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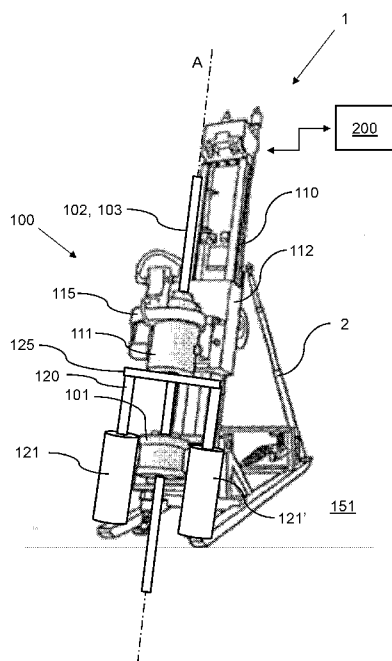


Fig. 1

(57) Abstract: The present disclosure relates to a drilling equipment (100), comprising: - a feed frame, a rod holder (101) for holding a drill string (103) in a fixed position, and a chuck (111) for clamping the drill string, the chuck being movable relative to the rod holder along the feed frame to longitudinally move the clamped drill string, - a hydraulic force enhancing device (120) configured to push on the chuck via a pushing member (125). The drilling equipment is configured to, during drill string retrieval: - clamp the drill string by the chuck and release it from the rod holder, - apply a feed force by the feed frame to pull on the clamped drill string, - detect that the feed force applied by the chuck is insufficient, and in response thereto control the force enhancing device to push on the chuck.



A DRILLING EQUIPMENT AND A METHOD FOR CONTROLLING A DRILLING EQUIPMENT

5 TECHNICAL FIELD

The present disclosure relates to rock drilling and to the retrieval of a drill string during a rock drilling process, in particular in the drilling of deep downholes. In particular aspects, the disclosure relates to a method and a drilling equipment used in connection with the retrieval of a drill string during rock drilling. The disclosure also relates to an electronic
10 control unit and a drill rig.

BACKGROUND

A drill string used in rock drilling typically comprises a number of drill rods that are threadedly engaged with one another so as to form the drill string of a drilling equipment.
15 In so called surface drilling, where the drill rig performing the drilling operation is located above ground, the drilling is generally performed downwards, or at least partly downwards, to form a downhole. When the depth of the drilled hole increases, the drill string is prolonged by adding new drill rods such that a drill head of the drill string is in contact with the rock at the bottom of the hole. To retrieve the drill string from a drilled
20 downhole when the desired depth has been reached, a feed frame comprising a chuck is used to pull on the drill string by applying a hydraulic force, whereafter a rod holder engages it and fixes it such that an uppermost drill rod can be disengaged by rotating the chuck. The process is repeated until the entire drill string is retrieved.

25 In some applications, such as in exploration drilling, the drilled hole may be several kilometres deep. For such deep downholes, the drill string becomes heavy, and it may be problematic to retrieve it using the hydraulic force of the feed frame, unless the drill rig is designed for the large forces required in those particular situations.

30 It would be advantageous to achieve a drilling equipment that facilitates retrieval of heavy drill strings in connection with deep downhole drilling.

SUMMARY

The primary object of the present disclosure is to overcome or alleviate at least one of the disadvantages of the prior art, or to provide a useful alternative. In particular, it is an object to provide a drilling equipment, a drill rig and a method for controlling a drilling
5 equipment that facilitate retrieval of heavy drill strings in connection with deep downhole drilling.

At least the primary object above may, according to a first aspect of the present disclosure, be achieved by a drilling equipment according to claim 1. The drilling
10 equipment is configured to break a mineral substrate during a drilling operation, and it comprises:

- a feed frame, a rod holder and a chuck, wherein the rod holder is fixed to the feed frame and is configured to releasably hold a drill rod of a drill string in a fixed position, the drill string extending along a longitudinal axis, and wherein the chuck
15 is movable along the feed frame relative to the rod holder by application of a longitudinal feed force, the chuck being configured to releasably clamp the drill rod, and
- a force enhancing device comprising at least one hydraulic cylinder and a pushing member movable by the at least one hydraulic cylinder, the force enhancing
20 device being configured to push on the chuck via the pushing member.

The drilling equipment is configured to, during a drill string retrieving operation:

- clamp the drill rod by the chuck and subsequently release the drill rod from the rod holder,
- apply the longitudinal feed force by the feed frame to pull on the clamped drill rod
25 in a longitudinal pulling direction via the chuck, and
- detect that the longitudinal feed force applied by the feed frame is insufficient to move the clamped drill rod in the pulling direction, and in response thereto control the force enhancing device to push on the chuck in the pulling direction.

30 By the proposed drilling equipment, it is possible to increase the force used when retrieving a drill string in comparison with a traditional drilling equipment using only a feed frame with a chuck to retrieve the drill string. This is particularly advantageous for deep downhole drilling operations in which the drill string may be too heavy to retrieve using only the feed frame and the chuck. It is also advantageous for retrieving a drill string that
35 is for some reason stuck in the hole.

Optionally, a cylinder body of the at least one hydraulic cylinder of the force enhancing device is configured to be supported on the feed frame, such as on a housing of the rod holder. In this way, support for the force enhancing device is provided regardless of
5 whether there is a stable ground surface present against which the force enhancing device can be supported. Hence, a versatile drilling equipment is provided. A piston of the at least one hydraulic cylinder of the force enhancing device may in this case be fixed to the pushing member via a piston rod. In an alternative configuration, the piston may be supported on the feed frame, such as on the housing of the rod holder, via a piston rod,
10 and the cylinder body may be fixed to the pushing member.

Optionally, the cylinder body of the at least one hydraulic cylinder of the force enhancing device is releasably mountable to the feed frame, such as to the housing of the rod holder. This makes it possible to selectively fix the cylinder body to the housing, such as
15 when no stable ground surface is available for support. Furthermore, it is possible to remove the force enhancing device from the drill rig when it is not needed. In the alternative configuration mentioned above, the piston rod may be releasably mountable to the housing of the rod holder.

20 Optionally, the force enhancing device is separate from the feed frame. In this way, the same force enhancing device can be used with different drill rigs, and it can be mounted only when it is deemed likely that the feed force of the feed frame will be insufficient.

Optionally, the force enhancing device comprises at least one support member configured
25 to be supported against a ground surface during the drill string retrieving operation. In this way, the force enhancing device does not need to have a specific interface for fitting with the housing of the rod holder, meaning that the same force enhancing device may be used with different types of rod holders. The ground surface may herein be understood as a surface of a rock body comprising the mineral substrate.

30

Optionally, the force enhancing device comprises at least two hydraulic cylinders. The force enhancing device may comprise more than two hydraulic cylinders, such as three or four hydraulic cylinders. By providing at least two cylinders, sufficient force for pushing may more easily be achieved than if a single cylinder is used. However, it is possible to
35 provide the force enhancing device with a single hydraulic cylinder.

