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(54) **Flexible drill rod**

(57) A drill rod (10) for a drilling rig (1) comprises a tube (19) comprising at least one corrugated cut (20) extending through a wall of the tube (19) in a transverse (G) direction. Each corrugated cut (20) has a substantially spiral baseline (21) and is arranged to deviate from its baseline on both sides of the baseline forming a cut

of a substantially corrugated shape spiralling along the tube (19). Such tube (19) is flexible enabling bending in a transverse direction (G) of the drill rod (10) and rigid to enable transmitting torque and thrust in a lengthwise (E), transverse (G) and rotational (H) direction of the drill rod (10) when rotated for drilling.

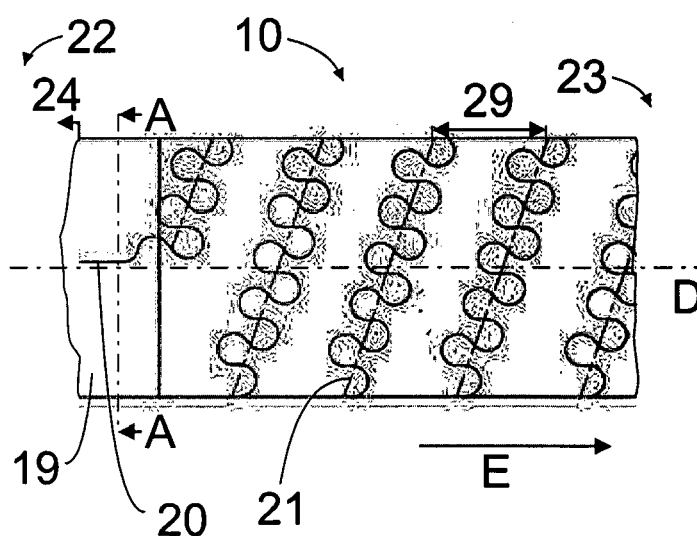


FIG. 2a

Description

BACKGROUND

[0001] The invention relates to drilling, and more particularly to a drill rod for drilling, to a drilling machine and a method for drilling.

[0002] Holes can be drilled in rock by means of various rock drilling machines. Drilling may be performed with a method combining percussions and rotation (percussive drilling), or drilling may be based on mere rotation without a percussive function (rotary drilling). Further, percussive drilling may be classified according to whether the percussion device is outside the drill hole or in the drill hole during the drilling. When the percussion device is outside the drill hole, the drilling is usually called top hammer drilling, wherein so-called top hammers are used, and when the percussion device is in the drill hole, the drilling is typically called down-the-hole drilling (DTH) and the drilling machine may be called a DTH drill or down-the-hole drill, for example.

[0003] Both these drill types may comprise one or more drill rods, which may also be called drilling tubes, to guide a drill bit to the hole and to supply at least the rotation provided by a rotation unit to the drill bit. Especially in tunnels of very low height, such as low profile and extra low profile mines, the height of the tunnel typically limits the length of the drill rods. This causes problems especially when the hole to be drilled is deeper than the height of the tunnel, which is often the case especially in these low profile and extra low profile mines.

[0004] Some applications are known, where this problem has been attended by using manual extension rods, that is several drill rods, or similar, that are joined or coupled together one at a time. In some applications, these types of elements may be arranged around a hose. However, a problem with these solutions is that they slow down the process considerably, as the drilling work has to be stopped to add a new element. The manual work to be done by an operator, which is typically needed in these applications, causes many kinds of problems, including occupational safety hazards, especially when working in tunnels of low and extra low profile mines, for example.

BRIEF DESCRIPTION

[0005] The object of the invention is to provide a new and improved drill rod, drilling machine and method for drilling a hole. The object of the invention is achieved by an apparatus, arrangement and method that are characterised by what is defined in the independent claims. Some preferred embodiments of the invention are disclosed in the dependent claims.

[0006] The invention is based on the idea of providing through the drill rod surface at least one corrugated cut extending around the drill rod in a spiral-like manner from the direction of a first drill rod end towards a second drill

rod end, that is an opposite end to the first drill rod end. With such cut(s) sufficient flexibility can be provided in a drill rod made of steel or other rigid material to enable bending the drill rod in a direction transverse to the direction of the longitudinal axis of the drill rod.

