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(54) Drilling machine for drilling for example soil or rock formations, and method for using such machine

(57) In the drilling machine (100) according to the invention the proximal joint (103) allows the arm (4) to vary its orientation with respect to the machine body by rotating around at least a first (20), a second (23) and a third (22) proximal axis. The first (20) and the third (22) proximal axis are substantially orthogonal to each other and integral with at least the support mechanism (19). The second proximal axis (23) is non-orthogonal to the plane defined by the other two axes (20) and (22). The distal joint (104) allows to rotate the drilling mast (1) with respect to the mechanical arm (4) around a first distal axis (9) and a second (3) distal axis, wherein the first (9) and the second (3) distal axes are orthogonal to each other and the mast (1) extends perpendicularly with respect to the first distal axis 9; the support mechanism (19) may perform rotations on itself around the first proximal axis (20), substantially equal to or greater than 90° oriented in a single direction. The machine (100) is arranged for driving the distal joint (104) allowing the mast (1) to perform rotations around the first distal axis (9), by at least 90° oriented in a single direction.

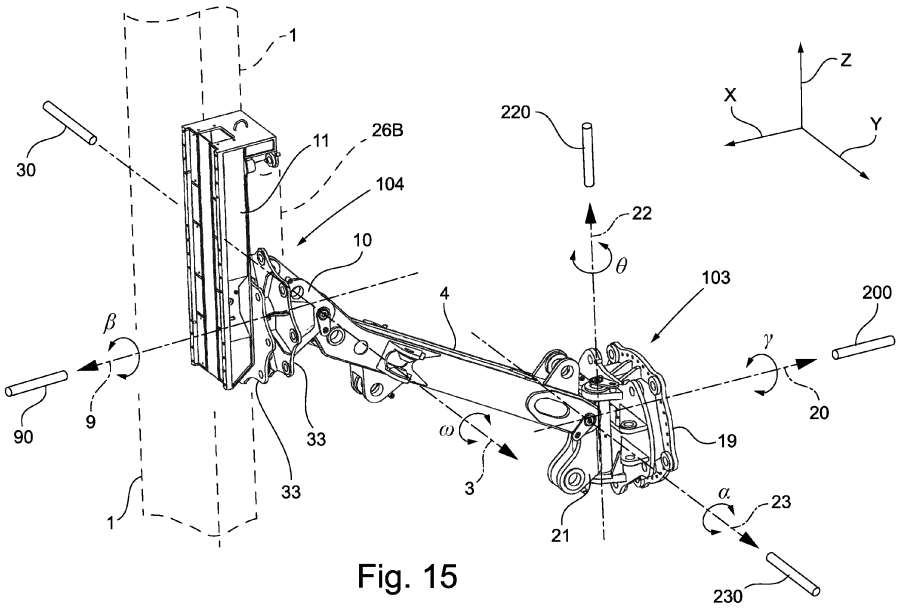


Fig. 15

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Description

Field of the invention

[0001] The present invention regards a machine for drilling soils or rock formations of the type provided for example with a mast and an array of drilling rods, useable for example for positioning vertical or variously tilted tie elements. The invention is particularly suitable to be applied to drilling devices which provide drillings of relatively small diameter, for example variable between 30 mm and 400 mm.

State of the art

[0002] In the field of small diameter drilling are known in the industry different types of self-propelling machines which have the common feature of having the following fundamental components: a machine body, a mast which bears the drilling means, clamps fixed to the base of the mast for gripping the drilling rods and an arm (part of the main support of the mechanism) for connecting the mast to the machine body. The movement of the mast with respect to the machine body occurs through mechanisms of different types which are driven by suitable actuator means. The various mechanisms may allow the machines to operate in various drilling configurations but they are generally optimised for maximising the performance only in some operations while having limitations in others. For example if optimised for vertical operations they shall be limited in other operations such as for example those for the execution of tilted tie elements wherein the drilling axis is tilted minimally with respect to the horizontal plane.

[0003] In particular there are the present operation configurations:

C.1) vertical with drilling in proximity of the centreline plane as shown by Figure 1;

C.2) vertical with side-swinging drilling as shown by Figure 2. From the configuration C.1 it is possible to obtain the configuration C.2 by rotating the arm with respect to the machine body around a vertical axis. Such manoeuvre, called swinging manoeuvre, allows to laterally move the drilling axis also beyond the outer edge of the track. In this configuration, when the drilling axis is flush with respect to the track there will however be a side overall dimension of the clamps beyond the edge of the track which limits the excavating condition near the existing walls;

C.3) Vertical with the mast rotated laterally of 90° with respect to the arm as shown by Figure 3. From configuration C.1 it is possible to obtain the configuration C.3 by rotating the mast by 90° with respect to the arm around a joint with vertical axis, typically located at the top part, in proximity of the mast. Such manoeuvre allows to laterally move the drilling axis without laterally moving the arm with respect to the centreline plane of the machine. In this condition there will be a minimum overall dimension of the clamps beyond the drilling axis in a direction lateral to the machine, but the mechanism is more complex with greater clearance and deterioration of the stability with respect to the previous solutions.

C.4) Anchoring with front drilling tilted between 0° and 45° with respect to the horizontal plane as shown by Figure 4. From configuration C.1 it is possible to obtain the configuration C.4 by rotating the mast with respect to the arm around a joint with horizontal axis and reclining it backwards towards the machine body. Subsequently, it is possible to rotate the arm with respect to the machine body around a joint with horizontal axis so as to reduce the tilting thereof with respect to the soil and so as to approach the mast to the ground.

C.5) Tie elements with transverse -or side-drilling tilted between 0° and 45° with respect to the horizontal plane and drilling means positioned over the mast as shown by Figure 5. Starting from configuration C.1, reaching configuration C.5 requires in a first step to rotate the mast with respect to the arm around a first joint with horizontal axis reclining it backwards towards the machine body (transport condition). Subsequently, it is possible to rotate the arm with respect to the machine body around a joint with horizontal axis perpendicular to the centreline plane so as to lower the overall height of the mast and arm up to the transport condition (horizontal mast laying on the machine body). From this configuration it is possible to rotate the mast with respect to the arm around a second joint with vertical axis so as to make it perpendicular to the centreline plane of the machine. Subsequently, after moving the arm in horizontal condition, it is possible to rotate the arm with respect to the machine body around a joint with horizontal axis lying on the centreline plane. The latter manoeuvre causes a tilting between 0° and 45° of the mast with respect to the ground, maintaining the drilling equipment at a greater height with respect to the mast. Starting instead from the mechanism of Figure 3 it is possible to laterally recline the mast by exploiting a further joint with horizontal axis between the arm and the mast. Such further joint simplifies the manoeuvres (with respect to the mechanism of fig 1) but further complicates the mechanism itself deteriorating the stability and rigidity of the machine.

C.6) Tie elements with transverse -or side- drilling tilted between 0° and 45° with respect to the horizontal plane and drilling means positioned cantilevered at the front part (for "cutting") with respect to the mast (Figure 6). Starting from configuration C.1, reaching configuration C.6 simply requires rotating the mast with respect to the arm using the horizontal axis (which was initially vertical in transport conditions, unfolded for Fig 5). In case of Figure 3 it is possible to use a further movement between the arm

and the mast joint which allows through a rotation around a horizontal axis to tilt the mast and rotary in a configuration by 90°, so as to move the rotary in a "cutting" configuration on the mast.

It is clear that some movements, in particular C.1, C.3, C.4 and C.5 can be simultaneously obtained by the current mechanisms only at the price of making the machines less stable (due to the positioning of the joints in an advanced and high position due to the fact that it is beyond the arm and in proximity of the mast), less precise (the positioning rigidity is lost due to the high number of joint elements present and the rotation axes required to cover all the movements) and more expensive due to their complexity, with several actuations and higher weight.

[0004] As regards small diameter drilling machines, mechanisms like the one disclosed in DE102007012055 are known which shows the machine in operating configuration 1, vertical with drilling in proximity of the centreline plane. Such mechanism also allows to obtain the operating configurations C.4 and, with some limitations on the angles, configurations C.5 and C.6. In configuration C.5 it is known (even though not represented in the patent) that the tiltings of the mast allowed by this mechanism extend over a range of 30° above and 30° below the horizontal or over a range 45° above and 15° below the horizontal and such limitation is caused by structural and mechanism reasons, the presence of a single actuator which should not exceed in terms of overall dimensions length-wise. Following the rotation of the arm with respect to the machine body around a horizontal axis lying on the centreline plane, the increase of the tilting of the mast with respect to the soil causes indeed a base of the mast to approach the soil up to about 45°, when the base comes into contact therewith preventing the continuation of the rotation. In order to be able to continue the rotation it would be necessary to either reduce the distance between the base and the connection fulcrum between the arm and the mast (which would imply reducing the length of the mast and thus the stroke of the rotary or fixing the mast in an eccentric manner on the arm but thus paying considerably in terms of side instability in the configurations with tie elements) or lift further in the vertical direction, the height at which said fulcrum is found (very complex, expensive and with problems in the transport configuration which would become too high). However, the first solution is not feasible in that a sliding of the mast upwards with respect to the arm would be required so wide that it would cause the clamps to impact against the arm or the arm-mast joint.

[0005] Also the second solution is not feasible in that with the arm resting on the horizontal plane and rotated by 90° around its longitudinal axis, the mechanism does not allow to control a vertical movement of the arm capable of increasing the tilting with respect to the soil and mounting it higher would lead to the aforementioned related transport problems. From a structural point of view it should also be observed that the arm in the rotated condition described above is strained to bend laterally by the vertical loads. Such stress shall increase proportionally with the increase of the rotation angle and this angle might also need to be limited according to the lateral bending resistance of the arm.

[0006] Thus in the operating configuration C.5 the mechanism does not allow to rotate the arm up to moving the mast from the horizontal condition to the vertical condition, i.e. it does not allow to obtain the operating configuration C.3. Such operating configuration C.3 can never be attained, not even starting from the operating condition C.1 because there is no joint with vertical axis capable of connecting the arm to the mast.

Another shortcoming of the mechanism lies in the fact that starting from the configuration C.1, it does not allow to attain the operating configuration C.2 given that there is no fulcrum with vertical rotation axis capable of connecting the arm to the machine body and at the same time there are no actuation means capable of allowing its swinging movement (as observable from Figure 2 which shows the mast positioned on the centreline plane).

[0007] Document DE20311847 shows in Figure 3 a machine provided with a mechanism (similar to the one illustrated for configuration C.3) which allows to laterally swing the arm reaching the operating configuration C.2 and it highlights the problems caused by the side overall dimensions of the clamps and the need to reduce the minimum distance "D" at which it is possible to move the drilling axis with respect to a wall when the tracks of the machine are parallel to such wall and the mast is vertical. Though complex, the mechanism does not have a joint with vertical axis between the arm and the mast like those indicated in fig 3 of the present application and it does not allow to reach the vertical operating condition C.3 with the mast rotated laterally by 90°. The solution proposed in Figure 2 of DE20311847 to reduce the height "d", provides that the clamps are not mounted directly on the mast but are connected thereto by interposing a plate (20) which can be bolted and shaped to allow the mounting of the clamps in a position rotated by an angle smaller than 90°. Still in this Figure, it can be observed that the height "d" is not the minimum height that can be theoretically obtained but that the limits of the described mechanism prevent it from being further reduced. Indeed, the arm cannot be further swinged in that the plate (20) would end up interfering with the track. Likewise, it is not possible to further rotate the clamp with respect to the mast, for example by modifying the shape of the plate (20), maintaining the centre distance between the drilling axis and the mast unvaried. In this case, there would be indeed an interference of the clamp with the mast. Thus also exploiting the use of the plate 20 it is not possible to reach the operating configuration C.3. Another disadvantage of this solution lies in that in order to pass from a first configuration adapted to perform drilling operations near a wall on the right side of the machine to a second

configuration adapted to perform drilling operations near a wall on the left of the machine requires unbolting the plate 20 from the mast and from the clamps and bolting it again at a different position.

[0008] Understanding the complexity of a mechanism capable to attain the operating configuration C.3 simply requires analysing patent EP1696100A1, which only shows part of mechansim elements to be mounted between the mast and the arm, i.e. a series of non-articulated elements arranged at great heights from the ground and far from the machine body, thus constituting a sufficient reason for the instability, poor rigidity and structural complications.

[0009] An object of the present invention is to provide a machine and a drilling method capable of overcoming at least some of the previously outlined limitations and drawbacks of the currently known drilling machines.

Summary of the invention

[0010] In a first aspect of the present invention, such object is attained with a drilling machine having the characteristics according to claim 1.

In a second aspect of the invention, such object is attained with a method for using a drilling machine having the characteristics according to claim 11.

In a third aspect of the invention, such object is attained with a method for using a drilling machine having the characteristics according to claim 12.

In a fourth aspect of the invention, such object is attained with a method for using a drilling machine having the characteristics according to claim 15. Further characteristics of the device are subject of the dependent claims.

The advantages that can be attained with the present invention shall be more apparent to the person skilled in the art from the following detailed description of a particular non-limiting embodiment illustrated with reference to the following schematic Figures.

