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(54) Drilling device with telescoping Kelly tube

(57) A pile boring machine comprising:
- a mast (2)
- a kelly for the realization of bored piles, constituted by a battery of rods (7,19) displaceably inserted one into the other wherein the most inner rod (9) supports an excavation tool (5);
- a rotary table (1) which bears the kelly and vertically slides along the drilling mast (2), the said rotary table being provided with means (8a) for rotating the battery of rods (7,19) around its longitudinal axis;
- means (10) adapted for displacing and recompacting the rods of the battery and;
- motorized means (6) adapted for exerting a traction and a thrust on the rods during the excavation. Characterized in that, at least part of the rods (19) of the battery of the kelly is entirely positioned under the rotary table (1) by which it is put in rotation.

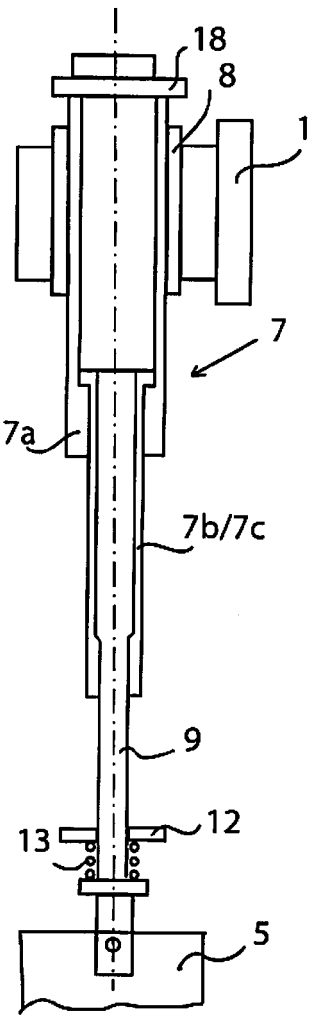

Fig.2

EP 2 390 458 A1

Description

[0001] The present invention finds itself in the field of equipments for the realization of bored piles realized through a battery of telescopic rods, known in the field as kelly, with related excavation and handling tool through a drilling rotary table.

[0002] The present invention originates from the study of drilling equipments which are designed for a use in low spaces (under bridges, under buildings and existing structures and so on) where there i<s the need of reaching elevated excavation depths keeping the height encumbrances limited.

[0003] Patent DE19626223 describes a drilling system with telescopic kelly rod containing retaining devices which lock the rod when moving radially. This movement is due to the axial translation and can be unlocked rising in closure the kelly rod.

[0004] Patent EP0947664 describes method and equipment related to a weight measuring system of the kelly for the control of the correct opening sequence of the removals of the various elements of which the kelly is constituted. During the ascent steps, when the rods in lifting are withdrawn, it is possible that two or more rod elements can get caught and this can cause the falling of the not retained elements.

[0005] Patent US5396964A describes a ground mixing equipment provided with variable articulation which permits to orient of the drilling battery along the two main planes. The battery is constituted by a tool and a rod, in particular the rod can be of telescopic type, that is a kelly which is moved by a traction winch and a thrust device, still of winch type which permits the driving of the tool in the ground.

[0006] A characteristic which combines the equipments of the above mentioned three patents consists in the fact that the respective rotary table have an inner passage through which pass all the elements of which the kelly is constituted.

[0007] In patent US5396964A, in particular, once lifted, the rod occupies all the space over the rotary table and the tower mast of the crane must be opportunely sized in length, for limiting this encumbrance.

[0008] It is now described the method of use of these equipments, which represents the prior art.

[0009] As shown in figure 1, a rotary table 1, sliding along a tower 2 mounted on an operating machine 3 generally tracked, puts into rotation a telescopic rod with many removals 4, commonly known as kelly, to which is fixed the excavation tool, which is normally a bucket or a drill 5.

[0010] The rotary table itself is also moved along the drilling mast by suitable elements, such as hydraulic jacks 6 or rope winches (not shown in figure) which exert the extraction traction and the penetration thrust on the batteries.

[0011] A rod guiding head 31, sliding on the guides of the drilling mast, generally the same which guide the rotary carriage, keeps the kelly in position on the excavation axis being fixed to the most outer rod. An interface bearing (not shown) between guiding head 31 and the outer rod permits to the kelly to freely rotate and to transfer to the guiding head the movements exerted through the rotary table.

[0012] Therefore, the rotary table transmits to the kelly both a rotational and a vertical translation movement. Under the action of the rotary table, the excavation tool, initially leaned against the field-plane, penetrates into the ground and loads the excavated ground. When the tool is full of ground, the operating machine stops the rotation and impresses to the rods and to the tool an upward movement such as to disengage the tool from the hole just realized.

[0013] Once the tool is again outside of the hole, through the rotation of the turret, the machine arranges it in a zone away from the excavation for discharging it of the excavated and accumulated ground. The discharge of the ground from the tool occurs with different modalities according to the use of a bucket or a drill.

[0014] When the bucket is used, a spring striker strikes against a suitable flange and opens the base or the walls of the bucket. The ground excavated and accumulated inside the bucket is instantly released on the ground. With the drill, on the other hand, the machine sets a strong and the most possible speedy counter-rotation to the tool through the rotary table forcing the excavated material, which has been accumulated between the spires, to a sudden outward centrifugation. In both the cases, the element which connects the rotary and the excavation tool is the same telescopic kelly.

[0015] The detailed functioning of a telescopic rod of the mechanic locking type of known type is shown in the following figures:

- fig. 2 is a longitudinal section of a known telescopic rod in extended/open condition;
- fig. 3 is a partial section of a displaceable element of a known telescopic rod;
- fig. 4 is the section according to the section IV-IV of the displaceable element of fig. 3;
- fig. 5 is the section according to section V-V of the displaceable element of figure 3;
- fig. 6 is a lateral view partially sectioned of a inner rod element of a telescopic kelly of known type;
- fig. 7 is a lateral view of the mounting of a known kelly on the drilling mast.

