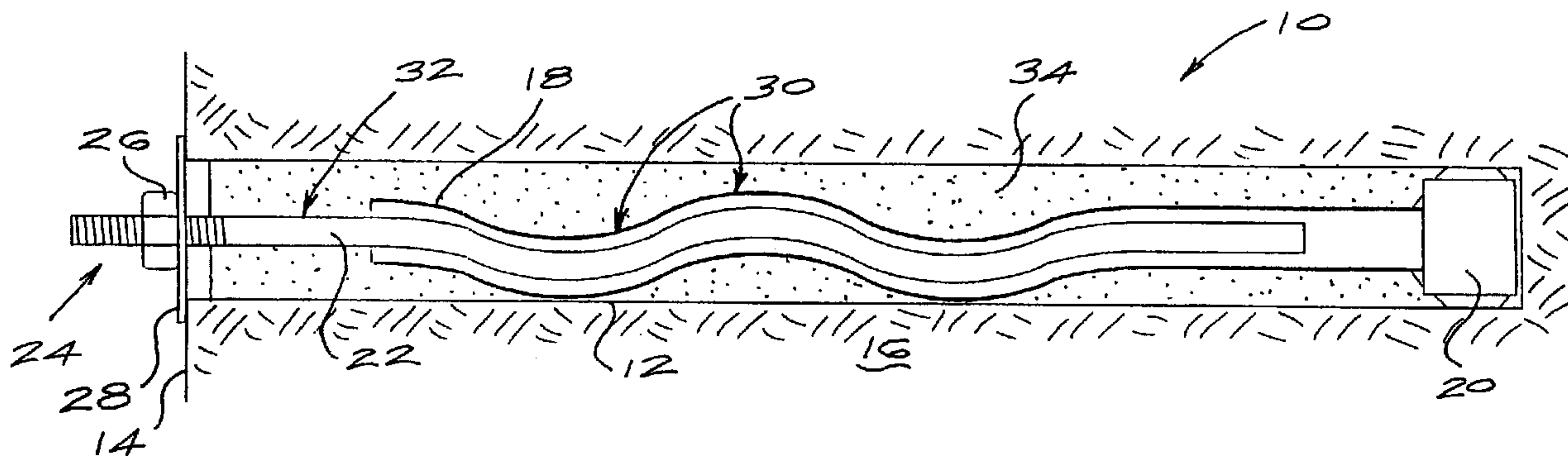




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(57) Abrégé/Abstract:

A rock bolt which includes a tubular member, a device at one end of the tubular member for mechanically anchoring the tubular member inside a hole in a rock face, a bar which is partly inside the tubular member with a threaded portion which projects from the tubular member, and wherein the tubular member is formed with load resisting formations which restrain the bar from being pulled out of the tubular member.

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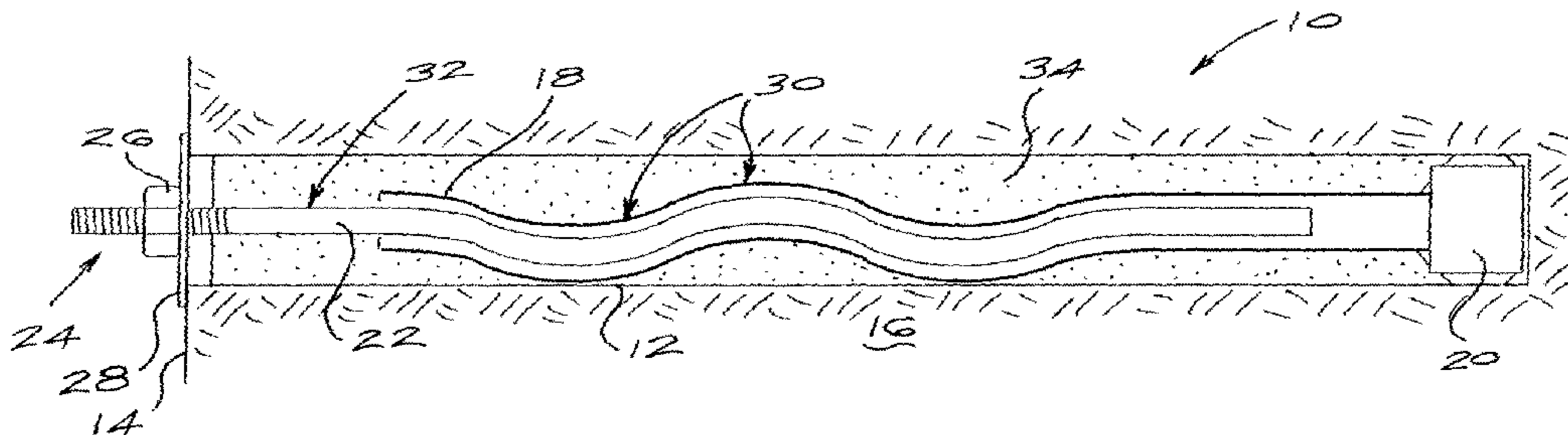
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(54) Title: ROCK BOLT



