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(72) Inventors:
• **VERHO, Samuli**
33311 Tampere (FI)
• **KOKKONEN, Annukka**
33311 Tampere (FI)

(74) Representative: **Sandvik**
Sandvik Mining and Construction Oy PL 100
Patent Department
33311 Tampere (FI)

(71) Applicant: **Sandvik Mining and Construction Oy**
33311 Tampere (FI)

(54) **DRILLING ARRANGEMENT, DRILLING MACHINE AND METHOD**

(57) A drilling arrangement, a mine drilling machine and a method. The arrangement comprises
- a hollow, flexible and rotatable drill rod (2),
- a feed unit (1) for feeding and rotating said drill rod (2),
- a feed beam (4) arranged to support the feed unit (1),
- a guiding element system (5) arranged to support a section of the drill rod (2) entering the rotation unit (1), the guiding element system (5) comprising

-- an inner guide (6), arranged to envelop said section of the drill rod (2),
-- an outer support arrangement (9) arranged to support and guide a first length of the inner guide (6) in/on a carrier (10) of the mine drilling machine, and
-- the inner guide (6) being movable in its lengthwise direction in the outer support arrangement (9).

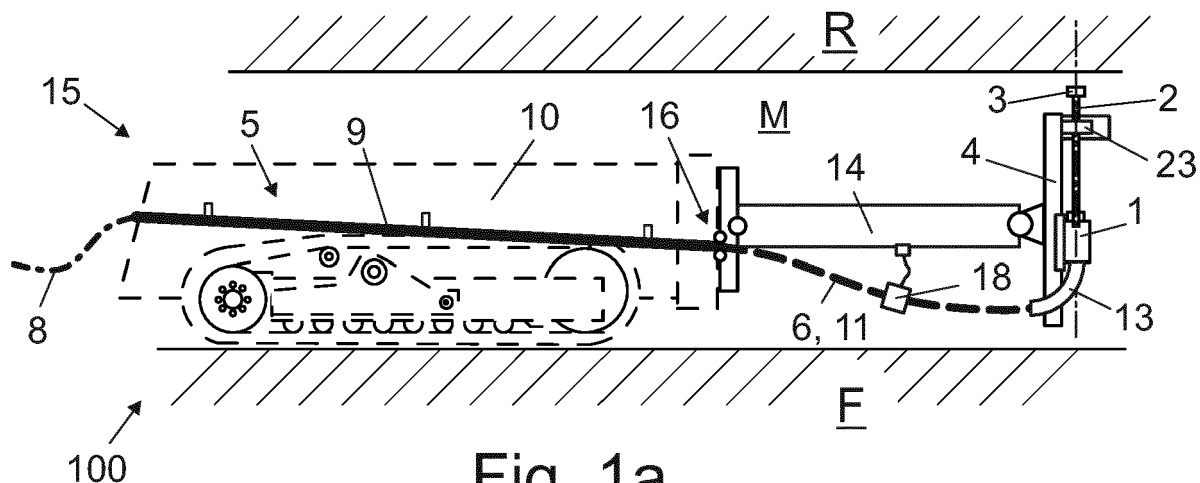


Fig. 1a

Description

BACKGROUND

[0001] The invention relates to a drilling arrangement for a mine drilling machine.

[0002] The invention further relates to a mine drilling machine.

[0003] The invention still further relates to a method for drilling a hole into a rock.

[0004] The need for continuous drilling arises especially in the low profile (LP) and extra low profile (XLP) mines where rock support is a critical part of the process. The height of the mine gallery may be as low as 1.2 meters. Due to the rock conditions it is necessary to install up to 2-6 meter long rock reinforcement bolts to the roof of the mine.

[0005] Since the drilled length required is much longer than the height of the mine, currently extension drilling by adding rods is used. Adding rods takes time, lowers the efficiency of the process and risks persons when adding rods are often done by hand. Due to the space restriction a mechanic rod handler has not been seen feasible or as effective as manual handling.

[0006] A document EP2896780 discloses a flexible drill rod for continuous drilling, in which adding of rods may be avoided. However, there are some aspects regarding durability of the drill rod that could be improved or developed further.