Optionally, the pushing member comprises a plate configured to be positioned between the rod holder and the chuck at least during the drill string retrieving operation. As described above, the plate can be mechanically connected to one of the piston rod and
5 the cylinder body of the at least one hydraulic cylinder of the force enhancing device.

Optionally, the feed frame comprises at least one hydraulic cylinder configured to apply the longitudinal feed force to move the chuck relative to the rod holder. The feed frame may preferably comprise two or more hydraulic cylinders.

10

Optionally, the at least one hydraulic cylinder of the force enhancing device has a shorter stroke length than the at least one hydraulic cylinder of the feed frame. Hence, the at least one hydraulic cylinder of the force enhancing device can be activated at the beginning of a feed stroke of the at least one hydraulic cylinder of the feed frame. A more compact
15 force enhancing device can hereby be provided.

Optionally, the pushing member is mechanically connected to at least one piston of the at least one hydraulic cylinder of the force enhancing device. The connection may be a releasable connection, such as by mechanical connection members, or a fixed
20 connection. The pushing member may, e.g., be fixed to a piston rod of the at least one hydraulic cylinder, in turn fixed to the piston. Of course, when two or more hydraulic cylinders are provided in the force enhancing device, the piston of each hydraulic cylinder may be mechanically connected to the pushing member.

25 Optionally, the drilling equipment is configured for rotary drilling, such as for rotary exploration drilling.

According to a second aspect of the disclosure, at least the primary object is achieved by a computer-implemented method for controlling a drilling equipment to retrieve a drill
30 string extending along a longitudinal axis according to claim 11. The drilling equipment comprises:

- a feed frame, a rod holder and a chuck, wherein the rod holder is fixed to the feed frame and is configured to releasably hold a drill rod of the drill string in a fixed position, and wherein the chuck is movable along the feed frame relative to the rod

holder by application of a longitudinal feed force, the chuck being configured to releasably clamp the drill rod,

- a force enhancing device comprising at least one hydraulic cylinder and a pushing member movable by the at least one hydraulic cylinder.

5 The method comprises, by an electronic control unit:

- controlling the chuck to clamp the drill rod and the rod holder to subsequently release the drill rod,
- controlling the feed frame to apply the longitudinal feed force to pull on the clamped drill rod in a longitudinal pulling direction via the chuck,
- 10 - detecting that the longitudinal feed force applied by the feed frame is insufficient to move the clamped drill rod in the pulling direction, and in response thereto controlling the force enhancing device to push on the chuck in the pulling direction.

By the proposed method, it is possible to increase the force used to retrieve a drill string in
15 comparison with methods in which only a feed frame with a chuck is used to retrieve the drill string. This is particularly advantageous for deep downhole drilling operations in which the drill string may be too heavy to retrieve using only the feed frame. It is also advantageous for retrieving a drill string that is for some reason stuck in the hole.

20 Advantages and advantageous features of the proposed method largely correspond to those of the drilling equipment according to the first aspect.

Optionally, detecting that the feed force applied by the feed frame is insufficient to move the clamped drill rod in the pulling direction comprises detecting that the longitudinal feed
25 force applied by the feed frame is a maximum applicable feed force. It may further comprise detecting that there is no movement of the chuck upon application of the feed force.

Optionally, the method further comprises, by the electronic control unit:

- 30 - during application of the longitudinal feed force by the feed frame, detecting that a predetermined condition is fulfilled, and in response thereto controlling the rod holder to hold the drill rod, and the chuck to subsequently release the drill rod,
- controlling the force enhancing device and the feed frame to assume a retracted state while the rod holder holds the drill rod.

The predetermined condition may be a condition indicative of that the force enhancing device is no longer able to assist the feed frame in the drill string retrieving operation, e.g., due to that it has reached its maximum extension.

- 5 Optionally, the predetermined condition is fulfilled when it is detected at least that the clamped drill rod is not moving in the pulling direction. This may, e.g., be detected by detecting that the chuck is not moving. This may indicate that the force enhancing device has reached its maximum extension, but that the feed frame is still not able to pull the drill string upwards without assistance from the force enhancing device.

10

Optionally, the predetermined condition is fulfilled when it is detected that the at least one hydraulic cylinder of the force enhancing device has reached a maximum extension, and when the longitudinal feed force applied by the feed frame is a maximum applicable feed force. This may be in addition to detecting that the clamped drill rod is not moving in the

- 15 pulling direction.

According to a third aspect, an electronic control unit comprising processing circuitry configured to control a drilling equipment to perform the method according to the second aspect is provided.

20

According to a fourth aspect, a drill rig comprising the drilling equipment according to the first aspect is provided. The drill rig may further comprise the electronic control unit according to the third aspect.

- 25 Further advantages and advantageous features are disclosed in the following description, in the drawings, and in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

- 30 The present disclosure will hereinafter be further explained by means of non-limiting examples with reference to the appended drawings wherein:

Fig. 1 is a schematic illustration of a drill rig according to an embodiment,

Fig. 2 schematically illustrates parts of a drilling equipment according to a first

- 35 embodiment in a first position,

Fig. 3 schematically illustrates the drilling equipment according to the first embodiment in a second position,

Fig. 4 is a schematic top view of a pushing member according to an embodiment,

Fig. 5 schematically illustrates parts of a drilling equipment according to a second

5 embodiment in a first position,

Fig. 6 schematically illustrates the drilling equipment according to the second embodiment in a second position,

Fig. 7 is a flow chart illustrating a method according to the disclosure.

10 It should be noted that the appended drawings are schematic and that individual components are not necessarily drawn to scale and that the dimensions of some features may have been exaggerated for the sake of clarity.

15 DETAILED DESCRIPTION

The disclosure will, in the following, be exemplified by embodiments. A feature from one embodiment may be combined with one or more features of any other embodiment.

Fig. 1 illustrates a drill rig 1 comprising a drilling equipment 100 according to a first

20 embodiment of the disclosure. The drill rig 1 comprises a support arrangement 2 configured to support the drill rig 1 against a ground surface 151. The support arrangement 2 is herein adjustable, such that a drilling angle of the drill rig 1 may be adjusted.

25 The drilling equipment 100 is configured to break a mineral substrate, such as a rock body, by drilling a hole therein during a drilling operation. For this purpose, a drill string 103 is provided, comprising a plurality of drill rods 102, that may be attached to one another by threaded connections (not shown). The drill string 103 extends along a longitudinal axis A, defining a longitudinal direction of the drilling equipment 100.

30

The drilling equipment 100 comprises a feed frame 110 on which a rod holder 101 and a chuck 111 are arranged. The rod holder 101 is fixed onto a lower portion of the feed frame 110, such that it can releasably hold the drill rod 102 of the drill string 103 in a fixed position with respect to stationary parts of the feed frame 110. The rod holder 101 is

35 configured to hold the drill string 103 when no drilling is performed. It may be movable

between a closed position, in which it holds the drill rod 102, and an open position, in which it does not hold the drill rod 102. The rod holder 101 may be hydraulically or electrically controlled. It may comprise a spring for holding the drill rod 102, such as a mechanical spring or a gas spring that opens hydraulically or electrically and closes with
5 gas pressure.

