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(54) **DRILLING MACHINE**

(57) A drilling machine comprises a frame (11) mounted on a slider (12), a drilling unit (14) comprising a mast, or guide beam (16), along which a rotation head (20) is mounted sliding and able to make the work tools rotate, and a first positioning unit (21) provided with an articulation device (23) suitable to allow the rotation of the mast (16) on a vertical plane around a first horizontal axis of rotation (X1). The drilling machine comprises a second positioning unit (22), connected between the first positioning unit (21) and the mast (16).

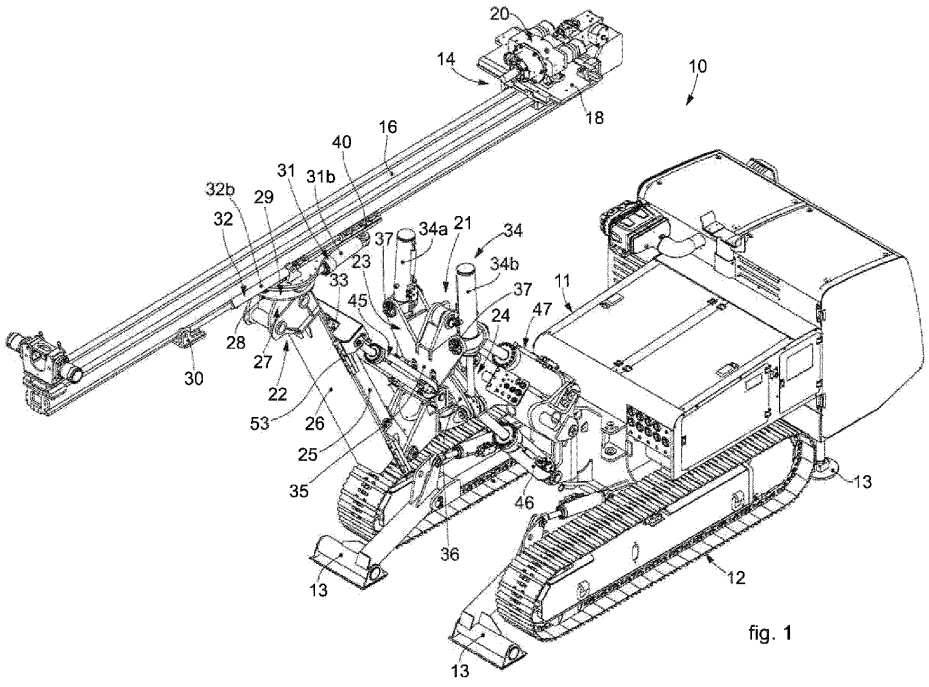

fig. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention concerns a drilling machine which can be used to prepare excavations to make tunnels.

[0002] In particular, the machine according to the invention can be used to make holes and drillings in tunnels and to consolidate excavations, for example by injecting filling and anchoring materials into the holes.

BACKGROUND OF THE INVENTION

[0003] Drilling machines, generally of the horizontal type, are known, used to prepare excavations in tunnels, able to make holes in a substantially horizontal direction in the walls to be excavated, and possibly inject filling and anchoring materials in them to consolidate the walls.

[0004] It is known that in order to make excavations of a tunnel it is necessary to first of all make a plurality of holes positioned substantially along a circumference, and possibly inject filling materials in them suitable to consolidate the walls and the vault of the tunnel itself, before proceeding with operations to remove the material, such as rock, earth, and suchlike.

[0005] These drilling machines are generally provided with a drilling unit comprising a mast, or guide beam, on which a rotating head is mounted, sliding in a longitudinal direction, with which the drilling member is rotated to make the holes.

[0006] In known drilling machines, the mast is connected to a fifth wheel positioning device, that is, a gear that allows a rotation of about 180° around a horizontal axis of rotation, and is made to rotate on each occasion so as to make holes disposed radially with respect to the drilling machine itself.

[0007] The fifth wheel is pivoted at one end to the mast, and at the opposite end to the frame of the drilling machine and its rotation around the axis of rotation selectively makes the mast move along a circumference arc, with its longitudinal axis disposed in a substantially horizontal direction.

[0008] Drilling machines are also known which provide the fifth wheel pivoted in correspondence with one of its central points to the frame, and connected on one side and the other to a respective mast, so as to simultaneously position two drilling members.

[0009] The fifth wheel positioning device, although it allows to make holes disposed in a radial pattern, has some disadvantages.

[0010] A first disadvantage is that the fifth wheel has few degrees of freedom, and only allows to rotate the mast and not to position it in a lateral direction. In order to correctly align the mast with the excavation front, it is therefore necessary to correctly position the drilling machine with respect thereto, as it is not possible to correct any possible misalignments with the fifth wheel device.

[0011] Another disadvantage of fifth wheel devices is the fact that, in order to make holes on circumferences with different radiuses, it is necessary to move the drilling machine itself, or to replace one or more components, causing downtimes and delay in the work.

[0012] Another disadvantage is that, although they allow to easily make the holes on a circumference which extends above the drilling machine, fifth wheel devices do not allow to make the holes equally well in a frontal position to the machine.

[0013] The fifth wheel, in fact, does not allow to lower the mast frontally, keeping it substantially parallel to the ground, in order to position the drilling member effectively, therefore the holes in the frontal direction are generally made with an inclination accentuated downward instead of substantially horizontal.

[0014] Another disadvantage of the solutions that provide to use a fifth wheel is also that they are not very versatile and robust; if the fifth wheel malfunctions or breaks, in particular, it is necessary to interrupt operations and carry out the maintenance or replacements required to continue the work.

[0015] Other drilling machines are known from documents DE-A-28 36 659 and WO-A-03/031764.

[0016] DE-A-28 36 659 describes a multi-use drilling machine for the mining industry comprising a vehicle mounted on tracks with a vertical structure in the front part which supports an elbow-shaped arm on which multifunction tools are installed. The elbow-shaped arm can rotate completely around a horizontal axis and carries actuator cylinders to drive extended tie rods which in turn carry additional cylinders for other arms and the tools themselves. WO-A-03/031764 describes a drilling machine comprising a frame mobile with respect to the ground, an arm of the tool, a drilling tool operatively mounted on the arm of the tool and defining a drilling end and an actuator of the arm of the tool which can be selectively driven, and which connects the arm of the tool to the frame. The support of the arm of the tool comprises five actuators that respectively allow a rotation of the arm of the tool around a vertical axis, a translation along a first horizontal axis, a translation along a second horizontal axis perpendicular to the first horizontal axis, a rotational displacement on a third horizontal axis, and a rotatable displacement around a fourth horizontal axis.

[0017] One purpose of the present invention is to produce a drilling machine which overcomes at least some of the disadvantages of the state of the art.

[0018] One purpose of the present invention is to produce a drilling machine, in particular to prepare excavations in tunnels, which allows the precise positioning of the mast and of the drilling member.

[0019] Another purpose of the present invention is to provide a drilling machine which requires lower power and energy consumption than machines known in the state of the art.

[0020] Another purpose of the present invention is to provide a drilling machine which allows to make in a hor-

izontal direction both holes on circumferences with a larger radius, as well as holes on circumferences with a smaller radius in a frontal zone of the drilling machine itself.

[0021] Another purpose of the present invention is to provide a drilling machine to prepare excavations in tunnels which allows to position on each occasion the mast and the drilling member in a suitable position without the need to move the drilling machine, thus reducing the work time required to perform operations.

[0022] Another purpose of the present invention is to produce a drilling machine which is versatile and can also be used, with simple modifications, to make drilling holes in a vertical direction.

[0023] Another purpose of the present invention is to produce a drilling machine that is robust and efficient even if some components malfunction.

[0024] The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

[0025] The present invention is set forth and characterized in the independent claims, while the dependent claims describe other characteristics of the invention or variants to the main inventive idea.

[0026] In accordance with the above purposes, a drilling machine according to the invention comprises, in a known manner, a movement unit to move it, a work member suitable to perform one or more operations, such as for example drilling, and support members suitable to support and position the work member, for example a drilling member, and/or devices to inject consolidation material.