[0016] Telescopic rod (kelly) 7 of known type appears as a series of coaxial tubes (generally from 2 to 6). Each one

is provided with means, called strips 26, adapted for the transmission of the torque between two adjacent tubes for mechanic striking between the element which transmits the movement and the one that receives it.

[0017] The most outer tube 7a, the one with higher diameter and conventionally called "outer rod", is directly inserted in grooved sleeve 8 of rotary table 1 from which it receives torque and thrust through strips 26 and related mechanical joints 24A and 24B. In cascade, the outer rod transmits torque and thrust to the most inner rods 7b-7c up to reach the rod with the smallest diameter called "inner rod" 9 under which it is fixed drilling tool 5.

[0018] With reference to figure 3 strips 26 of each rod raised with respect to the shaft, receive the torque from the rod with higher diameter whereas a grooved terminal 22 of limited length, generally less than a meter, transmits the torque to the rod of lower diameter, with the same jointing modality. On the outer diameter exist also joint zones 23 wherein it is locked the terminal of the upper rod in such a way as to transmit to the whole battery the thrust and the traction of designed elements 6 which connect rotary table 1 to tower 2.

[0019] With reference to figure 6 extraction rope 10 is connected to inner rod 9 through a rotating joint 11 positioned for preventing the rope to wind on itself during the rotation, of the battery of kelly rods. The rope then passes through all the rods during their related movement, when the telescopic kelly is wide open.

[0020] A circular flange 12 of size similar to the diameter of the outer rod is connected to the lower part of inner rod 9, right over the tool joint. This flange has the function of closing again the battery of telescopic rods. By operating the main lifting winch 30 (see figure 1), rope 10 pulls upwards inner rod 9 which through flange 12 drags with it all the other rods 7a/7b which progressively meets during the ascent. The flange 12 can be provided with a damping system 13 for dampening the solicitations due to the contact with the rods.

[0021] With reference to figure 7 rotary table 1 within which passes outer rod 7a, has traction/thrust elements 6 which, independently from the position and the removal condition of the rod itself, lift or drive the battery. Pulling on rope 10, fixed to rotating element 11 on the top of inner rod 9, the rods pack one into the other up to reach the minimal encumbrance m. By releasing the rope itself, owing to the weight of the displaceable elements, the rods displace inside the hole up to reach their maximum extension, coincident with the maximum depth of the hole.

[0022] It has been described the functioning of a "mechanical locking" kelly wherein the transmission of the thrust between rotary and kelly and between one rod and the other occurs for mechanical striking. There are also kelly so-called "friction kelly" wherein the strips are smooth and do not have mechanical joints (24A and 24B) and whose displaceable elements transmit the thrust by means of the friction which generates between the strips in contact. The present invention can be used indistinctly in both the solutions.

[0023] It is known that the maximum length which the battery can assume in all displaceable condition is given approximately by the length of the battery closed for the number of rods (or removals) which compose it, to which nearly 0.8 meters of minimum superimposition must be detracted between a rod and another (terminal 22 figure 3). For example a battery of 10 m formed by five rods will have a maximum extension of:

$$\text{Max. depth} = (10\ \text{m} \times 5) - (0{,}8\ \text{m} \times (5-1)) = 46{,}9\ \text{m}$$

[0024] The excavation depth limit is therefore determined by the length of the battery, directly proportional to the height of the tower and by the number of removals, also depending on two factors, apparently inconsistent. The outer rod must have the smallest diameter possible, for passing inside the grooved rotary tubes of sizes generally limited, whereas the inner rod should have the biggest diameter possible for ensuring a considerable torque transmission which otherwise should be limited.

[0025] Practically, the sum of these factors presently limits the field of application of telescopic rods at a maximum depth of nearly 100 m (obtained with 5 removals), with torques limited to 500 kNm. However, this solution for encumbrances, performances and weights is certainly "exaggerated" and finds few possibilities of application, apart from machines with high weight and sizes.

[0026] As from the above mentioned patents, all the solutions shown as prior art show a kelly passing through the rotary table. For increasing the depth of the excavation on solutions of this type, once the inner saturation is reached (having inserted as many removals as possible) and the maximum compromise acceptable on the inner size of the rod which cannot be smaller than a determined value is obtained (otherwise it could not transmit the necessary excavation forces: torque and thrust), the only possibility left is the one of increasing the sizes of the inner passage of the rotary table.

[0027] This approach produces a double problem: the first relates to the dimensions of the rotary table which are increased and consequently, other than the higher encumbrances, an increase of expenses and weights will be caused. The second aspect is that the rotary table itself must necessarily be different losing then the economic and logistic advantages of the standardization.

[0028] These problems, in case of height limited encumbrances, are again exasperated because the lengths of the displaceable elements must necessarily be reduced for entering again in the required sizes. The direct effect of this

reduction is a depth loss (as results from the previously shown formula) and can be at least partially retrieved with the increase of the number of removals.

[0029] This causes an increase of the inner sizes of the rotary table, even higher than the preceding case.

[0030] The purpose of the present invention is to overcome these depth limits which characterize the battery of traditional telescopic rods with the possibility of using standard rotary table, without using rotary table with an increased passage, and without applying modifications on the drilling mast of the drilling machine.

[0031] For reaching these and other purposes which will be better understood in the followings, the invention proposes to realize a half-passing excavation equipment for the realization of piles according to claim 1.