The chuck 111 forms part of a rotation unit 115, which is movable relative to the rod holder 101 along the feed frame 110 by application of a longitudinal feed force. The movement may be achieved by means of one or more hydraulic cylinders (not shown) of
10 the feed frame 110, applying the longitudinal feed force to the rotation unit 115 via a movable cradle 112 or similar on which the chuck 111 is mounted. The chuck 111 is configured to releasably clamp the drill rod 102, such that when the chuck 111 clamps the drill rod 102, it can move the drill string 103 along the longitudinal axis A by applying a longitudinal feed force by means of the feed frame 110, i.e., by the one or more hydraulic
15 cylinders and the cradle 112. The chuck 111 may comprise a spring similar to that of the rod holder for clamping the drill rod 102, such as a gas spring or a mechanical spring. The chuck 111 may further be configured to close hydraulically and to open by means of at least one spring.

20 In some cases, at least two hydraulic cylinders may be provided for moving the chuck 111 along the feed frame 110, although a single hydraulic cylinder may in some cases be provided. The hydraulic cylinder(s) may preferably be double acting hydraulic cylinders.

During a drilling operation, the rotation unit 115 is used to drive the drill string 103 into the
25 ground whilst rotating the same. During a drill string retrieving operation, the rotation unit 115 is instead used to pull the drill string 103 out from the drilled hole. It may further be used to loosen connecting threads of two connected drill rods 102 of the drill string 103 during drill string retrieval by rotating a clamped drill rod with respect to another drill rod being held by the rod holder 101. The drilling equipment 100 according to the illustrated
30 embodiment does not comprise any percussion unit, although in other embodiments the drilling equipment may further comprise a percussion unit configured to provide a striking action to the drill string 103 when drilling is performed.

The drilling equipment 100 further comprises a force enhancing device 120 configured to
35 temporarily increase a force applied to the drill string 103 by means of the chuck 111

during a drill string retrieving operation, such as after a drilling operation when the drill string 103 is retrieved from the drilled hole. The force enhancing device 120 comprises at least one hydraulic cylinder, herein two hydraulic cylinders 121, 121', and a pushing member 125 movable by the hydraulic cylinders 121, 121'. The force enhancing device
5 120 is configured to push on the chuck 111 via the pushing member 125. For this purpose, the pushing member 125 is provided below the chuck 111.

The drill rig 1 herein further comprises an electronic control unit 200. The electronic control unit 200 is configured to control the drilling equipment 100 during at least the drill
10 string retrieving operation, as will be further described below in connection with the method illustrated in Fig. 7.

The electronic control unit 200 may be provided on the drill rig, or it may be located remotely from the drill rig 1 and configured to communicate with modules on the drill rig 1
15 by wireless or wired communication. The electronic control unit 200 may include a microprocessor, a microcontroller, a programmable digital signal processor or another programmable device. Thus, the control unit comprises electronic circuits and connections (not shown) as well as processing circuitry (not shown) for communicating with different parts of the drilling equipment as well as with the external control unit. For example, the
20 control unit 200 may be configured for communicating with various sensors, devices, systems, and control units of the drilling equipment 100 and/or of the drill rig 1. The electronic control unit 200 may comprise several sub-units (not shown) or be embodied as a single control unit.

25 The electronic control unit 200 may comprise modules in either hardware or software, or partially in hardware or software, and communicate using known transmission buses such as a CAN-bus and/or wireless communication capabilities. The processing circuitry may be a general-purpose processor or a specific processor. The control unit 200 may comprise a non-transitory memory for storing computer program code and data. Thus, the skilled
30 person realizes that the electronic control unit 200 may be embodied by many different constructions.

The drilling equipment 100, and in particular the force enhancing device 120, will now be discussed in greater detail with reference to Figs. 2–6, wherein Figs. 2–3 illustrate parts of
35 the drilling equipment 100 including the force enhancing device 100 according to a first

embodiment, and Figs. 5–6 illustrate parts of the drilling equipment 100 including the force enhancing device 100 according to a second embodiment. Both embodiments may be used with the drill rig 1 illustrated in Fig. 1.

5 In the first embodiment, the force enhancing device 120 is separate from the feed frame 110 (not shown in Fig. 2) and the rod holder 101. It comprises two hydraulic cylinders 121, 121' that are each supported against the ground surface 151 by means of a respective support member 126, 126' during the drill string retrieving operation. Each hydraulic cylinder 121, 121' of the force enhancing device 120 comprises a longitudinally movable
10 piston 122, a cylinder body 123, and a piston rod 124 fixed to the piston 122. In the illustrated embodiment, the cylinder body 123 is fixed to the support member 126 and the pushing member 125 is mechanically connected to the piston 122 of each hydraulic cylinder 121, 121' of the force enhancing device 120 via the respective piston rod 124. The pushing member 125 is inserted between the chuck 111 and the rod holder 101.

15

Fig. 2 shows the drilling equipment 100 in a first position, with the hydraulic cylinders 121, 121' of the force enhancing device 120 in a retracted state. When the drilling equipment 100 is to be used in a drill string retrieving operation, the drill string 103 is initially held in a fixed position by the rod holder 101. The chuck 111 is thereafter controlled to clamp the
20 drill rod 102 and the rod holder 101 is subsequently controlled to release the drill rod 102. The feed frame 110 (see Fig. 1) is thereafter controlled to apply a longitudinal feed force to pull on the clamped drill rod 102 in a longitudinal pulling direction A1 via the chuck 111. If it is detected that the longitudinal feed force applied by the feed frame 110 is insufficient to move the clamped drill rod 102 in the pulling direction A1, the force enhancing device
25 120 is controlled to push on the chuck 125 in the pulling direction A1 while applying the longitudinal feed force by the feed frame 110.

Fig. 3 shows the drilling equipment 100 in a second position, with the hydraulic cylinders 121, 121' of the force enhancing device 120 in an extended state. The hydraulic cylinders
30 121, 121' of the force enhancing device 120 may have a shorter stroke length than the at hydraulic cylinder(s) of the feed frame 110, such that, when the hydraulic cylinders 121, 121' have reached their extended state at an end of the stroke length, the feed frame 110 may continue to pull the drill string 103 upwards, if possible.

Fig. 4 shows a schematic view of a pushing member 125 according to an example. The pushing member 125 is in the form of a plate with a through-hole 126 for allowing the drill string 103 to pass through. The pushing member 125 may be arranged around the drill string 103 by clamping an upper drill rod of the drill string 103 by the chuck 111 and
5 clamping a lower drill rod of the drill string 103 by the rod holder 101, rotating the chuck 111 to loosen a threaded connection between the upper and lower drill rods, and subsequently raise the upper drill rod by the feed frame 110 and arrange the pushing member 125 around the upper or lower drill rod. The upper drill rod may thereafter once again be attached to the lower drill rod and the drill string retrieving operation may
10 commence. The pushing member 125 may of course have many different configurations, for example, it may be formed by two parts releasably connectable together by mechanical connection members so as to allow insertion of the pushing member around the drill string 103 without unthreading two drill rods from one another. The pushing member 125 may be fixed to the piston rod 124 of each cylinder 121, 121', or releasably
15 fixed thereto using mechanical connection members.