[0027] According to some embodiments, the support members comprise a support rod, defined as mast in the specific field, and a rotating head slidable along the mast and to which the work member is connected.

[0028] The drilling machine comprises a first positioning unit provided with an articulation device configured to allow the rotation of the mast on a vertical plane around a first horizontal axis of rotation.

[0029] According to some embodiments, the drilling machine comprises a second positioning unit connected between the first positioning unit and the mast and configured to allow other movements of the mast with respect to the first positioning unit.

[0030] According to some embodiments, the second positioning unit comprises an oblong support element, connected to the articulation device of the first positioning unit and provided with a support surface for the mast.

[0031] The second positioning unit also comprises positioning means cooperating with the oblong support element and each suitable to confer at least one degree of freedom to the mast with respect to the support element.

[0032] According to some embodiments, the articulation device comprises a fixed body and a rotatable body pivoted to said fixed body and connected to said support arm of said first positioning unit by pivoting means defining a second horizontal axis of rotation and said drilling machine comprises inclination adjustment actuator means connected with one end to said rotatable body and with the opposite end to said support arm and configured to incline said oblong support element with respect to said second axis of rotation respectively toward the excavation front or toward a vertical position.

[0033] According to some embodiments of the present invention, the drilling machine comprises a swivel actuator connected between the frame and the first positioning unit, and configured to allow a swivel movement of the first positioning unit, and of the components connected thereto.

[0034] In this way it is also possible to position the drilling machine in an inclined position with respect to the excavation front, and subsequently to align the mast with respect to it simply by actuating the swivel actuator.

[0035] This movement confers a degree of freedom to the mast which cannot be obtained with the known solutions.

[0036] According to some embodiments, the second positioning unit is connected to the mast by means of a rotational joint and comprises vertical rotation actuator means suitable to allow a rotation of the mast around a first vertical axis with respect to the support surface.

[0037] According to other embodiments, the support surface is inclined with respect to the wall of the support element connected to the positioning unit. This inclination allows to reach more positioning angles of the mast with respect to the horizontal plane, so as to be able to reach all the positions necessary to make the holes to prepare the excavations.

[0038] According to other embodiments, the second positioning unit comprises horizontal sliding actuator means configured to move the mast in a linear and planar direction with respect to the support surface.

[0039] This allows to position the mast, and therefore the work member, on each occasion in a simple and precise manner with respect to the excavation front.

[0040] According to some embodiments, the first positioning unit comprises the fixed body and the body rotatable with respect to the fixed body around the first horizontal axis and horizontal rotation actuator means comprising a pair of linear actuators acting in opposite directions on opposite sides of the fixed body with respect to the first horizontal axis, so as to allow a continuous rotation movement of the rotatable body, and therefore of the mast, along a circumference arc.

[0041] This solution allows to reduce the overall weight of the positioning unit with respect to the fifth wheel device, and consequently obtain a reduction in energy consumption.

[0042] The provision of a plurality of positioning units which allow movements that are independent of one another, each provided with respective linear actuators,

makes the drilling machine according to the invention more robust than known solutions. A malfunction or failure of one of the actuators of the drilling machine can, in fact, be at least partly compensated by actuating the remaining actuators, so as to allow the continuation of the works, possibly in a partly limited operating area.

[0043] Embodiments described here also concern a method to position the mast of a drilling machine with respect to an excavation front to make holes in a tunnel.

[0044] The method according to the invention provides to position the drilling machine in correspondence with an area to be subjected to drilling, and to move the mast on a vertical plane, around a first horizontal axis of rotation by means of a first positioning unit provided with an articulation device.

[0045] The positioning method also provides to move the mast with respect to the first positioning unit by means of a second positioning unit.

[0046] According to some embodiments, the method provides to support the mast with an oblong support element connected to the articulation device and to drive positioning means cooperating with the oblong support element to move the mast with respect thereto.

[0047] According to some embodiments, the method provides to incline said oblong support element with respect to said articulation device making it rotate around a second horizontal axis of rotation by means of inclination adjustment actuator means.

[0048] According to other embodiments, the method provides to swivel the first positioning unit, and with it the second positioning unit and the mast, on a horizontal plane, around a vertical axis of rotation lying on the longitudinal median plane of the drilling machine by means of a swivel linear actuator connected between the frame and the articulation device, so as to allow a correct positioning of the mast with respect to the excavation front even in the case where the drilling machine is not aligned with it.

[0049] According to other embodiments, the method provides to rotate the mast around the first horizontal axis of rotation by means of an articulated device, by rotating a rotatable body of the latter with respect to a fixed body thereof by means of horizontal rotation actuator means comprising a pair of linear actuators acting in opposition to each other on opposite sides of the horizontal axis of rotation. This allows to continuously move the mast along a circumference arc to make the holes necessary to prepare the excavations in the positions desired on each occasion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0050] These and other characteristics of the present invention will become apparent from the following description of some embodiments, given as a non-restrictive example with reference to the attached drawings wherein:

- fig. 1 is a three-dimensional view of a drilling machine according to embodiments described here with the mast in an operating position;
- fig. 2 is a lateral view of the drilling machine in fig. 1;
- fig. 3 is a view from above of the drilling machine in fig. 1;
- fig. 4 is a lateral view of the drilling machine according to embodiments described here with the mast rotated around a first horizontal axis of rotation with respect to the operating position of fig. 1;
- fig. 5 is a view from above of the drilling machine in fig. 4;
- fig. 6 is a lateral view of the drilling machine according to embodiments described here with the mast positioned at a lower height with respect to the operating position of fig. 1;
- fig. 7 is a lateral view of the drilling machine with the mast in a retracted position with respect to the operating position of fig. 6;
- fig. 8 is a lateral view of the drilling machine according to embodiments described here with the mast rotated around a vertical axis of rotation with respect to the operating position of fig. 1;
- fig. 9 is a view from above of the drilling machine in fig. 8.

[0051] To facilitate comprehension, the same reference numbers have been used, where possible, to identify identical common elements in the drawings. It is understood that elements and characteristics of one embodiment can conveniently be incorporated into other embodiments without further clarifications.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

[0052] Embodiments described here with reference to figs. 1 to 9 concern a drilling machine 10, of the type suitable to prepare excavations in tunnels, in particular to make holes or perforations and/or to inject filling and consolidation materials therein.

[0053] The drilling machine 10 comprises a frame 11 mounted on a slider 12, for example with tracks, and provided with stabilizing brackets 13 able to rest on the ground to prevent the slider 12 from moving when the drilling machine 10 is in operation.

[0054] The drilling machine 10 also comprises a drilling unit 14 comprising a mast or guide beam 16, along which a rotation head 20 is mounted sliding and able to make the work tools (not shown) rotate.

[0055] The work tools can comprise, for example, a drilling member, injection means suitable to inject consolidating material into the holes to prepare the excavations, or other tools.

[0056] According to some embodiments, the drilling machine 10 comprises a first positioning unit 21 configured to allow a movement of the mast 16 with respect to the frame 11, in particular a rotation of the mast 16 on a vertical plane around a first horizontal axis X1 in the di-

rection indicated by arrows G1.

[0057] According to some embodiments, the first positioning unit 21 comprises an articulation device 23 suitable to allow a rotation around the horizontal axis X1.

[0058] The first positioning unit 21 can also comprise a first support arm 24 connected between the articulation device 23 and the frame 11, and a second support arm 25 connected to the articulation device 23 on the opposite side of the frame 11 and configured to support the mast 16.

[0059] The drilling machine 10 according to the invention also comprises a second positioning unit 22 connected between the first positioning unit 21 and the mast 16 and configured to allow another movement of the latter with respect to the first positioning unit 21.

[0060] In particular, the second positioning unit 22 comprises an oblong support element 26, suitable to be connected to the second support arm 25 of the first positioning unit 21, and provided with a head 27 provided with an upper surface suitable to define a support base 28 for the mast 16.

