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DESCRIPTION

Description

[0001] The invention relates to a method for onshore or offshore erecting an upstanding construction comprising longitudinal construction parts, in particular parts of a windmill, comprising the steps of

- providing the longitudinal parts of the construction;
- transporting the longitudinal parts of the construction on a vehicle to an erection site;
- providing a crane for hoisting the longitudinal parts of the construction; and
- using the crane for placing the respective longitudinal parts of the construction on top of each other on a construction base at the erection site.

[0002] US2014/0102039 discloses a method in accordance with the preamble of claim 1.

[0003] WO2014/082176 discloses a crane in accordance with the preamble of claim 7.

[0004] JP-S51-62222 discloses an erection device of a structure, wherein vertical guide frame members of a guide frame is composed with a mounting piece so as to disengage alternately via a pin.

[0005] DE 196 47 515 discloses a wind converter mounting device, wherein an at least two-armed crane scissors with a foot part and a head part pass, and which forms a temporarily unit with a converter tower, wherein each of the foot part and/or head part is detachably connected with the respective tower part, and the crane shears are provided with at least two hydraulic cylinders which realize a climbing rhythm. A boom of the crane scissors is equipped with a cable, with the help of which the tower parts of the tower are successively placed on each other.

[0006] EP-A-2 908 000 discloses a lifting device to assemble and disassemble turbine components in a wind turbine generator having a nacelle, wherein the lifting device comprises a fixed or revolver platform, that carries a tiltable and extendable set comprised by several telescopic modules, with stabilizing and guiding arms that dynamically adapt their position to the diminishing wind turbine tower diameter along the height of the tower by embracing pressure arms and sliding with wheels, while the telescopic modules extend or shrink to enable the access to the precise vertical position of the turbine component that needs to be changed or repaired; and wherein the last module is provided with supporting and fixing elements to hold the turbine component during the ascending or descending maneuver.

[0007] JP-S59-158794 discloses a crane for assembling a tower.

[0008] The following four publications are relevant for the preamble of claim 13.

[0009] NL 1 032 591 discloses a crane for working with slender constructions, such as wind turbines or masts for broadcasting, comprising a basic unit with multiple telescoping sections which are extended in a working situation, wherein the sections are further oriented in a vertical direction and wherein the basic unit in its working position is anchored with a construction to the slender construction.

[0010] JP2012 092534 discloses a construction crane for lifting a support member mounted on a telescopic boom in order to construct a tower-like structure column extending up to a high position above the sky by stacking a plurality of strut members.

[0011] WO2013/012761 discloses an enhanced stability crane comprising a platform assembly; a telescoping main support mast coupled to the platform assembly; a crane base mounted on the main support mast; a power source residing within the crane base; a boom coupled to the crane base at a boom first end and projecting upwardly therefrom; a jib pivotably coupled to the boom proximate a boom second end and projecting upwardly therefrom; a maximum jib height of at least 262 feet; a crane load capacity of at least 160,000 pounds; and a clamping assembly coupled directly to the main support mast, the clamping assembly being configured to affix securely to a tower structure to stabilize the crane.

[0012] WO2014/163490 discloses a crane for erecting a structure, such as a wind turbine, comprising a base for support on the ground, a telescopic boom extendable to a predetermined height, and a top assembly comprising a guide for one or more hoist cables connectable to a load. The crane further has at least one connector connected to the telescopic boom, the at least one connector comprising a fixing assembly for rigidly connecting the crane to the structure in operation.

[0013] The prior art method to erect an upstanding longitudinal construction, such as a windmill, is to lift and stack column segments to create a tower on which, in the case of a windmill, the wind turbine generator can be positioned at its design height. A crane is used to erect the column and place the wind turbine generator and rotor blades on top of the construction. Depending on the height of the windmill, the length of the crane boom needs to be adapted thereto in order to be able to reach the necessary elevation for the placement of the wind turbine generator and the rotor blades at the top of the upstanding construction. Disadvantageously however an increased length of the crane boom implies that the crane as a whole has to increase in size and weight in order to be able to provide the required capacity for erection of the upstanding construction.

[0014] It is an object of the invention to provide a method for onshore or offshore erecting of an upstanding construction comprising longitudinal construction parts, in particular parts of a windmill, wherein:

- the eventual height of the upstanding construction is not determining the required length of the crane boom;
- a more stable method of erecting an upstanding construction is provided that is less sensitive to weather conditions so that construction can continue also in weather conditions that would in the prior art prevent the continuation of erecting the upstanding construction;
- the parameters of the crane in other respect is also independent of the height of the upstanding construction and of the mass of its components;
- cost and effort to implement the method of erecting an upstanding construction remain relatively small and are basically independent from the height of the upstanding construction; and
- the ground area or footprint required for the crane in proximity of the upstanding construction is relatively limited and smaller than with a crane of the prior art.

[0015] The inventors stress to note that particularly with the erection of a windmill the time gained or saved during the erection of the windmill is very valuable and can amount to millions of dollars, particularly when a series of windmills have to be erected. There is therefore an ongoing effort within the industry to come to smarter, quicker, and less costly solutions for the erection of windmills. The instant invention will hereinafter be basically elucidated with reference to the erection of a windmill, but it will be clear for the skilled person that the advantages that come within reach with the invention are equally available when the invention is used for the construction of other high upstanding constructions. The application of the invention to the erection of a windmill must therefore be seen as purely illustrative, without the invention being limited thereto.

[0016] The invention is embodied in the features of one or more of the appended claims.

[0017] Basically the method of the invention comprises the steps of:

- providing the construction base and/or the longitudinal parts of the construction with a support and guide facility for the crane;
- arranging that the crane is mountable on the support and guide facility; and
- mounting the crane on the support and guide facility of at least one of the construction base and the longitudinal parts of the construction that is placed on the construction base, so as to arrange that the crane is then movable up and down along the support and guide facility of the construction, wherein completing the erection of the upstanding construction is done by removing the crane and removing the support and guide facility from the longitudinal parts of the construction, wherein the crane is used for picking up and placing a windmill generator and hub on top of the upstanding construction, followed by using the crane for picking up and placing rotor blades on the hub.

[0018] Removal of the support and guide facility is particularly desirable with windmills to avoid inducements of turbulence when the wind is blowing past the upstanding construction. Such turbulence could adversely affect the rotor blades when in rotating operation.

[0019] The just-mentioned features of the invention provide the advantage that the footprint of the crane is independent from the size of the upstanding construction which is to be erected. Also the other dimensions and the weight of the crane are thus independent from the upstanding constructions size.

[0020] Another advantage is that the movements of the crane can remain limited which contributes to the stability of the entire construction process when the upstanding construction is build up from the ground. Severe weather conditions, particularly wind, only have a limited effect on the upstanding construction and on the crane mounted thereon during erection of the construction, particularly in comparison with the prior art solution.

[0021] Cost and effort to erect the upstanding construction can further remain limited since all preparatory work off-site can remain limited and be delayed until the construction will be done on-site. The prior art method is comparatively costly since most construction is then required to be done off-site, which necessitates also the use of costlier transportation and high-capacity cranes. The invention however provides the advantage that transporting the longitudinal parts of the construction and the crane to the erection site can be done on the same vehicle.

[0022] According to the invention:

- transporting the longitudinal parts of the construction and the crane to the erection site is done with the construction parts and the crane resting in a horizontal position on the vehicle; and that
- the crane is up-ended at the site into a vertical position so as to enable that the crane is mounted on the support and guide facility of at least one of the construction base and the longitudinal parts of the construction that is placed on the construction base. Thereafter the crane is immediately functional to be moved up and down the support and guide facility for moving loads up and down the gradually growing upstanding construction, as will be further explained hereinafter.

[0023] Up-ending of the crane into a vertical position can be done by different means; for instance using hydraulic cylinders or by using pull wires between the construction base and the crane. During up-ending a foot of the crane can be provided with a pivot point close to the support and guide facility provided on the construction base on which the crane will be mounted.

[0024] In connection with both onshore and offshore activities, the vehicle can be appropriately moved into the position which is best suited for mounting the crane on the supporting guide facility. If no appropriate position can be found, then the crane can first be mounted on an

additional support that is provided on the construction base (or on a higher longitudinal construction part above the construction base), and then moved into its final position mounted on the support and guide facility on the construction base or the higher longitudinal construction part on top of the construction base.

[0025] For limiting the costs of transport and making handling of all parts of the upstanding construction and the crane easy, it is preferred that at least one of the longitudinal construction parts and the crane is/are provided with dimensions equal or less than the dimensions of a standard sea freight container.

[0026] The actual erection of the upstanding construction is preferably initiated by moving the crane from the vehicle into an initial position on the support and guide facility that is provided on one of the construction base and the longitudinal part of the construction that is first placed on the construction base.

[0027] The erection of the upstanding construction can then take place by repeatedly positioning the crane at a top level of the support and guide facility of the highest longitudinal part of the construction, and picking up with the crane a next longitudinal part of the construction that still rests on the vehicle or at base level, and subsequently placing said next longitudinal part on top of the longitudinal part that supports the crane, while arranging that the support and guide facility of the respective longitudinal parts of the construction that are placed on top of each other are kept in line. Accordingly the crane can reach ever increasing heights corresponding each time with the up till then latest placed and highest longitudinal construction part of the tower of construction parts.

[0028] The upstanding construction is a windmill and the crane is used for picking up and placing the windmill generator and hub on top of the upstanding construction, followed by using the crane for picking up and placing the rotor blades on the hub.

[0029] As mentioned the method of erecting the upstanding construction can be used onshore and offshore. It is preferred that with onshore erection the vehicle is a trailer, and that with offshore erection the vehicle is a floating vessel or a jack-up vessel. In case of a floating vessel it is preferred that the vessel deck is stabilized.

[0030] The invention is also well equipped to execute maintenance on or to execute dismantling of the upstanding construction. Both activities involve replacing the support and guide facility along the longitudinal parts of the construction and mounting a crane on the support and guide facility. The crane can then be applied for providing maintenance to the upstanding construction or for part by part top-down removal of the respective longitudinal parts of the construction.

[0031] The invention is further embodied in a crane according to claim 7 which is arranged for moving up and down a vertical support and guide facility, wherein the crane comprises a mast which is movable up and down the support and guide facility, and wherein the remainder of the

crane which comprises the crane's hoisting means is rotatably mounted on the mast.

[0032] In a preferred embodiment of the crane the mast is provided with upper and lower mounting slides for cooperation with the vertical support and guide facility, and that the mast is telescopically extendable between the upper and lower mounting slides. This makes it possible to selectively guide the hoisting forces at its strong points into the construction being erected, and also results in a simpler design of the crane which is easier to use.

[0033] The invention will hereinafter be further elucidated with reference to the drawing primarily illustrating methods according to the invention as defined by the appended claims.

[0034] In the drawing:

- Figures 1 - 7 illustrate mounting a crane on a construction base for an upstanding construction which is to be erected according to the invention;
- Figures 8 - 18 illustrate the method of erecting an upstanding construction comprising longitudinal construction parts using a crane according to a first embodiment in accordance with the invention;
- Figures 19 - 25 illustrate the method of erecting an upstanding construction comprising longitudinal construction parts using a crane according to a second embodiment in accordance with the invention.
- Figures 26 - 30 illustrate the method of erecting an upstanding construction comprising longitudinal construction parts using a crane according to a third embodiment in accordance with the invention.
- Figures 31 - 36 illustrate the releasable attachment of an intermediate mount of the third embodiment.
- Figures 37 - 50 illustrate the method of up-ending a crane according to the third embodiment.

[0035] Whenever in the Figures the same reference numerals are applied, these numerals refer to the same parts.

[0036] First an explanation will be provided with reference to Figures 1 - 7 of mounting a crane 1 according to the invention on a support and guide facility 2 on a construction base 3 onshore. The way of mounting the crane 1 when the construction base is onshore is basically the same as when the construction base would be offshore, so a detailed explanation and showing of mounting the crane on a support and guide facility on a construction base which is located offshore can be dispensed with.

[0037] In Figure 1 the longitudinal parts of the construction are for clarity not shown. Figure 1 shows however that the crane 1 is placed in a horizontal position on a vehicle 4, that is to say a trailer, and moved to an erection site 5 where for instance a windmill construction base 3 is located.

[0038] Figure 2 shows the subsequent up-ending of the crane 1 into a vertical position which is reached in Figure 3, and which enables that the crane 1 is mounted on the support and guide facility 2 of the construction base 3. Needless to say that if there would already be a first or higher longitudinal part positioned on the construction base 3, the crane 1 could also be mounted on this first or higher longitudinal part of the construction that would be on top of the construction base 3.

[0039] Figure 3 shows that the crane 1 is still in a folded condition. In Figures 4 - 7 the crane is unfolded by extending first the struts 6 of the crane (Figure 4); and subsequently extending the jib 7 of the crane 1 (Figure 5); extending the jib extension 7' (Figure 6); and extending a telescopic piece 8' from the mast 8 that is mounted on the support and guide facility on the construction base 3 (Figure 7). The crane 1 is then ready for use. It is to be noted that the crane 1 as depicted in Figures 1 - 7 is a crane according to a first embodiment of the invention. The invention however also embraces a crane 1 according to a second embodiment of the invention as will be explained hereinafter with reference to Figures 19 - 25. In the crane 1 according to this second embodiment of the invention the mast 8 is provided with upper and lower mounting slides 14, 15 (as is shown in Figures 19 - 25) for cooperation with the vertical support and guide facility 2 mounted on the construction to be erected, wherein the mast 8 is telescopically extendable between the upper and lower mounting slides 14, 15. Mounting this crane 1 according to the second embodiment on the vertical support and guide facility 2 is executed similarly as explained with reference to Figures 1 - 7 relating to the crane 1 according to the first embodiment of the invention. Use of the crane 1 according to the second embodiment differs however slightly from the use of the crane 1 according to the first embodiment, which will now first be discussed.

[0040] Using the Crane 1 according to the first embodiment of the invention can be elucidated with reference to Figures 8 - 18 illustrating the case that the erection of the upstanding construction is done offshore. It is remarked that the following elucidation of erecting the construction offshore will likewise be applicable to erecting the upstanding construction onshore. The details of the method of the invention are the same in both situations. A specific elucidation with reference to an erection onshore can therefore be dispensed with.

[0041] Figures 8 and 9 depict two alternative situations in which the vehicle 4 to be used for transporting the longitudinal parts 9 of the construction and the crane 1 in a horizontal position to the erection site 5 is different, notably either a floating vessel 4' (Figure 8) or a jack-up vessel 4" (Figure 9).

[0042] Figure 8 shows a fully loaded floating vessel 4' after arrival at the construction site 5, and this Figure shows a moment during the initial up-ending of the crane 1 so as to enable its eventual mounting on the support and guide facility that is provided on the construction base 3 on which a windmill column will be completed.

[0043] Likewise Figure 9 shows a fully loaded jack-up vessel 4" at the construction site 5, and

shows a moment during the initial up-ending of the crane 1 so as to enable its eventual mounting on the support and guide facility that is provided on the construction base 3 on which a windmill column will be completed.

[0044] With reference to Figure 8 and Figure 9 it shows that besides the crane 1, also the longitudinal parts 9 of the construction that have already been provided off-site with support and guide facilities 2 for the crane 1, a windmill generator 10, and a hub 11 for mounting the rotor blades 13, and said rotor blades 13 can be moved to the erection site 5 on one and the same vehicle 4', 4".

[0045] The remainder of the explanation of using the crane 1 of the invention for erecting the upstanding construction of the windmill will now be provided for the case that the vehicle is a jack-up vessel 4" in accordance with Figure 9, but the skilled person will understand without further explanation that any other type of vessel could similarly be used for this purpose, and not necessarily only the alternative of the floating vessel 4' of Figure 8.

[0046] Turning now to Figures 10 - 15, these Figures show the consecutive building up and erection of the tower of longitudinal construction parts 9, wherein after mounting the crane 1 on the construction base 3 (in a way similar to what is discussed hereinabove with reference to Figures 1 - 7) a first construction part 9' is picked up by the crane 1 from the vessel 4" and positioned on top of the construction base 3. This is shown in Figure 10.

[0047] In Figure 11 it shows that the crane 1 is moved to a higher altitude than in Figure 10, until it reaches the top level 12 of the support and guide facility 2 of the then highest first longitudinal part 9' of the construction. This shows Figure 12.

[0048] Figure 12 further shows that a next longitudinal construction part 9" is picked up by the crane 1 from the vessel 4" and positioned on top of the first longitudinal construction part 9' that was earlier placed on the construction base 3.

[0049] Figure 13 shows a subsequent placement of a next yet still intermediate longitudinal construction part 9''' in the tower of construction parts 9, whereas Figure 14 shows the generalization of the placement of construction part X in the tower of construction parts 9. Each intermediate placement of a construction part according to the building method of the invention can therefore be deemed illustrated by the generalization of placing construction part X in the tower of construction parts 9. Figure 15 shows the final and uppermost longitudinal construction part being placed on top of the pile or tower of construction parts 9.

[0050] Figure 16 and Figure 17 depict respectively the placement after picking up from the vehicle 4" of the wind turbine generator 10 (Figure 16), and the hub 11 for the rotor blades (Figure 17).

[0051] Figure 18 shows the placement of the rotor blades 13, after their picking up from the vehicle 4", in their final mounted position on the hub 11.

[0052] With reference to Figures 19 - 25 the use of a second preferred embodiment of the crane 1 of the invention will be discussed for erecting an upstanding construction. The discussion hereinafter concentrates on the process of erecting the construction itself, without details regarding the supply of the construction parts 9 which is similar or the same as is shown with reference to Figures 8 - 9. For reasons of brevity repeating this discussion is avoided.

[0053] Turning now to Figures 19 - 25, these Figures show the consecutive building up and erection of a tower of longitudinal construction parts 9', 9" on a construction base 3.

[0054] Figure 19 shows that the mast 8 of the crane 1 is provided with an upper mounting slide 14 and a lower mounting slide 15 for cooperation with the vertical support and guide facility 2 on the construction base 3. In the following Figures it will be shown that on behalf of erecting the tower of construction parts 9', 9" on top of the construction base 3, the mast 8 is telescopically extendable between the upper and lower mounting slides 14, 15.

[0055] As is shown in Figure 19 the upper mounting slide 14 is positioned slightly below an upper end of the construction base 3, and the lower mounting slide 15 is positioned at a lower end of the base part 3. After thus having the crane 1 mounted on the construction base 3 (in a way similar to what is discussed hereinabove with reference to Figures 1 - 7) a first construction part 9' which is picked up by the crane 1 is positioned on top of the construction base 3. This is shown in Figure 20.

[0056] Thereafter Figure 21 shows a next step wherein the mast 8 is telescopically extended such that the extremities of the mast parts 8' and 8" move away from each other. Because upper mounting slide 14 is connected to the upper mast part 8", the upper mounting slide 14 moves along the support and guide facility 2 which is present on the first longitudinal construction part 9' which has just been placed on top of the construction base 3. At the same time the lower mounting slide 15 temporarily maintains its position on the supporting guide facility 2 present on the construction base 3.

[0057] Figure 22 shows then that subsequently the mast parts 8', 8" are retracted so that the distance between the mounting slides 14, 15 diminishes and the lower mounting slide 15 assumes a higher than initial position on the supporting guide facility 2 present on the construction base 3. This enables that the mast 8 and its mast parts 8', 8" again telescopically extend from each other so that -as shown in Figure 23- the upper mounting slide 14 assumes a position slightly below an upper end of the then highest longitudinal construction part 9', in preparation of the placement of a further longitudinal construction part 9" on top of the current highest longitudinal construction part 9'. Before such further longitudinal construction part 9" is placed, the lower mounting slide 15 is manipulated into a desired position as depicted in Figure 24 which best accords to a desired flow of forces from the crane 1 into the supporting guide facility 2. At that time the crane 1 is ready to pick up and place the further longitudinal construction part 9" on top of the up to then highest longitudinal construction part 9', whereafter subsequently the upper mounting slide 14 and the lower mounting slide 15 can be

moved to a new position by appropriately longitudinally extending the mast parts 8' and 8" from each other. This is shown in Figure 25.

[0058] The placement of the wind turbine generator, and the hub for the rotor blades can follow similarly as is explained hereinabove with reference to Figures 16 - 18.

[0059] Figures 26-50 show views of the third embodiment and illustrate the use thereof. In the following, only the aspects in which this embodiment differs from the first and second embodiment will be described. It will be apparent that in all other aspects, the methods and concepts described above may be applied to this third embodiment.

[0060] In the third embodiment, the crane 1 comprises the vertical support and guide facility 2', and the construction parts are provided with attachment or fixation points which can cooperate with the vertical support and guide facility 2' to releasably attach the facility to the stacked segments of the upstanding construction. Thus, the vertical support and guide facility 2' is provided at the same time as the crane 1. This allows to reduce the size and dimensions of the support and guide facility, as well as the time and effort needed to erect and install the crane. Additionally, the need to already provide the longitudinal parts 9 off-site with support and guide facilities is obviated as well.

[0061] In this third embodiment, the vertical support and guide facility 2 is movable up and down along the upstanding construction. This allows to use a vertical support and guide facility 2' which is shorter than the upstanding construction to be erected, and e.g. which has substantially the same length (in its longest position) as the mast 8 of the crane or is shorter. For example, this allows to use a vertical support and guide facility 2' which is not longer than two or three longitudinal parts of the construction.

