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(54) **A device for ground compaction**

(57) A device (10) for the supply of inert materials to vibrating systems of ground compaction, installed on a compacting equipment (20) of the ground (100) having: a self-propelled operating machine (21) provided with a tower (22) or arm (50) for supporting a drill battery (22a) comprising a vibrating tool for the compaction for the ground; and a caisson (23)(23') for conveying inert materials to be fed to said drill battery (22a) in a hole on the ground (100); the device (10) presents a substantially hopper shape and slides between a first lower height near the ground (100) and a second height, higher than the first, where the caisson lies (23)(23'); the device (10) is provided with an openable discharging door (11) of inert materials; the opening takes place by means of activation of mechanical means associated to the hopper (10) and to the caisson (23)(23').

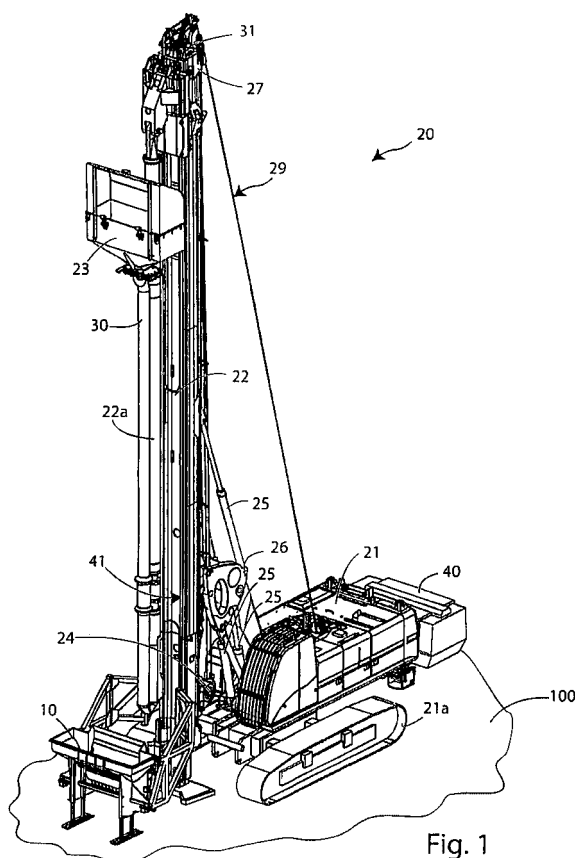


Fig. 1

Description

[0001] The present invention is inserted into the field of technologies of ground compaction by means of compaction and in particular refers to a device for the supply of inert materials to vibrating systems for ground compaction.

[0002] It is known that the ground compaction through induced vibration can be carried out by means of vibrating systems for ground compaction operating on one or more holes in the ground.

[0003] Three different typologies of compaction are known:

- the humid vibro-floatation for non-coherent soils;
- the vibro-compaction through columns of dry inert material (generally gravel), for cohesive and mixed soils; and
- the vibro-compaction through columns of cemented inert material (generally gravel), still dry.

[0004] In the first case, that is for the compaction of non-coherent soils, the compaction of sandy-gravel soils requires the use of systems operating at low frequency, whose action produces the better possible grade of self-thickening. This is due to the fact that the typologies of granulated soils, subject to vibration, tend to self-thicken. The system can be hanging from a cableway excavator or directed along a *mast* (guiding tower).

[0005] Both the piling and the ground compaction are favored by water jets adjustable in flow rate and pressure, whose supplying is carried out through pumps and dedicated lines within the system itself. The compaction is carried out from the bottom upwards, with fixed rising intervals and treatment times.

[0006] The filling ground, also known as carried inert material, is inserted by the opening of the hole (generally with a conical opening) with the aid of operator means, such as gummed blades. These systems are called top feed in technical jargon.

[0007] The final result of the treatment depends on the right choice of the compaction system, adapted to the type of ground present in the place of operation.

[0008] From the mechanical point of view, the vibration produces a settlement of the granules composing the ground after which these arrange themselves in a thicker layer. The radius of vibro-compaction reachable starting from the axis of the hole depends on the ground, on the compaction system used and on the procedure chosen. In some types of ground and for elevated treatment intensity it is possible to see reductions of the deposit volume up to 10%.

[0009] On the other hand, concerning the vibrating systems of ground compaction operating through columns of dry gravel, for cohesive and mixed soils, pneumatic systems are mostly used, where the supply gravel material exits, under air pressure, at the tip of a tool (these systems are known as *Bottom Feed System*). In these

systems, a vibrating battery is guided along a guiding tower (*mast*) and in-depth drilled with the aid of a thrusting device (e.g. a winch, a cylinder or a system with motor reducer). When the final depth is reached (generally lower than 20m), the tool is drawn in such a way as to permit the contemporaneous output of the inert materials. The next sinking of the tool produces the compression of the inert materials in the ground and its compaction.

[0010] The action of a thrusting winch causes an optimal compaction of the column and an in-depth extension of the thickening further than the maximum reached depth. The column of compacted inert material within the hole in the ground is then formed by subsequent steps of extraction, output and compression of the inert materials both downwards and laterally in the ground. In this way columnar elements which, by interacting with the ground, support the loads, can be obtained.

[0011] From the mechanical point of view, in presence of cohesive and mixed soils, it is possible to obtain also a self-thickening of the ground itself, through horizontal vibrations and a lateral compression of the ground, but this thickening effect must be previously evaluated and is anyway connected, firstly, to the presence of water in the ground.

[0012] On the other hand, the columns in compacted gravel through a vibration, in their typical shape, presuppose that the ground is not arranged for self-thickening through vibration. The improvement produced through the use of this technique consists therefore in a higher rigidity, a higher shearing strength and in the effect favorable for the thickening supplied by the columns themselves. The main advantages of the vibrating systems for ground compaction operating through columns of dry inert materials are:

- the inert material exits at the tip of the tool and the ground is always kept supported and the column is continue in all its length;
- the backflow of soils is excluded;
- the piling takes place in only one step and continuously;
- the use of the mast and of the battery guide prevent from deviations from the vertical line;
- water is not used, therefore there are no backflows, mud or flooding of the working plane.