[0061] According to some embodiments, the second positioning unit 22 also comprises positioning means 29, 30, 31, 32, 40 cooperating with the support base 28 and each suitable to confer at least one degree of freedom to the mast 16 with respect thereto.

[0062] According to possible solutions, the positioning means comprise a rotatable joint 29.

[0063] According to other embodiments, the positioning means also comprise a gripping element 30 attached in a stable manner to the mast 16, and a block 40 suitable to support the mast 16 in a sliding manner.

[0064] According to some embodiments, the rotatable joint 29 is disposed on the support base 28 of the oblong support element 26, and the gripping element 30 is connected to the rotatable joint 29, so that the mast 16 rests on and is supported by both.

[0065] According to some embodiments, the rotatable joint 29, the gripping element 30 and the block 40 cooperate to support the mast 16 on a support plane parallel to the support base 28.

[0066] According to some embodiments, the second positioning unit 22 comprises vertical rotation actuator means, or first actuator means 31, suitable to allow a rotation of the mast 16 in cooperation with the rotatable joint 29 around a first vertical axis of rotation Y1 substantially orthogonal to the support base 28.

[0067] For example, according to some embodiments, the first actuator means 31 comprise a pair of first linear actuators 31a, 31b connected to the rotatable joint 29, in opposite positions to one another with respect to the mast 16.

[0068] According to some embodiments, the first linear actuators 31a, 31b can be connected between the gripping element 30 and the rotatable joint 29.

[0069] The first linear actuators 31a, 31b can be driven in counter-position, that is, one can be extended and the other retracted, and vice versa, to allow the rotation of the mast 16 with respect to the first vertical axis of rotation Y1 in the direction indicated by arrows F1 in figs. 2, 6 and 7.

[0070] For example, according to some embodiments, the first linear actuators 31a, 31b can allow a rotation of about +/- 15° with respect to a central position of alignment.

[0071] In this way it is possible to accurately position the mast 16 with respect to the excavation front even if the drilling machine 10 is not perfectly aligned therewith, allowing to make the drilling holes with the correct alignment.

[0072] According to other embodiments, the second positioning unit 22 also comprises horizontal sliding actuator means, or second actuator means 32 configured to allow the mast 16 to slide with respect to the support base 28 and to the block 40 in the direction indicated by arrows F2.

[0073] According to some embodiments, the second actuator means 32 comprise a pair of second linear actuators 32a, 32b disposed parallel to each other on opposite sides of the mast 16, connected at one end to the mast 16 by the gripping element 30, and at the other end to the block 40, in opposite positions to each other.

[0074] The second linear actuators 32a, 32b can be driven in the same direction, to allow the mast 16 to slide with respect to the block 40, forward or backward with respect to the drilling machine 10 and the excavation front. For example, figs. 6 and 7 show two different operating positions of the mast 16 with respect to the support base, in which in fig. 6 the second linear actuators 32a, 32b are in a condition close to the maximum end-of-travel, while in fig. 7 they are in a partly retracted condition.

[0075] This sliding movement allows to precisely position the mast 16 in proximity to, or in contact with, the excavation front, so as to allow the drilling member to make a first hole, and subsequently to move the mast 16 away from it by acting solely with the second positioning unit 22, keeping the first positioning unit 21 stationary.

[0076] According to other embodiments, sliding means 33, 53 can be provided between the first positioning unit 21 and the second positioning unit 22 and configured to allow the sliding of the latter with respect to the former.

[0077] The sliding means can comprise, for example, sliding blocks 53 disposed between the second support arm 25 and the oblong support element 26, suitable to allow a sliding of the latter in the direction indicated by arrows F3 in the drawings.

[0078] According to some embodiments, the sliding means comprise vertical sliding linear actuator means, or third linear actuator means 33, configured to move the oblong support element 26 along the support arm 25 of the articulation device 23.

[0079] According to some embodiments, the vertical sliding linear actuator means 33 comprise at least one linear actuator 33a connected at one end to the support arm 25 and at the other end to the head 27. The third

linear actuator 33a can be extended or retracted respectively, to make the oblong support element 26 slide upward or downward, and as a consequence lift or lower the mast 16.

[0080] According to some embodiments, the support base 28 is inclined by an angle α with respect to a direction orthogonal to the longitudinal development of the oblong support element 26, for example comprised between 0° and approximately 20°. This inclination allows a greater versatility in positioning the mast 16.

[0081] According to possible variant embodiments, adjustment means (not shown) can be provided, configured to adjust the inclination of the head 27 and therefore of the support base 28 with respect to the oblong support element 26.

[0082] According to some embodiments, the articulation device 23 of the first positioning unit 21 comprises a fixed body 35 and a rotatable body 36, pivoted to the fixed body 35.

[0083] According to some embodiments, the fixed body 35 is connected to the first supporting arm 24 and the rotatable body 36 is connected to the second support arm 25 and is configured to make it rotate together with it around the first horizontal axis of rotation X1.

[0084] The articulation device 23 can also comprise horizontal rotation actuator means, or fourth actuator means 34, each connected between the fixed body 35 and the rotating body 36 on opposite sides with respect to the first horizontal axis of rotation X1.

[0085] The horizontal rotation actuator means 34 are configured to rotate the rotatable body 36 on a vertical lying plane.

[0086] According to some embodiments, the fourth actuator means comprise a pair of fourth linear actuators 34a, 34b, for example of the piston 54 and cylinder 55 type, suitable to be driven in counter-position to each other to allow the rotation of the rotatable body 36 with respect to the fixed body 35.

[0087] By way of example, the rotatable body 36 can rotate continuously by an angle of about +/- 95° with respect to the fixed body 35, thus allowing to make the holes to prepare the excavations along a circumference arc.

[0088] For example, figs. 1 to 3 show an operating position of the drilling machine 10 in which the base of the mast 16 is aligned on a substantially horizontal plane, and the fourth linear actuators 34a, 34b have substantially the same extension, while figs. 4 and 5 show an operating position in which the mast 16 is rotated by about 90° around the first horizontal axis of rotation X1 with respect to figs. 1-3, and its base lies on a substantially vertical plane; in this case the linear actuator 34a facing the direction of rotation will be in the condition close to the maximum end-of-travel, while the other linear actuator 34b will be in the condition close to the minimum end-of-travel.

[0089] According to possible embodiments, for example, the articulation device 23 can rotate the mast 16 by an angle of about +/- 95° with respect to an intermediate position.

[0090] In accordance with some solutions, the fourth linear actuators 34a, 34b are rotatably connected to the fixed body 35 and to the rotatable body 36. For example, the cylinders 55 and the pistons 54 can be pivoted by hinge means, or pins 37, respectively to the fixed body 35 and to the rotatable body 36.

[0091] In this way the cylinders 55 of the fourth linear actuators 34a, 34b can oscillate with respect to the fixed body 35 during the opposite actions of extension or retraction of the respective pistons 54.

[0092] According to some embodiments, the rotatable body 36 is connected to the second support arm 25 by pivoting means 41, defining a second horizontal axis of rotation X2 of the support arm 25 with respect to the fixed body 35.

[0093] According to some embodiments, inclination adjustment actuator means, or fifth actuator means 45, are provided, connected with one end to the rotatable body 36 and with the opposite end to the support arm 25, defining with them a triangle shape. The fifth actuator means 45 can comprise one, or a pair of linear actuators 45a, 45b which can be extended, or retracted, to incline the oblong support element 26 respectively toward the excavation front or toward a vertical position.

[0094] According to some embodiments, it can be provided that the linear actuators 45a, 45b have an extension travel suitable to rotate the oblong support element 26 by about 15°, and the mast 16 connected thereto with respect to the second horizontal axis of rotation X2 in the direction indicated by arrows G2 in the drawings.

[0095] According to other embodiments, the first support arm 24 of the first positioning unit 21 is connected to the frame 11 by pivoting means 38 defining a third axis of rotation X3.

[0096] According to some embodiments, the third horizontal axis of rotation X3 is parallel to the second horizontal axis of rotation X2.

