DEVICE FOR A ROCK WALL

TECHNICAL FIELD

The invention relates to a device for sealing a rock wall, which device comprises an injection tube adapted to be introduced into a bore hole in the rock wall, into which bore hole a filling material is intended to be injected through the injection tube.

According to one aspect of the invention, the device may also comprise a reinforcement rod, e.g. a conventional reinforcement bar, so that both a sealing effect and a reinforcing effect is achieved through the use of the device. The invention is utilized in the construction of tunnels and other rock cavities.

PRIOR ART

On working in rock walls, e.g. for constructing tunnels or rock cavities, reinforcement of the rock wall is most often required to increase the strength, and sealing of cracks and the like to prevent damp and water from penetrating the tunnel or cavity. Known methods of reinforcement consist in providing the rock wall with evenly dispersed bore holes, which can have a diameter of about half a decimetre and a depth of about 1-6 metres.

One method of reinforcing rock walls has been and continues to be the insertion into the bore holes of two concentrically arranged tubes of different diameter. The space between the walls of the tubes is filled with cement or concrete, following which the tubes are taken out before the filling material has hardened and a reinforcement bar can be stuck into the central hole. A major disadvantage of this method is that the filling material and reinforcement bar fall out of the hole again relatively frequently, for which reason the reinforcement often has to be repeated several times before it succeeds. If in addition water leaks out of the rock into cracks which lead into the bore hole, the filling material can be washed away before it manages to harden. In this case, the rock must instead be sealed in a first stage, a rubber plug or tap normally being arranged in the bore hole opening and the hole being filled with concrete or cement which is then allowed to solidify. Following this, a hole is drilled in the concrete/cement which is reinforced in the same way as described above. As is clear, the method comprises several stages and it is nevertheless not entirely certain that the reinforcement remains in place.

In a more modern known system, a long bolt is introduced into each bore hole, which bolt is provided at the top with an expander for anchoring in the bore hole. Arranged in

the end of the bolt which sticks out of the bore hole is a washer which lies like a cover over the bore hole and in the centre of which a hemisphere is arranged. The bolt sticks a distance out of the hemisphere and is surrounded there by a nut which is tightened when the expander in the bolt top is to be anchored in the rock. Following anchoring, cement paste is injected into the hemisphere to proceed inwards into the bore hole, first inside a plastic tube which surrounds the bolt, and then outside this plastic tube until the cement paste emerges through a hole in the washer. This system certainly provides reinforcement of the rock wall, but no appreciable sealing of water-bearing cracks and the like. Problems of corrosion at the bolt can also occur if air bubbles are formed in the cement closest to this.

In connection with the sealing of a rock wall, using cement or concrete which is filled into bore holes, there is a problem in connection with water leakage through cracks in the rock wall. As to our knowledge there is no existing device which can be used to fill bore holes under a positive pressure of the filling material.

Conventional methods of sealing the rock wall comprise e.g. labour-intensive and expensive so-called "lining" of the rock wall, i.e. cladding with concrete. Another known method utilizes a sealing material which is injected into the rock wall. This has been found to lead to very great environmental disadvantages, as the sealing material contains the toxic substance acrylamide, which can be dispersed in the groundwater.

BRIEF ACCOUNT OF THE INVENTION

In the following, the invention is mainly described in connection with a device which is adapted to both seal and reinforce a rock wall. It is however to be understood that the invention also relates to a device which is adapted to seal but not to reinforce the rock wall, in which case the device does not comprise a reinforcement rod or anchoring means.

The aim of the present invention is to offer a device for reinforcing and sealing a rock wall, by means of which device the aforementioned disadvantages are avoided or at least minimized, it being possible to carry out reinforcement and sealing of the rock wall in just a few stages, meaning that the reinforcement remains securely in place at the same time as sealing of water-bearing cracks leading into the bore holes is achieved and air bubbles in the cement are avoided.

This is achieved by means of a device for reinforcing and sealing a rock wall, which device comprises a reinforcement rod, e.g. a conventional reinforcement bar intended to be introduced into a bore hole in the rock wall, into which bore hole a filling material is then injected, said device also comprising a non-return valve for the filling material. The non-return valve is adapted to withstand a positive pressure of the filling material in the bore hole. The filling material is thus injected under positive pressure, at which any cracks in the rock leading into the bore hole are sealed. Said non-return valve preferably consists of a rubber sleeve which encloses an injection tube provided with outlet openings, which injection tube is preferably joined to said reinforcement bar or equivalent.

