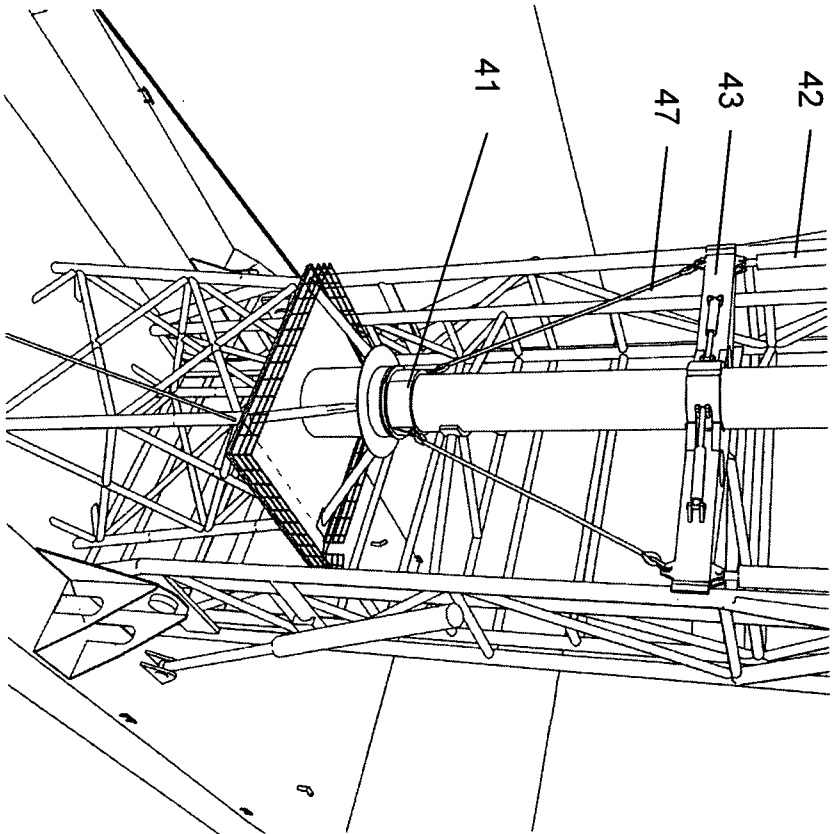
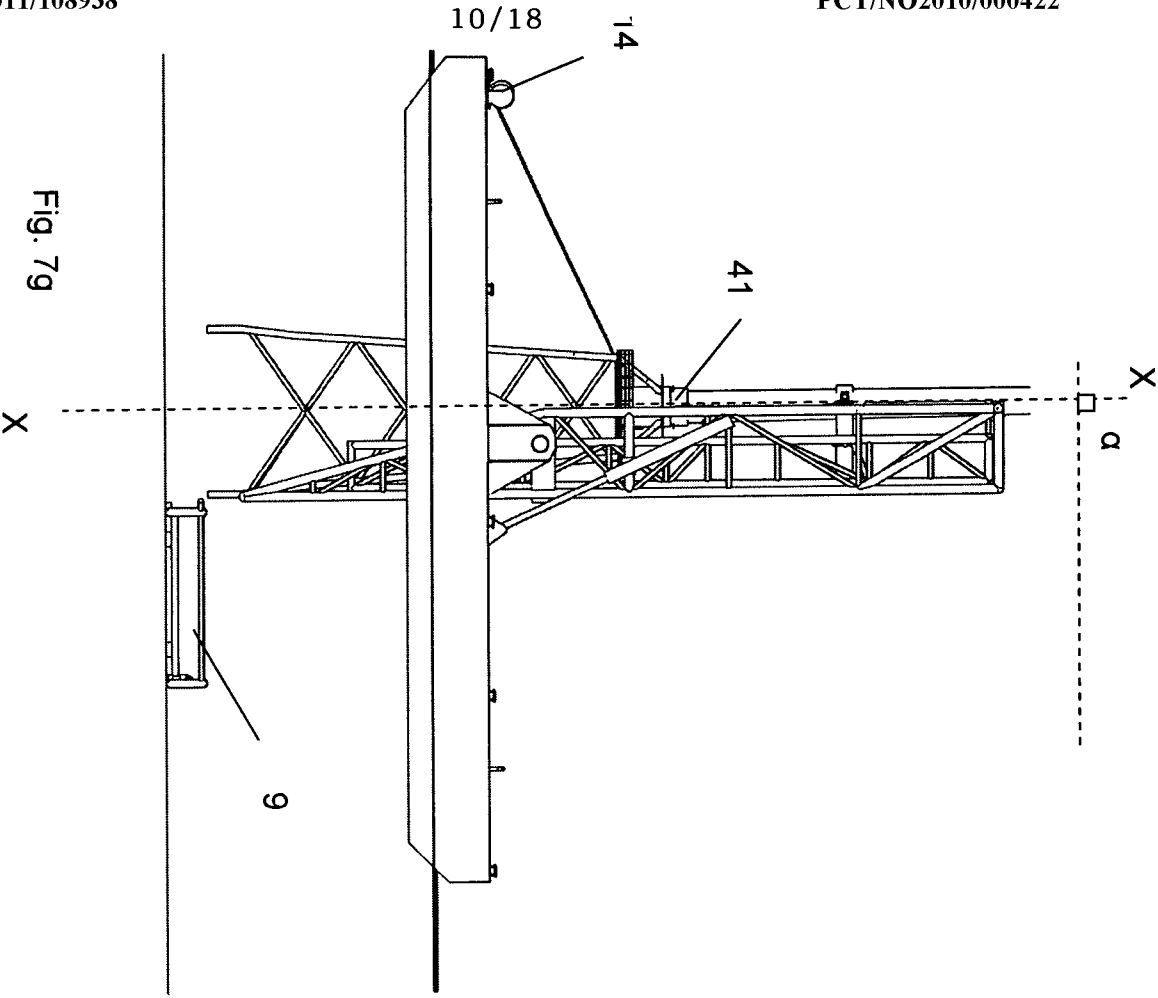
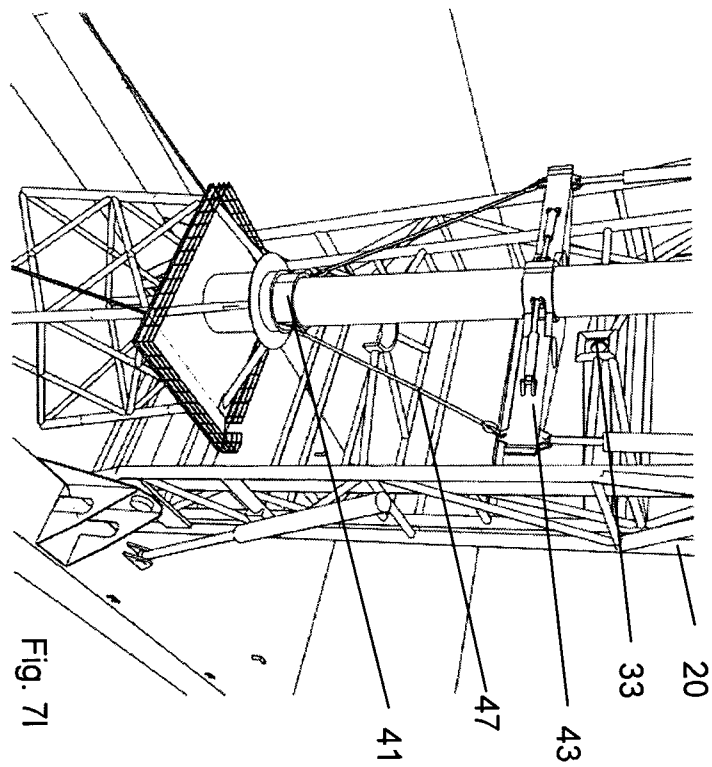
