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## Description

**[0001]** The invention concerns a method for production of drilling devices mainly for the pipe umbrella technique, a drilling device for making pipe-lined drill holes for the pipe umbrella (roof) technique and a method of supporting a roof with a pipe umbrella.

**[0002]** The so-called pipe umbrella technique is particularly used in tunnel construction in instable ground or rock, to secure and to accelerate progress and generally to allow drifts or tunnels to be built continuously in these grounds. Furthermore, the pipe umbrella technique is used to provide a tunnel cross section, when penetrating fault zones, that can be held open for long enough for the final tunnel lining to be inserted. Even in the case when the tunnel being made has only a very small covering, there are frequently no other options than to operate with the pipe umbrella technique. Here drill holes are made at small spacings in exposed rock areas and are secured by a drawn-in support pipe, so that concrete or another consolidation means can be brought in to produce a load-bearing zone around the respective drill hole and thus in the pipe umbrella, which then can be so reinforced over the conventional tunnel lining that an appropriately secure tunnel cross section is available.

**[0003]** Various drilling devices are known for the production of a pipe umbrella consisting of a number of drill holes. Basically, however, there is the problem that, because of the support pipe that has to be inserted, the drill bit has to have a diameter exceeding the outside diameter. This is achieved according to the system with the lost ring drill bit in which a ring drill bit is allocated to the support pipe and remains in the drill hole after the drill hole has been completed, while the core drill bit or pilot drill bit together with the drill rod are removed from of the drill hole through the support pipe again and can be re-used. A system with a lost solid drill bit is also known, wherein, by appropriate detachment of the pilot drill bit after completion of the drill hole, the whole drill bit remains in the drill hole while the actual rod is recovered through the support pipe. Finally, there is the so-called eccentric drill system, in which an eccentric broaching drill bit is assigned to the pilot drill bit which, depending on the direction of rotation, allows an enlarged drill hole diameter to be made or a withdrawal of the whole drilling device through the support pipe after the drill hole has been completed, in which the eccentric part is rotated in the opposite direction into a withdrawal position. The disadvantage of the last system is that a mounting bush must be provided for this eccentric broaching drill, weakening the actual drill head, and that this method or this system does not allow the support pipe to be carried in with it. It has to be driven in separately, which can create considerable problems, depending on the state of the rock.

**[0004]** The disadvantage of more recent systems is that they only have one pivoting out element, the so-called eccentric broach, and that the whole drill tool, consisting of pilot drill bit, eccentric broach and mounting

bush is very massively configured and probably has to be as well. As a result, the system drills in an unbalanced and non-circular manner. While the performance of the system when vertical drilling is little impaired, performance when drilling horizontally or near horizontally, as in pipe umbrella drilling, is severely affected. For this reason, the system known from EP 0 511 298 A1, for example, cannot become established. A similar one, only with a drilling device having several eccentrics is known from EP 0 563 561 A1. DE 22 38 598 4-24 A1 describes a drilling device and corresponding method in which a radially expandable boring bar bit is used behind the drill head or pilot drill bit. Irrespective of the fact that the support pipe is also not automatically drawn forward here, the disadvantage of this type of boring bar bit is that it can only be used in soft ground. In contrast, DE 10 2005 146 495 A1 teaches a drilling device in which drilling elements associated with the pilot drill bit are configured to be foldable, so that when drawn into the support pipe, which is carried in by means of an impact adapter, it is moved in the direction of the drill axis and so makes possible moving in and recovery of the whole drilling device following completion of the drill hole. When slid out of the support pipe, the additional drill elements are pivoted outwards against the drill axis by means of a spring. Their path is restricted in that they bear on the inside of the pipe-like shaft part of the pilot drill bit with their adapted contact surfaces at their front and rear end. Due to this arrangement, at the effective tip of the outermost chipping elements on the pivotable drilling elements, a maximum diameter of the drilling device is produced, also representing the diameter of the drilled holes to be created during the drilling process. In the described and disclosed solution, the imaginary line between the effective tip of the outermost chipping elements on the pivotable drilling elements and the support line of these drilling elements takes up a maximum angle of 30°. Therefore there is no assurance that the largest possible drill hole diameter is always made with the different compositions of the ground to be penetrated. However, only with a constant diameter is there the certainty that the support pipe can also always be drawn in afterwards, in order to make the required drill hole. Drainage holes and the like are made in a similar way.

**[0005]** The underlying object of the invention is therefore further to develop a drilling device with pilot drill bit and pivotable drilling elements so that a constant drill hole diameter is always guaranteed, even in unfavourable rock layers.

**[0006]** The object is achieved in accordance with the method of the invention in that the radial part (FGR) of the resulting rock loosening force (FG) is adjusted to prevent the drill elements pivoting back in the direction of the drill axis during the drilling operation.

**[0007]** When such a method is applied, it ensures that the diameter of the hole can be maintained at constant maximum size, irrespective of the stone conditions. In this way, when drilling out holes of this kind, there is al-

ways the assurance that the support pipe can be drawn or pushed along in, without jams or stoppages occurring. When a drilling device of this type is manufactured, the drill element designed to pivot is thus so configured that partial pivoting back under the prevailing forces is completely prevented. Therefore the forces acting on the pivotable drill element always have the effect of maintaining it in an 'operative position'. The device according to the invention also has the advantages that it operates consistently independent of the rock conditions and ensures the production of bores that are substantially of the same or similar cross section

**[0008]** According to a practical embodiment, it is provided that the radial part (FGR) of the rock loosening force (FG) applied by the drill element is configured to be less than the axial part (FGA). This may be achieved by an appropriate shaping and/or configuration of the drill element, which will be explained later. In this case, the problems of the prior art are overcome because drill element always remains active during drilling due to the corresponding distribution of the rock loosening force.

**[0009]** Furthermore, it has been noted that, according to the state of the art, the corresponding effective angle is 30° to 32° max. According to a further embodiment, the required adjustment of the radial loosening force is now assured by creation or configuration of the drill elements so that the effective angle  $\alpha$  between the imaginary connecting line / line of action between the pivot point of the drill elements and the active tip of the outermost chipping element of the drill elements is adjusted to be equal to or greater than 35°. The respective drill element is consequently so shaped and configured that the resulting effective angle is of the size identified as when a drill hole can be drilled with constant diameter.

**[0010]** In terms of the device, the object is achieved in that the one-part or multi-part drill element is configured to be pivotable about a basis point axis located at a distance from the drill axis and in that the effective angle between the line of action of the drill element and the drill axis is larger than the angle that the resulting rock loosening force has to the drill axis. If this angular ratio is ensured, it is possible to operate reliably with a drilling device of this type, because there is the assurance when rock conditions are unfavourable that the drill element or drill elements will not move out of their outermost position, even if the composition, hardness etc. of the rock varies.

**[0011]** According to a useful further embodiment, it is then provided that the effective angle between the imaginary line between the basis point axis and the effective tip of the outermost chipping elements and the drill axis is equal to or greater than 35°. This angle has proved to be sufficient to achieve the underlying object, thus of securing a drill hole diameter that is always the same when drilling with the device. If the angle is more than 35°, for example up to 55°, this characteristic is further assured, as can potentially be useful because naturally in the course of drilling operations the effective tip of the outermost chipping elements, for example, can change or

its position can change. This level of effective angle would counteract this and consequently ensure that, even in extended drilling operation, the drilled hole would always be made with constant diameter.