[0007] An advantage of the solution is that as the drill rod is formed to be flexible and rigid at the same time, a continuous drill rod, in other words a drill rod formed substantially as a single piece, can be provided that enables both substantially continuous drilling without manual work phases by an operator joining or coupling extension rod and drilling of holes considerably deeper than the height of the tunnel and in practice of any depth up to the drill rod length or even beyond by connecting several such drill rods to one another. Additionally, forming the drill rod of a single, unitary piece, the height of a tunnel or other drilling space may always be fully utilised to achieve an optimal sequence of uninterrupted drilling. It is also very well suited for percussive drilling, as the structure enables effective transmitting of sufficient feed force in the form of torque and thrust. In addition, such a flexible drill rod provides many possibilities for storing the drill rod, for instance in straight, bent or coiled formation, and, thus, it is easier to deliver the drill rod to the place of drilling and to store in the drilling machine and maintain while not in use.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] In the following the invention will be described in greater detail by means of preferred embodiments with reference to the attached [accompanying] drawings, in which

Figure 1 shows a drilling unit;
 Figures 2a and 2b illustrate a part of a drill rod according to current solution;
 Figure 3 illustrates a shape of a corrugated cut;
 Figure 4 shows a rock drilling rig;
 Figure 5a and 5b illustrate a drill rod arranged in a guiding tube;
 Figure 6 illustrates a method for drilling a hole using a drill rod;
 Figure 7 illustrates another embodiment of a method for drilling a hole using a drill rod; and
 Figure 8 shows further a rock drilling rig.

DETAILED DESCRIPTION

[0009] Figure 1 shows a drilling unit 4 comprising drilling equipment 9 provided with a percussion device 13. A rotation unit 7 may be supported to a carriage 8, or alternatively the rotation unit may comprise sliding parts or the like support members with which it is movably supported to the feed beam 5. The rotation unit 7 may be provided with drilling equipment 9 which may comprise one drill rod (or drilling tube) 10, or several drill rods / drilling tubes 10 connected to each other, and a drill bit

11 at the outermost end of the drilling equipment. The percussion device 13 is provided at an opposite end of the drilling equipment 9 and, thus, the drill rod 10 in relation to the rotation unit 7. During the drilling, the down-the-hole drill 13 is in the drill hole and the drill bit 11 may be connected directly to the down-the-hole drill 13. When the drill hole 12 has been drilled to a desired depth, the drilling equipment 9 can be pulled by means of the feed device 6 out of the drill hole 12 in return direction C.

[0010] Figures 1 is shown as an example of a drilling unit, wherein drill rods are used for drilling a hole, and the current solution is by no means limited to that particular embodiment. Instead, the drill rod described in this description, as well as a drilling machine comprising such a drill rod and a method for drilling holes using such a drill rod, are applicable to substantially all types of drilling wherein conventional drill rods have been used. The current solution is especially well suited for drilling in circumstances, where space is somehow limited, like in tunnels for limited height, such as in low profile mines comprising a height in the range of 1.6 to 2.2 m, for example, or in extra low profile mines comprising a height of 0.6 to 1.1 m, for example, or in drilling rigs of limited size and so on. Some embodiments in this description are explained in connection with a tunnel due to these special benefits related to tunnels, such as underground tunnels, but it is clear for a skilled person that these embodiments are suitable for other drilling circumstances as well, such as drilling in open mines. Similarly, at least some of the embodiments may be suitable for other types of drilling in addition to rock drilling.

[0011] A drill rod 10 according to the current solution is thus suitable for use in different types of drilling rigs. It is especially suitable for drilling, where the drill rod 10 is rotated, in other word the drill rod 10 is rotatably connectable to a drilling rig 1. Figures 2a and 2b illustrate a part of one example of such a drill rod 10. Figure 2a shows a detail of the drill rod 10 from a side and Figure 2b in a direction of the cut A-A shown in Figure 2a. The drill rod 10 comprises a tube 19 and at least one corrugated cut 20 extending through the wall of the tube 19 in a transverse direction G, in other words in a direction transverse to the longitudinal axis D of the drill tube 19 extending at each point substantially radially through the tube wall from the outside of the tube to the inside of the tube. In Figure 2b two examples of this transverse direction G are shown, but, naturally, the transverse direction varies at different points of the tube 19 wall and surface.