[0062] Figure 26 shows a mast 8 which, contrary to the second embodiment, is not telescopically extendable. However, it will be apparent that the mast of the second embodiment may be used as well with the vertical support and guide facility 2 of the third embodiment. The vertical support and guide facility 2 is releasably fixated to the upright construction and can move relative thereto, to move up or down the construction. The mast 8 in turn is movable relative to the facility 2', and can thus move up or down relative to the construction as well, e.g. when the facility 2 is fixated, as explained below in more detail.

[0063] The vertical support and guide facility 2 comprises mounts 14',15',16 releasably attachable to the upstanding construction and attached to the mast 8 in such a manner the mast 8 is movable up and down along the upstanding construction when, at least some of, the mounts are attached to the upstanding construction. The movement of the mast 8 is thereby guided by the mounts 14',15',16. Vice versa the mast 8 provides a guide bar for the movement of some of the mounts relative to the construction parts 9.

[0064] Figure 26 shows that the mounts can comprise a lower mount 15', an upper mount 14' and an intermediate mount 16 between the lower mount and the upper mount. The

intermediate mount 16 is displaceable between the lower mount and the upper mount in opposite directions along the longitudinal direction of the mast. In this example the path over which the intermediate mount can move ranges from the lower mount to the upper mount but it will be apparent that, depending on the specific implementation, a shorter path may be used as well.

[0065] In addition to the intermediate mount 16, one or more of the upper mount 14' and/or the lower mount 15' can be a displaceable mount. This mount can be displaceable, relative to the mast, between the intermediate mount and an extremity of the mast, in opposite directions parallel to the longitudinal direction towards and away from the extremity. Thus, the length of the facility 2, i.e. the distance between the most remote mounts 14', 15' can be varied to expand and retract in such a manner that the facility is moved up and/or down relative to the construction 9. For example, starting from a retracted state, the facility may expand at one end thereof in a first direction and subsequently retract at the other end, thus moving the other end in the first direction and thus the facility 2' be moved.

[0066] The mounts can be releasably attached to construction parts 9, 9'. As shown in more detail in Figures 31-36, in this embodiment, construction parts 9, 9' are provided with respective fixation points for the mounts, and more specifically at their top end. The fixation points are distributed circumferentially around the construction parts 9, 9' such that one mount can be attached at two circumferentially spaced apart positions at the same height. This provides for a stable releasable fixation which can resist horizontal forces in tangential direction of the construction part 9 to which the mount is attached.

[0067] In this third embodiment, the position of the lower mount 15' is fixated relative to the mast, at the lower extremity of the mast 8, although another position may be used. In this example, the weight of the crane is mainly or completely carried by the lower mount 15'. This avoids the corresponding vertical force being transferred on unfinished parts of the structure to be build.

[0068] The upper and intermediate mounts 14', 16 transfer horizontal forces exerted on the mast to the upstanding construction and hold the mast in position horizontally, when attached to the construction of course. The mounts 14', 16 in this example both have a passage, as more clearly seen in Figures 31-36 through which the mast 8 slidably extends and which thus do not bear the weight of the mast but ensure that the mast 8 is held in position horizontally, i.e. in tangential and radial direction of the construction parts 9, 9', when not moving and guide the movement of the mast.

[0069] The support and guide facility 2' may be lowered or raised as follows. Figure 26 shows the crane 1 in an initial position. In this initial position, the mounts 14', 15' and 16 are attached to the second and third highest longitudinal construction parts 9. More specific, lower mount 15' is attached to an upper or top end of the third highest longitudinal construction part 9 whereas upper mount 14' and intermediate mount 16 are attached to a top end of the second highest longitudinal construction part 9.

[0070] Figure 26 shows that the attachment of the upper mount 14' is released and, as the arrow indicates, the upper mount 14' is displaced along the mast to the top or upper end of the currently highest longitudinal construction part 9'. Figure 27 shows that the upper mount 14' is then attached to the top end of the now highest longitudinal construction part 9'.

[0071] Subsequently, the attachment of intermediate mount 16 to the top end of the second highest longitudinal construction part 9 is released. The intermediate mount 16 is then, as indicated with the arrow, moved upwards to be attached to the same fixation as before but instead of engaging from underneath now engages from above with the upper end of the second highest longitudinal construction part 9. The length of the facility 2' now corresponds to about two construction parts, and hence is expanded relative to Figure 26 where the length corresponds to about one construction part.

[0072] Figure 28 shows that thereafter the attachment of the lower mount 15' to the construction part is released. The mast 8 can then be moved upwards, guided by the upper mount 14' and intermediate mount 16 (which are both attached and thus fixated relative to the construction parts 9,9'). Figure 29 shows that after thus raising the mast 8, the lower mount 15' is attached again, but now to the top end of the second highest longitudinal construction part 9, and the facility 2' now extends over about one construction part.

[0073] The intermediate mount 16 is subsequently moved to the top end of the now highest longitudinal construction part 9' and attached thereto, which Figure 30 shows. This strengthens the attachment of the facility at the top.

[0074] The crane 1 is now in its new position and a next longitudinal construction part 9" can be placed. Figure 30 shows that the next longitudinal construction part 9" is placed on top of the currently highest longitudinal construction part 9' and thus becomes the next highest longitudinal construction part.

[0075] Figures 31-36 show in more detail how the mounts 14',15',16 are attached to the upstanding structure. Each of the mounts comprises a fixation system for releasably attaching to the upstanding construction simultaneously at different fixation points which in circumferential direction of the upstanding construction are spaced apart but at substantially the same height.

[0076] The upper mount 14' and lower mount 15' have similar fixation systems and the intermediate mount 16 has a fixation system which differs therefrom, for engaging at fixation points different from the upper mount and lower mount.

[0077] As shown in Figure 31 and 34, the intermediate mount 16 comprises a fixation system 160,161 which can engage at a top side and a bottom side of a protruding tab 90 of the upstanding construction located at a fixation point thereof. In this example, the fixation system comprises an 160 arm which extends from the mast 8 towards the construction part 9 and

which at a free end is provided with a coupling element 161 formed by an upwards pointing pin and a downwards pointing pin. When engaging at the bottom side, as in Figure 31, the upwards pointing pin extends through an eye of the protruding tab whereas in the opposite case, shown in Figure 34, the downwards pointing pin extends from the top side into the eye.

[0078] Figures 31 shows the upper mount 14' and intermediate mount in the initial position of the crane shown in Figure 26. As shown, upwards pointing pin 161 projects from underneath into the eye of the protruding tab 90 and the fixation system of the upper mount 14' interlocks with a short beam 91 projecting from the part 9, by means of an upstanding, vertical lip of the beam 91 at the free end thereof at, which is admitted in a recess of the fixation system and interlocked therewith.

[0079] Figure 32 shows that upper mount 14' is raised and thus the interlocking attachment released. The fixation system thereof is retracted towards the mast 8, to allow, as Figure 33 shows displacing the upper mount 14' to the position shown in Figure 27. The intermediate mount 16 is slightly lowered to remove the pin 161 out of the eye and arms 160 are retracted. As indicated with the arrow in Figure 33 the intermediate mount 16 is raised, arms 160 are extended such that the downward pointing pin is positioned above the eye and subsequently the mount lowered to place the pin in the eye and hence attach the mount 16 to the construction part. Figure 34 shows the intermediate mount 16 thus re-attached to the construction part 9.

[0080] With upper mount 14' and intermediate mount 16 displaced and re-attached to the construction part 9, lower mount 15' can be released. Figure 35 shows that after lower mount 15' is released, the mast 8 is raised and hence lower mount 15' moved into position in front of the fixation points previously used by the upper mount 14'. The fixation system 151 of the lower mount 15' is placed above the beam and lip, such that the lip can be admitted into a corresponding opening of the fixation system. Figure 36 shows that arms 160 of the intermediate mount are retracted to pull the mast towards the construction part and thereby place the lip in front of the opening, and that the mast is slightly lowered to create the locking attachment.

[0081] Figures 37-50 show the use of a platform 17 for up-ending a crane 1 according to the third embodiment. The shown platform 17 comprises a support for transporting, in a non-upright position (e.g. horizontally), a bottom segment 80 of the mast 8 of the crane 1. The bottom segment 80 is provided with at least two of the mounts 14', 15', 16, in this example with all of them to allow a secure, releasable attachment to the base of the upright construction. The platform is further provided with a powered tilting system 18, such as a hydraulic or pneumatic cylinder and associated power supply, for tilting the bottom segment 80 relative to the support 17, and in this example also vice versa. It will be apparent that in FIGs. 37-50 the platform is shown only schematically and that e.g. the platform may be provided on a (semi)trailer or other transport means not shown in the figures and be held in position relative to the ground by e.g. not shown support legs.

[0082] Figures 37-50 illustrate a method of up-ending the crane using the platform. In such a method, the powered tilting system puts the bottom segment (provided in a non-upright position on the support) in an upright position. This is shown in Figure 37, where the bottom segment 80 is tilted, as indicated with the arrow, to come to stand upright on a base 170.

[0083] The bottom segment 80 may then be fixated relative to the upstanding construction by attaching the at least two mounts to the upstanding construction, as Figure 38 shows. The powered tilting system can then tilt the support relative to the bottom segment 80 to put the support in an upright position. For example, the hydraulic or pneumatic cylinder that expanded to push the bottom segment 80 upright may be retracted to pull the support towards the upright bottom segment.

[0084] Figure 39 shows the support 17 up-ended. As shown, the support is fixated relative to the bottom segment 80 by a releasable fixation 171. In this example the attachment of the cylinder is displaced as well to be further away from the pivot axis between support 17 and bottom segment 80 and hence keep the support 17 fixated. A support base 170' is provided on which bottom end of the support 17 rests.

[0085] Figures 40-42 shows putting one or more further segments 81,82, including a top segment 81, from a non-upright position in an upright position. As shown, the top segment 81 is pivotably attached to the support and pivoted to an upright position. In this example, the jib 7' of the crane on the top segment 81 is used to push the top segment upright, as shown in Figure 41. Once in an upright position, the top segment is fixated to the support 17. Figure 42 shows the crane and support after releasably fixating the top segment at a position 811 remote from the pivot point.

[0086] Figures 43-48 show guiding the further segment 81,82 along the upright support 17 to move them upwards. A lower extremity of the further segments 81,82 is moved beyond the top of the bottom segment 80, and the further segment 81,82 is placed on top of the bottom segment 80.

[0087] In these examples, this comprises, in addition to putting the top segment 81 from a non-upright position in an upright position, stacking the top segment 81 and one or more intermediate segments 82 of the crane.

[0088] Figure 43 shows that the top segment 81 is guided along the upright support to move upwards to a distance sufficient to place one or more intermediate segment in an upright position thereunder. It will be apparent that if there are intermediate segments already stacked thereunder, the entire stack is moved upwards to create sufficient space underneath the stack.

[0089] Figure 44 shows that one or more intermediate segments 82 are provided in the space created by moving the stack upwards. The intermediate segment(s) may be up-ended in a manner similar as the top segment 81. The process of moving the stack upwards and placing an intermediate segment can be repeated until all intermediate segments of the mast 8 are

stacked.

[0090] Figure 45 shows the stack resting on a support base 170". As indicated with the arrow the entire stack can be moved upwards until the bottom end thereof is above the top end of the bottom segment 80. This is shown in Figure 46.

[0091] Figure 47 shows that the stack is placed on top of the bottom segment 80. In this example, the stack is attached to the support which is rotated 180 degrees around its longitudinal axis, thus placing the stack at the other side of the support 17, which is the same side as the bottom segment 80.

[0092] Figure 48 shows that the stack is lowered and thereby placed on the bottom segment 80 and hence the crane 1 is completed.

[0093] Figures 49-50 show removing the support 17 from the crane 1. As shown in FIG., 49, the powered tilting system can tilt the support relative to the bottom segment to put the support in a non-upright position. Figure 50 shows that the support is detached and moved away from the crane. It will be apparent that the platform with the support 17 may then be used to install another crane. It will be apparent that, for example thereafter, the crane 1 may be unfolded, e.g. in the manner described with reference to FIGs.3-7 above.

[0094] Finally it is remarked that the upper part 1' of the crane 1 comprising the crane's hoisting means is at all times freely rotatable with reference to the mast 8, which is particularly beneficial for the crane's ability to handle all loads that are required for building and erecting the construction.

[0095] Although the invention has been discussed in the foregoing with reference to exemplary embodiments of applying the method of the invention, the invention is not restricted to these particular embodiments which can be varied in many ways without departing from the invention. The discussed exemplary embodiments shall therefore not be used to construe the appended claims strictly in accordance therewith. On the contrary the embodiments are merely intended to explain the wording of the appended claims without intent to limit the claims to these embodiments. The scope of protection of the invention shall therefore be construed in accordance with the appended claims only, wherein a possible ambiguity in the wording of the claims shall be resolved using these exemplary embodiments.

REFERENCES CITED IN THE DESCRIPTION

Cited references

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

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Patentkrav

1. Fremgangsmåde til onshore eller offshore opstilling af en opretstående konstruktion omfattende langsgående konstruktionsdele (9) af en vindmølle, omfattende trinene
 - at tilvejebringe langsgående konstruktionsdele (9);
 - transport af de langsgående konstruktionsdele (9) på et køretøj (4, 4', 4'') til et opstillingssted (5);
 - en kran (1) til at hejse de langsgående konstruktionsdele(9);
 - anvendelse af kranen (1) til anbringelse af de respektive langsgående konstruktionsdele (9) oven på hinanden på et byggefundament (3) på opstillingsstedet (5);
 omfattende trinene:
 - at tilvejebringe byggefundamentet (3) og/eller de langsgående konstruktionsdele (9) en støtte- og styreanordning (2) til kranen (1);
 - at sikre, at kranen (1) kan monteres på støtte- og styreanlægget (2), og
 - montering af kranen (1) på støtte- og styreanordning (2) på mindst et af byggefundamenterne (3) og de langsgående konstruktionsdele (9), som er placeret på byggefundamentet (3), således at kranen (1) kan bevæges op og ned langs konstruktionens støtte- og styreanordning (2), og
 - færdiggørelse af opstillingen af den opretstående konstruktion ved fjernelse af kranen (1) og fjernelse af støtte- og styreanordningen (2) fra de langsgående konstruktionsdele (9, 9', 9'', 9''', X), **kendetegnet ved**
 - transport af de langsgående konstruktionsdele (9) og kranen (1) i vandret stilling på køretøjet (4, 4', 4'') til opstillingsstedet (5) og
 - at vende kranen (1) i lodret stilling, således at kranen (1) kan monteres på støtte- og styreanordningen (2) på mindst en af byggepladserne (3) og de langsgående dele (9) af byggepladsen, som er placeret på byggepladsen (3), og
 - brug af kranen (1) til opsamling og placering af en vindmøllegenerator (10) og nav (11) oven på den opretstående konstruktion, efterfulgt af brug af kranen (1) til opsamling og placering af rotorblade (13) på navet (11).

2. Fremgangsmåde ifølge krav 1, **kendetegnet ved**:

- transport af de langsgående konstruktionsdele (9) og kranen (1) på samme køretøj (4, 4', 4'') til opstillingsstedet (5).

3. Fremgangsmåde ifølge et hvilket som helst af de foregående krav 1-2, **kendetegnet ved** at sørge for, at mindst en af de langsgående konstruktionsdele (9) og kranen (1) er forsynet med mål, der er lig med eller mindre end målene på en standardcontainer til søs.

4. Fremgangsmåde ifølge et hvilket som helst af de foregående krav 1-3, **kendetegnet ved** at flytning af kranen (1) fra køretøjet (4, 4', 4'') til en udgangsposition på støtte- og styreanordningen (2), der er til rådighed på en af byggepladserne (3) og den langsgående konstruktionsdel (9'), der først placeres på byggepladsen (3).

5. Fremgangsmåde ifølge et hvilket som helst af de foregående krav 1-4, **kendetegnet ved** gentagne gange at placere kranen (1) på et øverste niveau (12) i støtte- og styreanordningen (2) i den på det tidspunkt højeste langsgående del af konstruktionen, og ved med kranen (1) at samle en næste langsgående del (X) af konstruktionen, der stadig hviler på køretøjet (4, 4', 4''), og efterfølgende at placere næste langsgående del (X) på toppen af den langsgående del, der understøtter kranen (1), idet der sørges for, at støtte- og styreanordningen (2) for de langsgående konstruktionsdele (9, 9', 9'', 9''', X) af konstruktionen, der er placeret oven på hinanden, holdes på plads.

6. Fremgangsmåde ifølge et hvilket som helst af de foregående krav 1-5, **kendetegnet ved** at sørge for, at køretøjet (4) ved opstilling på land er en påhængsvogn, og at køretøjet ved opstilling offshore er et — fortrinsvis stabiliseret — flydende fartøj (4') eller et jack-up-fartøj (4'').

7. Kran (1) bestående af en mast (8), hvor den resterende del af kranen, som omfatter kranens hejsemiddel, er drejeligt anbragt på masten (8), og hvor:
kranen består af en lodret støtte- og styreanordning (2');

den lodrette støtte- og styreanordning (2') omfatter beslag (14', 15', 16), der kan løsnes fast på en opretstående konstruktion, der omfatter langsgående konstruktionsdele (9), hvilke beslag (14', 15', 16) er fastgjort til masten (8), således at masten er bevægelig op og ned langs den opretstående konstruktion, når i det mindste nogle af nævnte beslag (14', 15', 16) er fastgjort til den opretstående konstruktion, hvor beslagene (14', 15', 16) omfatter et nedre beslag (15'), et øvre beslag (14') og et mellemliggende beslag (16) mellem det nedre beslag og det øvre beslag, idet det mellemliggende beslag (16) kan forskydes mellem det nedre beslag (15') og det øvre beslag (14') i modsatte retninger langs mastens længderetning, **kendetegnet ved, at** hver af beslagene (14', 15', 16) omfatter en fastgørelsesanordning til løsbar fastgørelse til den opretstående konstruktion samtidigt ved forskellige fastgørelsespunkter, som i omkredsretningen af den opretstående konstruktion er adskilt fra hinanden, og mindst én af det øvre beslag (14') og/eller det nedre beslag (15') er et forskydeligt beslag, som er forskydeligt i forhold til masten (8), mellem det mellemliggende beslag (16) og en ende af masten (8), i modsatte retninger parallelt med nævnte længderetning mod og væk fra yderkanten.

8. Kran ifølge krav 7, **kendetegnet ved**, at det mellemste beslag (16) består af en fastgørelsesanordning (160, 161), som kan gå i indgreb med oversiden og undersiden af en fremspringende flig (90) på den opretstående konstruktion ved et fastgørelsespunkt på konstruktionen.

9. Kran ifølge et hvilket som helst af kravene 7-8, **kendetegnet ved**, at det nederste beslag (15') er fastgjort i forhold til masten (8).

10. Kran ifølge et hvilket som helst af kravene 7-9, **kendetegnet ved**, at det øverste beslag (14') og det nederste beslag (15') har lignende fastgørelsesanordninger og det mellemliggende beslag (16) har en fastgørelsesanordning, der adskiller sig ved fastgørelse på fastgørelsespunkter, der er forskellige fra det øverste beslag (14') og det nederste beslag (15').

11. Fremgangsmåde til at vende en kran ifølge et hvilket som helst af kravene 7-10 med en platform (17) for at vende kranen, hvor platformen (17) omfatter en støtte (17) til transport af et bundsegment (80) på kranens mast (8) i en ikke-opretstående stilling, hvilket bundsegment (80) er forsynet med mindst to af dets beslag (14', 15', 16), hvor platformen (17) omfatter et drevet vippesystem (18) til at vippe bundsegmentet (80) i forhold til støtten (17) og omvendt, hvor fremgangsmåden omfatter trinene:

det motoriserede vippesystem (18) sætter bundsegmentet (80) i opretstående stilling; fastgørelse af det på daværende tidspunkt opretstående bundsegment (80) på masten (8) i forhold til den opretstående konstruktion ved at fastgøre mindst to beslag (14', 15', 16) på bundsegmentet (80) til den opretstående konstruktion;

kendetegnet ved de yderligere trin:

det motoriserede vippesystem (18) vipper derefter støtten (17) i forhold til det opretstående bundsegment (80) for også at sætte støtten (17) i opretstående stilling; anbringelse af mindst et yderligere segment (81, 82), inklusive et topsegment (81), fra en ikke-opretstående position i en opretstående position og føring af det yderligere segment (82) langs den opretstående støtte (17) for at flytte dem opad, med en nedre ende af de yderligere segmenter (82) ud over toppen af bundsegmentet (80), og placering af det yderligere segment (82) oven på bundsegmentet (80).

