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(54) **Jack-up pontoon**

(57) Jack-up barge (1) comprising a floating platform (2) formed by a plurality of modules (4) that can be joined together mechanically by means of removable fixing means (5) and a plurality of support legs (3), mounted orthogonally on the floating platform (2). Said modules (4) comprise three or more lifting modules (16), each of which is mechanically associated with a leg (3) and is

provided with a support frame (17). The support frame (17) having centrally fixed a guide structure (18), in which the leg (3) is inserted, and having fixed a plurality of buffer panels (19), which define together with said guide structure (18), a closed box-shaped body. Said closed box-shaped body participates in the hydrostatic floating thrust of the floating platform (2).

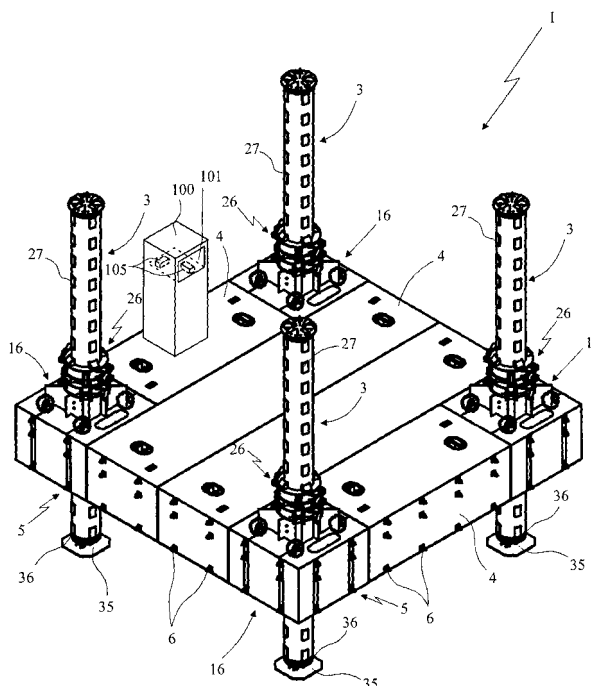


Fig. 1

Description

Technical field

[0001] The present invention relates to a jack-up barge according to the preamble of independent claim number 1.

[0002] The jack-up barge according to the present invention is intended for use in marine, lake or river environments and, more generally, in environments in which there is a need to install a stable artificial platform above the surface of the water, from which specific operations can easily be carried out beneath the surface of the water, for example to service underwater installations or perform work at the bottom of the sea, lake or river.

Prior art

[0003] As is known, jack-up barges are used in a variety of technical sectors. In the oil industry, for instance, they are used when searching for new oilfields and in the extraction and transportation of oil and natural gas under the sea.

[0004] Jack-up barges are also widely used in many other technical fields, for instance to carry out operations in connection with the restoration of the seafloor, maintenance of navigational channels, geological and penetration tests, and for many other operations besides.

[0005] These technical sectors require a stable platform from which operations can be carried out, for example using excavators or hoists on the seafloor or using specific equipment to service installations, carry out research, etc.

[0006] Jack-up barges, otherwise known as jack-up platforms, are special structures designed to respond to specific operational needs of the type mentioned above.

[0007] As is known, they comprise a platform capable of floating on the water and a number of legs to support the platform and which rest on the seafloor.

[0008] In the prior art the use is known of jack-up barges provided with a platform comprising a plurality of modular elements that can be joined together side by side to obtain platforms with a generally quadrangular shape. The possibility of assembling and dismantling the modular elements of such platforms makes them easier to transport before being assembled, usually in water. Moreover, the use of modular elements allows differently-sized platforms to be built, depending on the specific operational requirements of the application for which they are to be used.

[0009] The modular elements are generally available in a variety of sizes and are provided with suitable removable anchoring means, which are used to join them together.

[0010] Jack-up barges can assume two different configurations: as a floating platform, with the legs raised, and as a stable structure, with the legs lowered and resting on the seabed to support the platform.

[0011] In particular, jack-up barges are placed in the floating condition when they have to cover long distances over water, in which case, for example, they can be self-propelled or towed, and are usually only arranged in the stable configuration to enable the required operational activities to be carried out.

[0012] In the stable configuration, the platform of the barge is generally arranged so as to be raised above the surface of the water, to prevent waves or currents from placing excessive mechanical strain on the barge structure, especially in bad weather conditions.

[0013] To change from one configuration to the other, said barges are provided with means for adjusting the height of the legs with respect to the platform, so that the legs can be lowered or raised with respect to the platform.

[0014] For instance, in the prior art, barges have been provided with adjustment means comprising one or more racks attached to each leg of the barge and motor-powered means mounted on the platform, with pinions that engage the racks in order to lower or raise the legs with respect to the platform. Each leg is normally inserted in a seat that is integral with the platform suitable to guide it during its movement.

[0015] Said adjusting means have been found to have some practical inconveniences.

[0016] When the legs of the barge remain in the water for a long time, they can become subject to fouling, i.e. the deposition and build-up of marine, animal or vegetable organisms. The presence of these organisms on the surface of the legs can also lead to the subsequent formation of rust. This is especially the case of the racks attached to the legs, which have gaps between the teeth in which said organisms can easily develop. Constant maintenance is therefore required, making such platforms expensive in terms of maintenance costs.

[0017] Other prior art barges have adjustment means provided with hydraulic cylinders that are fitted to the platform and in which the heads of the pistons are mechanically connected to the legs, by means of selectively removable pins that can be inserted in specific holes arranged at regular intervals along the legs of the barge. The pistons in the hydraulic cylinders retract and extend so that, via the pin, they move the relative leg in the guide seat, raising and lowering it with respect to the platform.

[0018] However, said adjustment means have some drawbacks: selectively inserting the pins in the holes is not very convenient and there is the possibility of the pins bending or sticking in said holes, in which case they are difficult to remove.

[0019] According to another embodiment of the prior art solution described above, the barge is provided with adjustment means comprising hydraulic cylinders with clamping means fixed to the heads of the relative pistons that grip the legs by frictional force.

[0020] The main drawback of said barge lies in the fact that the clamps do not guarantee a secure grip, since they only rely on frictional force. Both the clamps and the legs are thus subject to significant wear and tear.

[0021] Patent US 3797256 describes a jack-up rig comprising a floating platform sustained on the sea bottom by four supporting legs arranged at corner portions of the platform and which can be raised and lowered.

[0022] The corner portions of this platform are not joined to the rest, which consists of mechanically connected removable modules that are arranged side by side, and do not contribute with closed chambers to the hydrostatic floating thrust of the platform.

[0023] The operations to raise and lower the floating platform are not performed automatically and involve the use of complex mechanisms that are not particularly safe.

Description of the invention

[0024] The present invention overcomes the inconveniences of the prior art described above by providing a jack-up barge comprising height adjustment means that are safe and operationally completely reliable.

[0025] A further object of the present invention is to provide a jack-up barge comprising height adjustment means that involve limited maintenance costs.

[0026] A further object of the present invention is to provide a jack-up barge comprising height adjustment means that are easy to use.

[0027] A further object of the present invention is to provide a jack-up barge with a reduced overall weight that also guarantees high safety standards.

Brief description of the drawings

[0028] The technical features of the invention, in accordance with the above purposes, will be apparent from the appended claims and the advantages will become clear from the detailed description that follows, with reference to the accompanying drawings, provided purely by way of a non-limiting example, in which:

Fig. 1 is a perspective view from above of the jack-up barge according to the present invention, with the legs partially raised;

Fig. 2 is a side view of the jack-up barge according to the present invention, with the legs completely lowered and resting on a sea bottom.

Fig. 3 is a side view of the jack-up barge according to the present invention, with the legs completely raised;

Fig. 4 is a plan view of the jack-up barge according to the present invention, with some parts removed so that others are more clearly visible;

Figs. 5A, 5B and 5C illustrate details of the jack-up barge according to the present invention, specifically removable fixing means and a clamping element for connecting two modules, i.e. for connecting a module to a lifting module;

Fig. 6 is a perspective view from above of a detail of the jack-up barge according to the present invention, specifically a lifting module;

Fig. 7 is a perspective view from above of the lifting module of Fig. 6, with some parts removed so that others are more clearly visible;

Fig. 8 is a plan view of a detail of the lifting module of Fig. 7, specifically a support frame and a guide structure attached thereto;

Fig. 9 is a cross-section of the detail of the lifting module of Fig. 8;

Figs. 10A and 10B illustrate, respectively, a detail of a longitudinal cross-section and a different cross-section of the guide structure of Fig. 8;

Figs. 11A and 11B are top views of a leg of the jack-up barge, with locking members for locking the adjusting means of the jack-up barge according to the present invention respectively in an interference position and in a non-interference position in relation to anchoring elements of said leg;

Fig. 12 is a detail of the locking members for locking the adjusting means of the jack-up barge according to the present invention, specifically an arched body;

Fig. 13 is a cross-section of a detail of the adjustment means of the jack-up barge according to the present invention, specifically a mobile ring;

Figs. 14a - 14f are schematic illustrations of a sequence of operations to raise or lower the legs of the platform of the jack-up barge according to the present invention, by means of adjustment means.

Detailed description of a preferred embodiment of the invention

[0029] With reference to the accompanying drawings, a jack-up barge according to the present invention is designated as a whole by reference number 1.

[0030] The jack-up barge 1 can be of any suitable size and for use in any field of application without departing from the scope of the present invention.

[0031] The jack-up barge 1 comprises a floating platform 2 and a plurality of support legs 3 mounted orthogonally on the floating platform 2.

[0032] Advantageously, there are at least three and, preferably, four support legs 3, in order to guarantee the necessary stability of the barge 1 even in the case, for instance, of an uneven seafloor or local seafloor subsidence or in case one of the legs 3 breaks.

[0033] The legs 3 are provided with feet 35 at the bottom, which rest on the seafloor and increase the stability of the barge 1. Each foot 35 is joined to the bottom end of the relative leg 3 by means of a first flange 36 and, advantageously, a spherical hinge 37 is inserted between the first flange 36 and the foot 35, which enables the foot 35 to tilt and adjust to the surface of the seafloor in the exact point on which it stands.

[0034] The legs 3 can be obtained by joining several consecutive posts 38 in an aligned fashion, using one or more second flanges 39, until reaching the desired length.

[0035] According to the accompanying figures, the

floating platform 2 consists of a plurality of modules 4, that can be joined mechanically by means of removable fixing means 5.

[0036] According to a non-limiting example of an embodiment of the jack-up bridge 1, illustrated in particular in figure 4, each of the modules 4 has a three-dimensional frame, preferably in the shape of a parallelepiped and generally consisting of steel separators and girders, with a plurality of protective metal walls, not illustrated in figure 4, which are also generally made of steel and are carefully welded together in order to guarantee the watertightness of the modules 4 and guarantee their floatability.

[0037] The term "modules" thus refers to watertight bodies that can be joined together mechanically and are arranged side by side to form the floating platform 2.

[0038] The removable fixing means 5, suitable to join the modules 4 laterally to one another, can advantageously be of the male-female type. In particular, according to the embodiment illustrated in the accompanying figures, the removable fixing means 5 comprise one or more pins 6, fixed to the three-dimensional frame of a module 4 and projecting from at least one side wall of the latter. Said pins 6 are intended to be inserted into the same number of matching holes 7 obtained in the three-dimensional frame of a different module 4 and opening out in at least one side wall of the latter to be placed alongside the side wall provided with pins 6 of the other module 4. Advantageously, the pins 6 and the matching holes 7 are arranged in one or more parallel vertical rows.

