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(54) Title: DEVICE FOR SEALING A ROCK WALL

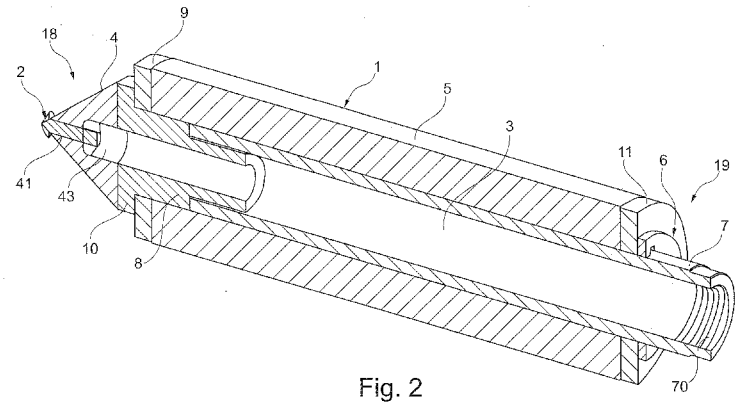

Fig. 2

(57) Abstract: The following 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, said device also comprising a check-valve for the filling material wherein said check-valve further comprises an opening means for keeping said chack-valve in an open position.

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DEVICE FOR SEALING A ROCK WALL

TECHNICAL FIELD

The following 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, said device also comprising a check-valve for the filling material.

BACKGROUND 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 decimeter and a depth of about 1-6 meters. Use of cement, concrete or other filling material which is filled into bore holes under positive pressure is common in connection with the sealing of a rock wall, and various methods are known within the field. In WO9956001 there is shown 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.

According to a general procedure a number of evenly dispersed bore holes are drilled into the rock wall whereupon each hole is pre-plugged with an injection packer, for instance a packer as the one disclosed in WO9956001. The holes are then filled with grouting through the injection packer. In case two or more pre-plugged bore holes are connected via cracks in the rock, injection of grouting into one of these holes may lead to that a very large pressure is created in the other holes posing problem during later injection of filling material.

DISCLOSURE OF THE INVENTION

The object of the present invention is to offer a device for reinforcing and sealing a rock wall, by means of which device the aforementioned disadvantage is avoided or at least minimized, it being possible to carry out sealing of the rock wall in just a few steps, at the same time being able to easily identify bore holes which are connected via cracks thus providing the opportunity of adapting the rock sealing operation according to such information. For instance, if upon starting of injection of filling material into a first bore hole, a connection to a second bore hole is noticed, injection into said first hole is temporarily interrupted and instead filling of grouting into the second hole is initiated. Thereafter, injection of filling material is performed into both holes more or less simultaneously or in an alternating manner. This way any air bubbles are forced into the rock and the chance of achieving a solid cement filling within both the first and the second hole is substantially improved.

The object of the present invention is achieved by means of a device for sealing a rock wall (i.e. an injection packer), 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, said device also comprising a check-valve for the filling material, wherein said check-valve also comprises an opening means for at least temporarily keeping said check valve in an open position. Upon having inserted injection packers into the bore holes of e.g. a tunnel each packer is still open thanks to the opening means. When starting a sealing procedure, injection pressure will cause any water residing in the rock wall to move through cracks and rock structures. If two bore holes are connected via cracks the water will be urged towards the one bore hole which is not subjected to grout filling operation. Thanks to the device according to the present invention, said water will flow through the open check valve of the pre-plugged injection packer and leak out from the bore hole into the tunnel so that an operator may identify the leakage (for instance visually) and conclude that a water-bearing connection exists.

According to one aspect of the invention the opening means is releasably arranged at the opening of the check valve, keeping the check valve in a temporarily open position at least during initial operation of sealing a rock wall. It is understood that by "initial operation" means from that an injection packer according to the invention is inserted and secured in a bore hole until the moment when filling material is introduced through the check valve. When grouting material is injected through the packer said opening means is arranged to become removed from said check valve by means of the passing

filling material injected through the injection tube. Removal of said opening means leads to that said valve functions as an ordinary check valve, that is, allowing for passage of grouting into the bore hole along the direction of injection while prevent reverse flow of grouting in the opposite direction before it solidifies, despite the positive pressure inside the bore hole. According to one aspect the check valve according to the invention is arranged to withstand a bore hole pressure of up to 100 bar.