Further features and aspects of the invention are evident from the following claims and the detailed description of the invention.

BRIEF DESCRIPTION OF DRAWINGS

Reference will be made in the detailed description of the invention to the enclosed drawings, of which

Fig. 1 represents a lateral view, partly in cross-section, of the part of the sealing and reinforcing device which is positioned adjacent to the opening of the bore hole and which contains the non-return valve.

Fig. 2 represents a lateral view, partly in cross-section, of the part of the device which is positioned furthest in in the bore hole and which contains an expander for anchoring in the rock.

Fig. 3 represents a top view of a lock washer for the expander in Fig. 2, before the lock washer is formed for application.

Fig. 4 represents a lateral view, partly in cross-section, of the bore hole and the reinforcement during the hardening phase of the filling material.

Fig. 5 represents a lateral view, partly in cross-section, of the finished reinforcement in the rock.

Fig. 6 represents a lateral view, partly in cross-section, of the embodiment of the invention which is a sealing device without a reinforcement rod, the figure

showing the device inside the bore hole during the hardening phase of the filling material.

DETAILED DESCRIPTION OF THE INVENTION

With reference first to Fig. 1, a reinforcement bar which forms part of the device is described by the number 1. For technical drawing reasons the reinforcement bar in the figure is cut away at the top but in reality has a length of about 0.5-10 m, preferably 1-7 m and even more preferredly 2-5 m. In Fig. 1 and 2 the device is shown as it is arranged in a vertical, upwardly directed bore hole in the roof of the tunnel or rock cavity, which position is used in the further description. However, it is to be understood that the device can just as well be used in a horizontal hole, an angled hole or in a vertical, downwardly directed hole. The reinforcement bar 1 has a strongly profiled surface for fastening securely in the cement or concrete, henceforth termed filling material, which will enclose the same. Joined as an extension of the reinforcement bar arranged at the bottom, via a coupling sleeve 2 welded firmly at both ends, is an injection tube 3 which accordingly has an inner longitudinal cavity and is open at the bottom for the connection of hosing for filling with the filling material.

Arranged a distance below the coupling sleeve for the reinforcement bar 1 and the injection tube 3 is a non-return valve 4. This non-return valve 4 is adapted to withstand a positive pressure of the filling material when this is injected under positive pressure into the bore hole via the non-return valve. Thanks to this non-return valve, the filling material does not run out of the bore hole before it solidifies, in spite of the positive pressure. The non-return valve 4 preferably comprises a rubber sleeve 5 which encloses a part of the injection tube 3. In the area of the rubber sleeve the injection tube has a number of outlet openings 6 for the filling material. The rubber sleeve, which can of course also be manufactured from another, to some extent elastic, strong material, is suitably formed as an envelope of a truncated cone, having a first diameter at the bottom and a second, smaller diameter at the top. At the first diameter, the rubber sleeve 5 is vulcanized firmly at an internally threaded eye nut 7, which in turn is screwed firmly on an externally threaded ring fastener 8. The ring fastener 8 encloses the injection tube 3 and is welded firmly to the same. The ring fastener 8 also has a flange 9 at the bottom, on the upper surface of which flange the eye nut 7 rests. The upper, smaller diameter of the rubber sleeve 5 is adapted to end sealingly around the injection tube 3. For this purpose the nose is suitably provided with a few, e.g. two, internal lip seals consisting of O-rings which are set into the rubber sleeve, or by a few continuous projections on the inside of the rubber sleeve in the tip part.

Below the flange 9, the injection tube is enclosed by a narrow tube 13 with an upper flange 14 which lies close to the lower surface of the flange 9. Resting against the lower surface of the flange 14 is the upper short end of a seal in the form of a sleeve 10 which suitably also consists of rubber. This rubber sleeve 10 encloses a part of the lower section of the injection tube surrounded by the narrow tube 13, its lower short end resting against a washer 11 which in turn rests against a nut 12. In the area of the nut 12 and a distance up under the rubber sleeve 10 the injection tube 3 and/or the narrow tube 13 are threaded externally with the same thread size as the nut 12.