[0039] Once inserted, to prevent the pins 6 of each row from coming out of the matching holes, a clamping element 8 is provided, suitable to lock the pins 6 in the matching holes 7. According to the embodiment illustrated in figures 5A, 5B and 5C, the clamping element 8 is a guillotine-type element that extends inside each module 4, in correspondence with a row of matching holes 7, along the entire height of the module 4 and projects from the top of the latter with a gripping portion 9, which enables it to be operated from the outside. More in detail, the clamping element 8 comprises a plurality of plates 10 decreasing in thickness towards the bottom, which are joined by means of one or more bars 11. The plates 10 are provided with shaped holes 12, obtained in correspondence with the matching holes 7. Said shaped holes 12 have a wide lower portion 13 and a narrow upper portion 14. When joining two modules 4, each pin 6 is inserted into the corresponding matching hole 7, conveniently passing through the wide lower portion 13 of the shaped hole 12, as illustrated in figure 5C. The clamping element 8 is then pushed down and the pin 6 enters the narrow portion 14 of the shaped hole 12. Each plate 10 is thus wedged into a specific groove 15 obtained on each pin 6, thus locking the latter in the matching hole 7, as illustrated in figures 5A and 5B, so that the two modules 4 arranged side by side are clamped together.

[0040] Advantageously, the pins 6 project from two adjacent side walls of each module 4 and the matching holes 7 are obtained in the other two adjacent side walls.

[0041] According to the present invention, the modules 4 comprise three or more lifting modules 16 each of which is mechanically associated with a leg 3 and is provided with a support frame 17. Said support frame 17 has, centrally fixed, a guide structure 18, in which the leg 3 is inserted, and has fixed a plurality of buffer panels 19, which define together with said guide structure 18, a closed box-shaped body, which participates in the hydrostatic floating thrust of said floating platform 2.

[0042] The guide structure 18 is suitable to receive and guide the leg 3 during its movements.

[0043] The panels are fixed to the support frame 17 on the outside of the guide structure.

[0044] According to the embodiment illustrated in the accompanying figures, the guide structure 18 has a hollow cylindrical shape and is fixed to the support frame 17 by means of first radial sheet plates 20, which can, for example, be welded.

[0045] Advantageously, as illustrated in figures 10A and 10B, the guide structure 18 bears a plurality of first radially mounted and inwardly facing rollers 21, suitable to facilitate the sliding of the leg 3 therein. Said first rollers 21 may be mounted, for example, on forks 24 fixed by means of screws 22a and clamping nuts 22b to the guide structure 18 and, preferably, also pivotally attached to radial stiffening ribs 23 of the guide structure 18. Said radial stiffening ribs 23 extend from a lower annular reinforcement 61 and from an upper annular reinforcement 62 of the guide structure 18. The latter is also advantageously provided with horizontal stiffening ribs 25, which increase the resistance of said guide structure 18 to the mechanical stress to which it is exposed during the raising and lowering of the leg 3.

[0046] Each lifting module 16 is provided with adjustment means 26 for modifying the height of the legs 3 with respect to the floating platform 2.

[0047] Said adjustment means 26 comprise a plurality of anchoring elements 27 arranged along the length of the legs 3, at least one fixed ring 28, fixed concentrically to the guide structure 18 of the lifting module 16 and through which the leg 3 inserted in the guide structure 18 passes, at least one mobile ring 29, axially aligned with the fixed ring 28 and through which the leg 3 passes, and lifting actuator means 30, which support the mobile ring 29 with respect to the fixed ring 28 and can be operated to modify the distance between the two rings.

[0048] The fixed ring 28 supports a first locking member 31 which is actuated by at least a first actuator 32 to move between a first interference position, in which it intercepts at least one anchoring element 27 of the leg 3, preventing it from making axial movements in at least one direction, and a first non-interfering position, in which it is unconstrained by the anchoring elements 27 of the leg 3, freeing it with respect to axial movements within the guide structure 18.

[0049] The mobile ring 29 supports a second locking member 33 which can be actuated by at least a second actuator 34 to move between a second interference po-

sition (see figure 11A), in which it intercepts at least one anchoring element 27 of the leg 3, preventing it from making axial movements in a least one direction, and a second non-interference position (see figure 11B), in which it is unconstrained by the anchoring elements 27 of the leg 3, freeing it with respect to axial movements within the guide structure 18.

[0050] According to a preferred embodiment of the invention, illustrated in the accompanying figures, the anchoring elements 27 consist of projecting plates attached to each leg 3. Advantageously said plates are aligned, in at least one row, along the longitudinal length of each leg 3, and arranged at equal distances apart. Said plates are preferably made of metal and are welded to each leg 3.

[0051] The first and the second locking member, 31 and 33, as illustrated in figure 12, each comprise at least one arched body 40, which extends at least partially around the leg 3 and is provided with a least one lock element 41 projecting towards the leg 3 and suitable to interfere with the anchoring elements 27 of the leg 3 when the first and/or the second locking members are respectively in the first and/or second interference position.

[0052] Advantageously, the first and the second locking member, 31 and 33, each comprise two arched bodies 40, arranged in diametrically opposite positions with respect to the leg 3 and each of which is provided with two lock elements 41.

[0053] The lock elements 41 are fixed, preferably welded, to each arched body 40 and advantageously have a flat upper surface 42 and lower surface 43, suitable to rest respectively on the lower interference surface 45 and on the upper interference surface 44 of the anchoring elements 27 of the legs 3, when the first and/or the second locking member are respectively in the first and/or in the second interference position.

[0054] The first and the second actuator, 32 and 34, actuate the first and the second locking member, 31 and 33, respectively, to rotate with the arched body 40 around the leg 3, between the respective interference positions and non-interference positions.

[0055] As illustrated in figures 11A and 11B, when the arched bodies 40 rotate by an appropriate angle the lock elements 41 attached to these either interfere or not with the anchoring elements 27 of the leg 3.

[0056] According to a preferred embodiment illustrated in the accompanying figures, the first and the second actuator, 32 and 34, respectively comprise one or more first hydraulic cylinders 47, suitable to activate the first locking member 31, and one or more second hydraulic cylinders 49, suitable to activate the second locking member 33.

[0057] More in detail, the first cylinders 47 are fixed externally to the fixed ring 28 and, advantageously, are pivotally attached to two second plates 50 welded to the fixed ring 28, as illustrated in figures 6 and 7. The first cylinders 47 are provided with first movable pistons 46 connected at the head to the arched bodies 40 of the first

locking member 31 and, in particular, are pivotally attached to first eyebolts 51 welded to the external surface of the arched bodies 40. The first eyebolts 51 project from the fixed ring 28 through first slots 52 specifically obtained therein.

[0058] In order to operate the first locking member 31, the first cylinders 47 act with their first pistons 46 on the arched bodies 40 which thus rotate by an appropriate angle, bringing the lock elements 41 to interfere or not with the anchoring elements 27 of the leg 3.

[0059] Likewise, the second cylinders 49 are fixed externally to the mobile ring 29 and are, advantageously, pivotally attached to two third plates 53 welded to the mobile ring 29, as illustrated in figures 6 and 7. The second cylinders 49 are provided with second movable pistons 48, connected at the head to the arched bodies 40 of the second locking member 33 and, in particular, are pivotally attached to second eyebolts 54 welded to the external surfaces of the arched bodies 40. The second eyebolts 54 project from the mobile ring 29 through second slots 55 specifically obtained therein.

[0060] In order to operate the second locking member 33, the second cylinders 49 act with their second pistons 48 on the arched bodies 40, which thus rotate by an appropriate angle, bringing the lock elements 41 to interfere or not with the anchoring elements 27 of the leg 3.

[0061] In order to facilitate and increase the smoothness of the rotation of the first and of the second locking member, 31 and 33, with respect to the fixed ring 28 and with respect to the mobile ring 29, respectively, the external surfaces of the arched bodies 40 of the first and of the second locking member 31 and 33, are advantageously provided with a plurality of anti-friction elements 56.

[0062] The lifting actuator means 30, which support the mobile ring 29 with respect to the fixed ring 28, comprise one or more third hydraulic cylinders 57, mechanically connected to the fixed ring 28 and provided with third pistons 58 connected to the mobile ring. Advantageously, in order to facilitate the operation of the mobile ring 29 and of the fixed ring 28 and make such operation safer, there are two third cylinders 57 which are arranged diametrically opposite the two rings.

[0063] According to the embodiment illustrated in the accompanying figures, the third cylinders 57 are pivotally attached to third eyebolts 59 welded to the external surface of the fixed ring 28, while the heads of their third pistons 58 are connected to the mobile ring 29, and, more in detail, pivotally attached to fourth eyebolts 60 welded to the external surface of the mobile ring 29.

[0064] Advantageously the fixed ring 28 and the mobile ring 29 bear one or more second radially mounted and inwardly facing rollers 63, suitable to facilitate the sliding of the leg 3 therein. Moreover, one or more anti-rotation elements 64 are attached to the top of the fixed ring 28 and of the mobile ring 29, suitable to be aligned with the rows of anchoring elements 27 fixed to the leg 3. When the leg 3 slides through the fixed ring 28, or through the

mobile ring 29, the anchoring elements 27 are made to slide through the anti-rotation elements 64, which guide them in their vertical motion, preventing the leg 3 from rotating about its longitudinal axis.

[0065] Having described the structural features of the jack-up barge 1 according to the present invention, its functional operation will now be explained.

[0066] In order to lower the legs 3 with respect to the floating platform 2, i.e. to move the jack-up barge 1 from the floating condition to the stable condition, the adjustment means 29 act according to a sequence of operations which are described below and schematically illustrated in figure 14.

[0067] In particular, the sequence of operations starts from the condition illustrated in figure 14a, in which the first locking member 31 is in the first interference position, with the lock elements 41, attached thereto, intercepting the anchoring elements 27 of the leg 3, preventing the latter from sliding axially within the fixed ring 28. In particular, in this condition, the lower interference surface 45 of an anchoring element 27 of the leg 3 comes to rest against the upper surface 42 of each lock element 41, to support said leg 3.

[0068] The second locking member 33 is then moved into the second non-interference position with the lock elements 41, attached thereto, which do not intercept the anchoring elements 27 of the leg 3, allowing the latter to slide axially within the mobile ring 29. In this condition, in particular, the lock elements 41 are interposed between two adjacent rows of anchoring elements 27, thus releasing the second locking member 33 from the anchoring elements 27 of the leg 3 and allowing the mobile ring 29 to slide axially along the leg 3.

[0069] Next (see figure 14b) the actuator lifting means 30 push the mobile ring 29 away from the fixed ring 28, so that it slides axially with respect to the leg 3.

[0070] More in detail, the third cylinder 57, mounted on the fixed ring 28, pushes out the relative third piston 58 connected to the mobile ring 29, thus raising the mobile ring 29 and moving it away from the fixed ring 28.

[0071] When the mobile ring 29 has reached the desired height, the second locking member 33 is brought to the second interference position (see figure 14c), with the lock elements 41 attached thereto that intercept the anchoring elements 27 of the leg 3, preventing the latter from sliding axially within the mobile ring 29. Next, the first locking member 31 is brought to the first non-interference position (see figure 14d) with the lock elements 41 that do not intercept the anchoring elements 27 of the leg 3, thus allowing the latter to slide axially within the fixed ring 28.