[0032] The equipment will be now described according to the invention according to some of the embodiments with reference to the attached drawings wherein:

- fig. 8 is a partially sectioned lateral view of a kelly according to the invention in a first f embodiment wherein the kelly is partially passing inside the rotary;
- fig. 9 is a lateral view of the equipment of fig. 8 in configuration of minimum encumbrance;
- fig. 10 is a lateral view of a traditional kelly in configuration completely extended/open;
- fig. 11 is a lateral view of a kelly according to the invention in configuration completely extended/open;
- fig. 12 is a lateral view of a first variant of the equipment of fig. 8;
- fig. 13 is a lateral view of a second variant of the equipment of fig. 8.

[0033] The object of the present invention provides for using a kelly called half-passing composed by two batteries of rods (see first of all figure 8); to a common battery of traditional telescopic rods 7, is added a second battery of telescopic rods 19 concentric to the preceding one and having a radial encumbrance higher than the inner passage of rotary table 1.

[0034] Inner rod 21, through its strips 26 of "locking" or "friction" type previously seen with reference to figures 3 and 4, transmits the torque and the thrust to outer rod 7a of the battery of traditional rods 7.

[0035] Outer rod 7a of the traditional kelly can be without striking flange 18 in its top the (see figure 2) provided in turn with a suitable elastic element (rubber or spring pad).

[0036] The traditional kelly can be also used removing the most outer rod 7a and leaving the other inner elements as parts mounted in the claimed solution, when for example striking flange 18 is not of a type that can be disassembled from the most outer rod.

[0037] The outer rod of bigger diameter 20 of battery 19 is fixed to the rotary table through a "screws-socket" mechanical coupling 17 to a "dragger" 16 having shape of flanged body which contains outer rod 20 and is fixed or welded directly on the bottom portion of rod dragging tube 8a, which receives the movement from the gears of rotary table 1 and can be preferably cylindrical (that is smooth, free from strips).

[0038] If the tube were of the strip standard type, there would still be a problem of insertion of the most outer rod 7a of the traditional kelly, during the reentering operation (closing of the kelly).

[0039] As a matter of fact, for obtaining the alignment between the strips of tube 8a and the ones between rods 21 and 7a in the pin, it would be necessary to rotate the kelly for helping the entering.

[0040] The modification of the interface could then be limited to the right conformation to give to tube 8a.

[0041] Outer rod 20 of battery 19 in proximity of its lowest portion, can be shaped with a bigger diameter 20 in such a way as to have a lower plane face to be used as striking element to the pusher 34 which controls the opening of bucket 38 (or 5).

[0042] In short, this innovation gives the opportunity to add to a traditional telescopic rod, another telescopic rod of bigger diameter sizes, slightly shorter because flanged under the rotary table 1, but such that as to considerably increase the number of removals of the traditional one.

[0043] With reference to figure 9 rope 10 of lifting/closing battery lies fixed to rotating element 11 of inner rod 9, which brings as usually a "collecting" flange 12a of diameter similar to the one of outer rod 20 thus permitting the dragging of all the rods when the rope of winch 30 is wounded. Encumbrance height m with lifted/closed battery (see figure 9) is not sensibly different from the one of a traditional kelly (height m of figure 7) and can even be advantageously reduced according to added displacement elements 19 which compensate for the length for reaching the same depths.

[0044] With reference to figures 10 and 11, it can be noticed that the half-passing kelly, being able to rely on a higher number of removals, permits to the tool to realize a hole with a depth considerably higher than the one that can be realized with the traditional kelly having the same closing length m.

[0045] With reference to figure 10, height P1 represents the maximum depth that can be realized with traditional telescopic rod 7 removed, measured under rotary table 1.

[0046] With reference to figure 11 height Q1 represents the increase of the height due to the presence of added telescopic rod 19 under glass 16 of rotary table 1. For quantifying this value, if we define as t the length of each removal of the "half-passing" kelly and as N the number of removals (three are the ones shown in figure 11), we can state that:

$$Q1 = (t \times N) - (0.8\ m \times (N-1))$$

[0047] In the object of the present invention, the limit within which removals can be added, is shown, further than by the lifting and stability capabilities of the operating machine, uniquely by the diameter of the outer rod 20 which should have a diameter smaller than the excavation tool because this rod is adapted for penetrating for some meters into the excavation realized once the depth comes near to the maximum reachable one.

[0048] Alternatively, it is however possible to realize a so called "telescopic" drilling where the first part of the hole has a higher diameter and with the depth, at successive steps, it is reduced the excavation size up to the required one, thus permitting to operate with rod diameters 20 even higher.

[0049] On the contrary, the outer rod could be provided with excavation means and/or wear-resistant plates for penetrating into the ground for all the necessary length.

[0050] With reference to figure 12 it is shown a first variant wherein it is added a lower guide 32 which permits to keep aligned the kelly on the excavation axis. Guide 32 can slide along drilling mast 2 on guides 33 and coupled to the outer element of rod 20 presents itself as a sleeve provided then with a smooth cylindrical hole.

[0051] This guide can be fixed or variable in height and movable by the kelly rod or by an outer positioning system constrained to it, with striking on drilling mast 2, not shown.

[0052] The guide can also be of traditional type openable on the front side for permitting the mounting of the battery.

[0053] The guide is preferably mounted on the lower side because for all the drilling the kelly remains guided. If the guide was mounted upperly (as in the solution shown in fig. 1) the kelly would be guided only for a minimum part of the excavation, the one related to the very first drilling meters, with a huge drawback.

[0054] With reference to figure 13, it is shown a second variant wherein it is added a predisposition for the tubing flange. In some drillings it can be required the insertion of a foreshaft (tube of diameter sizes higher than the ones of the tool and of length very reduced 4 - 6 m) or the tubing for more elevated depths. Traditionally, the tubing flange is directly connected to tube 8a and has a cylindrical tract, called "glass" which has a length of 1 or 2 m. According to this invention, on the other hand, if the tubing flange were directly dragged by tube 8a, it could have considerably high glass sizes because the length of rod 19 implies another encumbrance which there is not in the traditional solution. This would have an impact on weights and expenses.