Arranged in the upper part of the device, suitably at its top, is a top piece forming an expander. The expander is shown in Fig. 2, which forms a continuation of the device shown in Fig. 1, a longer piece of the reinforcement bar 1 (only partly shown) connecting the part according to Fig. 1 to the part according to Fig. 2. The expander is joined to the reinforcement bar by means of a sleeve-shaped spacing piece 21 which is welded firmly at the bottom on the end of the reinforcement bar and which at the top contains an internal thread. Screwed into this thread is a coupling pin 22 which consists of a straight pin provided with external thread at least a distance at the bottom and a distance at the top. At the top, the coupling pin 22 is partly screwed - in the unexpanded state - into a hole provided with an internal thread in a core part 23. The hole here is sufficiently long to permit further screwing in when anchoring of the device into the rock is to be executed, which will be described in greater detail. The core part 23 tapers off at the top into a short conical piece 24 and is threaded externally above this conical piece, a top cone 25 enclosing the conical piece 24 and a part of the upper section of the core part 23. The top cone 25 has an internal bevel at the bottom which is adapted according to the conical piece 24 of the core part 23. Arranged above the top cone is a top nut 26 to hold the top cone firmly. Between the internal bevel of the top cone and the conical piece 24 of the core part, a number, preferably 1-10, suitably 2-6, of lock washers 27 are fastened around the core part 23. A lock washer of this kind is shown in its level state in Fig. 3 and consists of a washer provided with a number of slits 41, preferably 2-10, suitably 4-7. When these lock washers are fastened over the conical piece 24 of the core part, they assume the form of an envelope of a truncated cone. Arranged under these lock washers, surrounding the upper part of the coupling pin 22 and the lower part of the core part 23 is a loose sleeve 28 with an inwardly facing flange 29 arranged at the bottom. This flange 29 rests against the upper short end of the spacing piece 21.

Unless otherwise indicated, the details described are manufactured preferably of so-called cam steel, which can be hot-galvanized or surface-protected in another way.

Fig. 3 shows as stated a lock washer 27 in its level state. The slits start out from the washer's circumference, extending almost, but not completely, in towards the inner bore diameter of the washer and suitably having a certain, inwardly tapering width and a radius furthest in. The inner bore diameter of the washer is suitably provided with a shorter straight piece 42, to prevent the washer from rotating when it sits on the core part 23. The lock washers are suitably manufactured from cold-rolled, hardened steel of a thickness of 0.1 - 1 mm, preferably 0.2 - 0.7 mm and even more preferredly 0.3 - 0.45 mm. In a preferred embodiment, the washer has an outer diameter of about 60 mm and an inner bore diameter of about 20 mm.

The function of the device is as follows. A hole 30, Fig. 4, is bored into the rock wall, of at least the same length as the length of the device. The device is introduced into the bore hole so far that the washer 11 and nut 12 will be located at the mouth of the bore hole. After this, the injection tube 3 is rotated a number of revolutions, suitably by means of a hydraulic device which grips the part of the injection tube sticking out of the bore. The rotation thereby extends to the reinforcement bar 1 and further to the sleeve-shaped spacing piece 21 which is joined to the upper part of the reinforcement bar. As a consequence of this, the upper part of the coupling pin 22 is screwed further into the threaded hole in the core part, at which the upper short end of the spacing piece presses on the lower flange 29 of the sleeve 28 so that the sleeve is pressed upwards against the lock washers 27. The sleeve 28 will then act as a pressing device on the lock washers so that their shape of an envelope of a truncated cone is at least flattened out somewhat. The circumference of the lock washers will hereby be pressed firmly into the walls of the bore hole so that the entire device is anchored in the rock. The next stage is to seal the bore hole with the device contained therein at the bottom by tightening the nut 12 so that the rubber sleeve 10 is compressed in an axial direction, at which it expands in a radial direction to seal between the injection tube 3 and the lower walls of the bore hole, Fig. 4. A pipe (not shown) can now be connected to the injection tube and the filling material 31A is injected under positive pressure, at which the filling material flows out of the outlet openings 6 in the injection tube and penetrates into the bore hole at the upper diameter of the rubber sleeve 5. The rubber sleeve 5 acts here as a non-return valve integrated into the device so that the filling material, in spite of being under positive pressure, cannot run back out of the bore hole before it manages to harden. Beneficially, there is also arranged a small diameter conduit 35, e.g. of a hydraulic tube type, which mouths in the most distant region of the bore hole 30. Preferably it ends upstream of the spacing piece 21. The conduit 35 is adapted to act as a degassing conduit which leads air and gasses out of the bore hole as the filling material is introduced. During introduction

of the filling material, the open end, adjacent the entry of the bore hole, of the conduit 35 is sealed when filling material starts to continuously come out of the conduit, whereafter the introduction of filling material into the bore hole can proceed under a positive pressure.