**[0012]** A further useful embodiment provides that the pilot drill bit acting as basic drill bit is attached by a threaded connection to a tubular base body associated with the basic drill bit, enabling displacement of the drill elements in the direction of the drill axis or parallel to it. This permits the necessary drill elements or even only a single drill element to be inserted into the base body from the front. This makes the insertion of the drill elements in the body of the basic pilot drill bit from the side unnecessary, so that the drill elements can advantageously have another support than has been the case up to now. Furthermore, the whole drill element can advantageously be made short, so that the effective angle in the region of 35° and above can be easily obtained by this design.

**[0013]** As already mentioned, because of the configuration of the drilling device, the drill elements are provided with greater support on the surrounding base body. The invention additionally provides that the drill element has side walls enabling lateral support in the window-like aperture of the base body. Thus the respective drill element can be supported over the whole side wall without requiring expensive special design.

**[0014]** In accordance with an advantageous embodiment, it is provided that the drill element is pivotable about an imaginary basis point axis on the impact adapter. The drill element or drill elements, as already mentioned, are introduced from the front with the basic drill bit or pilot drill bit and are positioned appropriately through the window, whereby they are not arranged pivotably about a real axis, but about the imaginary basis point axis, wherein the impact adapter has the necessary indentations. Thus, both the assembly is facilitated and the mode of operation is secured, because the drill element does not rotate about an axis but can actually be tilted about this basis point axis. The impact adapter provides the necessary bearing possibilities.

**[0015]** Drilling devices of this type have a rotary-percussive action, which is the reason for the impact adapter to be provided. For it to be possible to transmit these impacts effectively and, on the other hand, for the drill elements to absorb them, it is provided that an impact shoulder running radially to the drill axis is formed on the impact adapter and on the tubular base body and that on the associated rear side of the drill element itself there is a corresponding bearing face. This configuration provides adequately large surfaces, excluding deformation during extended operation and, as already mentioned, ensuring reliable transmission of impact energy.

**[0016]** The drill elements have to pivot from their working position against the force of a spring whereby, according to the invention, it is provided that the spring supporting the drill element is configured as a coil spring and is supported by means of a guide aid located on the back of the pilot drill bit. The coil spring can be arranged to run

in a slight curve to transmit the necessary forces securely, whereby this is still supported by the guide aid. Thus a sufficiently strong spring is available to perform the pivoting action of the drill element smoothly, while nevertheless always applying adequate forces, and is prevented from buckling by the guide aid.

**[0017]** The pivotable drill elements that are used must in part deliver a substantial chipping action. This is ensured by equipping the drill element with three chipping elements, whereby two are positioned on the outer edge of the drill element. The main chipping work has to be done here, so that the necessary reliability is given here by the double arrangement of chipping elements at the outer edge. It is possible for the chipping element disposed at the inner edge to project somewhat further than that positioned at the outer edge, so that this chipping element does a certain amount of initial work and thus supports the chipping element disposed at the outer edge and prevents overloading.

**[0018]** It has been noted above that the drill element can be pivoted or actually tilted about the imaginary basis point axis. To facilitate this process, the invention provides that the impact shoulder on the impact adapter has a guide bevel formed to assist inwards pivoting of the drill element. The guide bevel supplies the tilting process but also restricts it, advantageously, so that at the same time pivoting back or tilting back due to spring force is still facilitated.

**[0019]** In particular, the invention is characterised in that a drilling device is created that ensures, irrespective of the rock conditions, that a drill hole can always be made with constant diameter and sufficiently large diameter. The invention achieves this in particular in that pivotable or tiltable drill elements are provided that are located in the tubular base body and are configured so that they are pivoted with the aid of a spring in their initial position when they are moved out of the support pipe. In this position, however, they are no longer held by the spring in a sense but, due to the particular design which ensures that the radial part of the resulting rock loosening force excludes pivoting back of the drill elements by its size. The radial part is smaller than the axial part of the rock loosening force, which is achieved by the effective angle being equal to or more than  $35^\circ$ , thus clearly more than that in the state of the art. Because of this, the respective drill element, preferably comprising two drill elements per drill head, is always held in the outermost position without requiring any springs or similar. A drill hole that is constant in size and sufficiently large is always guaranteed during operation of a drilling device of this type, even after extended operating periods.

**[0020]** Further details and advantages of the subject of the invention are given in the following description of the drawings of the accompanying figures, in which a preferred embodiment is depicted with the necessary details and individual parts. The Figures are:

**Figure 1** showing a drift or a tunnel with pipe um-

brella, in cross section;

**Figure 2** showing a drilling device in drilling position, in side view;

**Figure 3** showing a drilling device in drilling position in perspective view with quarter section;

**Figure 4** showing a drilling device in drilling position in front view;

**Figure 5** showing a drilling device in retracted position in side view;

**Figure 6** showing a drilling device in retracted position in perspective view with quarter section;

**Figure 7** showing a drilling device in retracted position in front view; and

**Figure 8** showing a drilling device in drilling position with depiction of acting forces during the rock loosening process.

**[0021]** Figure 1 shows a tunnel or drift 55 driven into the rock 14, wherein a supporting structure 56 has already been installed. The tunnel roadway or floor is denoted by 57, where the area underneath has been back-filled. The drift 55 or tunnel itself is protected by a pipe umbrella 60, because the surrounding rock 14 necessitates the formation of such a pipe umbrella 60. This pipe umbrella 60 consists of steel pipes 58 driven into the rock 14 and grouting material, preferably concrete 59, which has been forced into the rock 14 over the steel pipes 58. The steel pipes 58 have been pushed into corresponding drilled holes or bores 35, on which further details are explained with the aid of the additional figures.

**[0022]** Figure 2 shows a drilling device 1, in which its pilot drill bit 2 projecting forwards has made the pilot hole 35a which is part of the hole 35. This pilot drill bit 2 is supported by drill elements 3, which are mounted and held by the tubular base body 4 attached to the pilot drill bit 2. Base body 4 and pilot drill bit 2 are joined together by a threaded joint 39 or similar. Apertures 40 are provided in the base body 4, through which the drill elements 3 project outwards and are held in this position by the spring 8.

**[0023]** The drill element 3 is also equipped with chipping elements 15, like the pilot drill bit 2. As Figure 4 makes clear, several such hard metal front pins and edge pins 16, 17 acting as chipping elements 15 are attached to the pilot drill bit 2 and hard metal front pins and hard metal edge pins 18, 19 are attached to the drill element 3. These are conventional chipping elements 15, wherein the placement on the drill element or drill elements 3 is exceptional, because two such chipping elements 15, 18, 19 are attached here to the outer edge 52' and one to the inner edge 51.

**[0024]** The operating position reproduced in Figure 1 and also in Figure 2 makes clear that, with the aid of the drill elements 3, a drill hole can be made having a diameter that is larger than the outside diameter of the support pipe 12. This support pipe 12 is equipped with a pipe shoe 11 in the direction of the deepest part of the drill hole. Pipe shoe 11 has an impact shoulder 7, by means of which it is ensured that the whole support pipe 12 is carried along during rotary-percussive drilling. As already mentioned, the drilled hole diameter is large enough to ensure that the support pipe 12 can be carried along in any case. The impact shoulder 7 on the pipe shoe 11 corresponds to the impact shoulder on the impact adapter, so that a continuous overall operation can be realised by means of the extension drill rod 22 when working with the drilling device. The drill rod 30 or extension drill rod 22 is connected in operation to a drill (not shown). A drill may be any device capable of providing suitable rotational and/or percussive forces to the drilling device.