[0097] According to some embodiments, the projections of the first X1 and of the second horizontal axis of rotation X2 on a horizontal plane can be orthogonal to one another.

[0098] According to possible solutions, the first positioning unit 21 comprises a vertical movement linear actuator, or a sixth linear actuator 46, connected with one end to the frame 11 and with the opposite end to the articulation device 23 by respective pivoting means 42.

[0099] In particular, the sixth linear actuator 46 can be driven respectively to lift, or lower, the articulation device 23, and therefore the second positioning unit 22 and the mast 16, moving it on a substantially vertical plane, for example in the direction indicated by arrows G3 in the drawings.

[0100] Figs. 2 and 6 show examples of operating positions of the mast 16 at different heights, wherein in fig. 2 the sixth linear actuator 46 is in a condition close to the maximum end-of-travel, while in fig. 6 the sixth linear ac-

tuator 46 is in a condition close to the minimum end-of-travel.

[0101] According to other embodiments, the sixth linear actuator 46 can be connected to the articulation device 23 by other intermediate connection members 43, for example integral with the first support arm 24, or connected thereto in a stable and fixed manner.

[0102] According to possible variants, it can be provided that the intermediate connection members 43 are connected with play, so as to allow greater degrees of freedom between the first support arm 24 and the articulation device 23.

[0103] For example, an intermediate connection member 43 can be provided connected to the first support arm 24, to the articulation device 23 and to the sixth linear actuator 46.

[0104] According to other embodiments, the first support arm 24, or the possible intermediate connection member 43, are connected to the articulation device 23 by pivoting means 44, defining a fourth horizontal axis of rotation X4.

[0105] According to these embodiments, an inclination modification actuator, or seventh linear actuator 47, can be provided configured to modify the inclination of the articulation device 23 toward the excavation front or toward a vertical position, respectively.

[0106] The seventh linear actuator 47 can be connected at one end to the frame 11 in a rotatable manner, and at the end opposite to the articulation device 23.

[0107] The seventh linear actuator 47 can be connected directly or indirectly to the frame 11 and/or to the articulation device 23.

[0108] According to some embodiments, a second intermediate connection member 49 can be provided, connected to the first support arm 24 and to the frame 11 in correspondence with the common pivoting means 38, and with the seventh linear actuator 47 by respective pivoting means 50.

[0109] According to some embodiments, the drive of the seventh linear actuator 47 allows a rotation of the articulation device 23, and of the components connected thereto, on a vertical plane, around the fourth axis of rotation X4, in the direction indicated by arrows G4 in fig. 2.

[0110] According to other embodiments, the first positioning means 21 comprise a swivel linear actuator, or eighth linear actuator 48, hinged at one end to the frame 11 and at the opposite end to the articulation device 23 and configured to rotate the latter around a second vertical axis of rotation Y2 lying on a longitudinal median plane M of the drilling machine 10, in the direction indicated by arrows G4 in fig. 9.

[0111] The longitudinal median plane M of the drilling machine 10 can be defined as the median plane of the frame 11.

[0112] In particular, the eighth linear actuator 48 is connected laterally to the articulation device 23, so as to allow a swivel motion thereof with respect to the longitudinal median plane M.

[0113] According to some embodiments, the eighth linear actuator 48 can be extended, and respectively retracted to allow a rotation of the mast 16 on a substantially horizontal plane, so that its terminal end rotates on a circumference arc.

[0114] Figs. 8 and 9 show by way of example an operating position of the drilling machine 10 in which the mast 16 is positioned inclined with respect to the longitudinal median plane M by an angle β.

[0115] By way of example, a travel of the eighth linear actuator 48 can be provided, suitable to allow a rotation of the mast 16 by an angle β of about +/- 35° with respect to the longitudinal median plane M.

[0116] Providing the articulations and linear actuators 31-34, 45-48 hinged by pivoting means 37-38, 41-42, confers on the first 21 and second positioning unit 22 many degrees of freedom which therefore make the drilling machine 10 very versatile, allowing to position the mast 16 in a plurality of different positions.

[0117] Furthermore, providing the use of pairs of linear actuators 31, 32, 33, 34, 45 instead of single linear actuators allows on the one hand to decrease the overall power required, thus reducing consumption, and on the other hand to optimize the movement of the mast 16.

[0118] Embodiments described here also concern a method to position the mast 16 of a drilling machine 10 with respect to an excavation front, in particular to make holes to prepare tunnel excavations.

[0119] The method according to the invention provides to position the drilling machine 10 in correspondence with an area to be subjected to drilling, and to move the mast 16 on a vertical plane, around a first horizontal axis of rotation XI, by means of a first positioning unit 21.

[0120] The positioning method also provides to move the mast 16 with respect to the first positioning unit 21 by means of a second positioning unit 22.

[0121] According to some embodiments, the method provides to support the mast 16 on a support base 28 defined by a head 27 of an oblong support element 26 constrained to the first positioning unit 21 and to move the mast 16 with respect thereto by means of suitable actuator means 31, 32.

[0122] According to some embodiments, the method provides to rotate the mast 16 with respect to a first vertical axis of rotation Y1 substantially orthogonal to the support base 28 and passing through it, by means of vertical rotation actuator means, or first actuator means 31, to allow a correct alignment of the mast 16 with respect to the excavation front.

[0123] According to other embodiments, the method provides to translate the mast 16 in a linear direction on a plane parallel to the support base 28 by means of horizontal sliding actuator means, or second actuator means 32, so as to bring it closer to or farther away from the excavation front to allow a correct positioning of the work tool.

[0124] According to other embodiments, the method provides to slide the second positioning unit 22 with re-

spect to the first positioning unit 21 in a direction parallel to the longitudinal development of the oblong support element 26 by means of vertical sliding actuator means, or third actuator means 33, cooperating with sliding blocks 53.

[0125] According to other embodiments, the method provides to rotate the first positioning unit 21, and with it the second positioning unit 22 and the mast 16 on a horizontal plane, around a second vertical axis of rotation Y2 lying on the longitudinal median plane M of the drilling machine 10 by means of a swivel linear actuator, or eighth linear actuator 48.

[0126] According to other embodiments, the method provides to rotate the mast 16 around the first horizontal axis of rotation X1 by means of an articulation device 23, by rotating a rotatable body 36 of the latter with respect to a fixed body 35 thereof by means of horizontal rotation actuator means 34, comprising a pair of fourth linear actuators 34 acting in counter-position to each other on opposite sides of the horizontal axis of rotation X1.

[0127] According to other embodiments, the method provides to incline the oblong support element 26 with respect to the articulation device 23 causing it to rotate around a second horizontal axis of rotation X2 by means of inclination adjustment actuator means, for example a fifth linear actuator 45.

[0128] According to some embodiments, the method provides to move vertically, that is, to lift and/or lower the articulation device 23, and with it the second positioning unit 22 and the mast 16, by the action of a vertical movement linear actuator, or sixth linear actuator 46.

[0129] According to other embodiments, the method provides to modify the inclination of the articulation device 23 with respect to the frame 11, together with the second positioning unit 21 and the mast 16, by making the articulation device 23 rotate around a fourth horizontal axis of rotation X4 by the action of an inclination modification actuator, or seventh linear actuator 47.

[0130] It is clear that modifications and/or additions of parts may be made to the drilling machine 10 and positioning method as described heretofore, without departing from the field and scope of the present invention.

[0131] It is also clear that, although the present invention has been described with reference to some specific examples, a person of skill in the art shall certainly be able to achieve many other equivalent forms of drilling machine 10 and positioning method, having the characteristics as set forth in the claims and hence all coming within the field of protection defined thereby.

