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Rock bolt and installing method

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(56) Related Art
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ABSTRACT

The present invention relates to tubular rock bolts (1) closed at the bolt leading end and having a drive mechanism (8, 30) at the bolt trailing end. A sleeve (20) is carried by the bolt (1) and in turn carries a cartridge of resin (60). The bolt (1) is rotatable about its longitudinal axis by means of the drive mechanism (8, 30). The drive mechanism (8, 30) is rigidly connected to the bolt trailing end.

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COMPLETE SPECIFICATION

FOR A STANDARD PATENT

ORIGINAL

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Invention Title:	Rock Bolt and Installing Method
Details of Associated Parent Application:	739333 (formerly 22425/99)

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

ROCK BOLT AND INSTALLING METHOD

The present invention relates to rock bolts and methods of installation of rock bolts.

A form of rock bolt is known in the mining industry which is used for increasing the strength of a wall or roof of a mine. The bolt is formed of a solid steel rod having a diameter in the order of 22 millimetres and a nut threadably fitted to one end thereof. In use, the bolt is secured in a 27 millimetre diameter hole formed in the rock strata by means of a chemical anchor in the form of a resin. When so secured the nut is screwed along the bolt to draw the strata together and thereby increase the tensile strength of a portion of the wall or roof in which the bolt is secured. The method of installing the bolt includes drilling a hole in the rock, manually inserting a cartridge containing chemical (resin) components in the hole, inserting the bolt in the hole to rupture the cartridge and rotating the bolt so as to mix the components to form the chemical (resin) anchor. Such a method does however, have a number of disadvantages, one of which is that difficulties are experienced in preventing the cartridge from sliding back out of the hole before the bolt is inserted therein.

The aim of the present invention is to provide an alternative rock bolt.

In accordance with a first aspect of the present invention there is disclosed a rock bolt for insertion in a hole drilled in a surface, said bolt having a tubular side wall extending over at least a substantial portion of its length, and having a leading end substantially closed to ingress or egress of flowable resin, a trailing end and a longitudinal axis extending therebetween, wherein said trailing end has a drive means to permit said bolt to be rotated about said longitudinal axis and wherein said drive means is rigidly connected to said tubular side wall.

The nature of a chemical anchor, which is preferably a resin anchor, requires that the diameter of the bolt should be only slightly smaller than that of the hole in which it is inserted, say in the order of four millimetres. This provides a two millimetre angular gap therebetween. In the case of hard rock mining the holes are in the order of 50% larger in diameter than the holes used in coal mining. This increased size is a function of the drilling machinery used in hard rock mines itself being larger than that used in coal mines. Chemical anchors are, therefore, clearly not suitable for use with relatively small diameter bolts as the spacing between the bolt and the walls of the hole would be too great for a chemical anchor to be effective.

Due to the increased diameter of "hard rock" holes, a different method of installing rock bolts is generally practised in hard rock mining. This involves attachment of an expandable "shell" to an end of a bolt forming a mechanical anchor and, inserting the bolt into a hole. Once the bolt is fully inserted the shell is expanded to grip the walls of the hole to thereby locate the bolt, then cementacious grout is injected into the annular region between the bolt and the walls of the hole.

It would, of course, be possible to utilise a chemical anchor in hard rock mining if a bolt of sufficiently large diameter were employed. The cost of producing a solid bolt of such diameter would, however, tend to be prohibitive, such as for example, a 41 millimetre diameter solid bolt for use in a 45 millimetre diameter hole. A hollow bolt would incur less material cost but would not have significant cost advantage unless the wall thickness of the hollow bolt was relatively thin, to minimise the amount of material used in the bolt. A bolt of this type would, however, have reduced loading bearing characteristics and some additional structure would be required to provide sufficient strength to the bolt. Accordingly, the bolt used in a preferred embodiment also preferably has some form of deformations along its length. For example in the form of a thread. This both increases the stiffness of the bolt and increases the bonding effectiveness of the chemical anchor. However, formation of the thread by a conventional cutting, rolling or milling technique would further reduce the wall thickness of the bolt in the troughs of the thread and thereby lead to a decrease in the tensile strength of the bolt.

Accordingly there is disclosed a method of forming a thread on a tubular bolt comprising exerting an inwardly directed force relative to the bolt whereby to plastically inwardly deform a portion of a wall of the bolt whilst substantially maintaining the wall thickness along the length of the thread, the force being exerted at an angle to the normal of the bolt such that one of the flanks of the threads is inclined toward the normal to a substantially greater extent than the other flank. Such a method of forming the thread has the advantage of retaining the wall thickness of the tube therefore retaining tensile strength. Actual tests have shown an increase in tensile strength. In addition, a thread has the advantage that a corresponding thread is formed on the interior of the bolt whereby various fittings such as expandable shells, or drill bits may be mounted to the end of the bolt by being screwed on to the internal threading. Another advantage is that the flank that is angled toward the normal provides a surface which can be loaded with compressive force of the rock strata, thereby increasing the in-situ loading characteristics of the bolt. The overall strength of the bolt is also not adversely affected since the wall thickness of the bolt is maintained. However, a transverse cutting force exerted by, for example, a long wall miner will be able to cut through the bolt in a transverse direction relatively easily, as opposed to a solid bolt of the same dimensions.