List of figures

[0011]

Figures 1, 1A respectively show a side view and a top view of a known drilling machine in a first operating configuration, with the vertical mast and drilling in proximity of the centreline plane;

Figure 2 shows a top view of a known drilling machine in a second operating configuration, with the vertical mast swinged laterally;

Figures 3, 3A respectively show a side view and a top view of a known drilling machine in a third operating configuration, with the vertical mast rotated laterally by 90° with respect to the arm;

Figure 4 shows a side view of a known drilling machine in a fourth operating configuration, for tilted front drillings;

Figures 5, 5A respectively show a front view and a side view of a known drilling machine in a fifth operating configuration, for tilted transverse drillings with respect to the horizontal, and rotary table and drilling means arranged over the mast;

Figures 6, 6A respectively show a front view and a side view of a known drilling machine in a sixth operating configuration, for tilted transverse drillings with respect to the horizontal, and rotary table and drilling means positioned frontally cantilevered;

Figure 7 shows a side view of a drilling machine according to a particular embodiment of the invention, in position for performing vertical drilling operations in proximity of the centreline plane;

Figures 8, 9 respectively show a front view and a top view of the machine of Figure 7, in position for performing horizontal transverse - or side - drilling operations;

Figure 10 shows a front view of the machine of Figure 7, in position for performing drilling operations tilted transversely -or laterally-;

Figures 11 and 12 respectively show a side view and a top view of the machine of Figure 7, with the vertical mast and rotated laterally by 90° with respect to the arm;

Figure 13A shows an exploded perspective view of some components of the proximal joint 103 of the machine of Figure 7;

Figure 13B shows a perspective view of the support mechanism 19 of the joint of Figure 13A;

Figure 14 shows a perspective view of the rear plate of the support mechanism 19 of Figure 7, and the roll actuators arranged for driving such support mechanism.

Figure 15 shows, in perspective view, a mechanism scheme of the mast mechanism of the machine of Figure 7;

Figures 16, 16A show, respectively in a side and top view, the machine in a transport configuration, with the mast substantially horizontal and resting on the machine body.

Detailed description

[0012] Figures 7-15 regard a drilling machine, indicated with an overall reference 100, according to a particular embodiment of the invention. The drilling machine 100 may be arranged for drilling for example soil and/or rock formations, and it comprises:

a) a machine body 15, containing or in turn comprising for example a possible thermal engine to supply power to the entire machine and a hydraulic circuit for driving the actuators and the mechanisms described below;

b) a drilling mast 1 generally elongated and suitable to guide the tool driving means slidably mounted along its longitudinal axis;

c) a drilling array generally consisting of a rod or a

tube of the type that can be joined connected at the lower part to tools or drilling means (not shown but generally known, such as for example tricones, chisels, helical bits or twist drills, ...) and arranged longitudinally to the mast 1. The drilling array may consist of a plurality of rods connected to each other when intending to reach considerable depths for providing foundation micropiles. In such case, the array of rods has considerable diameter and weight, for example much greater with respect to the arrays used in the mine industry for the drilling operations required to place explosive charges. At times, screws or complex solutions consisting of external tubes and rods or inner screws can be used as drilling arrays whereas in some cases the machine may be used for fitting elements such as steel section bars and tubular elements into the soil, and in this case they could also be inserted by simply pushing and/or vibrating the drilling array without rotating it;

d) tool driving means 12 fixed to the drilling mast 1 and arranged for driving the drilling array, for example rotating it on itself around its longitudinal axis AT so as to drill the soil or the rock formation, the axis AT being substantially parallel to the longitudinal axis of the mast 1;

e) a mast mechanism 102, in turn comprising:

e.1) a mechanical arm 4;

e.2) a proximal joint 103 in turn comprising a support mechanism 19 and a swingable support arm 21;

e.3) a distal joint 104 arranged substantially at a further distance from the machine body 15 with respect to the proximal joint and which fixes the drilling mast 1 to the mechanical arm 4 allowing it to vary at least its orientation with respect to the mechanical arm 4.

The distal joint 104 preferably comprises a slide support 10 and a slide 11.

The machine 100 is preferably self-propelling and for such purpose may be provided with tracks 27A, 27B.

The tool driving means 12 may comprise a rotary table, also commonly referred to as rotary.

The mechanical arm 4 may substantially be a beam, more or less extended and even formed by a single rigid bar without intermediate articulations (Figures 7-15). The support mechanism 19 can have a more or less complex shape like the one indicatively shown in Figures 13, 14.

[0013] According to an aspect of the invention:

- the proximal joint 103, and in particular the relative support mechanism 19 and the swingable support arm 21 fix the mechanical arm 4 to the machine body allowing the arm to vary its orientation, i.e. its tilting in the space, with respect to the machine body 15 by rotating around at least a first 20, a second 23 and a third 22 proximal axis (Figure 15);
- the first 20 and the third 22 proximal axis are integral with at least the support mechanism 19 while the second proximal axis 23 is integral with the swingable support arm 21.
- at least in one operating condition the second proximal axis 23 is not orthogonal to the plane defined by the other two axes 20 and 22;
- the distal joint 104 allows to rotate the drilling mast 1 with respect to the mechanical arm 4 preferably only around a first distal axis 9 and a second distal axis (3), so that preferably the distal joint 104 obtains only two degrees of rotational freedom; the first 9 and the second 3 distal axes are orthogonal to each other, and the mast 1 extends perpendicularly with respect to the first distal axis 9. Having only two degrees of rotational freedom, the distal joint 104 has less clearances and deformations with respect for example to joints with three or more degrees of freedom, and thus it ensures more accurate positionings. In particular the five degrees of rotational freedom of the mechanism, three of which are present in the proximal joint and two of which are present in the distal joint, are necessary and sufficient to allow the achievement of all operating configurations described previously without introducing superfluous degrees of freedom which would further complicate and slow down the manoeuvres of positioning the mechanism.

[0014] The three proximal axes are two by two orthogonal to each other, and all three of them do not lie on the same plane; thus, regardless of the configuration of the arm 4, the mechanism subject of the present invention allows to rotate the arm with respect to two rotation axes 20, 22 perpendicular to each other and with respect to a third rotation axis 23 which is always perpendicular to at least one of the two previous axes 20, 22; for such purpose the first 20, the second 23 and the third proximal axis 22 may coincide with the actual and respective hinging pins 200, 230, 220 each of which makes only one degree of rotational freedom freely unconstrained, or can be simply ideal rotation axes (Figure 13, 15); in this second case the arm 4 may be fixed to the support mechanism 19 not with two distinctive hinging pins 220, 230 and the swingable support arm 21 -in such case substantially forming a cardanic joint- but for example with a ball joint;

- preferably the first proximal axis 20 is arranged for extending parallel or however longitudinally to the soil on which the drilling machine 100 rests in a normal condition of use;
- the machine 100 is arranged for driving the support mechanism 19 allowing it to rotate on itself by an angle γ, around the first proximal axis 20, substantially equal to or greater than 90°. Such rotation shall be deemed oriented in a single direction, such to move the mast 1 lying on a substantially horizontal

plane (plane X-Y with longitudinal axis of the mast arranged parallel to Y) to a final one which is at least substantially vertical (plane X-Z with longitudinal axis of the mast arranged parallel to Z) wherein the mast has thus been rotated around the axis 20 (parallel to X) by an overall angle equal to at least 90°. Greater rotations correspond to positions of the mast tilted with respect to the vertical plane (X-Z). In particular, in a first preferred solution such rotation should occur so that the third proximal axis (22), starting from a position substantially perpendicular to the soil, reaches a position at least substantially parallel to the soil. By convention, the ideal axis X is parallel to the front-rear direction of the machine 100, the axis Z indicates the direction vertical or however perpendicular to the soil or floor on which the machine 100 rests, and the axis Y is parallel to the right side-left side direction of the machine 100.

[0015] For such purpose the support mechanism 19 may for example be fixed through a pin 200, coaxial to the first proximal axis 20, to a flat and substantially vertical face suitably arranged at the front part of the machine body 15.

The rotatably unconstrained connection between the support mechanism 19 and relative front flat face of the machine body may be obtained for example through a bearing support, a bushing (both connected to the pin 200), guide slides or a center plate interposed between the machine body 15 and the centring surface 200A of the support mechanism 19 for the relative rotation. The fixing between the parts is preferably with removable means, screws, bolts or pins.

[0016] Advantageously the machine 100 is arranged for driving the support mechanism 19 allowing it to perform rotations γ around the first proximal axis 20, substantially equal to or greater than 90° oriented in a single direction, more advantageously equal to or greater than 120° (for performing the corrections of the mast 1 on the vertical) and even more advantageously equal to or greater than 180° so as to allow the drilling from both sides of the machine.

The stroke end positions of the rotations γ are preferably, even though not necessarily, symmetrical with respect to the vertical centreline plane -i.e. plane XZ- of the machine body 15.

Preferably the first proximal axis 20 is parallel to the front-rear direction of the machine 100, i.e. the direction of advancement thereof, for example the axis X of an ideal triad of Cartesian axes XYZ integral with the machine body (Figure 7).

[0017] Preferably the proximal joint 103 is arranged for rotating the mechanical arm 4 even around the second proximal axis 23 -rotation α- and to the third proximal axis 22 -rotation θ. For such purpose, the mechanical arm 4 may be fixed to the machine body 15 through two hinges obtained for example on the swingable support arm 21 interposed between the two. The first one comprises for example the proximal end of the arm 4, the swingable support arm 21 and the hinging pin 230 which connects them, the second hinge comprising for example the swingable support arm 21, the support mechanism 19 and the hinging pin 220 which connects them (Figure 13A). The pins 230 and 220 are respectively coaxial to the axes 23, 22. In addition, the machine 100 is preferably provided with at least two actuators 5 and 25A, also indicated as arm movement actuator 5 and first swinging actuator 25A, arranged for rotating the arm 4 respectively around the second proximal axis 23 and around the third proximal axis 22.

[0018] Preferably the machine 100 is also provided with a second swinging actuator 25B, also arranged for rotating the arm 4 around the third proximal axis 22. Advantageously the first 25A and the second 25B proximal actuator are arranged on two opposite sides of the mechanical arm 4, preferably arranged adjacent to each other and to the arm 4; in other words, preferably the mechanical arm 4 and the first 25A and the second 25B proximal actuator are substantially coplanar.

[0019] The first 25A and the second 25B actuator may be fixed, at one end thereof, to the support mechanism 19, and at the other one to the arm 4. The first 25A and the second proximal actuator 25B may be connected to the support mechanism 19 through a first coupling provided with a cardanic joint with two axes or a ball joint, and they are connected to the side of the arm 4 through a second coupling provided with a cardanic joint with two axes or a ball joint. The presence of the two cardanic joints 31 or ball joints (not illustrated) allows each cylinder 25A, 25B to accompany the movements of the arm 4, both when it rotates with respect to the axis 22 and when it rotates with respect to the axis 23, in that the cylinder is free to vary its tilting with respect to the arm without ever being stressed by bending loads. The arm movement actuator 5 may be fixed for example at an end thereof to the arm 4, and at the other end to the swingable support arm 21. Preferably the arm movement actuator 5 is fixed longitudinally to the arm 4 and along its lower side, in a position substantially symmetric with respect to the first 25A and to the second 25B swinging actuator, for example so as to be able to lift or lower the arm 4 with respect to a horizontal plane passing through the proximal axis 23.

[0020] Advantageously, the machine 100 is arranged for driving the distal joint 104 so as to rotate the drilling mast 1 with respect to the mechanical arm 4 by rotating around a first distal axis 9 integral with the slide 11 connected to the mast 1 or integral with the slide support 10 connected to the arm 4, preferably through at least a first distal actuator 26A -rotation β. For such purpose the distal joint 104 may be provided with a pin 90 coaxial to the axis 9 and which hinges the slide 11 to the slide support 10. Otherwise, analogously to the previous ones, it may be provided with bushings or center plates which allow the unconstraining of the rotation around that axis.

[0021] Advantageously, the machine 100 is arranged

for driving the distal joint 104 and in particular the slide support 10 so as to rotate the drilling mast 1 with respect to the mechanical arm 4 also rotating around a second distal axis 3 (rotation ω, still parallel to the axis 23) preferably through a second distal actuator 2, also indicated as tilting mast actuator. For such purpose the distal joint 104 may be provided with a pin 30 coaxial to the axis 3 and which hinges the slide support 10 to the arm 4. The second distal actuator 2 may for example comprise a hydraulic cylinder fixed at an end to the arm 4 directly or returned through connecting rods 6.

The second distal axis 3 is preferably orthogonal or transverse to the first distal axis 9 and to the longitudinal axis of the mechanical arm 4.

Analogously to the rotation axes of the proximal joint, also the rotation axes 3, 9 of the distal joint may each be obtained with a relative hinging pin which allows a single degree of rotational freedom, or with cardanic joints, ball joints or other joints which allow each two or more degrees of rotational freedom.