Claims

1. Drilling machine comprising a frame (11) mounted on a slider (12), a drilling unit (14) comprising a mast or guide beam (16), along which a rotation head (20) is mounted sliding and able to make the work tools rotate, and a first positioning unit (21) provided with an articulation device (23) suitable to allow the rotation of said mast (16) on a vertical plane around a first horizontal axis of rotation (X1), and with a first support arm (24) connected between said articulation device (23) and said frame (11) and a second support arm (25) connected to said articulation device (23) on the opposite side of said frame (11), and a second positioning unit (22), connected between said first positioning unit (21) and said mast (16), and provided with an oblong support element (26), connected to said articulation device (23) by means of said second support arm (25) and suitable to support said mast (16), and with positioning means (29, 30, 31, 32, 40) cooperating with said oblong support element (26) and each suitable to confer at least one degree of freedom on said mast (16) with respect thereto, **characterized in that** said articulation device (23) comprises a fixed body (35) and a rotatable body (36) pivoted to said fixed body (35) and connected to said second support arm (25) by pivoting means (41) defining a second horizontal axis of rotation (X2) and said drilling machine comprises inclination adjustment actuator means (45) connected with one end to said rotatable body (36) and with the opposite end to said support arm (25) and configured to incline said oblong support element (26) with respect to said second axis of rotation (X2) respectively toward the excavation front or toward a vertical position.

2. Drilling machine as in claim 1, **characterized in that** said inclination adjustment actuator means (45) comprise one or a pair of linear actuators (45a, 45b) having an extension travel suitable to rotate said oblong support element (26) and the mast (16) connected thereto by about 15° with respect to said second horizontal axis of rotation (X2).

3. Drilling machine as in claim 1 or 2, **characterized in that** said positioning means comprise a rotatable joint (29) disposed between a support base (28) of said oblong support element (26) and said mast (16), and vertical rotation actuator means (31) acting on said rotatable joint (29) and suitable to allow a rotation of said mast (16) around a vertical axis of rotation (Y1) substantially orthogonal to said support base (28).

4. Drilling machine as in any claim hereinbefore, **characterized in that** said positioning means comprise a gripping element (30) and a block (40) cooperating with each other to support said mast (16) on a support plane parallel to said support base (28), and horizontal sliding actuator means (32) configured to allow the sliding of said mast (16) with respect to said support base (28) and said block (40).

5. Drilling machine as in any claim hereinbefore, **char-**

acterized in that it comprises sliding means (33, 53) disposed between said second support arm (25) of said articulation device (23) and said oblong support element (26) and configured to allow the sliding of the latter with respect to said support arm (25).

6. Drilling machine as in claim 5, **characterized in that** said sliding means comprise vertical sliding linear actuator means (33) configured to move said oblong support element (26) along said second support arm (25).

7. Drilling machine as in any claim hereinbefore, **characterized in that** said articulation device (23) comprises horizontal rotation actuator means (34) comprising a pair of linear actuators (34a, 34b) each connected to said fixed body (35) and to said rotatable body (36) on opposite sides with respect to said first horizontal axis of rotation (X1) and suitable to be driven in counter-position to each other to allow the rotation of said rotatable body (36) with respect to said fixed body (35) around said first horizontal axis of rotation (X1).

8. Drilling machine as in any claim hereinbefore, **characterized in that** said first positioning unit (21) comprises a vertical movement linear actuator (46) connected with one end to said frame (11), and with the opposite end to said articulation device (23) by respective pivoting means (42) and configured to lift or lower said articulation device (23) on a substantially vertical plane, and with it said second positioning unit (22) and said mast (16).

9. Drilling machine as in any claim hereinbefore, **characterized in that** said first positioning unit (21) comprises an inclination modification actuator (47) connected with one end to said frame (11), and with the opposite end to said articulation device (23) and configured to modify the inclination of the latter respectively toward the excavation front or toward a vertical position.

10. Drilling machine as in any claim hereinbefore, **characterized in that it** comprises an inclination linear actuator (48) connected to an end of said frame (11) and to the opposite end of said articulation device (23) and configured to rotate it around a vertical axis of rotation (Y2) lying on a longitudinal median plane (M) of said drilling machine.

11. Method to position the mast, or guide beam (16), of a drilling machine (10), the drilling machine (10) comprising a frame (11) mounted on a slider (12), and a drilling unit (14) comprising said mast, or guide beam (16), along which a rotation head (20) is mounted sliding and able to make the work tools rotate, with respect to an excavation front to make holes to prepare the excavations, the method comprising:

- moving said mast (16) on a vertical plane, around a first horizontal axis of rotation (X1) by means of a first positioning unit (21) provided with an articulation device (23) comprising a fixed body (35) connected to said frame (11) and a rotatable body (36) pivoted to said fixed body (35) to position said work tools along a circumference arc,
- positioning said mast (16) with respect to said first positioning unit (21) by means of a second positioning unit (22) supporting said mast (16) on a support base (28) of an oblong support element (26) connected to said articulation device (23),
- driving positioning means (29, 30, 31, 32, 40) cooperating with said support base (28) in order to move said mast (16) on a plane parallel to said support base (28), and
- inclining said oblong support element (26) with respect to said articulation device (23) making it rotate around a second horizontal axis of rotation (X2) by means of inclination adjustment actuator means (45).

12. Method as in claim 11, **characterized in that** it comprises making said rotatable body (36) rotate with respect to said fixed body (35) acting in counter-position on a pair of linear actuators (34a, 34b) connected between said fixed body (35) and said rotatable body (36) on opposite sides of said first horizontal axis of rotation (X1).

13. Method as in claim 11 or 12, **characterized in that** it comprises sliding said second positioning unit (22) with respect to said first positioning unit (21) in a direction parallel to the longitudinal development of said oblong support element (26) by means of vertical sliding actuator means (33) cooperating with sliding blocks (53).

14. Method as in any claim from 11 to 13, **characterized in that** it comprises vertically moving said articulation device (23), and with it said second positioning unit (22) and said mast (16), by means of the action of a vertical movement linear actuator (46).

15. Method as in any claim from 11 to 14, **characterized in that** it comprises rotating said first positioning unit (21) on a longitudinal median plane (M) of said operating machine (10) with respect to a vertical axis of rotation (Y2) lying on said longitudinal median plane (M) by means of a swivel linear actuator (48) connected between said frame (11) and said articulation device (23) in order to align said mast (16) with said excavation front if said drilling machine (10) is not aligned with said excavation front.