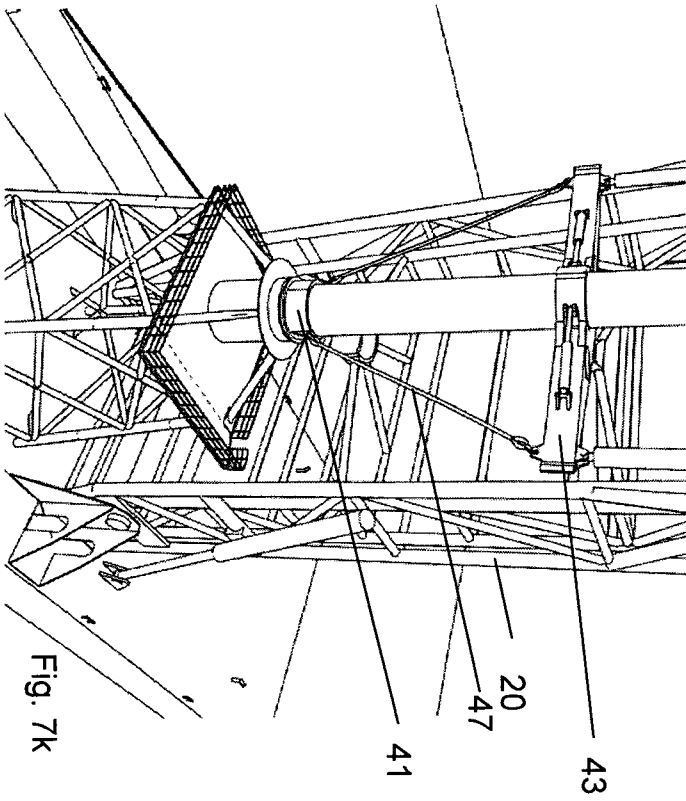
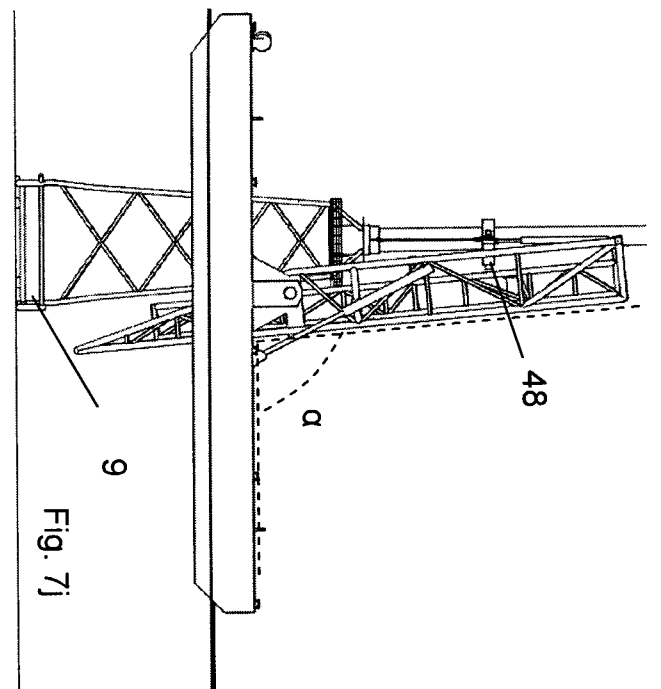
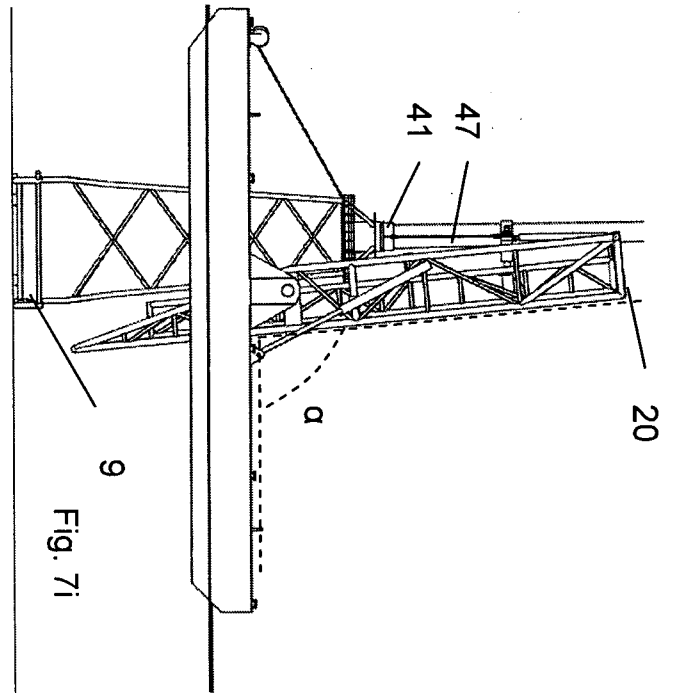