BRIEF DESCRIPTION

[0007] Viewed from a first aspect, there can be provided a drilling arrangement for a mine drilling machine, comprising a drilling arrangement for a mine drilling machine, comprising a hollow, flexible and rotatable drill rod, a feed unit for feeding and rotating said drill rod, a feed beam arranged to support the feed unit, a guiding element system arranged to support a section of the drill rod entering the rotation unit, the guiding element system comprising an inner guide, arranged to envelop said section of the drill rod, an outer support arrangement arranged to support and guide a first length of the inner guide in/on a carrier of the mine drilling machine, and the inner guide being movable in its lengthwise direction in the outer support arrangement.

[0008] Thereby an arrangement increasing the lifetime of the drill rod may be achieved.

[0009] Viewed from a second aspect, there can be provided a mine drilling machine comprising the drilling arrangement described above.

[0010] Viewed from a still further aspect, there can be provided a method for drilling a hole into a rock, comprising a method for drilling a hole into a rock, comprising

- using a hollow, flexible and rotatable drill rod,
- rotating the drill rod by a rotation unit,
- feeding the drill rod into the rock by said rotation unit,

- supporting and guiding a section of the drill rod entering the rotation unit by a guiding element system, said guiding element system comprising

-- an inner guide, arranged to envelop said section of the drill rod,

-- an outer support arrangement arranged to support and guide a first length of the inner guide, the method further comprising

- keeping the first length of the inner guide and said section of the drill rod straight or at least essentially straight.

[0011] Thereby a method increasing the lifetime of the drill rod may be achieved.

[0012] The arrangement and the method are characterised by what is stated in the independent claims. Some other embodiments are characterised by what is stated in the other claims. Inventive embodiments are also disclosed in the specification and drawings of this patent application. The inventive content of the patent application may also be defined in other ways than defined in the following claims. The inventive content may also be formed of several separate inventions, especially if the invention is examined in the light of expressed or implicit sub-tasks or in view of obtained benefits or benefit groups. Some of the definitions contained in the following claims may then be unnecessary in view of the separate inventive ideas. Features of the different embodiments of the invention may, within the scope of the basic inventive idea, be applied to other embodiments.

[0013] In one embodiment, the inner guide is flexible or comprises a flexible section. An advantage is that the drill rod may adapt easily to movements of the feed unit.

[0014] In one embodiment, the outer support arrangement comprises a straight or at least essentially straight outer tube, arranged to keep the section of the drill rod straight or at least essentially straight. An advantage is that the inner guide is well protected in the tube.

[0015] In one embodiment, the outer support arrangement is attached unmovably to the carrier part of the mine drilling machine. An advantage is that a stable attachment of the support arrangement may be achieved.

[0016] In one embodiment, the outer support arrangement is arranged at least partly inside the carrier part. An advantage is that the support arrangement is well protected.

[0017] In one embodiment, all the length of the outer support arrangement is arranged in the carrier part. An advantage is that the support arrangement is even better protected.

[0018] In one embodiment, the outer support arrangement is adapted to keep said first length of the inner guide and the section of the drill rod therein straight or at least essentially straight, such that radius of bending of the drill rod in the outer support arrangement is not less than three times of the bending radius of the drill rod. An ad-

vantage is that stresses of moving and rotating drill rod may be minimized.

[0019] In one embodiment, the arrangement comprises a flushing medium hose connected to the drill rod by a flushing medium connector and arranged for providing flushing medium in the drill rod, the connector enabling the flushing medium hose remaining unrotating while the drill rod is rotating. An advantage is that stresses of the flushing medium hose may be minimized.

[0020] In one embodiment, the flushing medium connector is dimensioned to fit and move to and fro in the inner guide. An advantage is that the connector is well protected and supported in the inner guide.

[0021] In one embodiment, the connector comprises an opening for delivering flushing medium between the inner guide and the drill rod. An advantage is that the flushing medium may reduce friction between the inner guide and the drill rod, and thus their wearing may be decreased.

[0022] In one embodiment, the method comprises providing flushing medium in the drill rod in a rear end thereof by using a flushing medium hose, and allowing the flushing medium hose moving in the inner guide. An advantage is that the flushing medium hose may allow the drill rod move very freely in its axial direction.