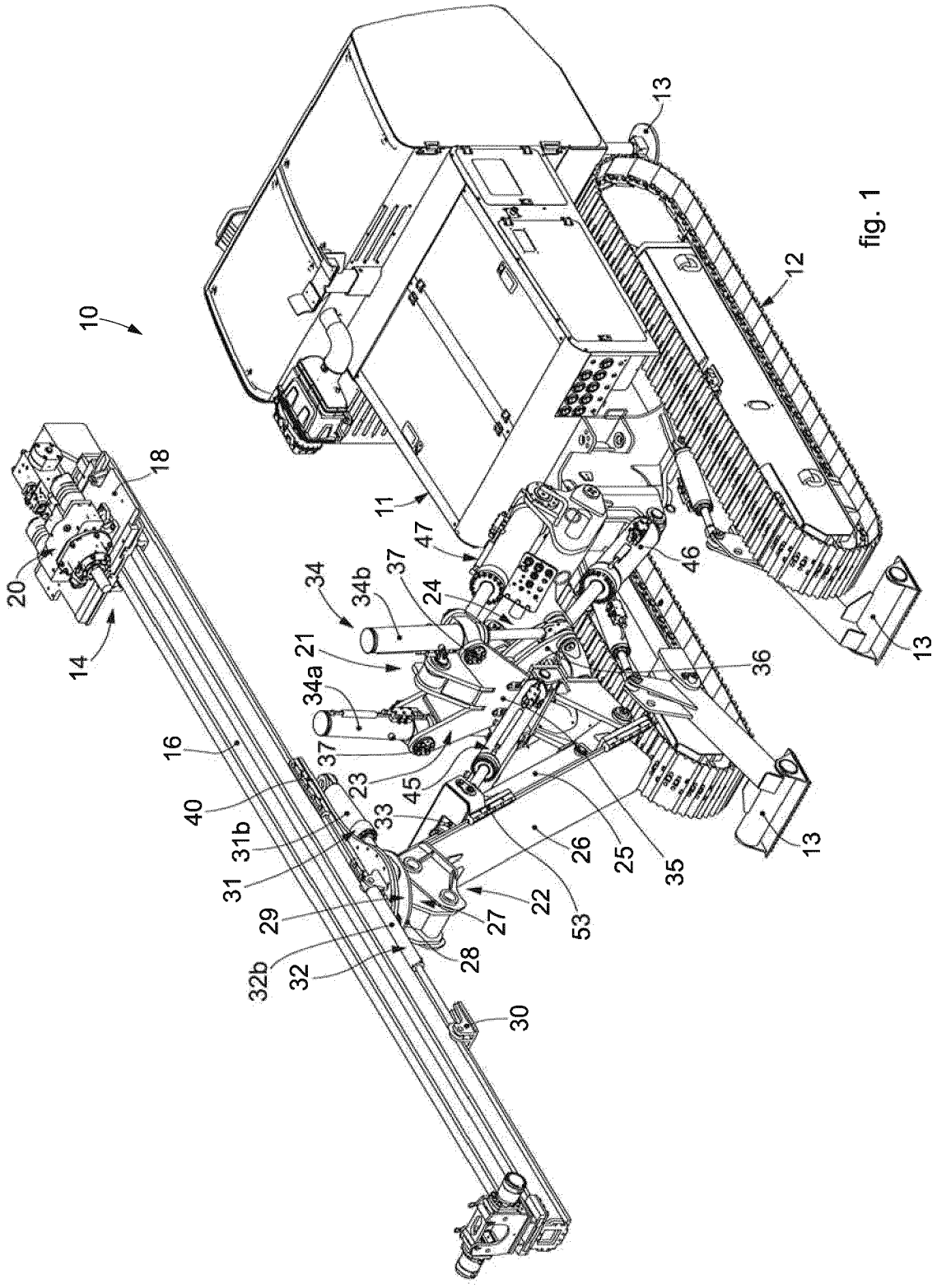
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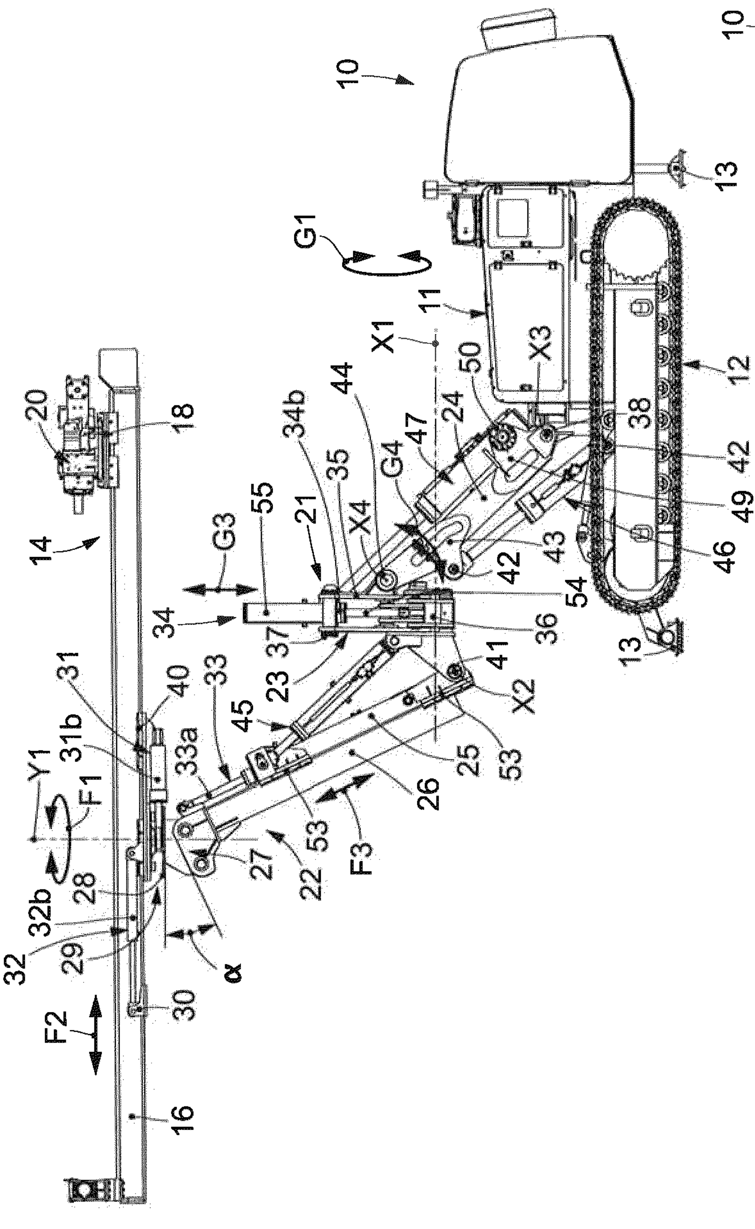
fig. 1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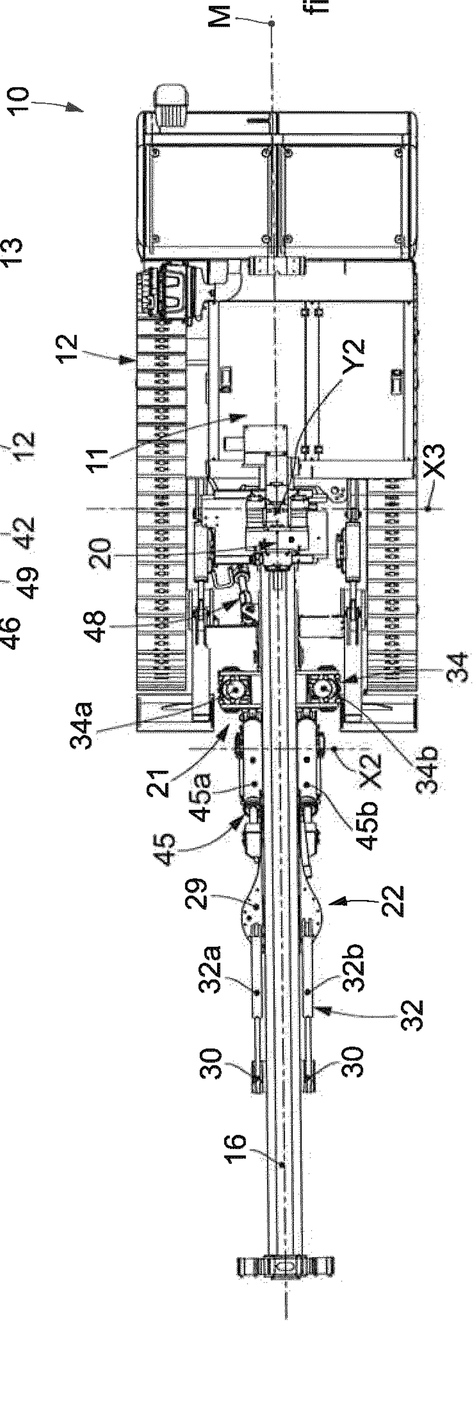
X2
X3
X4
Y1
F1
F2
F3
α