Fig. 7f







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Fig. 7m

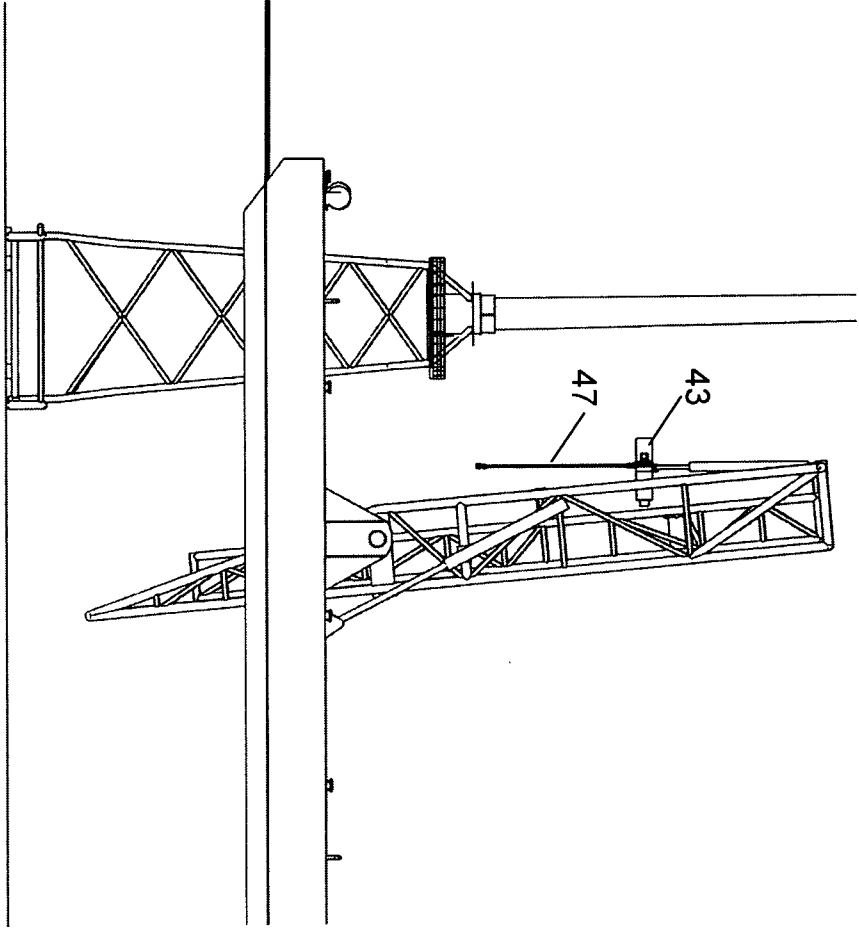
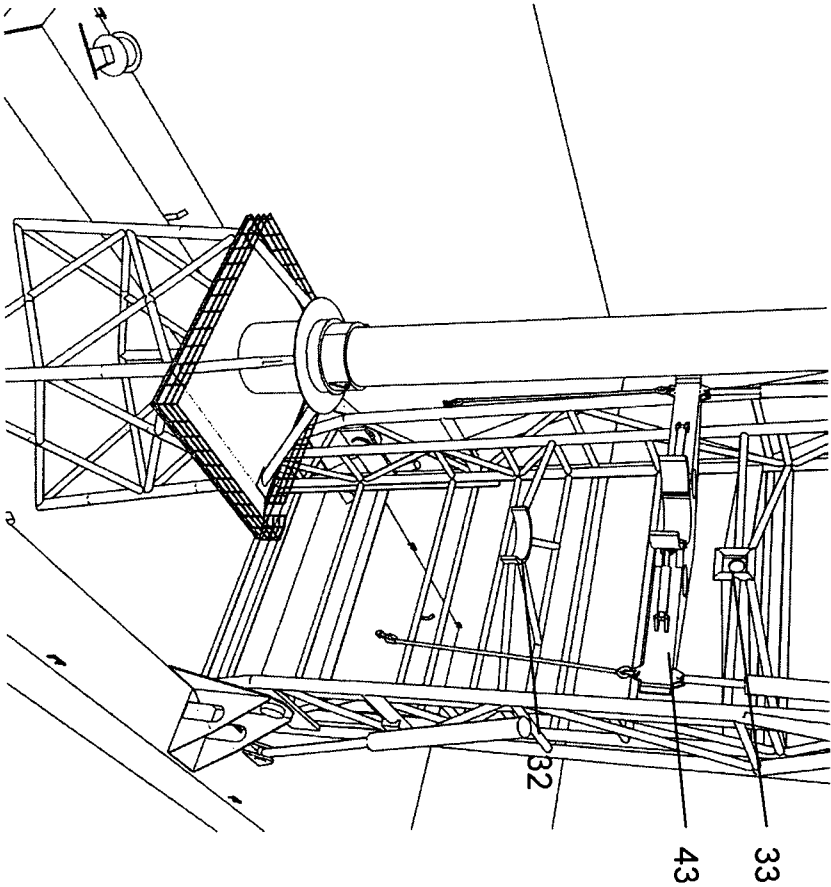


