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Method and apparatus for steering ram drills

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Abstract

In a method for steering a ram drill, a steering head mounted eccentrically and rotatably in the drill housing can be brought into a predetermined starting position for straight drilling or curved travel by twisting the drill housing. In the event of a change of direction into the starting position for curved travel, the current position of the steering head relative to the drill housing is initially ascertained, and the drill housing is then twisted through the angle between the ascertained steering head position and the starting position for curved travel.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for steering a ram drill with the aid of a steering head rotatably mounted in the drill housing, wherein the steering head can be brought into a predetermined starting position for straight drilling or curved travel by twisting the drill housing, in the event of a change of direction into the starting position for curved travel, the current position of the steering head relative to the drill housing is initially ascertained, and the drill housing is then twisted through the angle between the ascertained steering head position and the starting position for curved travel.

2. A steerable ram drill having a steering head rotatably mounted in the drill housing, comprising a position sensor (10,19) for ascertaining the steering head position relative to the drill housing (1).

3. The ram drill as claimed in claim 2, wherein a position sensor (10,19,28) is arranged both in the steering head (2) and in the drill housing (1).

4. The ram drill as claimed in claim 2 or 3, wherein the position sensors (10,19,28) are designed as rolling sensors.

5. The ram drill as claimed in one of claims 2 to 4, wherein at least one of the position sensors (10,19,28) is provided with a transmitter (11) and the drill housing (1) and/or the steering head (2) is provided with transmission slits (12,13;20,21).

6. The ram drill as claimed in one of claims 2 to 5, wherein the steering head (2) or the drill housing (1) is provided with two twist stops.

7. The ram drill as claimed in claim 6, wherein an entraining pin (5) of the steering head (2) engages into an arcuate slit (6) in the drill housing (1).

8. The ram drill as claimed in claim 6, wherein an expansion measurement spring extends between the steering head (2) and the drill housing (1).

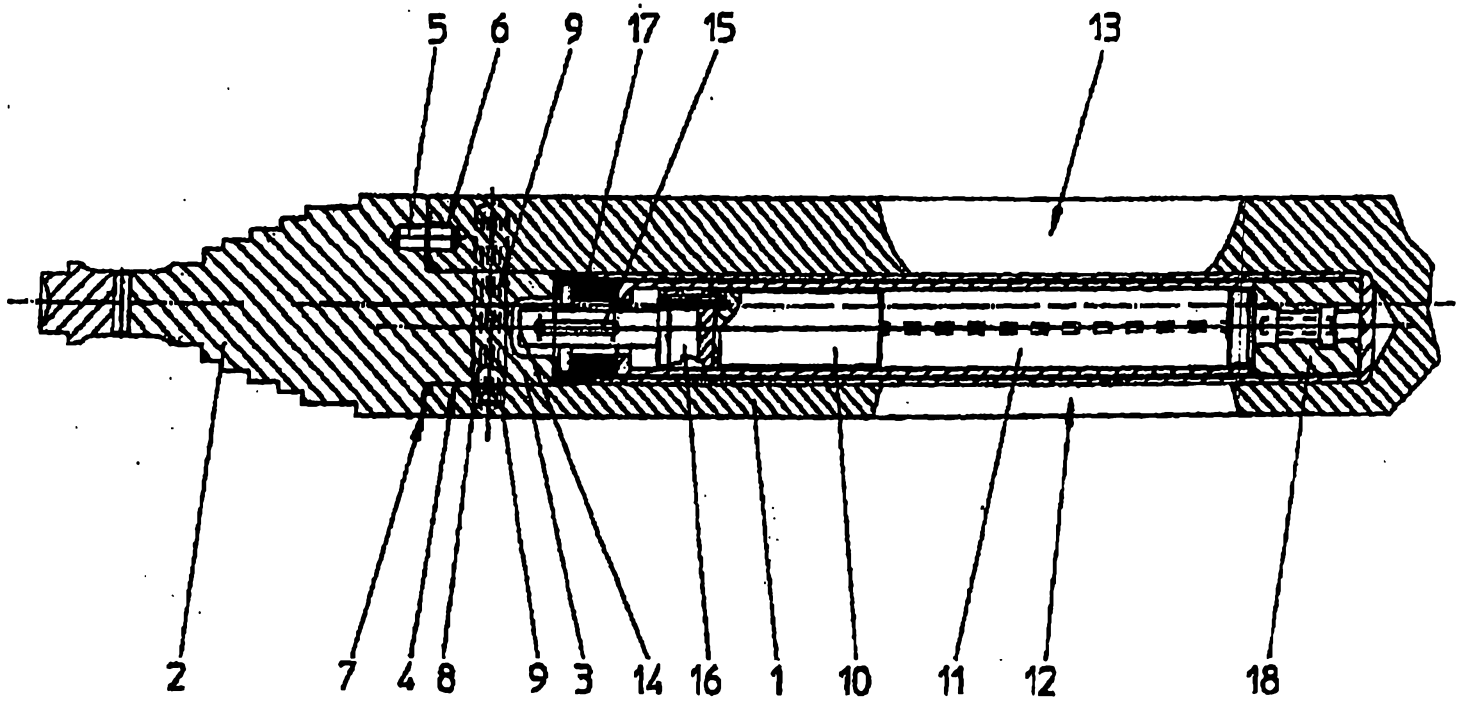

Fig.1

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Invention Title:

METHOD AND APPARATUS FOR STEERING RAM DRILLS

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The following statement is a full description of this invention, including the best method of performing it known to applicant(s):

Method and apparatus for steering ram drills

The invention relates to a method for steering ram drills for straight or curved travel.