[0023] In one embodiment, the method comprises drilling the hole in a continuous way. An advantage is that drilling especially in low profile (LP) and extra low profile (XLP) mines may be realized effectively.

BRIEF DESCRIPTION OF FIGURES

[0024] Some embodiments illustrating the present disclosure are described in more detail in the attached drawings, in which

Figure 1a is a schematic side view of a drilling machine and method in partial cross-section,

Figure 1b is a schematic top view of the drilling machine shown in Figure 1a in partial cross-section,

Figure 2a is a schematic side view of a detail of an arrangement in partial cross-section,

Figure 2b is a schematic crosscut view of the detail shown in Figure 2a,

Figure 3 is a schematic view of a flexible drill rod, and

Figure 4 illustrates a method for drilling a hole.

[0025] In the figures, some embodiments are shown simplified for the sake of clarity. Similar parts are marked with the same reference numbers in the figures.

DETAILED DESCRIPTION

[0026] Figure 1a is a schematic side view of a mine drilling machine and method in partial cross-section, and Figure 1b is a schematic top view of the drilling machine shown in Figure 1a in partial cross-section. This particular type of a mine drilling machine 15 is especially suitable for tunnels and other drilling spaces of limited height, such as low profile mines.

[0027] The mine drilling machine 15 is equipped with at least one drilling arrangement 100. In Figure 1a, the drilling machine 15 is shown in a mine M comprising floor F and roof R. The drilling arrangement 100 is shown in about to drill a hole on the roof R. However, it is to be noted that the drilling arrangement 100 may also be used for drilling the floor F or walls of the mine M. The height of the mine M is very low, such that the mine M may be called as low profile or extra low profile mine. Therefore, a flexible drill rod 2 is used in the arrangement 100. The flexible drill rod 2 is hollow and rotatable drill rod, the details of which will be described later in this description. In the front end of the drill rod 2 there is arranged a drill bit 3.

[0028] It is to be noted that the mine drilling machine 15 may comprise not only drilling arrangement(s) 100 described in this description, but also other type of mining equipment.

[0029] The drilling arrangement 100 further comprises a feed unit 1 for feeding and rotating said drill rod 2, and a feed beam 4 arranged to support the feed unit 1. In the feed beam 4 there may be a rod holder 23 arranged at the front end of the feed beam for supporting the drill rod or drill bit at the close proximity of the rock.

[0030] The feed beam 4 and the feed unit 1 attached therein are connected to a carrier part 10 of the drilling machine 15 by a boom 14. The position of the feed beam 4 and the feed unit 1 in relation to the carrier part 10 may be changed by movements of the boom 14.

[0031] In an embodiment, the feed unit 1 comprises a rotation chuck (not shown) that may grip tightly to the drill rod 2 when the feed unit 1 starts rotating and pushing the drill rod 2 into the hole, such that the torque and the thrust are transmitted to the drill rod 2 and further to the drill bit 3.

[0032] A guiding element system 5 is arranged to support a section of the drill rod 2 entering the rotation unit 1.

[0033] The guiding element system 5 comprises an inner guide 6, arranged to envelop said section of the drill rod 2, and an outer support arrangement 9 arranged to support and guide a first length of the inner guide 6.

[0034] In an embodiment, the outer support arrangement 9 comprises a sleeve or tube, the inner profile being e.g. round. The sleeve or tube may have an essentially rigid structure. In another embodiment, the outer support arrangement 9 comprises a series of discrete guiding elements, such as guiding rings or guiding rolls.

In an embodiment, the inner guide 6 is a tube, the inner profile of which is round. The inner guide 6 is able to

move in its lengthwise direction in the outer support arrangement 9. Furthermore, the inner guide 6 is flexible on all its length, or comprises at least one flexible section 11. Thus the inner guide 6 may adapt to the movements of the feed beam 4 and the feed unit 1.

[0035] In an embodiment, there is a stiff guiding element 13 in which the inner guide 6 is attached. The guiding element 13 is arranged to guide the drill rod 2 in the feed unit 1.

[0036] According to an idea, an auxiliary support element 18 may be arranged to support a section of the inner guide 6 being out of the outer support arrangement. The auxiliary support element 18 may be attached flexible way to e.g. the boom 4 by a wire, a chain etc.