Fig. 7n



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Fig 8a

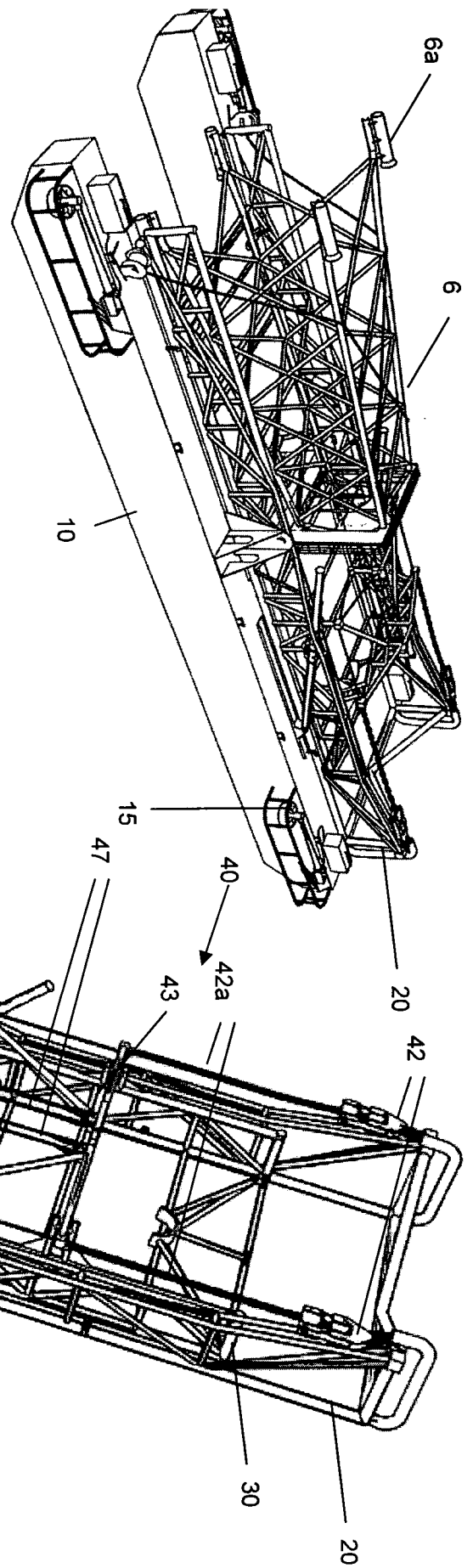