[0012] Each corrugated cut 20 has a substantially spiral baseline 21 extending in a circulating manner around the tube 19 in the lengthwise direction E of the tube 19 from the direction of a first end 22 of the drill rod to a direction of a second end 23 of the drill rod. The lengthwise direction is, thus, a direction of the longitudinal axis D of the drill rod or a direction substantially parallel to the longitudinal axis D of the drill rod. The actual ends 22 and 23 are not shown in Figure 2a, as it only shows a section of the drill rod 10 and the tube 19 the drill rod

comprises. The baseline 21 is explained in more detail in connection with Figure 3, but the baseline 21 is not a physical part of the cut, but provides a spiral-like path on both sides of which the corrugated cut 20 extend in a corrugated manner. This, too, is explained in more detail in connection with Figure 3.

[0013] According to an embodiment, the drill rod 10 may comprise one such corrugated cut 20 extending in the lengthwise direction E substantially from a vicinity of a first end 22 of the drill rod to a vicinity of a second end 23 of the drill rod 10, which second end 23 is an opposite end to the first end 22. According to another embodiment, the drill rod 10 may comprise two or more of such corrugated cuts 20. These corrugated cuts 20 may be arranged subsequently, in other words one after another, in the lengthwise direction E of the drill rod 10 and/or they may be arranged at least partly parallel to one another. Embodiments where the corrugated cut(s) 20 extend substantially continuously along substantially the whole length of the drill rod 10 and, thus, the tube 19 provide the additional benefit that the drill rod may be formed to be very flexible such that it can be easily arranged, for instance, in a coiled formation during storage and/or use for the part that is not currently used for drilling.

[0014] According to an embodiment, an uncut portion 24 of a drill rod 10 may be left between two corrugated cuts 20 arranged subsequently. According to a further embodiment, an uncut portion 24 may be, in addition or instead of an uncut portion 24 between two subsequent corrugated cuts 20, provided at one or both ends 22, 23 of the drill rod 10. These alternatives may be beneficial considering the machining of the drill rod 10, for example, and they may provide sufficient flexibility for certain applications. Naturally, the length of such an uncut portion 24 should not exceed the height of the tunnel, where the drill rod is to be used.

[0015] According to an embodiment, the tube 19 comprises steel material. Preferably, the steel material comprises stainless steel. According to an embodiment, the tube 19 is formed as a single, unitary piece. Thus, the drill rod 10 may also be formed as a substantially single, unitary piece. This makes the structure of the tube 19 and the drill rod 10 simple to manufacture, store and transport and no connection elements, such as connector objects or threads, are needed. The absence of connection elements also means that such means are not lost, worn down or damaged during transportation, storing and use. Naturally, such connections also do not need to be tightened.

[0016] According to another embodiment, the tube length is at least 2.5 meters, and more preferably at least 3 meters long. The length of the tube 19 and, thus, the drill rod 10 is measured in the lengthwise direction E of the drill rod 10. With a single, unitary piece, such as a metal tube 19, of a length of at least 2.5 meters, on which the corrugated cut 20 is provided, a drill rod 10 may be achieved that may be used to drill holes 12 deeper than the height of the tunnel or other drilling environment also

in low profile and extra low profile mines, as the bendable drill rod may be used in environments lower than the length of the drill rod 10, the drill rod 10 may be stored in a very compact manner and the tube 19 of the drill rod 10 is rigid enough to transmit torque, at least in a substantially rotational direction H of the drill rod 10, and thrust, at least in a substantially lengthwise E direction of the drill rod 10, needed for drilling. While in use and under the torque and thrust, such a tube 19 is also rigid enough in a transverse direction G of the drill rod 10 to transmit the torque and thrust. With rotational direction H of the drill a direction directed around the longitudinal axis D of the drill rod, or in other words around a lengthwise direction E of the drill rod, is meant. By using a single, unitary piece to form the tube 19 and/or the drill rod 10, also the bending and rigidity properties are more evenly distributed over the length of the drill rod 10 that in solutions where several shorter, stiff drill rods are joined or coupled together to provide the length needed for drilling the hole.