**[0025]** The drill element 3 is in the working position in Figures 2 and 3, wherein the necessary forces are reliably transmitted into the rock, because a sufficiently large impact shoulder 6 is provided between impact adapter 5 and the rear of the drill elements 3. There are two impact shoulders 42, 43, one associated with the impact adapter 5 and the other with the tubular base body 4. Due to the large contact surface 45 of the drill element 3, it is ensured that the forces in question are securely transmitted into the rock 14 via the drill element 3. Furthermore, advantageously there are additional impact shoulders 7, 62, 63 between the impact adapter and the base body 4, between base body 4 and pilot drill bit 2, as well as between impact adapter 5 and pipe shoe 11.

**[0026]** Figure 2 otherwise makes clear that the hard metal pin 19 as chipping element 15 is located somewhat ahead of the front hard metal pin 18, so facilitating the work of the two front hard metal pins 18.

**[0027]** As already mentioned, the drill elements 3 can be pivoted in the tubular body 4 via a window-like aperture 40, firstly by means of the spring 8 and secondly against the force of the spring when the extension drill rod 22 is drawn into the support pipe 12. As can be seen in Figure 3, the spring is configured as a coil spring 48, which has a degree of curvature, which can be seen in Figure 2. To ensure that the coil spring 48 can move evenly and reliably, a guide aid 50 is provided at the rear 49 and in the spacer 9, effectively preventing deflection of the coil spring 48. The shape of this guide aid 50 can be seen in both Figure 3 and in Figure 2, wherein the reference number 10 is given to this particular configuration of the spacer in Figure 2.

**[0028]** Figure 3 further shows a guide bevel 53, which produces or facilitates tilting of the drill elements 3, as can be seen, for example, in Figure 5. In doing so, the drill element tilts about the so-called basis point 46 or, put more correctly, about the imaginary basis point axis 26. Figures 5, 6 and 7 show the drilling device in retracted position. It is clear that the drill elements 3 are in the tilted

position, when the spring 8 or coil spring 48 is compressed in its limit position. This tilted position of the drill elements can be seen particularly clearly in Figure 5, in which it is also clear, in half longitudinal section, that the drill elements 3 protrude out of an aperture 40 in the tubular base body 4 and thereby are supported by the side walls 41 that cannot be seen here. As mentioned, Figure 6 shows the drilling device 1 in retracted position and in oblique view, in which the particular configuration of the spring 8 as coil spring 48 is shown. It can be seen here, as also in other sections, that the pipe shoe 11 is attached to the support pipe by means of a thread 13. Figure 7 shows the drilling device 1 in retracted position and in front view, in which the chipping elements 15 of the drill elements 3 can now no longer be seen.

**[0029]** Figure 8 shows the position of the pilot drill bit 2 and the drill elements 3 indicated in Figure 2, in which the forces acting during the rock loosening process are also shown. The two-part basic drill bit with its pilot drill bit 2 and the tubular basis body 4 have a threaded connection 39. Both, including the impact adapter 5, are attached to the extension drill rod 22 or drill pipe 36. This connection option makes very short drill elements 3 possible, which in turn makes it possible to achieve an effective angle of more than 35° between the line of action 24, which is formed from the imaginary connecting line 37 between the basis point axis 26 and the active tip 38 of the outermost chipping elements 15, 18 on the drill elements 3, and the drill axis 23. In other words, the stable position of the drill elements 3 in the drilling position is ensured in that the angle 25 between the line of action 24 of the drill elements 3 and the support line of these drill elements 3, that is the imaginary line between effective tips 38 of the peripheral chipping elements 15, 18 on the pivotable drill elements 3 and the support line of these drill elements 3, and the drill axis 23 is more than the angle 30 which the resulting chipping force or resulting rock loosening force 27, which is exerted on these peripheral chipping elements 15, 18, makes with the drill axis 23. The axial and radial rock loosening forces are denoted by 28 and 29. The rock loosening force FEW acting on the drill elements 3 to the drill axis 23 is 31 and 32 is the radial rock loosening force FER, which actively acts on the drill elements 3.

**[0030]** At the end of the drilling process, the prior art drill systems must release the lost ring drill bit or the lost solid drill bit from the drill rod 36 or must pivot an element back in that was pivoted out (in the case of an eccentric reamer). This is almost always done by rotating the drill rod 36 in the direction opposite to the direction of rotation when drilling. The remaining drill rod 36 can only be withdrawn when the release process has been completed. The release process is often very difficult and can often be associated with considerable loss of time. Furthermore, there is the risk that the connection between the lost drill bit and the pilot drill bit is not loosened, but another of the many connections between the extended drill rods 22 of the drill rod 36. This means further loss of time

and perhaps even loss of the eccentric system if the eccentric reamer does not pivot inwards.

**[0031]** The drilling system of the invention does not suffer from these problems because, when the drill rod 36 is withdrawn, no counter-rotation is necessary. Each drill element 3 folds inwards by itself on withdrawal, its rear side having an inclined face 80 which bears on the front inner edge 81 of the pipe shoe 11. Withdrawal of drill rod 36 forces the drill elements 3 inwards against the force of the spring and consequently forces them to fold inwards. Whether the drill rod 36 is turning or whether there is no rotary motion when the drill rod 36 is withdrawn is unimportant.

1. Method for production of drilling devices for the pipe umbrella technique, with which the pipe-lined drilled holes are made in the rock by the drilling device while introducing the support pipe, whereby the drilling device is composed of a pilot drill bit, which represents the front end of the drilling rod in the drill hole, and one or several drill elements producing the enlargement of the drill hole for the support pipe, so that through the chipping elements the necessary rock loosening force for the enlarged bore is reliably transmitted to the rock to be drilled, characterised in that the radial part (FRG) of the resulting rock loosening force (FG) is adjusted to prevent the drill elements pivoting back in the direction of the drill axis during the drilling operation.

2. Method in accordance with statement 1, characterised in that the radial part (FGR) is adjusted to be smaller than the axial part (FGA) of the rock loosening force (FG).

3. Method in accordance with statement 1, characterised in that the radial rock loosening force (FGR) is influenced by creation or configuration of the drill elements to the effect that the effective angle  $\alpha$  between imaginary connecting line / line of action pivot point of the drill elements and the effective tip of its outermost chipping element is adjusted to be equal to or more than  $35^\circ$ .

4. Drilling device for production of pipe-lined drill holes for the pipe umbrella technique with a pilot drill bit (2) with an associated drill element (3) for the production of the enlarged hole for the accompanying support pipe, whereby the drill element (3) connected to the drill rod (36) by means of an impact adapter (5) is equipped with chipping elements (15) and during drawing in and forcing out of the support pipe (12) is configured to be pivotable with or against the force of a spring (8), characterised in that the one-part or multi-part drill element (3) is configured to be pivotable about the basis point axis (26) located at a distance from the drill axis (23) and that the drill element (3), its chipping elements (15) and the basis

point axis (26) are so configured and arranged that the effective angle (25) between the line of action (24) of the drill element (3) and the drill axis (23) is more than the angle (30) which the resulting rock loosening force (27) makes with the drill axis (23).