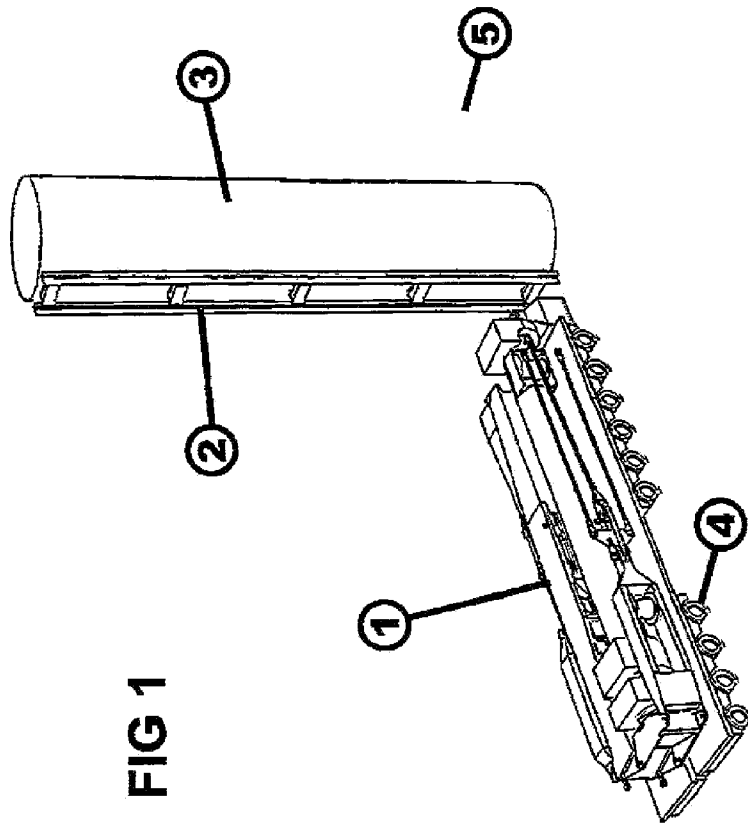
12. Fremgangsmåde ifølge krav 11, **kendetegnet ved** at anbringe de yderligere segmenter (82) fra en ikke-opretstående position i en opretstående position, hvilket omfatter at anbringe det øverste segment (81) fra en ikke-opretstående position i en opretstående position og stable det øverste segment (81) og mindst et mellemliggende segment (82), hvilket omfatter:

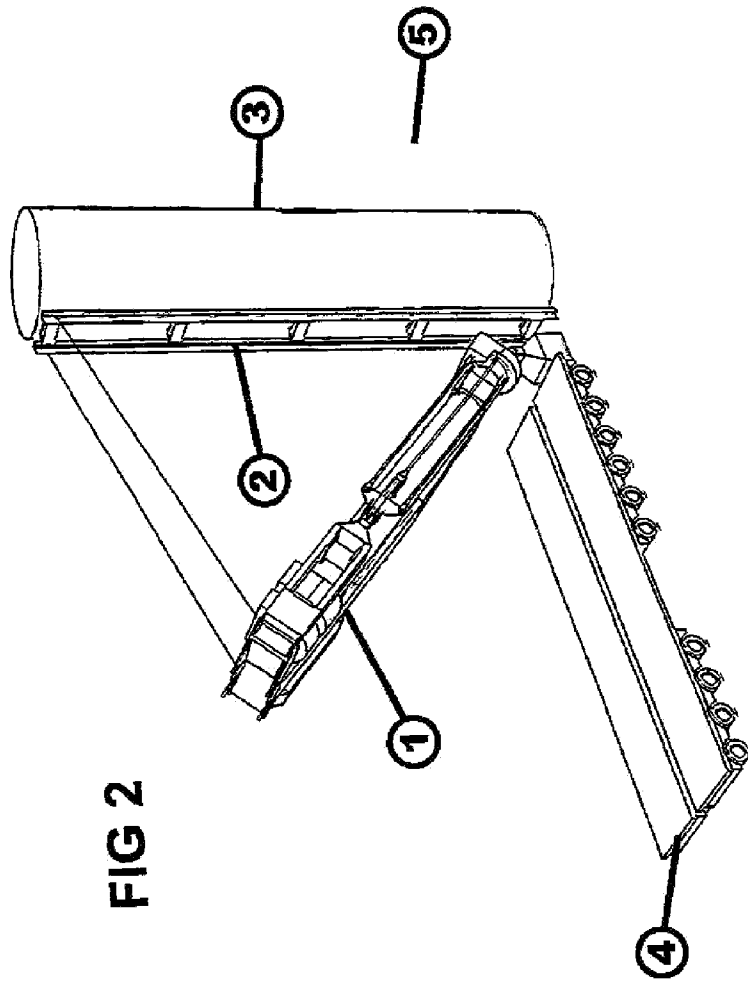
at styre det øverste segment (81) og eventuelle mellemliggende segmenter (82), der allerede er stablet der, langs den opretstående støtte (17) for at bevæge sig til en afstand, der er tilstrækkelig til at placere mindst et mellemliggende segment (82) i opretstående position under bunden af stakken og anbringe mindst ét mellemliggende segment (82) i denne stilling, og gentage dette, indtil alle mellemliggende segmenter (82) er stablet.

13. Fremgangsmåde ifølge krav 11 eller 12, **kendetegnet ved**, at det motoriserede vippesystem (18) vipper støtten (17) i forhold til bundsegmentet (80) for at bringe støtten (17) i en ikke-opretstående stilling, og fjerner støtten (17) fra kranen.