[0022] Advantageously the distal joint is also provided with a third distal actuator 26B also arranged for rotating the slide 11 -and thus also the drilling mast 1- with respect to the slide support 10 and thus to the mechanical arm 4 by rotating around the first distal axis 9. Each of the actuators 26A, 26B advantageously comprises a hydraulic cylinder or other linear actuator arranged on the opposite side, with respect to the mast 1, in which the other distal linear actuator (respectively 26B, 26A) is located. Preferably but not necessarily, the arm movement actuator 5, the first 25A and the second tilting actuator 25B, the actuator for tilting the mast 2, the first 26A, the second 2, the third 26B and the fourth distal actuator 18 are or comprise hydraulic cylinders or other types of linear actuators, such as for example pneumatic cylinders, linear induction motors, rotary motors that actuate screw/nut screw systems. The linear actuators are generally capable of developing considerable actuation forces, and thus considerable drive torques, while maintaining small overall dimensions which facilitate a better positioning thereof with respect to the rotation axes of the mechanism. Thus, given that it is possible to use more lever arms, the linear actuators may advantageously have smaller dimensions and weights, for example with respect to rotary actuators; lower weight is an advantage particularly appreciated in the actuators located in the distal position: indeed, having lighter distal actuators 26A, 26B implies lesser cantilevered masses, and hence lower instability of the drilling machine 100 and greater lifting capacity of the mechanical arm. Due to the aforementioned reasons, i.e. the possibility of using suitable lever arms, the linear actuators are cheaper than the rotary ones considering the same developed torque. In addition, the linear actuators are almost free of clearances and thus they allow a greater precision in positioning the mechanism and they ensure the maintainment of the attained configuration even when the mechanism is subjected to external loads due to the work steps. The use of said linear actuators to move the mechanism is thus advantageous with respect to the rotary actuators such as gear motors, which require the presence of a given angular clearance between the toothed wheels in order to ensure the correct gearing thereof. In addition, said clearance increases as the number of reduction stages present in the rotary actuator increases. Alternatively, part or all actuators 2, 5, 18, 25A, 25B, 26A, 26B may be replaced by one or more actuators each capable of actuating several degrees of freedom of the mast mechanism 102.

The support mechanism 19 may for example comprise a front plate 190 and a rear plate 192, both for example made of metal (Figure 13A, 13B, 14).

[0023] The front rotation of the support mechanism 19 and, along with it, of the arm 4 by an angle γ (gamma) with respect to the first proximal axis 20 is preferably actuated through at least one actuator 24A - conventionally also indicated as the first roll actuator 24A- which preferably, just like the second roll actuator 24B shall be described hereinafter, is a linear actuator. In a first preferred embodiment the first roll actuator may be a hydraulic cylinder constrained (hinged) at a suitable point 240A to the machine body 15 and at another point 242A preferably hinged to the support mechanism 19 so that the extension and retraction of the stem 244A of the cylinder 24A applies to the support 19 a non-null moment and causes the rotation of the support. Such rotation γ (gamma) by at least 90° may preferably occur through a single continuous stroke of the cylinder 24A. Alternatively, when greater strokes are required, the at least one cylinder 24A may allow the support 19 to perform rotations greater than 90° with returns at several pitches, i.e. with several extension and retraction strokes of the stem 244A, by performing at least one second sequential actuation of the cylinder 24A once the external end of the stem 244A is disconnected so as to be reconnected in a different configuration.

[0024] Preferably, in the latter case, several actuator-fixing points 192A-192D are provided on the support mechanism 19 arranged to fix the support 19 to the actuator 24A. Such fixing points 192A-192D are located preferably on the same circumference concentric to the first axis of proximal rotation 20 and spaced apart from each other by a given angle, so that a complete stroke of the cylinder 24 allows a partial rotation of the support mechanism 19. Upon terminating such stroke, it will be possible to block the movement between the machine body 15 and the support mechanism 19 through suitable mechanical stop means, for example a manually or automatically removable locking pin and disconnect the stem 244A of the cylinder 24 from the support 19, for example from the fixing point 192B. The locking pin may for example be a pin inserted by hand into one of the pairs of holes 192A-192E so as to traverse at least one between the plate 192 and 190 and being engaged in a suitable abutment on the framework 15 so as to prevent the support mechanism 19 from rotating.

[0025] The peripheral sheets of the support 19, which

connect the front plate 190 to the rear one 192, are obtained with a "cam" shape 32 so that when the stem 244A of the cylinder is disconnected it lies on the aforementioned sheets stopping after minimum rotation of the cylinder and relieving the operator from the need of holding the cylinder in a raised position; given that it weighs many tens of kilograms, this allows to facilitate the operation of disengaging the pins.

In the subsequent step of moving the cylinder to connect it again to a new fixing point -for example 192C- of the support 19, the cam shape 32 guides the head of the stem 244A up to positioning it at such point 192C and facilitating the insertion of the connection pin.

[0026] After unlocking the movement between the support mechanism 19 and the machine body 15, for example by disengaging the locking pin, it will be possible to perform a new stroke of the rotation cylinder 24A so as to rotate the support mechanism 19 by a further arch. In brief the steps are as follows:

- first front rotation for a first angle $\gamma 1$ (gamma 1);
- engaging the locking pin of the rotation or another mechanical stop device;
- disconnecting the actuator 24A;
- retracting the stem 244A if it was extended or extension of the stem if it was retracted;
- moving the stem 244A guided by the cam 32 without requiring human intervention;
- fixing the stem 244A to the support mechanism 19 again;
- disengaging the locking pin of the rotation or any other mechanical stop device;
- rotating $\gamma 2$ (gamma 2) the support mechanism 19 again around the front plane.

[0027] In a second preferable alternative it is possible to use two cylinders or other roll actuators 24A, 24B constrained on the opposite sides of the machine body 15 with respect to the first proximal axis 20 and both connected to the support mechanism 19 so that they cooperate during the rotation of the latter, thus reducing by half the loads to which they are subjected and thus having lower size and overall dimensions. The use of roll actuators of the linear type is advantageous due to their small dimensions which allow to obtain a very compact distal joint and thus reducing the total overall dimensions of the drilling machine. Said roll actuators, having overall dimensions almost equal to the thickness of the support mechanism 19 along the axis 20, may be arranged adjacent to said support and entirely outside the machine body 15. Said positioning of the roll actuators is advantageous in that it does not occupy space inside the machine body 15, simplifying the arrangement of the components contained in the machine body such as the thermal engine and the hydraulic circuit of the machine itself. During the movement, while a first cylinder -e.g. 24A- operates in extension, the second one -e.g. 24B- operates retracting. Thus, at the end of the partial rotation it is possible to disconnect only one of the two cylinders -e.g. 24A- while the other 24B, still engaged, performs the task of blocking the rotation.

[0028] Upon reconnecting the first cylinder 24A in a new constraint point 192A-192E on the support 19, it will be possible to disconnect the second cylinder 24B while the first one 24A performs the function of anti-rotating and reconnecting also in a new fixing point 192A-192E of the support 19. This more complex variant in terms of times is more favourable in terms of optimised dimensioning of the structures and of the actuators, and in terms of safety.

In both solutions indicated herein the blocking pin can be replaced with a linear actuator, preferably hydraulically controlled for the automatic unlocking and subsequent locking of the actuators 24A, 24B in the respective seats 192a, 192b, 242a, 242b, etc. Such linear actuators are preferably remote-controlled.

[0029] Instead of by one or more linear actuators, in a third embodiment the rotation γ (gamma) of the support mechanism 19 may be actuated by at least one gear motor or any other equivalent rotary actuator. In this second case, a connection of the pinion sprocket type may be provided between the machine body 15 and the support 19 wherein the pinion of the gear motor is integral with the support mechanism 19 while the sprocket is integral with the machine body 15 or vice versa, so that the rotation of the pinion induces a relative rotation between the support mechanism 19 and the machine body 15.

[0030] Advantageously, the distal joint 104 may rotate the mast 1 around the first distal axis 9 thanks to actuators and mechanisms analogous to those described previously for rotating the support mechanism 19 around the first proximal axis 20. More precisely, an end of the first 26A and possibly the third distal actuator 26B, which preferably, as mentioned, are hydraulic cylinders or other linear actuators, are fixed to the slide 11 on which the mast 1 is mounted so as to be able to slide longitudinally with respect to itself, and their other ends -for example the external heads of the relative stems- are fixed to a plate 33 integral with the slide support 10 so as to be able to apply, extending or retracting, an arm and a non-null moment with respect to the first distal axis 9.

[0031] Analogously to the actuation of the support mechanism 19, the first 26A and possibly the third distal actuator 26B may cause the desired rotation stroke β (beta) of the mast 1 around the axis 9:

- with a single continuous translation stroke, for example the extension or retraction of their stems; or, more preferably
- with a plurality of translation strokes with pitch-by-pitch return, for example allowing the stems of the hydraulic cylinders 26A, 26B to perform a first extension or contraction stroke, and disconnecting one of the two cylinders -e.g. 26A- while the other 26B, still engaged, serves the purpose of locking the rotation.

[0032] Upon reconnecting the first cylinder 26A in a new constraint point on the plate 33, it will be possible to disconnect the second cylinder 26B while the first one 26A performs the function of anti-rotation and to reconnect the same also in a new point of the plate 33. Should there be present only one cylinder, during the disconnection step the rotation will be locked with a mechanical stop element, for example a pin. Then, the stems of the hydraulic cylinder 26A, 26B will be allowed to perform another extension or contraction stroke, until completing the desired rotation β, which may thus be greater than 90° with respect to an initial condition wherein the drilling mast 1 belongs to a substantially vertical plane (plane X-Z with longitudinal axis of the mast parallel to Z) and a final condition in which the mast belongs to at least one substantially horizontal plane (plane X-Y with longitudinal axis of the mast parallel to Y). In particular the mast 1 and the arm 4 are substantially coplanar and the mast is rotated in a single direction around the axis 9 for rotations equal to at least 90°, or at least 180° or even 360° around the axis 9; - with one or more rotation strokes, in the latter case the actuators 26A, 26B being of the rotary type.

[0033] As a further alternative, in order to perform the rotation β of the mast 1 directly by an angle substantially equivalent to 180° (thus allowing operating in configuration C.3 on both sides of the machine) around the first distal axis 9 it is possible to use two hydraulic cylinders mounted on connecting rods as described in Figure 2 of patent DE102007012055. Preferably the mast mechanism 102 is arranged to allow the mast 1 to translate longitudinally on itself (arrow F1 in Figure 7) with respect to the arm 4 and in particular with respect to the slide 11 which is constrained to the arm through the slide support 10. For such purpose the mast 1 and the slide 11 may be fixed together for example through a prismatic coupling or any other suitable sliding guide, and preferably be actuated through a fourth distal actuator 18, also referred to as mast extraction actuator 18 (Figure 7) which shall be connected at one of its end to the slide 11 and at the other end to the mast 1.

[0034] There shall be now described some examples of operation of the drilling machine 100.

Starting from the condition of Figure 7, by actuating the tilting mast cylinder 2, the mast 1 is reclined backwards (clockwise rotation with reference to Figure 7) allowing it to rotate around the second distal axis 3. Subsequently, by actuating the arm movement actuator 5, the arm 4 is lowered with a rotation α around the second proximal axis 23, reaching the operating condition C.4 to perform tilted front anchoring with rotary 12 resting over the mast 1.

[0035] It is thus possible to continue the rotations around the second proximal axis 23 and the second distal axis 3 until the mast 1 is moved in a substantially horizontal position at a height slightly higher than that of the machine body 15. Thus the first 26A and the possible third distal actuator 26B rotate the mast 1 by an angle β = 90° around the first distal axis 9, which is now in a substantially vertical position. Such rotation of the mast develops according to a substantially horizontal plane. When the mast 1 reaches the transverse plane YZ of the machine 100, the operating condition C.5 shown in Figures 8, 9 is obtained with tie elements with rotary resting on the mast 1 for transverse drilling in the particular case of null tilting visible. In Figures 8 and 9 the mast 1 is horizontal with respect to the soil and perpendicular with respect to the arm 4, the arm 4 is substantially parallel to the longitudinal axis X of the machine 100, it is not rotated with respect to the first proximal axis 20 and the drilling means are above the mast 1, i.e. the drilling axis is at a greater height with respect to the mast 1.

[0036] In the configuration of figure 8 the vertical eccentric loads, determined by the weight of the structures, would tend to rotate the arm 4 with respect to the second proximal axis 23 (rotation α). The second proximal axis 23 is now parallel to the transverse axis Y and the aforementioned rotation α is prevented by the thrust of the arm movement cylinder 5. The eccentricity or in any case the transverse asymmetry of the weights of the mechanism components and of the mast 1 with respect to the first proximal axis 20 would tend to rotate the mechanism around the axis 20 and such rotation γ is counteracted by the action of at least one of the roll actuators 24A, 24B.

[0037] Thus in the configuration of figures 8 and 9, when not in the drilling step, no load tends to rotate the arm 4 around the third proximal axis 22 which is substantially parallel to the vertical axis Z. Thus, in this condition the swinging cylinders 25A, 25B should not counteract any load and they do not serve any function of supporting the mechanism 102. In this configuration, the swinging cylinders 25A, 25B may be actuated and in this case they only serve the positioning function, allowing the arm 4 to rotate around the third distal axis 22 and only having to overcome the frictions of such rotation.