Thanks to the features of the invention the check valve is kept in an open position only during initial operation of sealing a rock wall, while the injection step will lead to activation of the check valve and normal functioning thereof.

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

BRIEF DESCRIPTION OF THE DRAWINGS

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

Fig. 1	represents a perspective view of the sealing device according to one embodiment of the invention,
Fig. 2	represents a perspective view of the sealing device in cross section according to one embodiment of the invention
Fig. 3a	represents a detailed view of the sealing device with an opening means positioned at the valve opening,
Fig. 3b	represents another detailed view of a sealing device where said opening means being removed from the valve opening, and
Figs 4a-d	illustrate a grout filling operation according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

With reference to Fig. 1 and 2, a sealing device in the form of an injection packer according to a preferred embodiment of the present invention is described by number 1. In Fig. 1 the injection packer is seen from a perspective view, and in Fig. 2 in cross section.

The packer 1 comprises a through going injection tube 3 with an inner cavity intended for passage of injection material there through. The rear end 19 of the injection tube 3 comprises an inlet in the form of a connecting portion 7 intended for connection to hosing for filling with the filling material. Further, the front end 18 of the injection tube

3 comprises an outlet component 8 having an externally threaded portion arranged to be screwed firmly onto an internally threaded portion of said injection tube 3. The outlet component 8 has an upper flange 10 arranged to be tightly sealed onto a fastening ring 9 which is positioned at the front portion of the injection packer 1. The front part of the injection packer 1 is further provided with a check valve 4 which is arranged to sealingly be attached to said outlet component 8, and which is adapted to withstand a positive pressure from filling material once it has been injected into the bore hole via the injection packer. The positive pressure inside a bore which has been filled with e.g. grouting can be extremely high, and the check valve 4 according to the invention is arranged to withstand up to at least 100 bar without collapsing. The check valve 4 is preferably made of rubber, but of course it may equally be manufactured from some other, to some extent elastic, strong material. In the preferred embodiment seen in Figs. 1 and 2 the check valve 4 comprises a tapered shape (here conical shape) with a frontal outlet opening 40 which opens up at the tip of said cone shaped check valve. Said check valve 4 is preferably tapered in a direction away from the injection tube 3 inlet 7 to form a positive seal, and its circumference at its broadest short end being tightly connected to the injection tube 3. At the opening portion of the check valve 4 there is arranged an opening means 2 which causes the check valve to be kept in an open position thereby allowing for a certain reverse flow, e.g. of water passage. The opening means 2 may be in the form of a plug, rivet or nail or any other suitable device which may be inserted into the elastic opening of the check valve keeping it from closing.

It is to be understood that the front portion 18 of the sealing device 1 is intended to face the inside of a bore hole where into it is inserted, and that the rear portion 19 is arranged to be facing e.g. the tunnel or cavity.

The rear portion 19 of the injection packer 1 is provided with a locking device comprising a support ring 11 resting against a locking washer 6, which washer 6 encloses the connecting portion 7 of the injection tube 3. The end connecting portion 7 of the injection tube 3 preferably comprises interior threads 70. Positioned between the fastening ring 9 and the support ring 11, upstream of the check valve 4, there is arranged a seal in the form of a sleeve 5 enclosing the mid-part of the injection tube 3, said seal 5 also suitably consisting of rubber or other elastic strong material. The washer 6 comprises gripping protrusions 60 arranged to grip around the circumference of the connecting portion 7 and locking the support ring 11 so that it tightly abuts the sleeve 5. By pushing the locking washer 6 in a direction against the support ring 11, the support ring 11 will move on the injection tube 3 in an axial direction pushing against the sleeve

5 thus compressing the sleeve 5 so that it expands in a radial direction. Radial expansion of the sleeve is desired for securing and sealing an injection packer 1 in a bore hole, as will become clear in connection to Figs. 4a – d.

Compression of the sleeve 5 may be achieved as follows. A first tube (not shown) with external threads is screwed into the meeting interior threads 70 of the connection portion 7. Next the locking washer 6 is pushed in an axial direction against the support ring 11 while said first tube withholds the injection tube 3 and thereby also the outlet component 8 and the fastening ring 9. Pressing of washer 6 leads to compression of sleeve 5, and further the gripping protrusions 60 prevent the locking washer 6 from sliding rearwards on the connecting portion 7 thereby also preventing the sleeve 5 from decompressing.

Pushing of said locking washer 6 may be performed for instance by means of a second pushing tube (not shown) arranged to slidably enclose the rear end 19 of the connecting portion.