[0013] Eventually, the compactions carried out through cemented columns of inert materials bring to the creation of foundation elements carried out with the same dry compaction technology previously described. The cementation of the element takes place contextually to the setting of inert materials: either through the injection of cemented mixing within the system, or by using a pre-mixed material, where to the inert material is added the sufficient quantity of cement for bringing to a finished product of the wanted quality. In both cases, the induced vibration and the forced introduction of inert material without removal of ground, bring to the same final compaction

effect of the ground.

[0014] The action carried out by the cemented vibro-compacted columns of gravel is equivalent to the one of a pole.

[0015] This last technique provides for carrying out the filling of the hole within which it is inserted the vibrating tool with ground drawn in situ or by means of inert material introduction which is inserted from the opening of the hole with appropriate mechanical means (gummed blades).

[0016] The two systems of vibro-compaction previously described, as shown, comprise the loading of a movable hopper upon the guiding tower which brings the inert material (generally gravel with different particle size) from the basis height wherein it is loaded by the gummed blade, up to the top of the system itself.

[0017] The mode with which the inert materials are inserted within the vibrating tool takes generally place by overturning the hopper.

[0018] This overturning can be carried out either in mechanical way or in hydraulic way.

[0019] According to this technique, the system presents an operating machine equipped with a guiding vertical tower, to which is constrained a drill battery provided with an ending vibrating tool (vibro) of ground compaction and, sometimes, with a container arranged on the upper part of the vibro. To the latter, it is fixed a "hook"-type mechanical coupling, which acts as seat upon which a roller integral with the hopper slides and which constrains the structure to the overturning.

[0020] If the container is not present, the hopper discharges the inert material directly within the battery.

[0021] Since the lever arms of this system are generally small, the forces required for carrying out the overturning are very high and force to dimension the supporting structures to this high loading conditions, often controllable with difficulty.

[0022] The advantage of this operating mode is to make the loading "automatic" and independent from the operator, who can continue to carry out the treatment without worrying about what is really taking place during the transfer of the gravel from the hopper to the system itself.

[0023] On the other hand, if the actuation is of hydraulic type, there is the advantage of enormously reducing the cyclical loads deriving from the overturning operations, by bigger working arms of the actuators, permitting among other things also the active control of the dosage of the inert materials.

[0024] The hydraulic actuation can be operated with a manual activation carried out by the operator, who generally has to suspend the treatment operations for dedicating to this operation.

[0025] In detail, during the loading of the hopper and its successive return to a rest position, different actuations are required to the operator which extend the duration of these steps, causing inefficacy in the process of formation of the treated ground columns.

[0026] The systems of known kind, and in particular the ones described, present some disadvantages. In detail, in the mechanical actuation of the hopper, the main disadvantage is constituted by the relevant supporting structure which must support the overturning loads of the entire hopper filled with inert material

[0027] On the other hand, regarding the hydraulic actuation of the hopper, it is important to remember that they have a bag containing all the inlet pipes of the jacks, the plant is obviously more complex and can cause issues in the construction site.

[0028] Furthermore, in order to inhibit the possibility of overturning the hopper before arriving to the top of the vibro, it is necessary to provide the system with a position microswitch safety logic (or equivalent break circuit devices) which permits the overturning only in the moment in which the hopper has reached its proper loading position.

[0029] In general, the systems of known kind are not efficient from the point of view of the optimization of the supply cycle of the hopper, and present high loading times, particularly if considered in comparison with other operations. The loads on the system, owing to the arms of relevant size are elevated, and furthermore the number of interventions that they have to carry out still remains relevant.

[0030] The purpose of the present invention is to describe a device for the supply of inert materials to vibrating systems for ground compaction which is free from the above described inconvenients.

[0031] According to the present invention, a device for the supply of inert materials to vibrating systems for ground compaction is made as claimed in the first claim.

[0032] The invention will be now described with reference to the attached drawings, which show a non-limiting form of embodiment, wherein:

- figure 1 shows a device for the supply of inert materials according to the present invention, mounted on a first type of equipment for the vibrating ground compaction;
- figure 2 shows a detailed perspective view of the device for the supply shown in figure 1;
- figure 3 is a 180° rotated perspective view of the device of figure 2 deprived of a particular;
- figure 4 shows a middle section of the device for the supply shown in figure 3;
- figure 5 shows a perspective view of part of the compaction system of figure 1;
- figure 6 shows a perspective view of a variant to the part of the compaction system according to the present invention;
- figure 7 shows the device for the supply of inert materials according to the present invention installed on a second type of equipment for the vibrating ground compaction.

[0033] With reference to figure 1, the device for the

supply of inert materials to vibrating systems for ground compaction according to the invention is generally designated with 10. Device 10 is installed on board of an equipment 20 for vibrating ground compaction 100.

[0034] Equipment 20 for ground compaction 100 comprises:

- an operating machine 21, of self-propelled type e.g. on tracks 21a, to which is constrained a guiding tower (*mast*) 22 for supporting a drill battery 22a containing a vibrating tool for the ground compaction; and
- a caisson 23 for storing and conveying inert materials inside a hole obtained in ground 100 after the reaching of the wanted depth.

[0035] One or more hydraulic pistons 25 fixed to the body of operating machine 21 and to a support 26 of tower 22 and to the tower itself, keep this last one in the wanted position during the operation, generally in vertical position with respect to ground 100.

[0036] An upper head 27 of tower 22, permits the hinge of a plurality of pulleys 31, upon which slides a traction cable or rope handled by a winch 24 positioned upon a rear part of tower 22; this winch 24 permits to lift up or down the drill battery 22a within the hole in ground 100, and acts with a return of second lower pulleys positioned near the basis of tower 22. To upper head 27 is also fixed a first end of a tensioning cable 29, whose second end is instead constrained to a winch positioned on operating machine 21.

[0037] To caisson 23 is connected a canalization 30; this canalization runs in parallel with drill battery 22a for substantially all of its length, ending with an opening in correspondence with the lower end near a tip of the vibrating tool comprised in drill battery 22a.

[0038] In a rear part of operating machine 21, opposed to the part upon which is constrained tower 22, is present an air compressor 40, needed for permitting the carrying out of the vibro-compression technology of the equipment.