Fig 8b

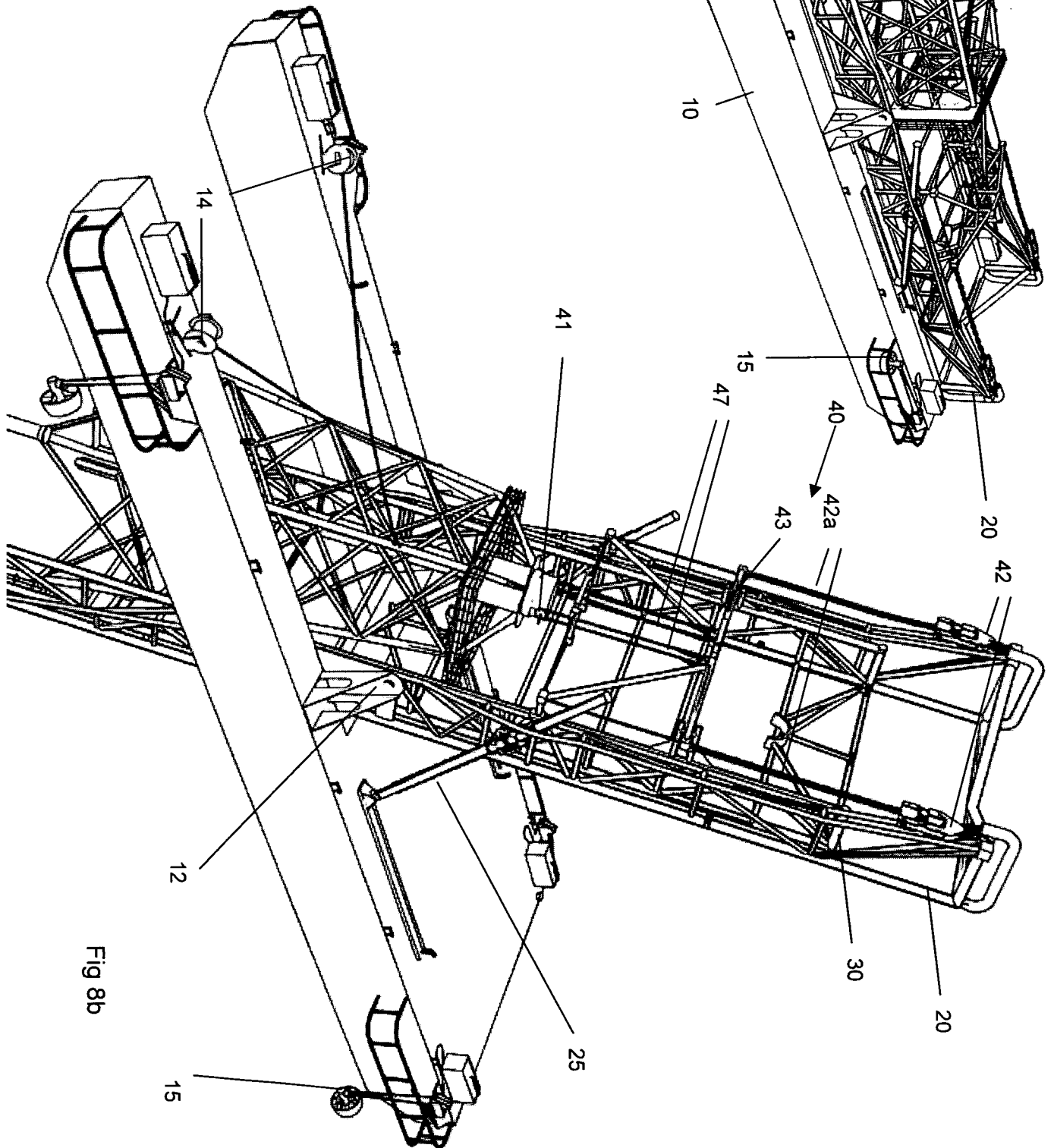


Fig 8c

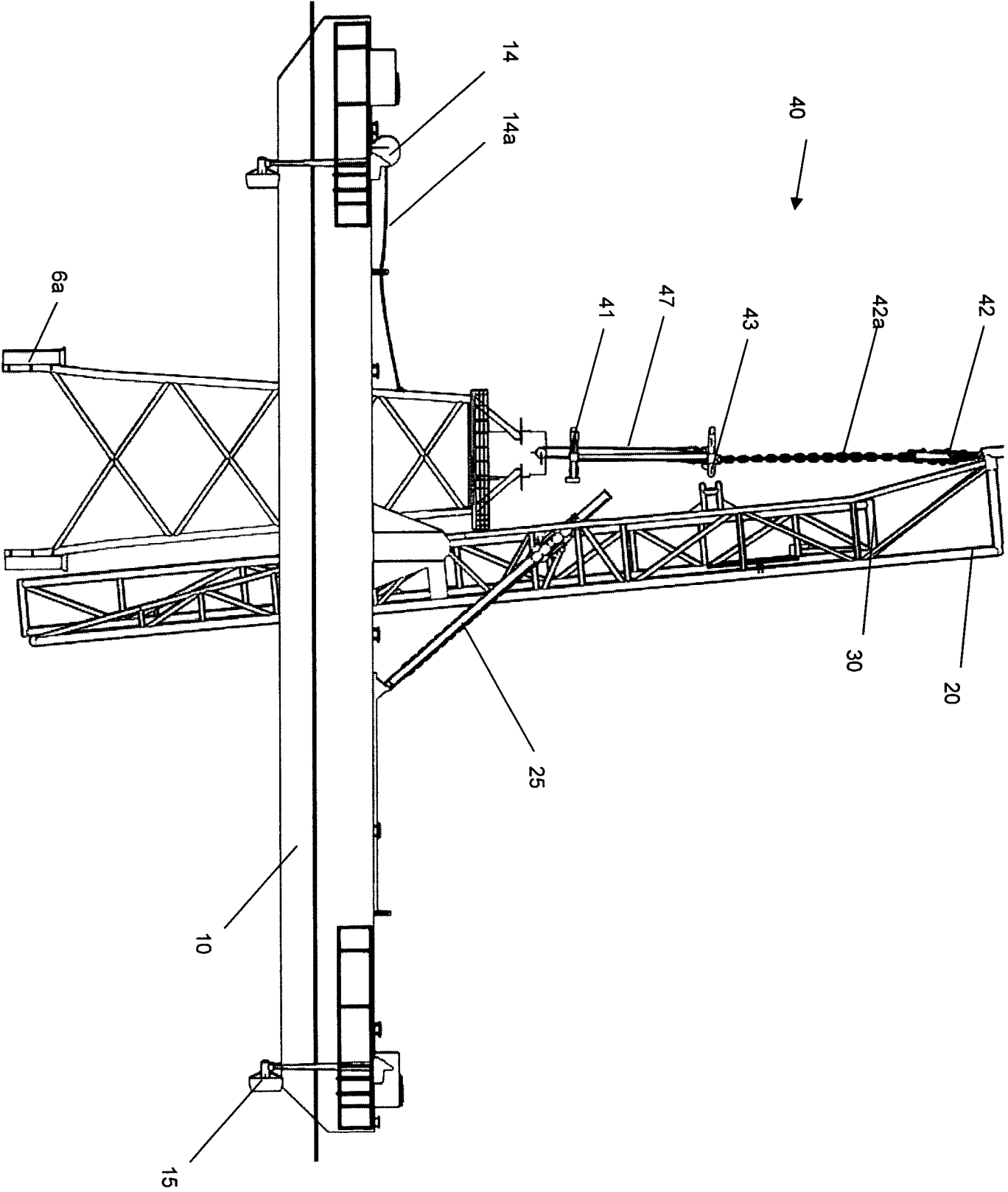