[0072] Lastly, the actuator lifting means 30 bring the mobile ring 29 towards the fixed ring 28 (see figure 14e), making the leg 3 slide axially with respect to the fixed ring 28 and then lowering it with respect to the floating platform 2.

[0073] These operations are repeated in the sequence described above until the feet 35 of the legs 3 are resting

on the sea bottom. In general, the platform 2 is then raised further with respect to the legs 3 so that it is raised above the surface of the water. The operations described above can be performed to raise the platform 2. However, in this case, as opposed to when lowering the legs 3, when the first and the second locking member, 31 and 33, are moved respectively to the first and second interference position, the lower surface 43 of each of the respective lock elements 41 rests on the upper interference surface 44 of an anchoring element 27 of the leg 3.

[0074] When the leg 3 has reached the desired height with respect to the platform 2, the first locking member 31 is preferably brought to the first interference position to prevent the leg 3 from weighing on the third pistons 58.

[0075] Likewise, *mutatis mutandis*, the adjustment means 26 can be used to move the jack-up barge 1 from the stable condition to the floating condition, i.e. to lower the platform 2 until it floats on the water and, then to raise the legs 3 with respect to the platform 2.

[0076] In this case the first step in the sequence of operations envisages passing from the condition in figure 14a with the first locking member 31 in the first interference position and with the second locking member 33 in the second non-interference position to the condition in figure 14e with the first locking member 31 in the first non-interference position and with the second locking member 33 in the second interference position, via the intermediate condition in figure 14f, in which both of the locking members 31 and 33 are in the respective interference position. At this point, when the lifting means 30 are actuated the platform 2 is lowered, passing from the condition in figure 14e to that in figure 14d. After bringing the first locking members 31 into the first interference position (see figure 14c) and then the second locking members 33 into the second non-interference position (see figure 14b) the third pistons 58 of the third cylinders 57 can be recuperated (see figure 14a) before starting the cycle to lower the platform 2 or raise the leg 3.

[0077] In particular, while the platform 2 is afloat, the lower surface 43 of each lock element 41 rests on the upper interference surface 44 of an anchoring element 27 of the leg 3 supporting the platform 2. Next, when the legs 3 are raised with respect to the floating platform 2, the lower interference surface 45 of an anchoring element 27 of the leg 3 comes to rest on the upper surface 42 of each lock element 41, supporting the leg 3.

[0078] The sequence of operations described above is then repeated until the legs 3 have been raised sufficiently and the jack-up barge 1 can, for instance, be transported over water.

[0079] To avoid the possibility of human error, all the sequences of operations to raise or lower the legs 3 with respect to the platform 2 are controlled by means of a dedicated software program.

[0080] Advantageously, according to a preferred embodiment of the present invention, the jack-up barge 1 comprises a control unit 11, preferably mounted above the floating platform 2, which, via distribution valves, sup-

plies the cylinders 47, 49 and 57, described previously, with the necessary hydraulic power, i.e. with the oil at an adequate pressure and flow rate.

[0081] A control panel 101, preferably mounted on a structure in common with the control unit 100 mounted above the deck of the floating platform 2, sends the command signals to said control unit 100 to operate the cylinders 47, 49 and 57, according to set operating sequences, as previously described in particular with reference to the raising or lowering of the floating platform 2, or according to set safety conditions.

[0082] The control panel 101 is housed in a watertight casing and is provided with a first logic controller or PLC, which is provided with digital and/or analog input connections to receive diagnostic signals from relative digital or analog sensors described more in detail below, and output connections to send the command signals to the central control unit 100 to operate the valves that control the cylinders 47, 49 and 57 in order to raise or lower the platform 2, and to define set safety conditions.

[0083] The first PLC monitors the state of all the actuators 30, 32 and 34, i.e. of the first, second and third cylinders 47, 49 and 57 (those that operate the locking members 31, 33 of the rings 28, 29 and those for raising the mobile ring 29 with respect to the fixed ring 28) and verifies, via the sensors, whether, for example, the cylinders are open or closed and/or their extension.

[0084] For that purpose first sensors 102 are provided, in particular of the linear type and preferably magnetostrictive sensors, each mounted in the liner of a hydraulic cylinder, to send an analog output signal to indicate the position of the piston in the cylinder liner.

[0085] The first linear sensors 102 may consist of simple proximity sensors, for example capacitive sensors, to signal to the first control unit whether the cylinders are open or closed. However, advantageously the first sensors 102 (schematically illustrated in figure 13) are also suitable to inform the first logic controller of the position of the cylinder piston and thus of the possible residual extension thereof so that the floating platform 2 can be raised and lowered more quickly, by controlling the two locking members 31, 33 so as to engage anchoring elements 27 at a distance from one another and not contiguous and thus controlling the third cylinders 57 to raise or lower the mobile ring 29 with respect to the fixed ring 28 of a corresponding stroke.

[0086] Sensing means 103 (schematically illustrated in figure 9) are also provided to monitor the anchoring elements 27 arranged along the length of the legs 3, in order to detect the position of said anchoring elements 27 with respect to the locking members 31, 33 of the fixed ring 28 and of the mobile ring 29, so as to control the activation of the relative first and second cylinders 47, 49.

[0087] Advantageously, said sensing means 103 comprise a number of second sensors 104, in particular four inductive sensors, mounted on the support frame 17, and preferably on the guide structure 18 aligned along the vertical axis thereof. Said guide structure 18 is specifi-

cally threaded and provided with specific holes to house the body of said second sensors 104 so as to be radially arranged towards the legs 3.

[0088] Said second sensors 104 are suitable to emit a status signal to indicate the presence or absence of the anchoring element 27 (corresponding to the increase or reduction in inductance in the case of inductive sensors).

[0089] From the signals sent by the second sensors 104 (which are, of course, provided for each leg 3), the first controller recognises whether the locking members 31, 33 are facing an anchoring element 27 or, even, only partially facing an anchoring element 27 (for example if they are half-way above or below the anchoring element 27).

[0090] The second sensors 104 are preferably arranged longitudinally (vertically) in succession so as to substantially cover the distance between two anchoring elements 27.

[0091] Different sensing means 103 capable of continuously indicating the exact position of the anchoring elements 27 may, of course, be provided.

[0092] There are also provided two third inclination sensors or clinometers 105 mounted inside the panel 101 and suitable to control the levelness of the floating platform 2. More in detail, the panel 101 is arranged on a base, which is level with respect to the deck of the floating platform 2 and set in place using adjustment screws to gauge its initial levelness. When a third inclination sensor 105 detects an inclination of the platform 102 exceeding a previously defined limit (for example preferably approx. 5 degrees) it sends a signal to the first logic controller so that the substantial levelness of the platform 2 is maintained during the operations performed to lower or raise the platform 2.

[0093] The raising and lowering operations controlled by the controller via the control unit which controls the various cylinders are subject to the preliminary hierarchical control of the levelness of the floating platform 2.

[0094] Thus for example, the locking members 31, 33 are actuated after appropriately raising or lowering the relative leg 3 by means of the third cylinders 57 that lift the mobile ring 29 with respect to the fixed ring 28, compatibly with the levelness conditions defined by said third inclination sensors 105.

[0095] Thanks to the logic controller connected to the control unit 100 and to the sensors described above, the barge 1 according to the present invention is made to stand on its support legs 3 resting on the seafloor or is lowered to the floating position by sending a simple start command.

[0096] The first logic controller is also capable of managing the operations to raise and lower the floating platform 2 automatically even in the case of an uneven seafloor, or more generally of a seafloor that is not horizontal or with variable ground stress.

[0097] A second logic controller is also provided (in particular with relay controls) to ensure the safety of all the drives of the barge 1 and which hierarchically prevails

over the commands of the first PLC. For example, said second controller prevents certain combinations of cylinder conditions from occurring (for example the simultaneous opening of the two locking members 31, 33).

[0098] Said second controller is operated by the same sensors that send information to the first logic controller.

[0099] Advantageously, pressure transducer sensors are also provided, arranged inside the liners of the cylinders 47, 49 and 57 to detect whether the individual cylinders are loaded and, for example with reference to the third cylinders 57, whether they are bearing the weight of the platform 2 or whether they have been unloaded and, for example, the weight of the platform is borne by the legs 3. In the event of faults or maintenance operations on the cylinders 47, 49 and 57, it is necessary to know whether the weight is borne by the cylinders 47, 49 and 57 or by the legs 3.

[0100] The invention thus conceived achieves all of the relative objectives.

[0101] It is clear that the invention described and illustrated herein may take other structural forms and configurations without departing from the scope of the present invention. Moreover all the elements can be conveniently replaced by other technically equivalent elements and can be of any suitable shape or dimensions and made of any suitable materials as required.

Claims

1. Jack-up barge (1), comprising:

- a floating platform (2) formed by a plurality of modules (4) that can be joined together mechanically by means of removable fixing means (5);
- a plurality of support legs (3) mounted orthogonally on said floating platform (2);

characterised in that said modules (4) comprise three or more lifting modules (16), each of which is mechanically associated with a leg (3), is provided with a support frame (17) having centrally fixed a guide structure (18), in which said leg (3) is inserted, said support frame (17) having also fixed a plurality of buffer panels (19), which define together with said guide structure (18) a closed box-shaped body, which participates in the hydrostatic floating thrust of said floating platform (2).

2. Jack-up barge (1) according to claim 1, **characterised in that** each lifting module (16) is provided with adjustment means (26) for modifying the height of said legs (3) with respect to said floating platform (2), which comprise:

- a plurality of anchoring elements (27) arranged along the length of said legs (3);
- at least one fixed ring (28), fixed concentrically

to the guide structure (18) of said lifting module (16) and through which said leg (3) passes and which supports a first locking member (31) able to be actuated by at least one first actuator (32) to move between a first interference position, in which it intercepts at least one anchoring element (27) of said leg (3) preventing it from making axial movements in a least one direction, and a first non-interference position, in which it is unconstrained by the anchoring elements (27) of said leg (3), freeing it with respect to axial movements within said guide structure (18);

- at least one mobile ring (29), axially aligned with said fixed ring (28) and through which said leg (3) passes and which supports a second locking member (33) able to be actuated by at least one second actuator (34) to move between a second interference position, in which it intercepts at least one anchoring element (27) of said leg (3) preventing it from making axial movements in a least one direction, and a second non-interfering position, in which it is unconstrained by the anchoring elements (27) of said leg (3), freeing it with respect to axial movements within said guide structure (18);
- lifting actuator means (30), which support said mobile ring (29) with respect to said fixed ring (28) and are able to be actuated to modify the distance between said two rings.

3. Jack-up barge (1) according to claim 2, **characterised in that** said first locking member (31) and said second locking member (33) each comprise at least one arched body (40) extending at least partially around said leg (3), equipped with a least one lock element (41) projecting towards said leg (3) and able to interfere with the anchoring elements (27) of said leg (3) when said first and/or second locking members (31 and/or 33) are respectively in said first and/or second interference position.

4. Jack-up barge (1) according to any one of the previous claims, **characterised in that** said anchoring elements (27) consist of fixed projecting plates aligned according to at least one row along the longitudinal length of each of said legs (3).

5. Jack-up barge (1) according to claim 4, **characterised in that** said at least one first and at least one second actuator (32 and 34) respectively actuate said first and second locking member (31 and 33) to rotate with said arched body (40) around said leg (3) between said interference position and said non-interference position.