[0037] In an embodiment, such as shown in Figures 1a, 1b, the outer support arrangement 9 is attached unmovably to the carrier part 10 of the mine drilling machine. However, in another embodiment, the outer support arrangement 9 is attached flexible in the carrier part, having thus some ability to adapt in movements of the drill rod 2.

[0038] In an embodiment, the outer support arrangement 9 is arranged at least partly inside the carrier part 10. In the embodiment shown in Figures 1a, 1b, all the length of the outer support arrangement (9) is arranged in the carrier part 10.

[0039] In another embodiment, the outer support arrangement 9 is attached at least partly outside of the carrier part 10, such as on at least one side or on top of the carrier part 10.

[0040] The outer support arrangement 9 comprises a straight or at least essentially straight outer tube 12, arranged to keep the section of the drill rod 2 being in the in the straight or at least essentially straight. According to an aspect, the term "straight or at least essentially straight" means that the outer support arrangement 9 keeps the first length of the inner guide 6 and the section of the drill rod 2 such that radius of bending of the drill rod 2 inside the outer support arrangement 9 is not less than three times of the bending radius of the drill rod 2.

[0041] In an embodiment, the term "straight or at least essentially straight" means that the drill rod 2 inside the outer support arrangement 9 is bending not less than four times of the bending radius of the drill rod 2.

[0042] In an embodiment, means that one can see through the "straight or at least essentially straight" outer support arrangement 9, from one end to another end thereof. For instance, the outer support arrangement 9 may be a tube or sleeve, the length of which is approximately length of the carrier part 10, and straight inasmuch that it can be seen through thereof.

[0043] The arrangement 100 may comprise guiding means, such guiding rolls 16, that supports the inner guide 6 at the end of the outer support arrangement 9 and facilitates the inner guide to enter and exit the outer support arrangement 9. In the embodiment shown in Figures 1a, 1b, the guiding rolls 16 are arranged at the front end of the outer support arrangement 9. In another embodiment, the guiding means are arranged in opposite

back end, or at both ends of the outer support arrangement 9.

[0044] The arrangement 100 further comprises a flushing medium hose 8 that is connected to the drill rod 2 and arranged for providing flushing medium in the drill rod 2.

[0045] In an embodiment, the flushing medium is liquid, such as water. In another embodiment, the flushing medium is gas or gas mixture, such as air. In still another embodiment, the flushing medium is a mixture of liquid and gas, such as water and air.

[0046] The flushing medium hose 8 has a bendable structure.

[0047] A flushing medium connector 7 (shown in Figure 2a) connects the flushing medium hose 8 to the drill rod 2. The connector allows flushing medium to flow from the flushing medium hose 8 to the drill rod 2, and enables the flushing medium hose 8 to remain unrotating while the drill rod 2 is rotating, typically at 1000 - 2000 rounds per minute.

[0048] In an embodiment, the length of the outer support arrangement 9 is dimensioned in relation to the drill rod 2 such that when the drill bit 3 is just out of a rock hole, or lies in the front holder 23, the flushing medium connector 7 is still inside the inner guide 6. In another embodiment, the flushing medium connector 7 is outside of the inner guide 6 in afore-mentioned situation.

[0049] In an embodiment, the outer support arrangement comprises at least one turn or bend in order arrange more length in the carrier. One embodiment of this kind of solution is shown by dashed line and reference number 9'. This kind of embodiments may keep a very long drill rod 2 inside and supported by the outer support arrangement. In said at least one turn or bend the radius of bending of the drill rod 2 may be smaller than "straight or at least essentially straight" as defined above.

[0050] Figure 2a is a schematic side view of a detail of an arrangement in partial cross-section, and Figure 2b is a schematic crosscut view of the detail shown in Figure 2a.

[0051] The drill rod 2 comprises a channel 22 through which flushing medium is fed forward.

[0052] The drill rod 2 is arranged inside the inner guide 6 mentioned above. The inner guide 6 is tube having at least some flexibility. The material of the inner guide 6 may be e.g. polymer, polymer composition etc.

[0053] The inner guide 6, in turn, is arranged in the outer support arrangement 9. In the shown embodiment, the outer support arrangement 9 is a tube that may be manufactured from a metal, polymer, polymer composition etc.