The second embodiment of the drilling equipment 100 illustrated in Fig. 5 is similar to the first embodiment but differs therefrom in that the force enhancing device 120 is configured to be supported on the feed frame 110, herein via a housing 104 of the rod holder 101,
20 instead of against the ground surface 151. In the illustrated example, the cylinder body 123 of each hydraulic cylinder 121, 121' is mounted to the housing 104 of the rod holder 101. The cylinders 121, 121' may be releasably mounted to the rod holder 101, such as by mechanical connection members (not shown), so that the force enhancing device 120 can be removed from the rod holder 101 when it is not needed.

25

Fig. 5 shows the drilling equipment 100 in a first position, with the hydraulic cylinders 121, 121' of the force enhancing device 120 in a retracted state. Fig. 6 shows the drilling equipment 100 in a second position, with the hydraulic cylinders 121, 121' of the force enhancing device 120 in an extended state.

30

Fig. 7 illustrates a computer-implemented method for controlling the drilling equipment 100 according to any one of the above disclosed embodiments to retrieve the drill string 103 from a drilled downhole during a drill string retrieving operation. When the method is initiated, the drill string 103 may be held in a firm grip by the rod holder 101. The method

comprises the following actions that are carried out by an electronic control unit, such as by the electronic control unit 200:

5 S1: Controlling the chuck 111 to clamp the drill rod 102, and subsequently controlling the rod holder 101 to release the drill rod 102. Hence, the chuck 111 is controlled to its closed position and the rod holder 101 is controlled to its open position.

10 S2: Controlling the feed frame 110 to apply the longitudinal feed force to pull on the clamped drill rod 102 in the longitudinal pulling direction A1 via the chuck 111. This may typically be achieved by controlling the hydraulic cylinder(s) of the feed frame 110 to move from a retracted to an extended state, such that the chuck 111 moves upwards along the feed frame 110. When the drill string 103 has a low weight and is not stuck somewhere in the drilled downhole, the longitudinal feed force applied by the feed frame 110 is usually sufficient to move the drill string 103 upwards.

15

S3: Detecting that the longitudinal feed force applied by the feed frame 110 is insufficient to move the clamped drill rod 102 in the pulling direction. This action may comprise detecting that the longitudinal feed force applied by the feed frame 110 is a maximum applicable feed force. This may be detected by monitoring a pressure applied by the 20 hydraulic cylinder(s) of the feed frame 110. It may further comprise detecting that the clamped drill rod 102, and/or movable parts of the feed frame 110, such as the cradle 112 and/or the chuck 111, is/are not moving in the pulling direction. This may, by way of example, comprise monitoring a position of the cradle 112 relative to the feed frame 110.

25 S4: In response to detecting that the longitudinal feed force applied by the feed frame 110 is insufficient to move the clamped drill rod 102 in the pulling direction A1, controlling the force enhancing device 120 to push on the chuck 111 in the pulling direction A1. This may comprise controlling the at least one hydraulic cylinder 121, 121' of the force enhancing device 120 to move from a retracted to an extended state. Hence, the longitudinal feed 30 force applied by the feed frame 110 is complemented by the force applied by the force enhancing device 120.

During application of the longitudinal feed force by the feed frame 110 in action S2, it may be detected that a predetermined condition is fulfilled. The predetermined condition may 35 be considered fulfilled when it is detected at least that the clamped drill rod 102 is not

moving in the pulling direction A1. The predetermined condition may further be determined such that it is considered fulfilled when it is detected that the at least one hydraulic cylinder 121, 121' of the force enhancing device 120 has reached a maximum extension, and when the longitudinal feed force applied by the feed frame 110 is a
5 maximum applicable feed force. The predetermined condition may hence be indicative of that the force that the feed frame 110 is able to apply is insufficient for moving the drill string 103 in the pulling direction A1.

In response to the predetermined condition being fulfilled, the rod holder 101 may be
10 controlled to hold the drill rod 102, and the chuck 111 may subsequently be controlled to release the drill rod 102. The feed frame 110 and the force enhancing device 120 may thereafter be controlled to assume a retracted state while the rod holder 101 holds the drill rod 102. The method may thereafter be repeated by performing the actions S1-S4 again.

15 Once it is detected that the longitudinal feed force applied by the feed frame 110 is sufficient to move the drill string 103 in the pulling direction A1, it is no longer necessary to perform action S4. Retrieval of the drill string 103 may thereafter proceed without using the force enhancing device 120.

20 Further modifications of the disclosure within the scope of the appended claims are feasible. As such, the present invention should not be considered as limited by the embodiments and figures described herein. Rather, the skilled person will recognize that many changes and modifications may be made within the scope of the appended claims.

CLAIMS

1. A drilling equipment (100) configured to break a mineral substrate (150) during a drilling operation, the drilling equipment (100) comprising:
 - 5 - a feed frame (110), a rod holder (101) and a chuck (111), wherein the rod holder (101) is fixed to the feed frame (110) and is configured to releasably hold a drill rod (102) of a drill string (103) in a fixed position, the drill string (103) extending along a longitudinal axis (A), and wherein the chuck (111) is movable along the feed frame (110) relative to the rod holder (101) by application of a longitudinal feed force, the chuck (111) being configured to releasably clamp the drill rod (102),
 - 10 - a force enhancing device (120) comprising at least one hydraulic cylinder (121) and a pushing member (125) movable by the at least one hydraulic cylinder (121), the force enhancing device (120) being configured to push on the chuck (111) via the pushing member (125),
 - 15 the drilling equipment (100) being configured to, during a drill string retrieving operation:
 - clamp the drill rod (102) by the chuck (111) and subsequently release the drill rod (102) from the rod holder (101),
 - apply the longitudinal feed force by the feed frame (110) to pull on the clamped drill rod (102) in a longitudinal pulling direction (A1) via the chuck (111),
 - 20 - detect that the longitudinal feed force applied by the feed frame (110) is insufficient to move the clamped drill rod (102) in the pulling direction (A1), and in response thereto control the force enhancing device (120) to push on the chuck (125) in the pulling direction (A1).
- 25 2. The drilling equipment according to claim 1, wherein a cylinder body (123) of the at least one hydraulic cylinder (121) of the force enhancing device (120) is configured to be supported on the feed frame (110), such as on a housing (104) of the rod holder (101).
3. The drilling equipment according to claim 2, wherein the cylinder body (123) is
 - 30 releasably mountable to the feed frame (110), such as to the housing (104) of the rod holder (101).
4. The drilling equipment according to claim 1, wherein the force enhancing device (120) is separate from the feed frame (110).