[0039] Device 10, which is present in the form of a hopper, is constrained to tower 22 through a plurality of guides 41, arranged in parallel to tower 22 itself and along which slides a double basket frame 50, fixed to plates 16, 17 of body 10 of the device; in detail plates 16, 17 are of removable type.

[0040] These guides 41 permit to device 10 to move along tower 22, starting substantially from a first lower height in proximity of ground 100 and reaching a second upper height where caisson 23 finds.

[0041] As it is better shown in figure 2 and 3, the device 10 has a discharging door 11 movable from a first open position to a second closed position; in this last one it permits to discharge the inert materials contained inside of it in caisson 23 positioned on the top of tower 22.

[0042] The discharging door, when closed, acts as wall of a tank 13 of pyramidal shape with V-type transversal section, whose vertex is directed downwards. On two

opposed sides of device 10, in correspondence with two lateral walls 10a, 10b, there are bars 14, directed along a first vertical axis X, which are centrally pivoted on a pin 14a, in such a way as to rotate on the plane upon which lies the axis X itself.

[0043] Bars 14 present each one a first and a second end; the first end of each of bars 14 is constrained to a spring 12, whereas the second end of each of bars 14 is provided with a roller 14b pivoted on an axis Y orthogonal with respect to axis X and to the plane upon which rotate bars 14 themselves.

[0044] Springs 12 are also fixed to a respective lateral wall 10a, 10b of the device 10.

[0045] A movable locking pin 15 is also fixed to each of bars 14, in proximity of springs 12, in parallel with respect to them.

[0046] Each of locking pins 15 passes in a respective hole of lateral walls 10a, 10b and extends behind the discharging door 11, in such a way as to lock it in position when closed.

[0047] Hopper 10 is loaded when it finds in proximity of the ground with supports 51 and 51', height-adjustable, suitable for being also leaned against the ground. When the loading is finished, with a gummed blade (not shown, but of known kind), hopper 10 is lifted up making frame 50 sliding along guides 41 till rollers 14b of levers 14 find strikers 52 of upper fixed caisson 23. Levers 14 are then automatically rotated in contrast to springs 12, by drawing retaining means 15 from the respective holes.

[0048] Door 11, not finding anymore contrasts and pushed by the inner pressure exerted by the inert material, rotates on hinge 11a reaching the open position of figure 4 up to find shock-absorbing devices 53. At this moment, the inert material contained in hopper 10 slides automatically in trunk 54 of caisson 23 for directly entering then canalization 30 which will bring it to the basis of the hole. During the step of transfer of the material from the hopper to caisson 23, protection (lateral, rear and upper) 55 causes that all the inert material falls in caisson 23 itself.

[0049] As it is better shown in figure 4, discharging door 11, when opened, rotates by an angle such that to form continuity with end wall 56 for enabling the complete descent of the inert materials within caisson 23 and from here in conduct 30 associated to drill battery 22a.

[0050] When the discharging of the inert material is ended, the step of the descent of the hopper can begin; the couple of spring pushers 57 positioned on caisson 23 knocks against the free end of door 11 moving it again toward the closed position.

[0051] Contemporarily, strikers 52 of caisson 23 leave rollers 14b of the hopper, therefore springs 12 not anymore tensioned thrust retaining means 15 in the respective holes for locking door 11 in the closed position for making the hopper ready for receiving a new charge when it will reach the ground.

[0052] A camera 58 positioned on the top of caisson 23 displays the presence of inert material or the need of

carrying out a new charge.

[0053] Obviously, the system of transfer of the inert material from hopper 10 to caisson 23 takes place through the automatic opening of door 11 only when hopper 10 has reached the relative height of charge wherein there are strikers 52.

[0054] As a matter of fact, during the carrying out of the treatment, the top of drill battery 22a finds at different heights and it is not defined a position of unique charge, but only a relative one.

[0055] As shown, leverage system 14, 14b, 15 actuated by the same hoisting arrangement of the hopper, automatically activates the opening of door 11 and the consequent exit of the inert material.

[0056] The relative position among rollers 14b and strikers 52 is not to be intended in a limiting way; in fact, the inversion of the positioning of rollers 14b with strikers 52 (that is the application of the rollers on caisson 23 and of the strikers on hopper 10) represent a solution equivalent to the one described.

[0057] A stop buffer positioned on the guide carriages (not shown in figure) upperly locks the ascent of the hopper with respect to the top of the part connected to the vibrator and permits to keep the parts referred between them (hopper and caisson).

[0058] Guides 59 positioned on caisson 23 have a reference function between the two faced particular hopper-caisson.

[0059] In figure 6 it is shown an alternative to caisson 23 for conveying inert material toward canalization 30 of connection to the hole.

[0060] In this alternative version caisson 23' loses its main function of storing of the inert material, but leaving unaltered both the function of conveying the inert material itself to canalization 30 and the one of activation of the opening of door 11.

[0061] Caisson 23' comprises lateral containing walls which protrude outwards of canalization 30; these containing walls are positioned in proximity of trunk 54 of opening and are characterized by a tapered tract (chute) which permits to discharge the material inside canalization 30.

[0062] On caisson 23' are then mounted the guiding devices 59 to hopper 10, stops 52 for the activation of the unlock of the door which takes place by acting on leverage 14 present on the hopper, and pushers 57 for favouring the closing of the door once the step of charging is terminated.

[0063] This solution can be used when the capacity of canalization 30 is suitable for keeping stored a sufficient quantitative of inert material.

[0064] Moreover, as shown in figure 7, device 10 according to the present invention can be also installed on equipments 20 wherein drill battery 22a is hanging in the vacuum, deprived of lateral guides, being fixed only in its upper part by one or more traction ropes.

[0065] In detail, in figure 7 excavation equipment 20 is a crane provided with an inclinable arm 50 (of lattice

shape, as shown in figure, or telescopic, not shown) and fixed upon a first end of operating machine 21 and having upon a second end a plurality of pulleys 51, 31 upon which slide the traction ropes which hang drill battery 22a.

[0066] The second end of arm 50 possesses also an extension directed outwards (technically known with the name of derrick), upon which is present a further pulley 52, upon which slides a traction cable 60 of device 10 independent from the traction rope of drill battery 22a. Device 10 is fixed in such a way as to, when drawn by traction cable 60, proceed along a vertical path parallel to the direction detected by drill battery 22a.