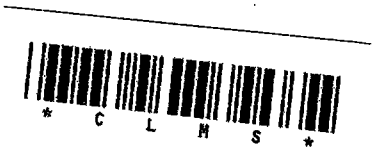
Due to the positive pressure, filling material is also caused to penetrate any cracks 32 leading into the bore hole, in spite of the fact that these cracks may be water-bearing. When the desired positive pressure, which may reach about 100 bar positive pressure or suitably about 50-80 bar positive pressure, has been attained, the pipe connection can be detached, at which the filling material 31A can be left to harden under positive pressure, thanks to the non-return valve 4 and the rubber sleeve 10. When the filling material has hardened, the nut 12 is unscrewed, the washer 11 removed and the rubber sleeve 10 is taken out of the hole by means of the narrow tube 13 provided with a flange.

The space below the flange 9 is then filled with filling material 31B (Fig. 5) by providing the opening of the bore hole with a larger washer (not shown) with a hole in one side for filling with filling material, air being made to evacuate the hole via an air pipe. If the risk of corrosion is not great, however, the narrow tube 13 provided with a flange can be left out of the device, in which case the rubber sleeve 10, washer 11 and nut 12 can instead remain permanently in place after the device has been applied to the bore hole. The opening of the bore hole and its immediate surroundings are then covered in a conventional manner with a plate, disc or washer 33, which is pressed against the rock wall by means of a nut 34, which is screwed on to the protruding part of the injection tube.

By means of the invention a relatively simple and cheap construction is achieved for sealing and a non-return valve function which thus permits filling material to be injected into a bore hole and allowed to harden under a favourable positive pressure. The relatively simple and cheap construction also allows the seal, non-return valve and expander to be cast in the bore hole and thereby form an admittedly permanent but nevertheless disposable material without incurring costs which are too great. Corrosion-promoting air bubbles close to the reinforcement bar are counteracted due to the positive pressure. A further advantage of the device according to the invention is that it can be used for filling material of varying viscosity or dry content according to the circumstances and preference.

Referring now to Fig. 6, it is seen that the embodiment of the invention, which is a device for sealing the rock wall without reinforcing it, corresponds fully to the lower part of the device shown in figures 1, 4 and 5. Accordingly, the device of the embodiment in Fig. 6 does not comprise a reinforcement rod nor anchoring means. Instead, the injection tube 3 ends just downstream the non-return valve 4 with a blind end wall 3A. By means of the device according to the embodiment in Fig. 6, filling material can be introduced into the bore hole under a positive pressure, and be allowed to harden under a retained positive pressure, thus achieving a good seal of cracks 32 that mouth in the bore hole. This embodiment of the invention is preferably used in rocks that are relatively strong, but water leaking.

The invention is not restricted to the embodiment described above but can be varied within the scope of the following patent claims. The expert thus easily perceives that e.g. the expander for anchoring the device in the rock can be executed in a number of different ways, some of which belong to the prior art. The sealing and reinforcing device can possibly even be used entirely without anchoring. The non-return valve 4 and the rubber sleeve 10 can also be conceived to be executed in other ways and in other materials.



CLAIMS

1. Device for sealing a rock wall, which device comprises an injection tube (3) adapted to be introduced into a bore hole (30) in the rock wall, into which bore hole a filling material (31) is intended to be injected through the injection tube (3), characterized in that said device also comprises a non-return valve (4) for the filling material.

2. Device according to claim 1, characterized in that said non-return valve (4) is adapted to withstand a positive pressure of the filling material (31) in the bore hole and is connected in the device to the injection tube (3).

3. Device according to claim 1 or 2, characterized in that said non-return valve (4) comprises a sleeve (5), preferably of a strong, elastic material, which encloses the injection tube (3), and that the injection tube (3) is provided with outlet openings (6) in the area of the sleeve (5).

4. Device according to claim 3, characterized in that said sleeve (5) is made of rubber.

5. Device according to claim 3 or 4, characterized in that said sleeve (5) has the shape of an envelope of a truncated cone, its circumference at its narrowest short end being arranged sealingly around the injection tube (3), and its circumference at its broadest short end being tightly connected to the injection tube (3).

6. Device according to any of the above claims, characterized in that said device, in the part which is adapted to be arranged adjacent to the opening of the bore hole (30), is provided with a seal (10) arranged to act against the walls of the bore hole.