5. The drilling equipment according to claim 4, wherein the force enhancing device (120) comprises at least one support member (126) configured to be supported against a ground surface (151) during the drill string retrieving operation.
- 5 6. The drilling equipment according to any one of the preceding claims, wherein the force enhancing device (120) comprises at least two hydraulic cylinders (121, 121').
7. The drilling equipment according to any one of the preceding claims, wherein the pushing member (125) comprises a plate configured to be positioned between the rod holder (101) and the chuck (111) at least during the drill string retrieving operation.
- 10 8. The drilling equipment according to any one of the preceding claims, wherein the feed frame (110) comprises at least one hydraulic cylinder configured to apply the longitudinal feed force to move the chuck (111) relative to the rod holder (101).
- 15 9. The drilling equipment according to claim 8, wherein the at least one hydraulic cylinder (121) of the force enhancing device (120) has a shorter stroke length than the at least one hydraulic cylinder of the feed frame (110).
- 20 10. The drilling equipment according to any one of the preceding claims, wherein the pushing member (125) is mechanically connected to at least one piston (122) of the at least one hydraulic cylinder (121) of the force enhancing device (120).
- 25 11. A computer-implemented method for controlling a drilling equipment (100) to retrieve a drill string (103) extending along a longitudinal axis (A), the drilling equipment (100) comprising:
- a feed frame (110), a rod holder (101) and a chuck (111), wherein the rod holder is fixed to the feed frame and is configured to releasably hold a drill rod (102) of the drill string (103) in a fixed position, and wherein the chuck (111) is movable along the feed frame relative to the rod holder (101) by application of a longitudinal feed force, the chuck being configured to releasably clamp the drill rod,
 - a force enhancing device (120) comprising at least one hydraulic cylinder (121) and a pushing member (125) movable by the at least one hydraulic cylinder (121),
- 30 the method comprising, by an electronic control unit (200):

- controlling (S1) the chuck (111) to clamp the drill rod (102) and the rod holder (101) to subsequently release the drill rod (102),
- controlling (S2) the feed frame (110) to apply the longitudinal feed force to pull on the clamped drill rod (102) in a longitudinal pulling direction (A1) via the chuck (111),
- detecting (S3) that the longitudinal feed force applied by the feed frame (110) is insufficient to move the clamped drill rod (102) in the pulling direction (A1), and in response thereto controlling (S4) the force enhancing device (120) to push on the chuck (111) in the pulling direction (A1).

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12. The method according to claim 11, wherein detecting that the feed force applied by the feed frame (110) is insufficient to move the clamped drill rod (102) in the pulling direction (A1) comprises detecting that the longitudinal feed force applied by the feed frame (110) is a maximum applicable feed force.

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13. The method according to claim 11 or 12, further comprising, by the electronic control unit (200):

- during application of the longitudinal feed force by the feed frame (110), detecting that a predetermined condition is fulfilled,
- in response to the predetermined condition being fulfilled, controlling the rod holder (101) to hold the drill rod (102), and the chuck (111) to subsequently release the drill rod (102),
- controlling the feed frame (110) and the force enhancing device (120) to assume a retracted state while the rod holder (101) holds the drill rod (102).

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14. The method according to claim 13, wherein the predetermined condition is fulfilled when it is detected at least that the clamped drill rod (102) is not moving in the pulling direction.

30 15. The method according to claim 13 or 14, wherein the predetermined condition is fulfilled when it is detected that the at least one hydraulic cylinder (121) of the force enhancing device (120) has reached a maximum extension, and when the longitudinal feed force applied by the feed frame (110) is a maximum applicable feed force.

16. An electronic control unit (200) comprising processing circuitry configured to control a drilling equipment (100) to perform the method according to any one of claims 11–15.

5 17. A drill rig (1) comprising the drilling equipment (100) according to any one of claims 1–10.