[0017] Figure 3 illustrates an example of a shape of such a corrugated cut 20. Each corrugated cut 20 may, thus, 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 10. The corrugated cut 20 may comprise curved portions of one or several radii. 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 10, more particularly around the longitudinal axis D of the drill rod 10 and, thus, the tube 19, and extending through the wall of the tube 19 in a spiral-like manner and extending from the direction of a first end 22 of the drill rod towards a second end 23 of the drill rod that is opposite to the first end 22 of the drill rod in the lengthwise direction E of the drill rod. By providing such a corrugated cut 20 on a rigid drill rod 10, the drill rod 10 may be made at the same time flexible, such that bending of the drill rod 10 is enabled in a transverse direction of the drill rod 10, and rigid, such that transmitting torque and thrust needed for drilling is enabled. The bending radius of the tube 19 is preferable less than 1 m, and more preferably under 0,5 m. This enables bending the drill rod 10 also at low drilling spaces and achieving an optimal amount of uninterrupted drilling at any circumstances using as much of the available drilling height as possible. It also enables storing the drill rod 10 in a compact space when it or part of it is not in use, in a bent or coiled formation, for example.

[0018] According to an embodiment, the shape of the

corrugated cut 20 is of a teardrop-like shape. With teardrop-like shape a shape is meant, wherein the end 25 of each corrugation, in other words the widest part of a continuous teardrop-like shape defined by the corrugated cut 20, is wider in the direction of the baseline 21 than width of the base 26 formed by the shortest distance between two adjacent corrugations. At the same time, the base 26 is also the narrowest part of the continuous teardrop-like shape defined by the corrugated cut on the opposite side of the baseline 21 compared to the side of the baseline where the end 25 of the corrugation, that is the widest part, is formed.

[0019] According to an embodiment, a first distance 27 between two adjacent corrugations in the direction of the baseline 21 and measured from the corresponding point of each corrugation is in the range of 1 to 10 mm. According to another embodiment, the width of the end 25 of each corrugation and/or the base 26 of each corrugation is in the range of 1 to 10 mm. According to a further embodiment, a second distance between the base line 21 and the widest part of the teardrop-like shape, in other words the end 25 of the corrugation, in a direction perpendicular to the direction of the baseline 21 is in the range of 1 to 10 mm. This helps to achieve a drill rod 10 flexible enough to enable bending it in a transverse direction G of the drill rod and at the same time rigid enough to enable transmitting torque and thrust needed for drilling while using the drill rod.

[0020] According to an embodiment, a third distance 29 between two adjacent turns, in other words the pitch between the turns, of the baseline 21 in the lengthwise direction E of the tube is smaller than or substantially equal to 50 mm. The third distance 29 should preferably be substantially equal to or greater than the sum of the height of the corrugation, in other words the greatest distance between the points of one corrugation in the direction perpendicular to the baseline 21, and the thickness of the tube 19 wall. This helps to achieve a drill rod 10 that is flexible enough to enable bending it in a transverse direction of the drill rod and at the same time rigid enough to enable transmitting torque and thrust needed for drilling.

[0021] According to an embodiment, the corrugated cut may be formed by laser cutting and/or high pressure water jet cutting.

[0022] Figure 4 shows a rock drilling rig 1 that may comprise a movable carrier 2 provided with a drilling boom 3. This particular type of a rock drilling rig 1 is especially suitable for tunnels and other drilling spaces of limited height, such as low profile mines. Similarly, the rock drilling rig of Figure 8 may comprise similar parts and features, but due to the different structure it may be especially well suited for extra low profile mines.

[0023] The boom 3 is provided with a rock drilling unit 4 comprising a feed beam 5, a feed device 6 and a rotation unit 7. The rotation unit 7 may be supported to a carriage 8, or alternatively the rotation unit may comprise sliding parts or the like support members with which it is movably

supported to the feed beam 5. The rotation unit 7 may be provided with drilling equipment 9 which may comprise one or more drill rods (or drilling tubes) 10 connected to each other, and a drill bit 11 at the outermost end of the drilling equipment. The rotation unit 7 may be arranged to slide on the feed device 6 by a feed cylinder 32. The rotation unit 7 may comprise a rotation chuck 33 that may grip tightly to the drill rod 10 when the rotating unit 7 starts rotating and the feed device 6 starts pushing the drill rod into the hole 12, such that the torque and the thrust are transmitted to the drill rod 10 and further to the drill bit 11. The rock drilling rig 1 and/or a drilling unit may further comprise a rod retainer 34 that keeps the drill rod 10 in place when the rotation chuck 33 is returned to the original position and a new drilling sequence is started.