So there is also disclosed a bolt having a thread formed in accordance with the above-described method. Preferably, the bolt has a drill bit fitted to an end thereof.

Also, in hard rock mining, tensioning of the bolt is generally not required and all that has been done hitherto after a bolt has been anchored in a rock face, is to secure a roof plate or the like to the rock face by means of securing a nut along a thread formed on the end of the bolt. Such a two step process of fixing the bolt and then securing the roof plate can, however, be achieved in a single step by having the nut fixedly secured to the bolt and driving the bolt into the rock to its maximum extent.

It will be appreciated that a number of different inventive concepts have been described above in relation to rock bolts but that a number of such concepts may be embodied in a single bolt formed in accordance with the present invention – or parts of the invention embodied in a single bolt depending on the requirements of the application for the rock bolt's use.

Preferred embodiments of the invention will hereinafter be described with reference to the accompanying drawings in which:

Fig. 1 is a schematic cross-sectional side view of a hollow rock bolt;

Fig. 2 is a partially cut-away view of the rock bolt shown in Fig. 1;

Fig. 3 is a cross-sectional view of the cartridge portion of the rock bolt shown in Figs. 1 and 2;

Fig. 4 is a side elevation of the cartridge sleeve of a cartridge for use with the form of rock bolt shown in Figs. 6A to 6D;

Fig. 5 is an end elevation of the cartridge sleeve shown in Fig. 4;

Figs. 6A to 6D show a form of rock bolt according to the present invention and a method of installation thereof.

Fig. 7A shows a side elevation with superimposed end elevations of drive members suitable for use in the installation of rock bolts according to the present invention;

Fig. 7B shows the driver tool of Fig. 7A in the coupled position with a rock bolt;

Fig. 7C shows a plan and sectional side elevation of the rock bolt shown in Fig. 9;

Fig. 8A shows a rock bolt according to a form of the present invention and Figs. 8B to 8D show various applications of that rock bolt;

Fig. 9 is a schematic view of an end portion of a form of rock bolt according to the present invention; and

Fig. 10 is a schematic sectional side elevation of a form of rock bolt according to the invention.

The rock bolt 1, as shown in Fig. 1, comprises a hollow shaft 2 with thread 3 formed on an exterior surface thereof and a cartridge 4 provided therewithin. The bolt may have an open front end 5 but is shown by way of example as having a drill bit 6 secured thereto. In operation, the front end 5 is inserted in a hole formed in a rock face and the cartridge 4 injected through the hollow shaft 2 with a syringe action from pressure on the plunger into the hole 9. Prior to exiting the bolt 1 the resin may be mixed by cross-wires 7, or alternatively, mixing of the resin may occur after exiting the bolt 1. As shown in Fig. 3, the cartridge contains a resin 60 and a catalyst 61 separated by a membrane 62. The bolt is then rotated whereby to mix the chemical (resin) components of the ruptured cartridge and to simultaneously work the components along the length of the bolt 1, toward the opening of the hole. Alternatively, a sufficiently large amount of chemical compounds may be forced into the hole 9 from the bolt such that additional spinning of the bolt is not required.

After the chemical anchor has set, a nut 8 may be screwed along the free end 10 of the bolt to secure a load bearing plate 11 against the rock face 12.

The chemical cartridge 4 is preferably forced along the bolt 1 by means of a plunger 15 which preferably has circumferentially arranged axially extended openings 16 formed therein to allow passage of water through the bolt 1 for lubrication of drill bit 6 during a drilling operation. The holes 16 may, however, be sealed such that the plunger is forced by way of hydraulic pressure along the inside of the cartridge 4, thereby forcing the resin from the bolt 1. The cartridge is also preferably formed with lengthwise extending splines 17 which serve to hold the cartridge 4 in a generally central position with respect to the shaft 2 whilst also allowing liquid from opening 16 to pass therearound.

As an alternative to the above-described bolt, the cartridge 4 may instead be removably attached to the front end of the bolt by means of a sleeve 20, as shown in Figs. 6A to 6D. Details of the sleeve are shown in Figs. 4 and 5. The sleeve 20 is formed of a resilient material which allows one end 21 thereof to be fitted on an end of the bolt and has an open end 22 for receiving and holding the cartridge 4. The sleeve is concertinaed with the ribs 24 running parallel with the axis of the tubular bolt thereby allowing the sleeve to expand to the diameter of the bolt when expanded and hold the smaller diameter cartridge when contracted. The sleeve 20 also preferably has a flange 23 which is adapted to engage the rock face 12 when the bolt is inserted in hole 9 such that further insertion of the bolt causes the bolt to pass through the sleeve 20 whereby the cartridge is carried forward by the front end of the bolt. The sleeve 20 and flange 23 are preferably formed of plastic whereby to protect the portion of the bolt adjacent the opening of the hole from water damage and corrosion. Preferably, the flange 23 is in the form of a conventional plate against which nut 8 may be engaged.