5. Drilling device in accordance with statement 4, characterised in that the effective angle (25) which lies between the imaginary connecting line (37) between basis point axis (26) and the effective tip (38) of the outermost chipping elements (18) and the drill axis (23) is equal to or more than  $35^\circ$ .

6. Drilling device in accordance with statement 4 or statement 5 characterised in that the pilot drill bit serving as basic drill bit (2) is attached by a threaded connection (39) to a tubular base body (4) associated with the basic drill tip, enabling movement of the drill elements (3) in the direction of the drill axis (23) or parallel to it.

7. Drilling device in accordance with any one of statements 4 to 6 characterised in that the drill element (3) has side walls enabling a lateral support (41) in the window-like aperture (40) of the base body (4).

8. Drilling device in accordance with any one of statements 4 to 7 characterised in that the drill element (3) is pivotable on the impact adapter about an imaginary basis point axis (26).

9. Drilling device in accordance with any one of statements 4 to 8 characterised in that an impact shoulder (42, 43) running radially to the drill axis (23) is formed on the impact adapter (5) and on the tubular base body (4) and the associated rear side (44) of the drill element (3) has a corresponding contact face (45).

10. Drilling device in accordance with any one of statements 4 to 9 characterised in that the spring (8) supporting the drill element (3) is configured as a coil spring (48) and is supported by means of a guide aid (50) located on the back (49) of the pilot drill bit (2).

11. Drilling device in accordance with any one of statements 4 to 10 characterised in that the drill element (3) is equipped with three chipping elements (15, 18, 19), whereby two are positioned on the outside edge (52) of the drill element (3).

12. Drilling device in accordance with any one of statements 4 to 11 characterised in that the impact shoulder (42) on the impact adapter (5) has a guide bevel (53) formed on it, favouring pivoting in of the drill element (3).

## Claims

1. A drilling device suitable for production of a support pipe-lined drill hole for the pipe umbrella technique wherein the device comprises:
  - a body (4);
  - a pilot drill bit (2) for drilling a pilot hole (35a);
  - one or more drill elements (3) for radially enlarging the pilot hole by drilling to apply a rock loosening force (FG, 27) having a radial component (FGR) and an axial component (FGA) wherein the one or more drill elements are mounted on the body so that the one or more drill elements may be extended or retracted from the body and wherein the one or more drill elements are arranged so that the radial component (FGR) of the rock loosening force is such that the one or more drill elements are prevented from retraction during the drilling.
2. A drilling device according to claim 1 wherein the drilling device has one or more of the following features:
  - the body has one or more apertures (40);
  - the radial component (FGR) of the rock loosening force (FG) is less than the axial component (FGA);
  - the one or more drill elements are pivotally mounted on the body; preferably each of the one or more drill elements are pivotally mounted on the body to extend through or to retract into each of the one or more apertures; preferably one or more drill elements has side walls enabling lateral support (41) in the one or more apertures; and/or
  - the one or more drill elements are biased to be in an extended position; preferably the one or more drill elements are biased by a resilient member; preferably the resilient member is a spring (8); preferably the spring is a coil spring; preferably the resilient member is supported by means of a guide aid (50); preferably the guide aid is located on the back (49) of the pilot drill bit (2).
3. A drilling device according to claim 1 or claim 2 wherein the pilot drill bit has a pilot drill axis (23) defined by its drilling direction and the or each drill element has a drill element axis (24) defined by its drilling direction and wherein the or each drill element is arranged so that the effective angle (25) between its drill element axis and the pilot drill axis is more than the angle (30) which the rock loosening force makes with the pilot drill axis; preferably the effective angle is equal to or more than 35°.
4. A drilling device according to any one of claims 1 to 3 wherein the drill bit and/or the one or more drill elements are equipped with one or more chipping elements (15); preferably the one or more drill elements are equipped with three chipping elements (15, 18, 19), whereby two are positioned on the outside edge (52) of each drill element.
5. A drilling device in accordance with any one of claims 1 to 4 wherein the pilot drill bit is attached by a threaded connection (39) to the body; preferably the body is tubular.
6. A drilling device according to any one of claims 1 to 5 wherein the drilling device has a drill rod (36) for connection to a drill and wherein the one or more drill elements are connected to the drill rod by means of an impact adapter (5); preferably the drill rod has one or more extension drill rods (22); preferably the one or more drill elements are pivotable on the impact adapter about an axis (26).
7. A drilling device according to claim 6 which has one or more radial impact shoulders (42, 43) for transmitting and/or absorbing the rock loosening force wherein the radial impact shoulder is formed on the impact adapter and/or on the body and/or on a rear side (44) of one or more drill elements.
8. A drilling device according to claim 7 wherein the impact shoulder (42) on the impact adapter (5) has a guide bevel (53) formed on it to assist extension and/or retraction of the one or more drill elements.
9. Method for production of a drilling device as defined in any one of the preceding claims for use in a pipe umbrella technique wherein a support pipe-lined drilled hole is made in a rock formation by the drilling device applying a rock loosening force (FG) having a radial component (FGR) and an axial component (FGA) wherein the method comprises the steps of:
  - (a) providing a drilling device composed of a pilot drill bit forming a front end of the drilling rod in the drill hole and one or more drill elements for producing radial enlargement of the drill hole for the support pipe;
  - (b) shaping and/or configuring the one or more drill elements so that the rock loosening force for the radially enlarged bore is transmitted to the rock to be drilled so that the radial component (FGR) of the rock loosening force (FG) is adjusted to prevent the drill elements pivoting back in the direction of the drill axis during the drilling operation.
10. Method according to claim 9 wherein step (a) comprises providing the drill bit and/or the drill elements

with chipping elements.

11. Method according to claim 9 or claim 10 wherein step (b) comprises shaping and/or configuring the one or more drill elements such that the radial part (FGR) is smaller than the axial part (FGA) of the rock loosening force (FG). 5
12. Method according to any one of claims 9 to 11 wherein the pilot drill bit has a pilot drill axis (23) defined by its drilling direction and the or each drill element has a drill element axis (24) defined by its drilling direction and wherein step (b) comprises shaping and/or configuring the one or more drill elements such that the effective angle (25) between its drill element axis and the pilot drill axis is more than the angle (30) which the rock loosening force makes with the pilot drill axis; preferably the effective angle is equal to or more than 35°. 10 15 20
13. Method of providing a drill hole having a support pipe for use in a pipe umbrella which method comprises the steps of:
  - (a) providing a support pipe and a drilling device as defined in any one of claims 1 to 8 which drilling device is composed of a pilot drill bit forming a front end of the drilling rod in the drill hole, one or more drill elements for producing radial enlargement of the drill hole and a drill rod for connecting the pilot drill bit and the one or more drill elements to a drill and for carrying the support pipe; 25 30
  - (b) shaping and/or configuring the one or more drill elements so that the rock loosening force for the radially enlarged bore is transmitted to the rock to be drilled so that the radial component (FRG) of the rock loosening force (FG) is adjusted to prevent the drill elements pivoting back in the direction of the drill axis during the drilling operation; 35 40
  - (c) operating the drill to cause the drilling device to drill the drill hole; and
  - (c) withdrawing the drill rod through the support pipe to leave the support pipe in the drill hole. 45