fig. 2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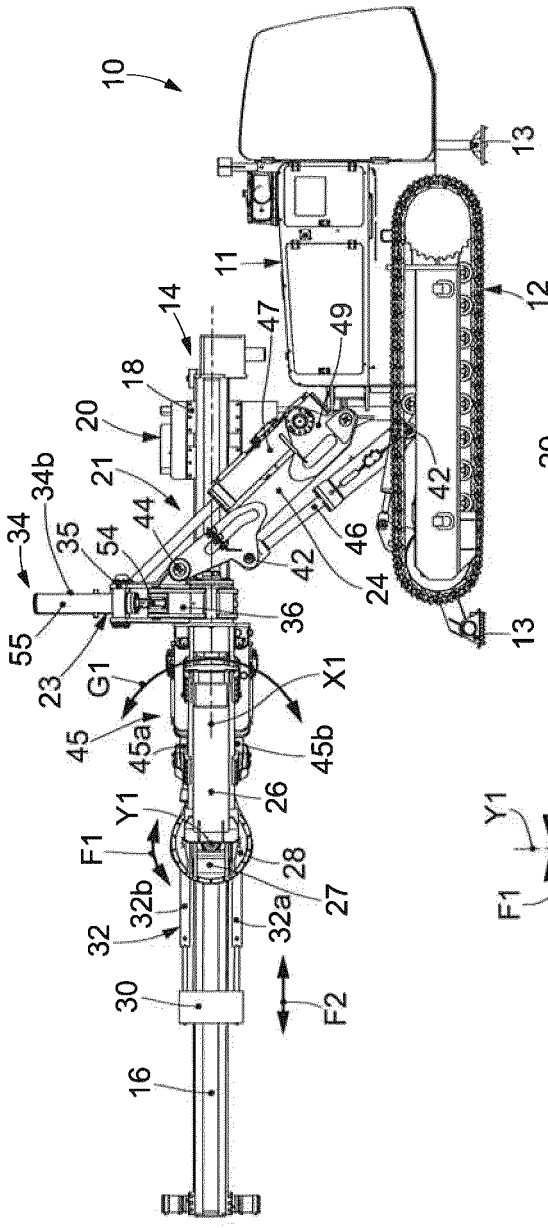
X2
X3
Y2

fig. 3

fig. 4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G1
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F2
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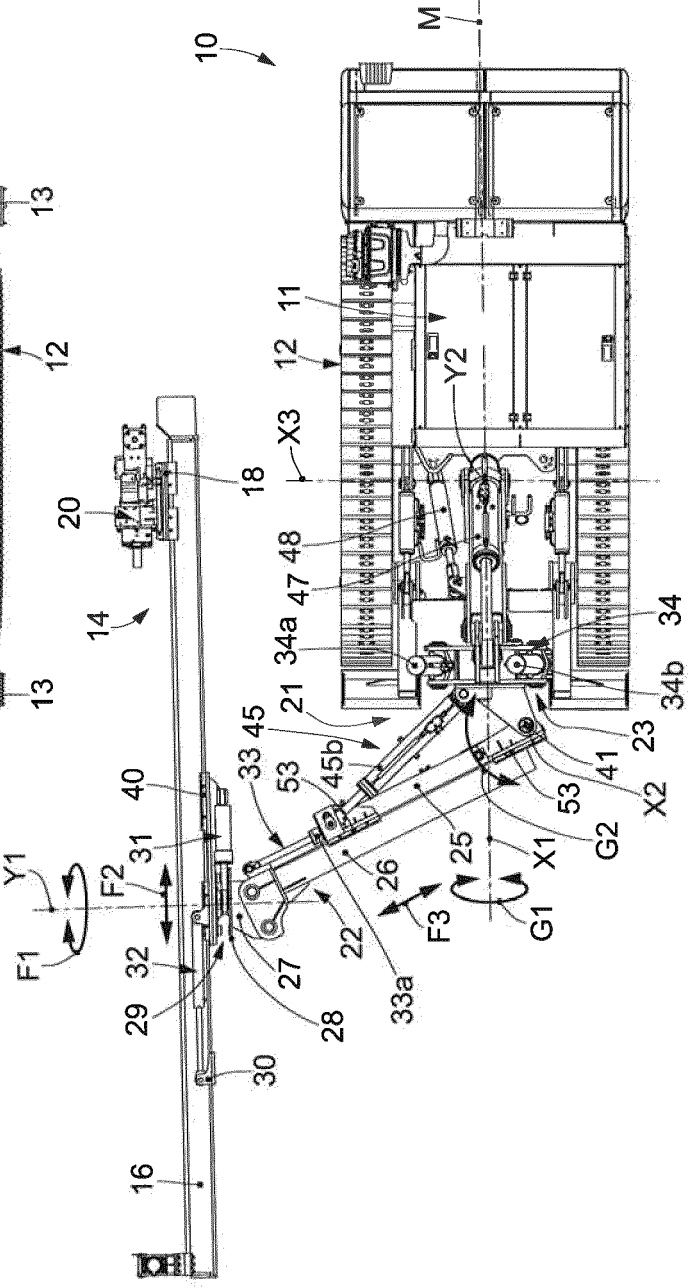
fig. 5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Y1
F2
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33a
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X1
G2
X2
F3
G1
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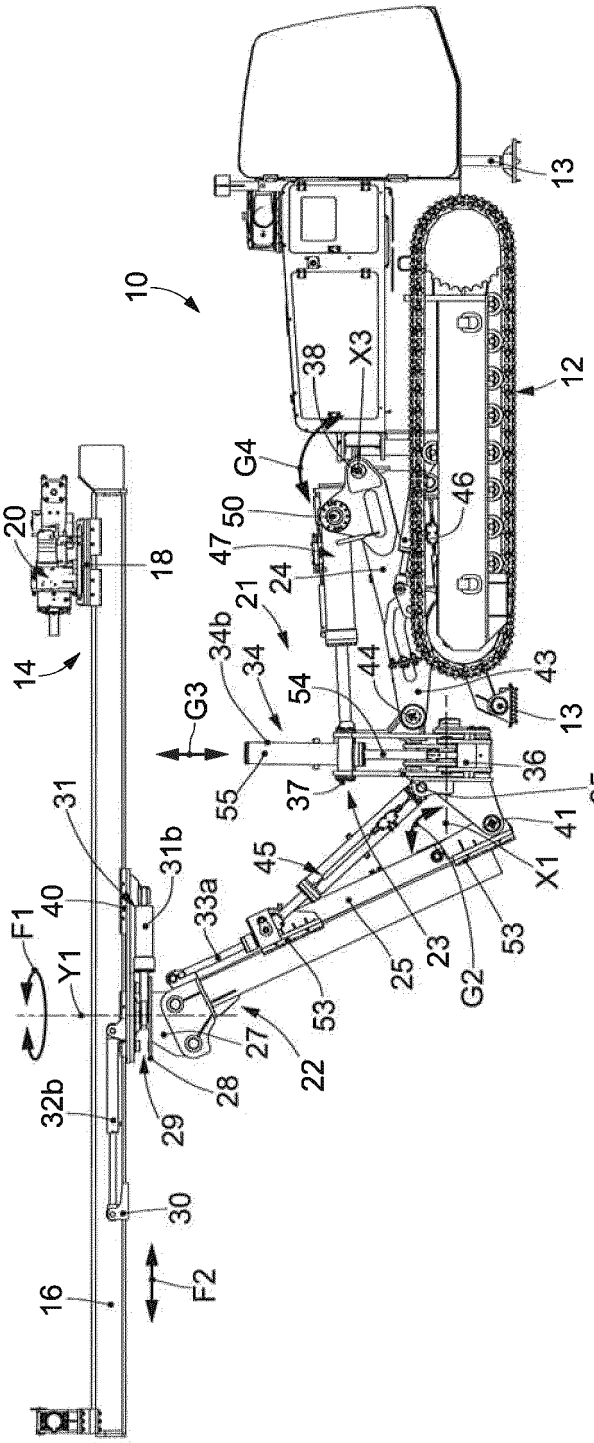
16