[0024] A drilling rig 1 may comprise several drilling units 4 comprising at least one feed device 6, rotation unit 7 comprising a rotation chuck 33 and/or a down-the-hole drill (DTG drill). The drilling rig 1 may also comprise one or several guiding tubes 30, that may comprise a straight portion, a bent portion and/or a coiled portion or any combination thereof.

[0025] According to an embodiment, a drilling machine 1, such as a drilling unit of Figure 1 or a drilling rig of Figure 4 or Figure 8, may comprise a drill rod 10 described in connection with the drill rod embodiments and corresponding figures or formed as a combination thereof. Such a drilling machine 1 may further comprise a hose 31 for air or water provided inside the drill rod 10 and a fixed guiding tube 30 for holding and guiding the part of the drill rod and the hose that is not currently used for drilling. With the guiding tube 30 being fixed, it is meant that the guiding tube 30 is rigid enough to force the flexible drill rod 10 to bend in transverse direction of the drill rod. The drill rod 10 and the hose 31 are preferably arranged to rotate together, as wear down of the hose 31 can be greatly reduced in this manner.

[0026] According to another embodiment, the fixed guiding tube 30 may be arranged to bend the drill rod 10 at least at one point of the drill rod 10. Figure 5a illustrates a detail of a bent guiding tube 30 and a tube 19 of a drill rod 10 arranged within the guiding tube 30 seen from a side. Figure 5b illustrates a cross-section of a hose 31 arranged inside a tube 19 of the drill rod 10 and a guiding tube 30. According to a further embodiment, the fixed guiding tube 31 may be arranged to hold a part of the drill rod 10 that is not currently at use in a coiled formation.

[0027] According to an embodiment, a drill rod described in connection with the drill rod embodiments and/or Figures 3 and 4 and/or a drilling machine comprising such a drill rod may be used in a method for drilling a hole. According to an embodiment, the method may comprise driving the drill rod by a rotation chuck on a linear zone.

[0028] According to an embodiment, the method may comprise rolling up the drill rod in a guiding tube 30 upstream from the rotation chuck 33. In other words, the guiding tube 30 may comprise a bent portion, inside

which a part of the drill rod 10 that is not currently in use, may be stored in a bent position. According to a further embodiment, the guiding tube 30 may comprise at least a portion of a coiled shape and, thus, at least a portion of the part of the drilling rod 10 not currently in use for drilling the hole 12 may be arranged within the guiding tube 30, thus coiling the drill rod 10 as well. This coiling of the drill rod 10 is enabled by at least one corrugated cut 20 provided on the drill rod 10 as explained in connection with the different embodiments related to the drill rod 10.

[0029] According to an embodiment, the method may comprise translating the drill rod 10 and the rotation chuck up and down by a feed cylinder to rotate the drill rod 10 and to feed it into the hole 12. Thus, a length of the drill rod substantially up to a height of the tunnel may be used at a time without interruptions to drill a hole or, in other words, a portion of the hole 12 that equals substantially in depth to the length of the drill rod 10 used at a time and to the height of the tunnel.

[0030] Figure 6 illustrates one example of a method for drilling a hole using a drill rod described in connection with the drill rod embodiments and/or corresponding figures and/or a drilling machine comprising such a drill rod. A method for drilling holes in drilling spaces of limited height, comprises using 601 at least one drill rod comprising a length that is larger than the height available in the drilling space, bending 602 said at least one drill rod in a transverse direction, and drilling 603 a hole using the drill rod in a substantially upward or downward direction.

[0031] Figure 7 illustrates one embodiment of a method for drilling a hole using a drill rod described in connection with the drill rod embodiments and/or corresponding figures and/or a drilling machine comprising such a drill rod. The method may comprise, in addition to or instead of the steps described in Figure 6, drilling 701 in a step-wise manner a maximum length allowed by a tunnel height or other predefined limit at a time; using 702 a rod retainer 34 to keep the drill rod in place while rotation unit is returned to a feed start position; releasing 703 the rod retainer once the rotation chuck jaws are clamped again at the feed start position to start feeding the drill rod and to continue drilling; and repeating 704 the step-wise drilling until a planned depth of the hole has been reached.