[0038] Described hereinafter is a preferred method of passing from the condition of Figures 8, 9 to the condition of Figure 11. The first and the possible second roll actuator 24A, 24B may rotate the support mechanism 19, and hence the arm 4 and the mast 1 by an angle $\gamma < 90°$ -for example γ = about 45°- around the first proximal axis 20 up to reaching the condition of Figure 10, in which also the second 23 and third 22 proximal axis will have been subjected to a rotation by an angle γ. In the condition of Figure 10 the swinging cylinders 25A, 25B are in an asymmetric position with respect to the vertical plane XZ and the vertical loads, determined by the weights, would tend to rotate the arm 4 both with respect to the second 23 and with respect to the third proximal rotation axis 22, acting on the arm 4 as a side load. Thus, in this condition both the arm movement cylinder 5 and the swinging cylinders 25A, 25B are loaded. In particular, starting from the condition of figure 8, as the rotation angle γ progressively increases with respect to the first proximal axis 20, the load resting on the arm movement cylinder 5 reduces and the load simultaneously weighing on the swinging cylinders 25A, 25B increases.

[0039] Thus, the mechanism 102 allows to use the at least one swinging cylinder 25A or 25B also for supporting the vertical loads and lifting the arm 4.

In addition, in the condition of figure 10 the loads acting in side action on the arm 4 -i.e. along the axis Z- may be at least partially counteracted by the cylinders 25A, 25B thus avoiding that it is the bending resistance of the arm 4 alone to counteract them and allowing a small dimensioning of the arm. From Figure 10 it can be observed that in this condition, by actuating the arm movement cylinder 5 so as to lift, according to the positive direction of the axis Z, the distal joint 104 of the arm 4, such joint is simultaneously moved in the positive direction of the transverse axis Y. On the other hand, actuating the swinging cylinders 25A, 25B so as to move the distal joint 104 in the positive direction of the axis Z, the distal joint 104 is simultaneously moved in the negative direction of the axis Y. Thus the mechanism subject of the present invention, through a combined and suitably modulated actuation of the cylinders 5, 25A, 25B allows to obtain a movement (rotation) of the arm 4 on a vertical plane -for example XZ nullifying the movement components in the transverse direction Y.

[0040] In addition, such vertical movement can be obtained independently from the rotation angle γ of the arm 4 with respect to the first proximal axis 20 and independently from the value of the tilting angle φ (phi) of the arm 4 with respect to the soil.

Thus, this movement allows, with reference to figure 10, to lift the mast 1 in the vertical direction without increasing the transverse cantilever thereof, thus without jeopardising the side stability of the machine. Analogously to what has been described above, with reference to figure 10, it can be observed that in such condition by actuating the arm movement cylinder 5 so as to move the distal joint 104 in the positive direction of the transverse axis Y, such joint is also simultaneously moved in the positive direction of the vertical axis Z. On the other hand, by actuating the swinging cylinders 25A, 25B so as to move the distal joint 104 in the positive direction of the axis Y, the joint 104 is simultaneously moved in the negative direction of the axis Z. Thus, the combined and suitably modulated actuation of the cylinders 5, 25A, 25B allows to obtain a movement in which the movement components nullify in the direction Z. The obtained result is thus a side swinging of the arm 4 and the mast 1 on a plane X-Y maintaining the distal joint 104 at a constant height Z. Such movement can also be independently obtained from the rotation angle γ of the arm 4 with respect to the first proximal axis 20 and regardless of the value of the tilting angle φ (phi) of the arm 4 with respect to the soil.

[0041] In the configuration of figure 10 the distance between the base 17 of the mast and the distal joint 104 was reduced to the minimum value allowed by sliding the mast 1 upwards with respect to the slide 11 by activating the mast extraction cylinder 18. As observable from figure 10, regardless of the adoption of an extremely long actuator 18 capable of allowing - in the entirely closed condition - to have the mast 1 centred with respect to the arm 4 thus being able to operate with the tie elements in a non-excessively eccentric configuration - (reduced problem of side stability) and - in the entirely open condition - to be able to lift the base 17 to the maximum height from the soil, without further adjustments it would not be possible to avoid the base - soil contact when the tilting gamma of the mast on the vertical plane reaches angles beyond 30-45°. Further upward extraction motion would cause problems of side instability and problems regarding interference between the lower part of the mast which is provided with supply systems for the clamps and the different actuators and the slide 11. Thus, starting from the configuration of figure 10, once the distal joint 104 and thus also the mast 1 with respect to the soil through the previously described vertical movement of the arm 4 are sufficiently lifted, it is advantageously possible to perform a further rotation of the support mechanism 19 thus increasing the rotation angle γ without the base of the mast 17 coming into contact with the soil. In particular the tilting of the mast 1 may be increased up to obtaining a final rotation γ of at least 90° with respect to the initial condition shown in figure 8 in which the mast 1 was horizontal. In the condition reached in Figure 11, the third proximal axis 22 is parallel to the axis Y. The second proximal axis 23, due to the the lifting of the arm 4 by an angle φ (phi) with respect to the soil, shall now also be tilted by an angle φ (phi) with respect to the vertical axis Z but it shall be however perpendicular to the third proximal axis 22. Still due to the lifting of the arm 4 by an angle φ (phi), the mast 1 which was rotated by an angle β equal to 90° with respect to the plane longitudinal of the arm, following the 90° rotation of the support mechanism 19 shall be tilted by an angle φ (phi) with respect to the vertical.

[0042] At this point the mast mechanism 102 allows to perform a further rotation β' of the slide 11, and thus of the mast 1, with respect to the first distal axis 9. This further rotation thus causes the overall value of the angle β to be greater than 90° and allows the returning of the mast 1 to the vertical position, thus allowing the machine 100 to reach the operating condition C.3 with the mast 1 vertical and rotated laterally by 90° with respect to the arm 4 as observable in figure 12.

In the configuration of figures 11 and 12, the vertical loads determined by the weights of the structures would tend to cause the rotation of the arm 4 and of the swingable support-arm 21 with respect to the third proximal axis 22 which is parallel to the transverse axis Y. The aforementioned rotation is prevented by the support action (through push or pull) of the swinging cylinders 25A, 25B.

[0043] The eccentricity of the weights of the components of the mechanism and of the mast 1 with respect to the first proximal axis 20 tends to rotate the mechanism 102 around the first proximal axis 20. Such rotation is counteracted by the action of the roll actuators 24A, 24B. Thus in the configuration of figures 11 and 12, no load tends to rotate the arm 4 with respect to the second prox-

imal axis 23 which now lies in plane X-Z. Thus, in this condition the arm movement actuator 5 should not counteract any load and it does not serve any function of supporting the mechanism 102. In this configuration, the cylinder 5 may however be actuated and in such case it only serves the function of positioning the arm 4, thus allowing the swinging rotation of the arm 4 around the second proximal axis 23 and only having to overcome the frictions of such rotation. In the mechanism 102 the same arm movement cylinder 5, which in the operating configuration of figure 7 serves the function of lifting the arm 4, may also serve a main function of the swinging movement of the arm 4 when the machine 100 is in the configuration of figures 11 or 12. Likewise, it allows the swinging actuators 25A, 25B, which in the operating configuration of figure 7 serve a function of swinging the arm 4, to also serve a function of lifting the arm when the machine 100 is in the configuration of figure 11 or 12.

[0044] In the operating configurations with tie elements with tilted transverse drilling visible in figures 8, 9 and 10 the mechanism 102 allows the tilting of the arm 4 with respect to the soil with an angle φ (phi) which may also be negative, so as to move the mast 1 and the drilling means 12 to the lowest height possible with the aim of lowering the barycentre and improving the stability of the machine. Starting from the operating configuration shown in figure 8 it is possible to rotate the distal joint 104 with respect to the second distal axis 3 so as to move the mast 1 and the rotary table 12 to a front cantilevered position with respect to the arm 4. Such rotation can be obtained through the second distal cylinder 2 and it allows the moving of the first distal axis 9 to a horizontal position. Subsequently, by actuating the first 26A and the third 26B distal actuator, it is possible to rotate the slide 11 and hence the mast 1 with respect to the first distal axis 9, reaching the operating condition C.6 with tie elements with tilted transverse drilling between 0° and 45° with respect to the horizontal plane and the rotary table 12 positioned cantilevered at the front with respect to the mast 1 and with respect to the machine body 15.

[0045] The mechanism 102 allows to reach all the operating configurations 1,2,3,4,5 and 6 with only one machine for small diameter drilling operations, overcoming the shortcoming of the mechanisms of the known art and allowing to maximise the performances under all work conditions.

With reference to figures 10, 11 and 12 it may be observed that the mechanism 102 upon reaching the operating condition C.5 visible in figure 10, allows to tilt the mast 1 with tilting γ greater than the maximum ones allowed by the known mechanisms when the mast is arranged for operations with tie elements with transverse drilling. In particular this tilting may be increased so as to move the mast 1 from a horizontal position to a vertical position with respect to the soil and this may be carried out regardless of the tilting φ (phi) of the arm 4 with respect to the soil.

[0046] In figure 12, which is a view from B of figure 11, it may be observed that the attained configuration allows to perform vertical drilling operations and simultaneously having an orientation of the clamps 13 such to generate the least overall dimensions possible in the Y direction with respect to the drilling axis. Such configuration can be obtained both with the arm 4 arranged with its longitudinal axis on a horizontal plane and with arm 4 tilted by a non-null angle φ (phi) with respect to the horizontal, and in addition it can be obtained with a small side cantilever of the drilling axis AT with respect to the machine. This is particularly advantageous when performing a series of aligned drilling operations with respect to a wall and as close as possible thereto, this application being typical of consolidating buildings. In this condition, the mechanism 102 indeed allows to move the drilling axis AT very close to the wall and simultaneously having tracks oriented parallel to the wall. This allows to make the performance of the series of drilling operations faster in that once one drilling operation is completed, it is sufficient a simple translation of the machine to move to the point provided for the execution of the subsequent drilling.

[0047] In the configuration of figure 12, the transverse positioning of the drilling axis AT in the Y direction may be corrected when the arm 4 is rotated by 90° around its longitudinal axis, i.e. upon executing a 90° rotation with respect to the first proximal axis 20 activating the arm movement actuator 5 which will perform a function of swinging the arm 4 in this configuration. This will allow the moving of the drilling axis AT slightly inwards with respect to the position of the tracks 27A, 27B so that the clamps 13 are flush with the outer wall of the tracks.

[0048] In addition, when the arm is rotated by an angle different from 90°, through the combined activation of the cylinders 5, 25A and 25B it is always possible to transversely translate the drilling axis AT in the direction of the axis Y thus regulating the side cantilever thereof with respect to the tracks 27A, 27B. Following this translation, through the second distal cylinder 2 it is possible to rotate the distal joint 104 with respect to the second distal axis 3 so as to maintain the overall dimension of the clamps minimum in the Y direction with respect to the drilling axis. Following this rotation, through the actuators 26A, 26B it is possible to rotate the slide 11 with respect to the first distal axis 9 so as to return the mast 1 in vertical position.

[0049] In addition, the mechanism 102 may allow to reach the operating condition C.3 with the vertical mast 1 rotated by 90° with respect to the arm 4 and arranged towards the left track 27A of the machine or with the vertical mast 1 rotated by 90° with respect to the arm 4 and arranged towards the right track 27B of the machine. In order to attain this double operating positions it is necessary that the front rotation performed by at least one rotation actuator (for example a cylinder 24A, 24B or a gear motor with pinion) covers a sector of at least 180°. Whereas in order to perform the drilling in at least one of the two side parts, the front rotation should be by at least

90°. These two conditions allow to have the minimum side overall dimension of the clamps and the mechanism 102 allows the passing from one to the other of the two aforementioned conditions without requiring to demount of the clamps. Lastly, it is clear that this mechanism implies the presence of additional joint elements 19, 21, 24 which are positioned in proximity of the machine body 15 thus slightly -ranged forward and low in height so as to confer maximum stability with respect to the known mechanisms in which a further joint is added in proximity of the mast 1.

[0050] The mechanism 102 may reach the operating condition C.3 or the operating condition of Figure 7 starting for example from a transport condition shown in Figure 16, 16A, wherein:

- the first proximal axis 20 is substantially parallel to the front-rear direction of the machine 100, and the arm 4 is preferably longitudinal, and thus oriented in the plane X-Z;
- the third proximal axis 22 is in a position substantially perpendicular to the soil, thus oriented substantially according to Z;
- the drilling mast 1 lies in a substantially horizontal plane X-Y and its longitudinal axis is oriented along X;
- the tool driving means 12 are at a greater height with respect to the mast 1.

[0051] The embodiments described above can be subjected to many modifications and variations without departing from the scope of protection of the present invention. In addition, all details can be replaced by technically equivalent elements. For example the materials used, as well as the dimensions, may vary according to the technical requirements. It shall be deemed that an expression such as "A *comprises* B, C, D" or "A *is formed by* B, C, D" also comprises and describes the particular case wherein "A *is constituted by* B, C, D". The examples and lists of possible variants of the present application shall be deemed to be non-exhaustive lists.