Such drills possess a steering or drilling head which can be twisted about its longitudinal axis relative to the drill housing and whose angular position relative to the drill housing determines the direction of movement of the drill.

The manner in which the relative position of steering head and drill housing is adjusted, and in which curved travel is achieved, may vary widely. Examples of steerable ram drills are to be found in US Patent Specifications 5 322 391, 5 350 254 and 5 597 046, and in PCT Published Application WO 94/05941, whose content is expressly incorporated here by way of reference.

In the drill according to the PCT specification, the steering head is designed as a cone and is rotatably mounted in the drill housing; its longitudinal axis extends at an angle relative to the longitudinal axis of the housing. At the same time, the contact surfaces between steering head and housing which extend perpendicularly to the longitudinal axis of the steering head and rest upon one another likewise extend at an angle relative to the longitudinal axis of the housing. In this manner, it is possible to rotate the drill housing about its longitudinal axis while the earth holds the steering head in position. By such a rotation of the housing, the steering head can be brought into an eccentric position relative to the drill housing, in which curved travel takes place. The angle of rotation - hereinafter referred to as the angle of difference - between the steering head and the drill housing or the two end positions of the steering head is determined by an entraining pin connected to the steering head and engaging into a circular slit in the drill housing. If the pin is at one end of the slit in the drill, then the steering head is in its position for straight travel (straight position), whereas at the other end of the slit in the drill it is in the position for curved travel (steering position). In this arrangement, the drill is so designed that the steering head is subject to a tendency always to move into one of the two working positions, as is described in the PCT published application.

In order to bring the ram drill from straight travel to a particular curved path, the drill housing must be rotated, with the aid of the compressed-air hose, until the drill has reached the necessary angular position (starting position) for the desired curved path.

This rotary movement may be composed of two phases. In this case, the first phase comprises a period during which, initially, only the drill housing is rotated, until the entraining pin has covered the entire angle of difference from the straight position into the steering position. As soon as this has occurred, the steering head and the drill housing are coupled to one another for the continuing rotary movement, in other words the drill housing and the steering head rotate together until the starting position for curved travel is reached.

If, by contrast, the entraining pin is in its steering position from the outset, then a rotation of the hose simultaneously entails a joint rotation of the drill housing and steering head. This case arises, for example, if the steering head unintentionally enters the steering position during straight drilling and a corrective movement of the drill housing is therefore necessary, or if a directional correction is necessary during curved travel.

On the other hand, the steering head can also unintentionally enter the straight position during curved travel, so that it has to be brought back into the steering position again by twisting the drill housing with the aid of the compressed-air hose.

It is a problem, in any event, that it is difficult to ascertain from outside the drilled hole or above ground whether the steering head is currently in its steering position or in the straight position. An additional factor is that it is also necessary to ascertain from above ground the angular position, based on the longitudinal axis of the drill, in which the steering position, in other words the end of the slit in the housing which determines curved travel, is located. This cannot be done with the aid of the compressed-air hose, because such hoses lack sufficient torsional strength and, in particular, the torsional strength diminishes with increasing hose length and increasing friction between the hose and the surrounding earth.

If, for example, the steering position is in the 6 o'clock position during straight drilling, and if the ram drill is to be brought from this position onto a

curved track extending upward in a vertical plane, then the steering position must be brought into the 12 o'clock position. This is done by rotating the drill housing with the aid of the compressed-air hose. If the steering head or its entraining pin is in the straight position, then the drill housing initially rotates through the angle of difference only until the entraining pin is located at the other end of the slit in the steering position and the housing then turns into the 12 o'clock position together with the steering head which is now in the steering position.

Since the steering head position is not known outside the drilled hole, it is also impossible to ascertain there what rotation of the hose - with or without covering the angle of difference - is necessary in order to bring the steering position into the correct initial position for curved travel.

In order to eliminate these difficulties, the invention proposes that, in the transition from straight travel to curved travel, the current steering head position relative to the drill housing or the position of the entraining pin in the slit in the housing should initially be ascertained and transmitted to outside the drilled hole, and the drill with the steering head should then be adjusted to the desired curved path or brought into the starting position for curved travel by a rotating action on the compressed-air hose. The necessary angle of rotation of the compressed-air hose can be readily determined if the instantaneous position of steering head and drill housing is known, because it is then also apparent whether the starting position of the drill for curved travel can be achieved with or without an initial, unaccompanied rotation of the drill housing through the angle of difference between the straight position and the steering position of the steering head.