[0032] The solution described in this description is particularly beneficial, when the depth of the hole to be drilled exceeds the height available for mining. However, the solution may be used in other kind of circumstances as well as it may still provide benefits related to storing and transportation, for example.

[0033] All the ranges disclosed in this description also include the upper and lower limit values, where applicable.

[0034] It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and

its embodiments are not limited to the examples described above but may vary within the scope of the claims.

Claims

1. A drill rod for a drilling rig, wherein the drill rod is rotatably connectable to the drilling rig, **characterized by** the drill rod comprising a tube comprising at least one corrugated cut extending through a wall of the tube in a transverse direction, wherein said at least one corrugated cut has a substantially spiral baseline extending in a circulating manner around the tube in the lengthwise direction of the drill rod from the direction of a first end of the drill rod to a direction of a second end of the drill rod and said at least one corrugated cut is arranged to deviate from its baseline on both sides of the baseline forming a cut of a substantially corrugated shape spiralling along the tube, such that at least part of the drill rod is flexible to enable bending in a transverse direction of the drill rod and the drill rod is rigid to enable transmitting torque and thrust needed for drilling.
2. A drill rod according to claim 1, **characterized in that** the tube comprises steel material.
3. A drill rod according to claim 1 or 2, **characterized in that** the corrugated shape is of a teardrop-like shape, wherein the end of each corrugation is wider in the direction of the baseline than width of the base formed by the shortest distance between two adjacent corrugations.
4. A drill rod according to any one of claims 1 to 3, **characterized in that** the distance between two adjacent corrugations in the direction of the baseline and measured from the corresponding point of each corrugation is in the range of 1 to 10 mm.
5. A drill rod according to any one of claims 1 to 4, **characterized in that** the distance between two adjacent turns of the baseline in the lengthwise direction of the tube is smaller or substantially equal to 50 mm.
6. A drill rod according to any one of claims 1 to 5, **characterized in that** each corrugated cut is formed by at least one of the following means: laser cutting and high pressure water jet cutting.
7. A drill rod according to any one of claims 1 to 6, **characterized in that** bending radius of the tube is less than 1 meter and that the length of the tube is at least 2.5 meters.
8. A drill rod according to any one of claims 1 to 7, **characterized in that** said at least one corrugated cut extends from a vicinity of a first end of the drill rod to a vicinity of a second end of the drill rod located at an opposite end of the drill rod compared to the first end.
9. A drill rod according to any one of claims 1 to 8, **characterized in that** the tube is formed as a single, unitary piece.
10. A drilling machine, **characterized by** the drilling machine comprising a drill rod according to one of the claims 1 to 9.
11. A drilling machine according to claim 10, **characterized in that** the drilling machine further comprises a hose for air or water provided inside the drill rod and a fixed guiding tube for holding and guiding the part of the drill rod and hose that is not currently used for drilling.
12. A drilling machine according to claim 10, **characterized in that** the fixed guiding tube is arranged to hold at least a portion of the part of the drill rod that is not currently at use in a coiled formation.
13. A method for drilling a hole in drilling spaces of limited height, comprising using at least one drill rod comprising a length that is larger than the height available in the drilling space, bending said at least one drill rod in a transverse direction, and drilling a hole using the drill rod in a substantially upward or downward direction, wherein a drill rod according to one of the claims 1 to 9 is used for drilling.
14. A method for drilling according to claim 13, **characterized in that** by rolling up the drill rod in a guiding tube upstream from the rotation chuck.
15. A method for drilling according to claim 13 or 14, **characterized by** drilling in a step-wise manner a maximum length allowed by a tunnel height or other predefined limit at a time; using a rod retainer to keep the drill rod in place while rotation unit is returned to a feed start position; releasing the rod retainer once the rotation chuck jaws are clamped again at the feed start position to start feeding the drill rod and to continue drilling; and repeating the step-wise drilling until a planned depth of the hole has been reached.