6. Jack-up barge (1) according to claim 2, **characterised in that** the lifting actuator means (30) of said adjustment means (26) comprise at least a third hy-

hydraulic cylinder (57) mechanically connected to the fixed ring (28) and having a third piston (58) mechanically connected to the mobile ring (29).

7. Jack-up barge (1) according to any one of the previous claims, **characterised in that** it comprises a control unit (100) mounted on said floating platform (2) to supply the hydraulic power to said actuators (30, 32, 34) and a first logic controller, which is provided with input connections to receive diagnostic signals from corresponding sensors, and output connections to send command signals to said control unit (100) to automatically operate said actuators (30, 32, 34) according to a logic of said sensors suitable to control sequences of operations to raise or lower said platform (2). 5
8. Jack-up barge (1) according to claim 7, **characterised in that** said first logic controller monitors, via said sensors, the position of said actuators (30, 32, 34) advantageously obtained with hydraulic cylinders. 10
9. Jack-up barge (1) according to claim 7, **characterised in that** said sensors comprise first sensors (102), in particular of the linear type and preferably magnetostrictive sensors, each mounted in the liner of a hydraulic cylinder, to send an analog output signal to indicate the position of the piston in the cylinder liner. 15
10. Jack-up barge (1) according to claim 7, **characterised in that** said sensors comprise sensing means (103) of said anchoring elements (27) to identify the relative position of said anchoring elements (27) with respect to said locking members (31, 33) of said fixed ring (28) and of said mobile ring (29). 20
11. Jack-up barge (1) according to claim 10, **characterised in that** said sensing means (103) comprise a number of second sensors (104), in particular four inductive sensors, which are mounted on the support frame (17) aligned along the vertical axis thereof, said second sensors being suitable to emit a status signal in relation to the presence or absence of the anchoring element (27). 25
12. Jack-up barge (1) according to claim 11, **characterised in that** said second sensors (104) are arranged in succession substantially covering the distance between two anchoring elements (27). 30
13. Jack-up barge (1) according to claim 7, **characterised in that** said sensors comprise at least two third inclination sensors (105) to control the levelness of said floating platform (2). 35
14. Jack-up barge (1) according to claim 13, **character-** 40

ised in that the logic of said first controller for automatically controlling the operations to raise and lower said floating platform (2) via said control unit is subject to the preliminary hierarchical control of the levelness of the platform detected by means of said third sensors.

15. Jack-up barge (1) according to claim 8, **characterised in that** said sensors comprise pressure transducers, arranged inside the liners of the cylinders (47, 49 and 57). 45