[0067] Device 10, which is free and deprived of guides too, is hoisted from the ground up to the reaching of the height of caisson 23, where it is then opened as previously described.

[0068] Avoiding the turnover of the hopper (known solution), structures much lighter are realized, with reduced costs and making more stable the equipment during the drilling.

[0069] Using only mechanical actuations without any aid of hydraulic, electrical or pneumatic type, it is also possible to simplify all the plant of the machine and to make the manoeuvre completely automatic, without requiring interventions of the operator, who can control all the steps with the aid of a camera.

[0070] The opening of door 11 is exerted by the inner pressure of the inert materials contained in the hopper, which, laterally exiting, find a simple escape way in the passing from the hopper to caisson 23.

[0071] Eventually, the truncated conical inner shape of the hopper helps the discharge of the inert material.

[0072] If the opening of door 11 takes place by means of actuator means (e.g. hydraulic jacks), the system would anyway be advantageous in terms of structural lightening since it would not be required the overturning of the hopper charged with inert material, but it would leave unaltered the complication issues of the systems and of the interventions required to the operator.

[0073] It is eventually clear that to the present invention can be made changes, adaptations and improvements obvious for an expert in the art without departing from the protective scope of the attached claims.

Claims

1. A device (10) for the supply of inert materials to vibrating systems for ground compaction, said device being installed on a compacting equipment (20) of the ground (100) comprises:

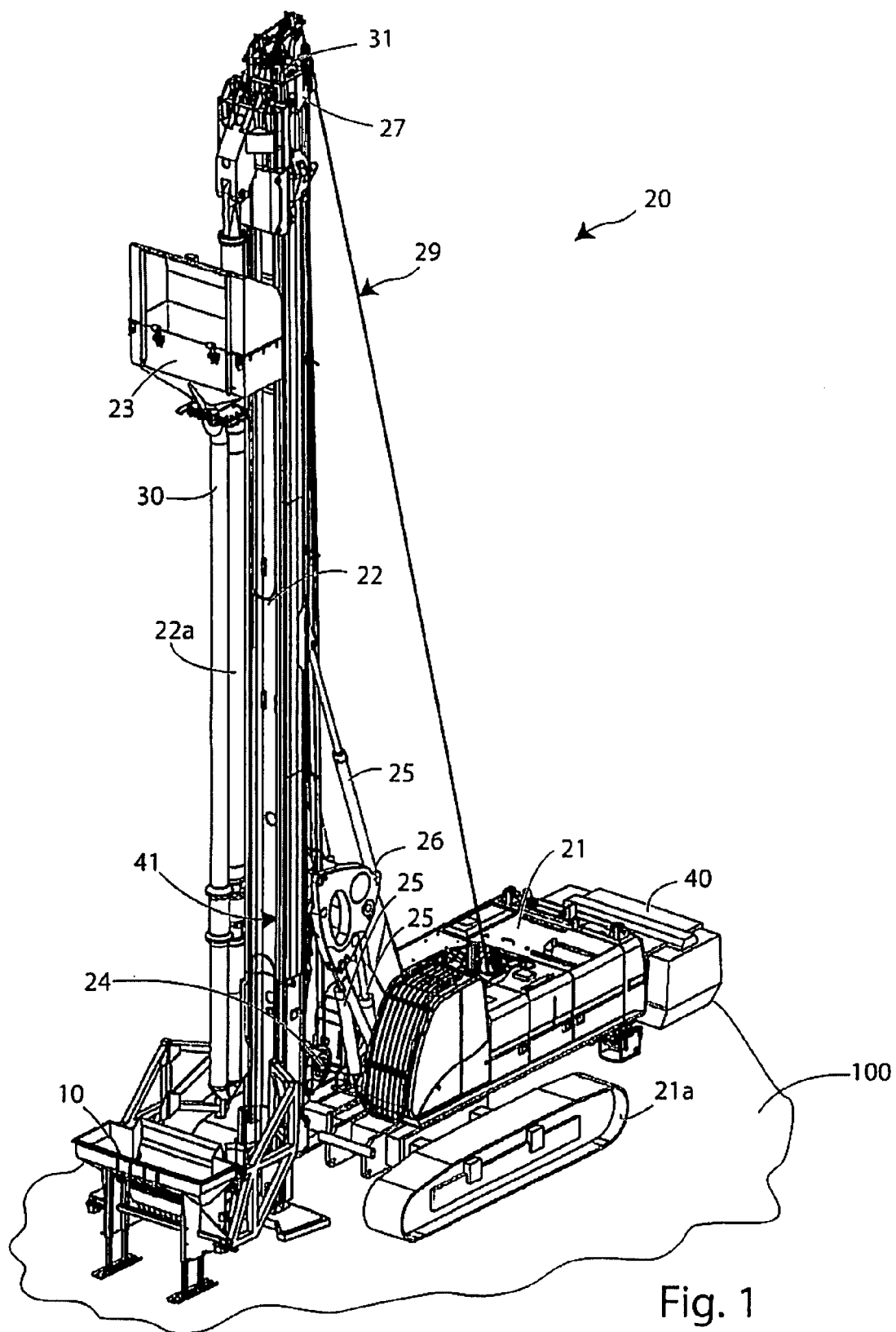
- a self-propelled operating machine (21) provided with a tower (22) or arm (50) for supporting a drill battery (22a) comprising a vibrating tool for the compaction of the ground; and
- a caisson (23) (23') for conveying inert materials to be fed, by means of a canalization (30),

to said drill battery (22a) in a hole in the ground (100) ,

the device (10) presenting a substantially hopper shape and sliding between a first lower height near the ground (100) and a second height, higher than the first one, where the caisson lies (23)(23'); the device (10) being **characterized in that** it is provided with a discharging door (11) of said inert materials contained into it, movable between a first closed position and a second open position; the opening being of temporary type and taking place by means of activation of mechanical means associated to the hopper (10) and to the caisson (23)(23').