Fig 8d

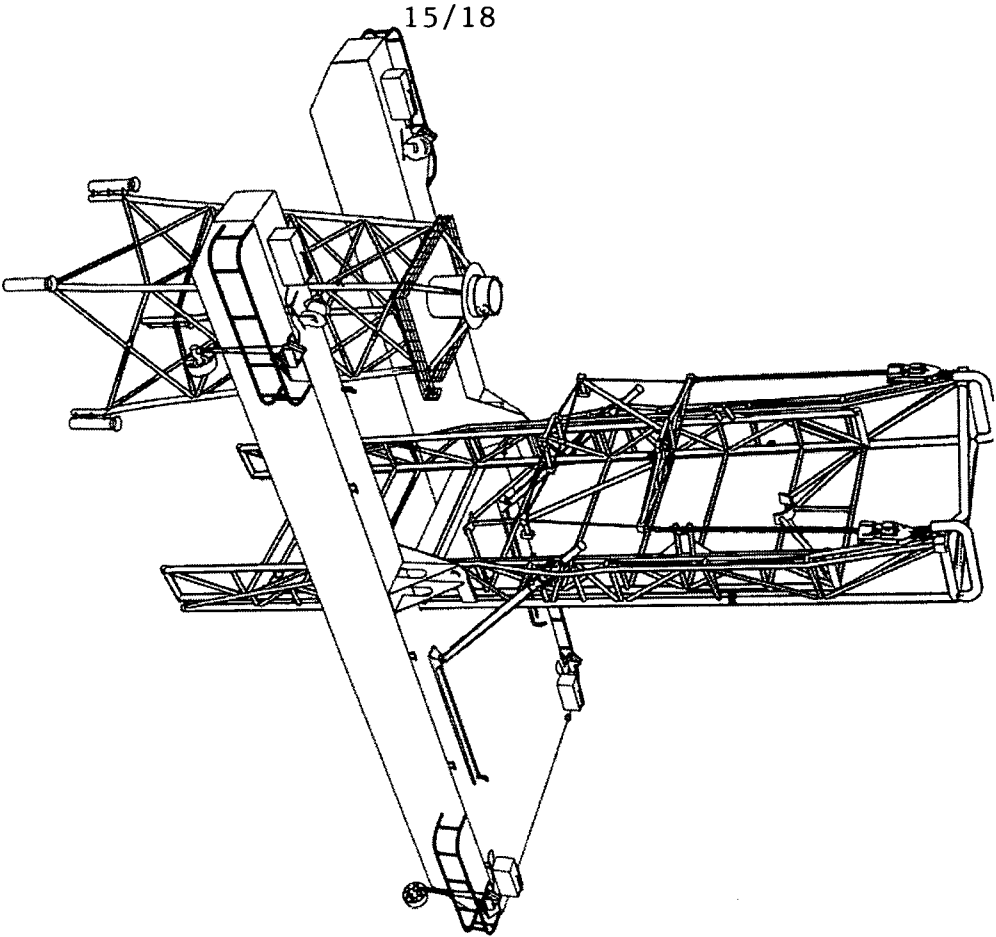
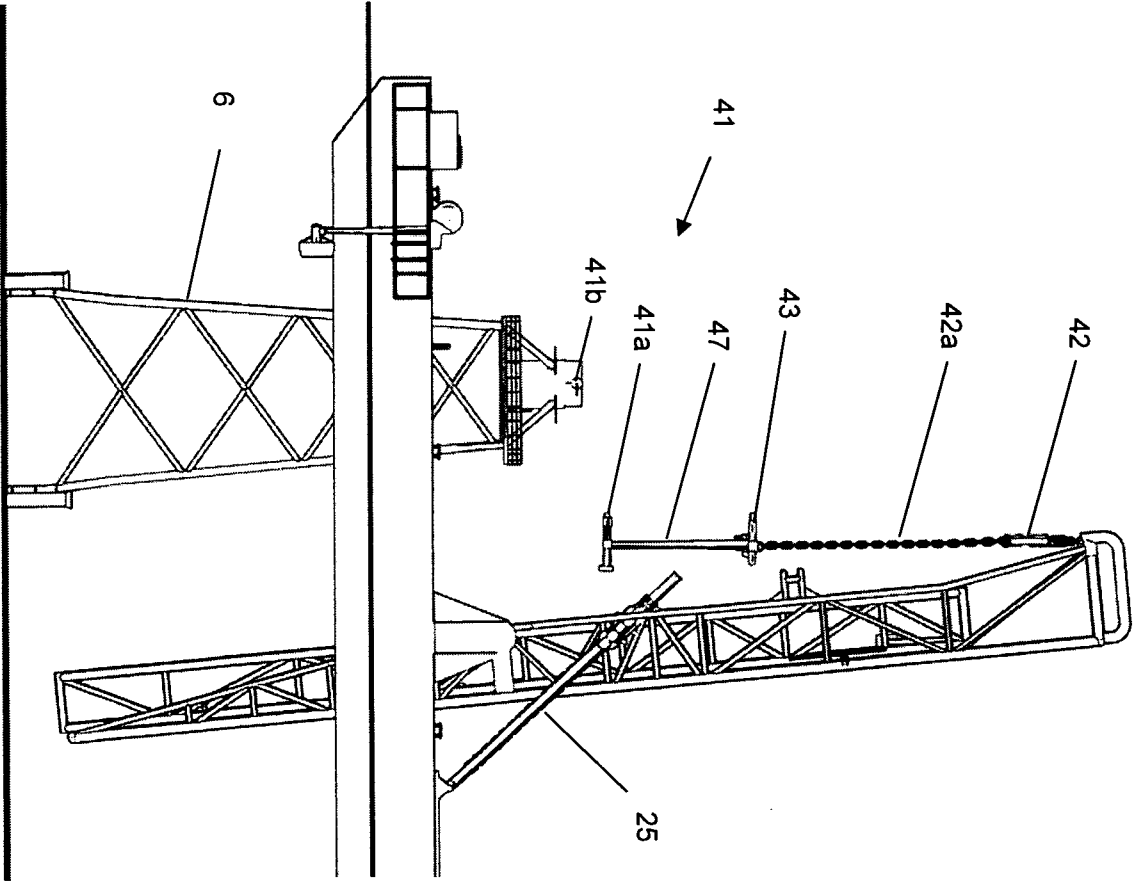