18. The drill rig according to claim 17, further comprising the electronic control unit (200) according to claim 16.

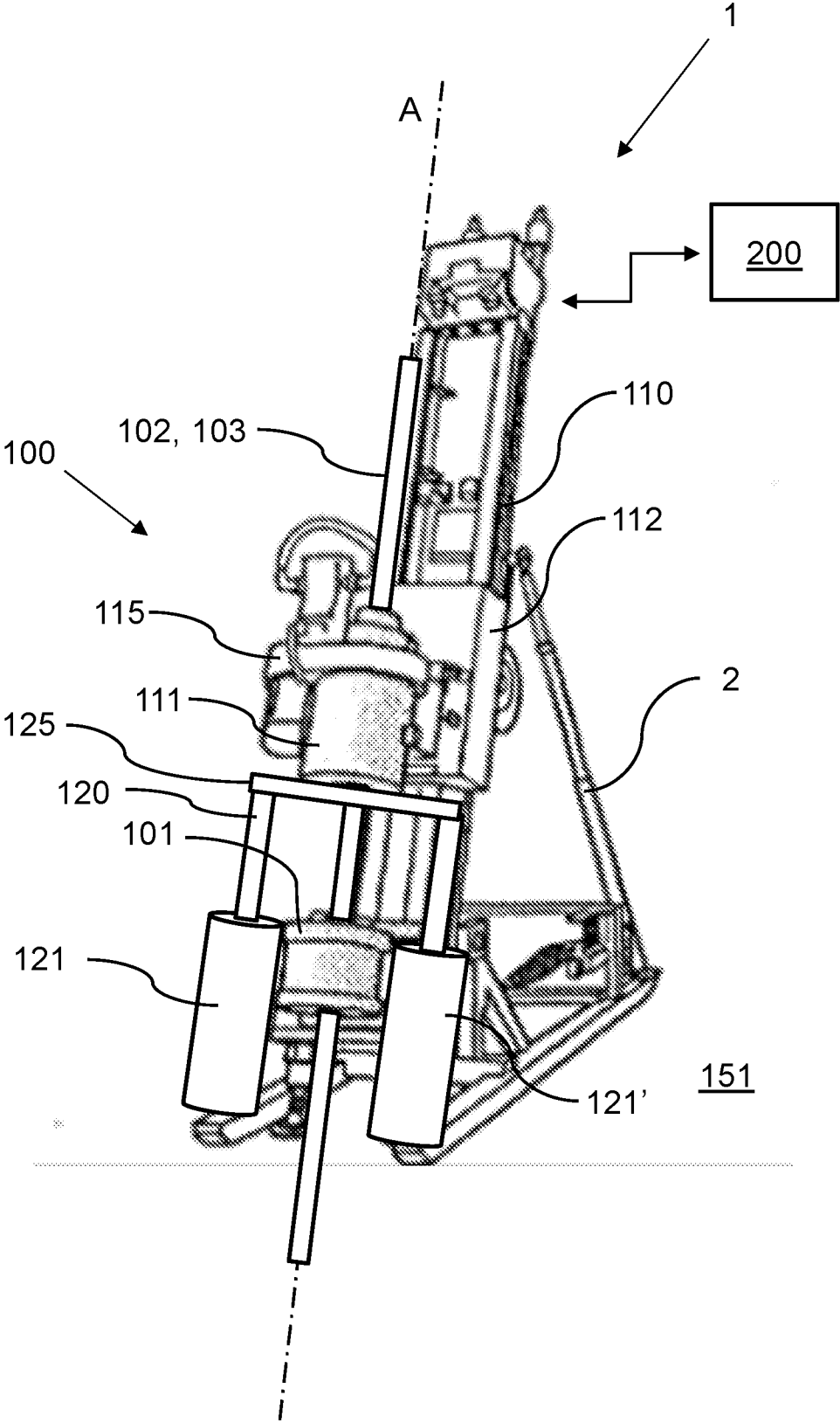


Fig. 1

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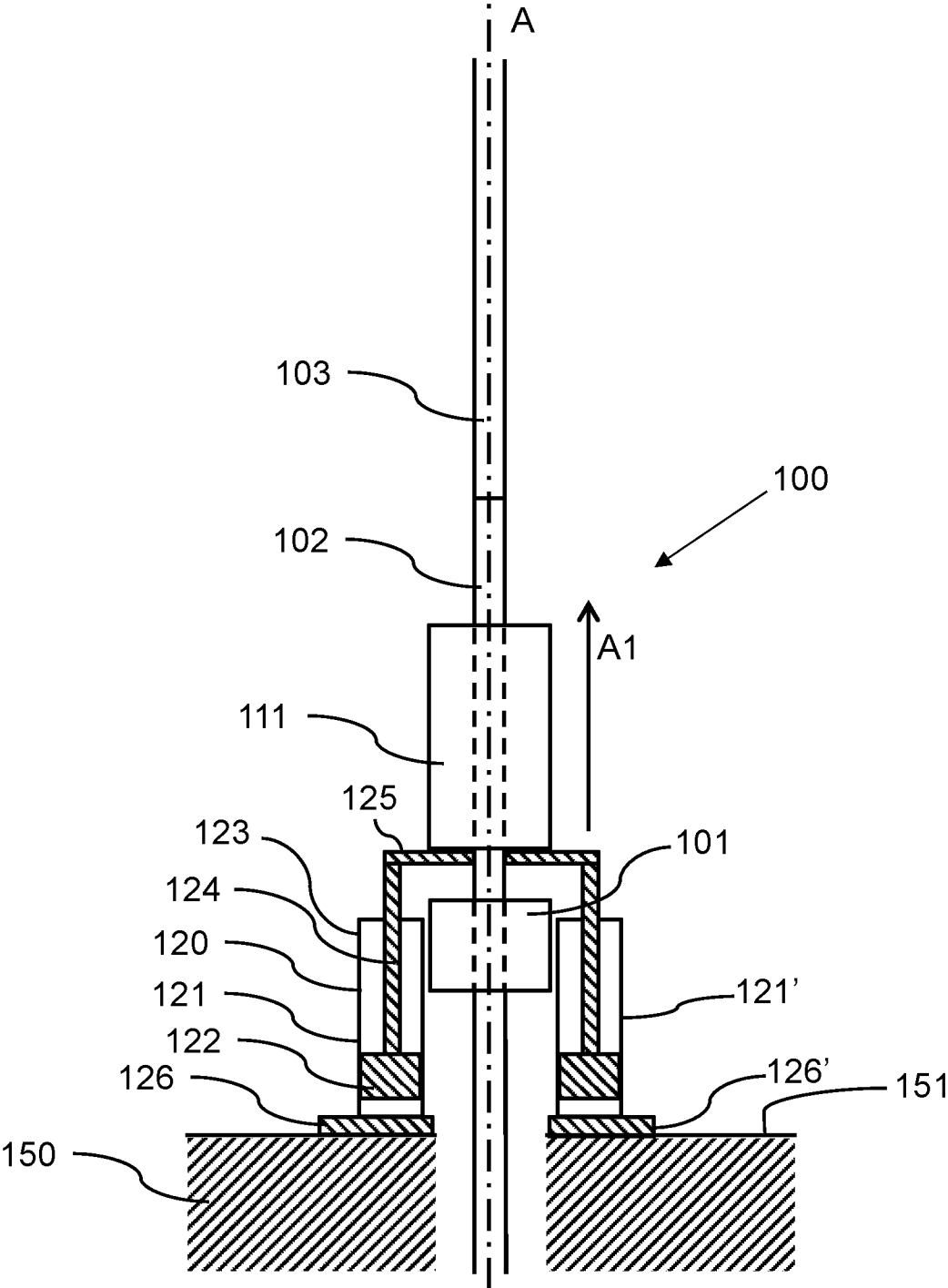