2. A device according to claim 1, **characterized in that** it is guided between said first height and said second height by a plurality of guides (41) of the tower (22).
3. A device according to claim 1, **characterized in that** the discharging door (11) is temporarily engaged in closed position by at least a mechanical stop in contrast with elastic means (12) .
4. A device according to claim 1 **characterized in that** the discharging door (11), when closed, constitutes at least a portion of lateral wall of said device (10) of tapered shape, having a plurality of walls arranged in a manner that it allows the discharge of the contained material toward said canalization (30).
5. A device according to claim 1 **characterized in that** the mechanical means associated to the device (10) and to the caisson (23) (23') are constituted by at least a couple of bars (14); each bar (14) being centrally pivoted on a pin (14a) to the device (10) and hinged at an end to restrain means (15) for said door (11), and at the other end to at least a roller (14b); the action of at least a stop (52) of the caisson (23) (23') on the roller (14b) causing the rotation of the bars (14) and the release of the locking means of the door (11) in contrast with the elastic means (12) with the consequent opening of the door itself.
6. A device according to claim 1, also comprising an end wall (56) and wherein the door (11) , when opened, rotates by an angle so that it forms continuity with the end wall (56) itself.
7. A device according to claim 6, wherein at least a spring pusher (57) positioned on the caisson (23) (23'), knocks against the door (11) moving it again toward the closed position, activated by the movement of descent of the hopper made at the end of the discharge, whereas the elastic means (12), when not tensioned, push the stopping means (15) until blocking the door (11) in the closed position.

8. A device according to claim 1, also comprising a camera (58) positioned on the top of the caisson (23) (23') for displaying the presence of inert materials within the hopper (10) or for signalling the need of a new charge.
9. A device according to claim 1 **characterized in that** the transfer of the inert materials from the hopper (10) to the caisson (23)(23') takes place through the automatic opening of the door (11) when the hopper (10) has reached the relative height of charge with respect to the top of the drill battery (22a).
10. A device according to claim 1, wherein said compacting equipment (20) upon which it is installed is provided with an inclinable arm (50) on which top said drill battery (22a) is hung, free of lateral guides and provided with traction means for its vertical handling; said device (10) being moved independently from said drill battery (22a) by means of a respective traction cable (60).