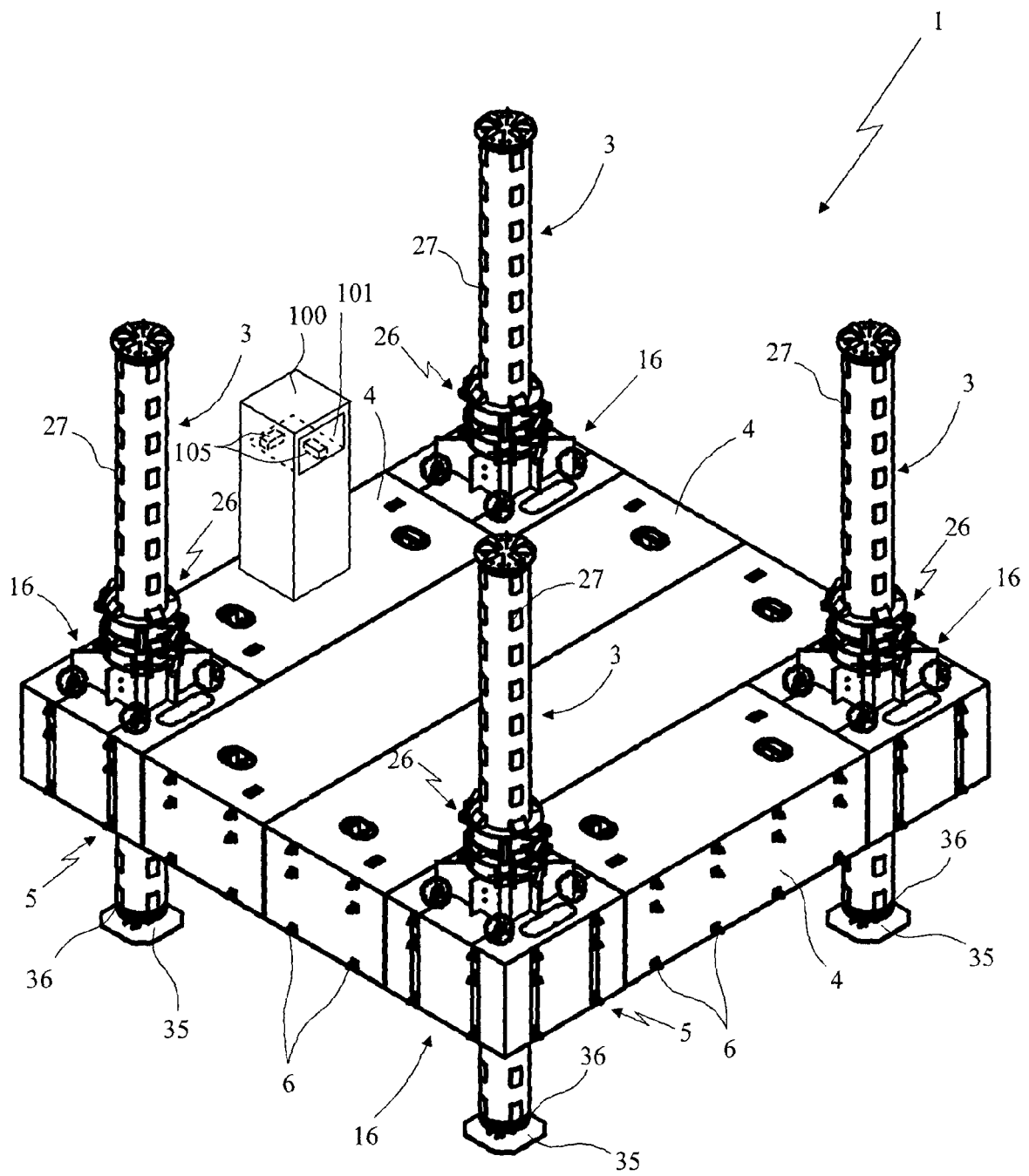


Fig. 1

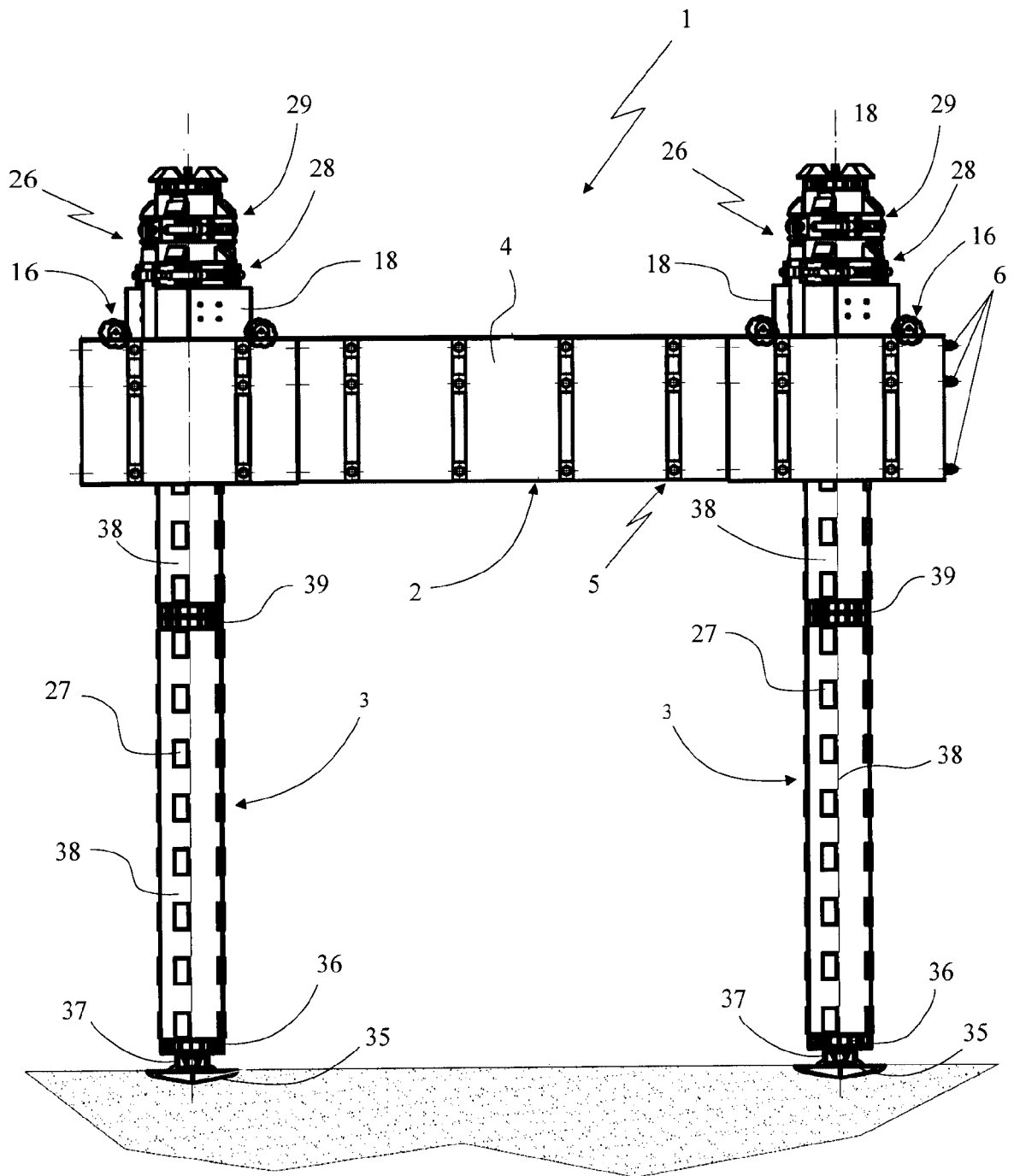


Fig. 2

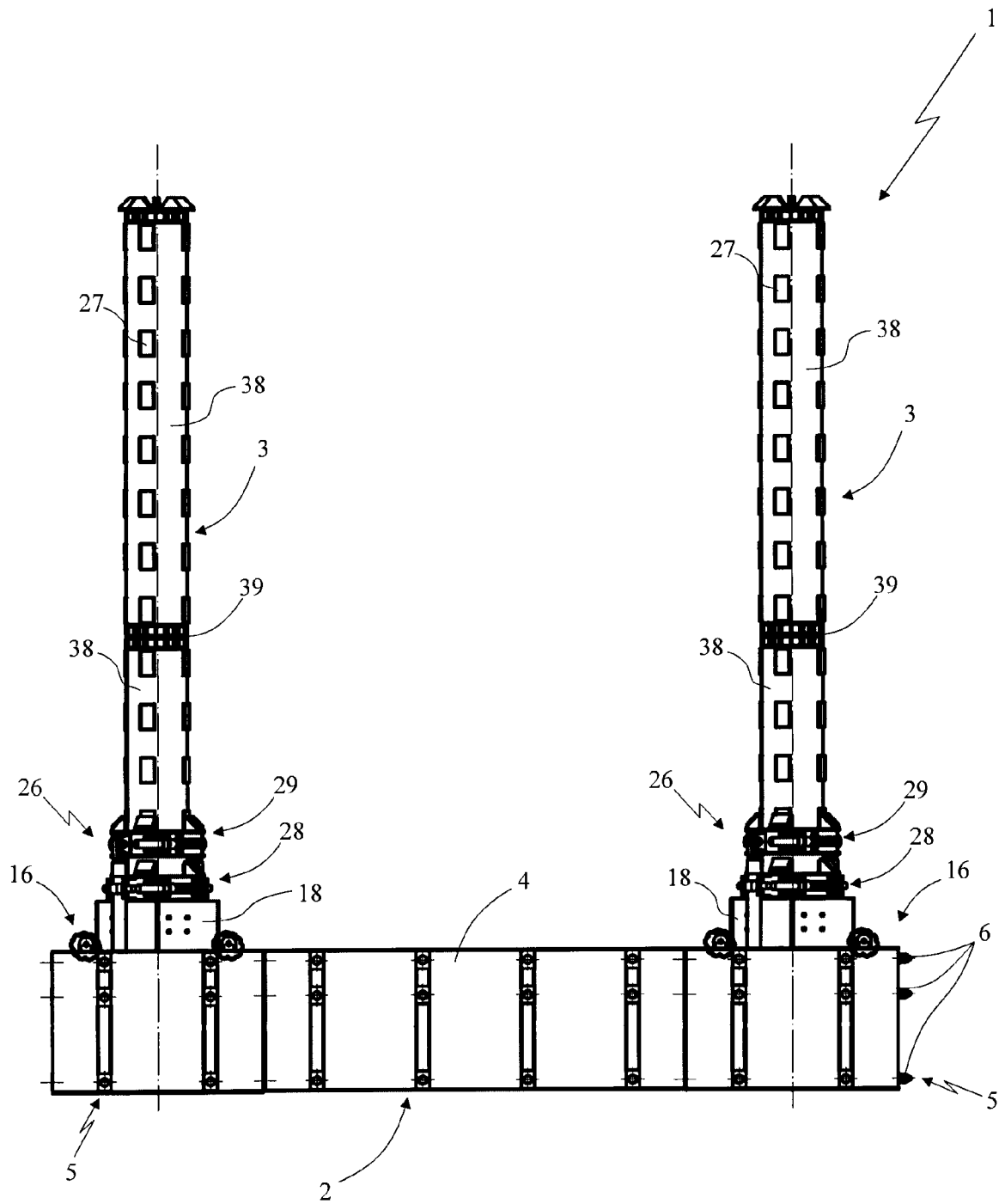
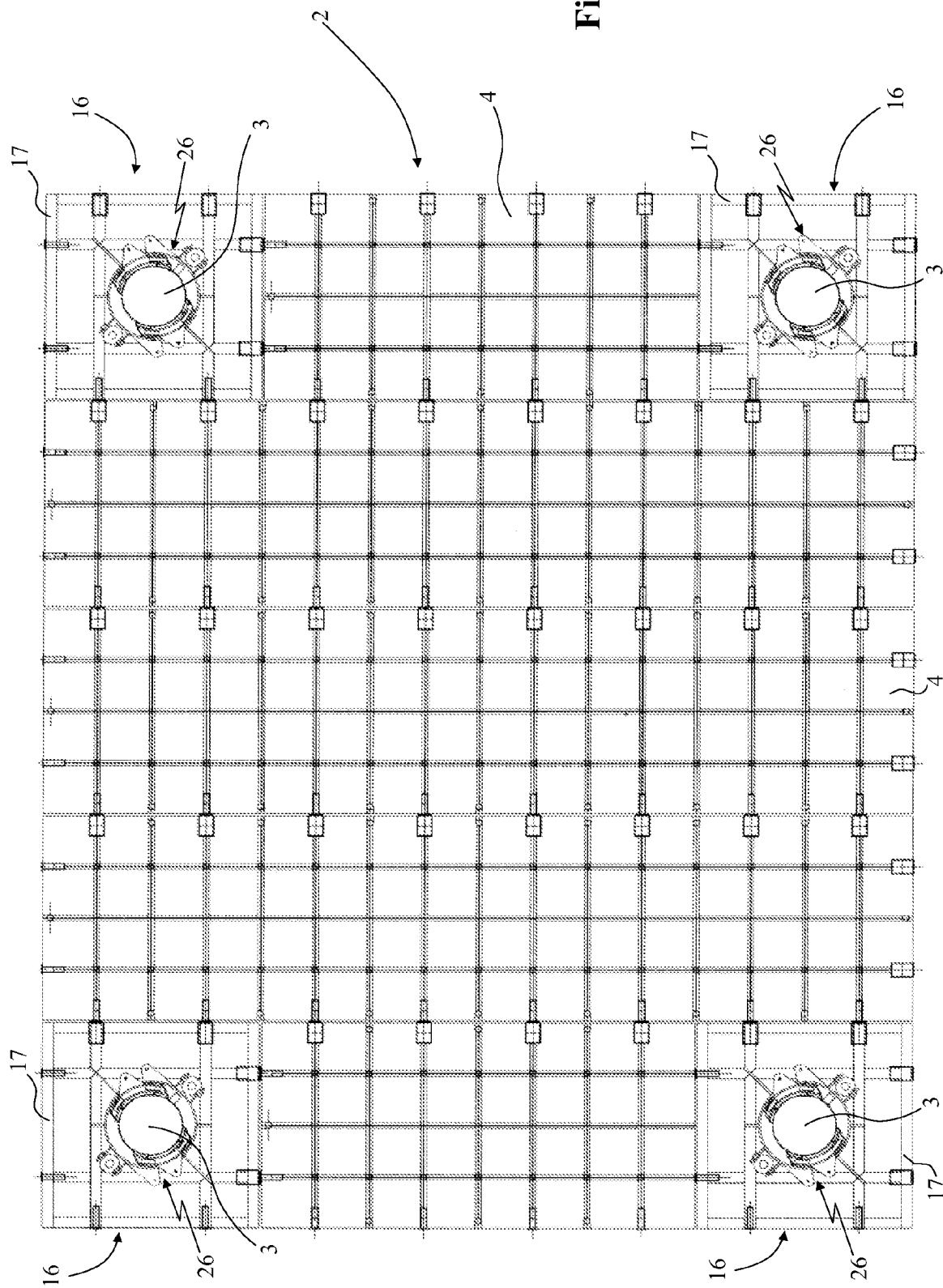