Fig. 2

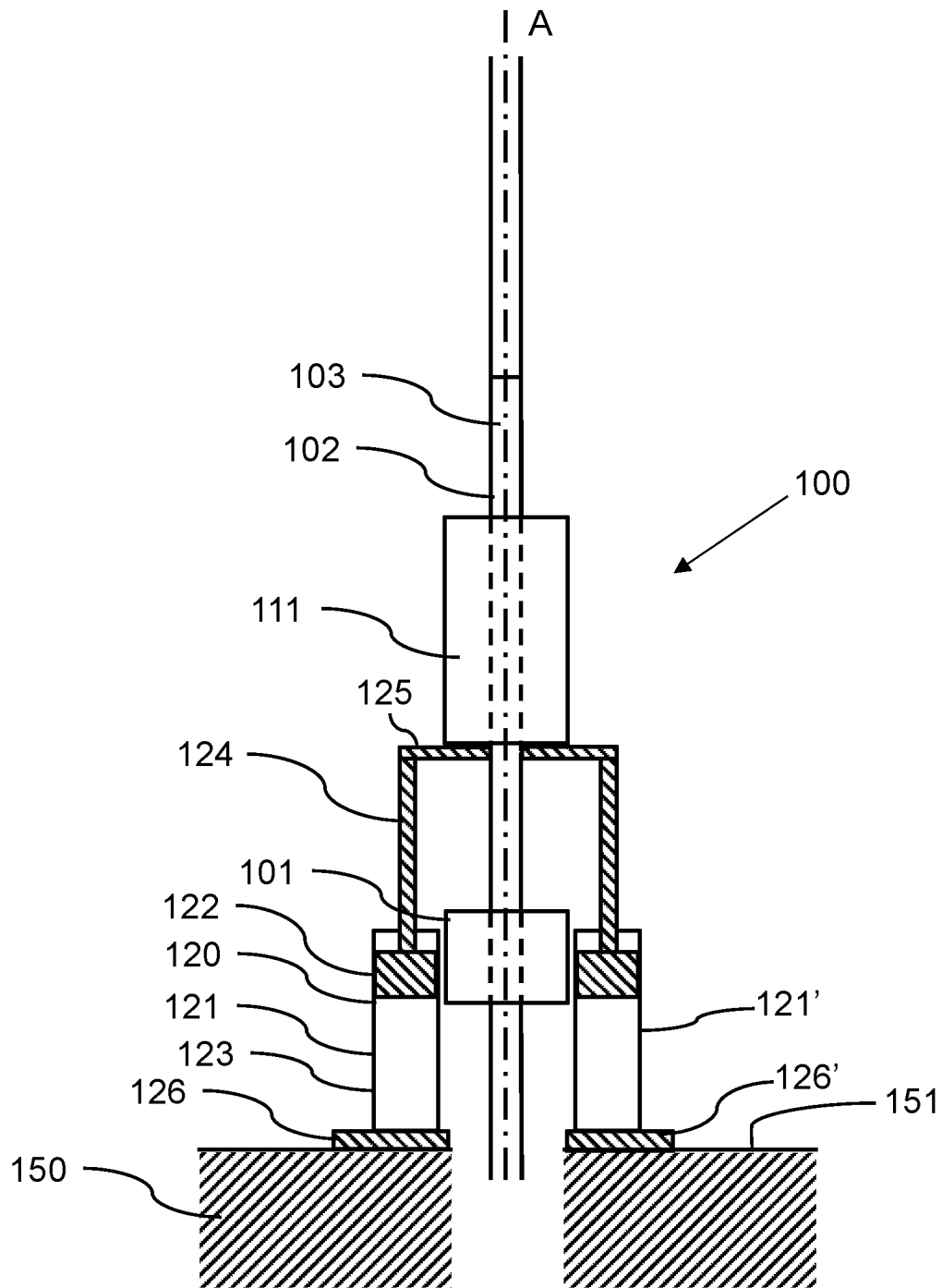


Fig. 3

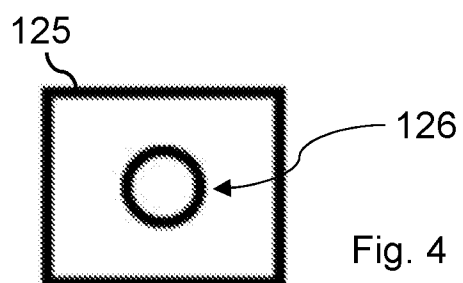


Fig. 4

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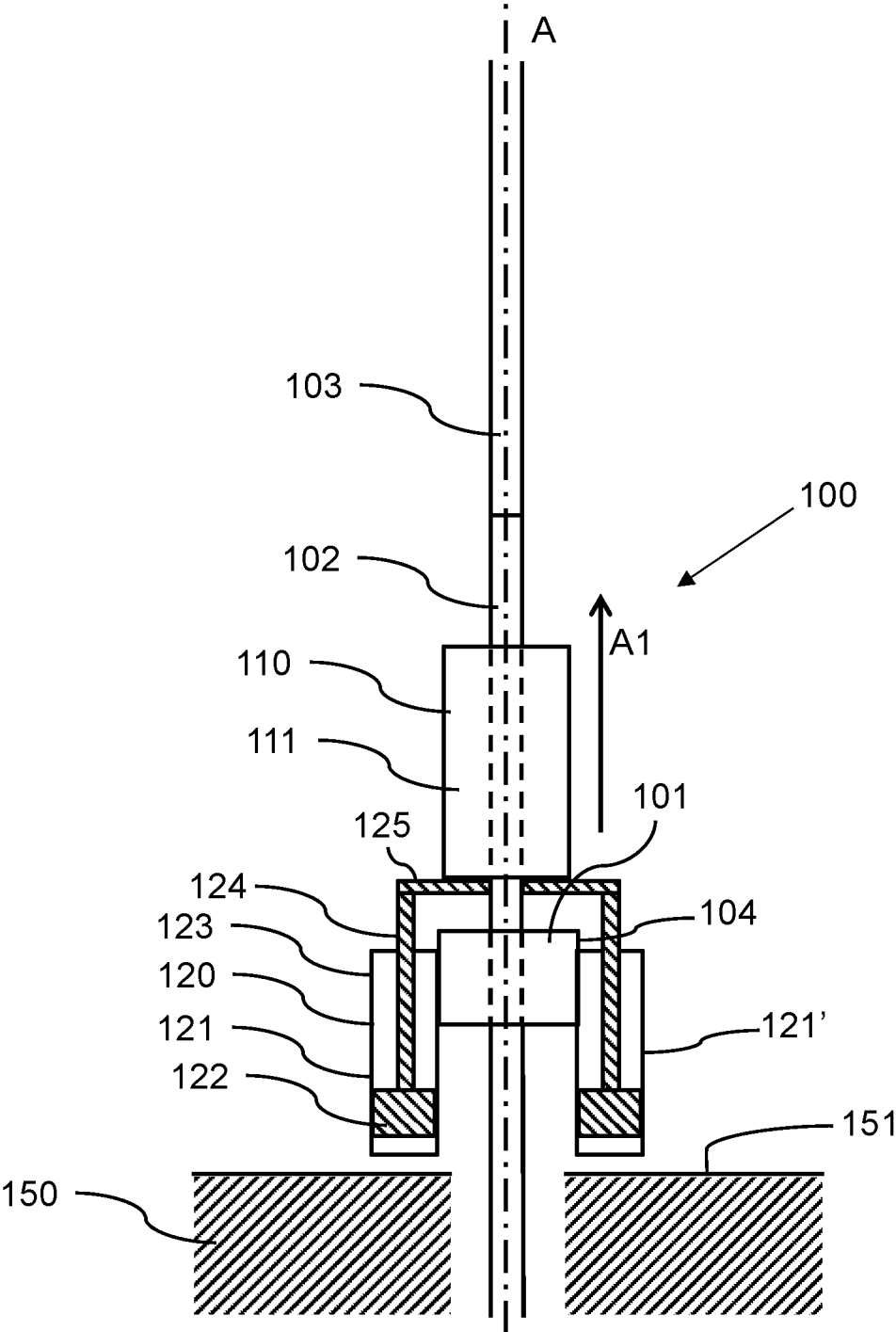