Either of the above described bolts can have the nut 8 formed integrally with the bolt 1, such as by welding or the like. This is particularly advantageous in hard rock mining wherein tensioning is generally not required and the only function to be served by the nut is that of securing the plate 11 to the rock face 12. In this regard, a driving member 30 of the type shown in Figs. 7A-7C and 9 can be employed. Such a member 30 comprises a ring 31 welded to the end of bolt 1 and provided with bosses 32 which engage in corresponding recesses of a driving mechanism (not shown) which is used for inserting and spinning the bolt 1 in hole 9. The form of the member 30 is particularly advantageous in that the material used can be significantly less than a conventional nut. The bosses 32 are preferably regularly spaced so that the ring 31 has a castellated appearance.

When using a hollow bolt in hard rock mining, the wall thickness of the bolt must be such as to maintain the strength of the bolt whilst also keeping material costs to a minimum. In order to achieve an optimal minimal wall thickness, the present invention provides a thread as illustrated in Fig. 10. Such a thread 40 is formed by plastically deforming the walls 41 of bolt 1 in a manner whereby the actual wall thickness of the bolt itself is maintained. This is achieved by applying a force in the direction indicated by the arrow marked "T" that is angled away from the normal "N" such that two generally perpendicular flank surfaces 42 and 43 are produced. This is done as the pitch of the thread is decreased while leading into the rolls and having the helix angle of the rolls at a ratio of pitch change to move the material inwards and in the direction of F without stretching and skimming the wall which results in the same diameter as the feed stock. The rolls, unlike conventional designs, are individually profiled to achieve a constant flow of material reducing stress. Surface 42 is substantially normal to the axis of bolt 1 and is thereby exposed to carry a greater force F than is possible with a conventional V-shaped thread. Also, maintaining the wall thickness means that the overall tensile strength of the bolt 1 is increased in comparison with a bolt having the same initial dimensions but formed with a conventional thread which reduces the wall thickness.

Figs. 8A to 8D show various rock bolts 1 with a thread as described above being used in various applications. Fig. 8A shows the standard rock bolt 1 with threaded section 3 and nut 8. Fig. 8B shows the rock bolt 1 having a mechanical anchor 30 attached to the end thereof. Fig. 8C shows the rock bolt similar to the arrangement shown in Fig. 1. Fig. 8D is a further variation.

As will be appreciated from the above, the diameter of the bolt hole used in hard rock mining is too great to justify material costs of chemically anchoring solid bolts with an optional resin annulus of 2 mm, the larger the annulus the poorer the mixing of the resin and the weaker the holding capacity of the bolt. The thread as described above, however, overcomes these problems to some extent at least by allowing for the bolt to have a reduced wall thickness of, for example, 4 mm (with say an 8 mm pitch) in a bolt of about 34 mm diameter, whilst maintaining a suitable tensile strength. A standard solid bolt of 21.7 mm diameter 2000 mm long, grade 250 Mpa, resin anchored in a 27 mm diameter hole uses 0.4 litres of resin and has a UTS of 18 tonnes. A standard solid bolt of 21.7 diameter 2000 mm long, grade 250 Mpa, resin anchored in a 45 mm diameter hole uses 2.4 litres of resin and has a resin failure of 12 tonnes. A hollow bolt of 41 mm diameter, 4 mm wall, 2000 mm long, grade 250 Mpa, resin anchored in a 45 mm diameter hole uses 0.54 litres of resin and has a UTS of 22 tonnes. The process of chemically anchoring rock bolts is, therefore, more economically viable for hard rock mining techniques using the present invention than has previously been the case. Also, the thread formed as described above provides a bolt with an internal thread that is suitable for mounting a number of different devices, such as drill bits etc.

Also, the injection of chemical through the bolt, or attaching the chemical to an end of the bolt as described above, increases the ease by which a bolt may be secured using a chemical anchor and increases the overall speed at which installation can be achieved compared with previous grouting techniques.

The installation of one of the above described bolts can also be further simplified by having the drive member, described with reference to Figs. 7A-7C and 10, formed integrally with the bolt.

Many modifications and variations may be made to the above described bolts and method of installing the bolts without departing from the spirit and scope of the invention.