Two parameters always determine the actual direction of drilling: the position of the drill tip in space, or the current deviation of the drill in the vertical and horizontal directions from the drilling axis, and the relative position of steering head and drill housing.

The method according to the invention can be carried out with a ram drill whose housing can be twisted between a straight and a steering position, relative to the steering head, and which is provided with a position sensor which ascertains which of the two working positions the steering head is adopting. The angle of rotation of the steering head can be limited by

engagement of an entraining pin of the steering head into an arcuate slit in the end or contact surface of the drill housing. One end of the slit then determines the straight position and the other end of the slit the steering position, or vice versa. The change from one position to the other then takes place by twisting of the drill housing relative to the steering head, which is held stationary by the earth, with the aid of the compressed-air hose.

The position sensor may be arranged in the drill housing or in the steering head and may, for example, consist of a sensor which ascertains the relative angular position of the drill housing or steering head and, for example, reports via a transmitter or a cable to outside the drilled hole whether the steering head is in the straight or steering position.

If the drill housing contains at least one rolling sensor which displays the lateral deviation of the drill from the intended drilling axis, then the position sensor and the rolling sensor can be so arranged, and provided with an above-ground display, that the latter displays the angle of difference when the steering head or its entraining pin is in the straight position, while the display reads zero when it is in the steering position. Such a display can very easily be implemented with the aid of a dial and a hand which appears only when the steering head - if appropriate after an initial, unaccompanied twisting of the drill housing through the angle of difference - is in the steering position and then displays the current or desired steering direction. In this case, a position sensor is necessary in order to ascertain the relative position of steering head and drill housing, together with a rolling sensor that displays the current angular position in which the housing is situated relative to the predetermined direction of drilling. The position sensor and the rolling sensor can, of course, be combined in a universal sensor which simultaneously also records other parameters, for example the temperature and inclination of the drill relative to a predetermined zero line or the predetermined direction of drilling.

In order to ascertain the two working positions of the steering head, the ram drill may be provided with two inductive stops. Another possibility is to use the transmitter for data transmission as a position sensor. This is possible, for example, by providing the steering head and/or the drill housing with transmission slits assigned to a transmitter which then close when the steering head is in its steering or straight position.

Another possibility is for the steering head and the drill housing to be connected to one another by a type of rotary potentiometer. This makes it possible, by way of a change in the electrical resistance, also to display all intermediate positions which the steering head adopts between its straight and steering positions.

Finally, catches, for example bullet catches, can also be used to fix and display the two working positions of the steering head. Also suitable for this are light barriers and position sensors which measure a radiation intensity that changes over the angle difference.

A second transmitter may also be arranged outside the drill housing, for example in the compressed-air line or in a separate housing outside the compressed-air line. Preferably, the transmitter is located in a separate cylindrical housing which is arranged in a trough-like recess of a half-shell-shaped compressed-air line.

If the ram drill is equipped with two transmitters, then it is advisable to operate the transmitters on different transmission frequencies. In this way, it is possible to separate the data transmitted by the transmitters and analyze them separately without error. This can be done optically with the aid of a receiver screen which displays the current steering position by means of a signal dot.

The rolling sensor should be arranged close to the steering head, but it may also be arranged close to the drill in or on the compressed-air line.

The invention is explained in detail below with reference to examples of the embodiment illustrated in the drawing, in which:

Fig. 1 shows a ram drill having a universal sensor and a transmitter,

Fig. 2 shows a ram drill having one sensor in the steering head and one in the drill housing,

Fig. 3 shows the rear end of a ram drill with a rolling sensor arranged close to the drill,

Fig. 4 shows a plan view of the ram drill according to Fig. 1 at its compressed-air line,

Fig. 5 shows a section along the line V-V in Fig. 4, and

Fig. 6 shows three diagrammatic illustrations of a receiver screen.

The ram drill, only the front part of which is shown in Fig. 1, corresponds in its general nature to the drill described in German Published Application 196 50 271; it consists of a housing 1 and a steering head 2, which is eccentrically mounted by means of a journal 3 in the drilled hole 4 in the housing 1. The steering head 2 possesses an entraining pin 5 which engages into an arcuate slit 6 in the end surface 7 of the housing. The journal 3 is secured by means of tensioning pins 8, which engage into journal recesses 9, against longitudinal movement within the drill housing 1. Located within the housing is universal sensor 10, with the aid of which the rolling of the housing 1, that is to say its angular position in space or in the earth, the angle of the housing relative to a predetermined zero line, the temperature and, in particular, the relative angular position between the housing 1 and the steering head 2 can be ascertained. The sensor 10 forms a structural unit with a transmitter 11, in the region of which the housing 1 possesses transmission slits 12,13. The structural unit 10,11 is mounted in the drill housing 1 with its front end via an anti-torsion device 14 with a connecting pin 15 to a damper pipe 16 and via a damper buffer 17, and by its rear end likewise via a damper buffer 18. Further details of the mounting can be obtained from German Utility Model 298 02 834.