The sealing device 1 and its function is further illustrated in Figs. 3a and 3b, wherein 3a shows a detailed view, both in perspective and in cross section, of the front portion of the injection packer 1 with said check valve 4 being kept in an open position by an opening means 2 positioned at the check valve opening 40. It is further seen that the check valve 4 of the embodiment shown in Figs. 3a-3b has a number of slits/cuts 42 at its narrowest end, for instance two perpendicular slits, forming said outlet opening 40. The opening means 2, here in the form of a rivet, will urge the slit-portions of the check valve 4 to spread apart thereby allowing for certain leakage through the slit openings 42.

In Fig. 3b there is seen a corresponding check valve 4 where the rivet 2 is removed from the outlet opening 40 leading to that the tip portion of the conical check valve 4 adopts a closed position where the slits are sealed tightly against each other forming a positive seal and preventing any reverse flow through the packer 1. As is seen in the cross section of Fig. 3b the check valve 4 comprises a central through channel 43 with at least one sealing portion 41 arranged to keep a shut configuration (when left unaffected e.g. by an opening means) preventing reverse flow. It is understood that the sealing portion 41 is formed by the meeting surfaces of the slit portions of the check valve 4.
The design of the check valve 4 and the cuts 42 will lead to that the sealing portion 41 is urged to open upon injection of filling material in a forward direction through the injection tube 3.

The sealing function of the check valve 4 is achieved among other things by means of the elasticity/resilience of the check valve material. The check valve is preferably manufactured by means of first molding the nose portion 4 into the desired shape, preferably conical, whereafter the tip is cut 42 according to illustrated in the appended figures for achieving the opening 40. The resilient property of the check valve material (e.g. rubber) leads to that the nose will strive at returning to its inherent shape, i.e. upon removing an opening means (e.g. a rivet) the slit-portions 42 will want to return to a closed conical position where said sealing portion 41 forms a positive seal and blocks reverse flow.

The function of the device 1 is now to be described, referring mainly to Figs. 4a – 4d. During initial operation of sealing a rock wall 12 an injection packer 1 provided with an opening means 2 (here in the form of a rivet 2) is inserted into predrilled bore holes 13 which are evenly dispersed in the rock wall of a tunnel or cavity. In Fig. 4a is shown an injection packer 1 arranged in a vertical, upwardly directed bore hole 13 which position is used in the present description of the function in a non-limiting sense. In order to fixate the injection packer into the bore hole 13 the sleeve 5 which surrounds the injection tube 3 is made to expand in a radial direction as indicated with arrows 14 in order to press tightly onto the walls of surrounding bore hole 13. Hereby a sealing is acquired as well as the injection packer 1 is kept in place. Radial expansion is achieved by means of the seal 5 being compressed in an axial direction, which is accomplished by screwing the support ring 11 onto the connecting portion 7 of the injection tube 3 thereby pressing the sleeve 5 together.

The opening means 2 is initially positioned at the outlet opening 40 of the check valve 4, as shown in Fig. 3a, keeping the check valve in an open position. It is to be understood that the purpose of keeping the check valve in an open position during initial sealing operation is to allow a reverse flow of water leakage out from the corresponding bore hole 13 as a consequence of injection of filling material into a distant bore hole that is connected to the bore hole via e.g. cracks.

In Fig. 4b an injection hose 15 is coupled to the connecting portion 7 of the injection tube 3 and filling material, for instance grouting or cement, is injected under pressure through the injection packer 1, further via the injection tube 3 out through the check valve 4 which will open up fully as a result of the pressure from the injected filling material 16. The filling material will hereby enter into the bore hole 13 filling it and preferably also filling any cracks leading into the bore hole 13. Said opening means 2 is

hereby removed from said check valve 4 by means of the pressing force from injection material and is swept along with the grouting 16 and into the bore hole 13 space. Removal of said opening means 2 leads to that the valve 4 will adapt the function of a check valve.

After that the bore hole 13 is completely filled with grouting 16, as shown in Fig. 4c, injection is interrupted resulting in a pressure drop inside the injection tube 3 so that the check valve slits 42 are free to return to a sealed configuration (i.e. the outlet opening 40 is not forced to be open neither by an opening means 2 nor by passage of pressurized filling material). Hereby the check valve 4 may close and the sealing portion is tightly held together so that no filling material 16 escapes out from the bore hole 13. Interruption of the injection further leads to that a pressure difference arises between the inside of the injection tube 3 and the bore hole 13 filled with the highly pressurized filling material 16. Thus the nose cone 4 of the check valve will become subjected to pressure from the surrounding filling material 16 inside the bore hole 13, and this will further contribute to the closing of the outlet opening 40 since the pressure surrounding the conical tip of the check valve 4 will urge the slits 42 at the check valve tip portion to close.