Claims

1. A drilling machine (100) for drilling for example soil and/or rock formations, comprising

- a machine body (15);
- a drilling mast (1);
- a drill string comprising a drilling tool;
- tool driving means (12) fixed to the drilling mast (1) and arranged for driving the drilling tool, for example, causing it to rotate on itself around a predetermined drilling axis (AT) so as to drill the soil or rock formation;
- a mast mechanism (102), in turn comprising, at least:
  - one mechanical arm (4);
  - a proximal joint (103) in turn comprising a support mechanism (19) and a tilting arm support (21);
  - a distal joint (104), positioned substantially at a further distance from the machine body (15) with respect to the proximal joint (103) and which fixes the drilling mast (1) to the mechanical arm (4) allowing the mast (1) to vary at least its orientation with respect to the same mechanical arm (4);

  and wherein:

  - the proximal joint (103) fixes the mechanical arm to the machine body, allowing the arm (4) to vary its orientation with respect to the machine body by rotating around at least a first (20), a second (23) and a third proximal axis (22);
  - the first (20) and third proximal axis (22) are substantially orthogonal to each other and integral with at least the support mechanism (19);
  - at least in one operating condition, the second proximal axis (23) is not orthogonal to the plane defined by the other two axes (20) and (22);
  - the distal joint (104) allows the drilling mast (1) to rotate with respect to the mechanical arm (4) around a first distal axis (9) and a second distal axis (3), wherein the first (9) and second distal axes (3) are orthogonal to each other and the mast (1) extends perpendicularly with respect to the first distal axis (9);
  - the machine (100) is arranged for driving the support mechanism (19) making it rotate on itself around a first proximal axis (20), substantially equal to or greater than 90° oriented in a single direction.
  - the machine (100) is arranged for driving the distal joint (104) making the mast (1) rotate around the first distal axis (9) by at least 90° oriented in a single direction.

2. The machine according to claim 1, arranged for driving the support mechanism (19) making it rotate on itself, around the first proximal axis (20), substantially equal to or greater than 180°.

3. The machine according to claim 1, arranged for driving the distal joint (104) making the mast (1) rotate around the first distal axis (9), by more than 180°.

4. The machine according to claim 1, arranged for driving the proximal joint (103), making the mechanical arm (4) rotate around the second proximal axis (23).

5. The machine according to claim 1, provided with at least a first tilting actuator (25A) for driving the proximal joint (103) by rotating the mechanical arm (4) around the third proximal axis (22).

6. The machine according to claim 5, provided with a second tilting actuator (25B), wherein said first and second tilting actuators (25A, 25B) are arranged for rotating the mechanical arm (4) around the third proximal axis (22), the first (25A) and second (25B) tilting actuators being arranged at two opposite sides with respect to the mechanical arm (4).

7. The machine according to one or more of the previous claims, wherein at least one of the first (25A) and second (25B) tilting actuators, the other possible actuators that drive the proximal joint or the actuators that drive the distal joint, is one of the following items: a rotary gear motor, a pinion-sprocket group or a linear actuator.

8. The machine according to claim 7, comprising a first (24A) and second (24B) roll actuators, at least one of which is a linear actuator and in its turn comprises a driving stem (244A, 244B) arranged for performing the following operations:

- extending or withdrawing so as to rotate the support mechanism (19) of a first rotation angle ($\gamma 1$) with respect to the first proximal axis (20), the driving stem (244A, 244B) being fixed to the support mechanism (19) or to the machine body (15) in a first fixing-actuator point (192A-192D);
- disconnecting from the first fixing-actuator point (192A-192D) and connecting to a second fixing-actuator point (192B-192D, 192A) of the support mechanism (19) or machine body (15);
- extending or withdrawing so as to make the support mechanism (19) rotate by a second rotation angle ($\gamma 2$) in a direction concordant with the first rotation angle ($\gamma 1$) with respect to the first proximal axis (20).

9. The machine according to claim 7, wherein the distal joint (104) comprises at least one slide support (10) connected to the arm (4) and a slide (11) connected to the mast (1), said machine also comprising a first distal actuator (26A) of the linear type, connected at its ends to the slide support (10) and to the slide (11), which, in turn, comprises a driving stem, arranged for performing the following operations:

- extending or withdrawing so as to rotate the mast (1) by a first rotation angle ($\beta 1$) with respect to the first distal axis (9), the driving stem being fixed in a first fixing-actuator point to the slide support (10);
- disconnecting from the first fixing-actuator point and fixing it to a second fixing-actuator point present on the slide support (10);
- extending or withdrawing so as to rotate the mast (1) by a second rotation angle ($\beta 2$) in a direction concordant with the first rotation angle ($\beta 1$) with respect to the first distal axis (9).

10. The machine according to claim 1, comprising a first (26A) and a third (26B) distal actuator, arranged for driving the distal joint (104) so as to rotate the mast (1) with respect to the arm (4) around a first distal axis (9), wherein the first (26A) and third (26B) distal actuators are of the linear type and are positioned at two opposite sides with respect to the mast (1) or to the arm (4).

11. A method for using a drilling machine (100) having the features according to claim 5, comprising the following operations:

- rotating the support mechanism (19) around the first proximal axis (20) so as to move the proximal axis (22) from an initial position in which it is substantially oriented according to the axis Z to a final position in which it is substantially oriented according to the axis Y;
- activating at least a first tilting actuator (25A) so as to tilt the arm (4) around the proximal axis (22) to put it in a tilted position by an angle φ with respect to the horizontal plane (X-Y) on which the machine (100) rests.

12. A method for using a drilling machine (100) having the features according to one of the claims 1-10 and substantially symmetrical with respect to its sagittal plane, i.e. a plane parallel to the front-rear direction of the machine (100), therefore on the plane X-Y, wherein the method comprises the following operations:

a) arranging the drilling machine (100) in an initial position in which:

- the first proximal axis (20) is substantially parallel to the front-rear direction of the machine (100), and the arm (4) is preferably longitudinal, and therefore oriented on the plane X-Z;
- the third proximal axis (22) is in a position substantially perpendicular to the ground, and therefore substantially oriented according to Z;
- the drilling mast (1) lies on a plane substantially horizontal (X-Y) and its longitudinal axis is oriented along X.
- the tool driving means (12) are at a greater height with respect to the mast (1);

b) moving the drilling machine (100) to a final operating position in which:

- the arm (4) is substantially tilted with respect to the ground or plane XY on which

the machine (100) lies by an angle φ;
- the mast (1) is substantially perpendicular to the ground and with the mast (1) vertical and rotated laterally with respect to the arm (4) due to the effect of the rotation of the support (19) around the proximal axis (20);
wherein the passage from the initial position to the final operating position comprises the following operations:

c1) performing a first partial rotation of the drilling mast (1) by an angle β at least equal to 90° around the first distal axis (9) which is situated in a substantially vertical position, until the longitudinal axis of the mast is parallel to the transversal axis Y;
c2) performing a rotation of the support mechanism (19) by an angle γ of at least 90° around the first proximal axis (20), so that the third proximal axis (22), starting from an initial position substantially perpendicular to the ground, reaches a final position substantially parallel to the ground.

13. A method for using a drilling machine (100) having the features of claim 12, comprising the following two additional phases possibly simultaneous one to another:

c3) the arm (4) is lifted by an angle φ with respect to the reference plane of the ground XY, by acting at least on the actuators (25A) and (25B);
c4) the mast (1) is further tilted around the distal axis (9) by an angle β (beta) which compensates the inclination φ of the arm (4) as the mast (1) can be repositioned with its longitudinal axis orthogonal to the ground.

14. A method for using a drilling machine (100) having the features of claim 12, wherein an intermediate phase is provided between phases c1 and c2 thus defined:

c5) performing a partial rotation of the support mechanism (19) around the proximal axis (20) so that the drilling mast (1) has an operating configuration with the axis AT tilted with respect to the horizontal plane XY and with the drilling means (12) positioned above the mast (1).

15. A method for using a drilling machine (100) having the features according to claim 6 and also comprising an arm-moving actuator (5) arranged for rotating the arm (4) around the second proximal axis (23), wherein the method comprises the operation of driving the first (25A) and second (25B) tilting actuator and the arm-moving actuator (5) in a coordinated way so as to translate the mast (1) only perpendicularly to the ground or floor (Z) on which the machine (100) rests, or only the direction (Y) parallel to the ground or floor and perpendicular to the front-rear direction of the machine (100).