Fig. 3

Fig. 4



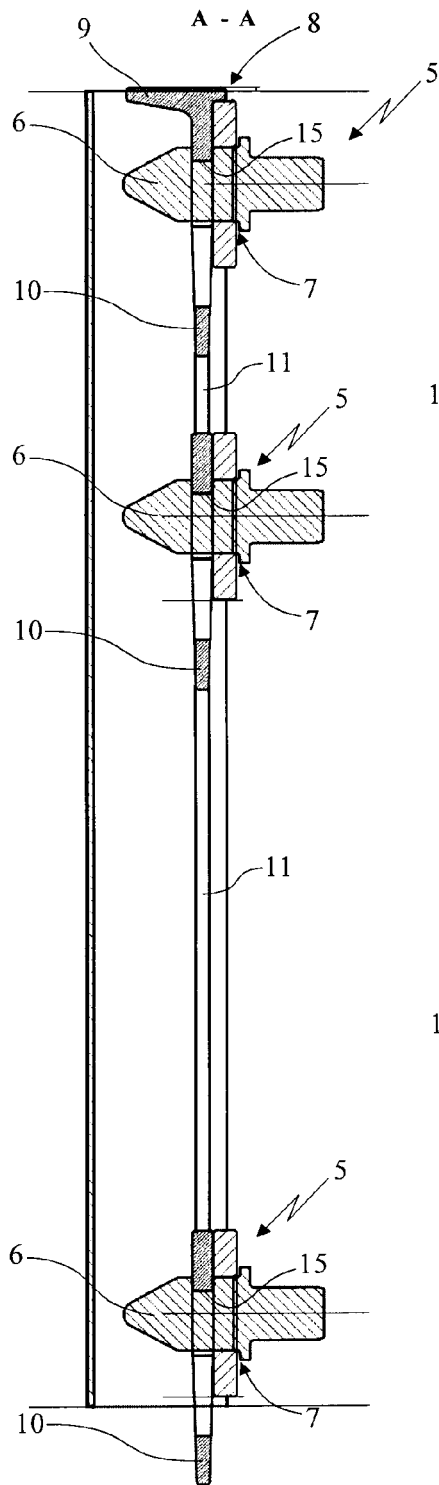


Fig. 5A

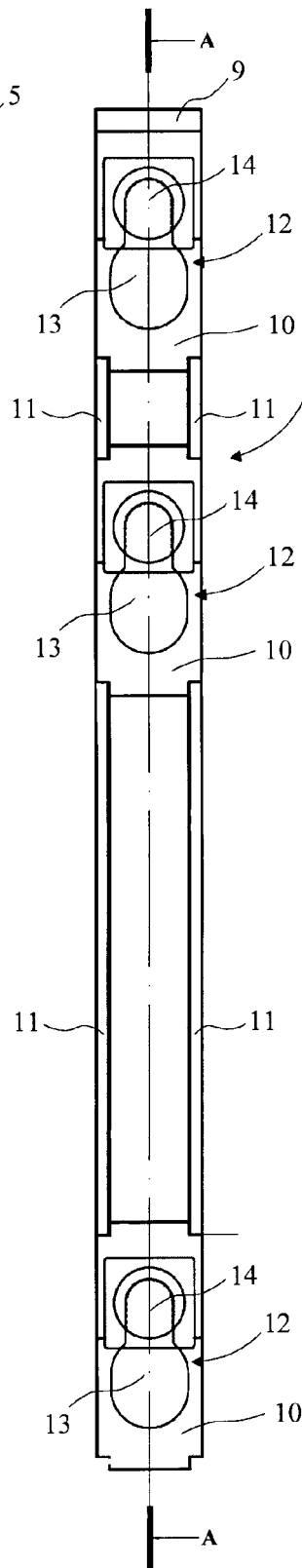


Fig. 5B

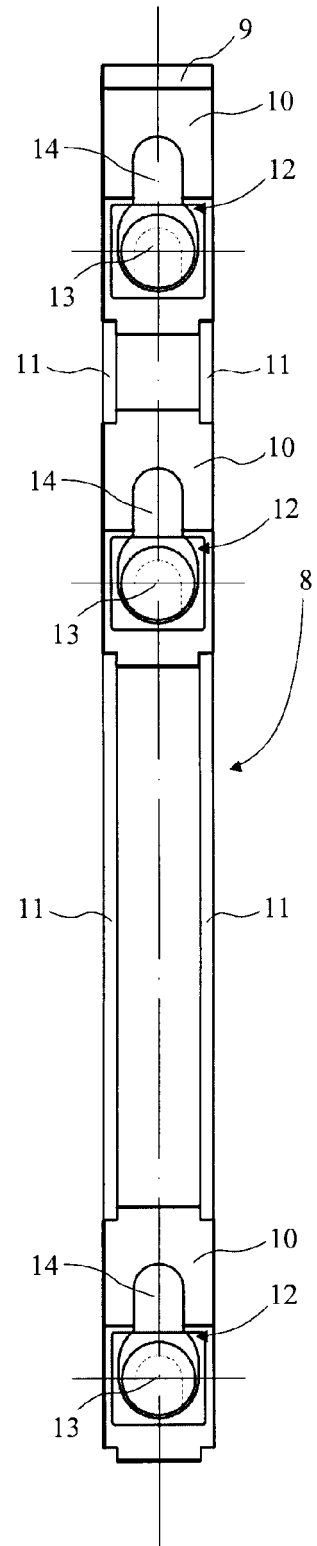


Fig. 5C

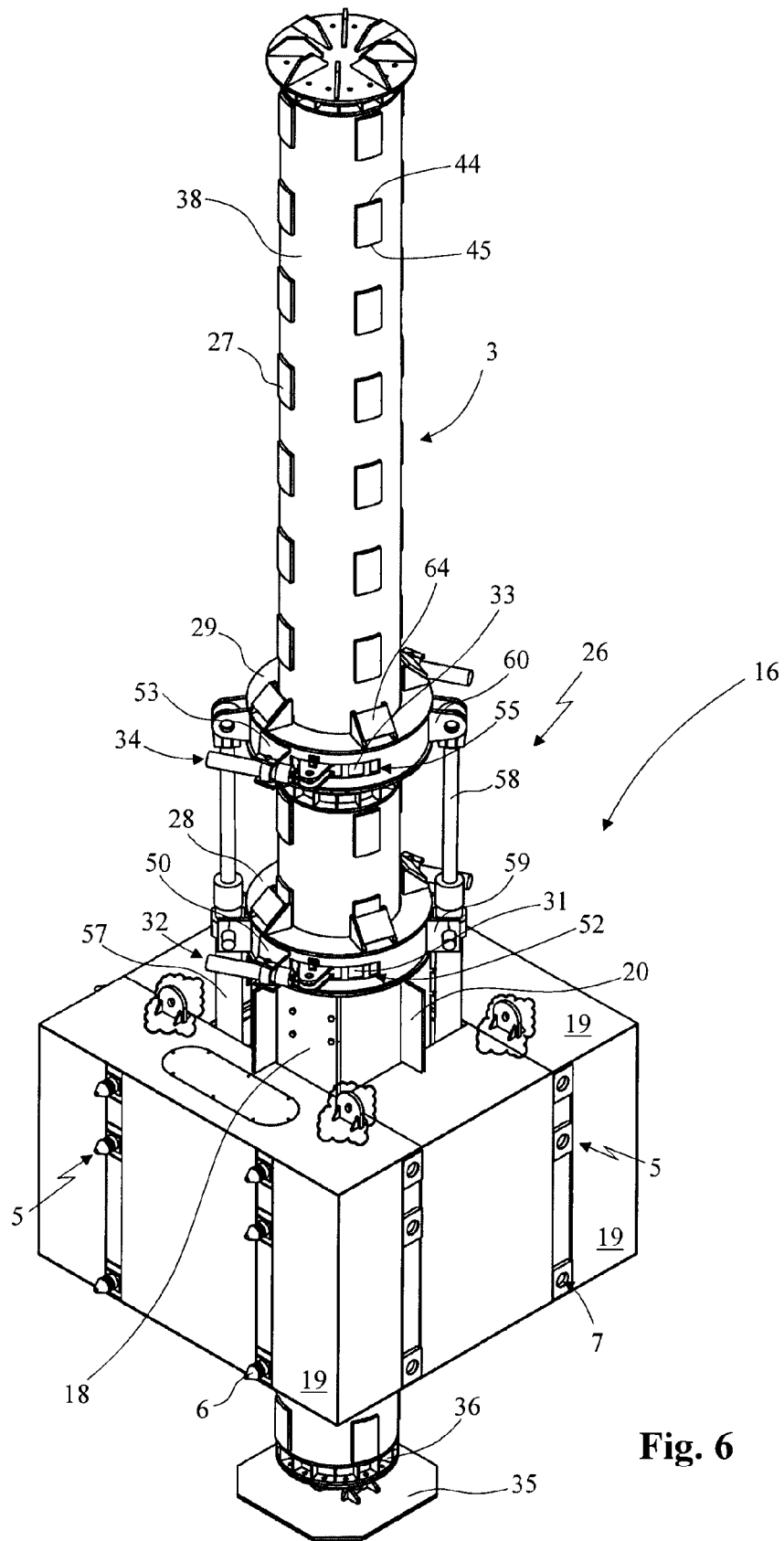


Fig. 6

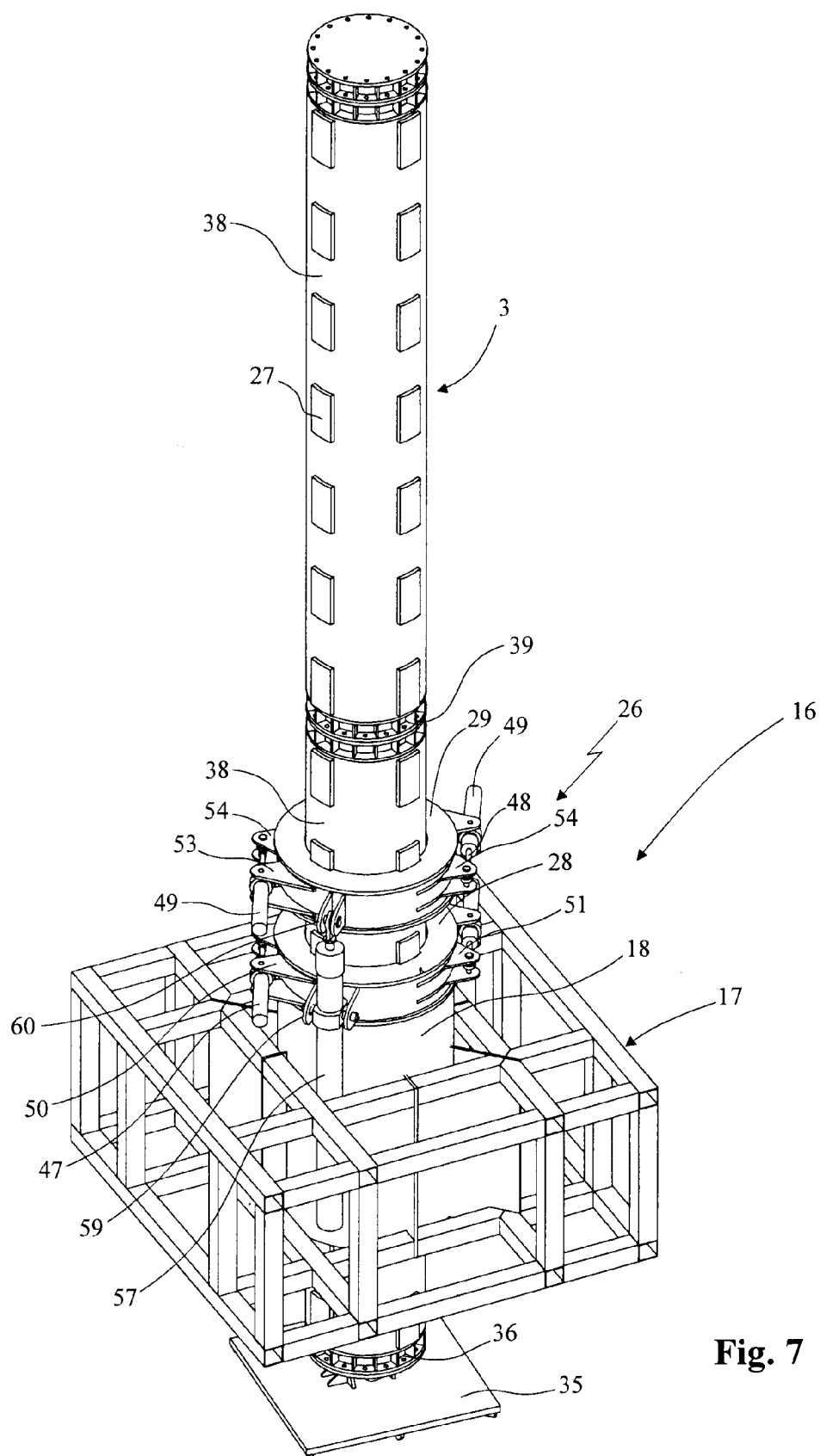


Fig. 7