The inner guide 6 can move, i.e. slide in relation to the outer support arrangement 9 in axial direction thereof. Furthermore, the drill rod 2 can slide in relation to the inner guide 6 in axial direction thereof.

[0054] The inner guide 6 supports the drill rod 2 during its movements and rotation. This reduces unnecessary vibrations of the drill rod. By choosing suitably the inner diameter of the inner guide 6 in respect to the outer di-

ameter of the drill rod 2, said vibrations may be minimized.

[0055] As mentioned above, the arrangement comprises a flushing medium connector 7 connecting the flushing medium hose 8 to the drill rod 2. The flushing medium connector 7 may be dimensioned so that it fits inside the inner guide 6, and moves therein to and fro together with the drill rod 2.

[0056] In an embodiment, the connector 7 comprises at least one opening 17 extending from a flushing medium channel (not shown) inside the connector to outside thereof. The opening 17 allow a part of flushing medium to be delivered between the inner guide 6 and the drill rod 2. Flushing medium reduces friction between the inner guide 6 and the drill rod 2 that may rotate at quite high speed, and thus facilitates their mutual movements.

[0057] Figure 3 is a schematic view of a flexible drill rod. The drill rod 2 may comprise a tube 19 and at least one corrugated cut 20 extending through the wall of the tube 19 in a transverse direction thereof, in other words in a direction transverse to the longitudinal axis D of the drill rod 2. The corrugated cut 20 extends at each point substantially radially through the tube wall from the outside of the tube to the inside of the tube.

[0058] In an embodiment, each corrugated cut 20 have a substantially spiral baseline 21 extending in a circulating manner around the tube 19 in the direction of longitudinal axis D from the direction of a first end of the drill rod to a direction of a second end of the drill rod.

[0059] Each corrugated cut 20 may be arranged to deviate from its baseline 21 on both sides of the baseline 21 forming a cut of a substantially corrugated shape. The baseline 21 is not a physical part of the corrugated cut 20, but a virtual line on both sides of which the corrugated cut extends at each portion of the drill rod 2.

[0060] The corrugated cut 20 may comprise curved portions of one or several radiuses. The corrugated cut 20 may also comprise straight portions connecting the curved portions. In different embodiments, the straight portions may be substantially parallel to the direction of the baseline 21, substantially perpendicular to the direction of the baseline 21 and/or arranged at an angle with respect to the baseline 21. This corrugated cut 20 may then spiral along the tube 19. In other words, the corrugated cut 20 may circulate around the drill rod 2, more particularly around the longitudinal axis D of the drill rod 2.

[0061] According to an embodiment, the shape of the corrugated cut 20 is of a teardrop-like shape.

[0062] By providing such a corrugated cut 20 on a rigid drill rod 2, the drill rod 2 may be made at the same time flexible, such that bending of the drill rod 2 is enabled in a transverse direction of the drill rod 2, and rigid, such that transmitting torque and thrust needed for drilling is enabled.

[0063] In an embodiment, the bending radius of the tube 19 is less than 1 meter, and preferably under 0.5 meter. This enables bending the drill rod 2 also at low drilling spaces and achieving an optimal amount of un-

interrupted drilling at any circumstances using as much of the available drilling height as possible.

[0064] The corrugated cut 20 may be formed by laser cutting and/or high pressure water jet cutting.

[0065] The corrugated cut 20, even though very narrow, causes unconformity and discontinuity on the outer surface of the drill rod 2. As a consequence, it may occur that the drill rod 2 slightly sticks or freezes in the feed unit or in the guiding element(s). In other words, moving or sliding of the drill rod 2 through the feed unit or the guiding element(s) is not smooth, which has a negative effect to the drilling process. Additionally, the drill rod or the feed unit or the guiding element may be damaged or even broken due to said sticking or freezing. The auxiliary feed unit 2 eliminates or at least decreases this problem by pushing the corrugated cut 20 as narrow as possible and thus levelling out the outer surface of the drill rod 2.