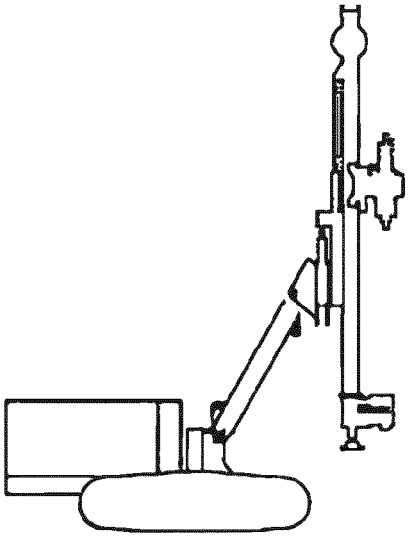


Fig. 1

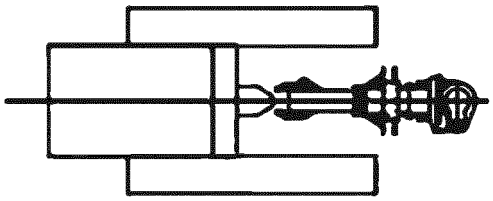


Fig. 1A

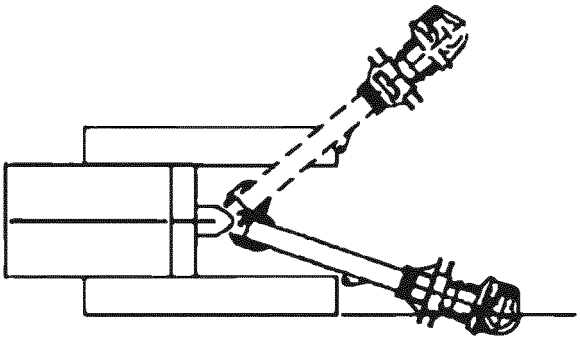


Fig. 2

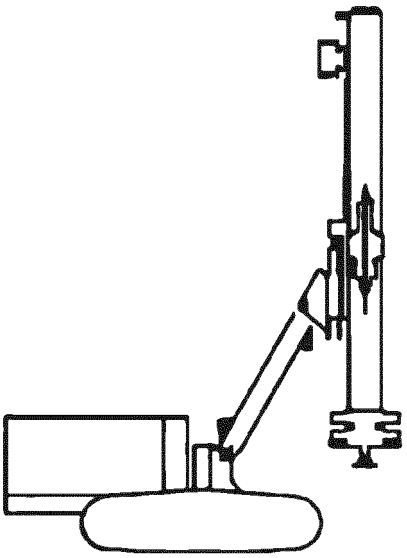


Fig. 3

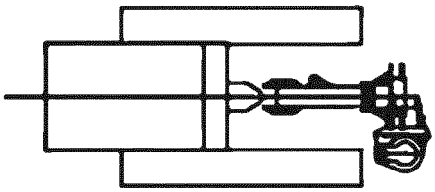


Fig. 3A

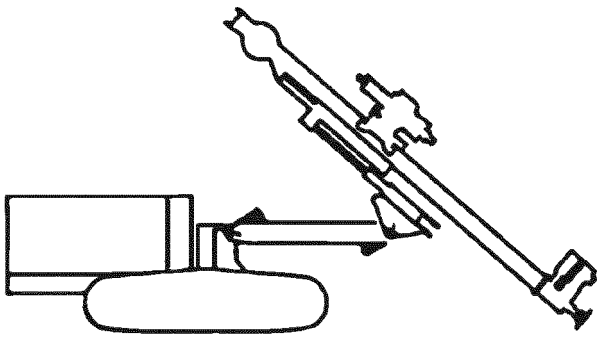


Fig. 4

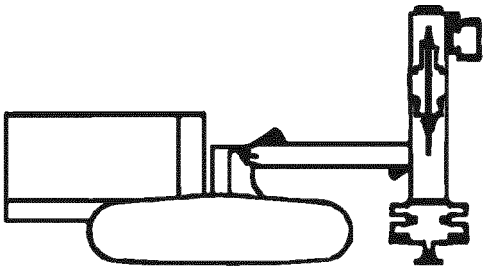


Fig. 5

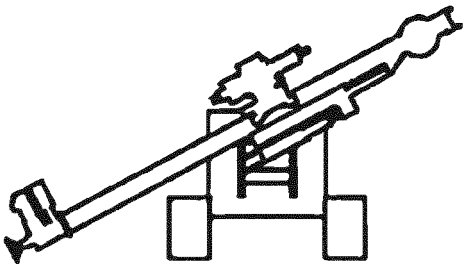


Fig. 5A

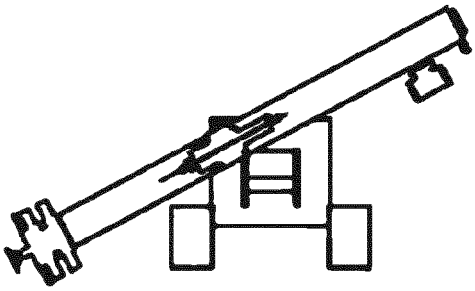


Fig. 6

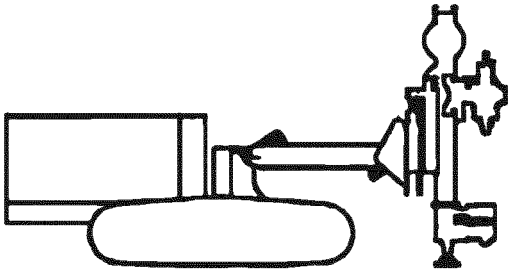
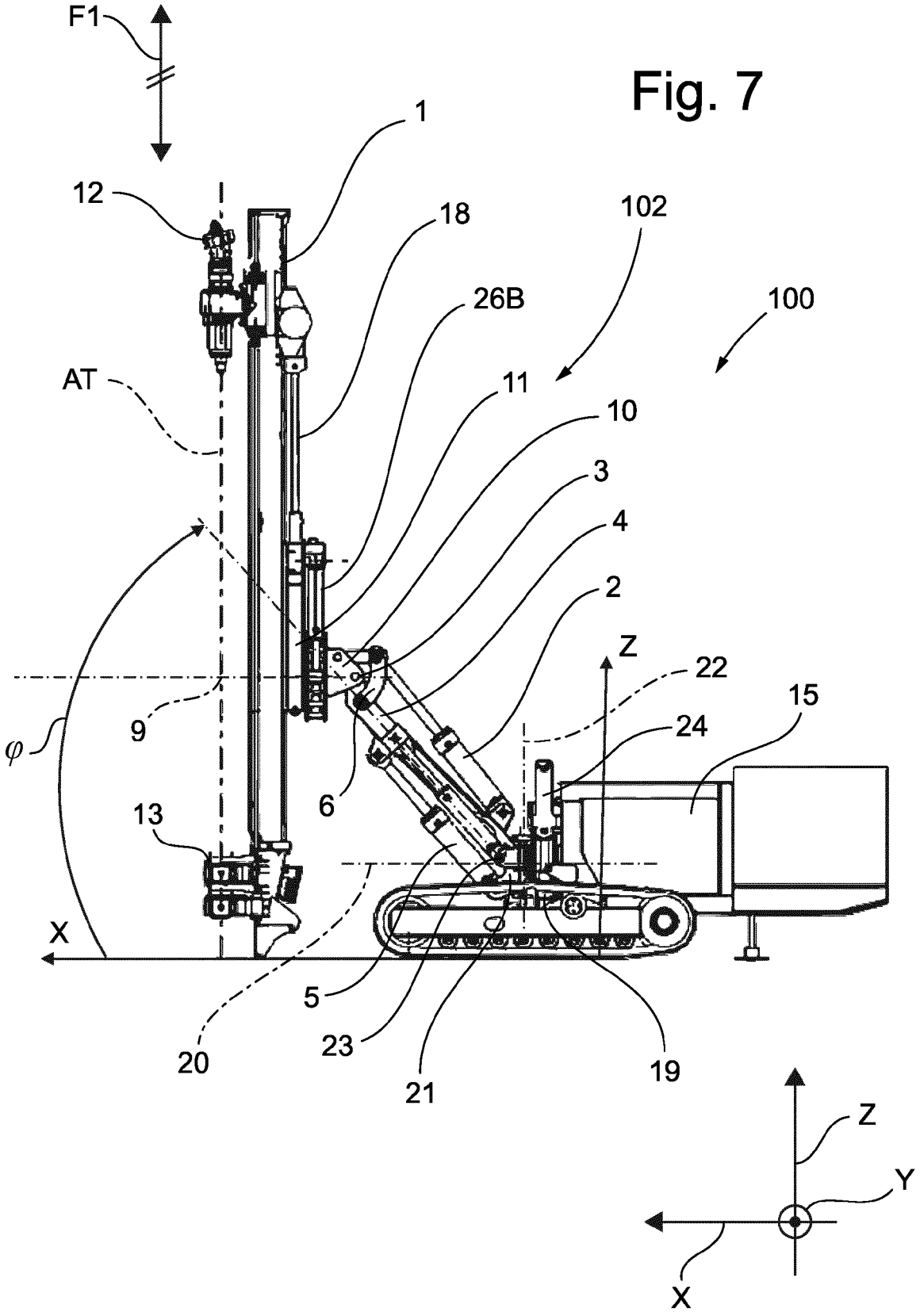


Fig. 6A

Fig. 7


F1
1
12
18
102
26B
100
AT
11
10
3
4
2
Z
22
15
24
9
φ
13
6
X
5
23
20
21
19
Z
Y
X

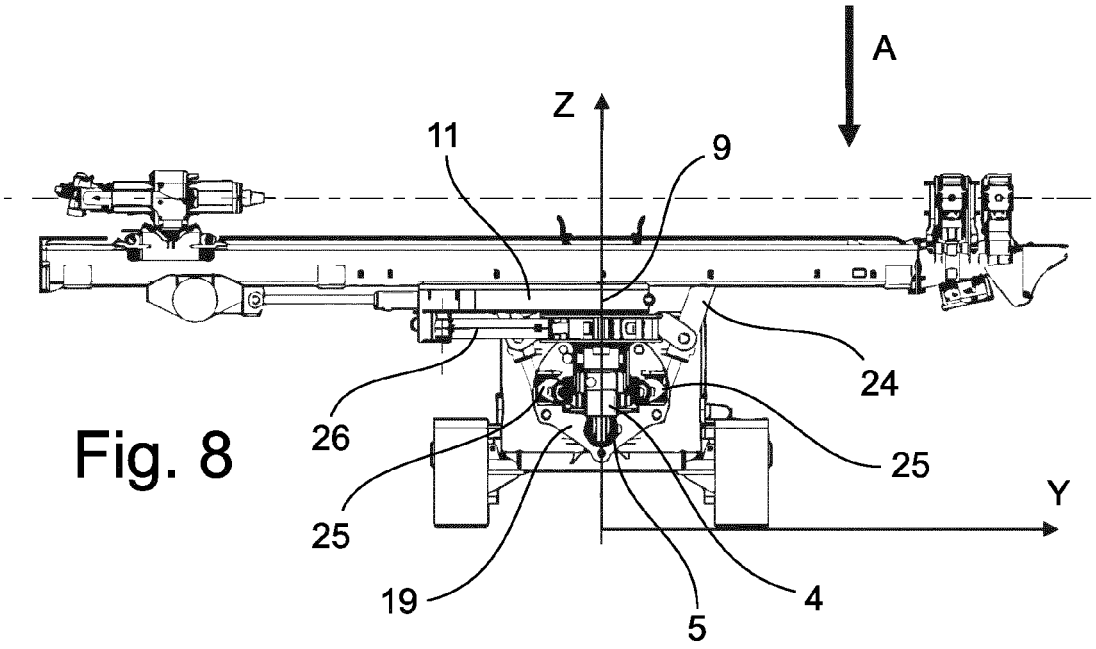

A
Z
11
9
24
26
25
Y
25
19
4
5

Fig. 8

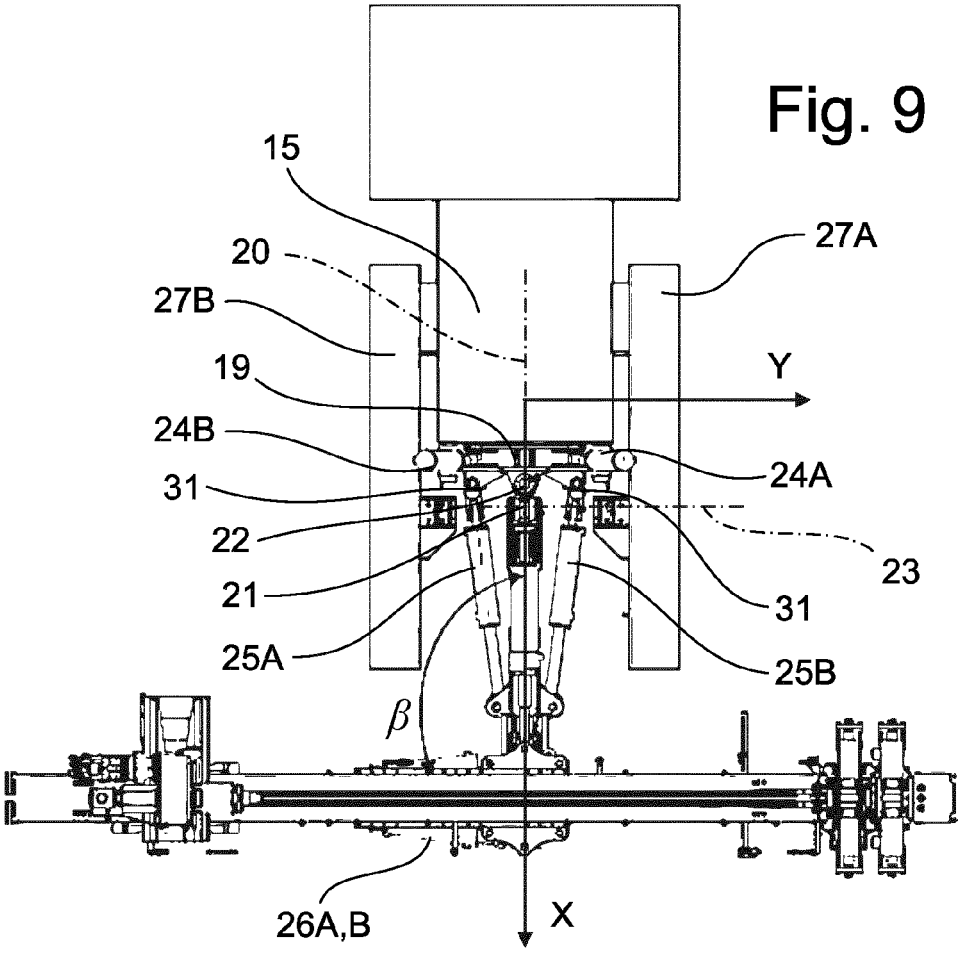
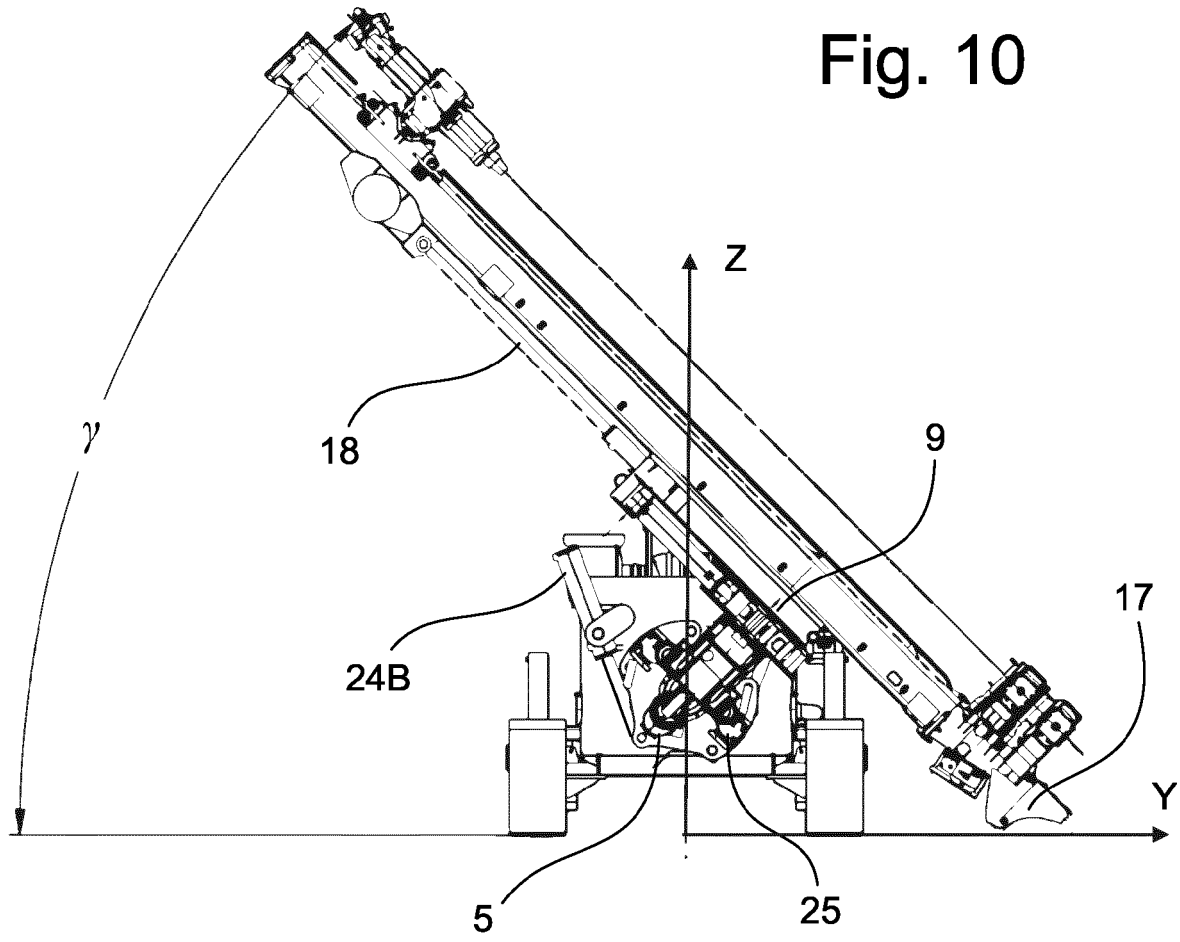