DRAWINGS

Drawing





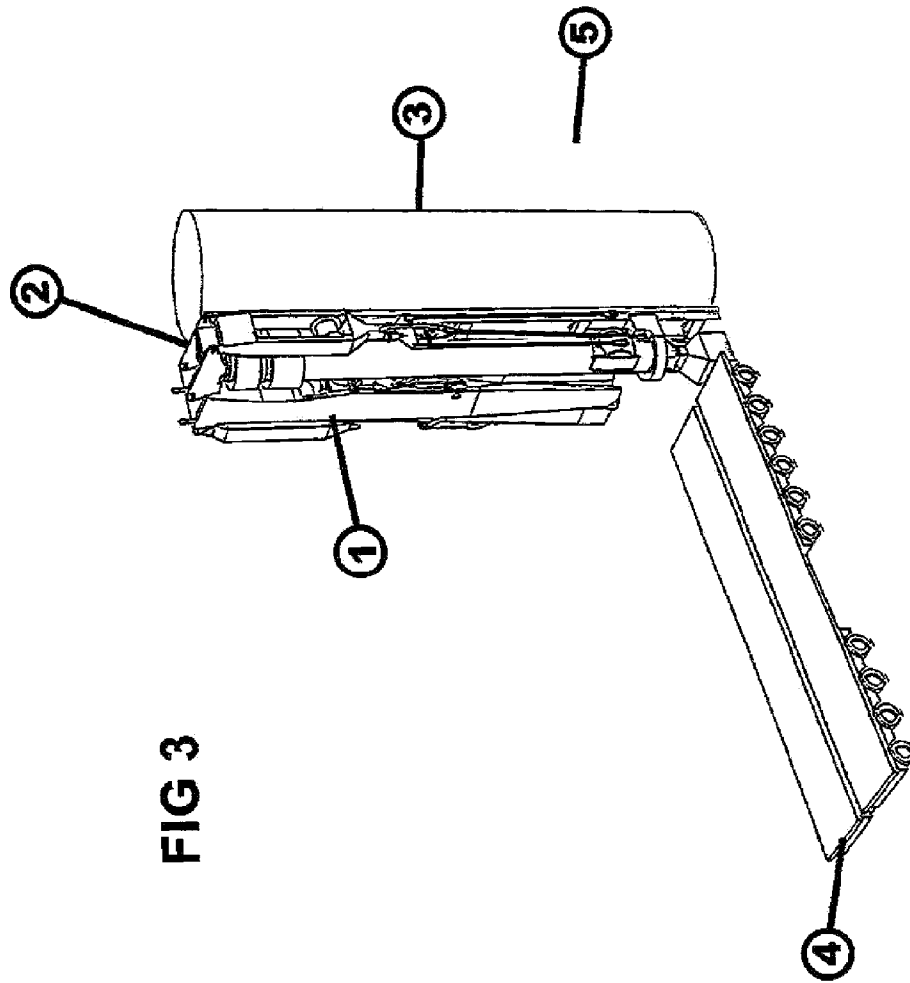


FIG 3

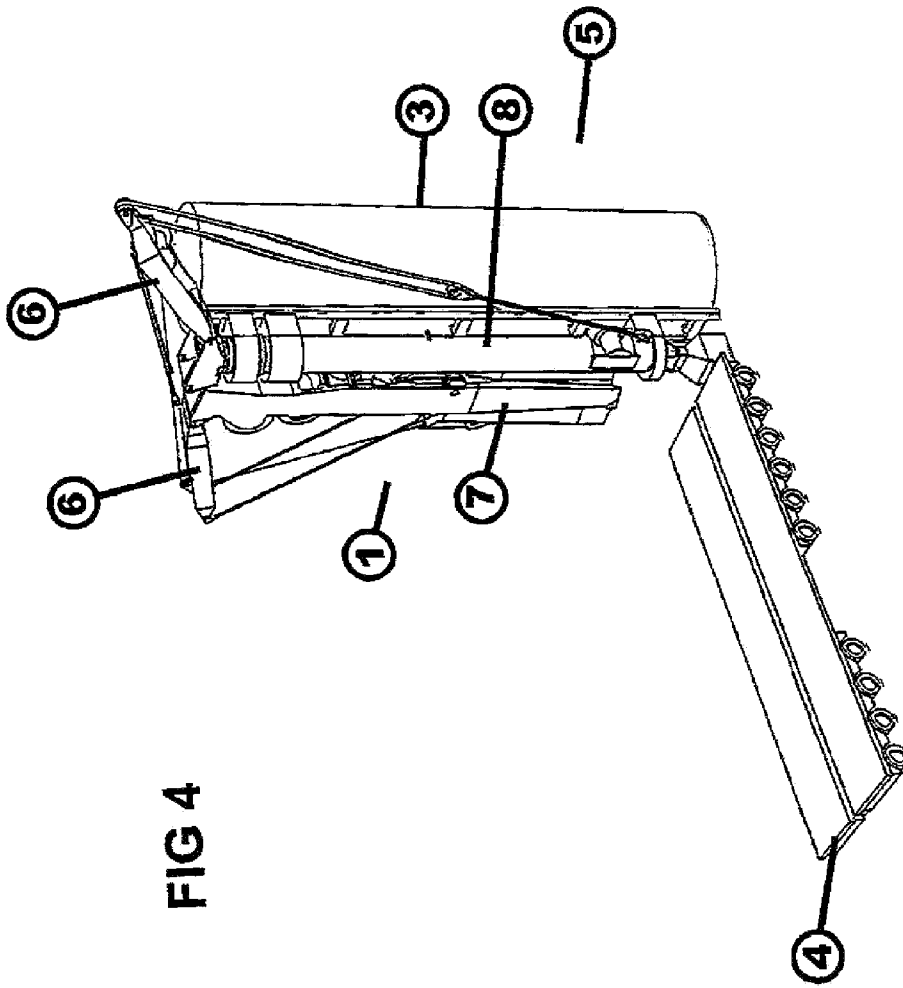


FIG 4

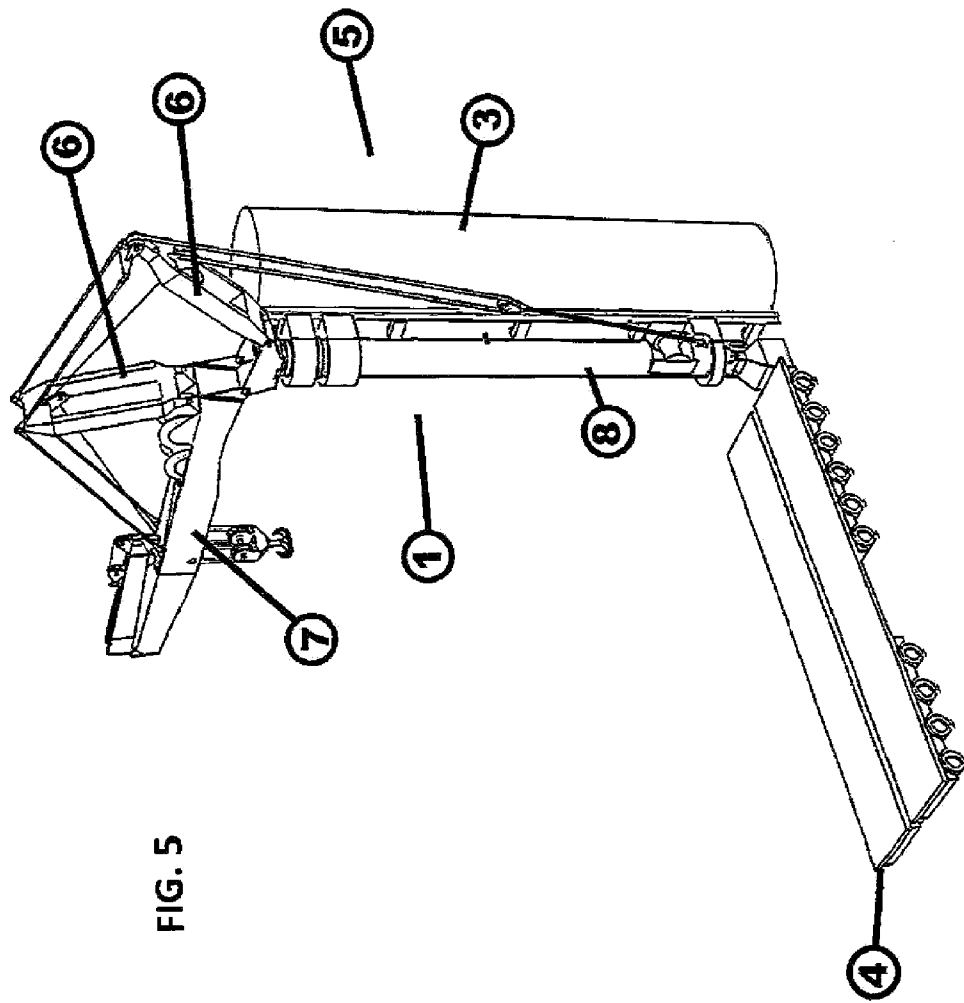


FIG. 5

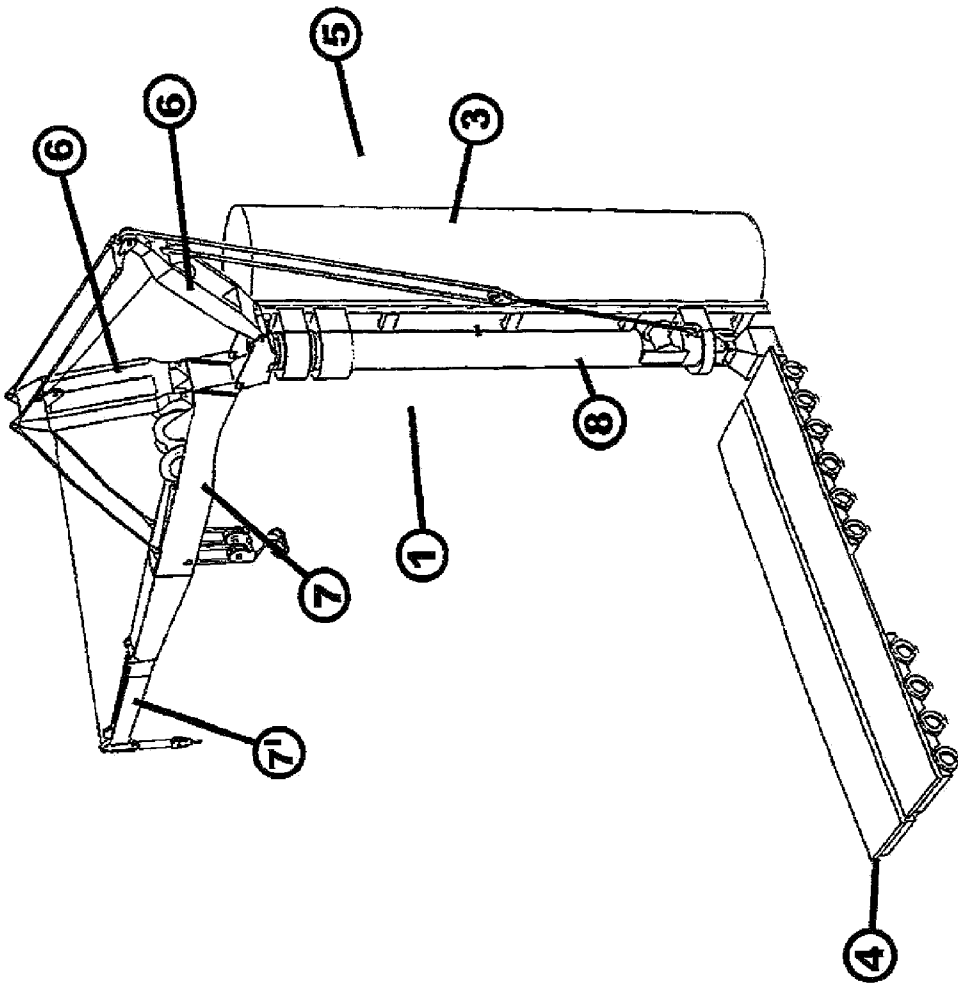


FIG 6

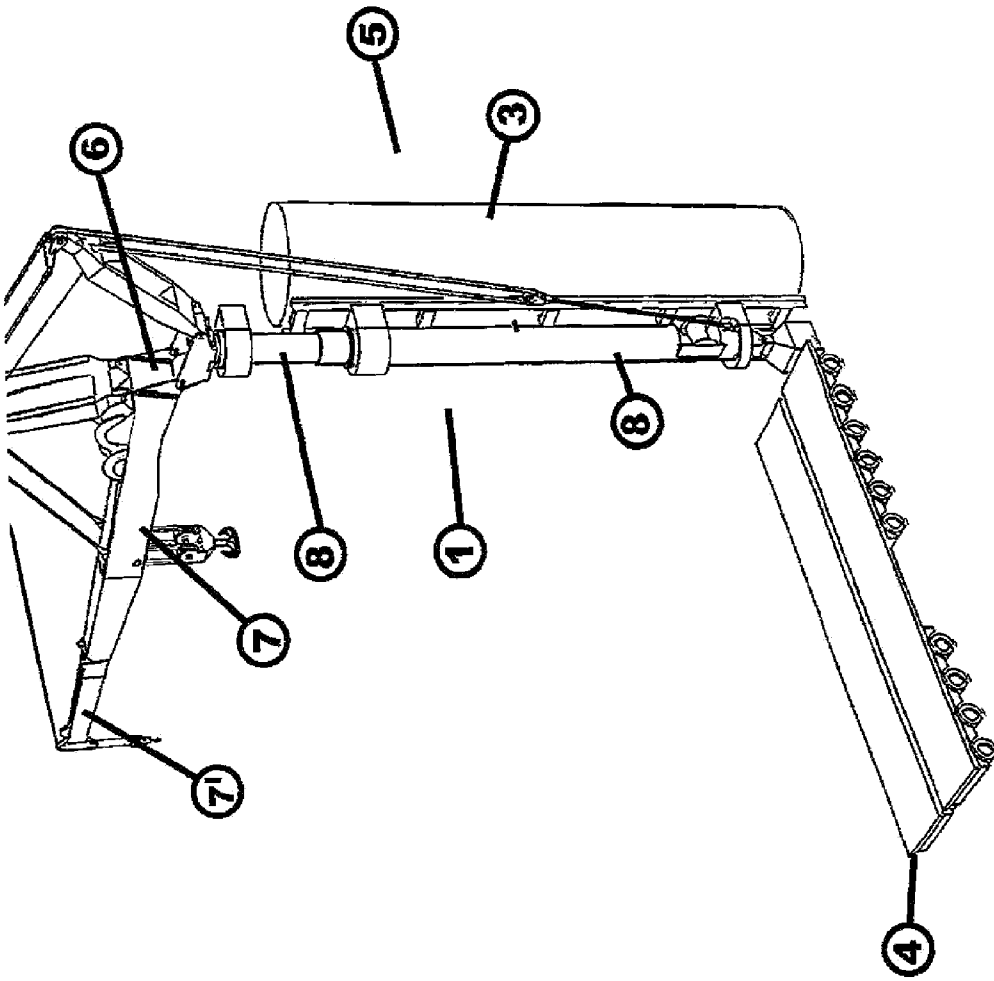


FIG 7

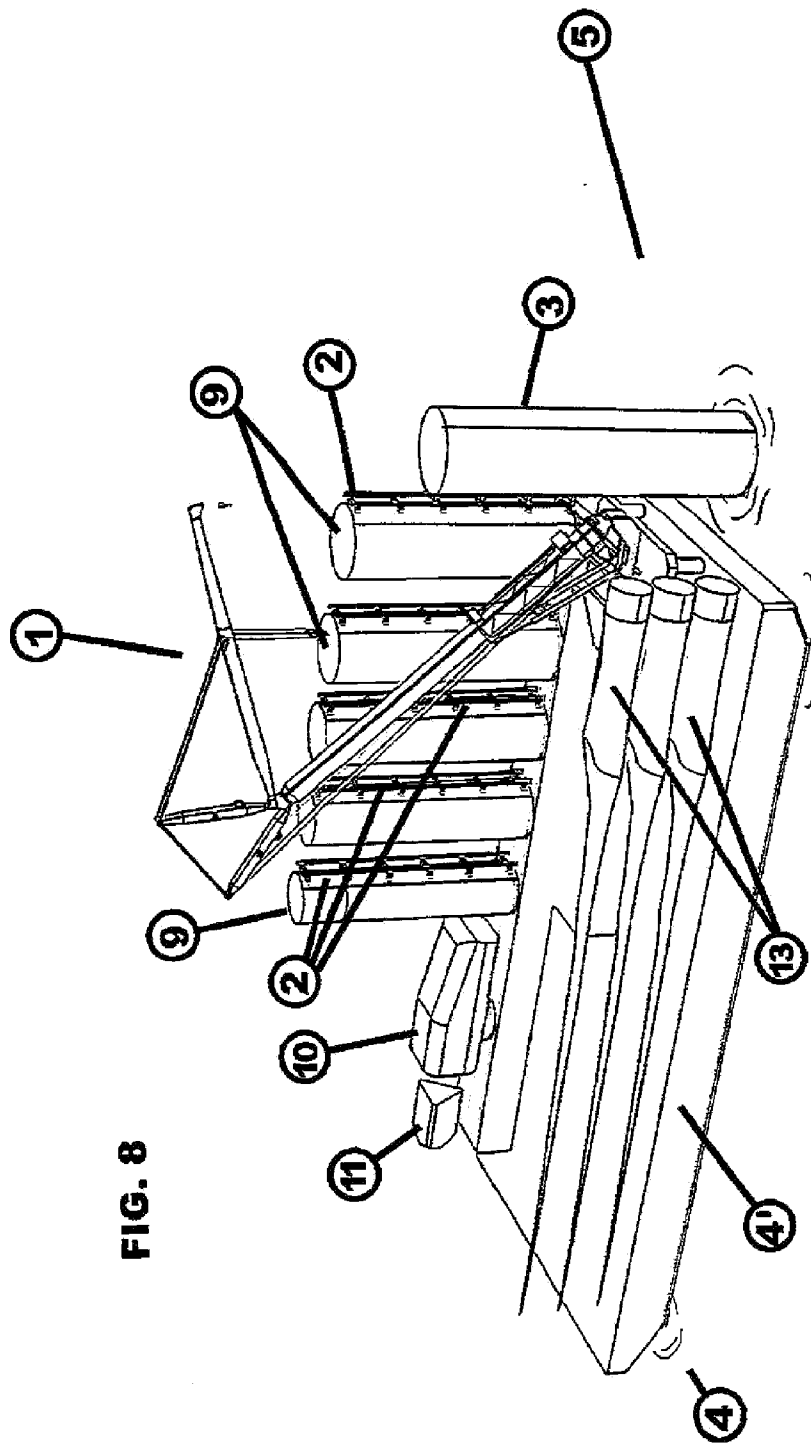
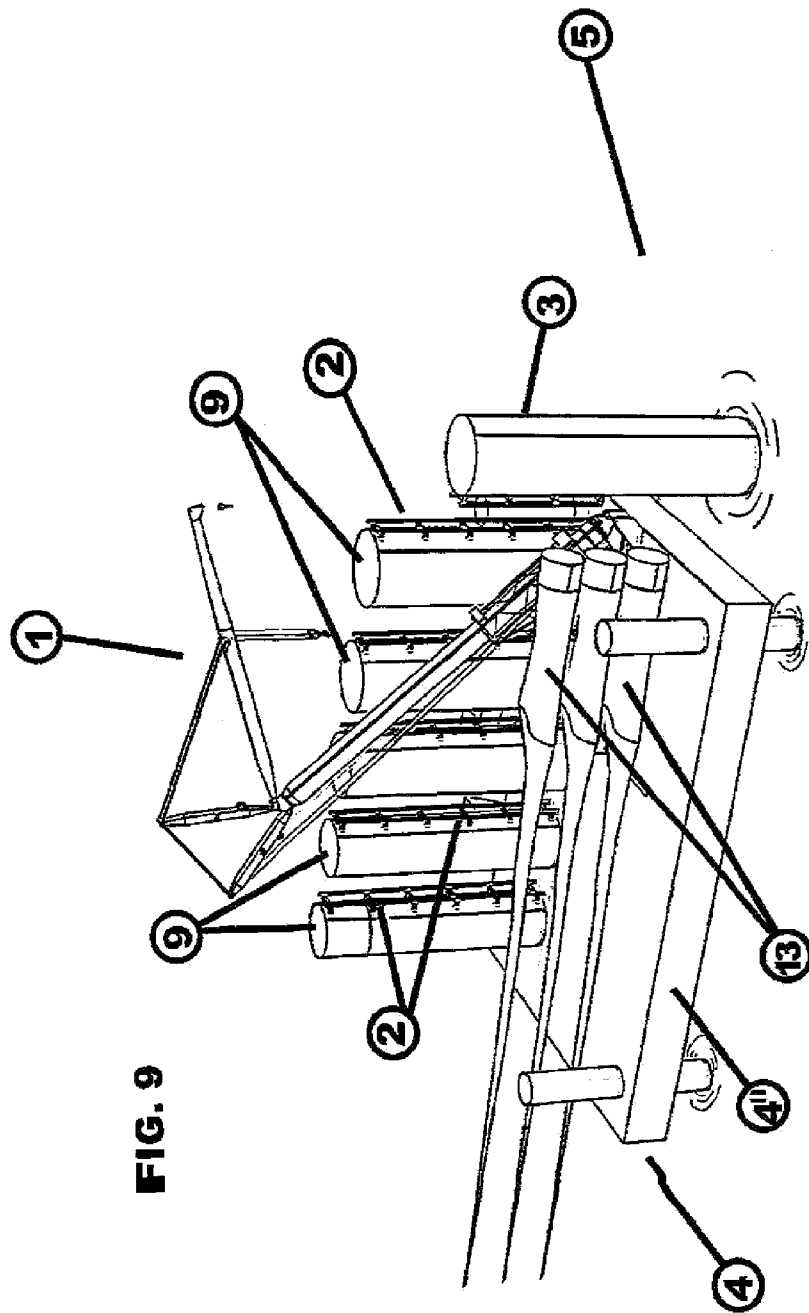