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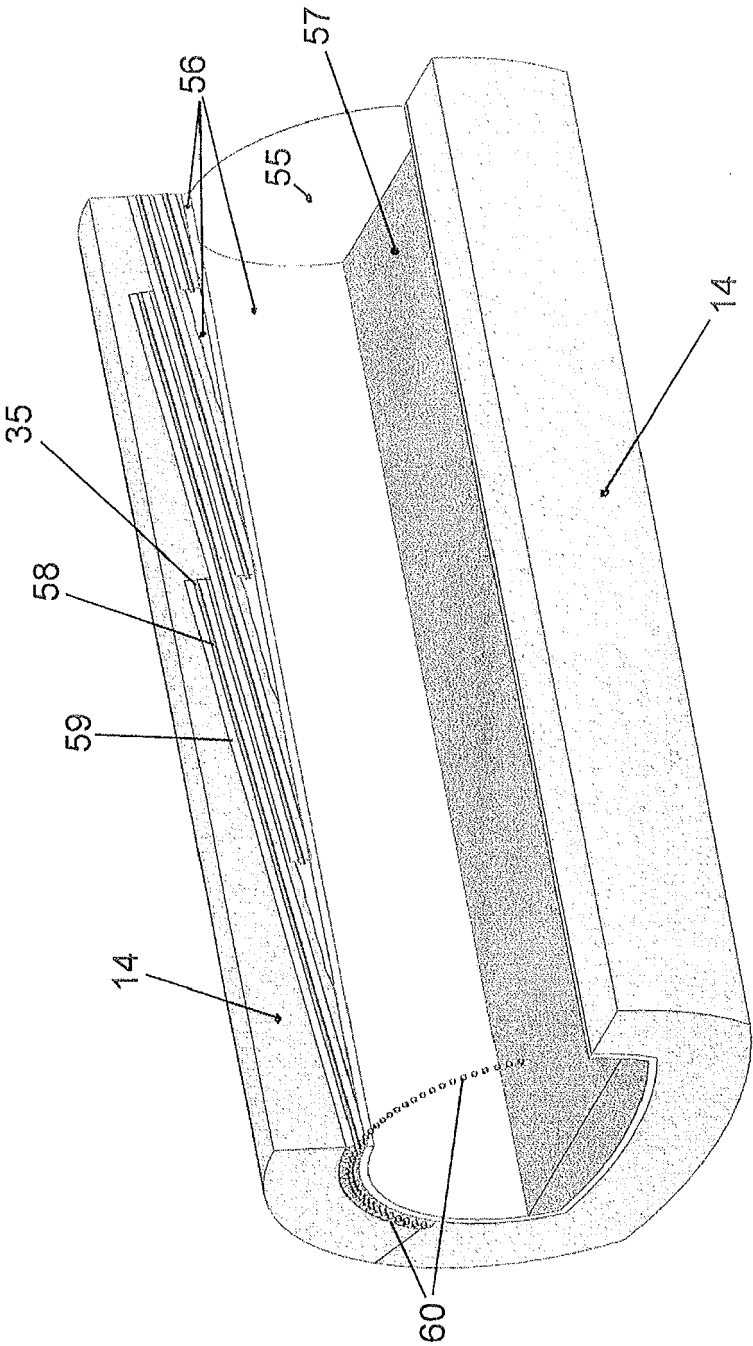