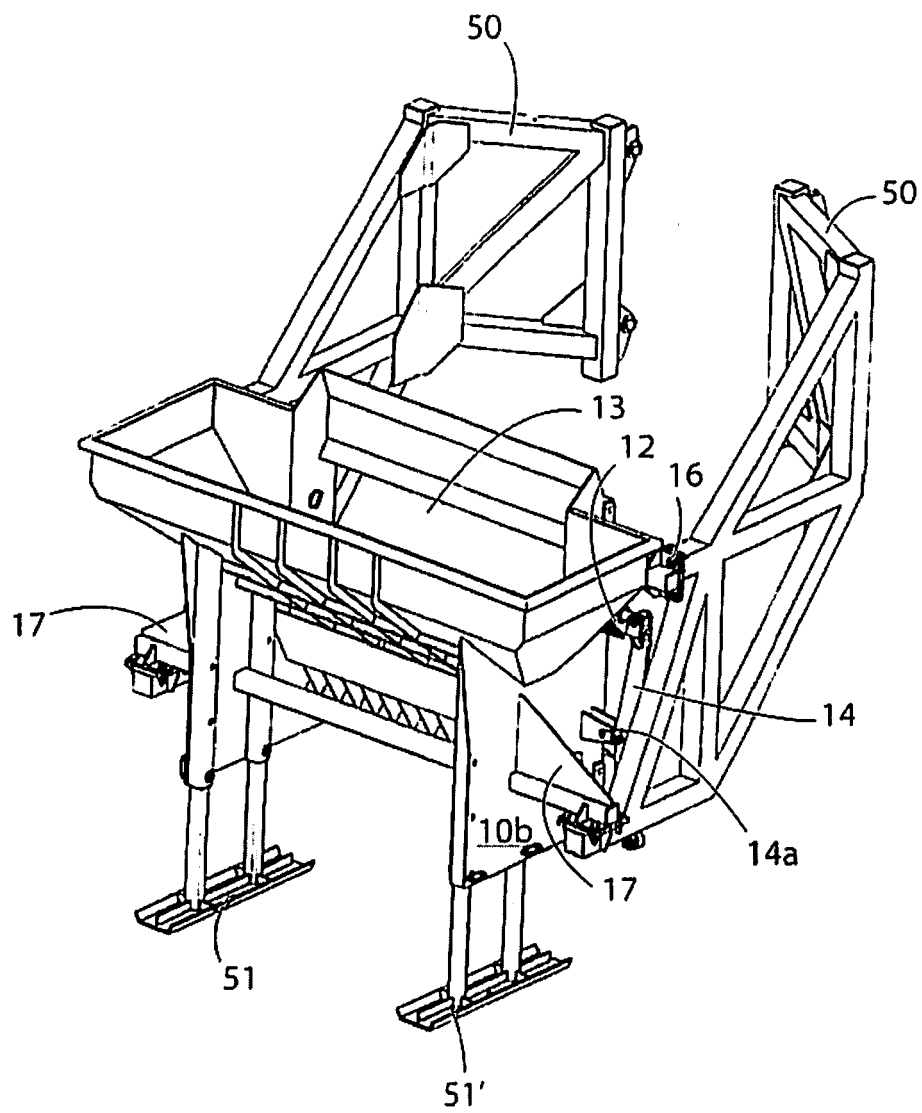


Fig. 2

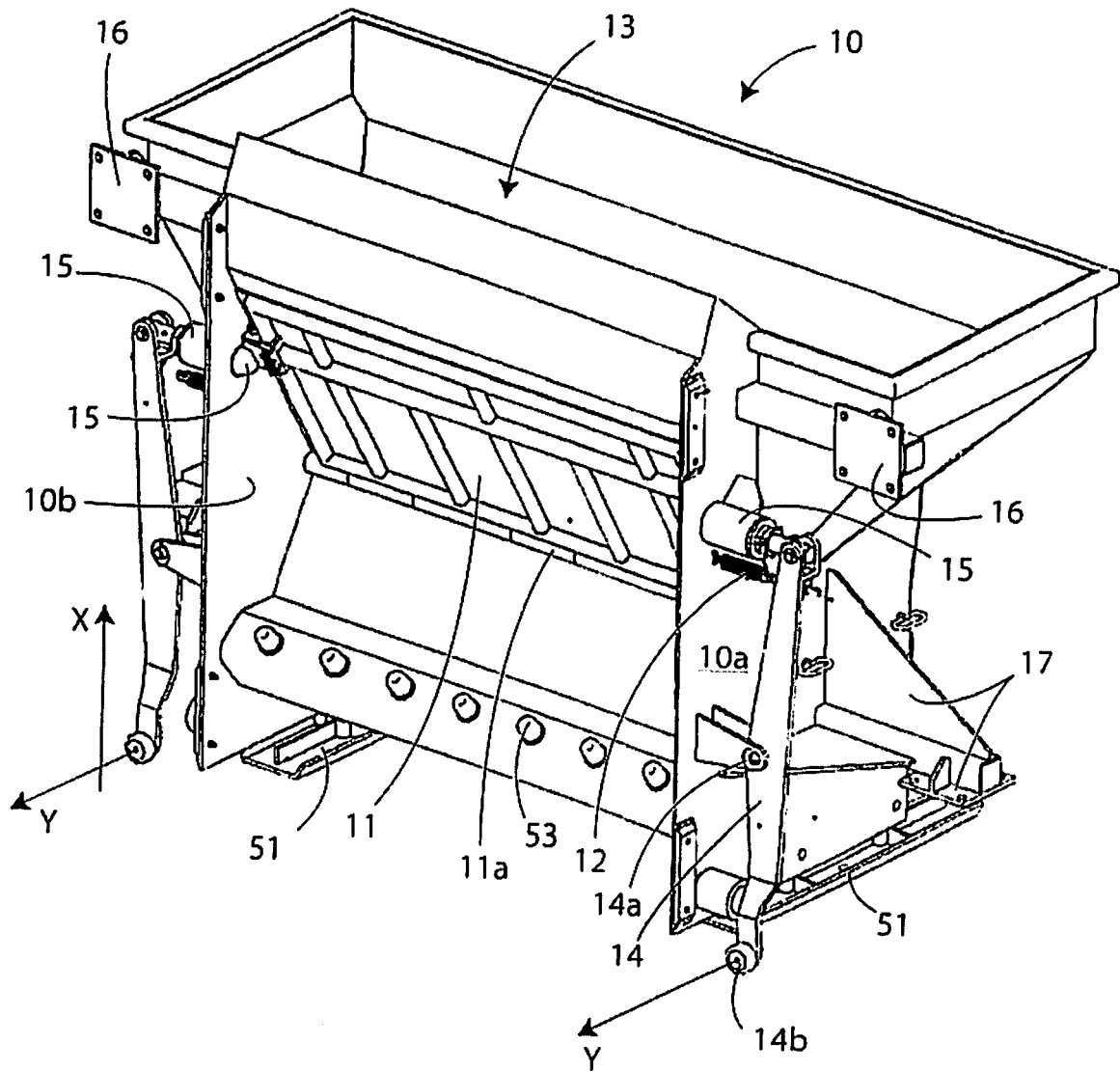


Fig. 3