(57) Abstract: A rock bolt which includes a tubular member, a device at one end of the tubular member for mechanically anchoring the tubular member inside a hole in a rock face, a bar which is partly inside the tubular member with a threaded portion which projects from the tubular member, and wherein the tubular member is formed with load resisting formations which restrain the bar from being pulled out of the tubular member.



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ROCK BOLTBACKGROUND OF THE INVENTION

This invention relates to a rock bolt.

5 In one technique of reinforcing a rock body a shank of a rock bolt is embedded in a settable material, eg. a grout, in a hole which is formed in the rock.

The grout, once it has set, provides resistance to movement of the shank, in a controlled manner, thereby ensuring that a desirable characteristic of yield versus load is achieved.

10 Although the aforementioned technique works satisfactorily it is only effective once the grout has set. In other words between the time of placement of the grout and the setting thereof very little support is provided by the rock bolt. This can give rise to a dangerous situation.

SUMMARY OF INVENTION

15 The invention provides a rock bolt which includes a tubular member with first and second ends, a device at the first end of the tubular member for mechanically anchoring the tubular member in a hole in a rock face, and an elongate member which is positioned inside the tubular member and which projects from the second end, and wherein at least one load resisting formation is provided in or on the tubular member or the elongate member.

At least a portion of the elongate member<sup>2</sup> which projects from the second end of the tubular member may be threaded, or be furnished in any other suitable way eg. formed with a hook or eye formations, or the like.

5 The device at the first end of the tubular member may be of any appropriate form and for example may be selected from an expansible anchor, a pivotal wedge, a hook-shaped formation or formations, a spring washer or the like. An objective in this regard is that the device mechanically anchors the tubular member to the hole and thereby immediately provides a load resisting capability. On the other hand the tubular member is grouted in position and once the grout has set the tubular member, which is adhesively bonded to the hole, provides a further load resisting capability.

10 The load resisting formation may be provided by means of one or more deformations on the tubular member, on the elongate member or on the tubular member and on the elongate member. In a preferred embodiment of the invention the tubular member and the elongate member are bent at one or more locations to provide the load resisting formation or formations. Preferably the tubular and elongate members are bent generally in the shape of a sine-wave.

15 The invention also provides a method of supporting rock which includes the steps of inserting an elongate member at least partially into a tubular member, engaging the elongate member with the tubular member in a manner whereby movement of the elongate member relatively to the tubular member is resisted at least in one direction by means of at least one load resisting formation on the tubular member or on the elongate member, mechanically anchoring an end of the tubular member in a hole in a rock face, and adhesively securing at least part of the tubular member to the hole.

The tubular member may be adhesively secured to the hole using any suitable composition and preferably use is made of a settable material, eg. a cementitious material such as a grout, or a resin.

5 The mechanical anchor is used to secure the tubular member to the hole while the load resisting formation constitutes a means of securing the elongate member to the tubular member.

Once the tubular member has been adhesively secured to the hole a yielding characteristic is provided by means of the load resisting formation which allows deformation of the elongate member or of the tubular member or both members, 10 when the load which is exerted on the elongate member exceeds a predetermined level.

The elongate member may be a rod, formed from wire, which includes a number of twisted wires, or a cable, and may be made from steel, plastics or any other suitable material.

## 15 BRIEF DESCRIPTION OF THE DRAWINGS

The invention is further described by way of examples with reference to the accompanying drawings in which:

Figure 1 illustrates from the side and in cross section a rock bolt according to a first form of the invention; and

20 Figures 2 to 7 respectively illustrate rock bolts according to variations of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 of the accompanying drawings illustrates a rock bolt 10 according to a first form of the invention which is positioned in a hole 12 formed from a rock face 14 into a body of rock 16.