Fig. 1

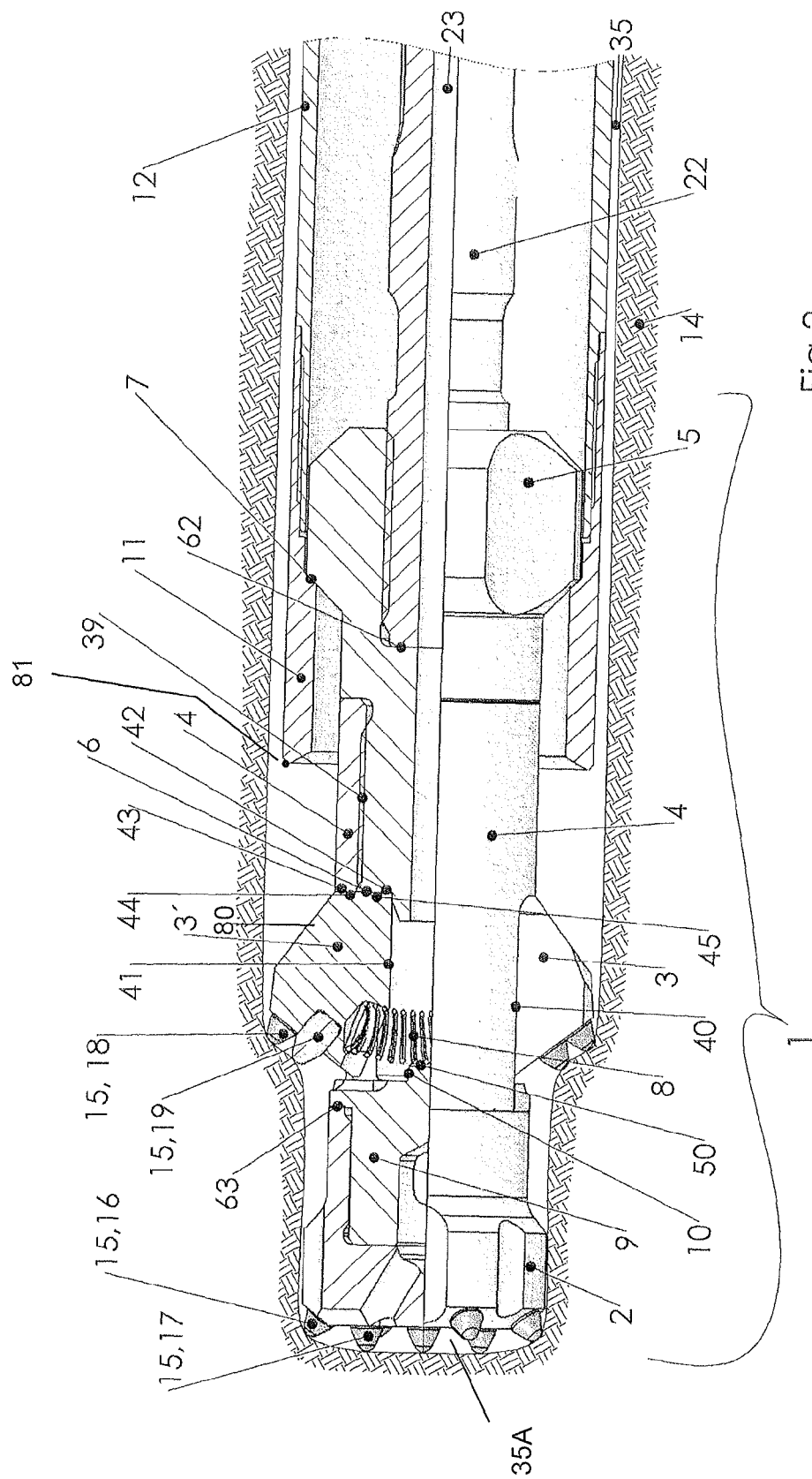
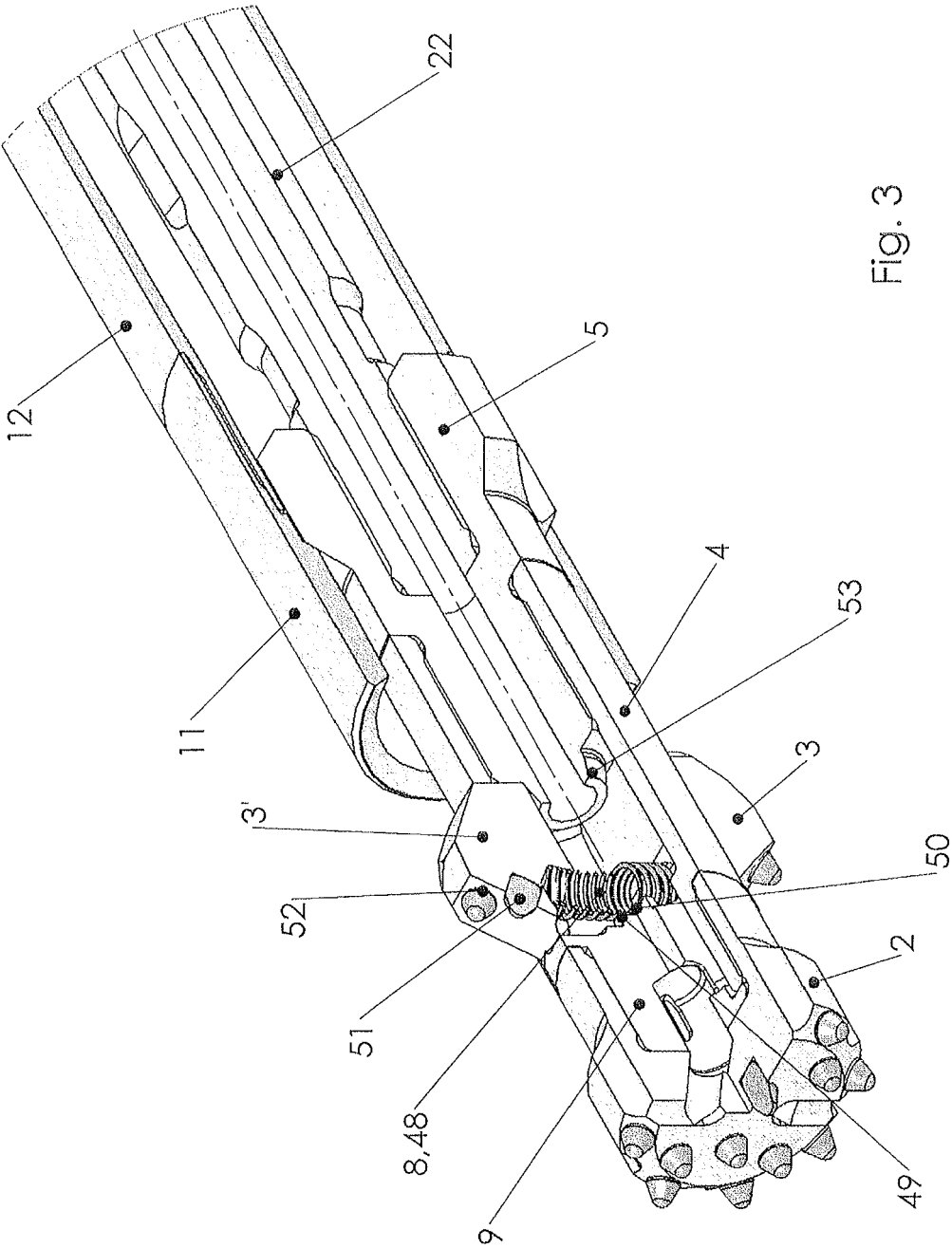