FIG. 8



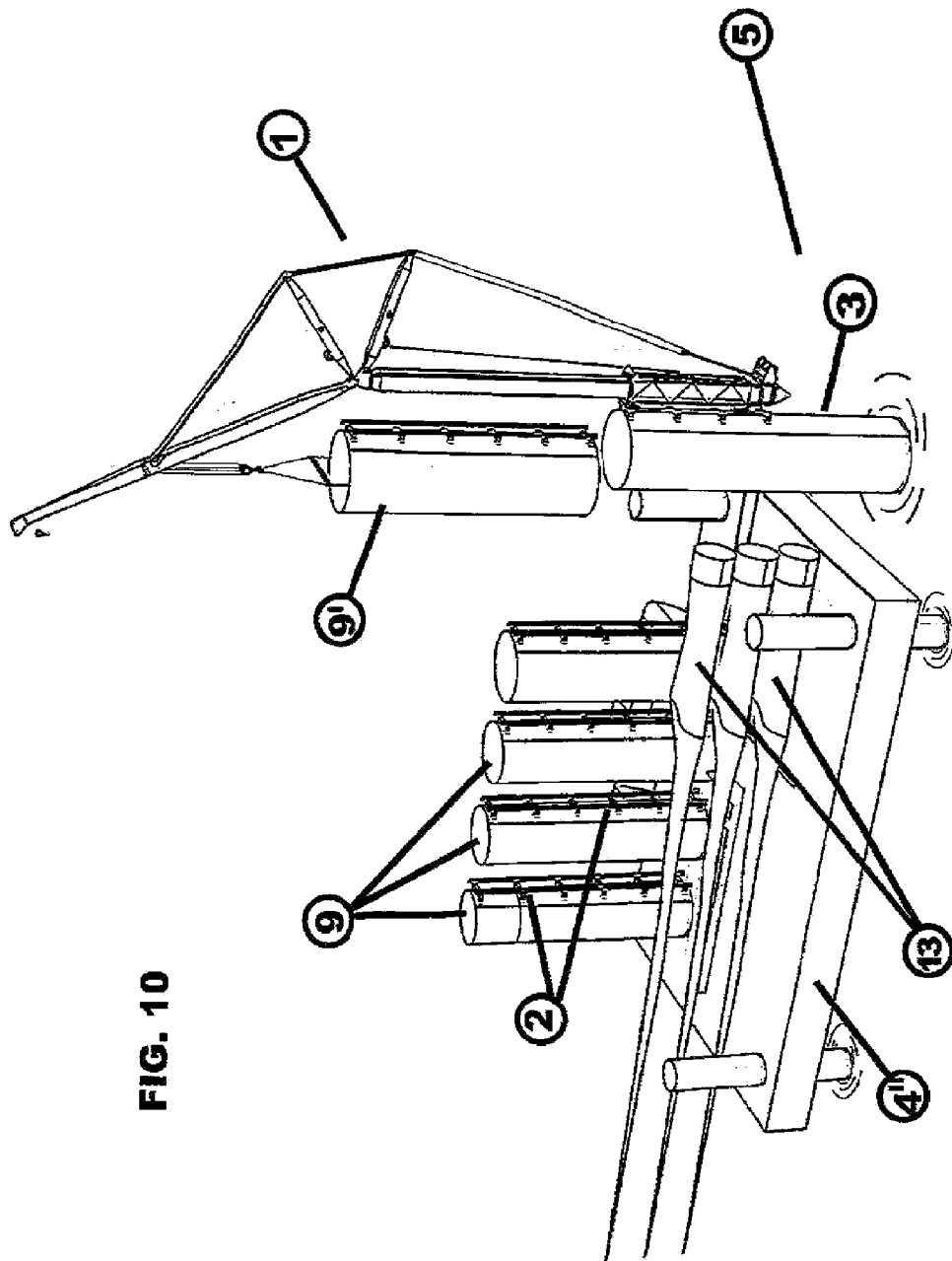


FIG. 10

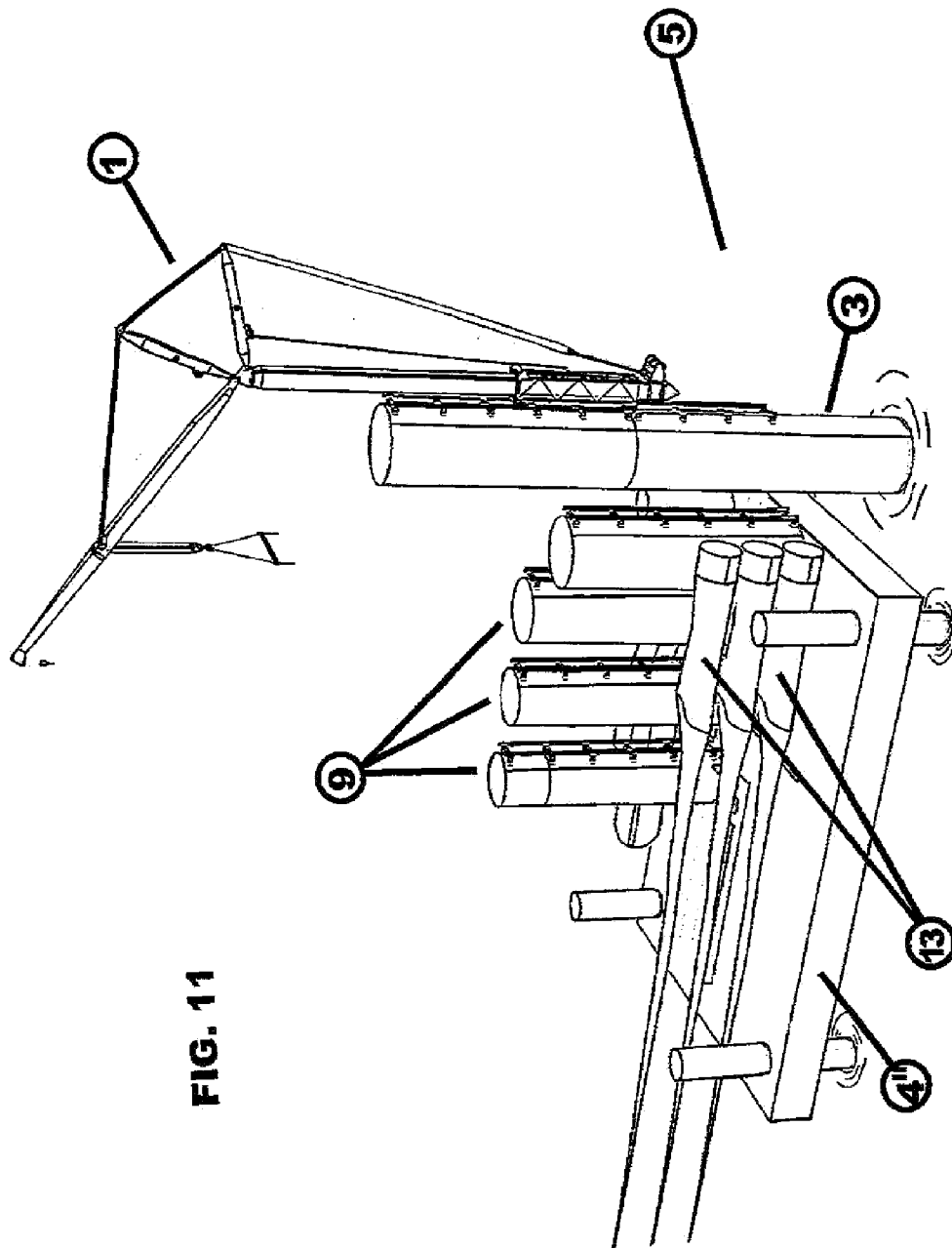


FIG. 11

FIG. 12

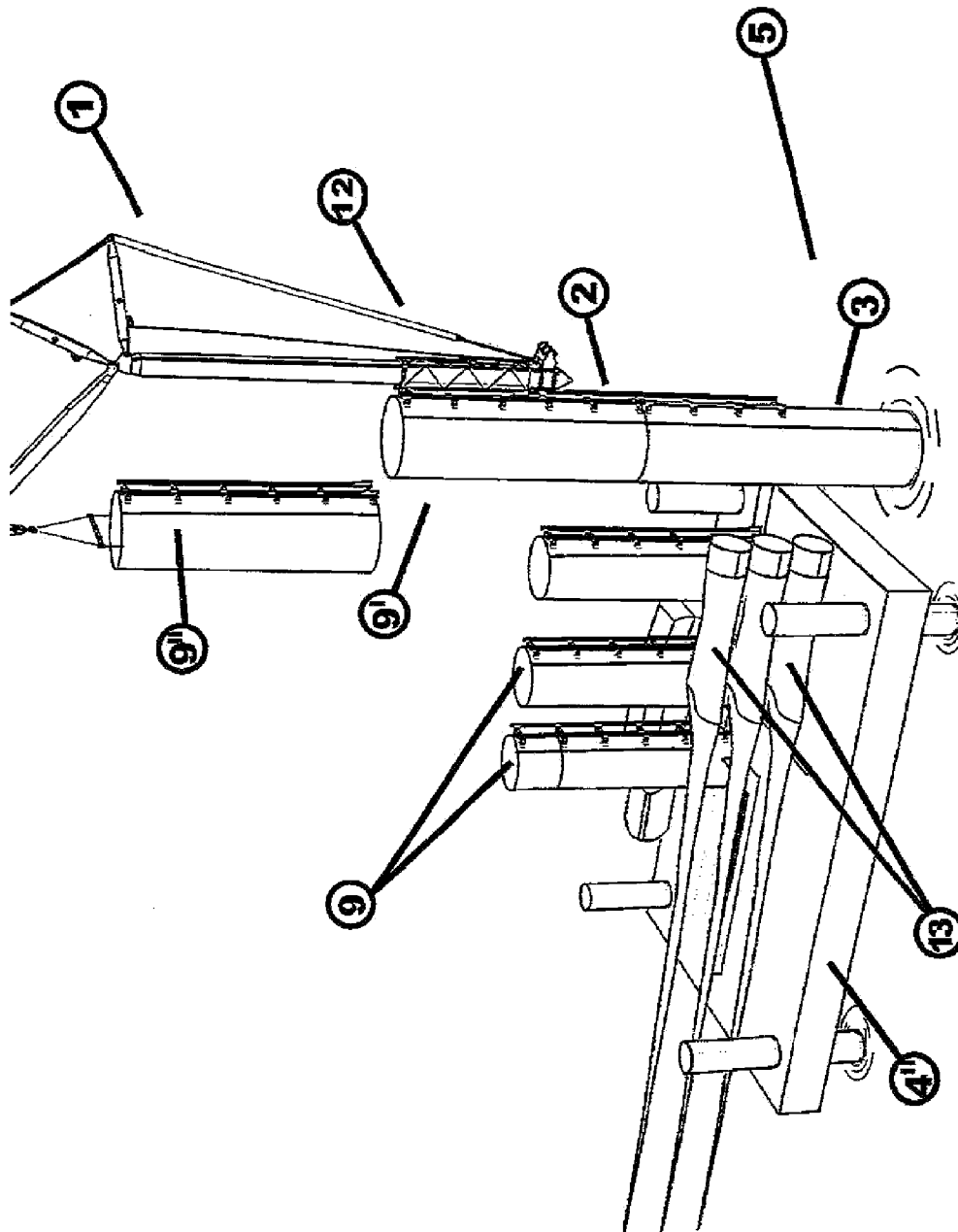


FIG. 13

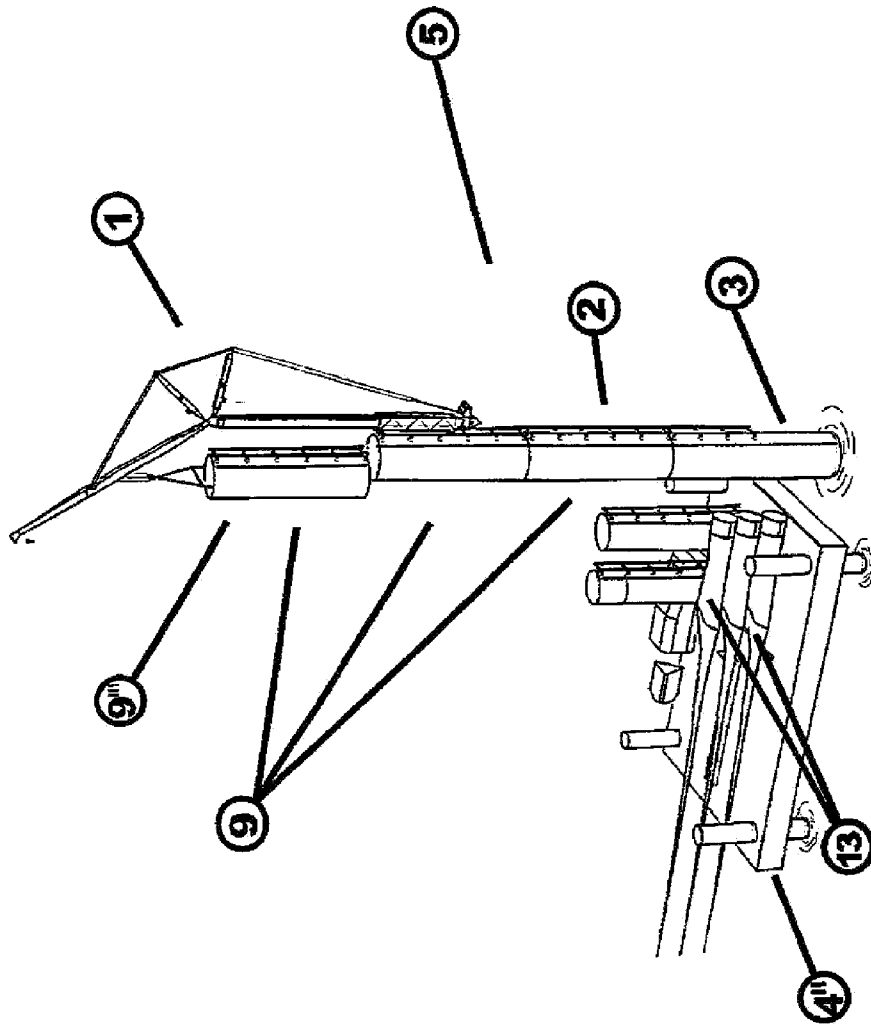


FIG. 14

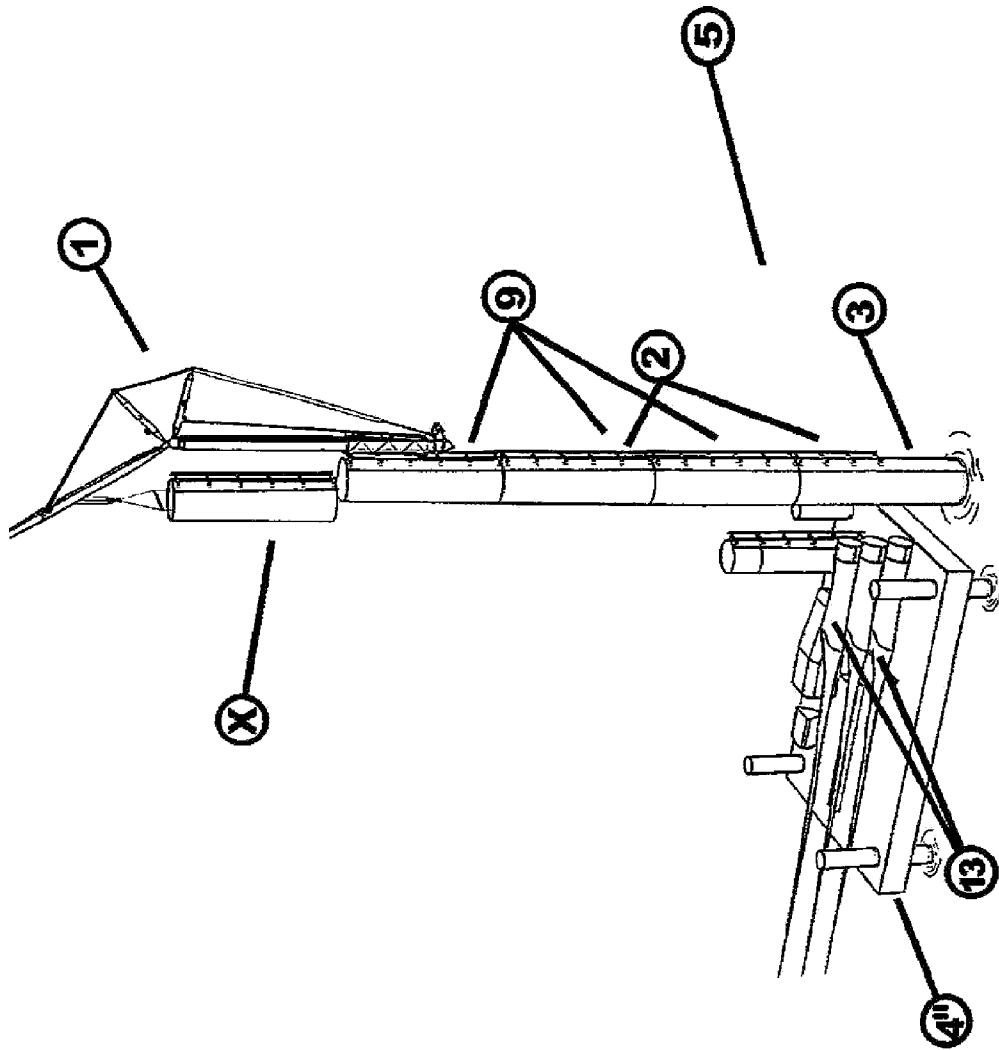


FIG. 15

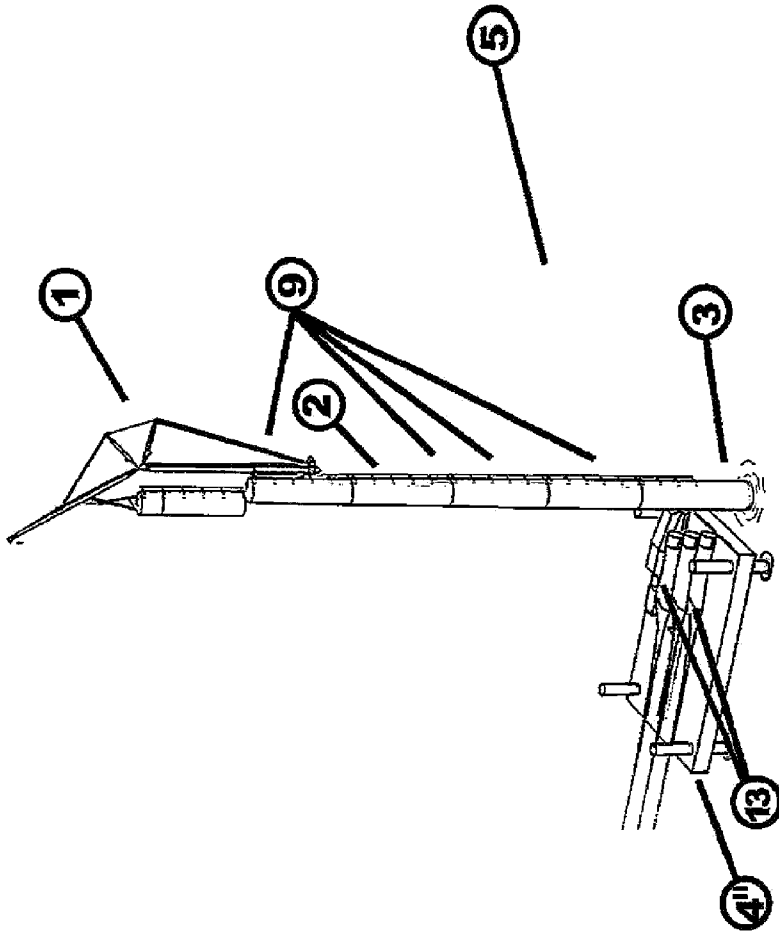


FIG. 16

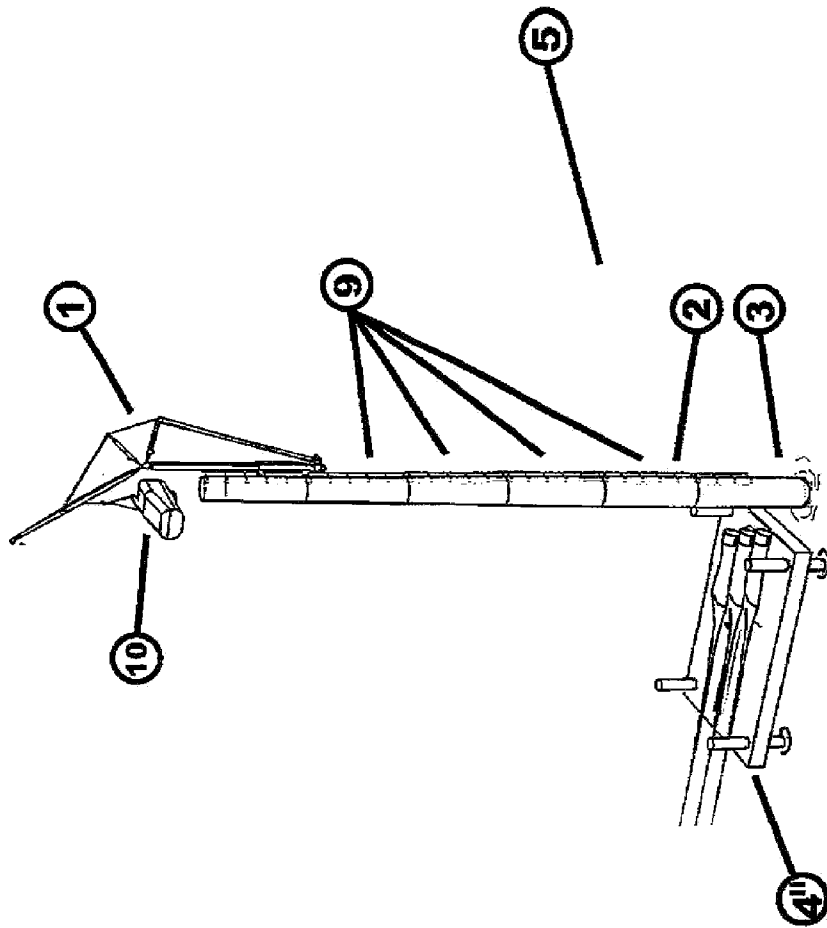


FIG. 17

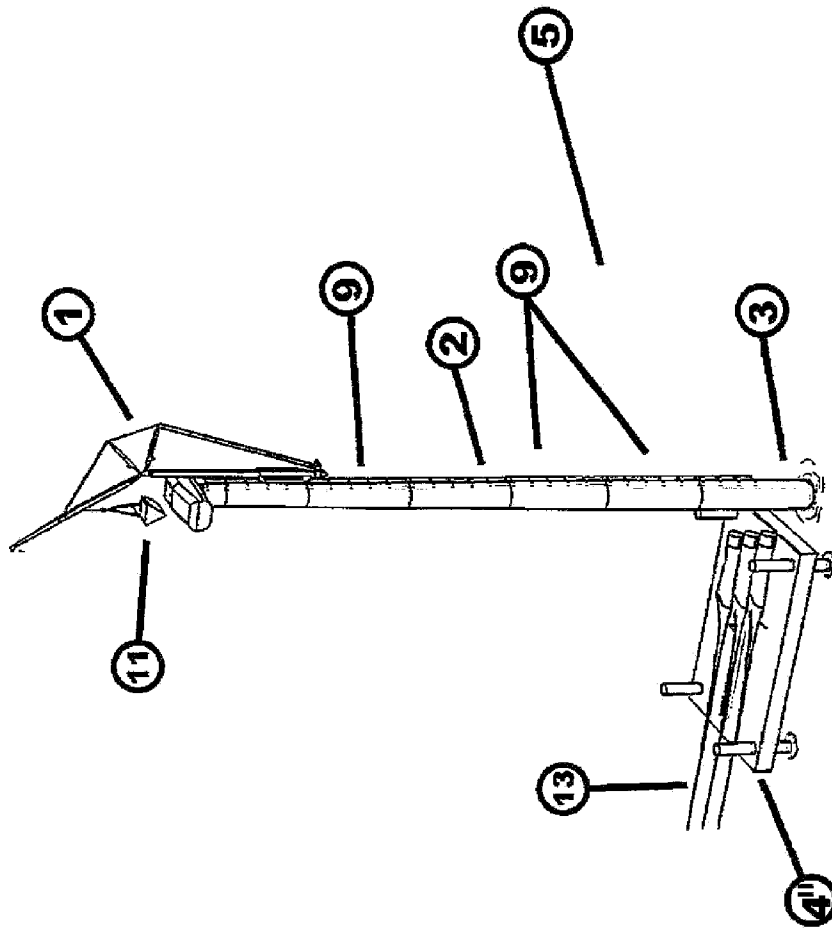
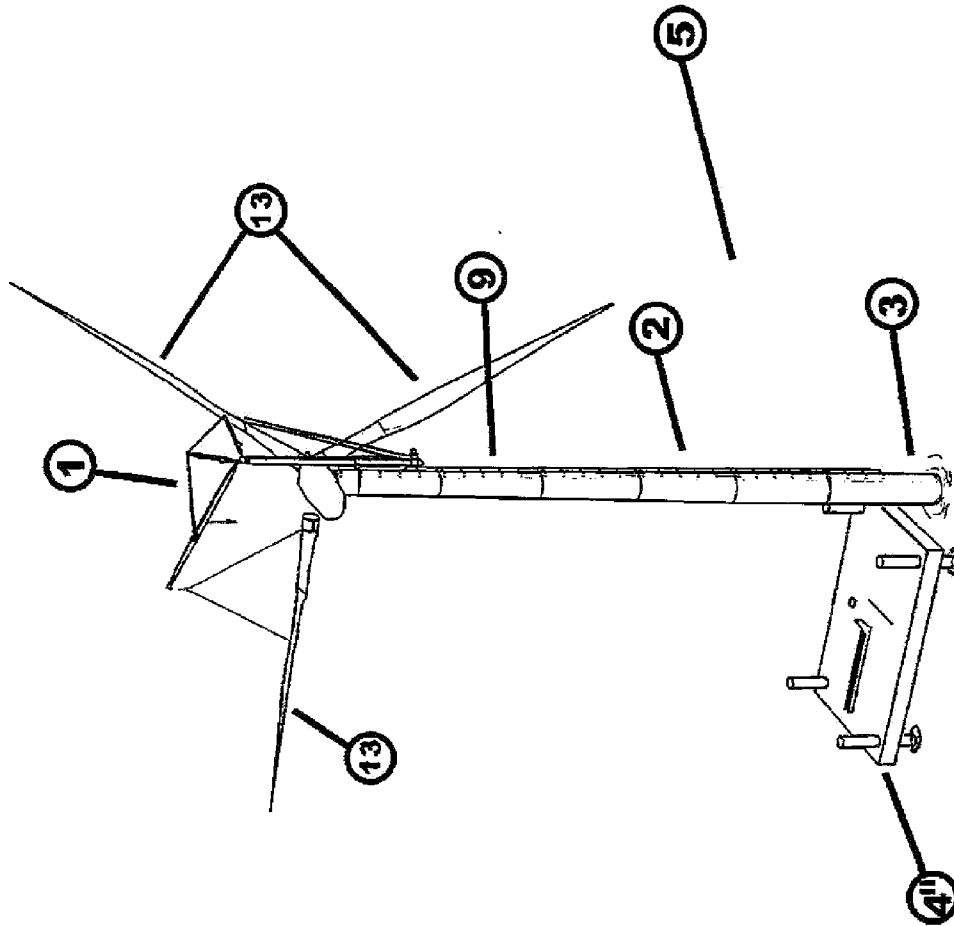