The term “comprising” (including grammatical variations thereof) as used herein is used in the inclusive sense of “including” or “having” and not in the exclusive sense of “consisting only of”.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A rock bolt for insertion in a hole drilled in a surface, said bolt having a tubular side wall extending over at least a substantial portion of its length, and having a leading end substantially closed to ingress or egress of flowable resin, a trailing end and a longitudinal axis extending therebetween, wherein said trailing end has a drive means to permit said bolt to be rotated about said longitudinal axis and wherein said drive means is rigidly connected to said tubular side wall.
2. The bolt as claimed in claim 1 wherein said drive means is integrally formed with said bolt.
3. The bolt as claimed in claim 1 wherein said drive means is permanently connected to said bolt.
4. The bolt as claimed in any one of claims 1-3 wherein said drive means comprises a nut.
5. The bolt as claimed in claim 4 wherein said nut is welded to said bolt.
6. The bolt as claimed in any one of claims 1-5 wherein the interior of said tube is accessible via said drive means.
7. The bolt as claimed in any one of claims 1-3 wherein said drive means is substantially annular and includes a plurality of bosses.
8. The bolt as claimed in claim 7 wherein said bosses are substantially evenly spaced and form castellations on said drive means.
9. The bolt as claimed in claim 7 or 8 wherein the interior of said bolt is accessible via said drive means.
10. The bolt as claimed in any one of claims 1-9 wherein at least a portion of the interior of said rock bolt is provided with an interior thread.

11. A drive means for a rock bolt, said drive means being substantially as herein described with reference to Figs. 6A-7C or Figs. 8A-8D or Fig. 9 of the drawings.

Dated this 11th day of January 2002.

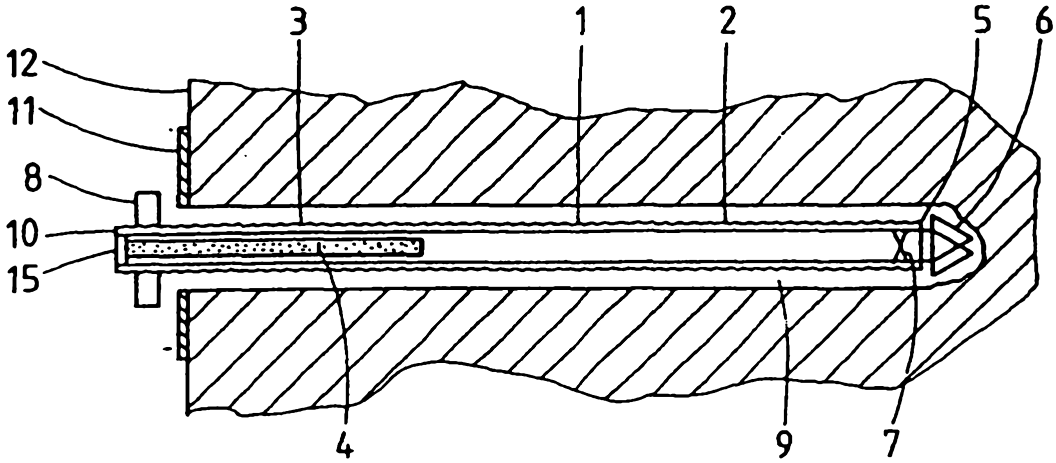
JEFFREY ROBERT FERGUSSON

BY:

HODGKINSON OLD McINNES

Patent Attorneys for the Applicant

FIG 1



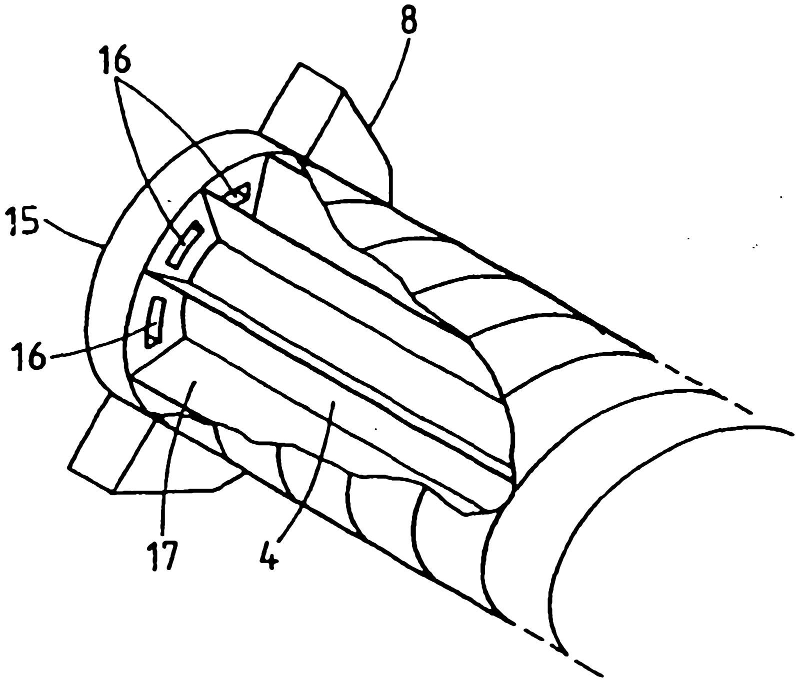


FIG 2

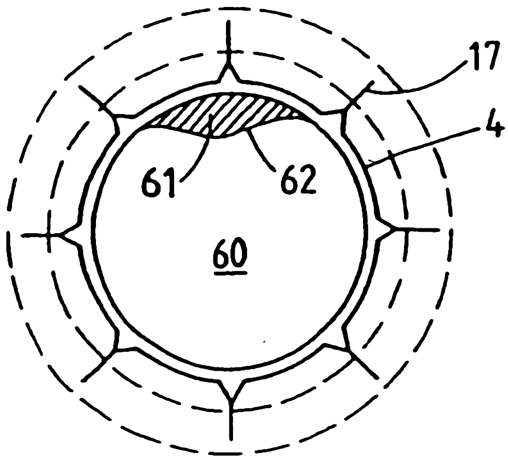


FIG 3

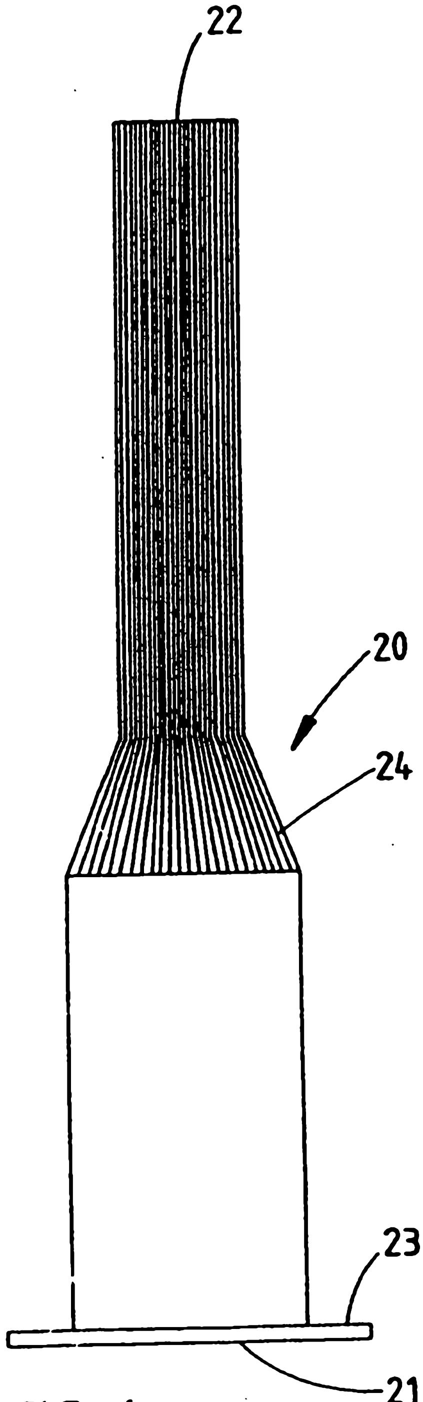


FIG 4