Fig. 2



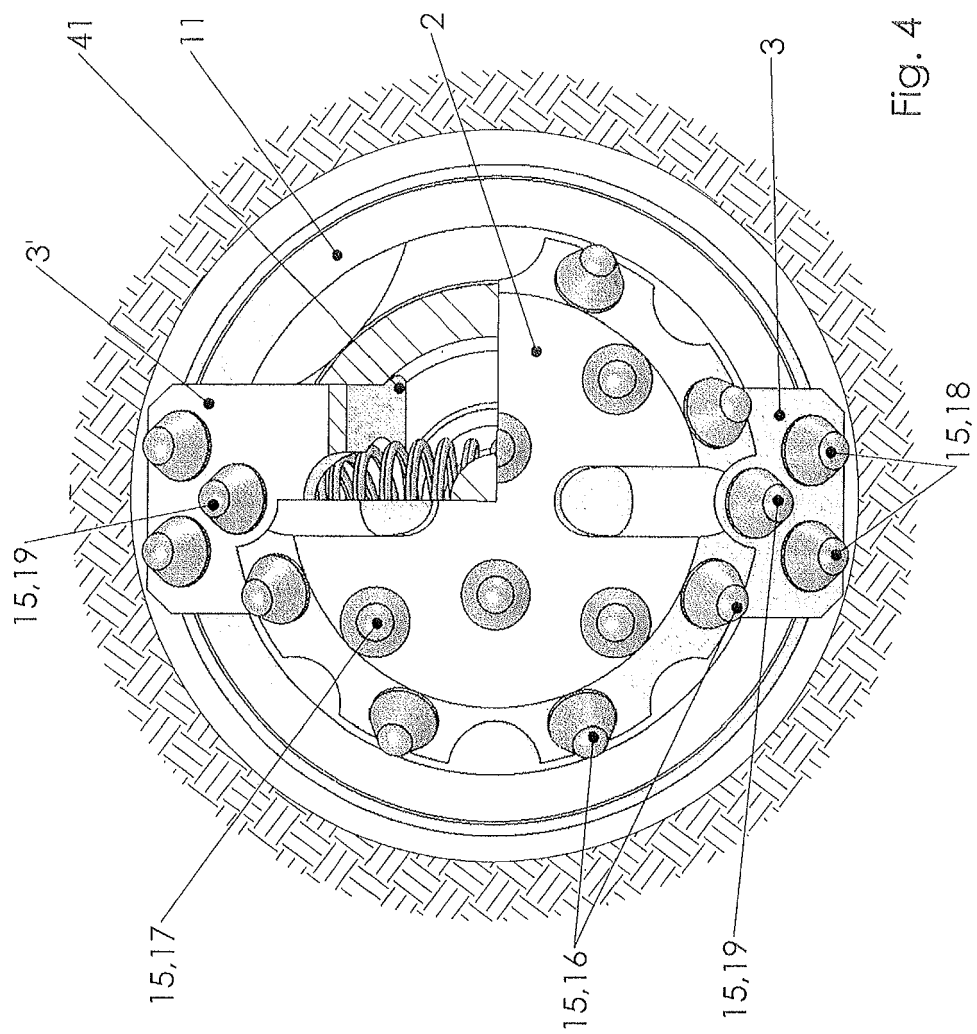


Fig. 4

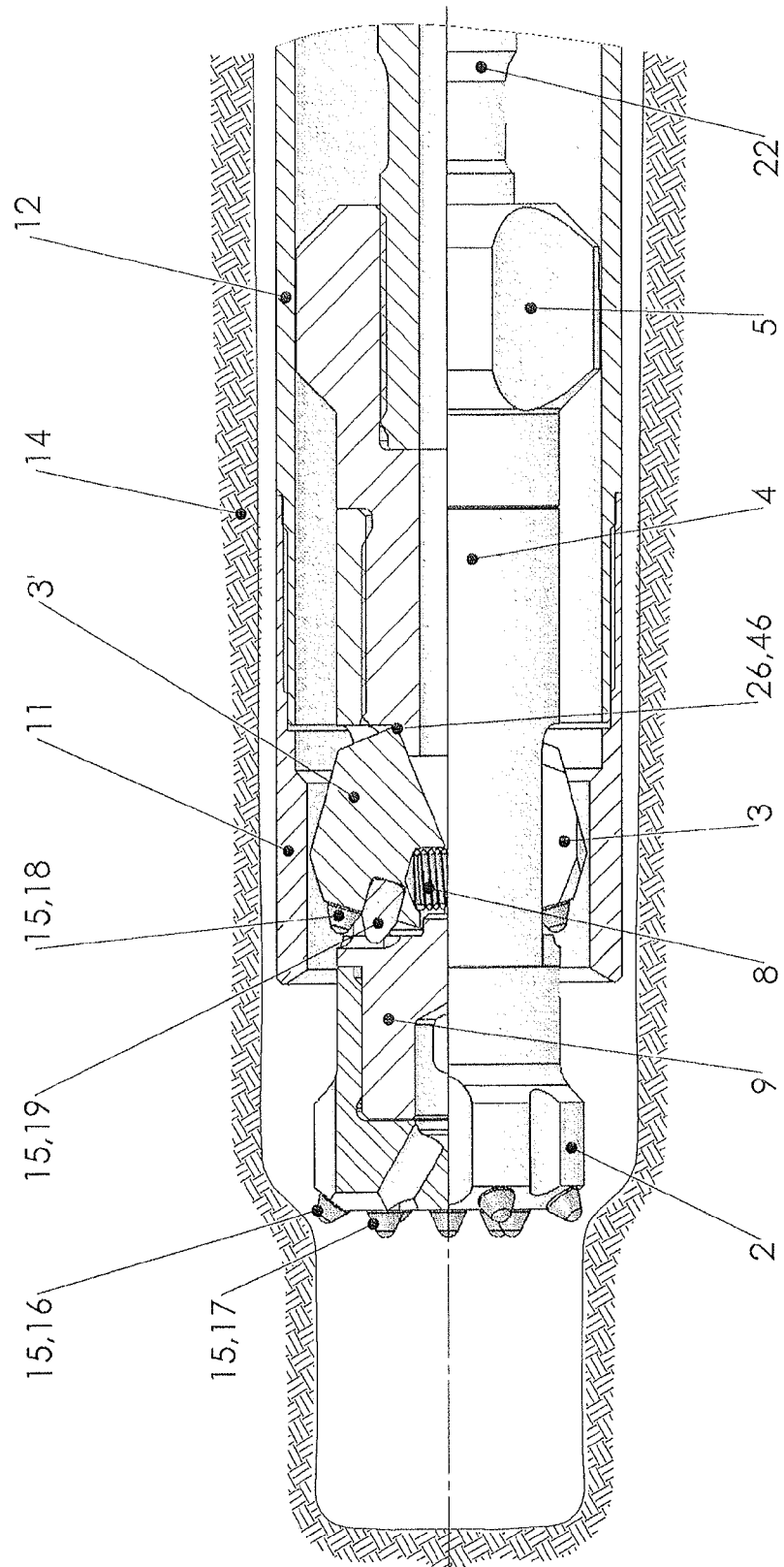


Fig. 5

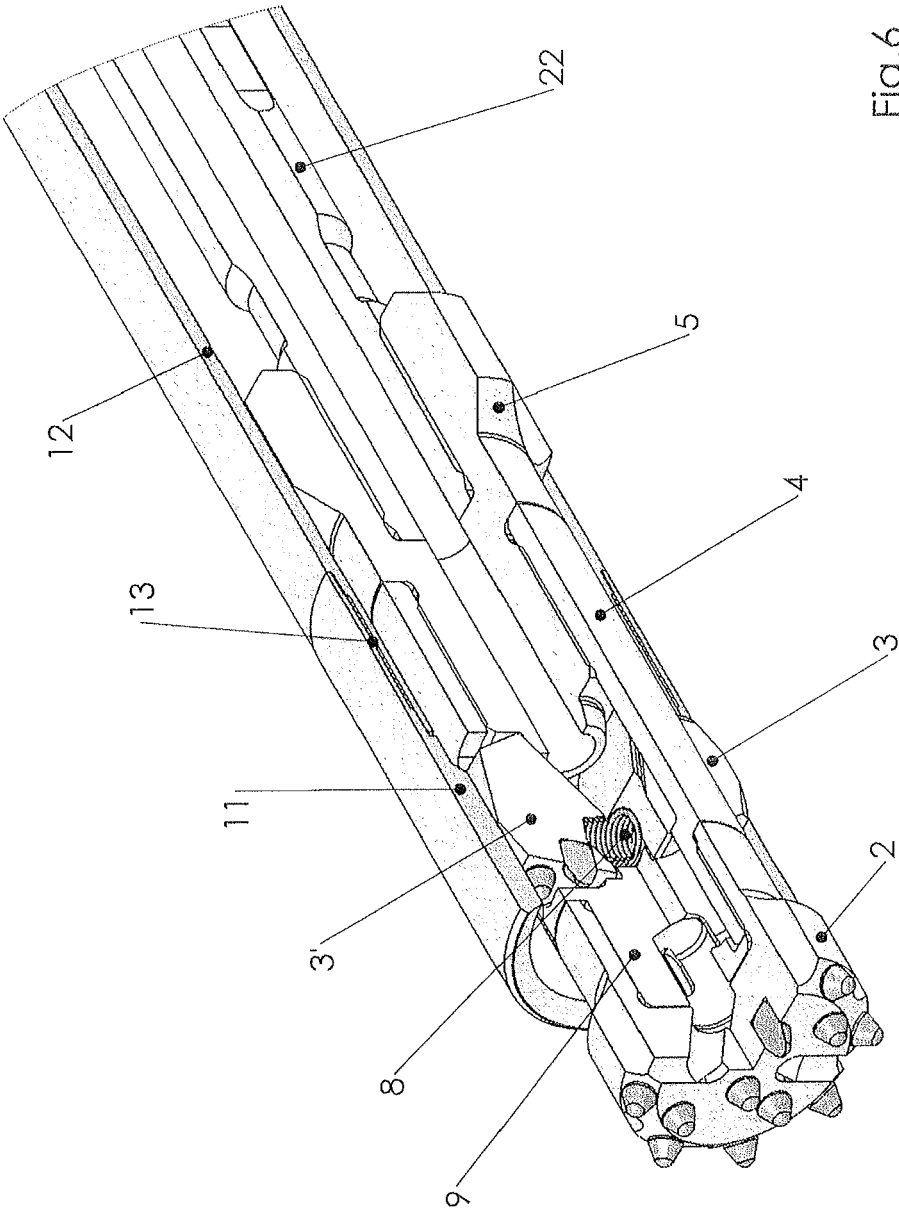