The universal sensor 10 performs two functions with regard to the steerability of the drill. First, it serves to determine the steering head position, as is shown in Fig. 1. This position is wherein the drill housing 1 and the steering head 2 are flush with one another and the entraining pin 5 is located in the straight position, so that the drill moves forward in the direction of the longitudinal axis of the drill under the action of the ram blows of an impact piston (not shown).

If the drill is now to be brought from this situation into the starting position for curved travel, then it is necessary to twist the housing 1 about the steering head pin 3 and, during this rotary movement, to entrain the steering head 2 via the pin 5. This, however, is only possible when the housing 1 has turned so far, relative to the steering head 2, held fixedly by the earth, that the pin 5 has reached the other end of the housing slit 6 and can act as an entraining pin. At this point, in fact, the steering head 2 and the housing 1 are connected to each other by positive fitting in a relative angular position which is connected to an eccentric displacement of the

steering head 2. The starting position for the desired curved track in space has normally, however, not yet been reached as a result of this. Instead, the housing 1 now has to be brought together with the steering head 2, in other words without relative movement thereof, by further rotation of the housing in the same direction into the right angular position in the space, in other words into the starting position for the desired curved track. As soon as the starting position has been reached, no further twisting of the housing 1 or, therefore, of the steering head 2 takes place until a correction of course is necessary or the predetermined end of the curved track is reached.

Such a course correction may occur as a result of further rotation of the housing in the same direction of rotation or a backward rotation of the housing into the original position shown in Fig. 1 relative to the steering head 2, in order to drill straight in the short term.

The ram drill shown in Fig. 2 is, in principle, no different in structure from the ram drill according to Fig. 1; identical parts are therefore also allotted the same reference numbers.

In this ram drill, however, a structural unit 19 comprising a further rolling sensor for ascertaining the angular position of the steering head and a transmitter is located in the steering head 2 provided with transmission slits 20 and 21. There, it is arranged in a metal pipe 22 likewise provided with transmission slits. In this drill, the relative position of the steering head and of the housing can be ascertained by means of the front sensor in the structural unit 19 and the rear sensor 10 and transmitted via the two associated transmitters to outside the drilled hole.

Fig. 3 merely shows the connecting socket 23 arranged at the rear end of a ram drill of the type shown in Figs. 1 and 2, to which the compressed-air hose 26 is fixed by means of a hose socket 24 and a pressure-fit sleeve 25, by means of which hose the drill housing can be twisted relative to the steering head or the drill housing can be twisted with the steering head. A hose 27, via which a control sleeve (not shown) is supplied with control air for switching the ram drill from forward running to reverse running extends through the compressed-air hose 26.

In contrast to the two drills according to Figs. 1 and 2, the rolling sensor is not located within the housing but, as a structural unit 28, is located at the end of the connecting socket 23 within the compressed-air hose 26.

The structural unit 28 may also contain a transmitter. Otherwise, a transmitter 29 may also be located in a cylindrical transmitter housing 30, which is arranged in the trough-like recess of a half-shell-shaped section of the compressed-air line 31.

The transmitter signals are visually displayed on a receiver screen 32 having concentric circles 33 in the form of a signal dot 34. If the signal dot 34 is at the center of the receiver screen 32 (Fig. 6, left-hand illustration), then the steering head 2 of the ram drill is in its straight position and straight drilling is accordingly taking place. If the signal dot 34 appears on the outermost circle (cf. Fig. 6, middle illustration), then the steering head 2 is fully deflected in the 1 o'clock position; the drill then moves toward the top right. If the signal dot is at the 10 o'clock position, however, on one of the center rings (cf. Fig. 6, right-hand illustration), then the drill is not fully deflected and moves toward top left.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for steering a ram drill with the aid of a steering head rotatably mounted in the drill housing, wherein the steering head can be brought into a predetermined starting position for straight drilling or curved travel by twisting the drill housing, in the event of a change of direction into the starting position for curved travel, the current position of the steering head relative to the drill housing is initially ascertained, and the drill housing is then twisted through the angle between the ascertained steering head position and the starting position for curved travel.

2. A steerable ram drill having a steering head rotatably mounted in the drill housing, comprising a position sensor (10,19) for ascertaining the steering head position relative to the drill housing (1).

3. The ram drill as claimed in claim 2, wherein a position sensor (10,19,28) is arranged both in the steering head (2) and in the drill housing (1).

4. The ram drill as claimed in claim 2 or 3, wherein the position sensors (10,19,28) are designed as rolling sensors.

5. The ram drill as claimed in one of claims 2 to 4, wherein at least one of the position sensors (10,19,28) is provided with a transmitter (11) and the drill housing (1) and/or the steering head (2) is provided with transmission slits (12,13;20,21).