Fig 8a



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Fig 9a

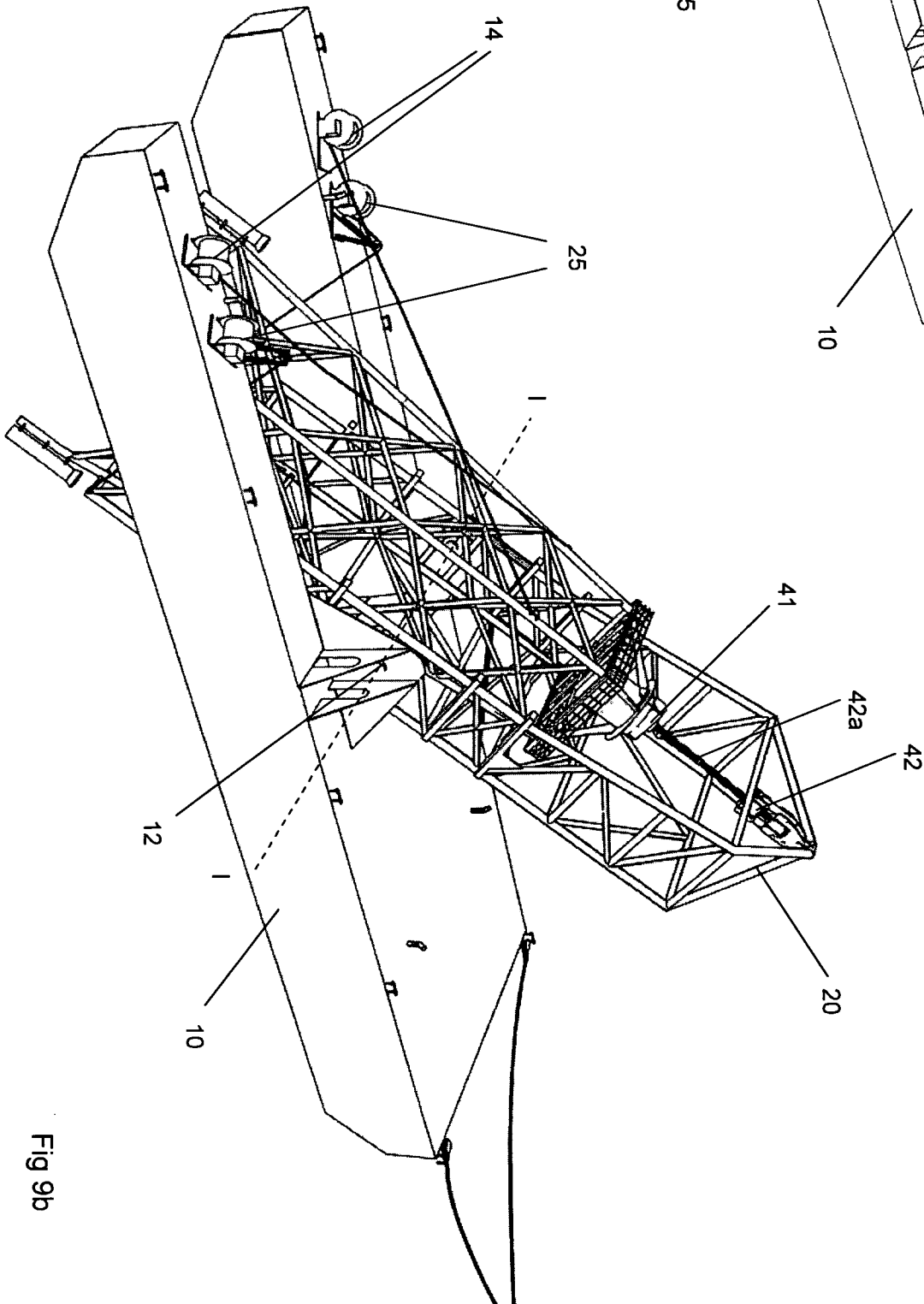
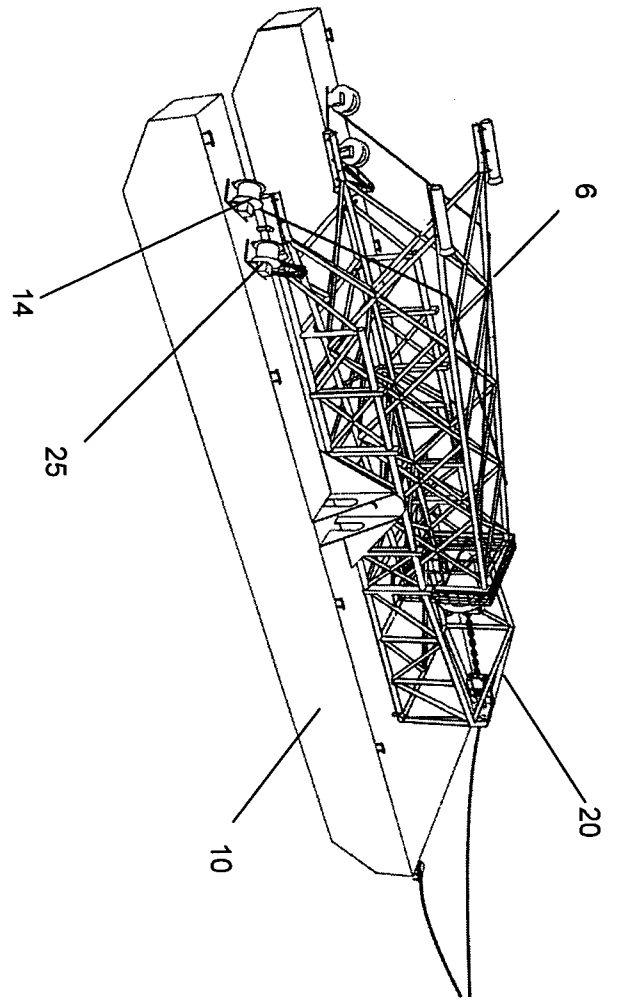