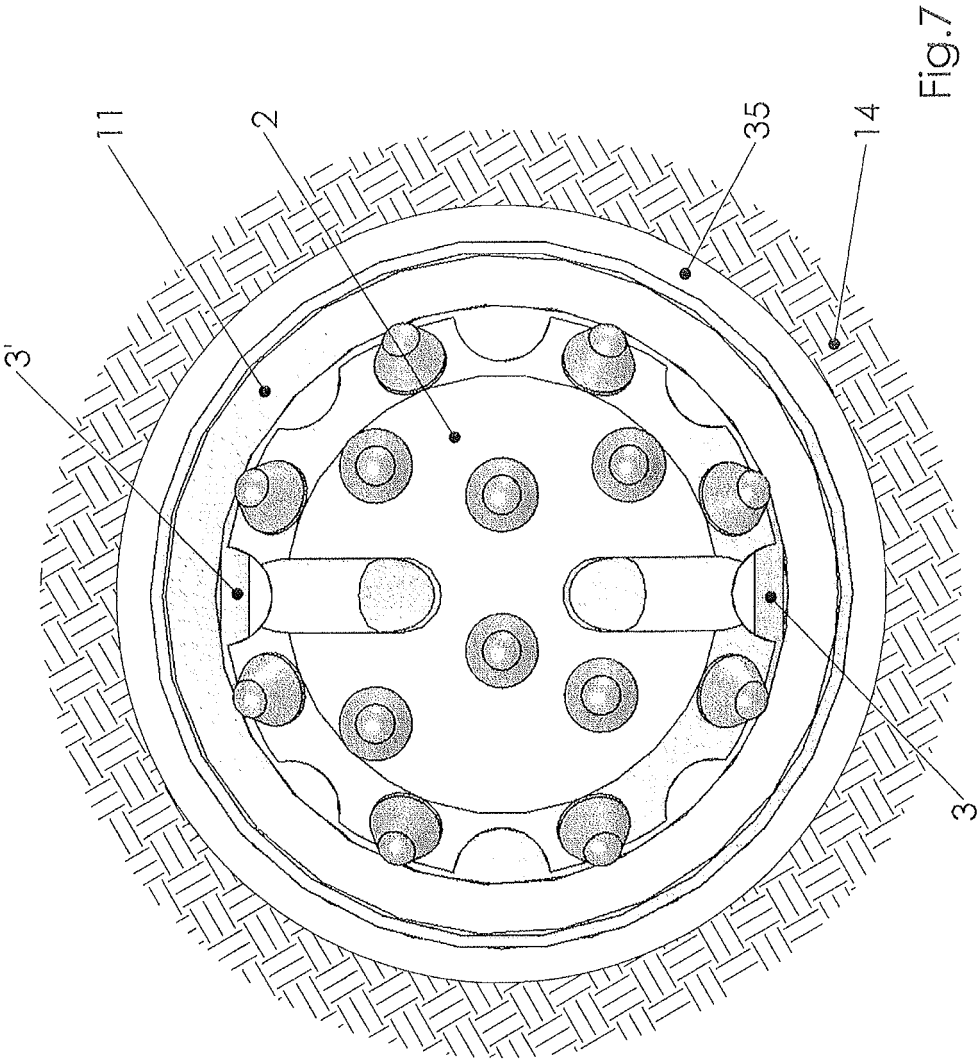
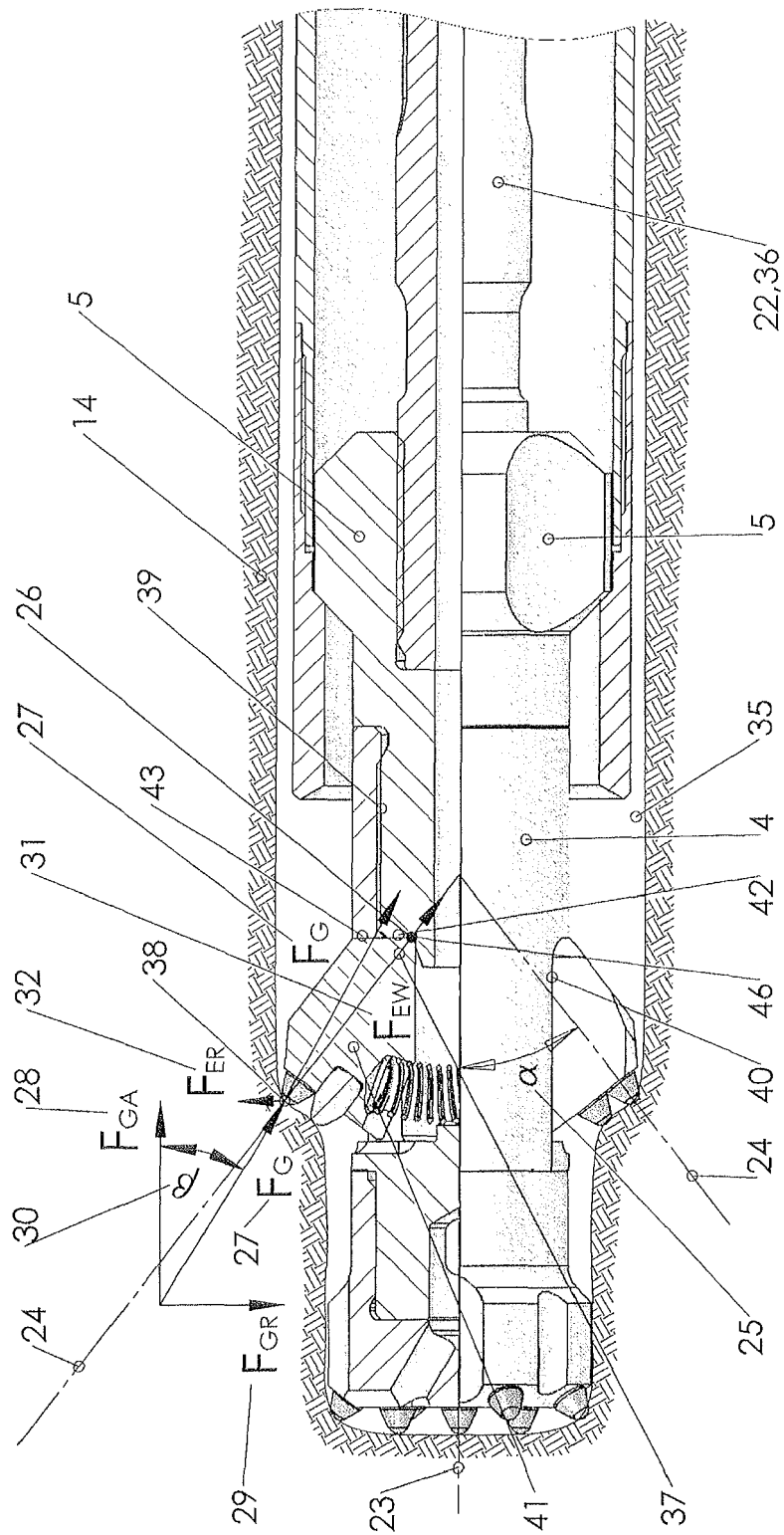


Fig. 6





**REFERENCES CITED IN THE DESCRIPTION**

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