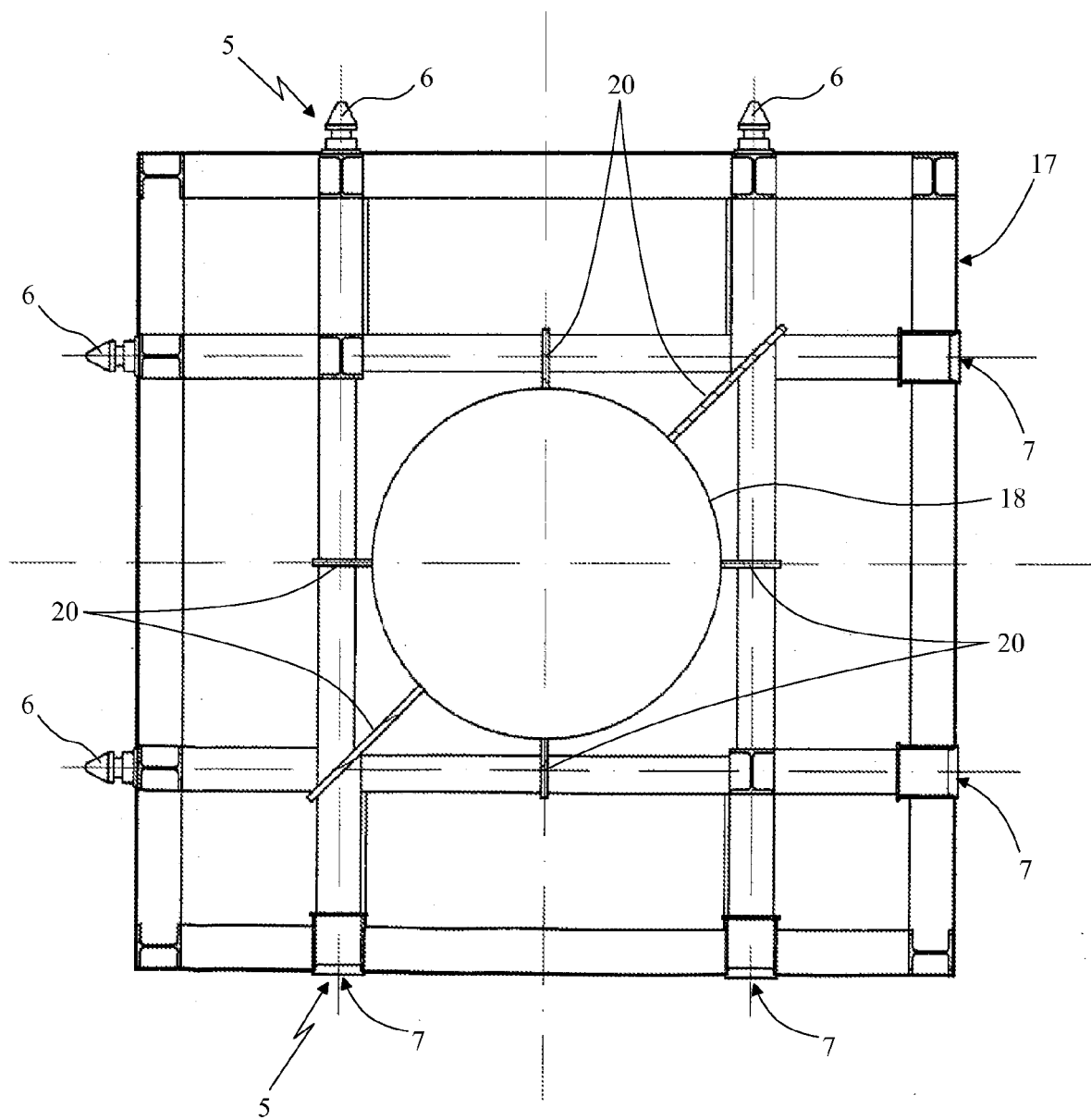
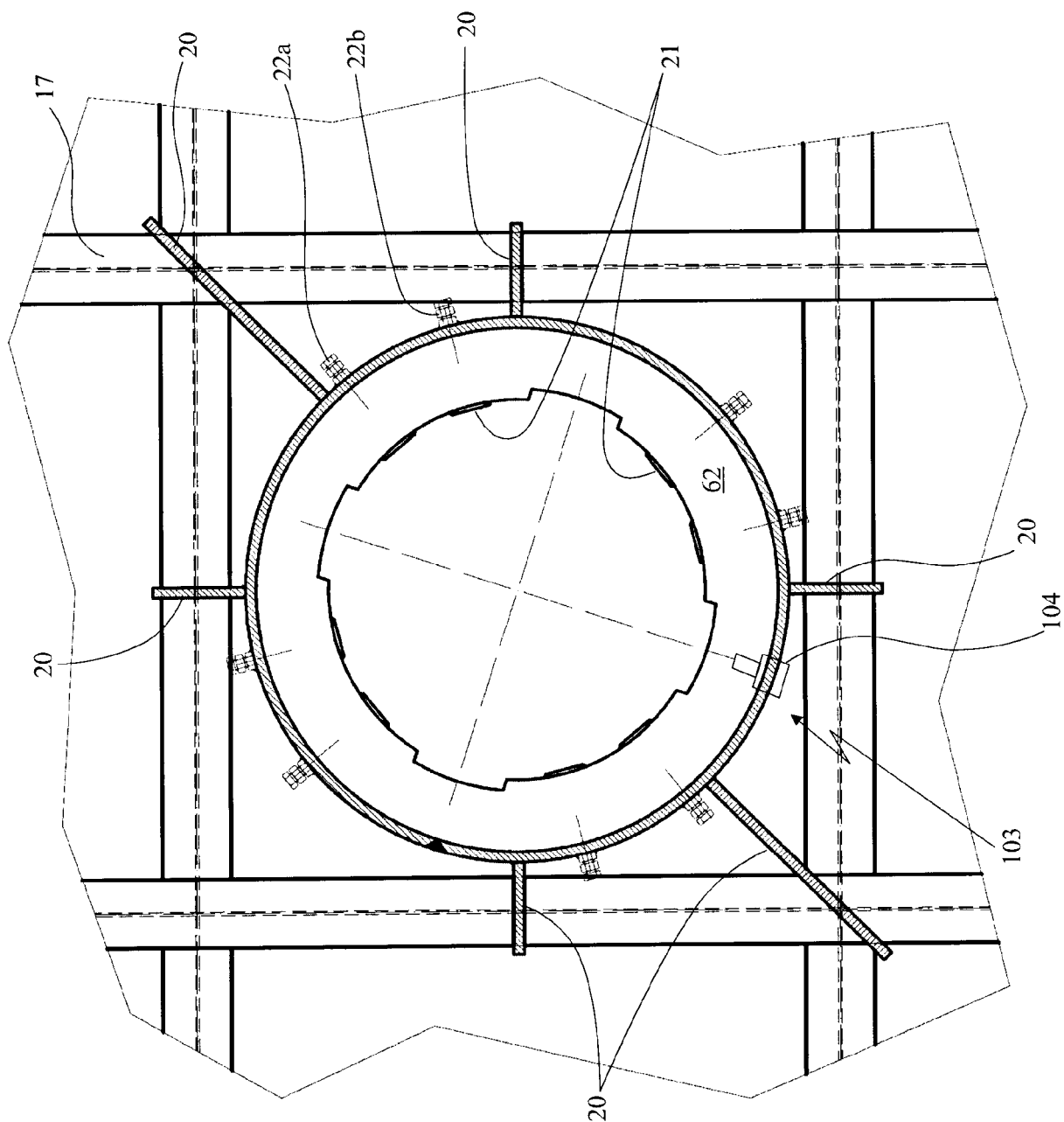


Fig. 8

Fig. 9



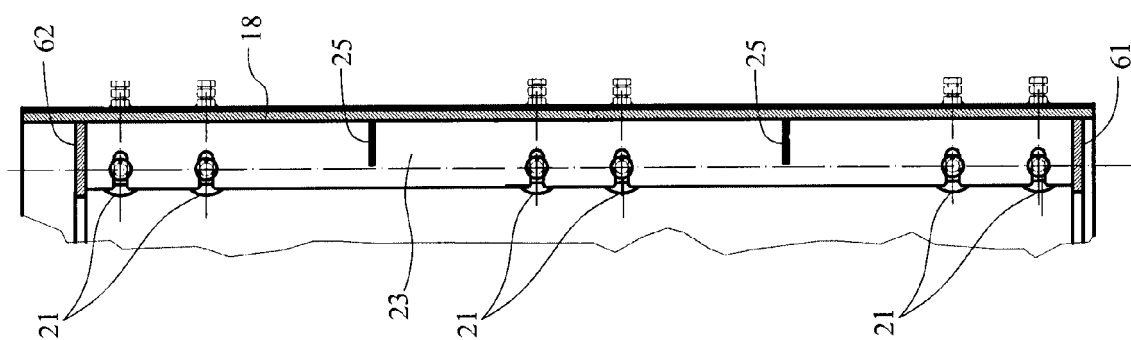


Fig. 10A

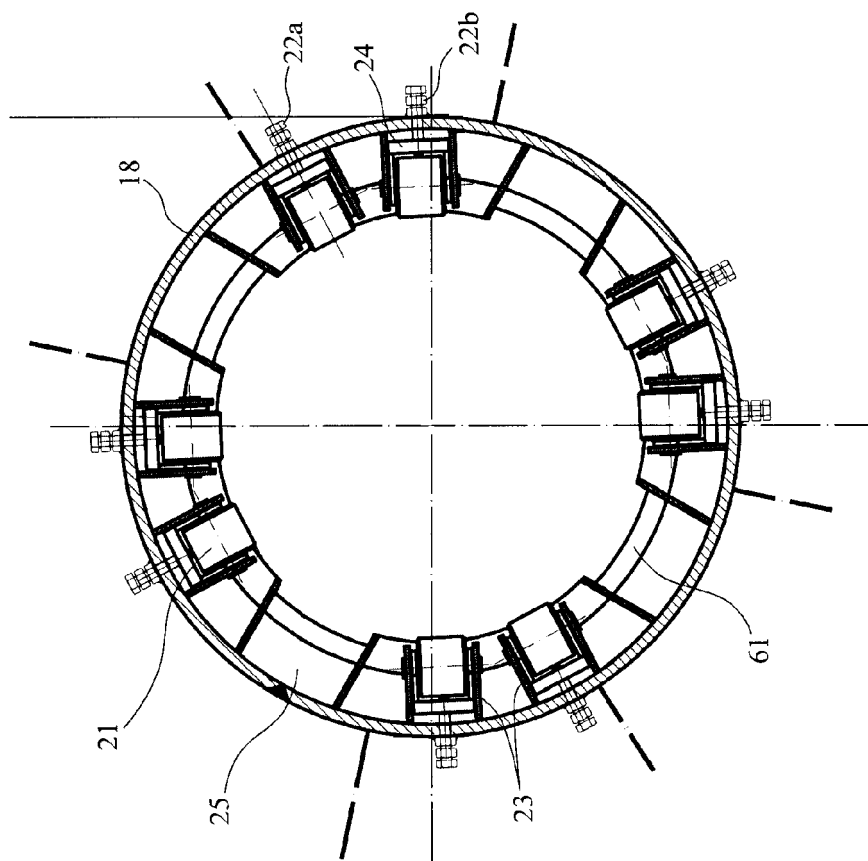
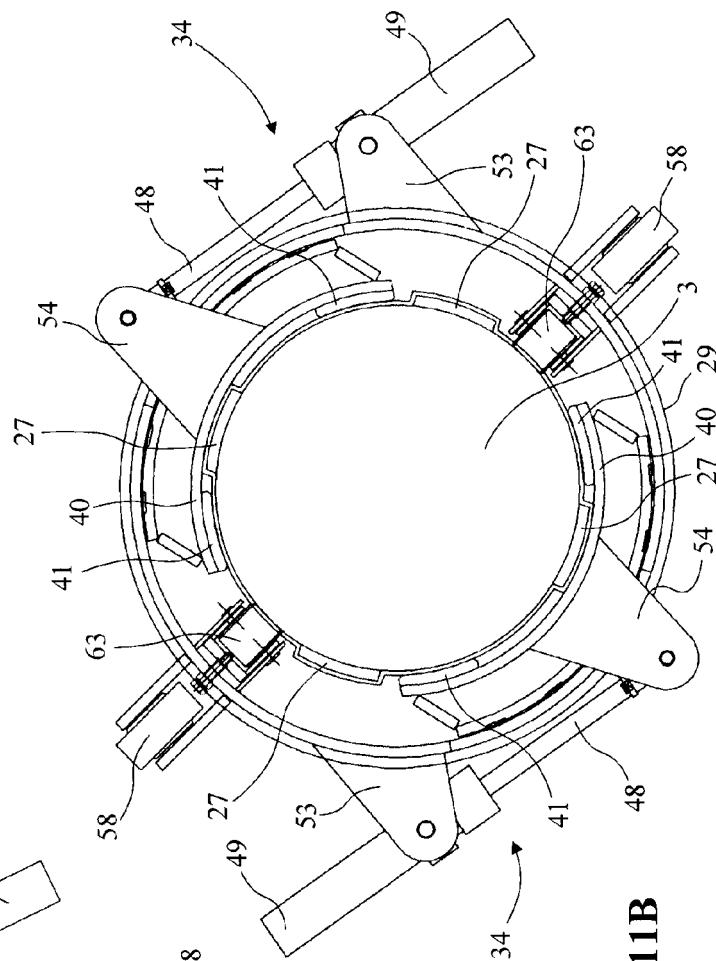
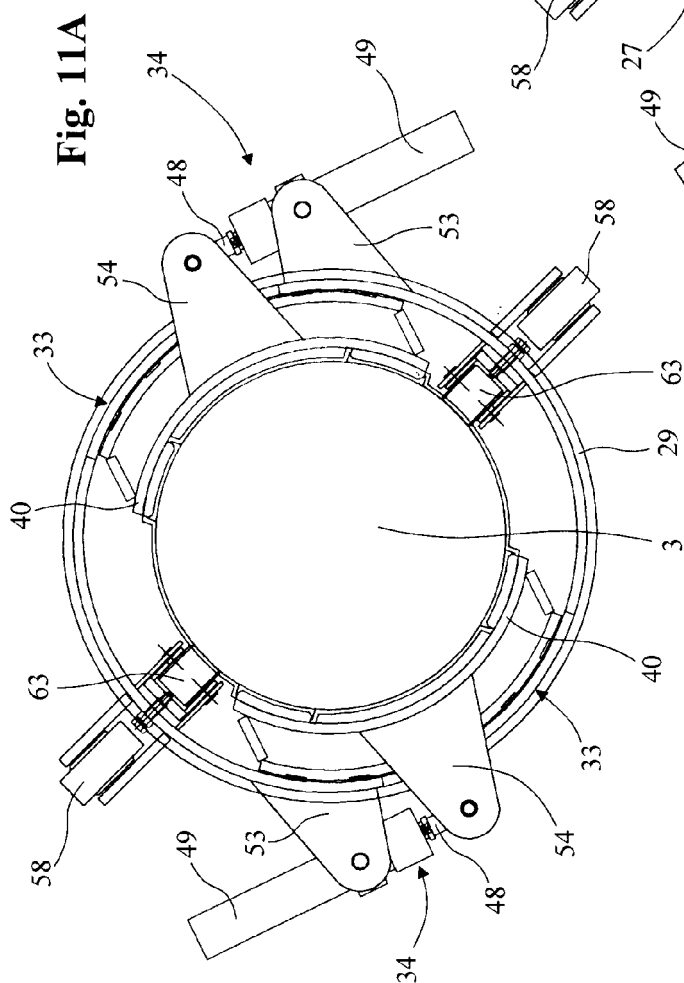