FIG. 18



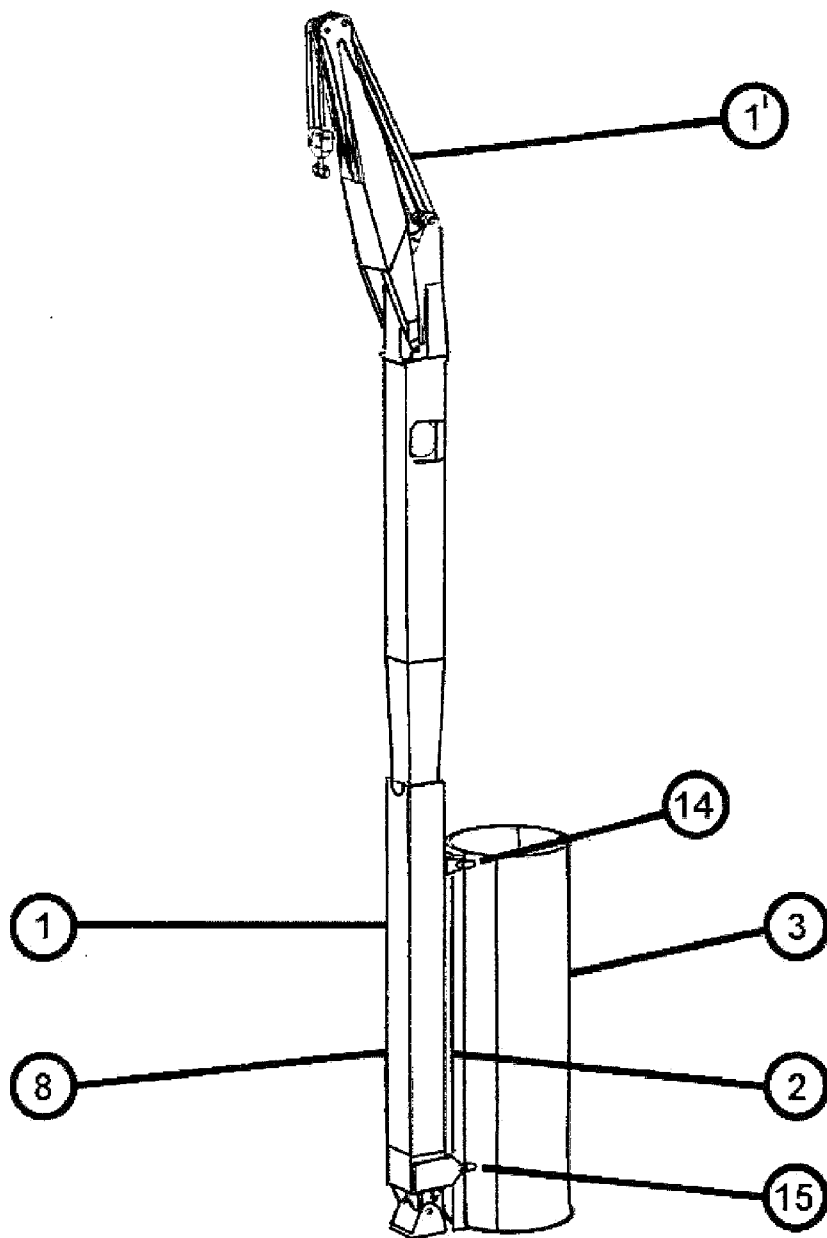


FIG. 19

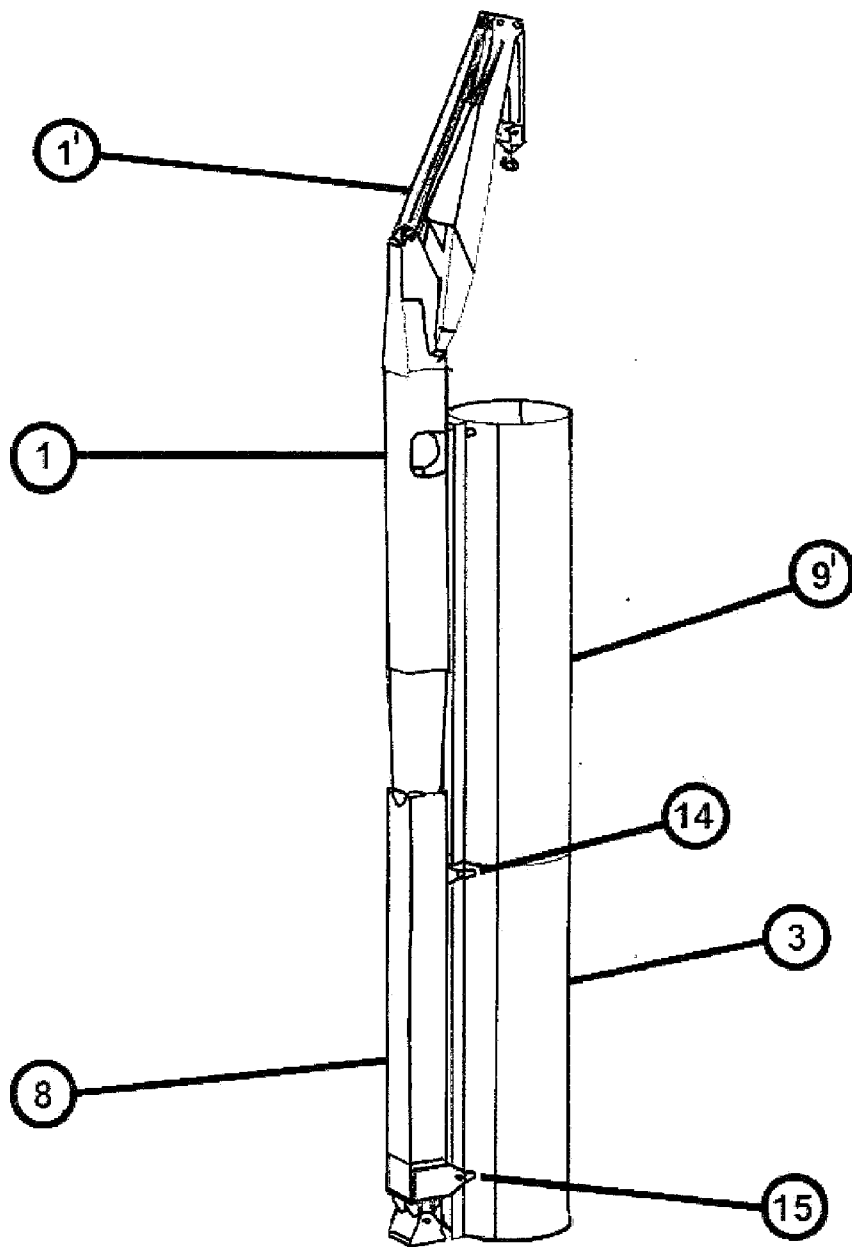


FIG. 20

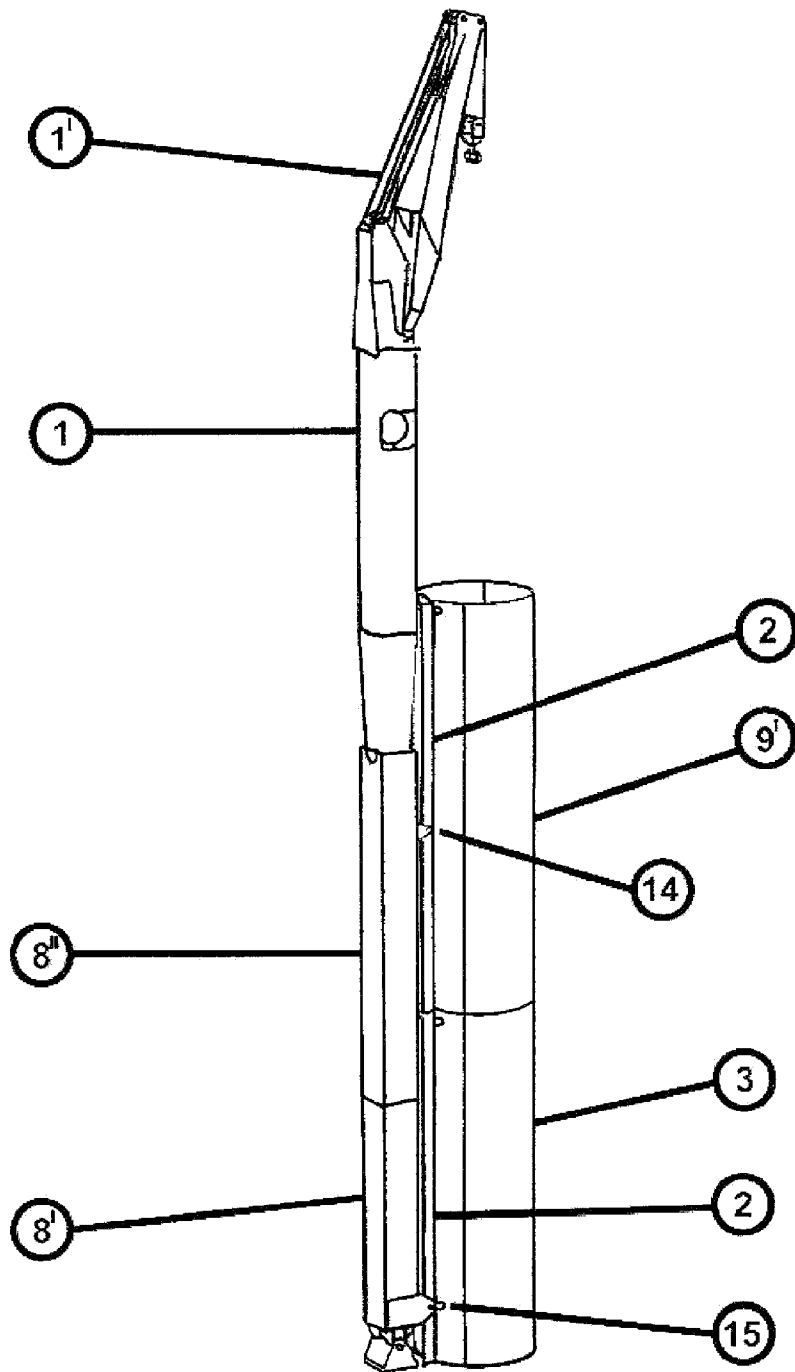


FIG. 21

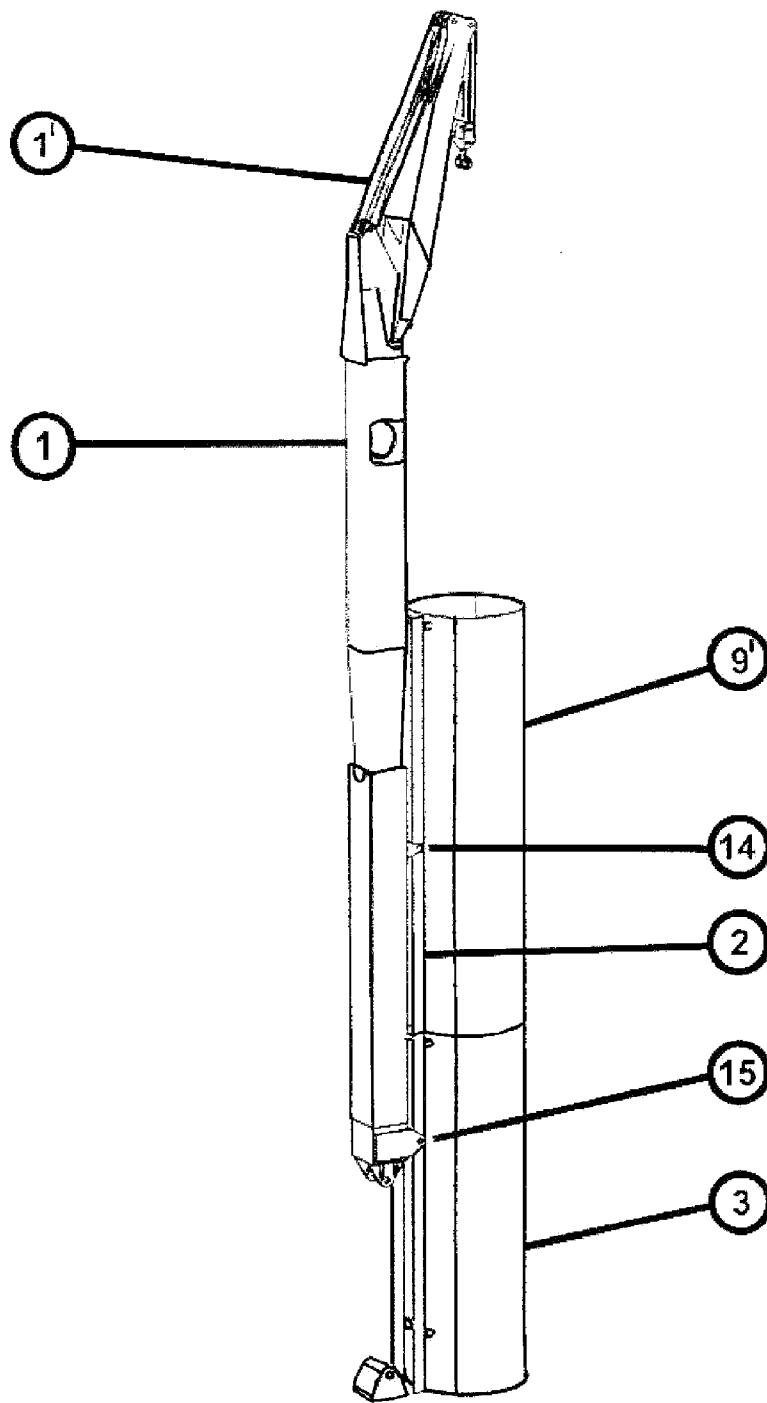


FIG. 22

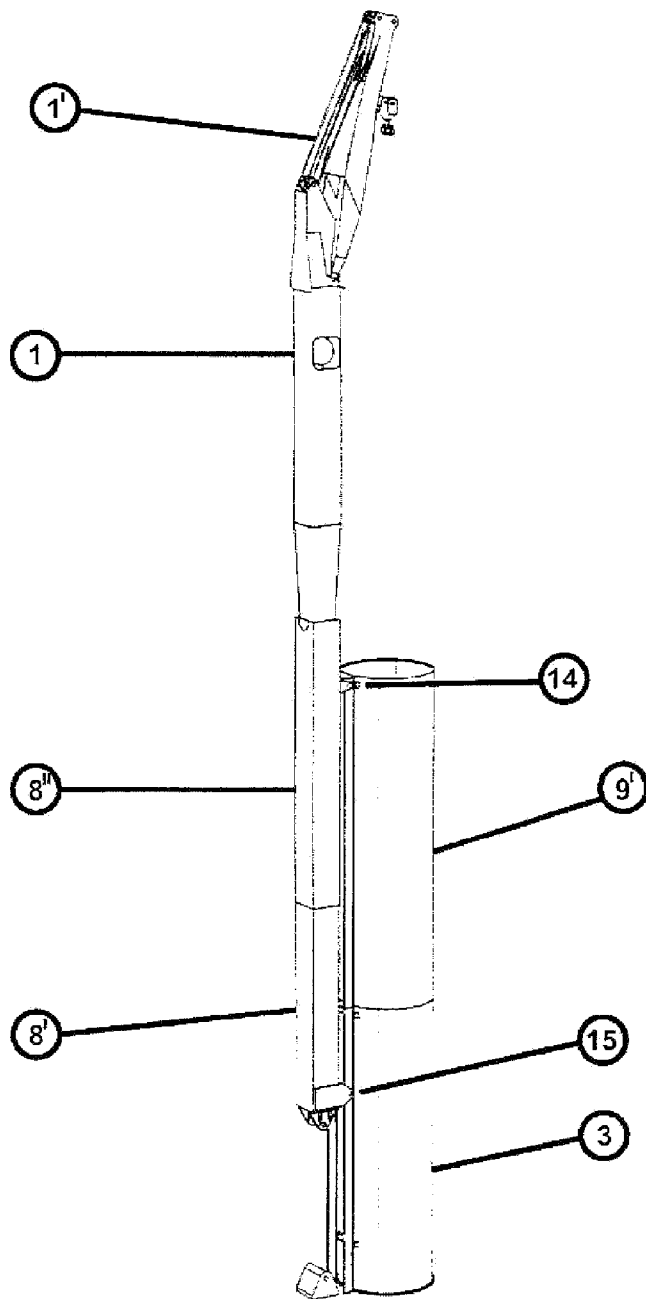


FIG. 23

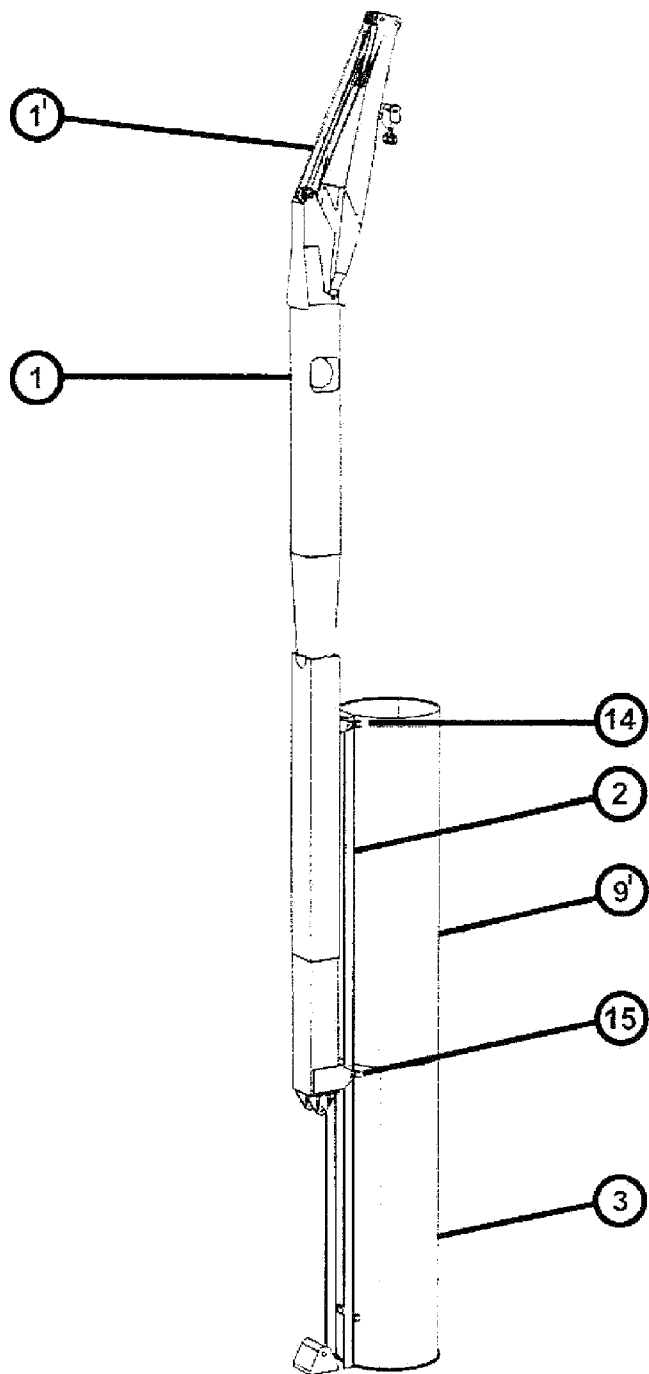


FIG. 24

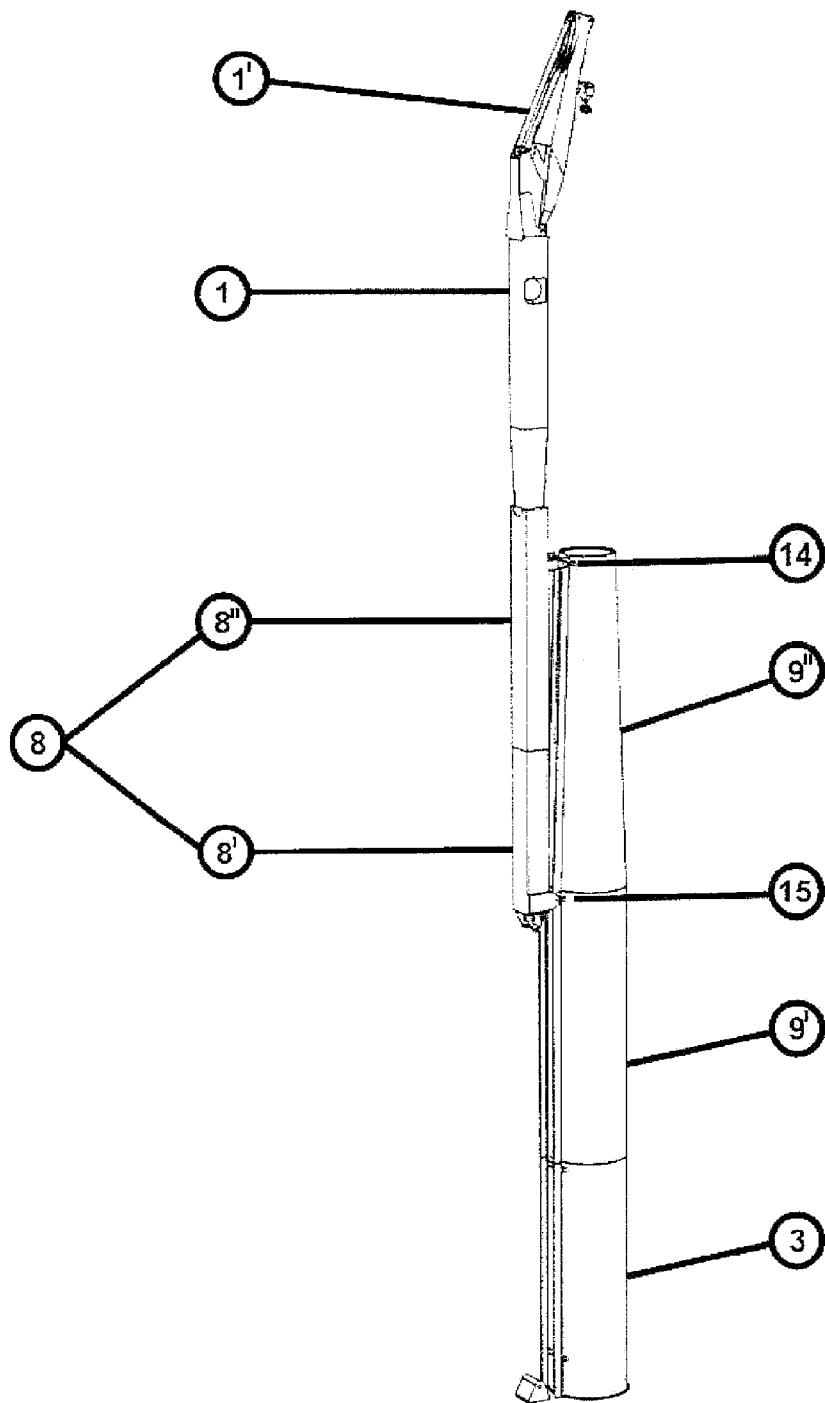


FIG. 25

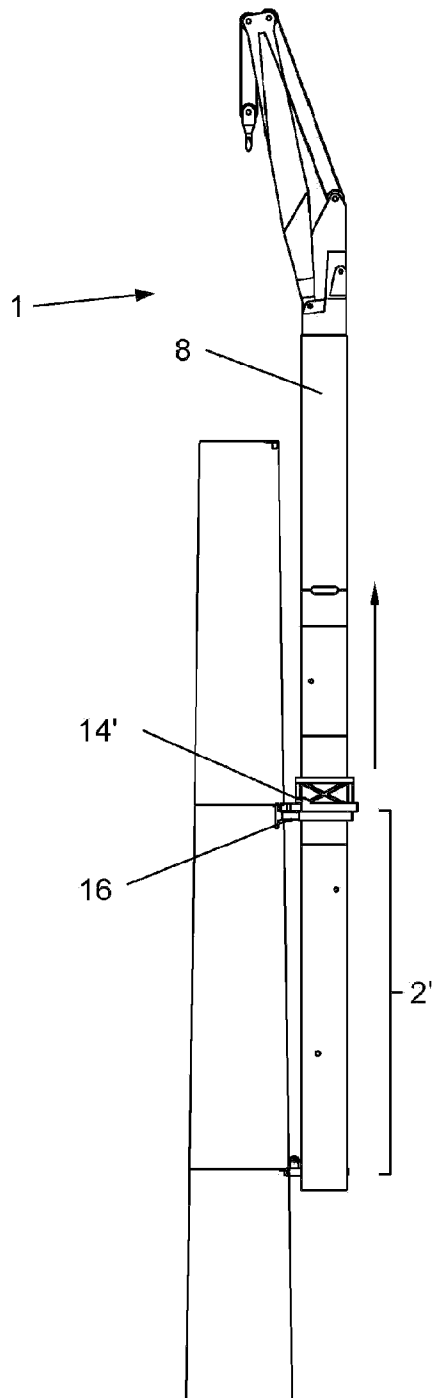


FIG. 26

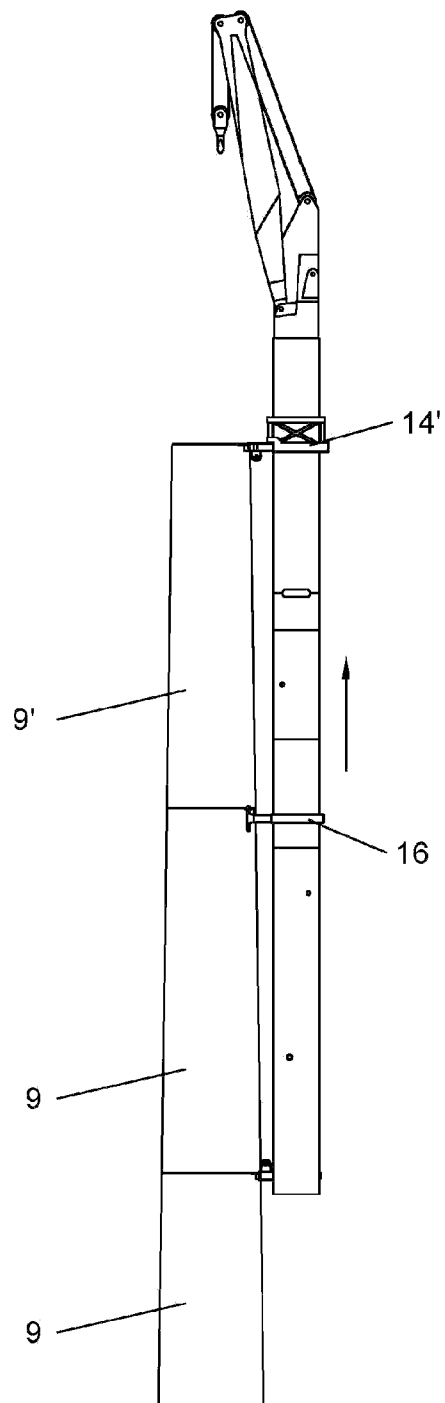


FIG. 27

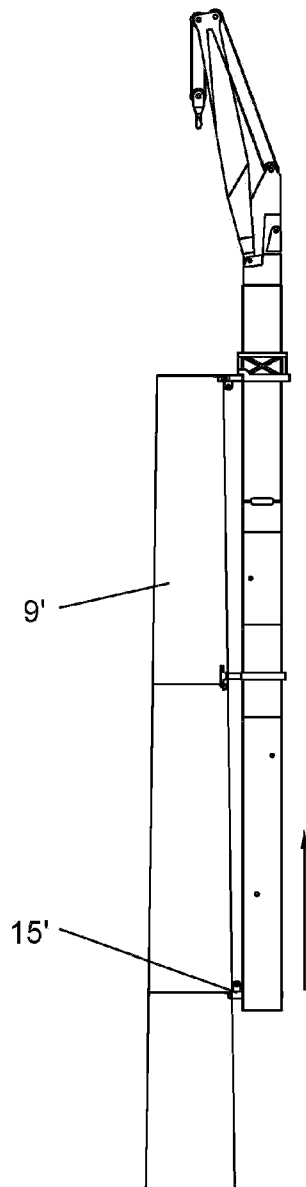


FIG. 28

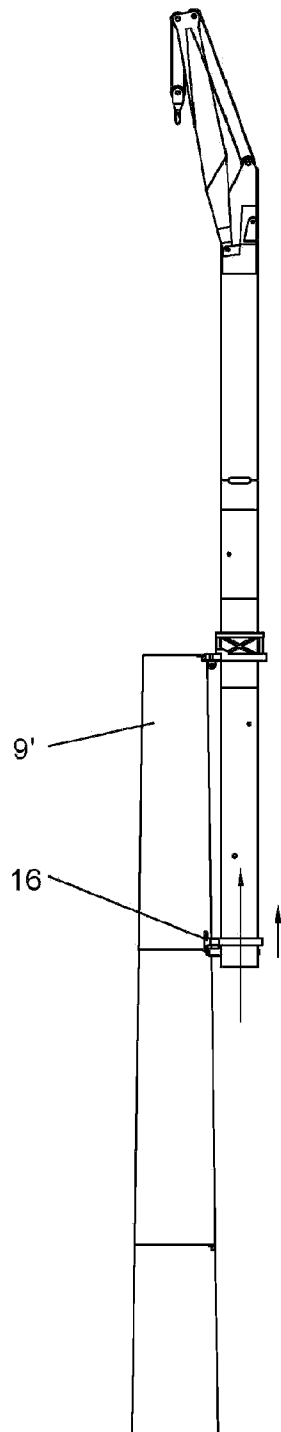