6. The ram drill as claimed in one of claims 2 to 5, wherein the steering head (2) or the drill housing (1) is provided with two twist stops.

7. The ram drill as claimed in claim 6, wherein an entraining pin (5) of the steering head (2) engages into an arcuate slit (6) in the drill housing (1).

8. The ram drill as claimed in claim 6, wherein an expansion measurement spring extends between the steering head (2) and the drill housing (1).

9. The ram drill as claimed in claim 6, comprising inductive stops.

10. The ram drill as claimed in claim 6, wherein the steering head (2) and the drill housing (1) are locked together in their two working positions.

11. The ram drill as claimed in claim 6, wherein the steering head (2) and the drill housing (1) are connected to each other via a type of rotary potentiometer.

12. The ram drill as claimed in one of claims 1 to 11, wherein the longitudinal axis of a conical steering head (2) extends at an angle relative to the longitudinal axis of the housing and the angle between the longitudinal axis of the steering head and the plane (7) of contact between the steering head and the housing (1) is 90°.

13. The ram drill as claimed in one of claims 2 to 12, comprising a transmitter (28;29) arranged outside the drill housing (1).

14. The ram drill as claimed in claim 13, wherein the transmitter (28) is arranged in the compressed-air line (26).

15. The ram drill as claimed in claim 13, wherein a transmitter (29) is arranged in a separate housing (30) adjacent to the compressed-air line (26).

16. The ram drill as claimed in claim 15, wherein a cylindrical transmitter housing (30) is arranged in the depression of a compressed-air line (31) in the form of a half-shell.

17. The ram drill as claimed in one of claims 2 to 16, comprising two transmitters (11,19,28,29) of different transmission frequencies.

18. The ram drill as claimed in one of claims 2 to 17, comprising two sensors for ascertaining a lateral deviation of the position of the drill in the earth, based on the predetermined drilling direction.

19. **The ram drill as claimed in one of claims 2 to 18, having a receiver, wherein the transmitter (11;19) generates a signal dot (34) on the receiver screen (32) showing the steering position of the steering head (2).**