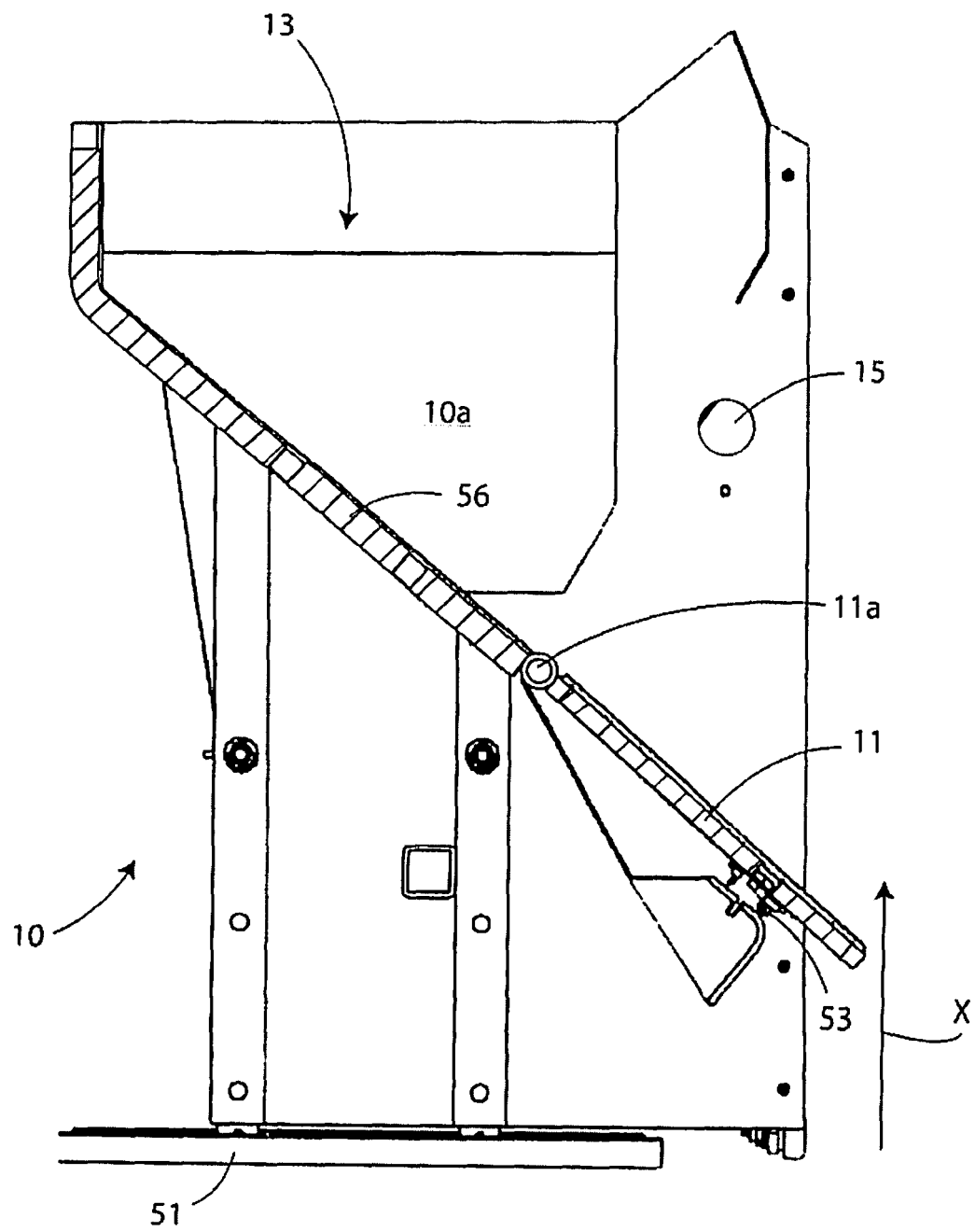


Fig. 4

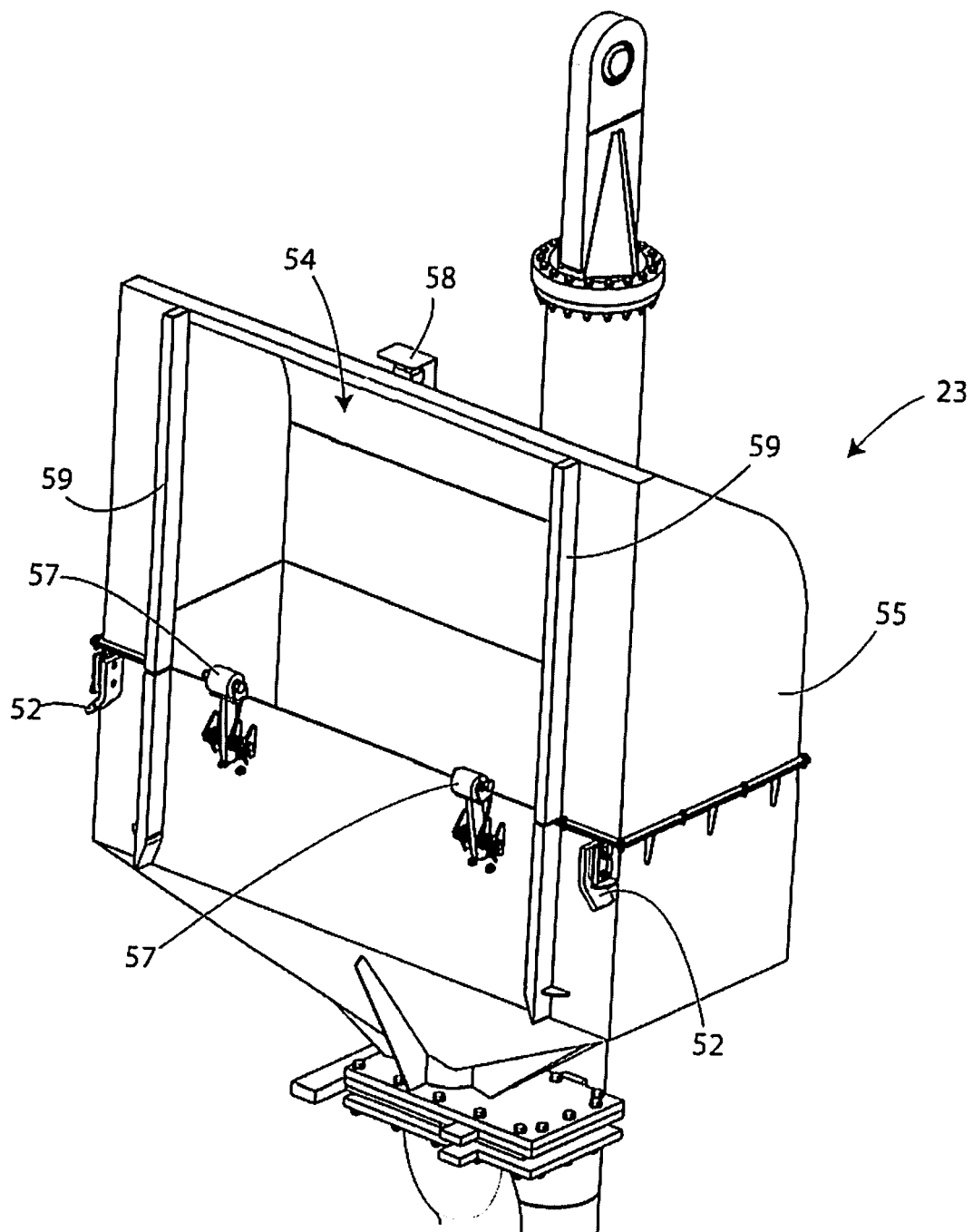


Fig. 5