fig. 6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41
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X1
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31b
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F1
33a
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G2
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F2
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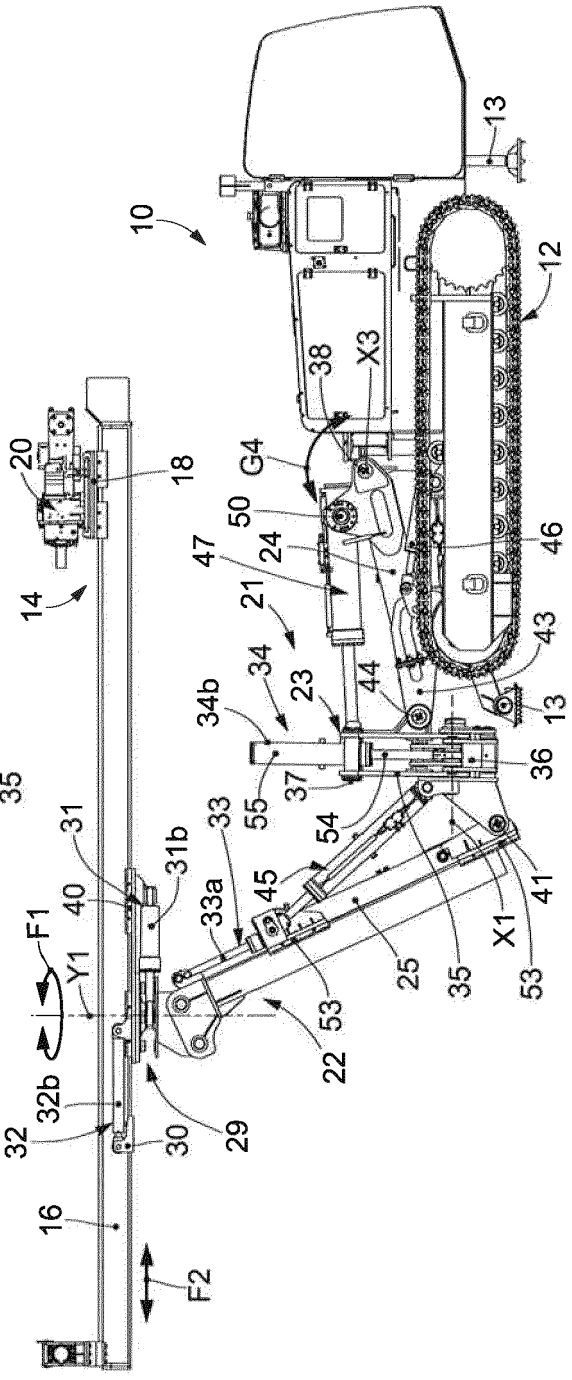
fig. 7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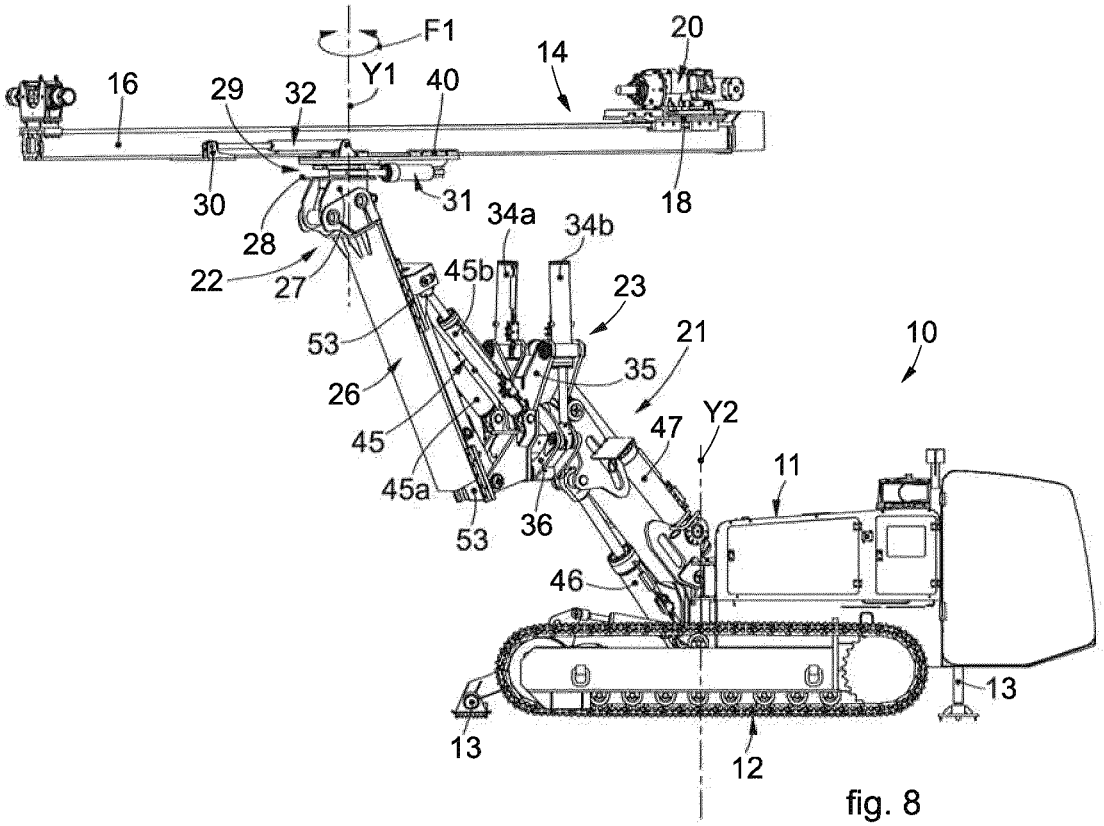
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45a
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36
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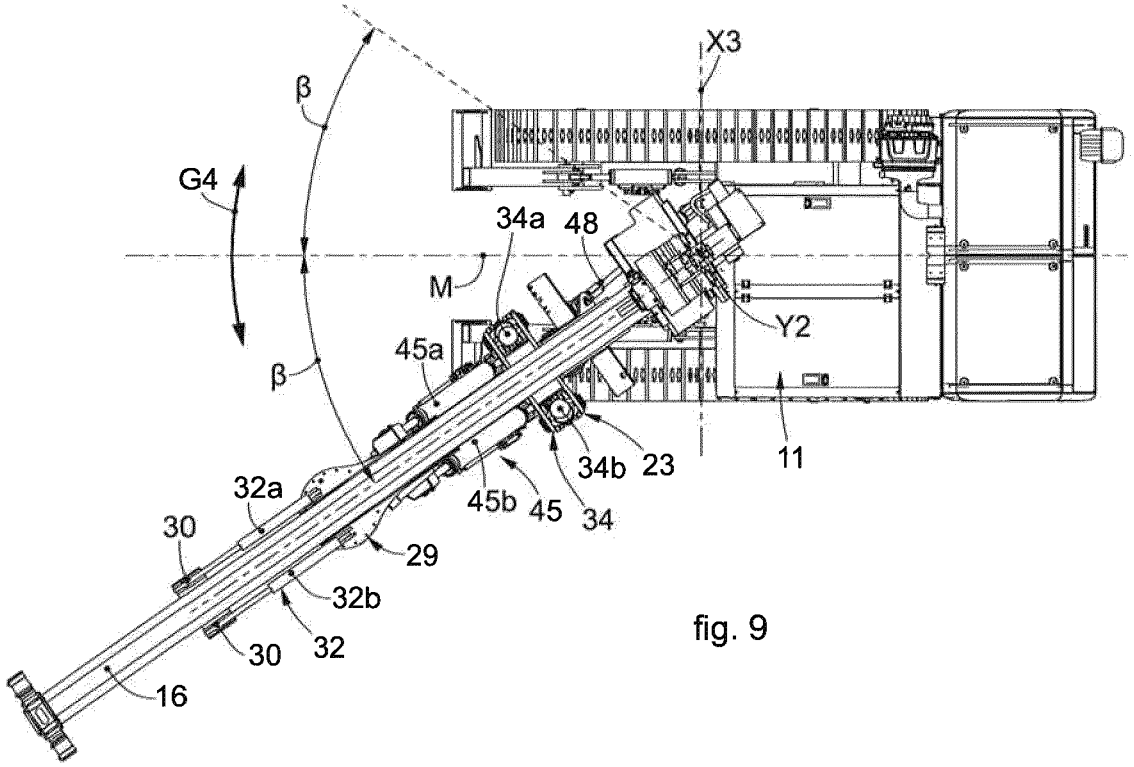
fig. 8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32b
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fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 21 19 5323

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Place of search	Date of completion of the search	Examiner
Munich	23 November 2021	Beran, Jiri

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