15
20
27A
27B
Y
19
24B
24A
31
22
23
21
31
25A
25B
β
26A,B
X

Fig. 9

Fig. 10



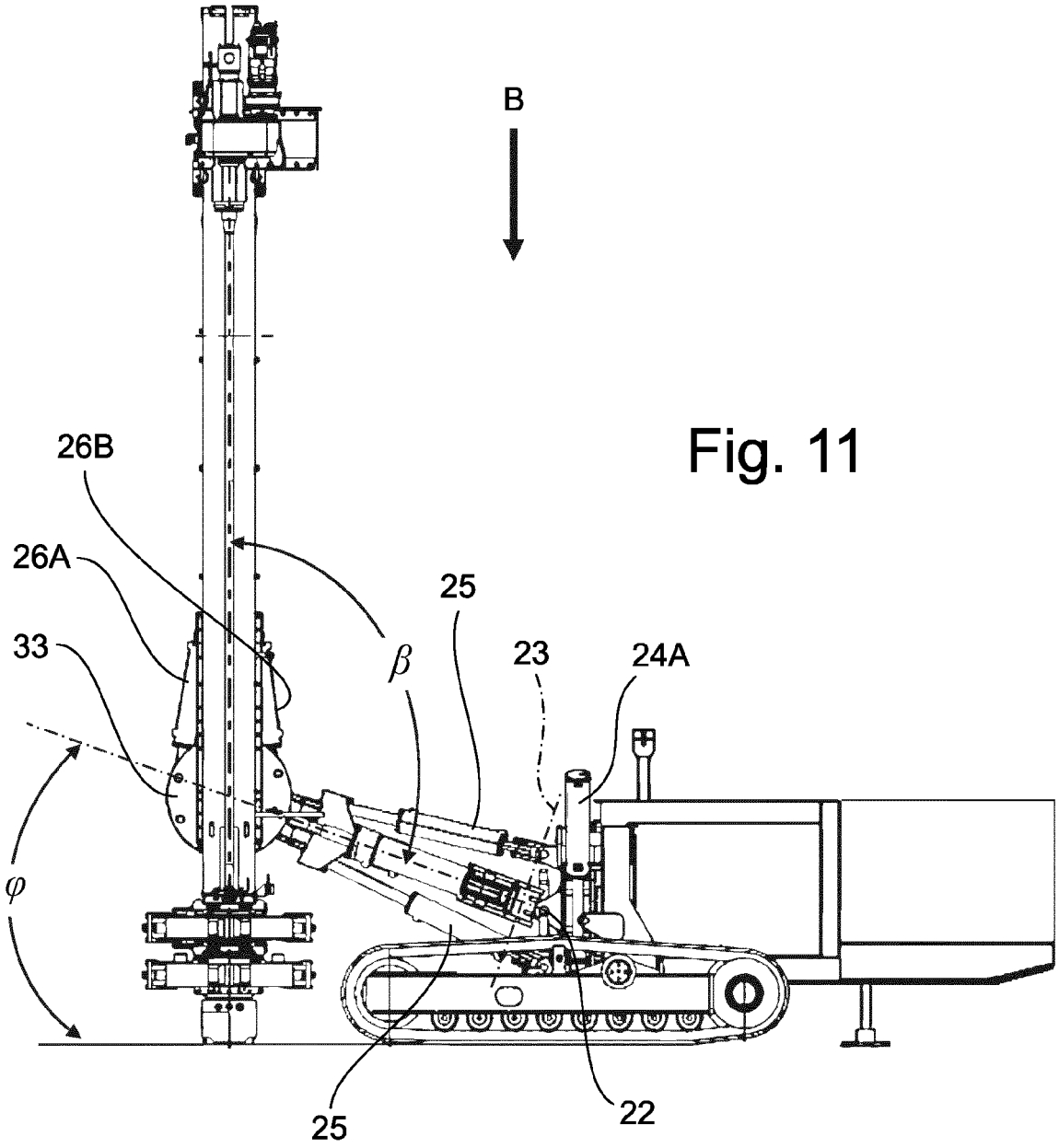


Fig. 11

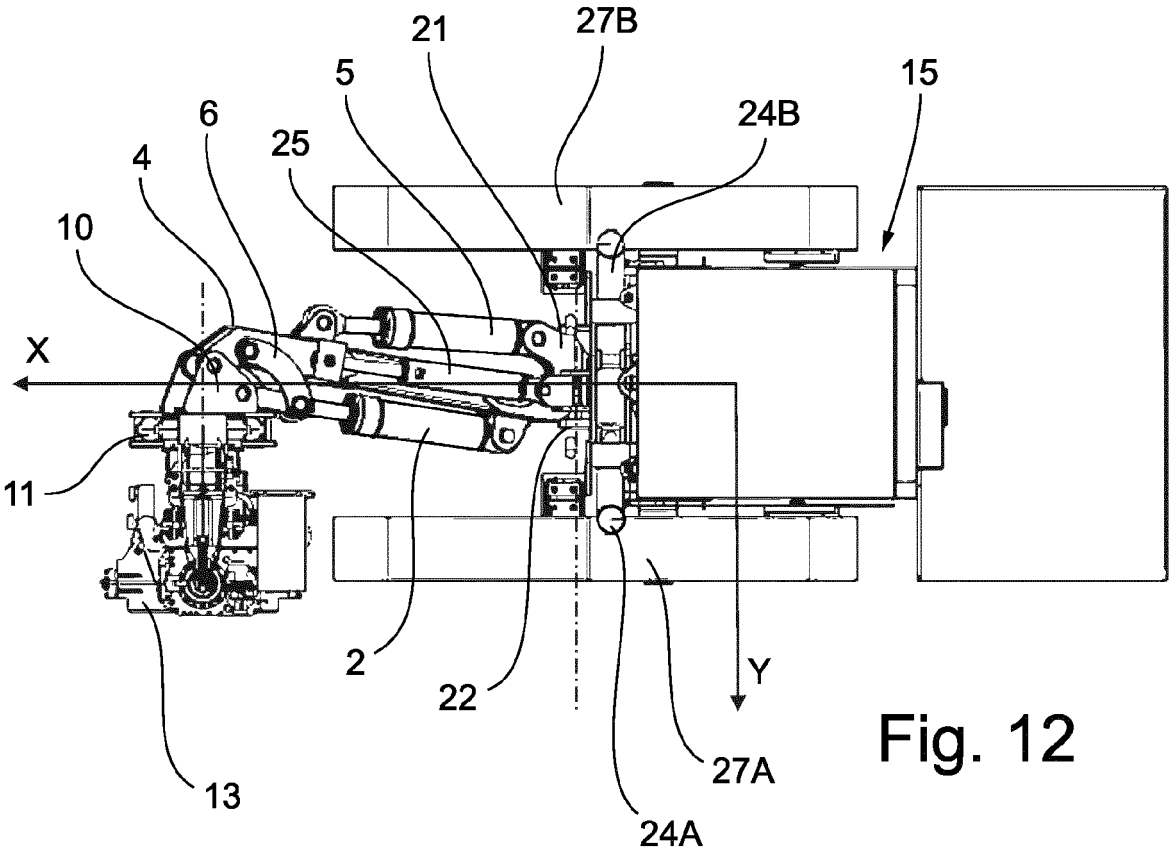


Fig. 12

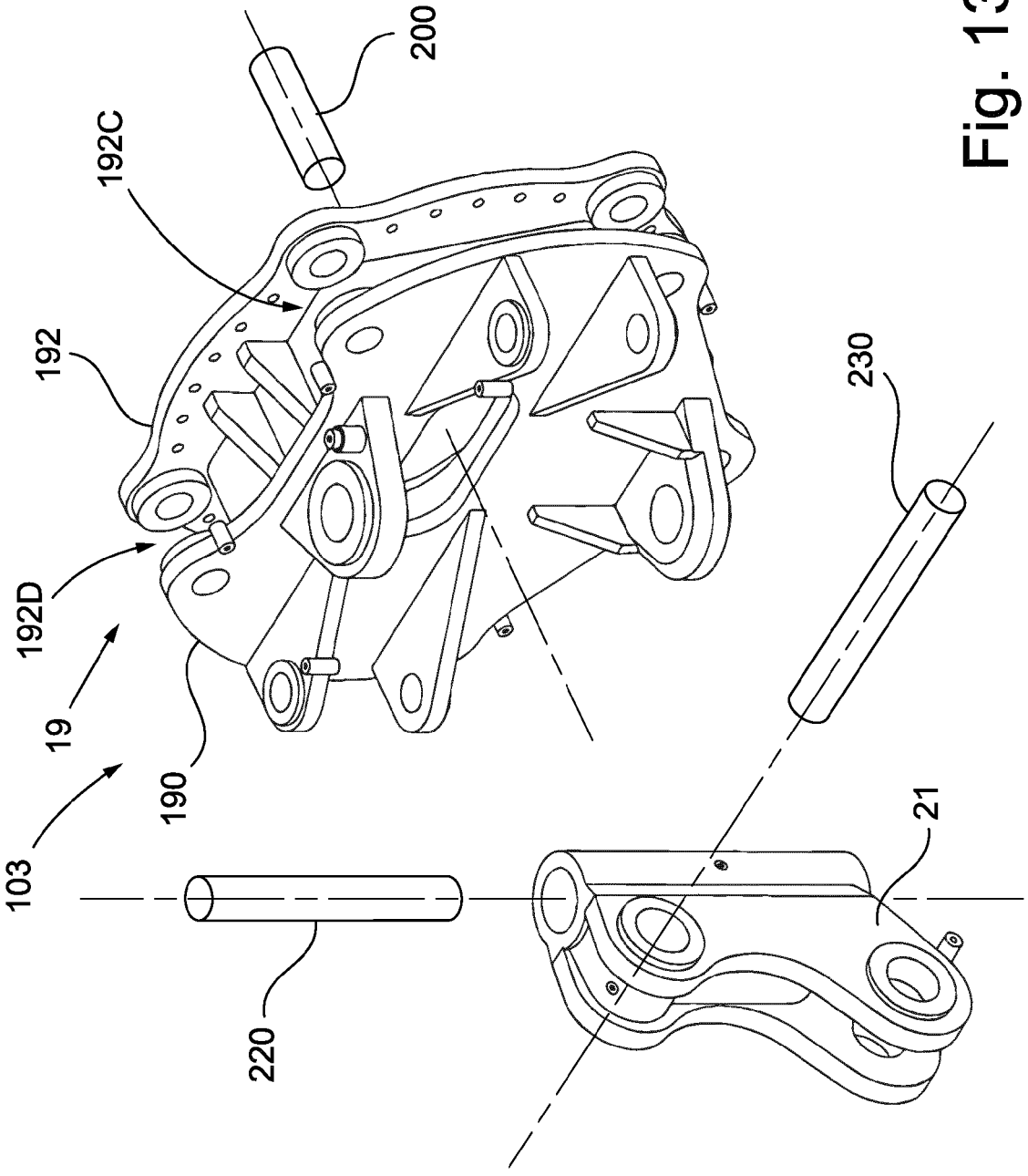


Fig. 13A

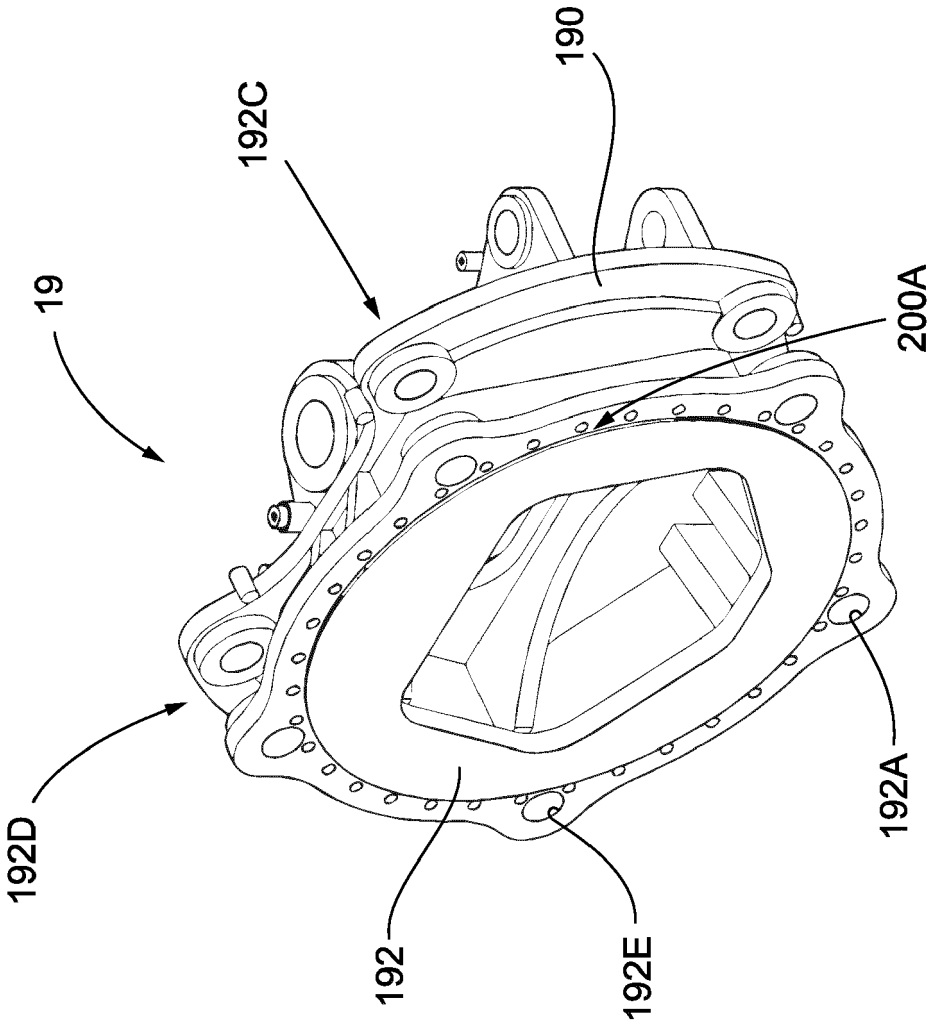


Fig. 13B

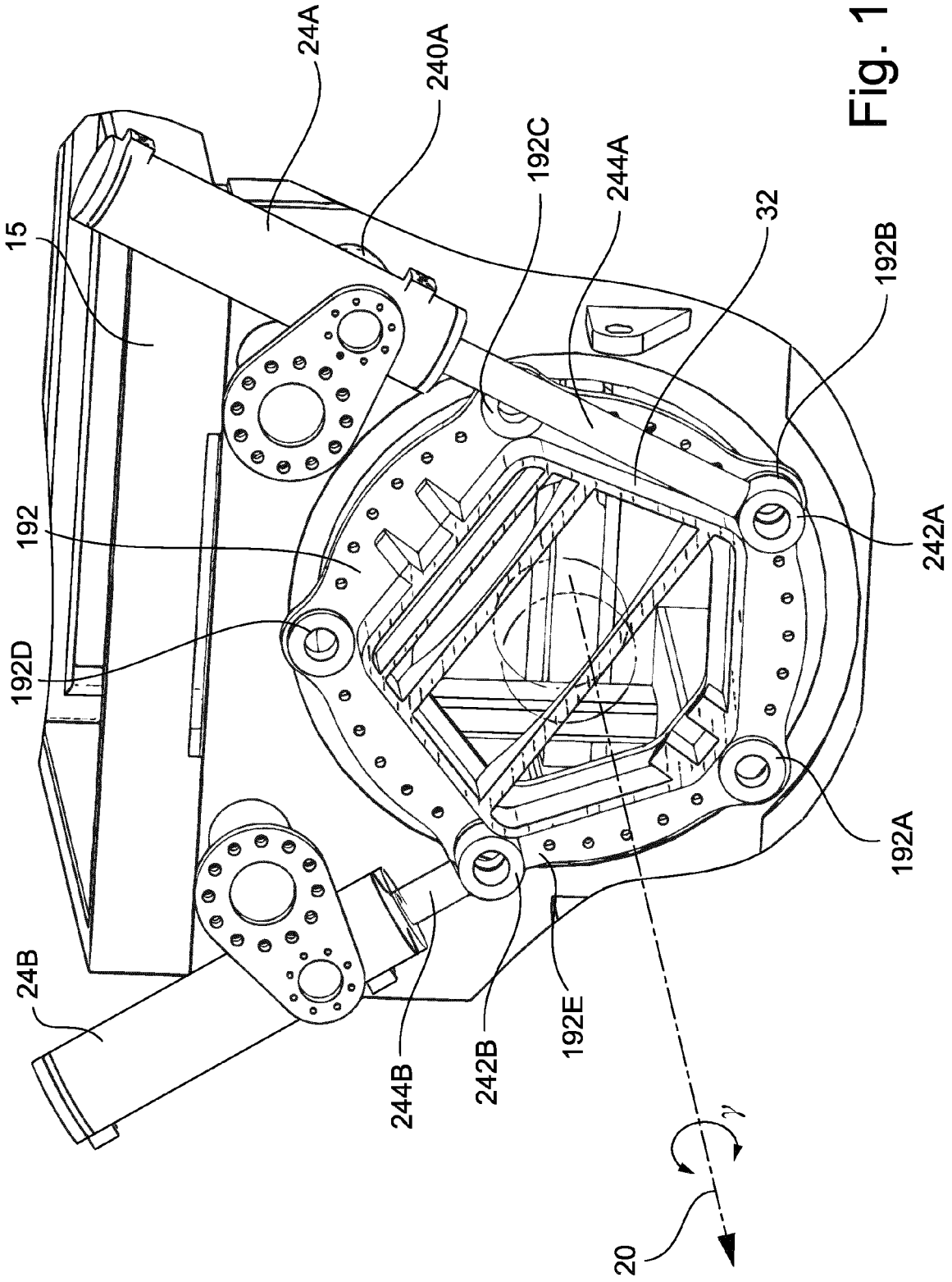

24A
240A
192C
244A
32
192B
15
192
242A
192D
192A
24B
244B
242B
192E
γ
20

Fig. 14

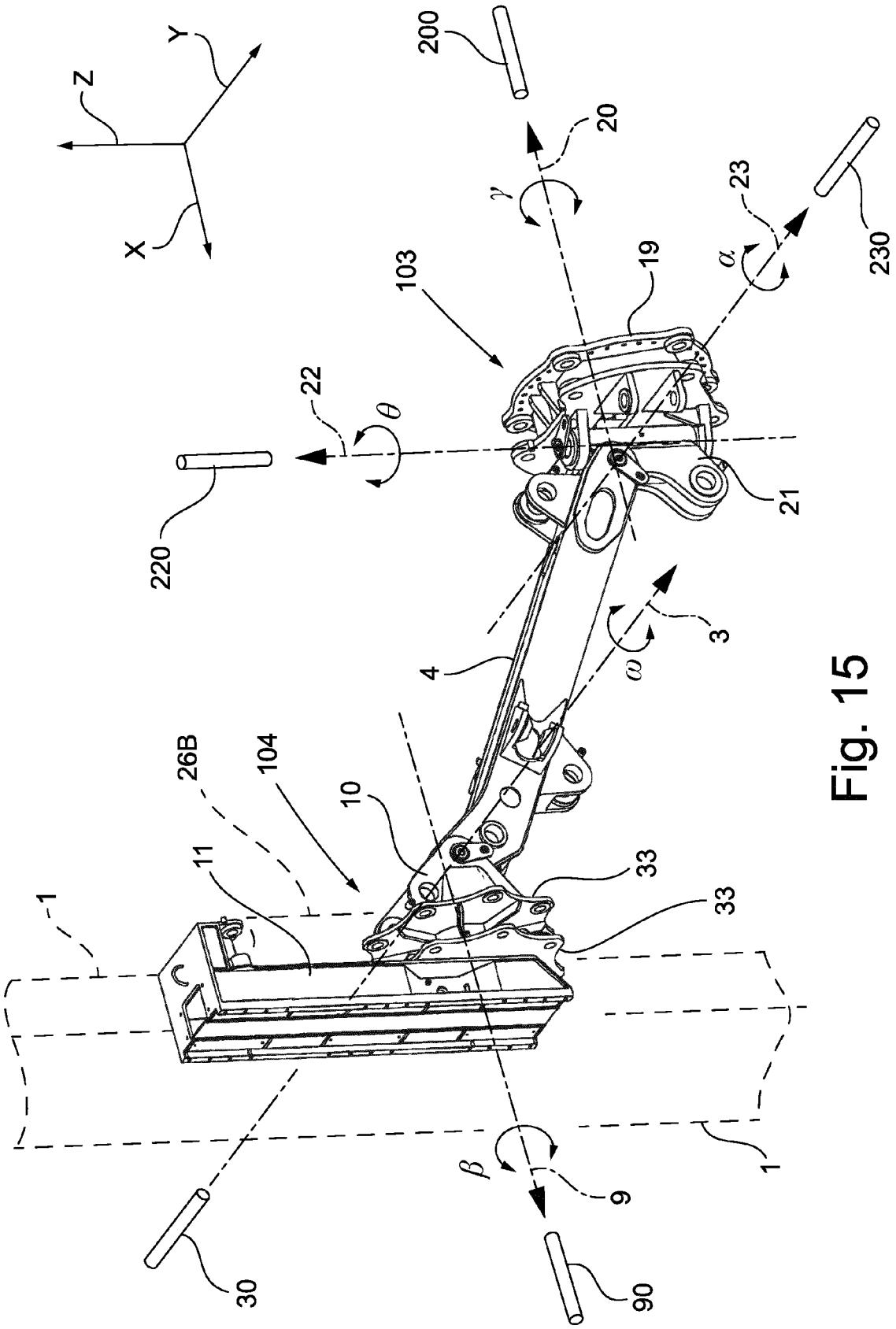

Z
Y
X
200
20
γ
23
α
230
103
19
22
θ
220
21
3
ω
4
26B
104
10
11
33
33
1
1
β
9
30
90

Fig. 15

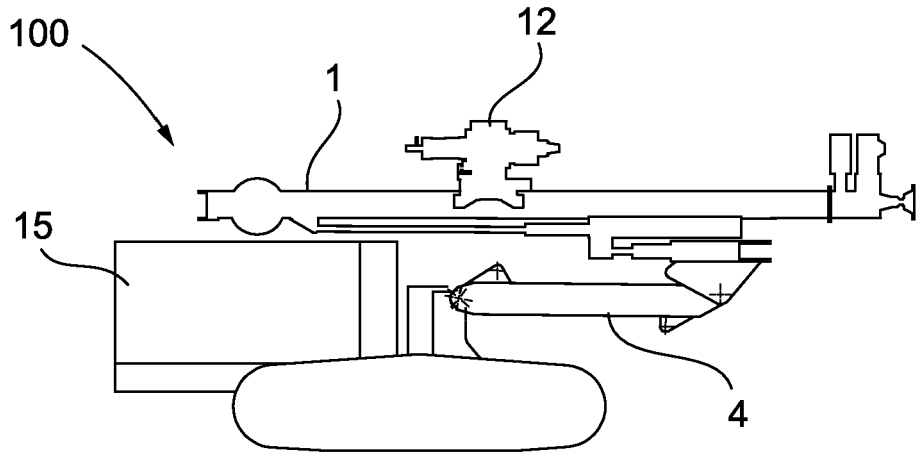


Fig. 16