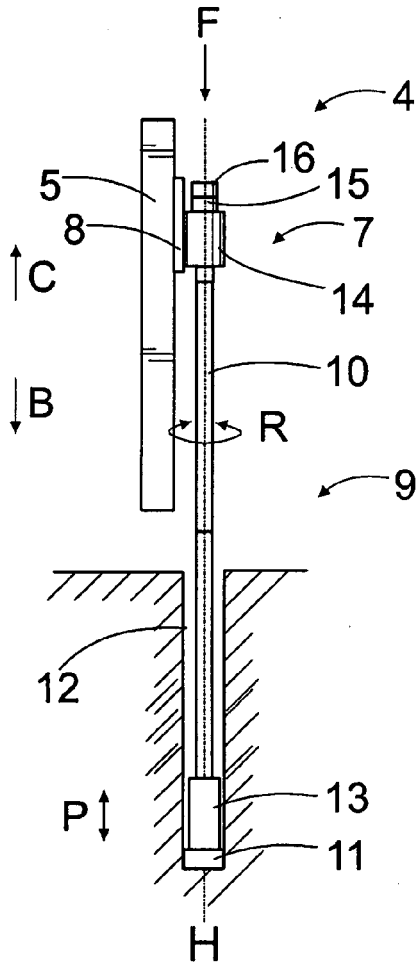


FIG. 1

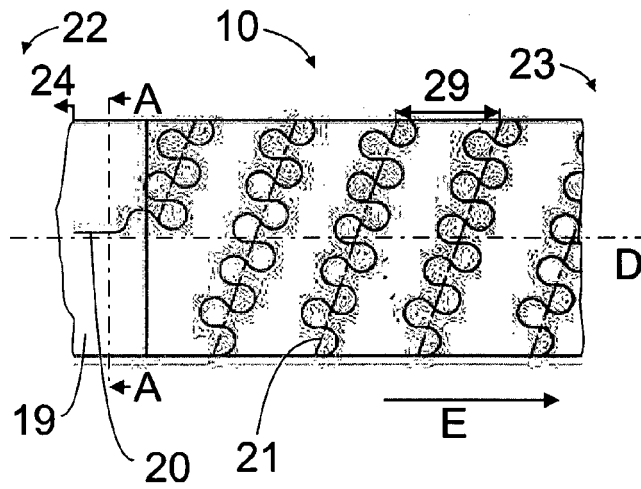


FIG. 2a

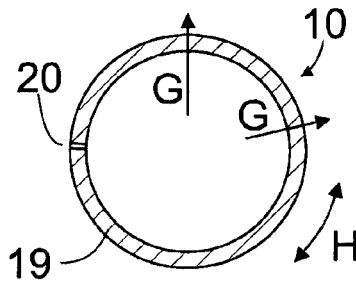


FIG. 2b

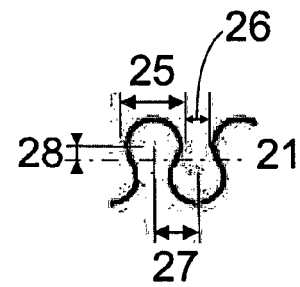


FIG. 3

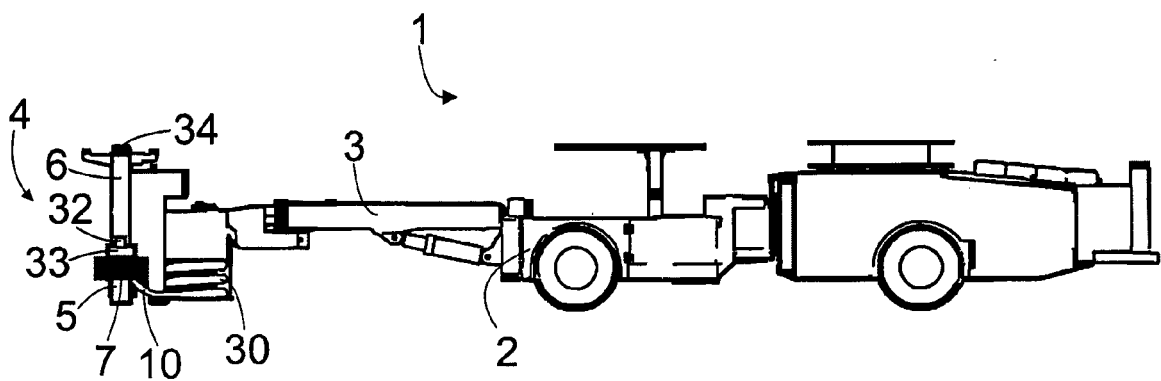


FIG. 4

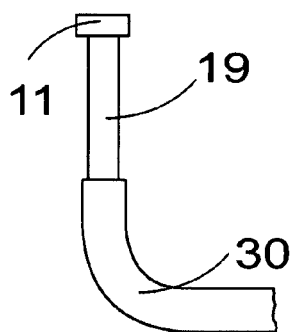


FIG. 5a

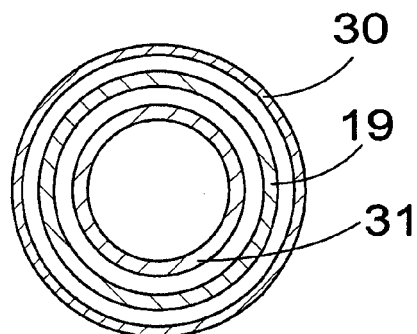


FIG. 5b

Use at least one drill rod comprising a length that is larger than the height available in drilling space

601

Bend said at least one drill rod in a transverse direction

602

Drill a hole using the drill rod in a substantially upward or downward direction

603

Drill in a step-wise manner a maximum length allowed by tunnel height or other limit at a time

701

Use rod retainer to keep the drill rod in place while rotation unit is returned to feed start position

702

Release rod retainer once rotation chuck jaws are clamped again at feed start position to start feeding the drill rod and to continue drilling

703

Repeat the step-wise drilling until planned depth of the hole has been reached

704