FIG. 29

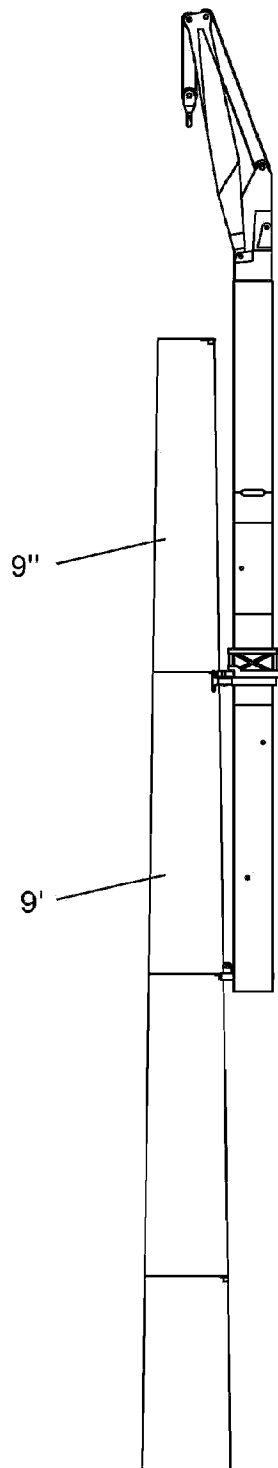


FIG. 30

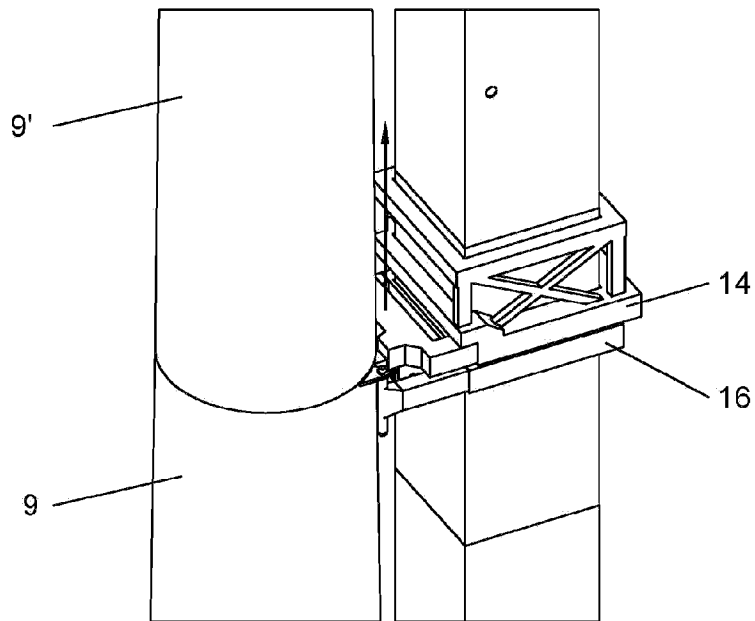


FIG 31

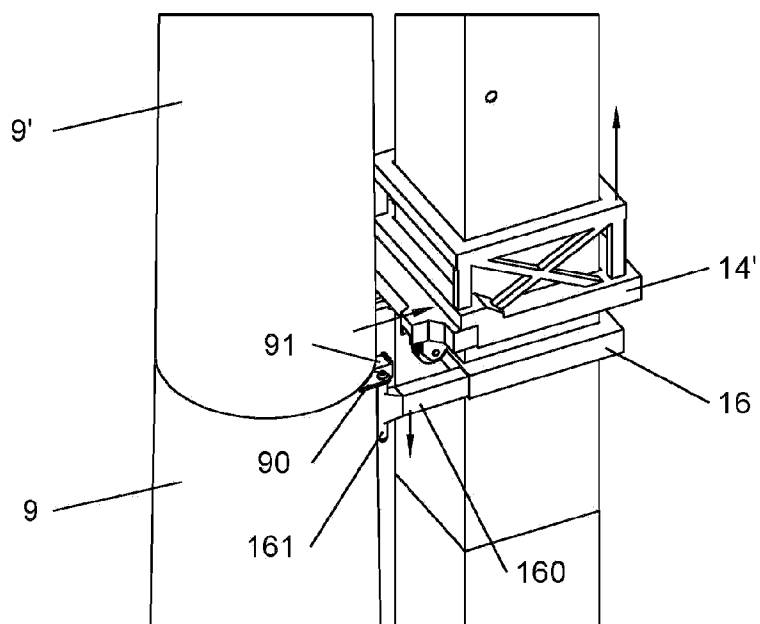


FIG 32

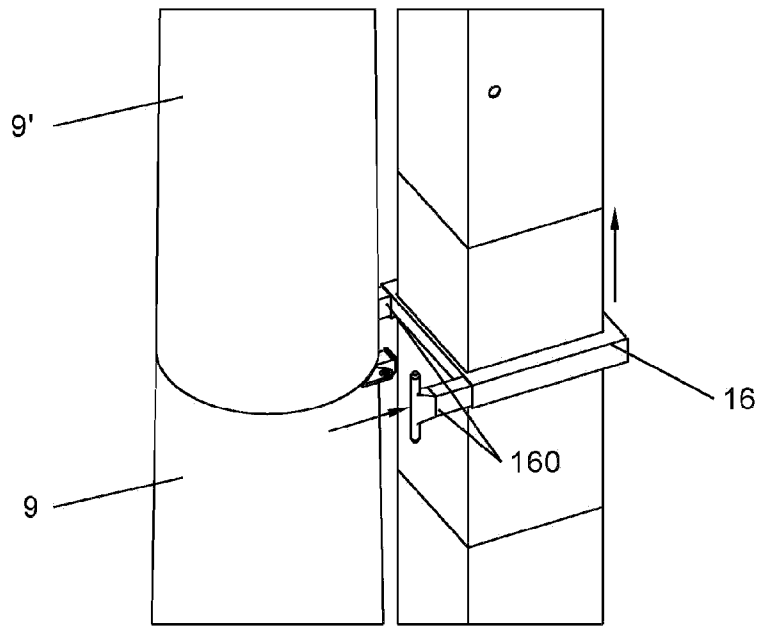


FIG. 33

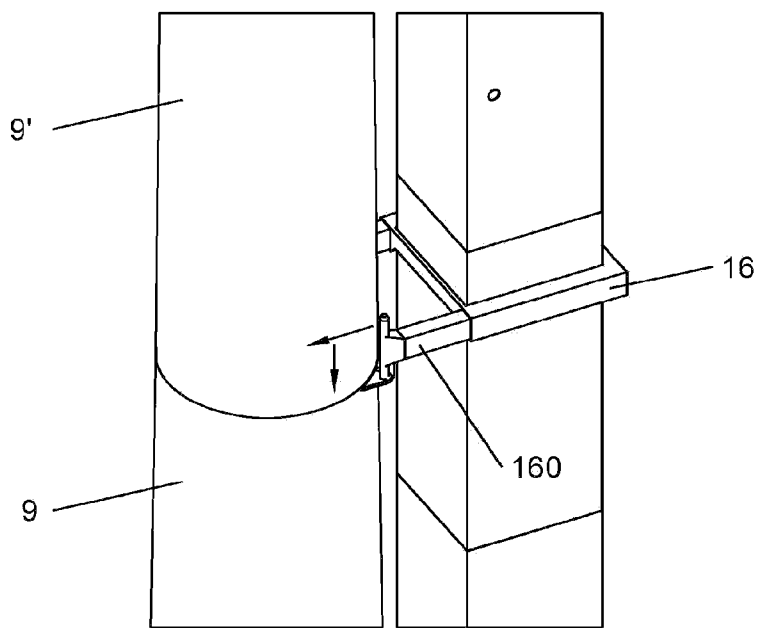


FIG. 34

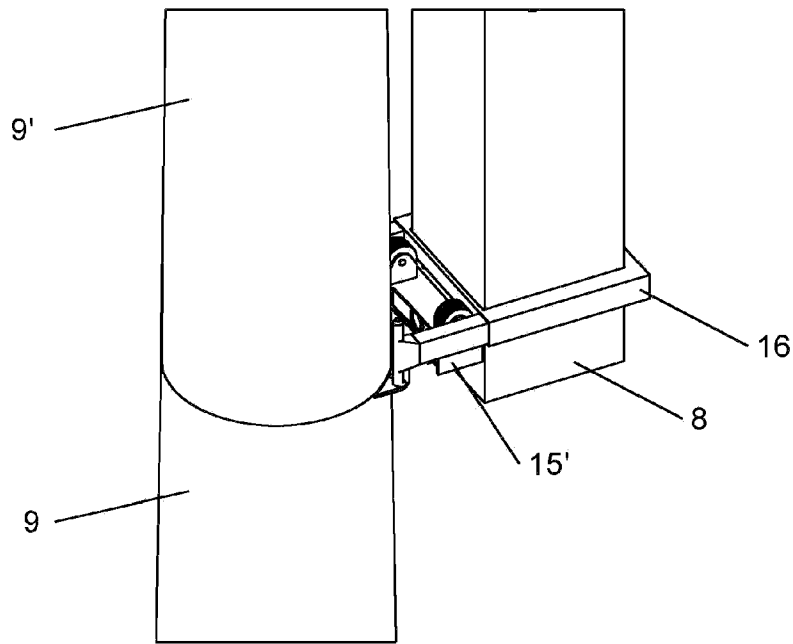


FIG. 35

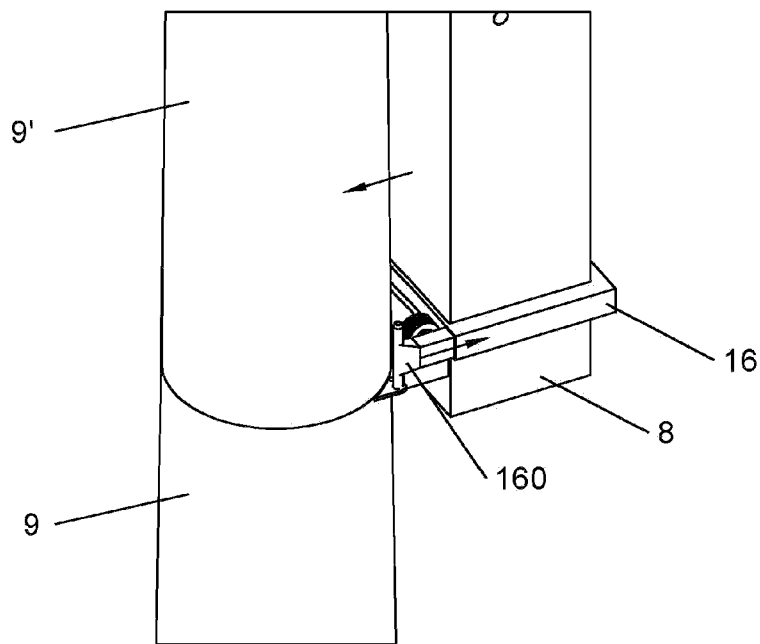


FIG. 36

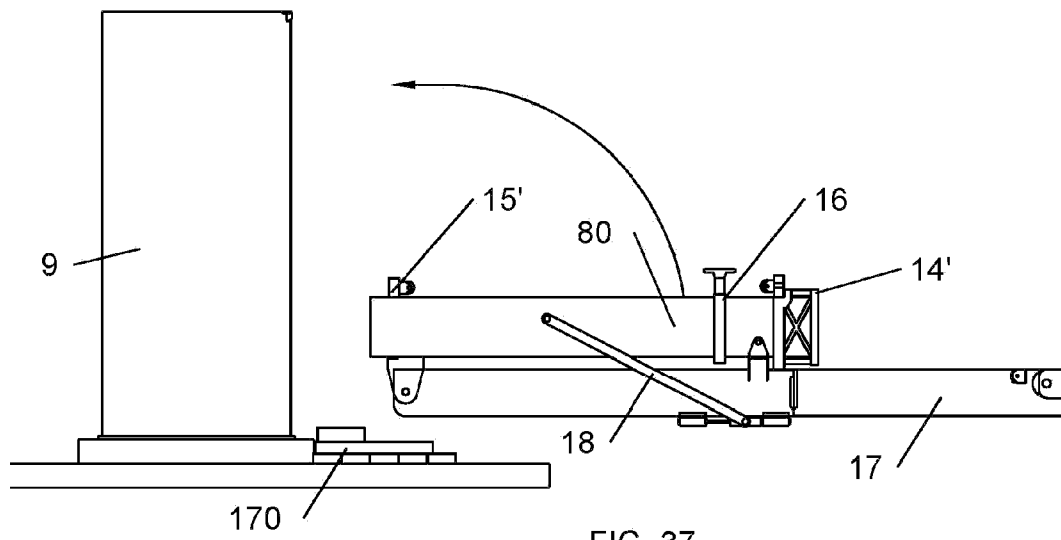


FIG. 37

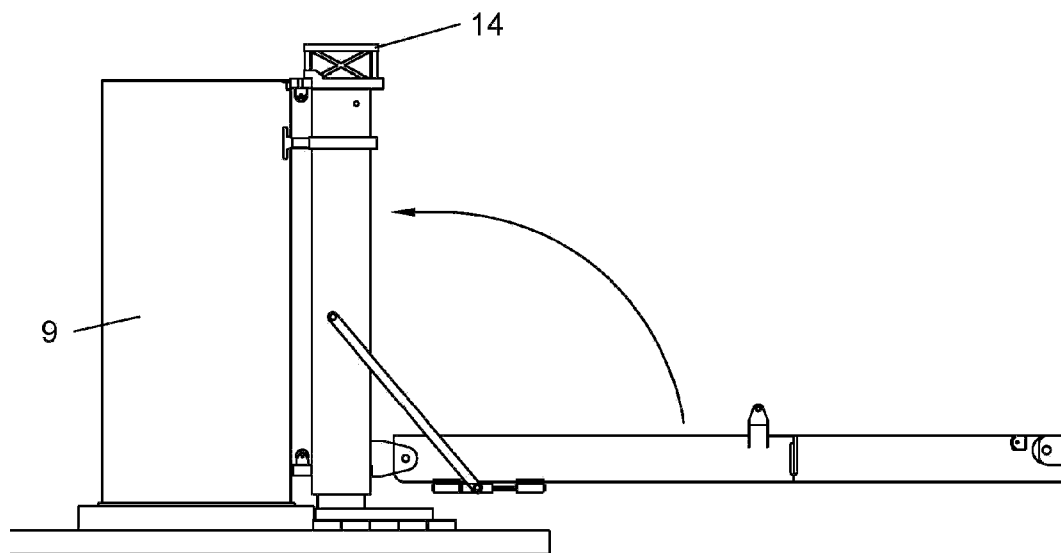


FIG. 38

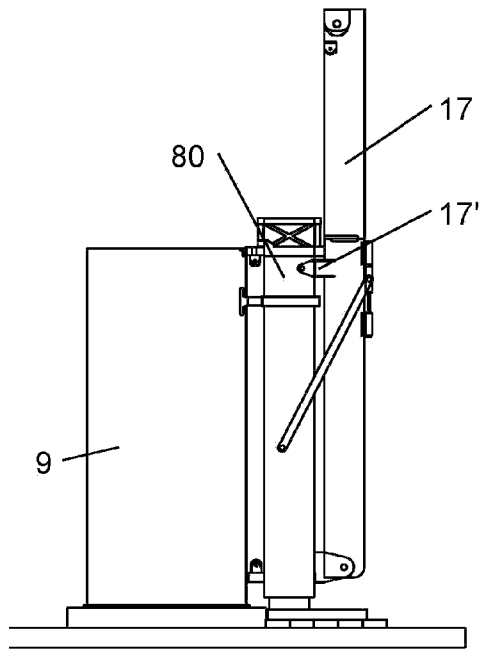


FIG. 39