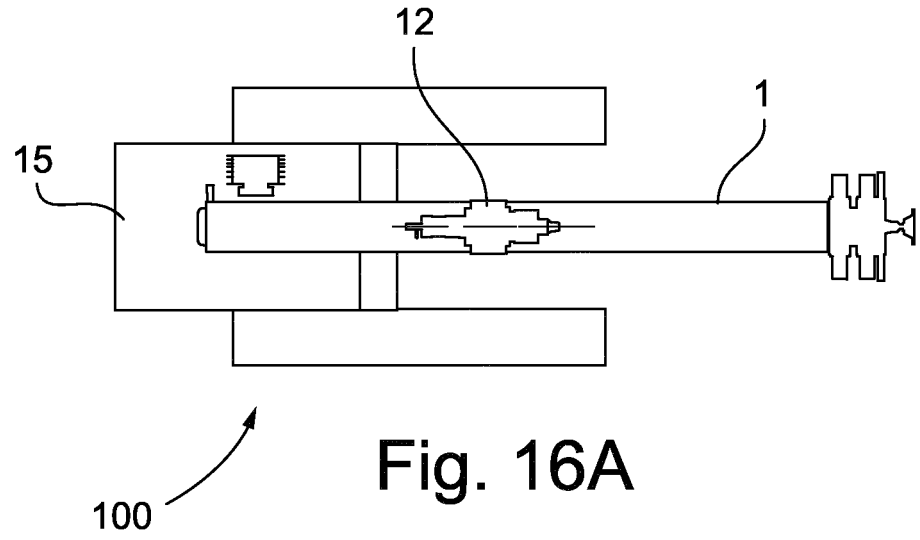


Fig. 16A

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EUROPEAN SEARCH REPORT

Application Number
EP 14 15 7616

DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	GB 2 028 693 A (GRIMSHAW G) 12 March 1980 (1980-03-12) * figure 1 *	1-15	
Y	WO 2006/096110 A1 (ATLAS COPCO ROCK DRILLS AB [SE]; SAF FREDRIK [SE]) 14 September 2006 (2006-09-14) * page 4, line 30 - page 5, line 13; figures 1-4 *	1-15	TECHNICAL FIELDS SEARCHED (IPC) E21B
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	14 August 2014	Dantinne, Patrick

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