FIG. 6

FIG. 7

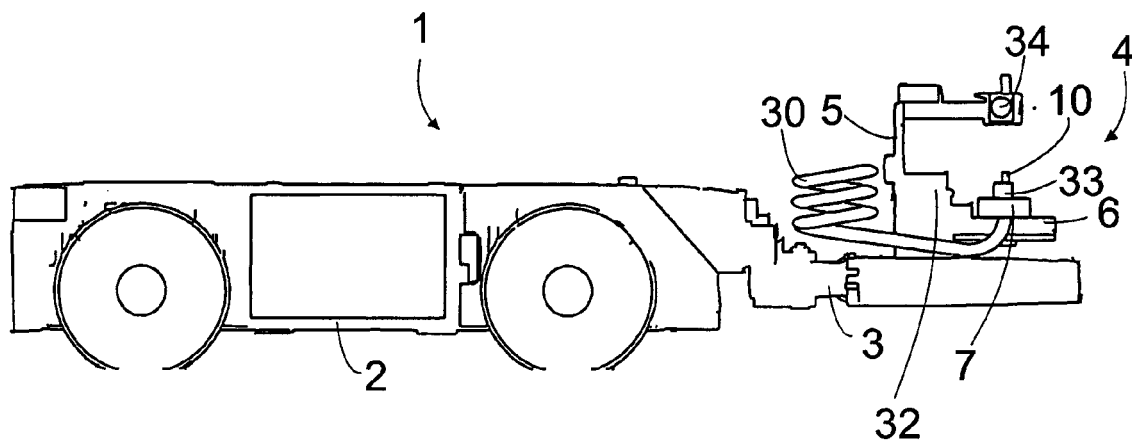


FIG. 8



EUROPEAN SEARCH REPORT

Application Number
EP 14 00 0169

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2 515 365 A (ZUBLIN JOHN A) 18 July 1950 (1950-07-18)	1-10	INV. E21B17/20
A	* column 1, line 9 - line 47; figures 1-3 * * column 3, line 24 - column 4, line 9 * -----	11-15	
X	US 2 706 615 A (ZUBLIN JOHN A) 19 April 1955 (1955-04-19) * the whole document *	1-3,8,9	
A	US 4 811 800 A (HILL GUY J [US] ET AL) 14 March 1989 (1989-03-14) * the whole document *	1-15	
A	US 5 671 816 A (TIBBITTS GORDON A [US]) 30 September 1997 (1997-09-30) * column 11, line 40 - column 12, line 28; figures 12A,12B * -----	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			E21B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 4 June 2014	Examiner Morrish, Susan
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 14 00 0169

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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04-06-2014

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