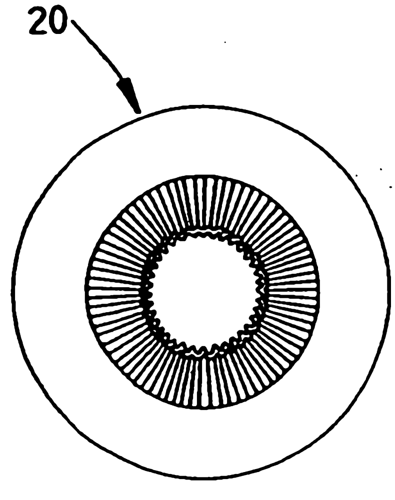


FIG 5

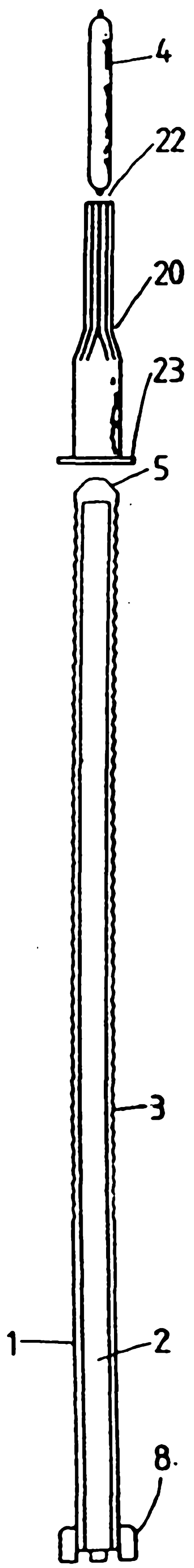


FIG 6A

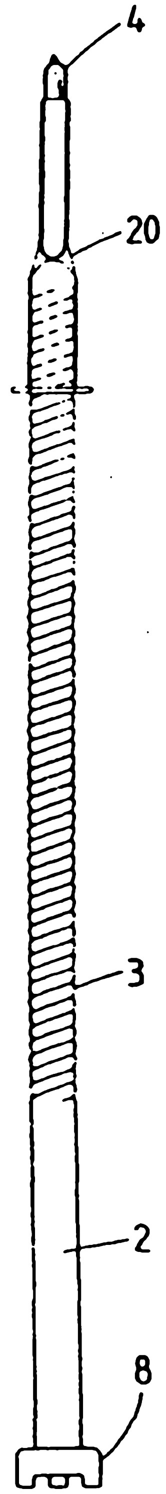


FIG 6B

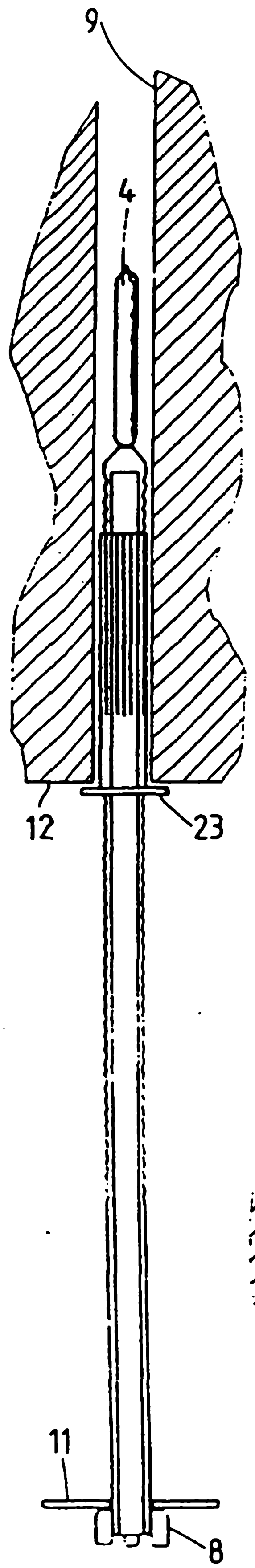


FIG 6C

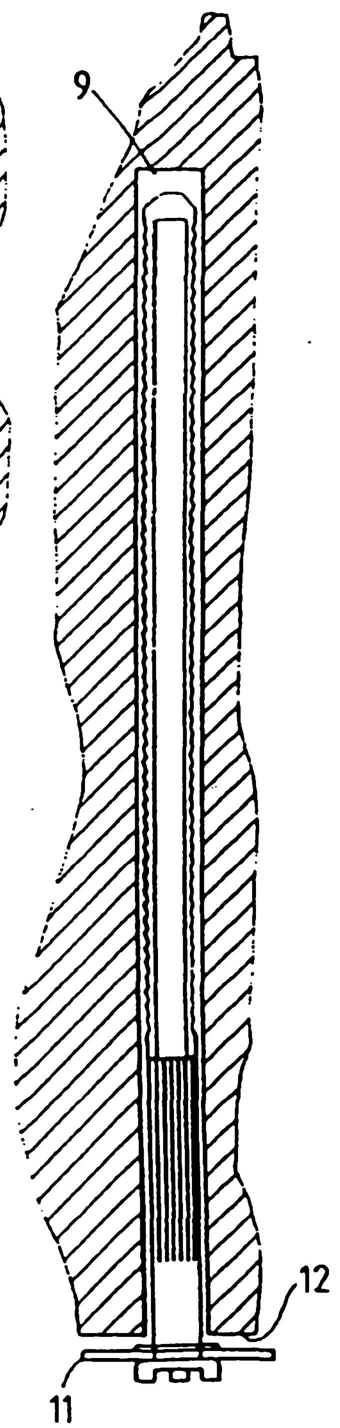