Fig. 5

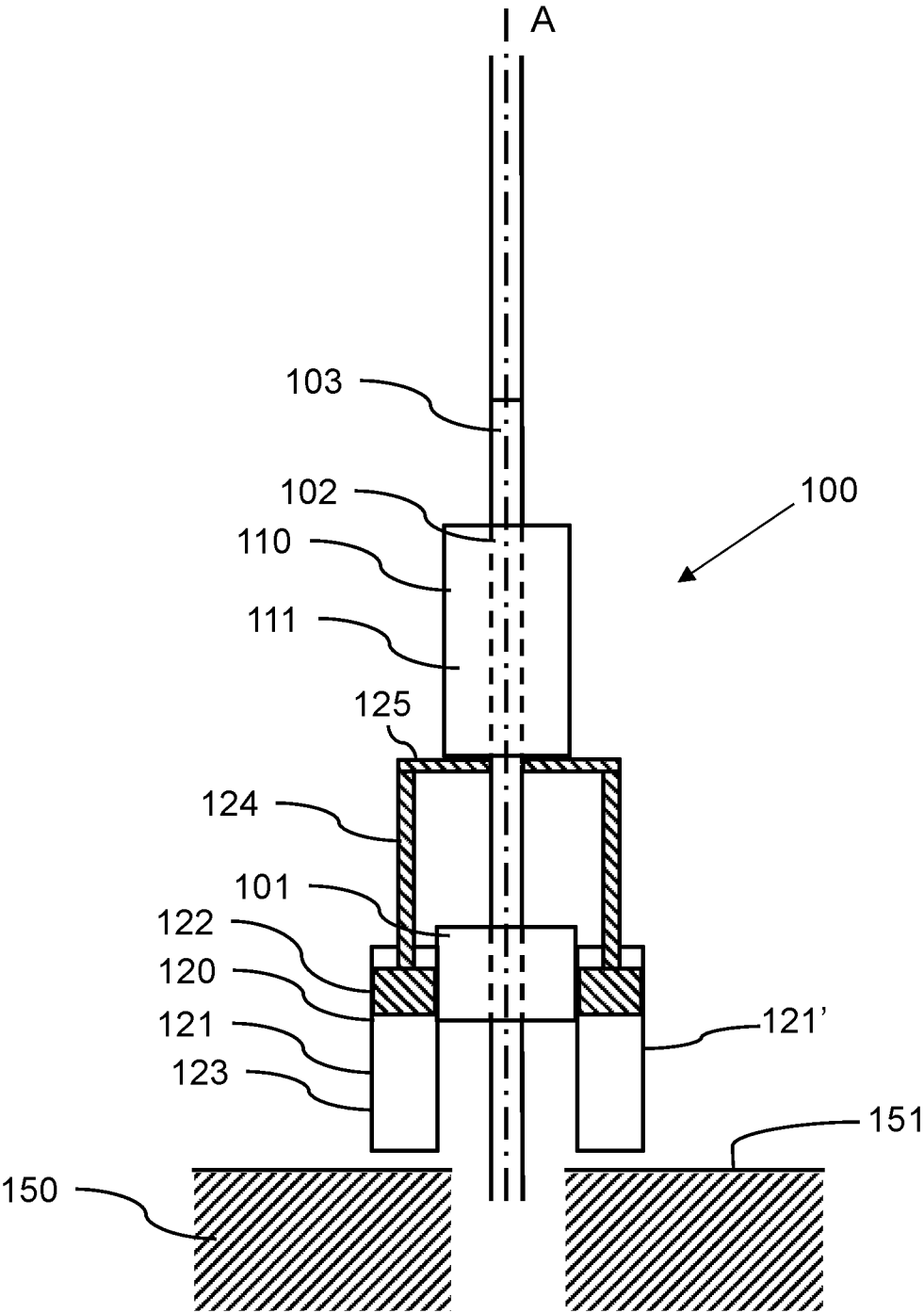


Fig. 6

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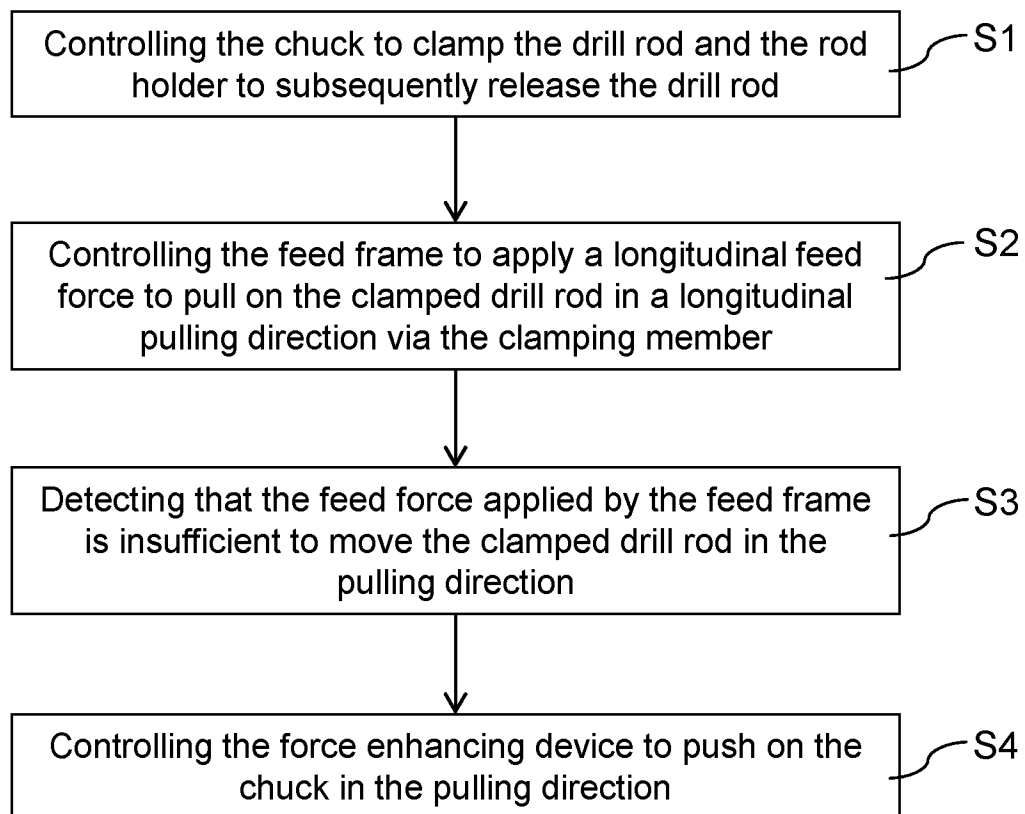


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2023/051274

A. CLASSIFICATION OF SUBJECT MATTER INV. E21B19/086 E21B44/00 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) E21B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2020/392798 A1 (CUTLER EDWARD LEE [US] ET AL) 17 December 2020 (2020-12-17) paragraph [0007] - paragraph [0014] paragraph [0055] paragraph [0064] paragraph [0094] - paragraph [0097] paragraph [0109] figures -----	1 - 7, 10 - 18
X	US 2002/117336 A1 (TREMBLAY HARVEY [CA]) 29 August 2002 (2002-08-29) paragraph [0026] - paragraph [0028] paragraph [0037] - paragraph [0039] figures -----	1 - 5, 7 - 10
A	US 6 279 667 B1 (CULVER R BARRY [CA]) 28 August 2001 (2001-08-28) the whole document -----	1
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 13 June 2024		Date of mailing of the international search report 02/07/2024
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Pieper, Fabian

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/SE2023/051274

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2020392798 A1	17-12-2020	DE 102020207315 A1 US 2020392798 A1	17-12-2020 17-12-2020
US 2002117336 A1	29-08-2002	CA 2338823 A1 US 2002117336 A1	27-08-2002 29-08-2002
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