7. Device according to claim 6, characterized in that said seal (10) consists of a sleeve, preferably of rubber or other strong, elastic material, which surrounds the injection tube (3) in a position upstream of said non-return valve (4), which sleeve is arranged to achieve a sealing effect against the walls of the bore hole (30) by expanding in a radial direction when it is compressed in an axial direction, said sleeve (10) preferably being arranged to be removed when the filling material has hardened so that the space taken up by the sleeve can instead be filled with further filling material.

8. Device according to any of the above claims, characterized in that a degassing conduit (35) is arranged in connection with the device, which degassing conduit (35) is adapted to lead out air and gasses from the bore hole (30) when the filling material (31) is injected into the bore hole.

9. Device for reinforcing and sealing a rock wall, which device comprises a reinforcement bar (1) adapted to be introduced into a bore hole (30) in the rock wall, into which bore hole a filling material (31) is intended to be injected, characterized in that said device also comprises a non-return valve (4) for the filling material.

10. Device according to claim 9, characterized in that said non-return valve (4) is adapted to withstand a positive pressure of the filling material (31) in the bore hole and is permanently connected in the device to the reinforcement bar (1), already before the device is introduced into said bore hole (30).

11. Device according to claim 9 or 10, characterized in that said filling material is arranged to be injected under positive pressure, any cracks (32) in the rock leading into the bore hole being sealed by filling material.

12. Device according to any of claims 9-11, characterized in that said non-return valve (4) comprises a sleeve (5), preferably of a strong, elastic material, which encloses an injection tube (3) provided with outlet openings (6) in the area of the sleeve (5), which injection tube is preferably permanently connected to said reinforcement bar (1).

13. Device according to claim 12, characterized in that said sleeve (5) is made of rubber.

14. Device according to claim 12 or 13, characterized in that said sleeve (5) has the shape of an envelope of a truncated cone, its circumference at the narrowest short end being arranged sealingly around the injection tube (3), and its circumference at its broadest short end being tightly connected to the injection tube (3).

15. Device according to any of claims 9-14, characterized in that said device, in the part which is adapted to be arranged adjacent to the opening of the bore hole (30), is provided with a seal (10) arranged to act against the walls of the bore hole.

16. Device according to claim 15, characterized in that said seal (10) consists of a sleeve, preferably of rubber or other strong, elastic material, which surrounds the injection tube (3) in a position upstream of said non-return valve (4), which sleeve achieves a sealing effect against the walls of the bore hole by expanding in a radial direction when it is compressed in an axial direction, said sleeve (10) preferably being arranged to be removed when the filling material has hardened so that the space taken up by the sleeve can instead be filled with further filling material.

17. Device according to any of claims 9-16, characterized in that a degassing conduit (35) is arranged in connection with the device, which degassing conduit (35) is adapted to lead out air and gasses from the bore hole (30) as the filling material (31) is injected.

18. Device according to any of claims 9-17, characterized in that the device, preferably in the part which is arranged to be positioned furthest in in the bore hole, is provided with an expander for anchoring in the rock, which expander is preferably arranged to be expanded by rotation of the reinforcement bar (1).

19. Device according to claim 18, characterized in that said expander comprises lock washers (27) provided with slits which are arranged around the reinforcement bar (1) or around a top piece (23) joined to the reinforcement bar, which lock washers before expansion assume the shape of the envelope of a truncated cone.

20. Device according to claim 19, characterized in that said expander comprises a pressing device (28) which for expansion of the expander is arranged to be pressed against said lock washers (27) so that their shape of the envelope of a truncated cone is flattened out at least somewhat, at which the lock washers are anchored in their circumference in the walls of the bore hole.