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David B Fitzpatrick

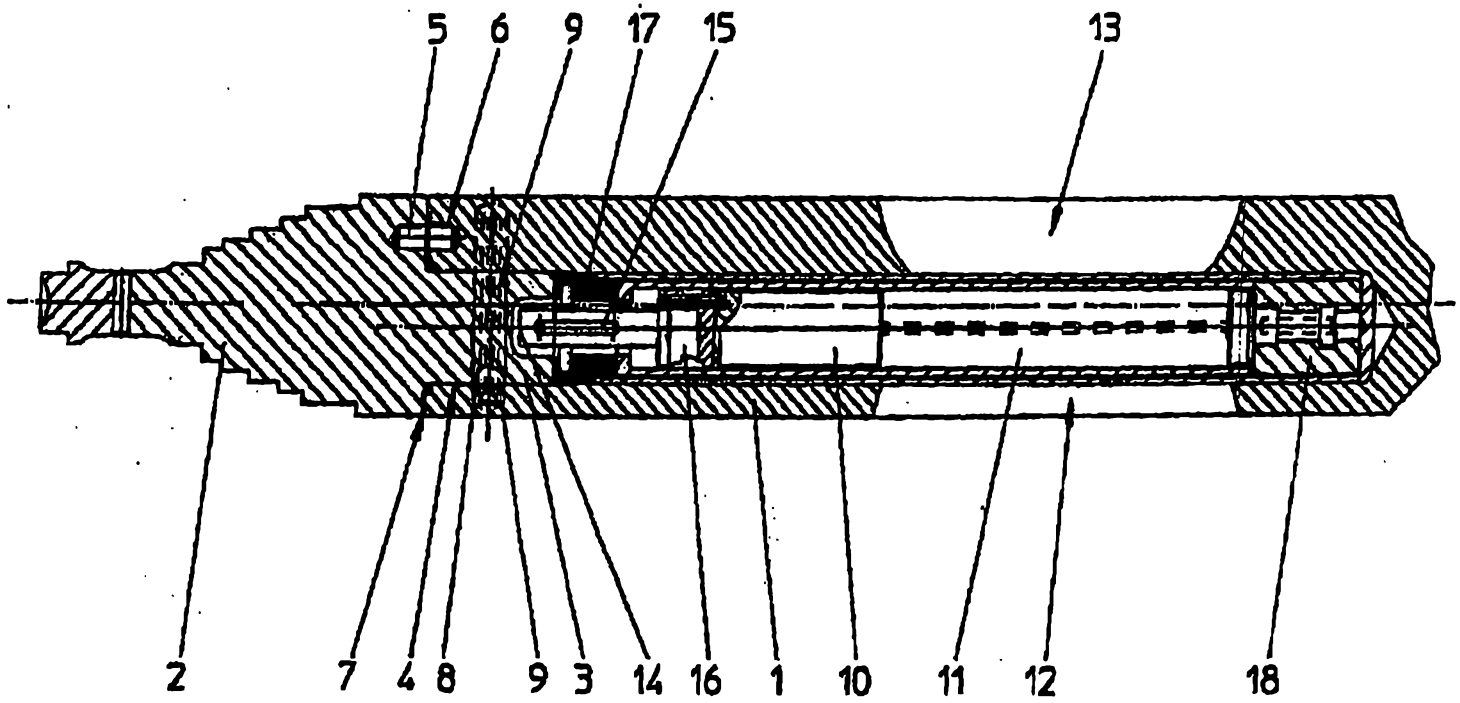

Fig.1