Fig 9b

Fig 9c

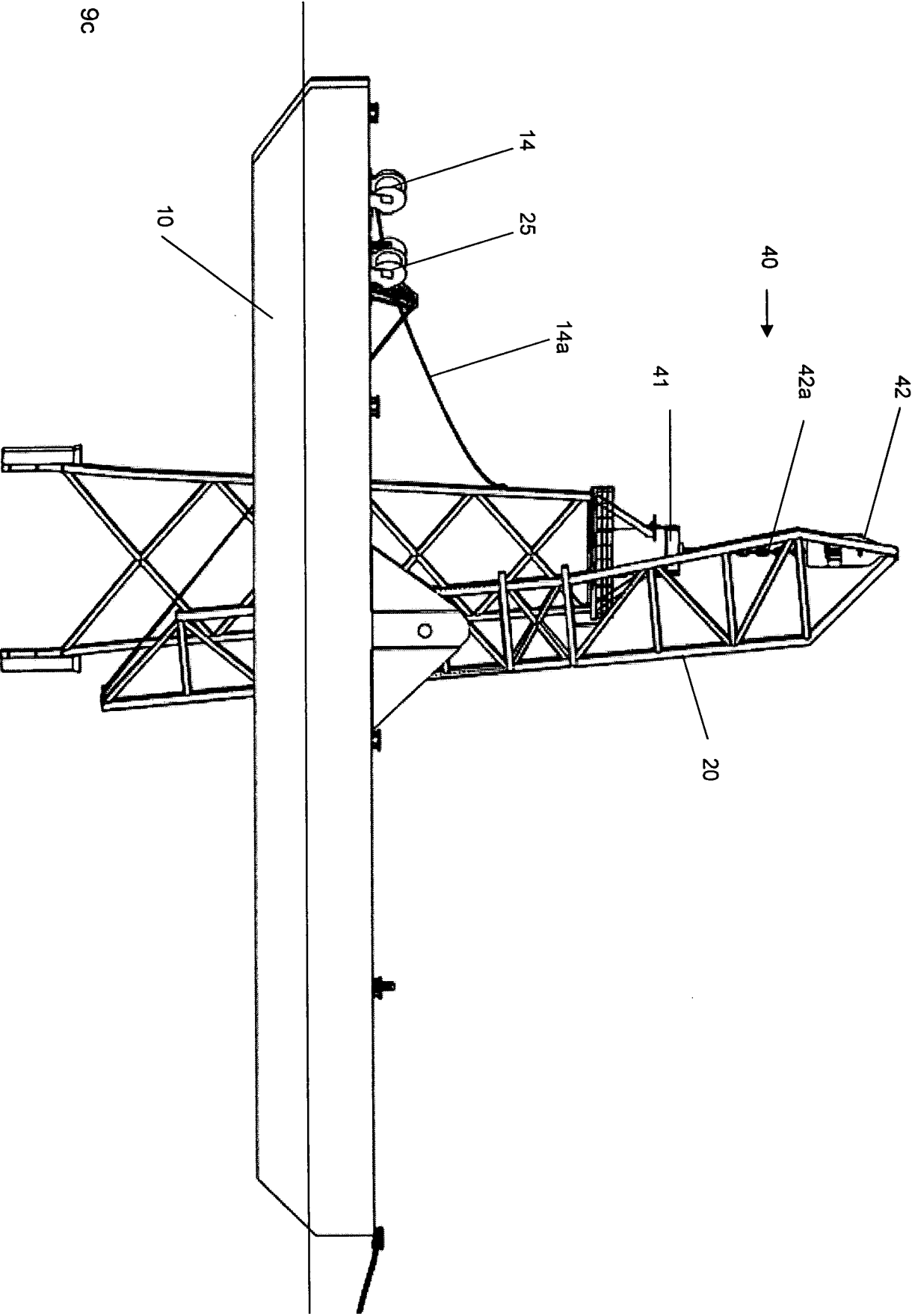


Fig 9d

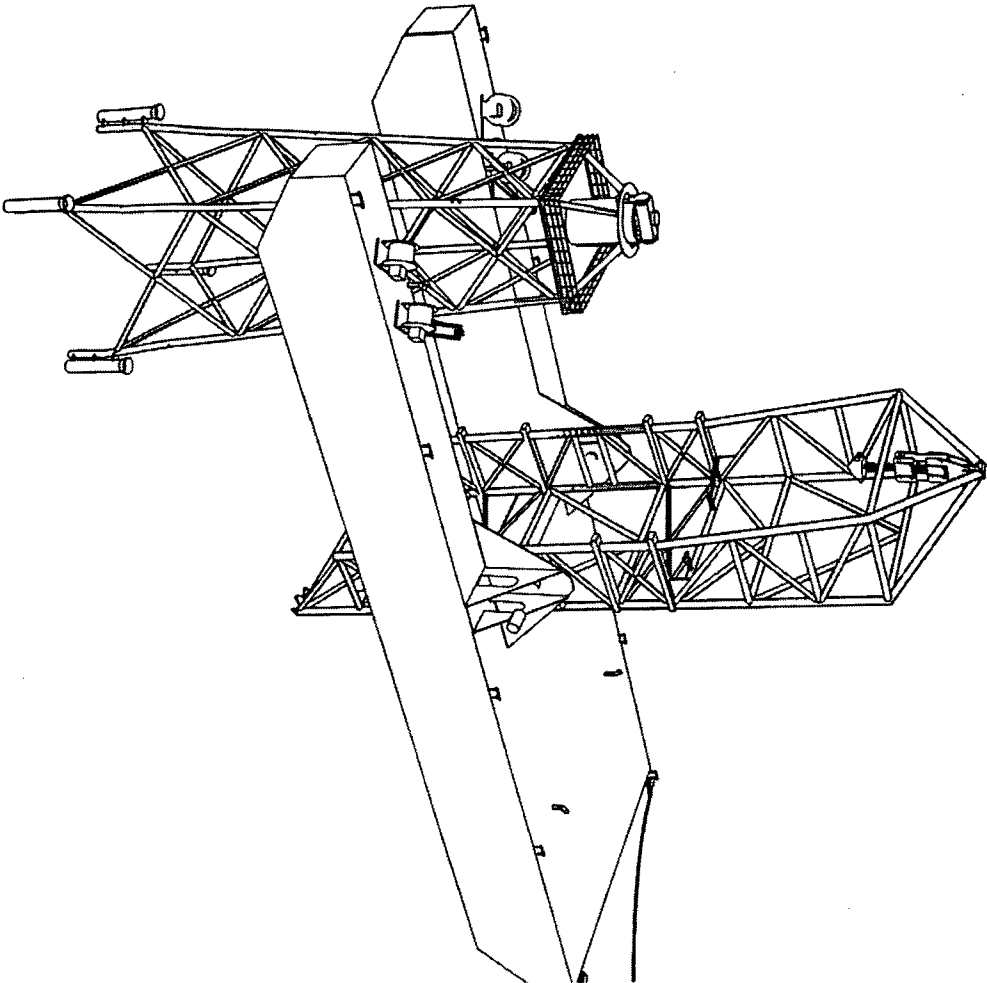


Fig 9e