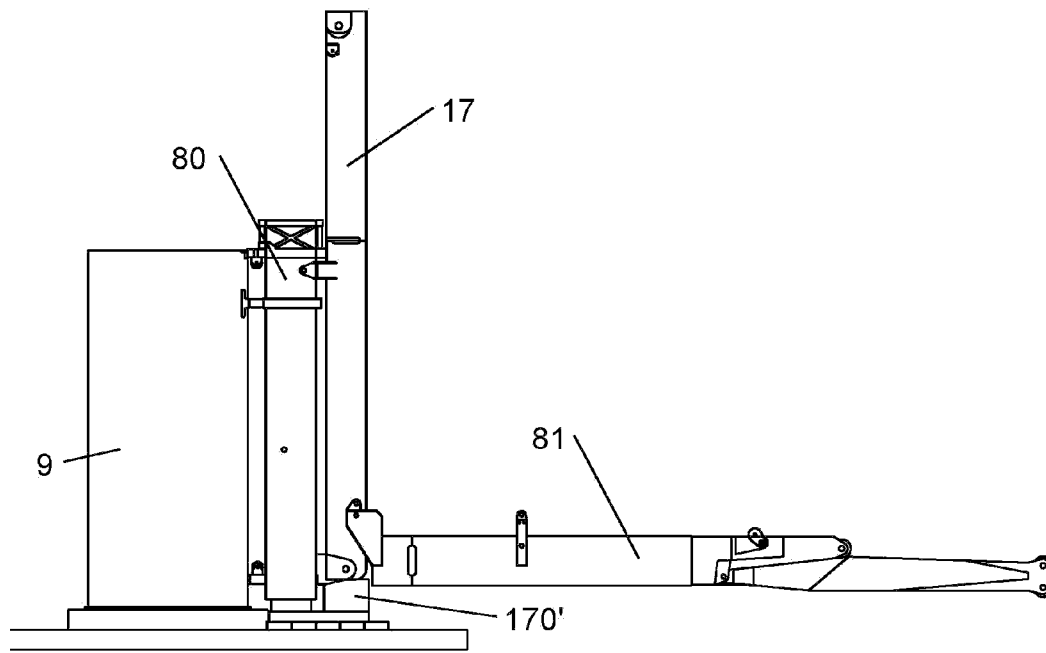


FIG. 40

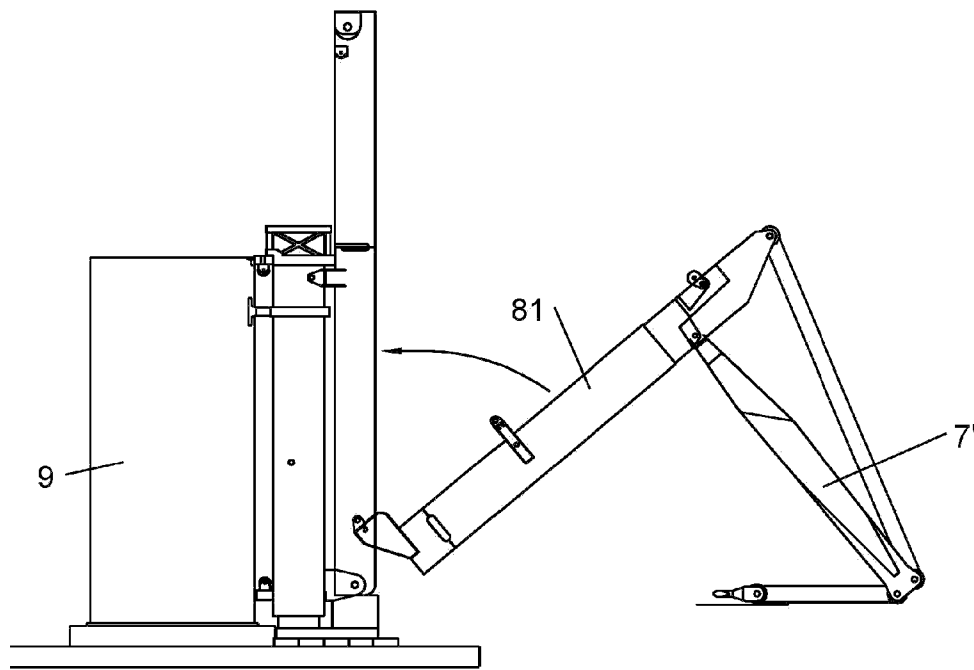


FIG. 41

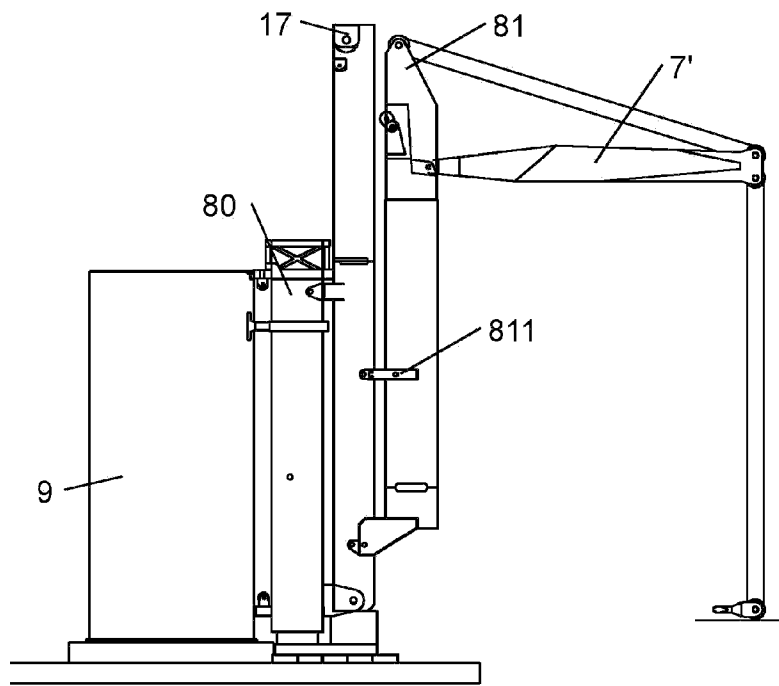


FIG. 42

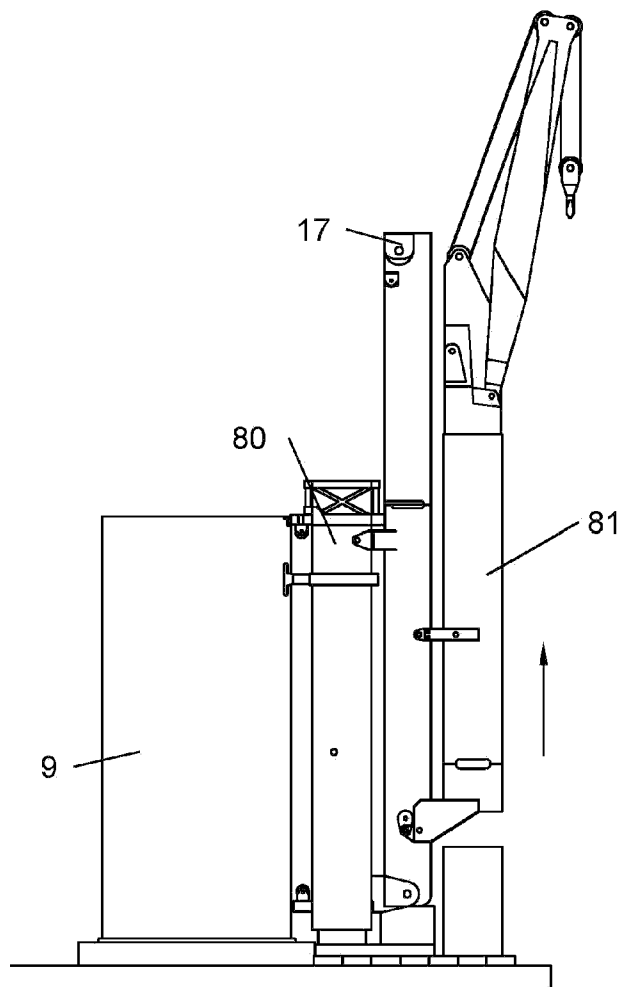


FIG. 43

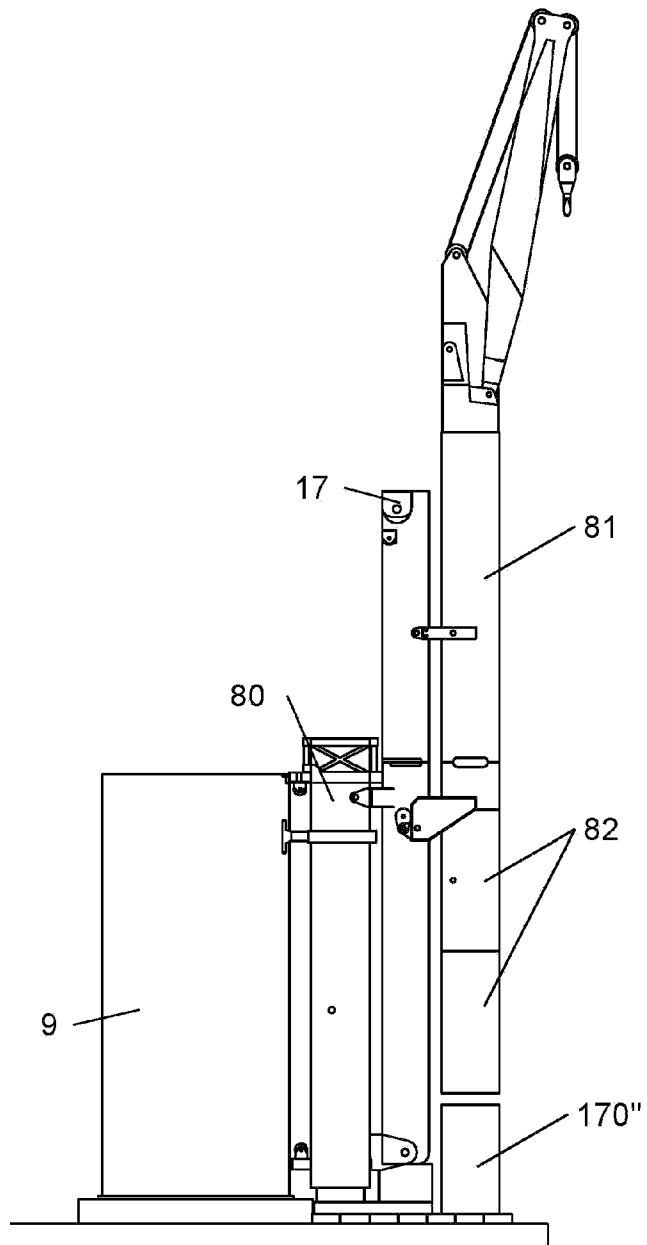


FIG. 44

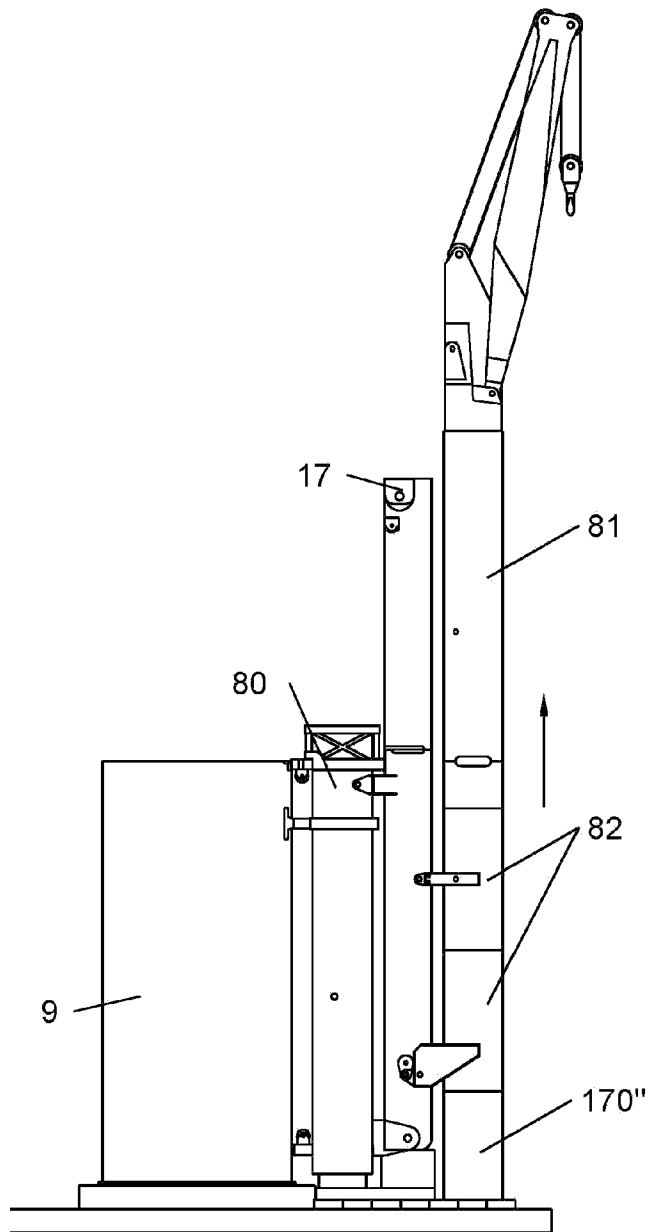


FIG. 45

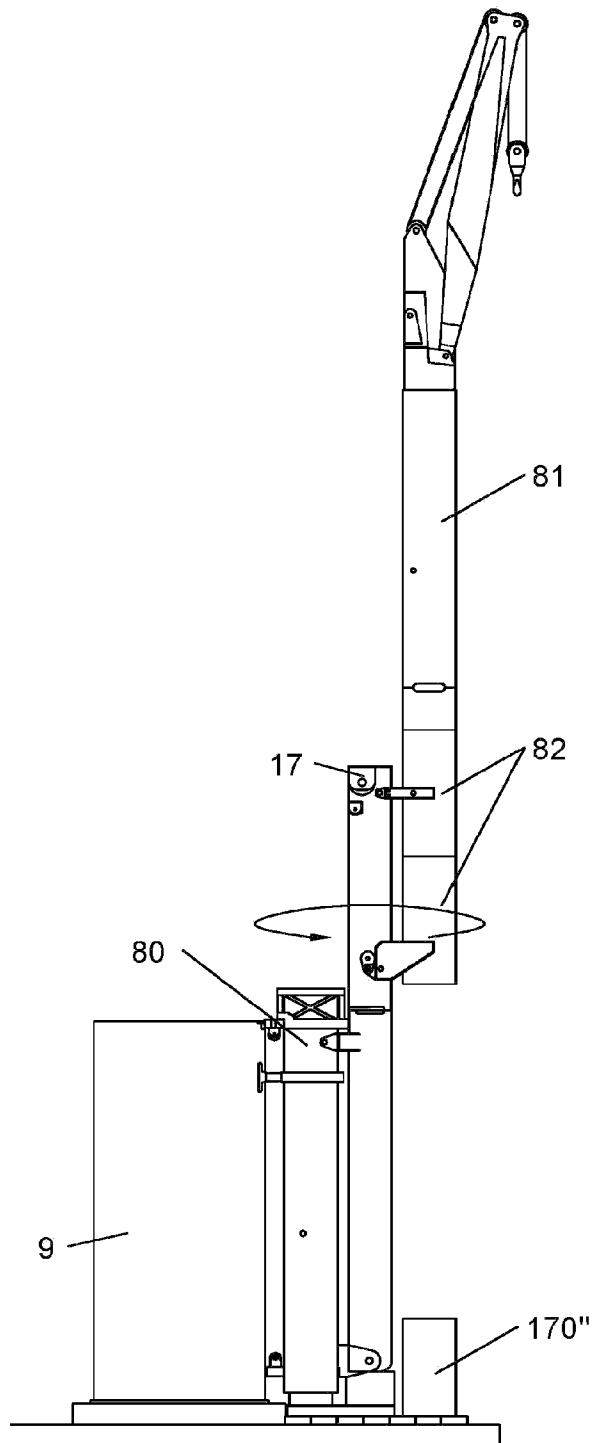


FIG. 46

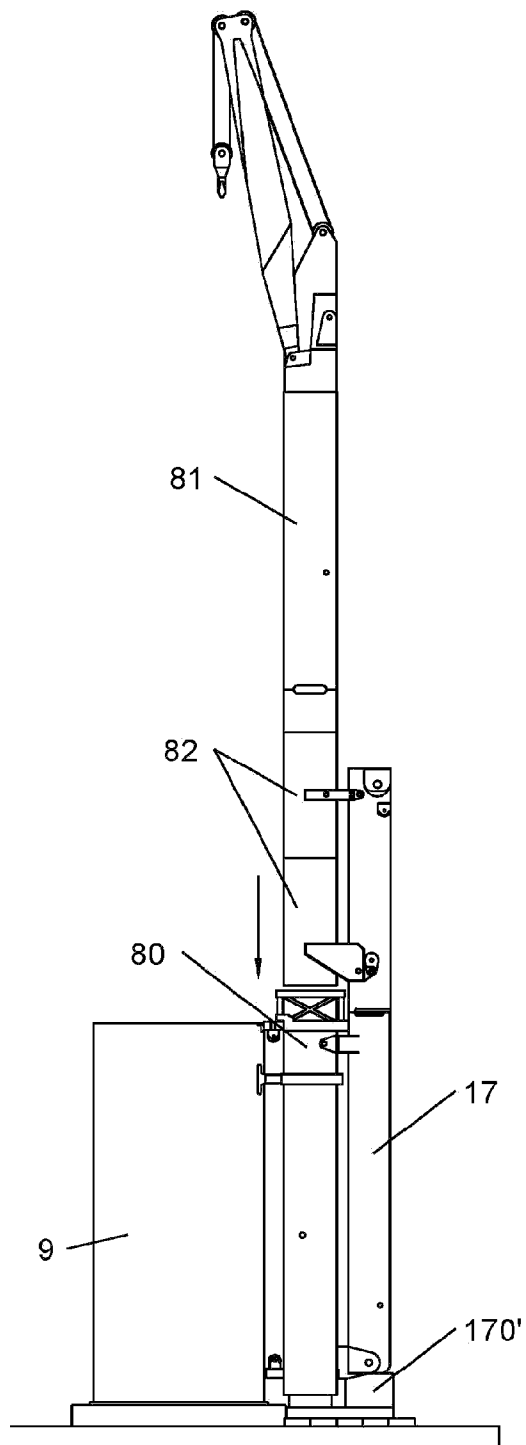


FIG. 47

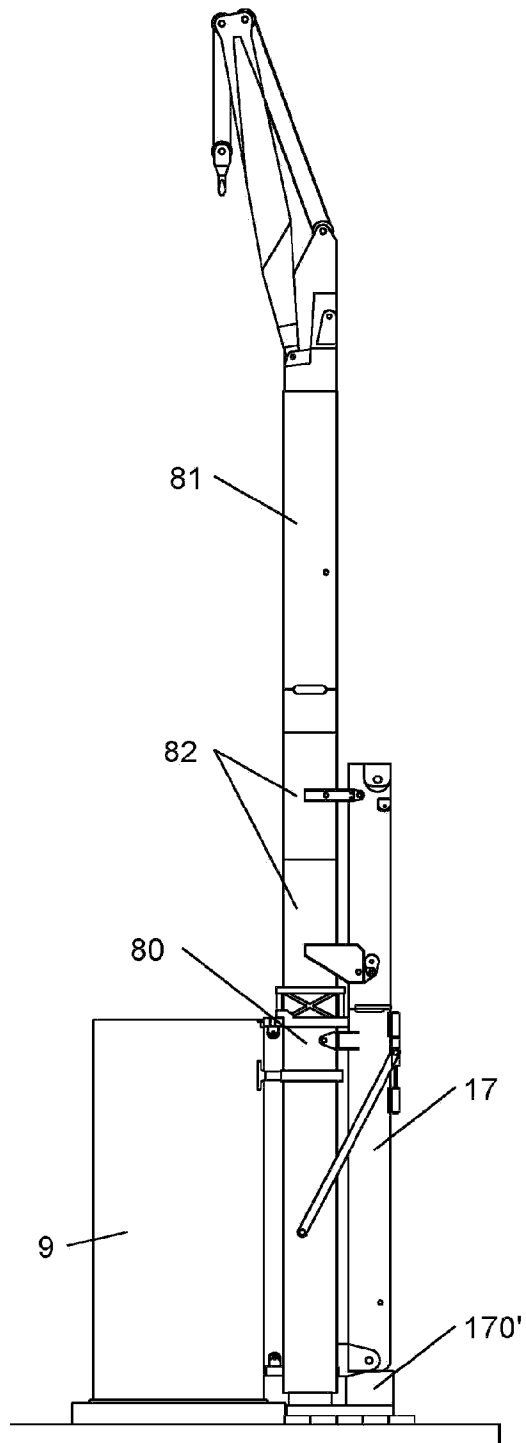


FIG. 48

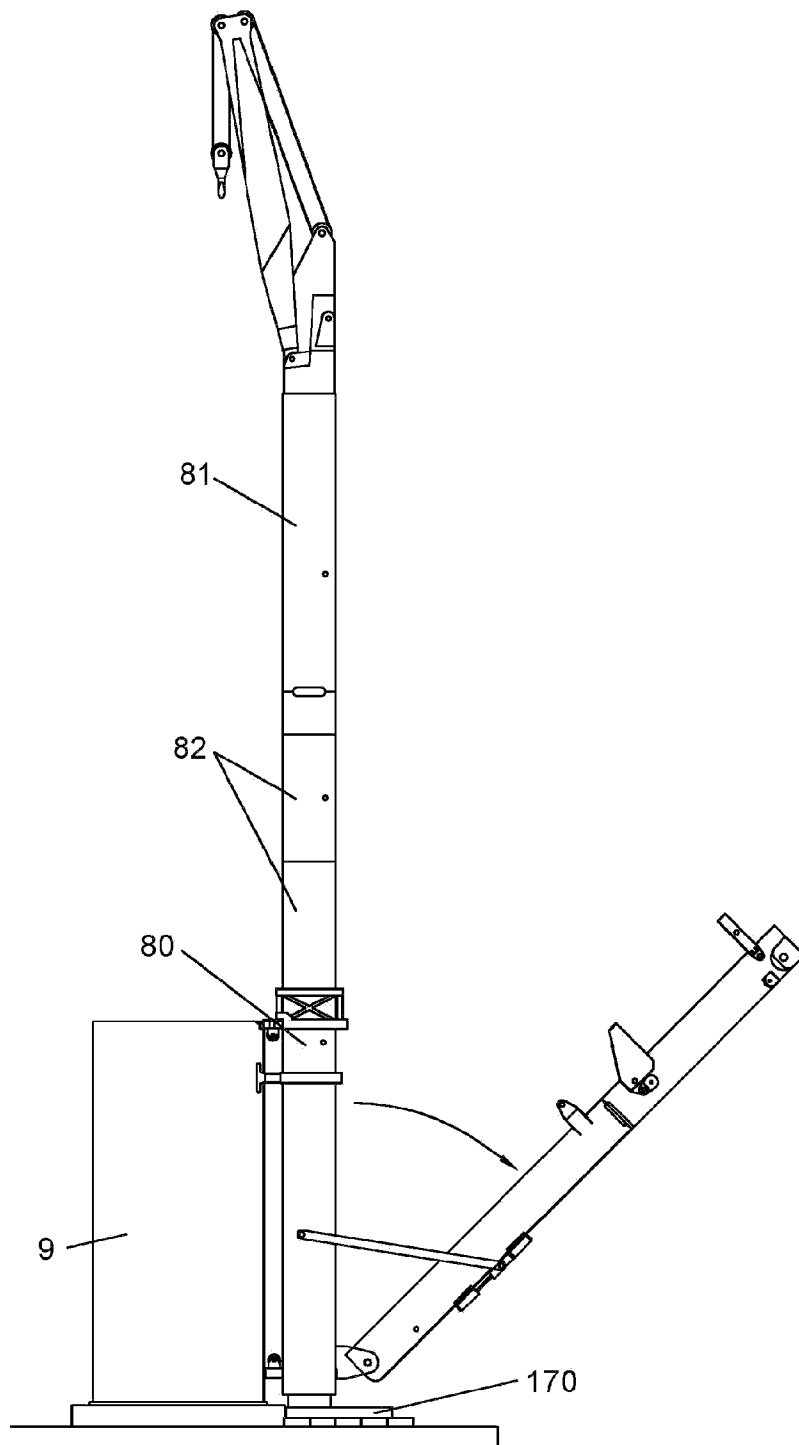


FIG. 49

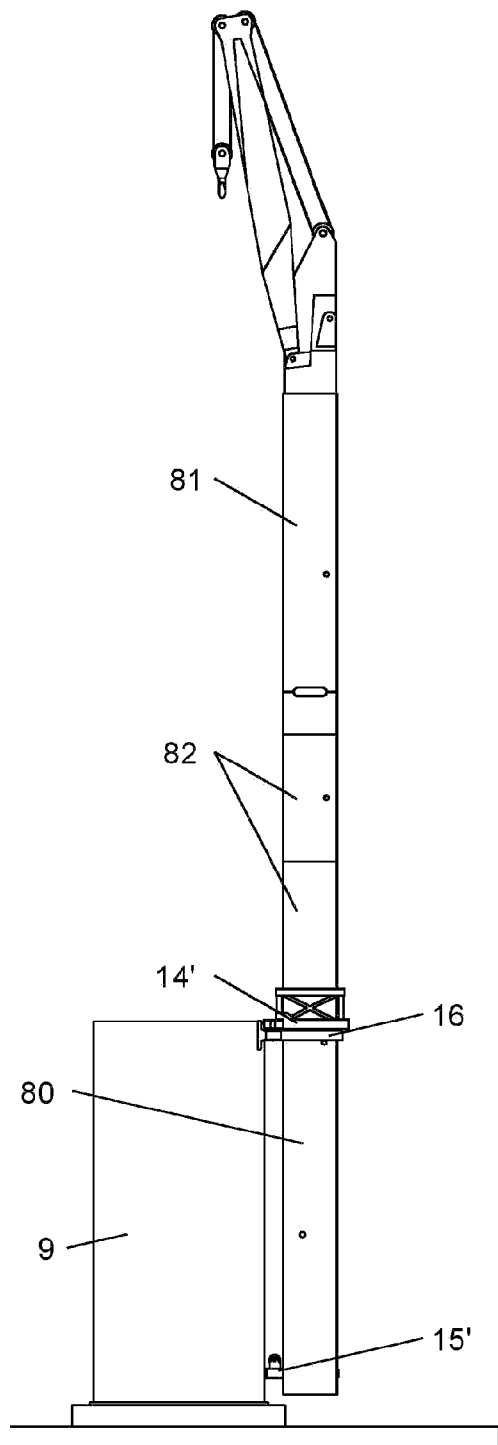


FIG. 50