FIG 6D

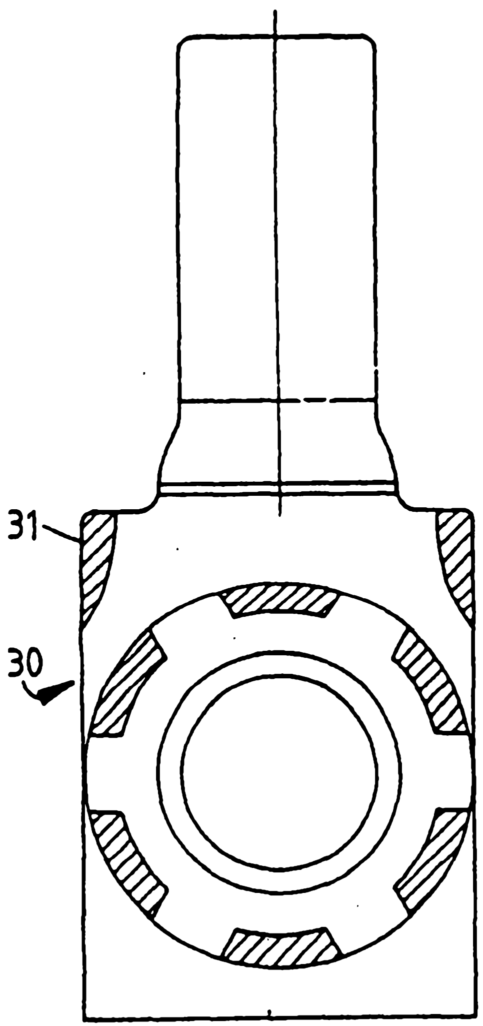


FIG 7A

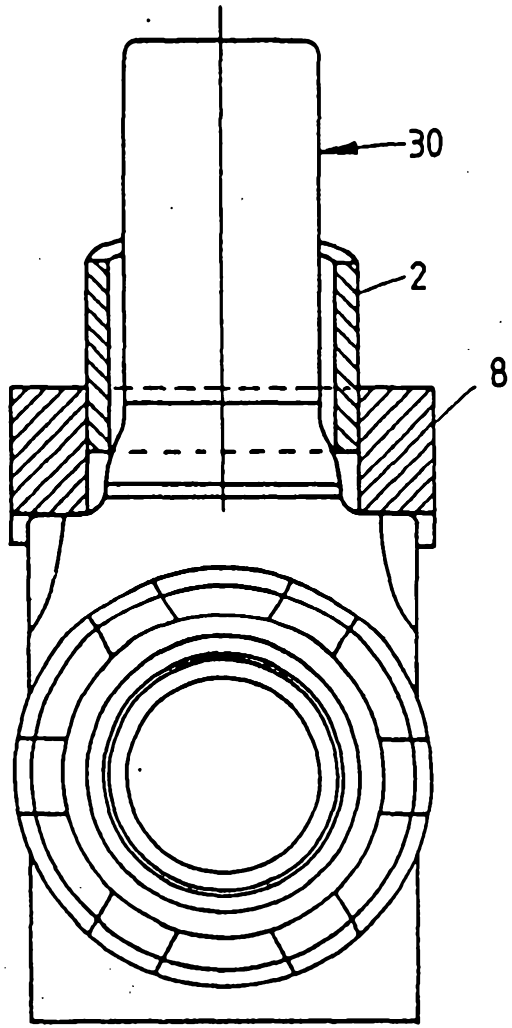


FIG 7B

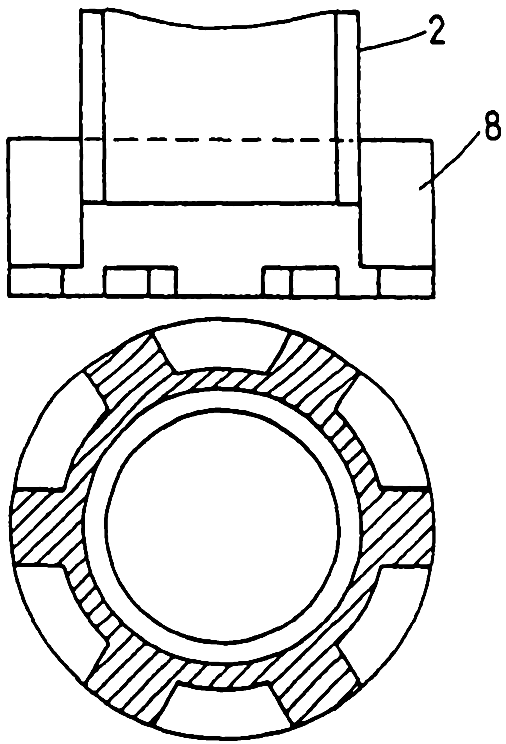


FIG 7C

FIG 8A

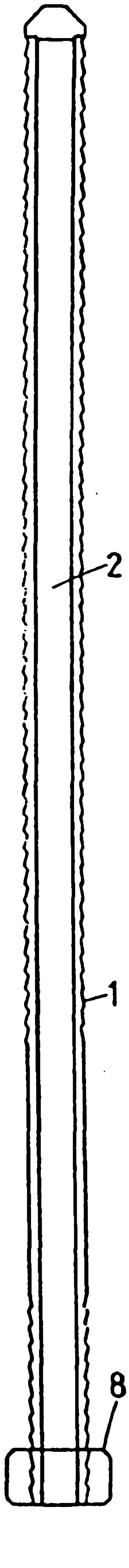


FIG 8B