[0055] However, taking advantage of the presence and the wide sizes of the most outer rod 20, it is now possible to drag the tube to be driven, connecting directly to the lowest ending zone, near projection 20A.

[0056] In this way, it can be used an outer rod which permits the transfer of the maximum torque and thrust present (differently from a solution on inner rod which has certainly limitations due to the lower sizes) and also, considering the higher sizes of outer tube 20 with respect to standard one 7a, to increase the torque with a suitable gear state positioned between the rotary table and the outer kelly, which permits then to drive the tube at a higher height.

[0057] As indicated in figure 13, in the projecting zone wherein there is flange 20a there are obtained cylindrical seats 37 which opportunely ribbed and angularly distributed, represent the striking seats for the dragging of tube 35 to be driven.

[0058] Pin systems 36 or mechanical equivalents, manually or automatically operated, can be inserted for the temporary fastening between the tube and dragging element 20.

[0059] The mechanical dragging systems between rotary table and kelly and the ones between kelly and the tube to be driven, can be conformed in an equivalent way and with shapes known in the field.

[0060] In particular, the transmission of the movements between "dragger" 16 and the element of outer rod 20 can be realized with devices such as the ones indicated in the above mentioned patents EP208567Al, EP1860275A1, EP1849956A1 or with direct hooking systems with thread, hexagon and all the equivalent ones.

[0061] The control of insertion of striking element 17 can be of manual type or remotely commanded.

[0062] The remote actuation can be of hydraulic, electric or pneumatic type.

[0063] In particular, the last one has the advantage of a simple installation because on rotating part 16 can find a housing a rechargeable compressed air storage tank, which through a suitable control can be operated for generating the forces necessary to the fastening system.

[0064] During the assembly steps, the rotary table is positioned in the highest reachable point of the drilling mast (which coincides with the top in case of winch traction/thrust of the rotary table) and at least additional telescopic kelly 19 can be mounted from the bottom. In this case, the introduction of the kelly with respect to the "dragger" could automatically trigger the leverages which permit the introduction of the locking devices between the two elements (as stated by the patent DE19626223).

[0065] Alternatively, the kelly, moving axially (during the introduction in "dragger" 16) presses on a device which actuates the power plant (for example the previously described pneumatic one) which inserts the striking and fastening elements between element 16 and most outer rod 20.

[0066] As additional variant, it is also possible to realize an at least temporary coupling of "bayonet" type which hooks

the "dragger" to outer rod 20 and with low rotary, the final fastening shall be eventually done with elements manually insertable.

[0067] It is clear that further modifications that can be applied to the described device do not alter the innovative characteristic of the invention. It is for example possible to disassemble all kelly rods 7 and add the only battery 19 wholly outwards, connecting most inner rod 21 to lifting rope 10, thus permitting a reduction of height encumbrances still higher.

[0068] Another possible variant can be represented by a length modification of passing kelly 7, which could be reduced and lies all under the rotary table too. In this case the depth reduction, if required, could be retrieved by increasing the outer removals of battery 19.

[0069] The innovation proposed permits to increase the depth reachable with existing drilling machines, without extending the drilling mast, without changing the rotary table nor other main systems.

[0070] The innovation proposes itself as reversible modification, which does not affect, in a successive step, the return to the traditional structure.

[0071] Given the same encumbrance length it permits to increase the depth as required in the low drillings.

[0072] The transmission of the torque to the tube to be driven is simplified and improved in terms of performances.

Claims

1. Kelly for the realization of bored piles, constituted by a battery of rods (7, 19) displaceably inserted the one into the other and wherein the most inner one (9) supports an excavation tool (5); a rotary table (1), vertically sliding along the drilling mast (2) of the operating machine (3) which bears the kelly, is provided with means (8a) for putting into rotation the battery of rods (7, 19) around its longitudinal axis; means (10) for displacing and recompacting the rods of the battery and motorized means (6) for exerting a traction and a thrust on the rods during the excavation are also provided; the kelly being **characterized in that** at least part of the rods (19) of the battery is entirely positioned under the rotary table (1) by which it is put in rotation.

2. Kelly according to claim 1 **characterized in that** part of the battery of rods (19) is entirely positioned under the rotary table and part (7) is passing inside the rotary table and both the parts of the battery are put in rotation by the rotary table (1); part of the battery of rods (7) passing inside the rotary table is also inside the part of the battery of rods (19) under the rotary table.

3. Kelly according to claim 1 **characterized in that** the whole battery of rods (19, 7) is entirely positioned under the rotary table (1) by which it is put in rotation.

4. Kelly according to any of the claims 1-3 **characterized in that** the portion of battery of rods (19) positioned under the rotary table (1), is made integral with the means (8a) for putting in rotation the kelly through a flanged body (16), fixed with locking means (17) to the external rod (20) of the battery of rods (19) and to said means (8a) of the rotary table (1).

5. Kelly according to claim 2 **characterized in that** the inner rod (9) of the battery of rods (7) passing through the rotary table (1) bears a flange (12a) for collecting all the rods of the two batteries (7,19) when said means are actuated (10) for recompacting the rods of the two batteries (7,19).

6. Kelly according to claim 1 **characterized in that** the most outer rod (20) of the battery of rods (19) positioned under the rotary table (1), in correspondence to its lower end, is provided with perimeter flange (20a) for dragging the tube (35) to be inserted into the ground.

7. Kelly according to claim 6 **characterized in that** in the flange (20a) are obtained cylindrical seats (37) which represent striking seats for pins (36) of temporary connection between the outer rod (20) and the tube (35) to be inserted.