[0066] Figure 4 illustrates a method for drilling a hole. The method comprises using 501 a hollow, flexible and rotatable drill rod, rotating 502 the drill rod 2 by a rotation unit, feeding 503 the drill rod into the rock by said rotation unit, 504 supporting and guiding a section of the drill rod 2 entering the rotation unit 1 by a guiding element system 5, said guiding element system 5 comprising an inner guide 6, arranged to envelop said section of the drill rod 2, and an outer support arrangement 9 arranged to support and guide a first length of the inner guide 6, and 505 keeping the first length of the inner guide 6 and said section of the drill rod 2 straight or at least essentially straight.

[0067] In an embodiment of the method, flushing medium is provided in the drill rod 2 in a rear end thereof by using a flushing medium hose 8, and allowing the flushing medium hose 8 moving in the inner guide 6.

[0068] In an embodiment of the method, the hole is drilled in a continuous way.

[0069] The invention is not limited solely to the embodiments described above, but instead many variations are possible within the scope of the inventive concept defined by the claims below. Within the scope of the inventive concept the attributes of different embodiments and applications can be used in conjunction with or replace the attributes of another embodiment or application.

[0070] The drawings and the related description are only intended to illustrate the idea of the invention. The invention may vary in detail within the scope of the inventive idea defined in the following claims.

REFERENCE SYMBOLS

[0071]

- | | |
|---|---------------------------|
| 1 | feed unit |
| 2 | drill rod |
| 3 | drill bit |
| 4 | feed beam |
| 5 | guiding element system |
| 6 | inner guide |
| 7 | flushing medium connector |

8 flushing medium hose
 9 outer support arrangement
 10 carrier part
 11 flexible section
 12 outer tube
 13 guiding element
 14 boom
 15 mine drilling machine
 16 guiding rolls
 17 opening
 18 auxiliary support element
 19 tube
 20 corrugated cut
 21 spiral baseline
 22 channel
 23 rod holder

100 arrangement

501- 504 method steps

F floor
 K rock
 M mine
 R roof

Claims

1. A drilling arrangement (100) for a mine drilling machine, comprising

- a hollow, flexible and rotatable drill rod (2),
- a feed unit (1) for feeding and rotating said drill rod (2),
- a feed beam (4) arranged to support the feed unit (1),
- a guiding element system (5) arranged to support a section of the drill rod (2) entering the rotation unit (1), the guiding element system (5) comprising

- an inner guide (6), arranged to envelop said section of the drill rod (2),
- an outer support arrangement (9) arranged to support and guide a first length of the inner guide (6) in/on a carrier (10) of the mine drilling machine, and
- the inner guide (6) being movable in its lengthwise direction in the outer support arrangement (9).

2. The arrangement as claimed in claim 1, wherein the inner guide (6) is flexible or comprises a flexible section (11).

3. The arrangement as claimed in any of the preceding claims, wherein the outer support arrangement (9)

comprises a straight or at least essentially straight outer tube (12), arranged to keep the section of the drill rod (2) straight or at least essentially straight.

4. The arrangement as claimed in any of the preceding claims, wherein the outer support arrangement (9) is attached unmovably to the carrier part (10) of the mine drilling machine.

5. The arrangement as claimed in any of the preceding claims, wherein the outer support arrangement (9) is arranged at least partly inside the carrier part (10).

6. The arrangement as claimed in any of the preceding claims, wherein all the length of the outer support arrangement (9) is arranged in the carrier part (10).

7. The arrangement as claimed in any of the preceding claims, wherein the outer support arrangement (9) is adapted to keep said first length of the inner guide (6) and the section of the drill rod (2) therein straight or at least essentially straight, such that radius of bending of the drill rod in the outer support arrangement (9) is not less than three times of the bending radius of the drill rod (2).

8. The arrangement as claimed in any of the preceding claims, comprising a flushing medium hose (8) connected to the drill rod (2) and arranged for providing flushing medium in the drill rod (2).

9. The arrangement as claimed in claim 8, comprising a flushing medium connector (7) connecting said flushing medium hose (8) to the drill rod (2), the connector enabling the flushing medium hose (8) remaining unrotating while the drill rod (2) is rotating.

10. The arrangement as claimed in claim 8, wherein the flushing medium connector (7) is dimensioned to fit and move to and fro in the inner guide (6).