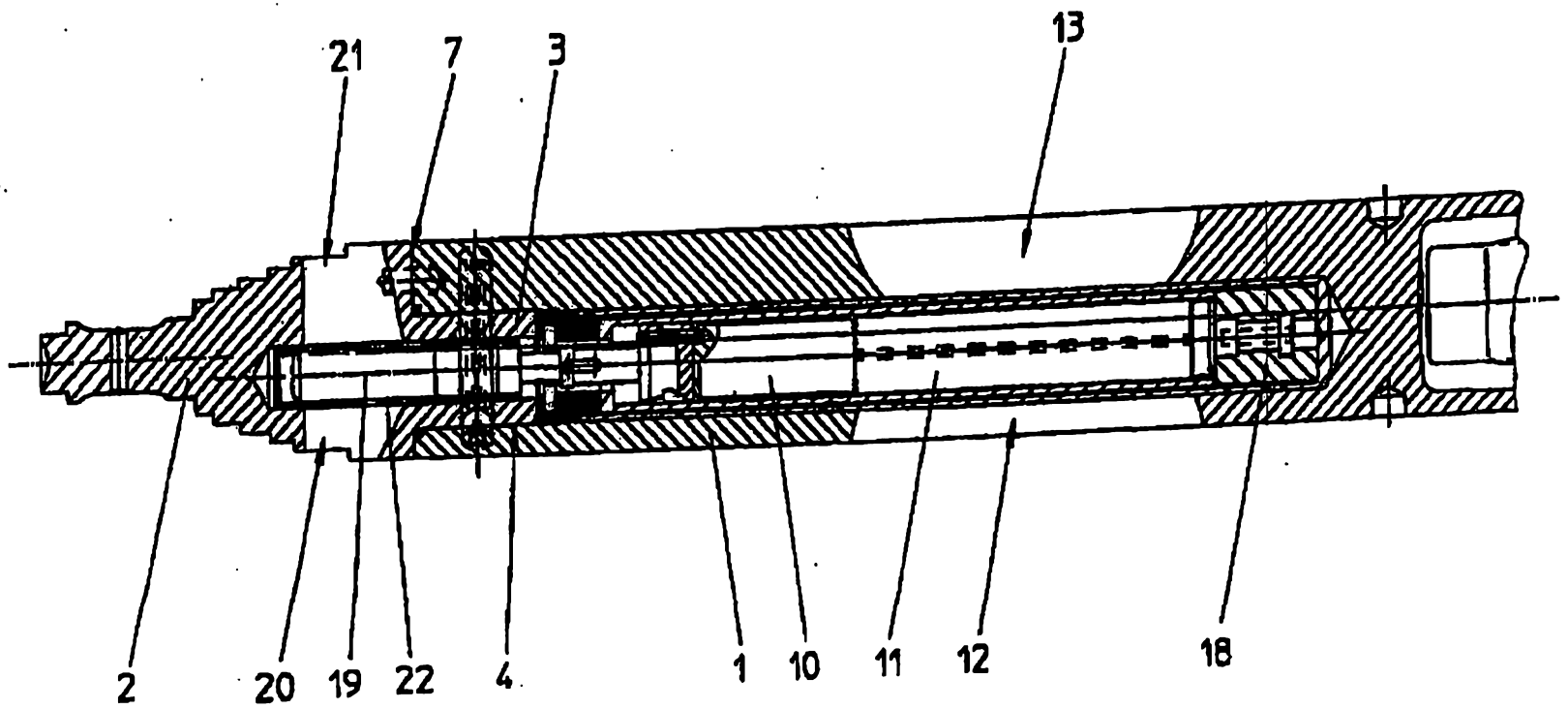

Fig.2

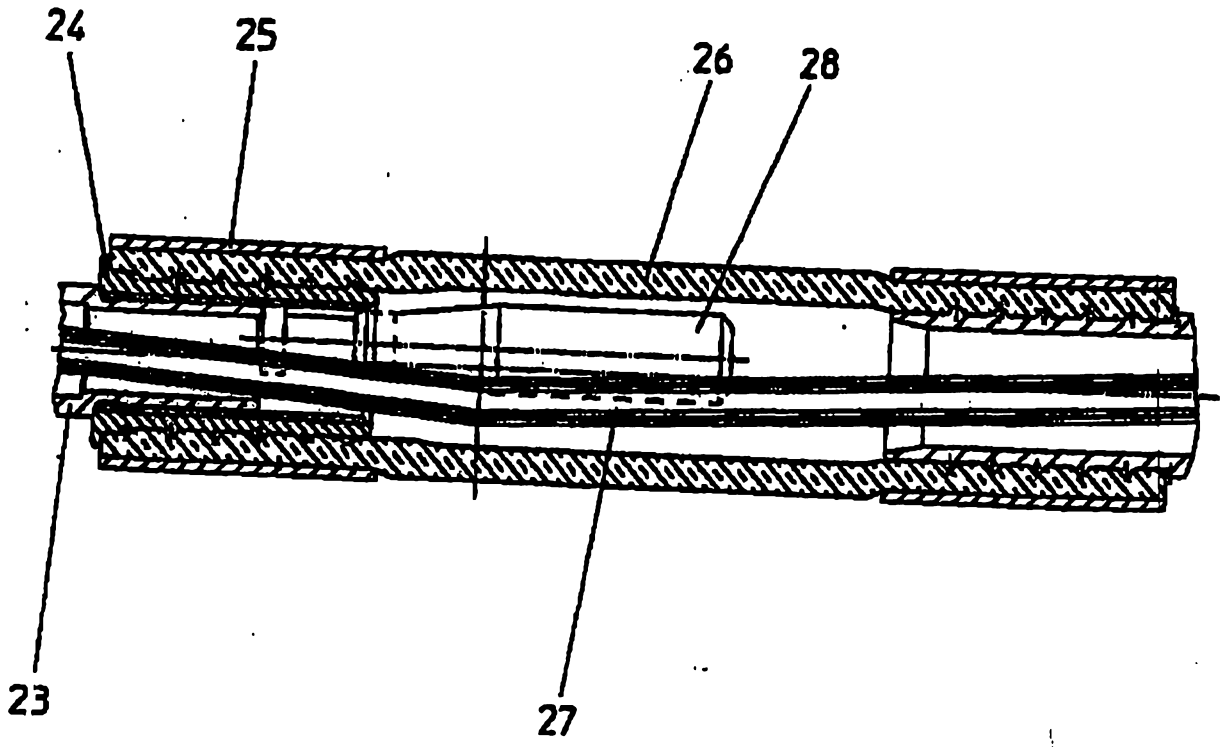

Fig.3

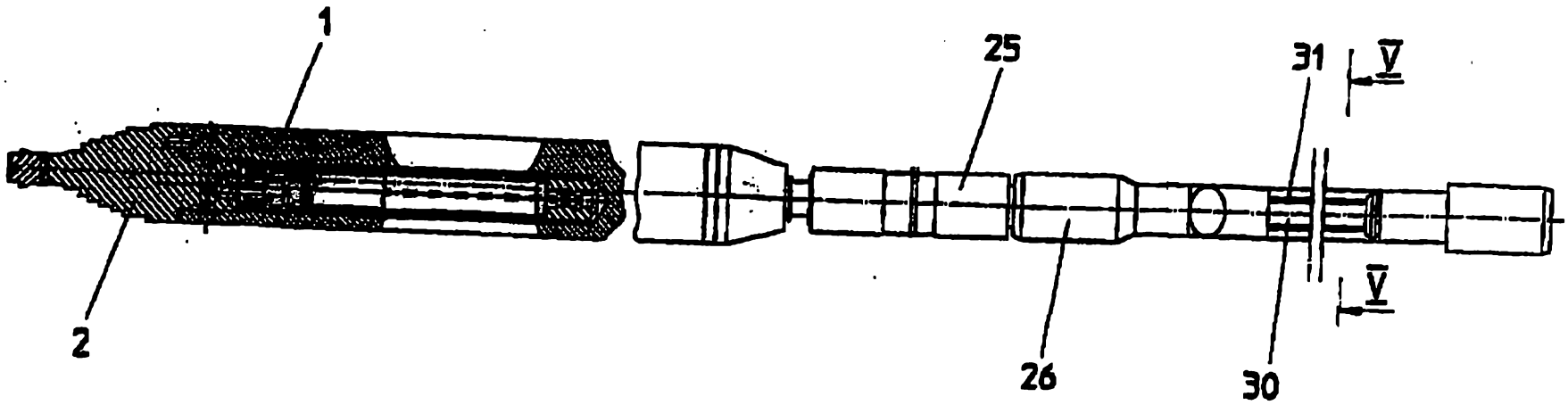