5 The hole 12 is drilled in a conventional manner using techniques which are known in the art.

The rock bolt 10 includes an elongate tubular member 18 formed from a length of pipe, an anchoring device 20 at one end of the pipe and an elongate member 22, for example in the form of round bar, which is partly positioned inside the pipe.

10 A portion 24 of the round bar is threaded and a nut 26 is engaged therewith. The nut, in use, bears against a washer 28 which in turn bears against the rock face 14.

The device 20 may be of any appropriate type which is capable of anchoring the pipe 18 to a wall of the hole 12. This aspect is further described hereinafter.

15 During manufacture of the rock bolt the round bar 22 is coated with a debonding or lubricating agent over its full length and is then inserted into the pipe 18 while both these components are straight ie. undeformed. The components are thereafter bent in unison, in a predetermined manner, so that the combined components have a sinusoidal-type shape 30 of the kind shown in the drawing with a relatively straight portion 32 of the bar extending from the pipe. The extent to which the bar and the  
20 pipe are bent, ie. the depth of each bend and the spacing between adjacent bends, is determined substantially by trial and experiment according to the desired yielding characteristics.

Grout 34 is injected into the hole 12 using any appropriate technique. Thereafter the rock bolt is inserted into the hole 12 through the grout and the device 20 is actuated so that the rock bolt is mechanically anchored in position. The way in which the device is actuated depends on its construction and this aspect is further described hereinafter. It is to be noted that the device 20 acts on the pipe only and does not directly act on the round bar. The grout is allowed to set around the pipe and the projecting portion 32 of the round bar.

Alternatively the bolt can first be placed in the hole and the device 20 is actuated before the grout is injected into the hole 12.

In order to activate the device 20 the washer 28 is threaded over the projecting end of the round bar and the nut 26 is engaged with the threaded end of the round bar and advanced to force the washer into engagement with the rock face. It is evident that a load-bearing mechanical anchor is immediately provided, even though the grout 34 may not have set, by virtue of the device 20 being urged into engagement with the wall of the hole 12 by placing the bar under tension as the nut is advanced along the bar. The load which can be carried depends on the nature of the device but, in practice, it is relatively easy to achieve loads of the order of four or five tons, a level of magnitude which is quite acceptable for temporary and immediate support.

Once the grout has set the load resisting capability of the rock bolt is considerably enhanced. Initially the device 20 provides the anchoring capability. However if the grout abuts the device then the device, in any event, is not capable of moving. Thus the only way in which the rock bolt can yield is if the round bar is drawn through the restraining sinusoidal formations provided by the pipe 18 and, where applicable, by the grout which has set around the projecting portion 32 of the round bar. The round

bar, as has been noted, carries a debonding or lubricating agent so that the grout does not bond directly, in a meaningful manner, to the round bar portion 32. The bonding agent also reduces the likelihood of unwanted bonding between the round bar and the interior surface of the pipe. The grout and the pipe provide a path through which the round bar must be drawn in order to provide a yielding action. In other words the yield characteristic is provided by the round bar 22 deforming through the shape which is formed in the grout and in the pipe and which is attributable to the shape to which the round bar and the pipe are initially formed, before being embedded in the grout.

The situation should be contrasted to what would be the case if the device 20 were to be engaged with an end of the round bar 22 and if the pipe 18 were dispensed with. In this instance the device and the grout would act accumulatively. The device 20 would, in any event, not be capable of moving and hence would provide an immovable anchor for the round bar which in all probability would fail catastrophically instead of yielding if its breaking point were to be exceeded.

Figures 2 to 7 illustrate variations of the principle shown in Figure 1.

Figure 2 illustrates a plastic head 40 which has hook-shaped formations 42 and which is designed to be engaged with an end of the pipe 18. The hook-shaped formations are angled so that the head can be inserted into a hole but when an attempt is made to withdraw the head the hook-shaped formations dig into a wall of the hole. This provides an immediate mechanical anchor.

Figure 3 shows an arrangement which makes use of an expansion anchor or shell principle, and wherein an end 44 of the pipe 18 is formed into a conical shape.

Expansion leaves 46, which are in the<sup>7</sup> nature of wedges, are engaged with the cone and are held in position by means of a band 48. The construction is such that the cone and the leaves can be inserted into a hole but when an attempt is made to withdraw the pipe the leaves wedge against the cone and provide a mechanical anchor.