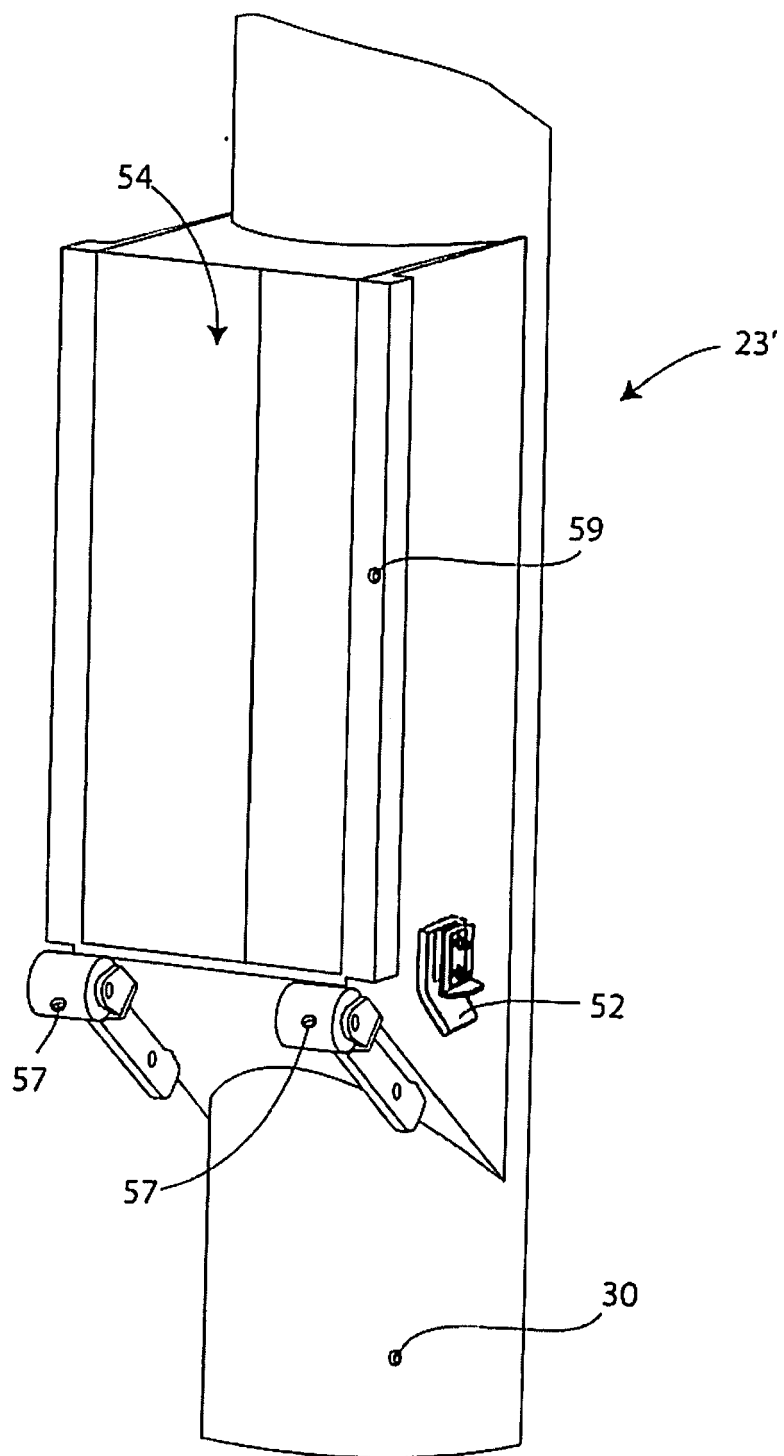


Fig. 6

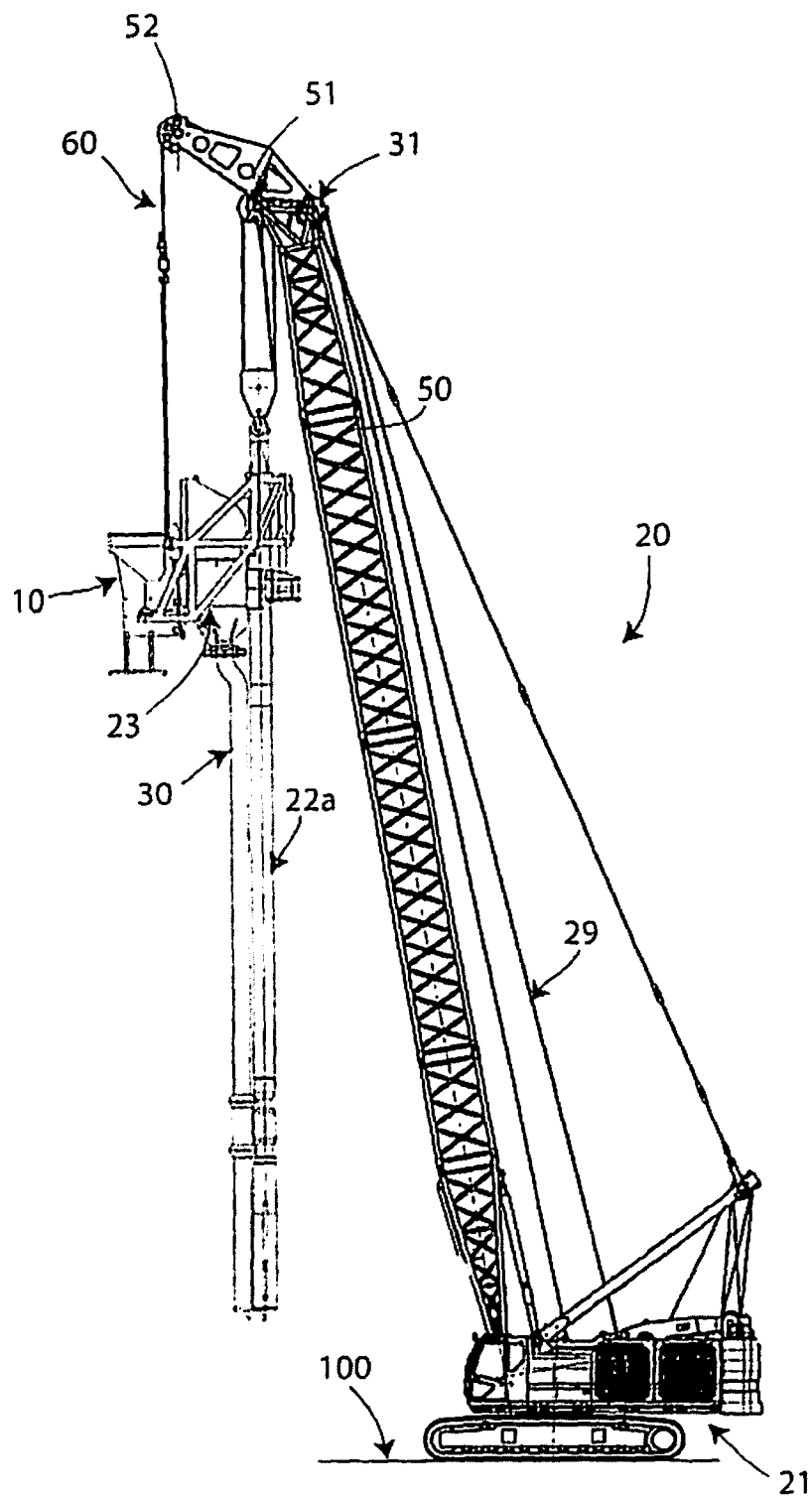


Fig. 7