Fig.4

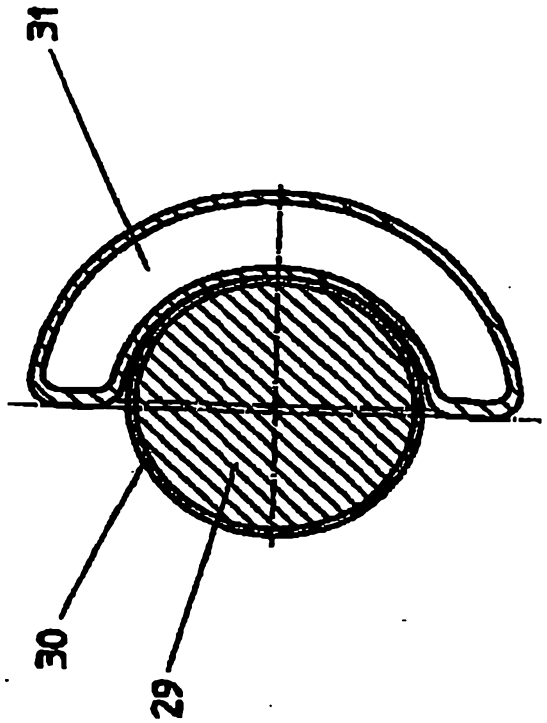

Fig.5

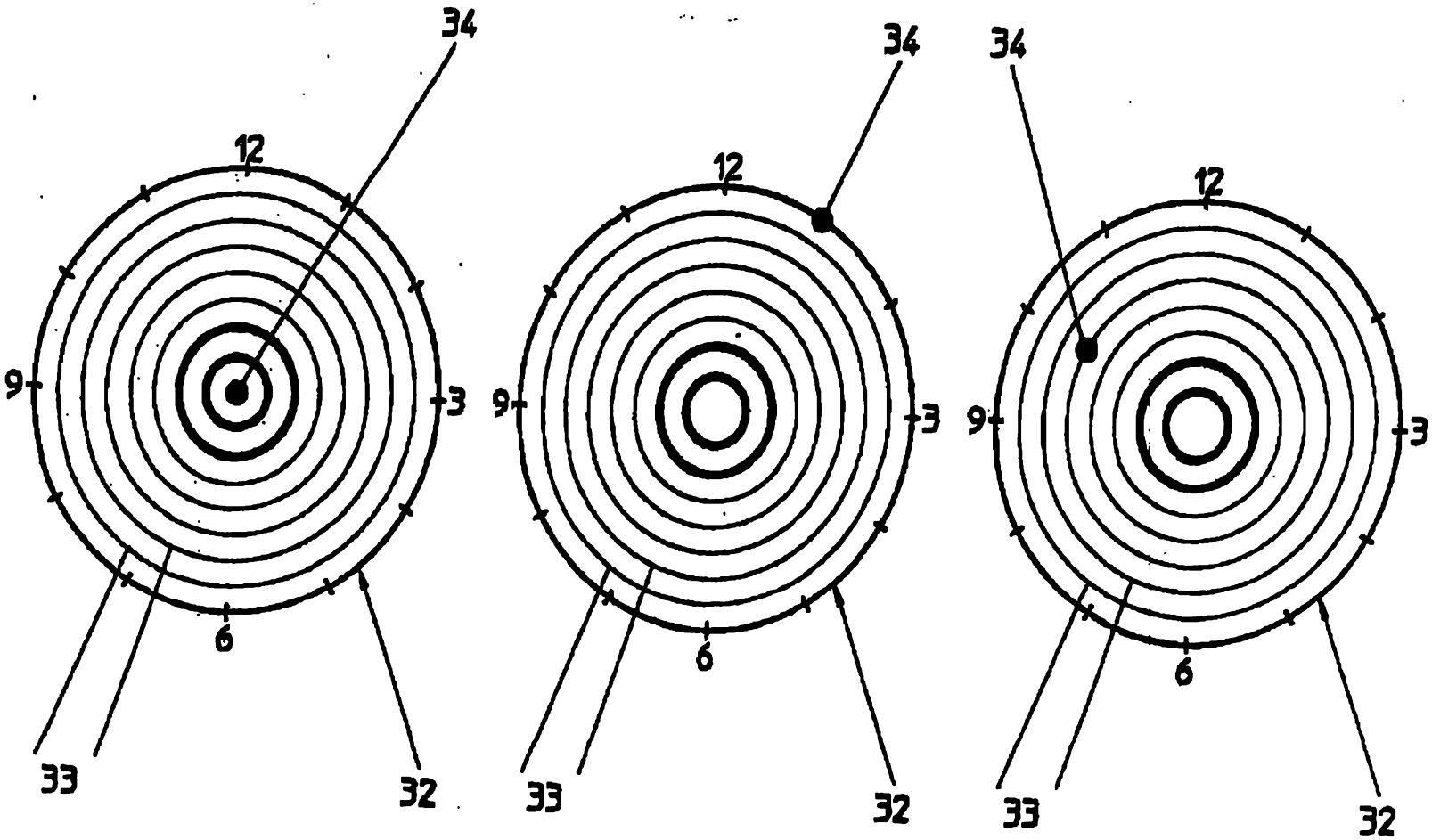

Fig.6