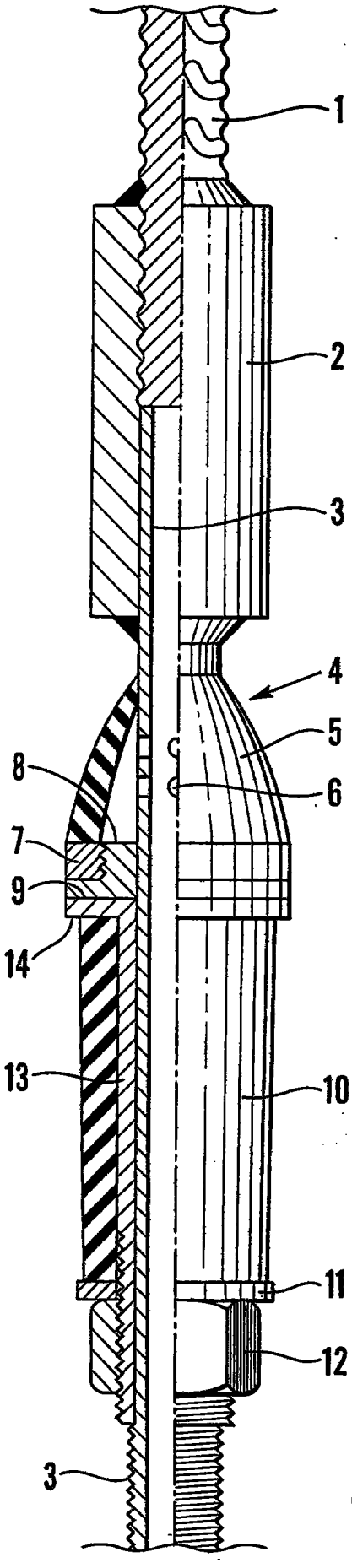


Fig. 1

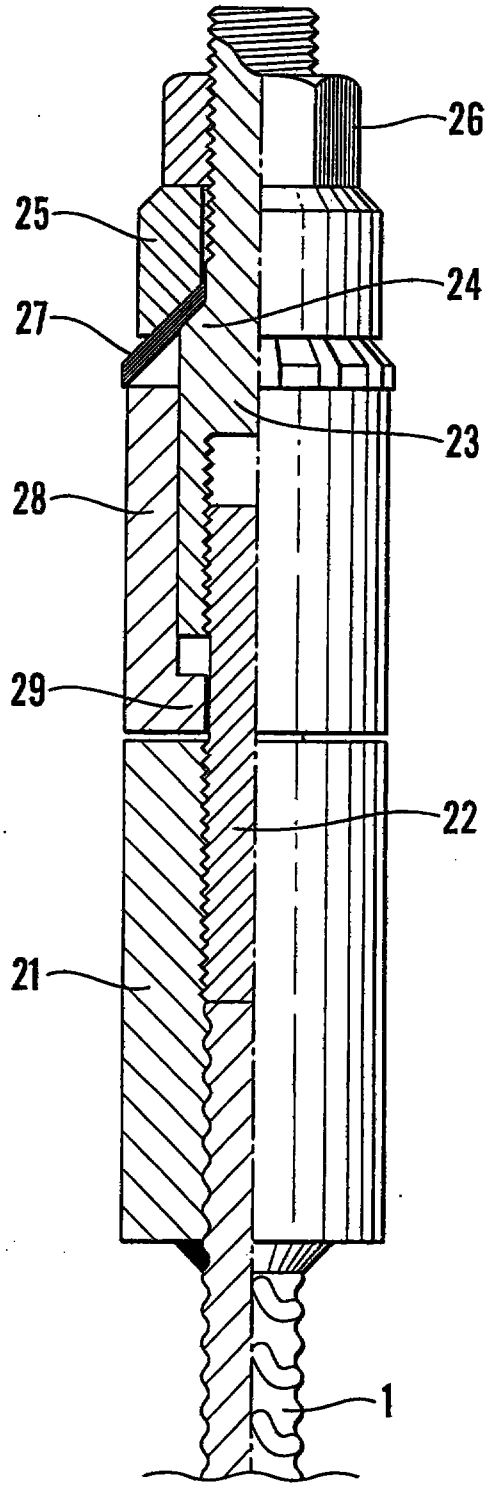


Fig. 2

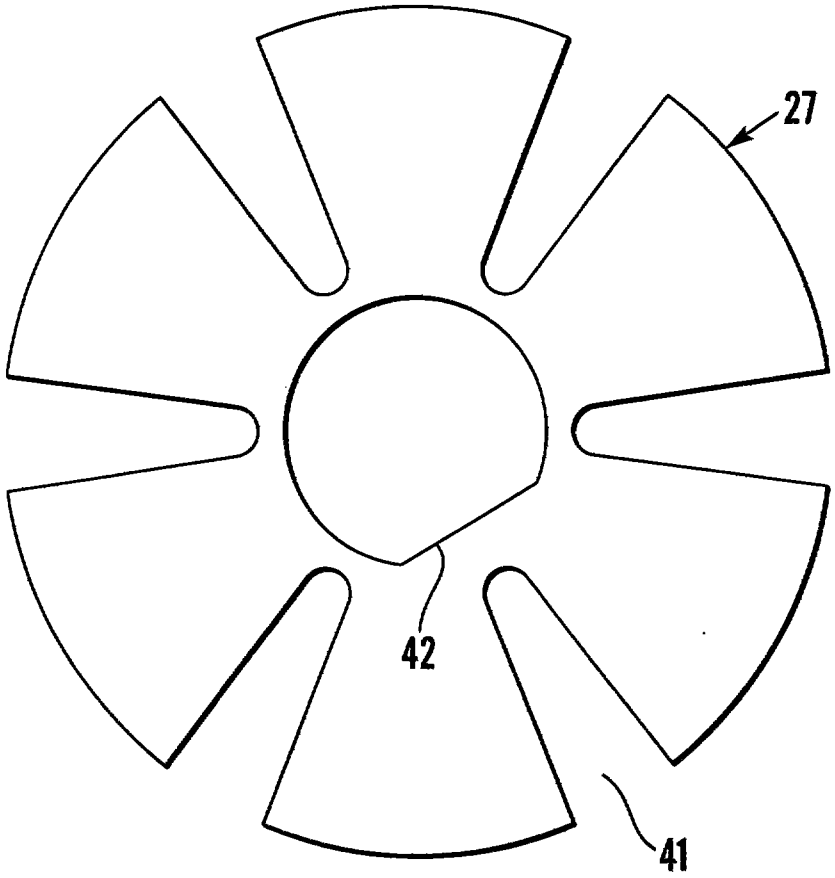


Fig.3

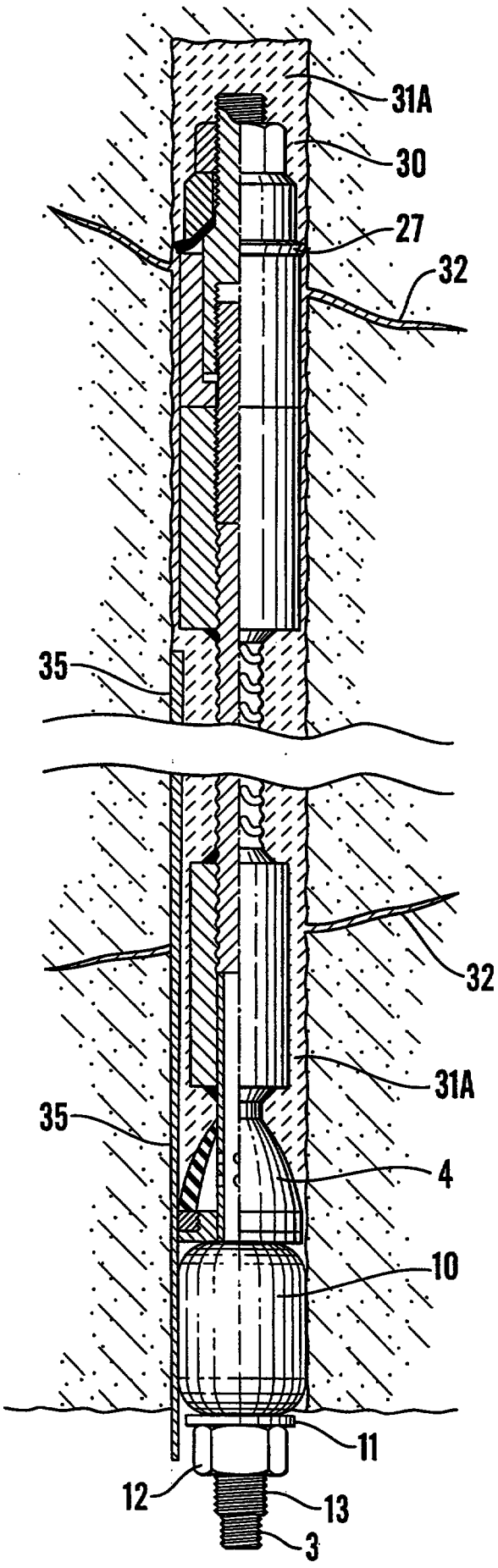


Fig.4

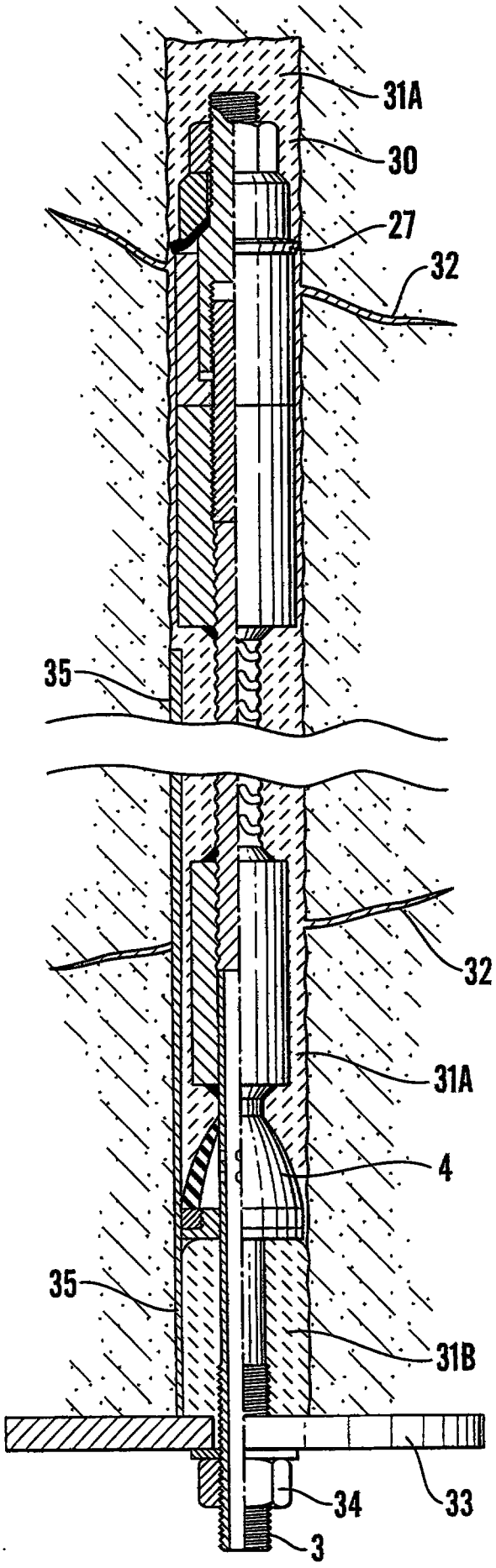


Fig.5

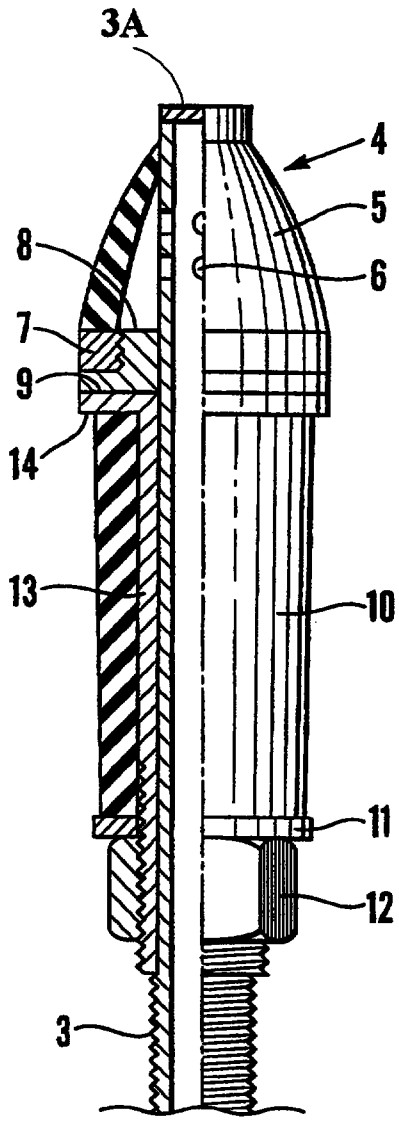


Fig. 6

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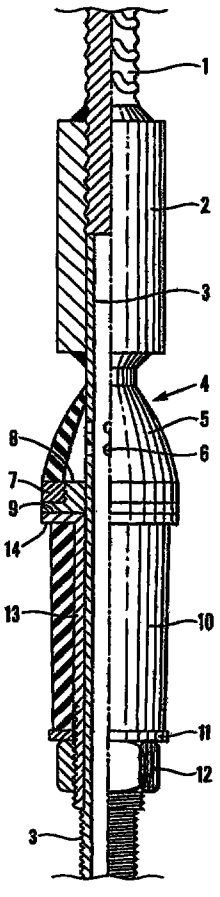
(57) Abstract

Device for sealing a rock wall, which device comprises an injection tube (3) adapted to be introduced into a bore hole (30) in the rock wall, into which bore hole filling material (31) is intended to be injected through the injection tube (3). The device also comprises a non-return valve (4) for the filling material, and may be permanently connected to a reinforcement bar (1) in order for the device to achieve both sealing and reinforcement.