Figure 4 shows a spring washer 50 which has a number of hook-shaped formations 52. The washer is attached to an end of the pipe 18 in any appropriate way, for example by means of welding, rivets or the like. The arrangement in Figure 4 is similar to that in Figure 2 in that the spring washer is easily inserted into a hole 12 for the hook-shaped formations 52 simply bend or deform to allow this movement. If an attempt is made to withdraw the pipe from the hole the hook-shape formations dig into the wall of the hole and provide a mechanical anchoring force.

Figure 5 shows that an end of the pipe 18 can, itself, be formed with hook-shaped formations 54 which allow the pipe 18 to be moved into a hole 12 but which inhibit withdrawal of the pipe from the hole by biting into a surface of the rock.

Figure 6 shows an arrangement 60 wherein the device 20, referred to in Figure 1, is formed by a cam or wedge 62 which is attached to a leading end of the pipe at a pivot point 64. The pipe can easily be inserted into the hole for the wedge 62 collapses onto the pipe. When an attempt is made to withdraw the pipe from the hole the wedge 62 digs into the surface of the hole and immediately provides a mechanical anchor.

Figure 7 illustrates a rock bolt 70 which is used in a similar way to what has been described but wherein the round bar, designated 22A, is inserted into a pipe 18A

which is not bent in the manner shown<sup>8</sup> in Figure 1. Instead the pipe is formed with a plurality of indentations or dimples 72 at spaced locations along its length.

A leading end 74 of the bolt 22A is formed with an enlarged or thickened head which is shaped into the form of a wedge.

5 An inner end of the pipe 18A has an anchor device 76 of the kind shown in any of Figures 2 to 6.

The rock bolt 70 is used in the manner described in that it is inserted into a hole in a body of rock and the anchor is actuated to provide a mechanical anchoring force. Thereafter grout is placed in the hole around the outer surface of the pipe and the  
10 protruding portion of the round bar 22A. The anchor 76 provides an initial mechanical anchoring force and once the grout has set the grout bonds to the outer surface of the pipe. The yielding action then arises when the bolt is loaded above a particular level at which the thickened end 74 is drawn through the interior of the pipe. When this happens the deformations 72 provide a load-resisting action which  
15 restrain movement of the bolt in a controlled manner, relatively to the pipe.

The invention has been described, by way of example only, with reference to the use of a round bar 22. In practice the bar can be replaced by a cable.

CLAIMS

- 5 1. A rock bolt which includes a tubular member with first and second ends, a device at the first end of the tubular member for mechanically anchoring the tubular member directly to a wall of a hole in a rock face, and an elongate member which is positioned inside the tubular member and which projects from the second end, and wherein at least one load-resisting formation is provided in or on the tubular member or the elongate member which restrains movement of the elongate member out of the tubular member in a controlled manner.
- 10 2. A rock bolt according to claim 1 wherein at least a portion of the elongate member which projects from the second end of the tubular member is threaded.
- 15 3. A rock bolt according to claim 1 or 2 wherein the mechanical anchor device at the first end of the tubular member is selected from an expansible anchor, a pivotal wedge, a hook-shaped formation or formations, and a spring washer.
4. A rock bolt according to any one of claims 1 to 3 wherein the load resisting formation is provided by means of one or more deformations on the tubular member, on the elongate member, or on the tubular member and on the elongate member.
- 20 5. A rock bolt according to any one of claims 1 to 4 wherein the tubular member and the elongate member are bent at one or more locations to provide the load resisting formation or formations.

6. A rock bolt according to claim 5 wherein the tubular and elongate members are bent generally in the shape of a sine-wave.
7. A rock bolt according to any one of claims 1 to 5 wherein the elongate member has an enlarged head and the tubular member has a plurality of indentations at locations along its length.
8. A rock bolt according to any one of claims 1 to 7 wherein the elongate member is selected from a rod and a cable.
9. A method of supporting rock which includes the steps of inserting an elongate member at least partially into a tubular member, engaging the elongate member with the tubular member in a manner whereby movement of the elongate member relative to the tubular member is resisted in a controlled manner at least in one direction by means of at least one load-resisting formation on the tubular member or on the elongate member, mechanically anchoring an end of the tubular member directly to a wall of a hole in a rock face, and adhesively securing at least part of the tubular member to the hole.
10. A method according to claim 9 wherein the tubular member is adhesively secured to the hole using a settable material.