11. The arrangement as claimed in claim 7 or 8, wherein the connector comprises an opening (17) for delivering flushing medium between the inner guide (6) and the drill rod (2).

12. A mine drilling machine comprising a drilling arrangement (100) according any one of the preceding claims.

13. A method for drilling a hole into a rock, comprising

- using a hollow, flexible and rotatable drill rod (2),
- rotating the drill rod (2) by a rotation unit (1),
- feeding the drill rod (2) into the rock by said rotation unit (1),
- supporting and guiding a section of the drill rod (2) entering the rotation unit (1) by a guiding el-

ement system (5), said guiding element system (5) comprising

- an inner guide (6), arranged to envelop said section of the drill rod (2), 5
- an outer support arrangement (9) arranged to support and guide a first length of the inner guide (6), the method further comprising 10

- keeping the first length of the inner guide (6) and said section of the drill rod (2) straight or at least essentially straight.

14. The method as claimed in claim 13, comprising 15

- providing flushing medium in the drill rod (2) in a rear end thereof by using a flushing medium hose (8), and
- allowing the flushing medium hose (8) moving 20 in the inner guide (6).

15. The method as claimed in any one of claims 13 - 14, comprising 25

- drilling the hole in a continuous way.

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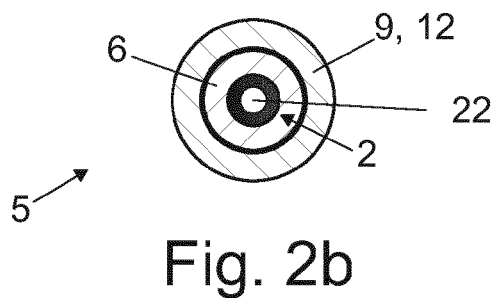
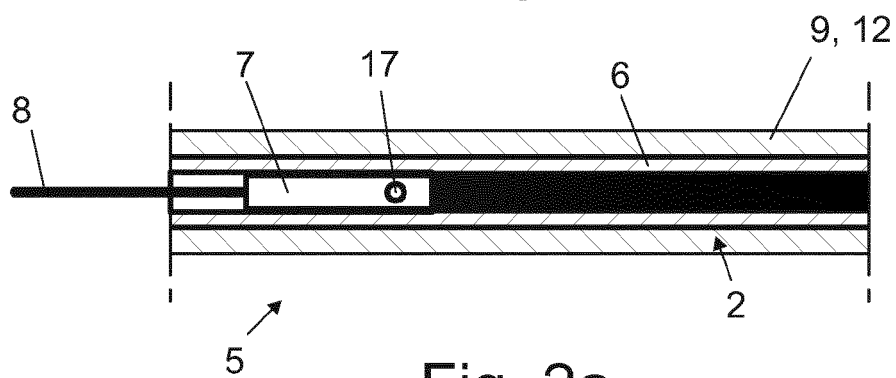
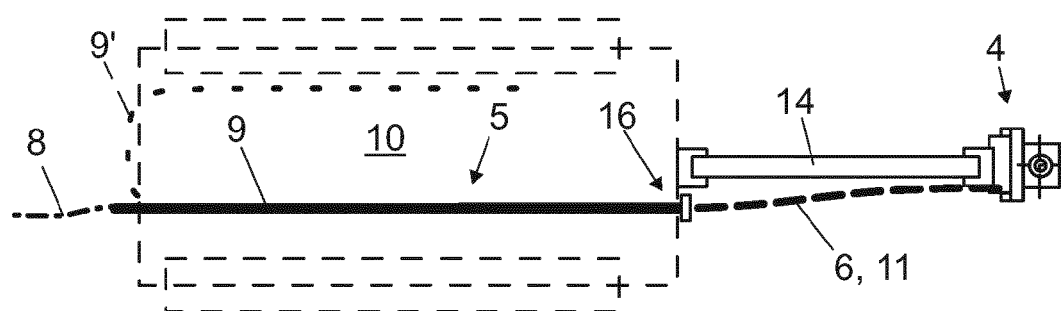
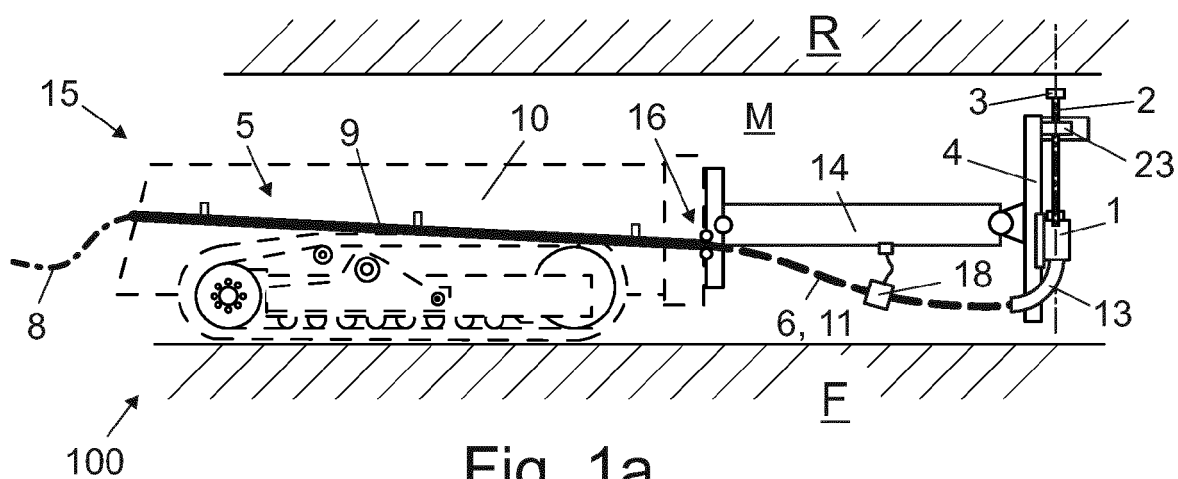
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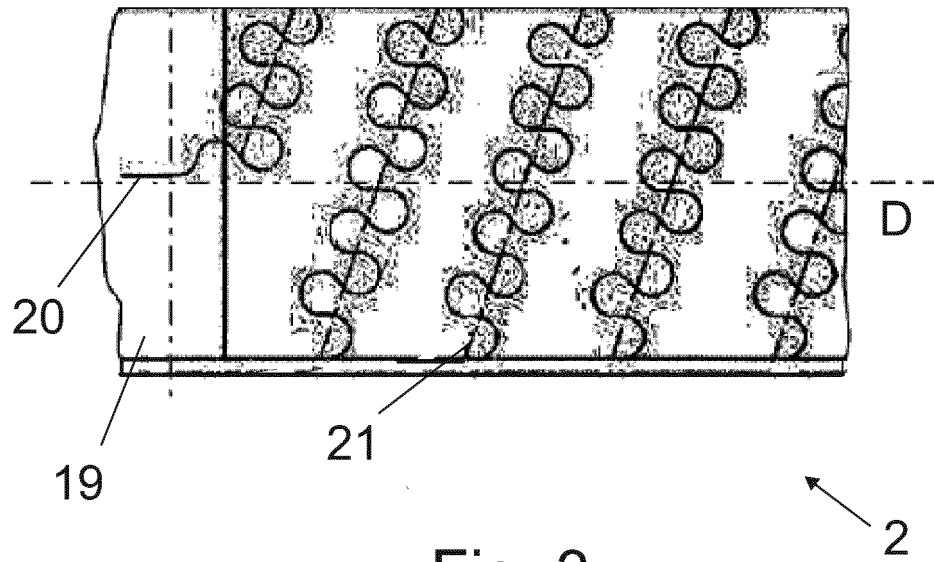


Fig. 3

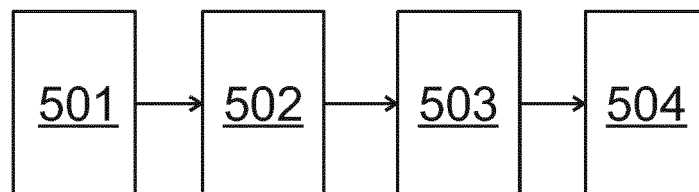


Fig. 4



EUROPEAN SEARCH REPORT

 Application Number
 EP 19 15 6382

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EPO FORM 1503 03.82 (P04C01)

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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