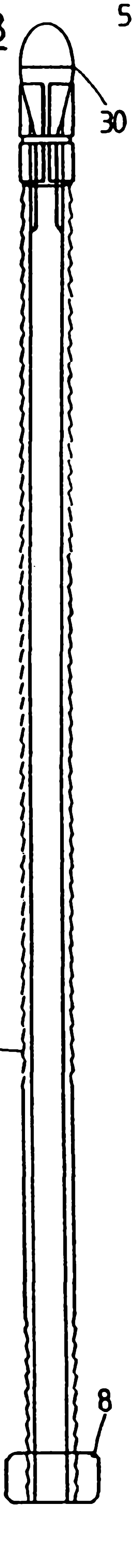


FIG 8C

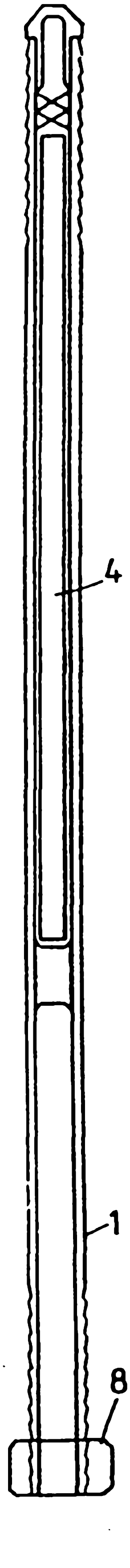
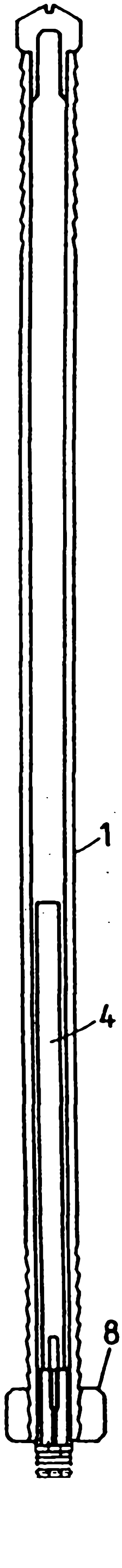


FIG 8D



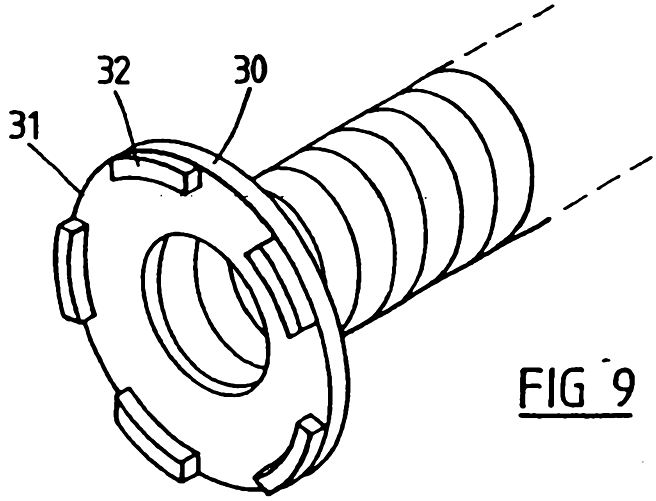


FIG 9

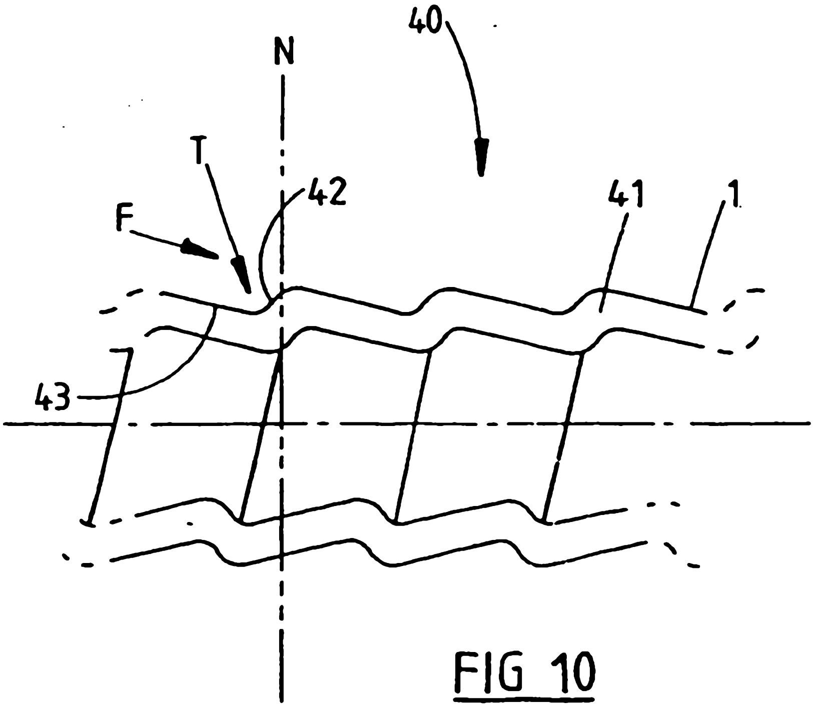


FIG 10