8. Kelly according to claim 1 **characterized in that** it is provided a lower guide (32) which permits to keep aligned the kelly on the excavation axis; said guide (32), sliding along the drilling mast (2) on guides (33), has the shape of a hose within which the external rod element of the battery inferior to the rotary table (1) is inserted passing through.

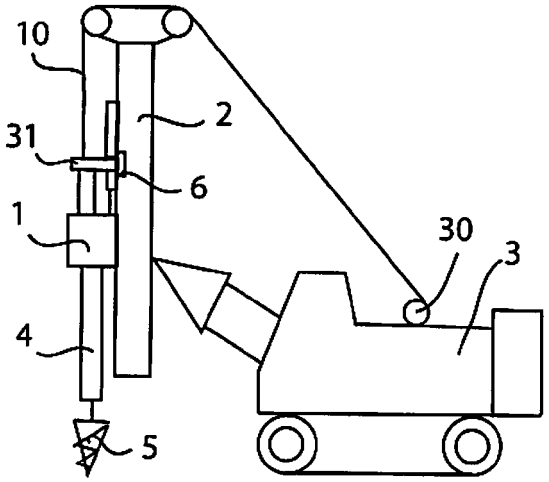

Fig.1

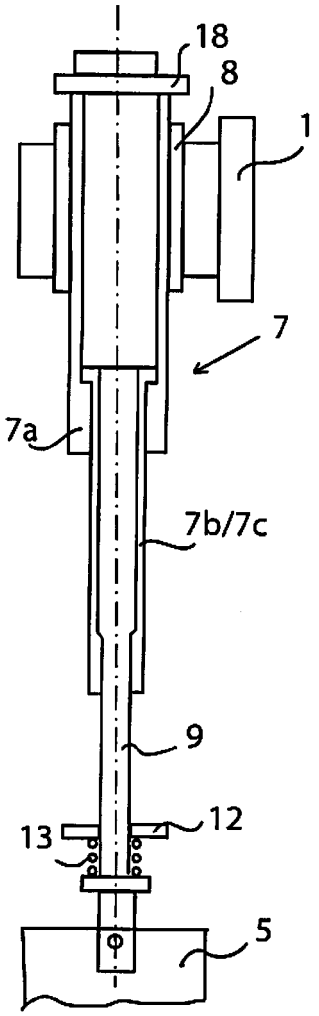

Fig.2

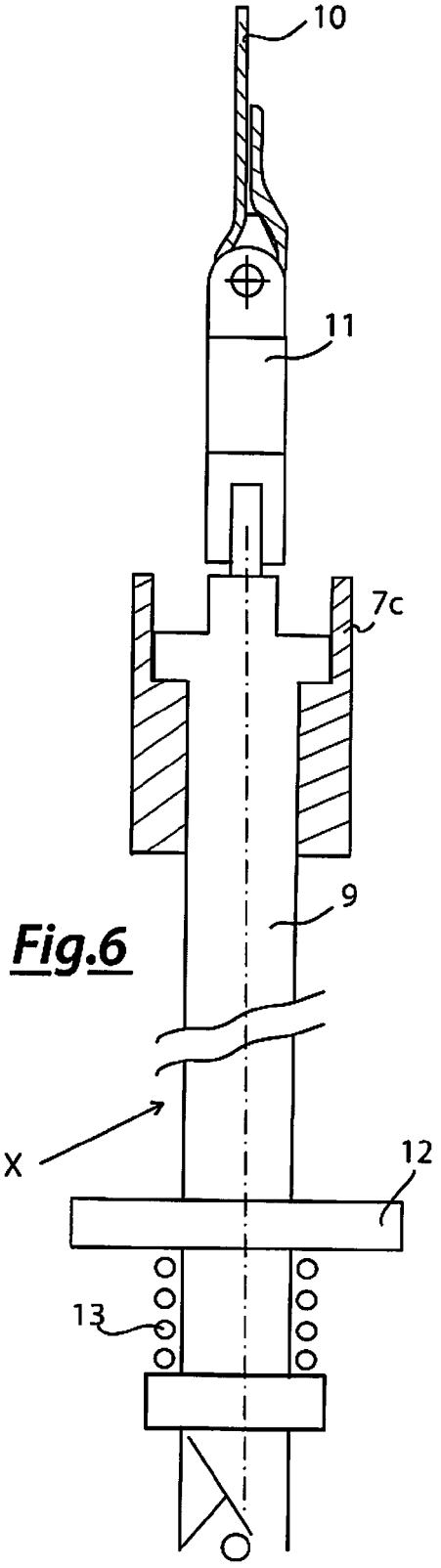

Fig.6

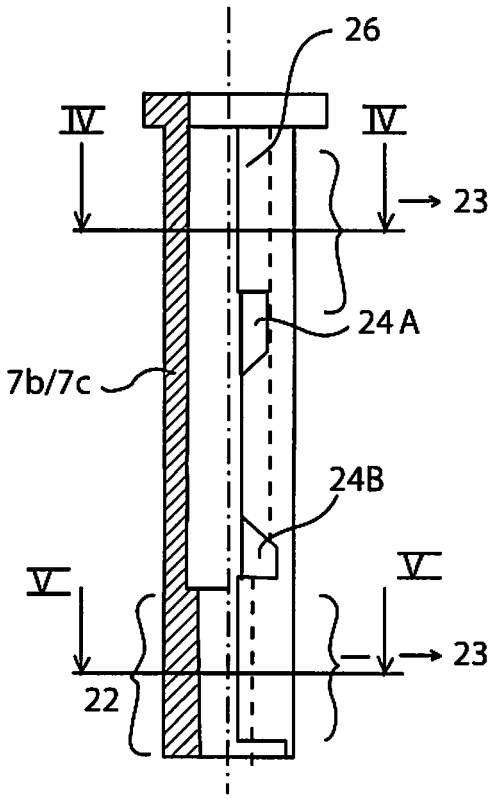

Fig.3

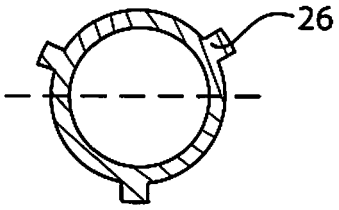

Fig.4

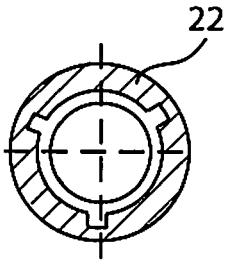

Fig.5