Fig. 10B



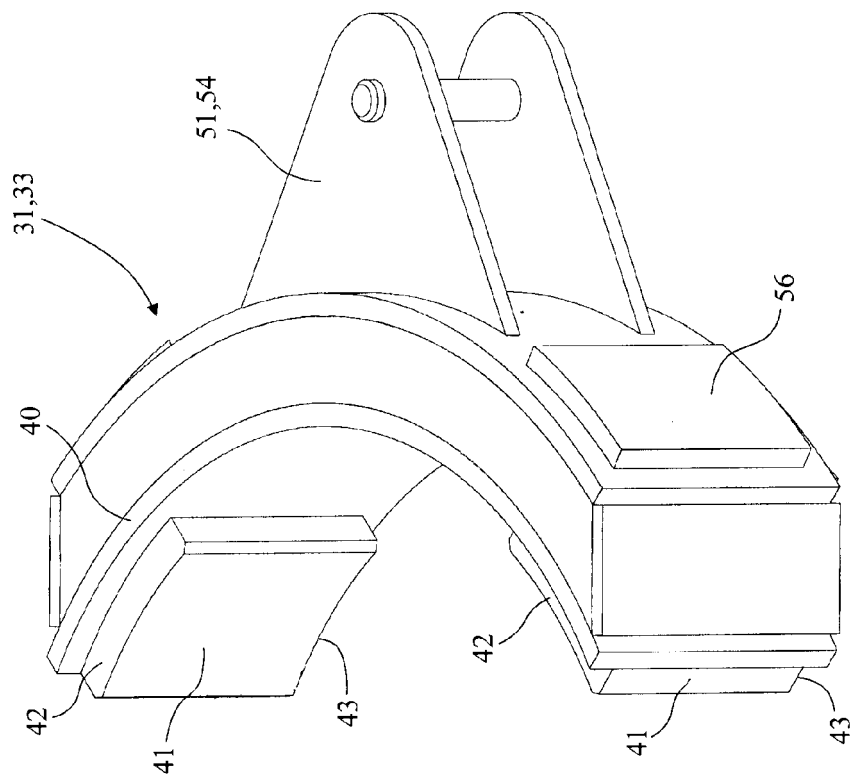


Fig. 12

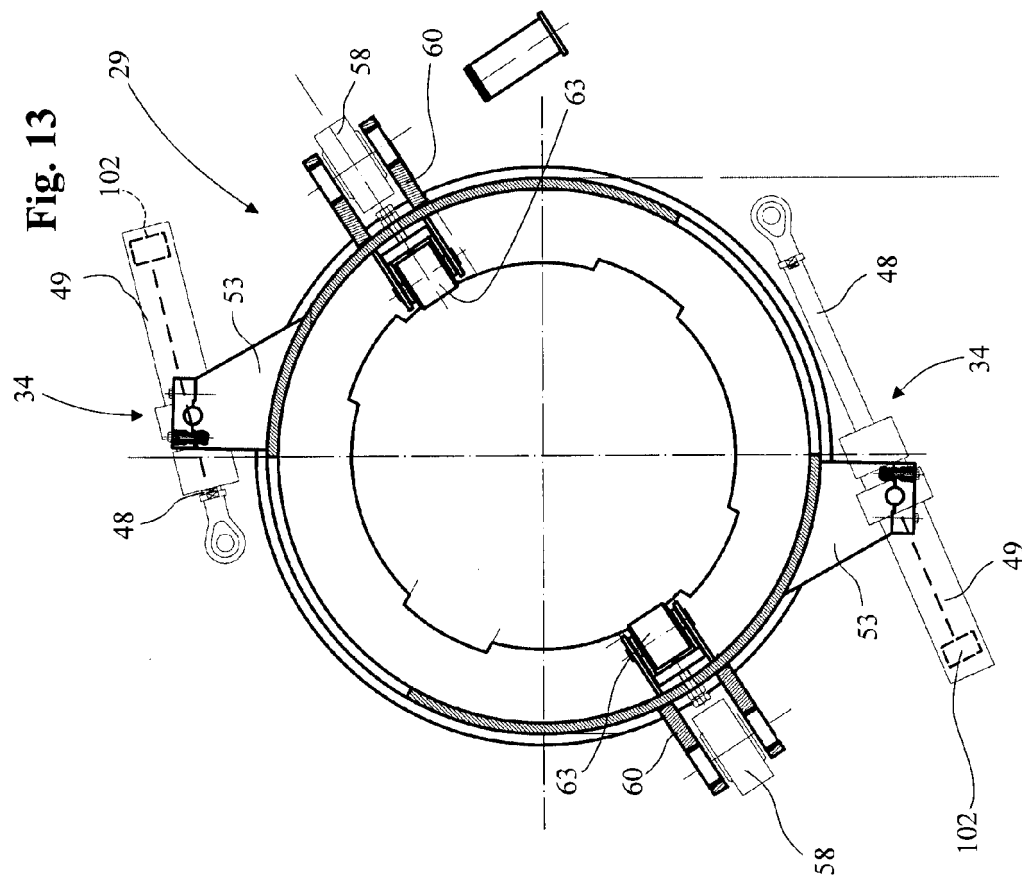


Fig. 13

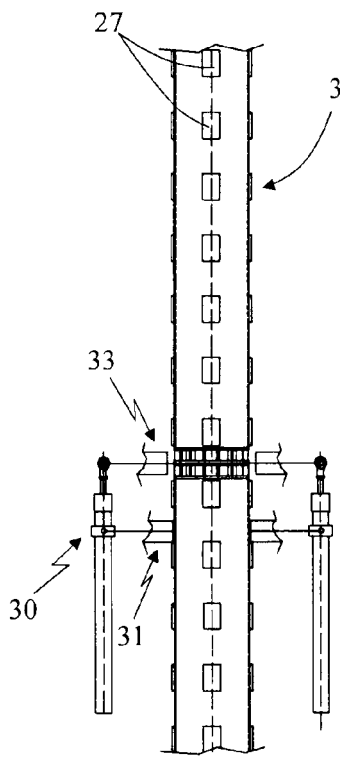


Fig. 14a

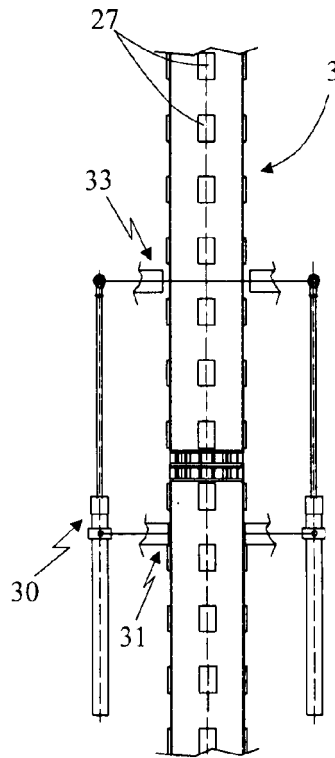


Fig. 14b

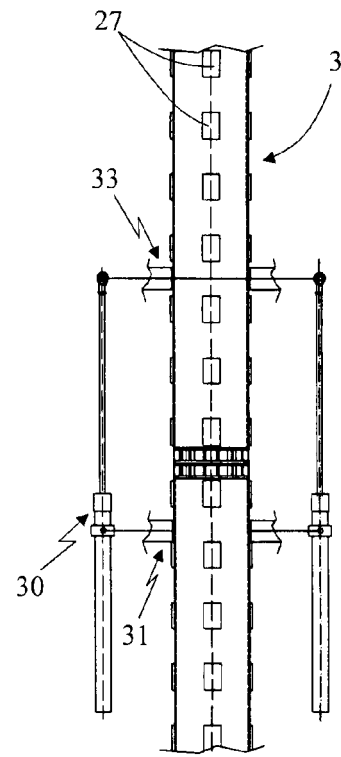


Fig. 14c

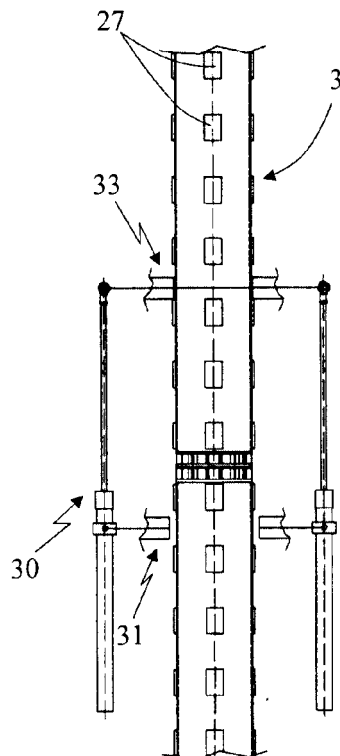


Fig. 14d

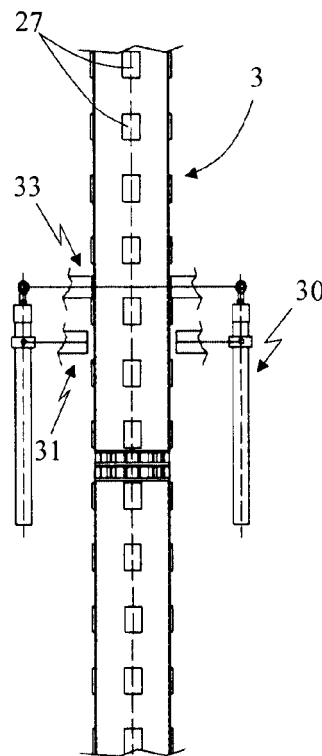


Fig. 14e

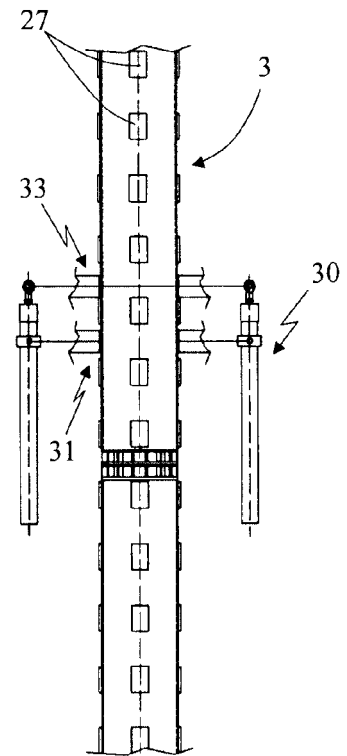


Fig. 14f

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Patent documents cited in the description

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