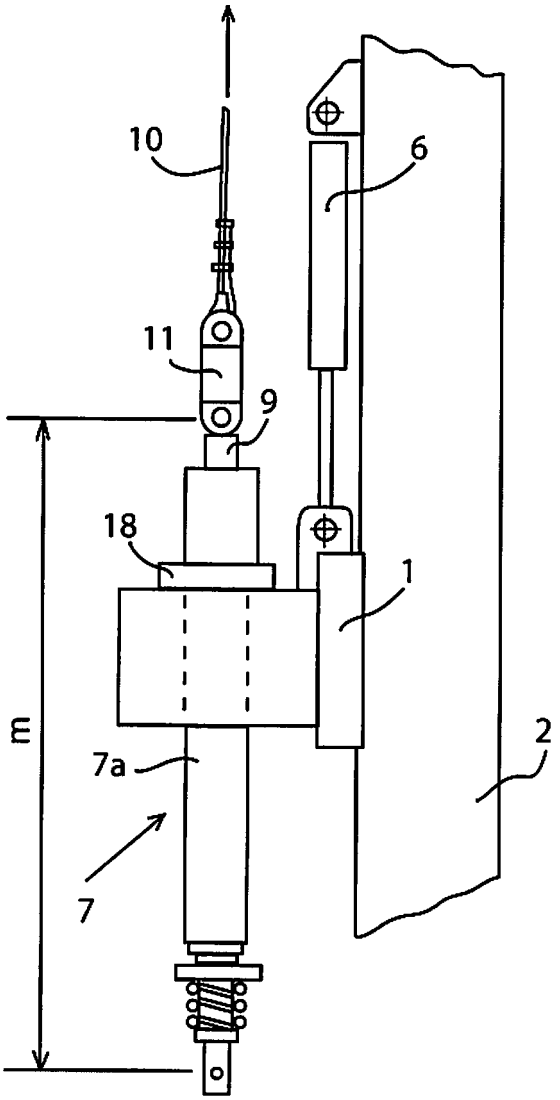

Fig.7

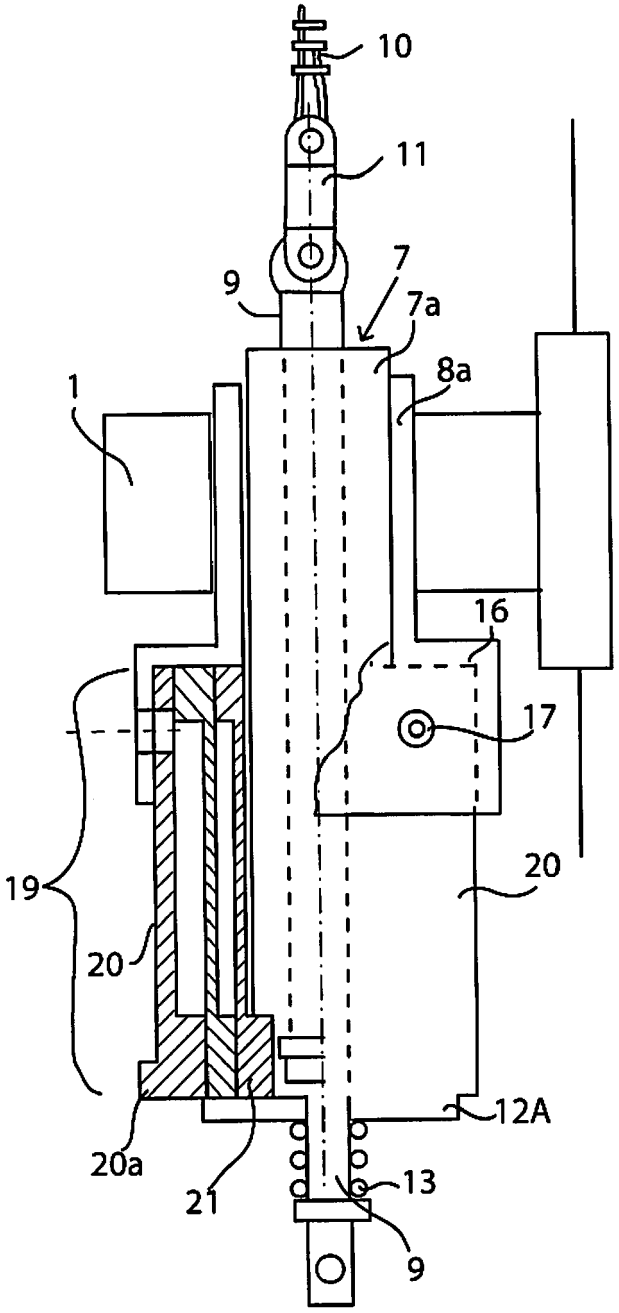

Fig.8

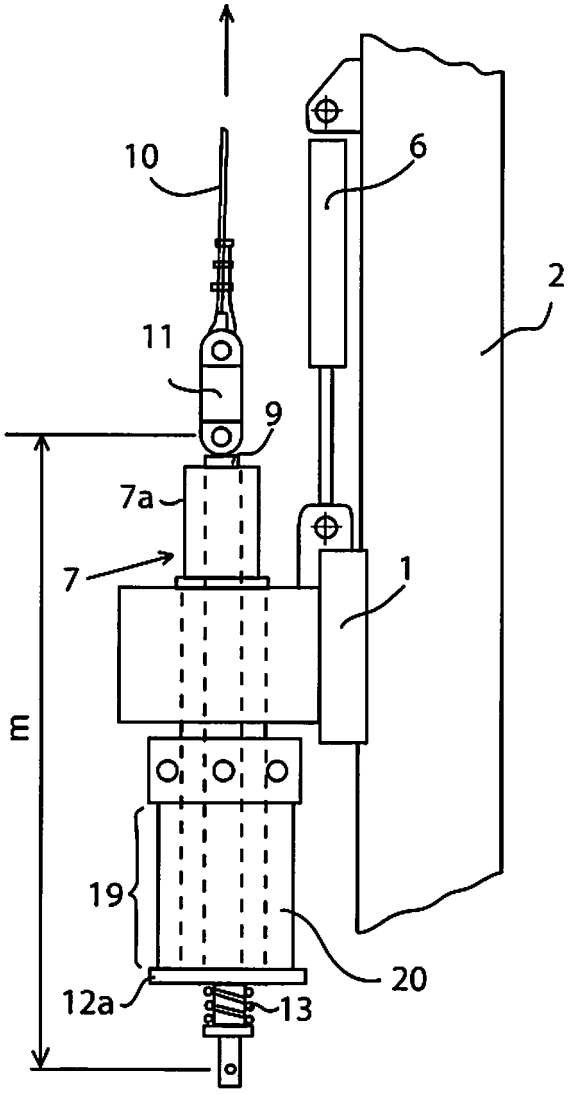

Fig.9

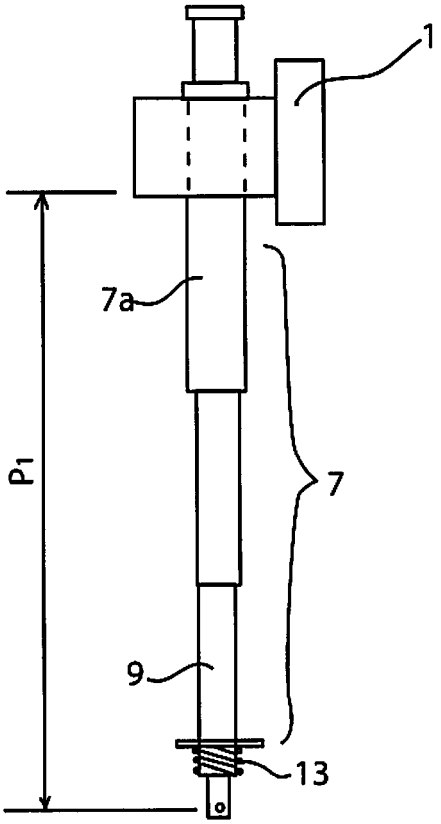

Fig.10

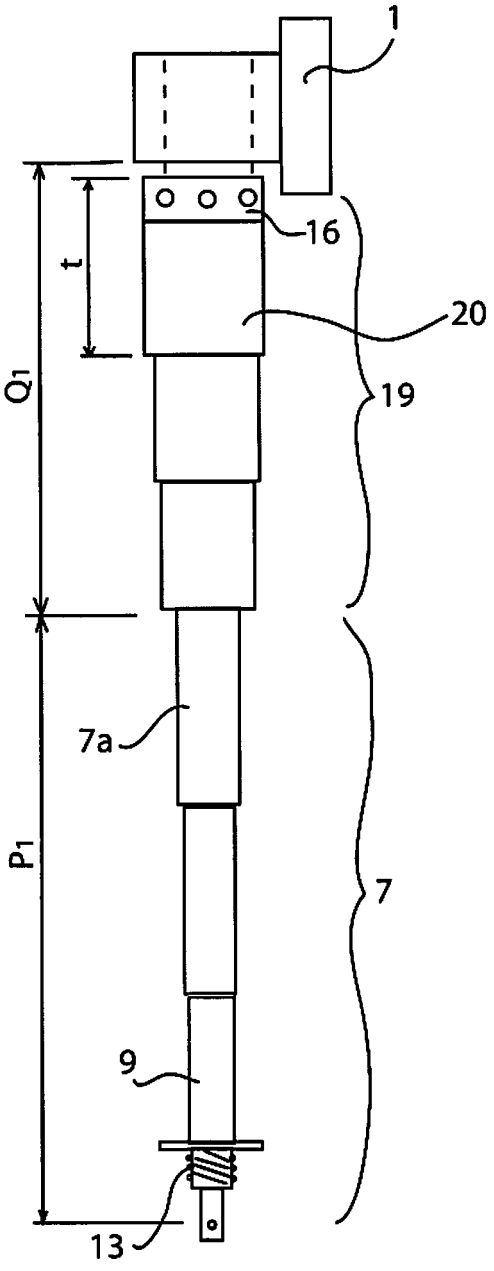

Fig.11

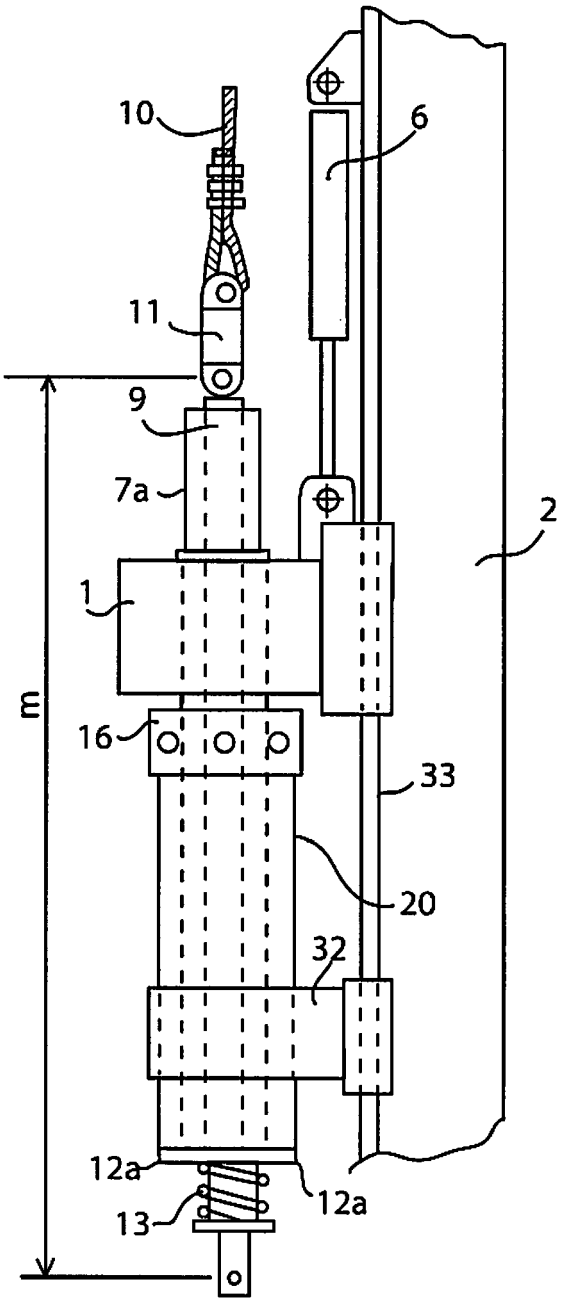

Fig.12

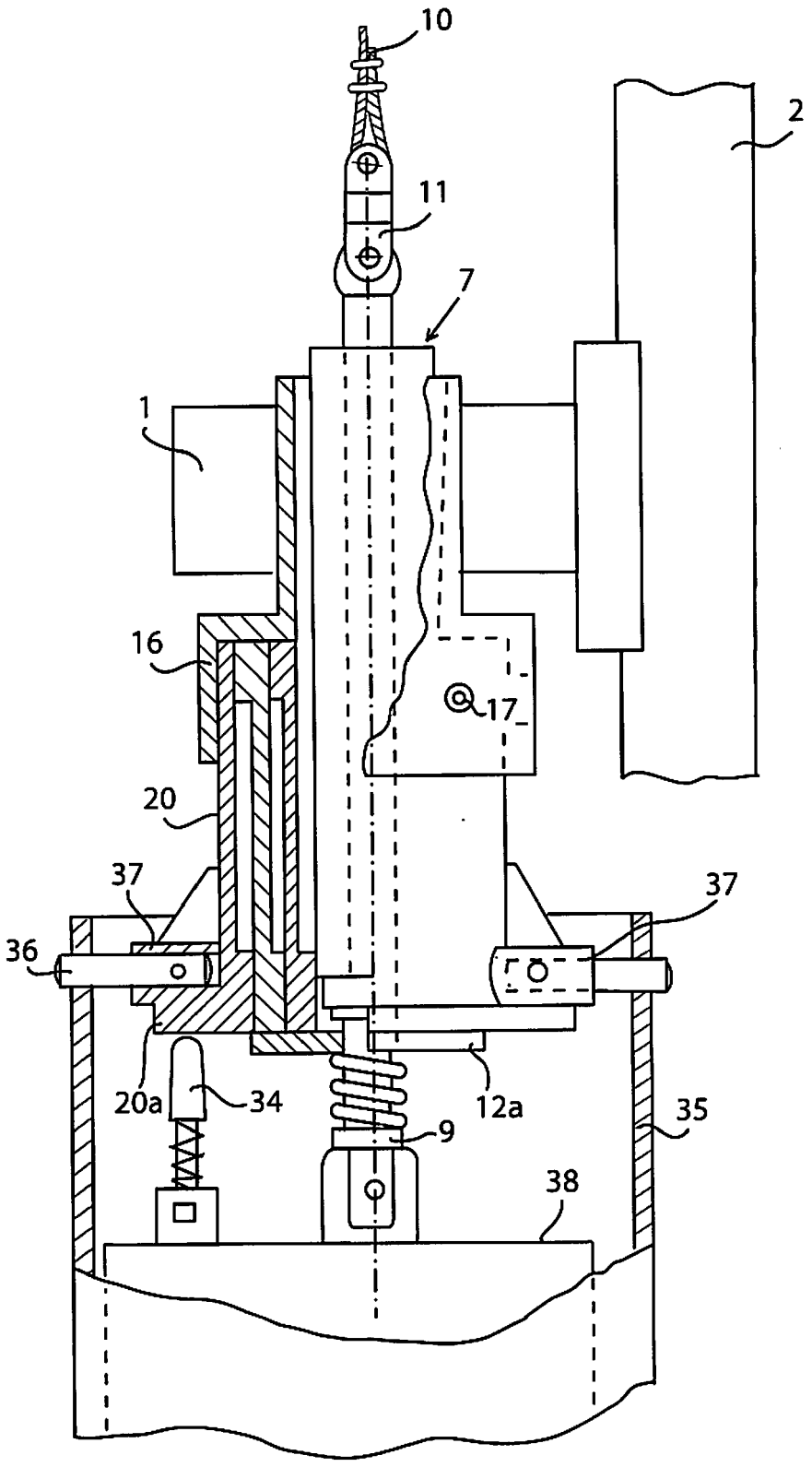

Fig.13

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EUROPEAN SEARCH REPORT

Application Number
EP 11 16 6700

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E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	14 July 2011	Manolache, Iustin

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