The shape of the check valve portion 4 is preferably conical, since such a shape will provide the best functionality regarding ability to withstand high pressure from filling inside the bore hole 13. A substantially tapered shape leads to that part of the pressure force acting on the check valve surface will be directed towards the cone center axis, helping the check valve to close upon interruption of injection. The skilled person understands that shapes other than conical are evidently possible, however that a check valve comprising a flat front surface – e.g. as on a truncated cone – will lead to a collapse of the rubber front portion at a lower pressure compared to a conical check valve.

As in Fig. 4d the filling material 16 is left to solidify, and the bore hole 13 is finally shielded by a cover plate 17 mounted over the hole opening.

The skilled person realizes that a large variety of modifications may be performed without the use of inventive skill, departing from the description above, e.g. the check valve 4 may have another shape than that of a cone, but preferably having at least a tapered shape, being tapered in a direction away from the injection tube inlet to form a positive seal, and its circumference at its broadest short end being tightly connected to

the outlet component 8 or the injection tube 3. Also the outlet opening 40 may consist of one or more slits 42, or any other type of opening however comprising at least one sealing portion 41 arranged to prevent reverse flow through the injection packer 1.

Many modifications and other embodiments of the inventions set forth herein will come to mind to one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the foregoing descriptions and the associated figures. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

CLAIMS

1. A device for sealing a rock wall, which device comprises an injection tube (3) adapted to be introduced into a bore hole (13) in the rock wall (12), into which bore hole (13) a filling material (16) is intended to be injected through the injection tube (3), said device (1) also comprising a check valve (4) for the filling material (16) characterized in that said check valve (4) further comprises a removable opening means (2) for at least temporarily keeping said check valve (4) in an open position.

2. Device according to claim 1, wherein said check valve (4) is connected to the injection tube (3) and is arranged to allow for a forwardly directed through flow of pressurized filling material (16) from the injection tube (3) into a bore hole (13), and which check valve (4) further is arranged to prevent a reverse through flow of filling material (16) from a bore hole (13) to the injection tube (3), which check valve (4) is arranged to withstand a positive pressure of a filling material (16) inside a bore hole (13), preferably arranged to withstand a positive pressure of 75 bar, preferably 90 bar more preferred 100 bar.

3. Device according to claim 1 or 2, wherein said opening means (2) is positioned in the opening portion (40) of said check valve (4).

4. Device according to claim 1, 2 or 3, wherein said check valve (4) comprises an elastic material enclosing the injection tube (3).

5. Device according to anyone of the previous claims, wherein said check valve (4) comprises an open position and a closed position and wherein said opening means (2) is arranged to keep the check valve (4) in an open position during initial operation of sealing a rock wall.

6. Device according to claim 4 or 5, wherein said check valve (4) comprises a tapered shape, preferably tapered in a direction away from the injection tube (3) inlet (7) to form a positive seal, and its circumference at its broadest short end being tightly connected to the injection tube (3).

7. Device according to claim 6, wherein said check valve (4) comprises a through channel (43) connected to said opening portion (40) of the check valve (4), said channel comprising at least at one sealing portion (41) arranged to keep a shut

configuration and prevent reverse flow, which sealing portion (41) is arranged to open upon injection of said filling material (16) through the injection tube (3).

8. Device according anyone of claims 4 - 7, wherein said check valve (4) has a conical shape and comprises, at its narrowest end, at least one slit (42) forming an outlet opening (40).

9. Device according to anyone of the previous claims, wherein the part which is adapted to be arranged adjacent to the opening of the bore hole (13), upstream of said check valve (4), is provided with a seal (5) arranged to act against the walls of the bore hole (13).

10. Device according to anyone of the previous claims, wherein said check valve (4) comprises at least one closed position (41) at the end portion of the device facing away from the injection tube inlet (7).

11. Device according to anyone of the previous claims, wherein said opening means (2) is arranged to be removed from said check valve (4) by means of a pressing force resulting from injection of said filling material (16) through the injection tube (3), whereupon removal of said opening means (2) leads to that said valve functions as a check valve.

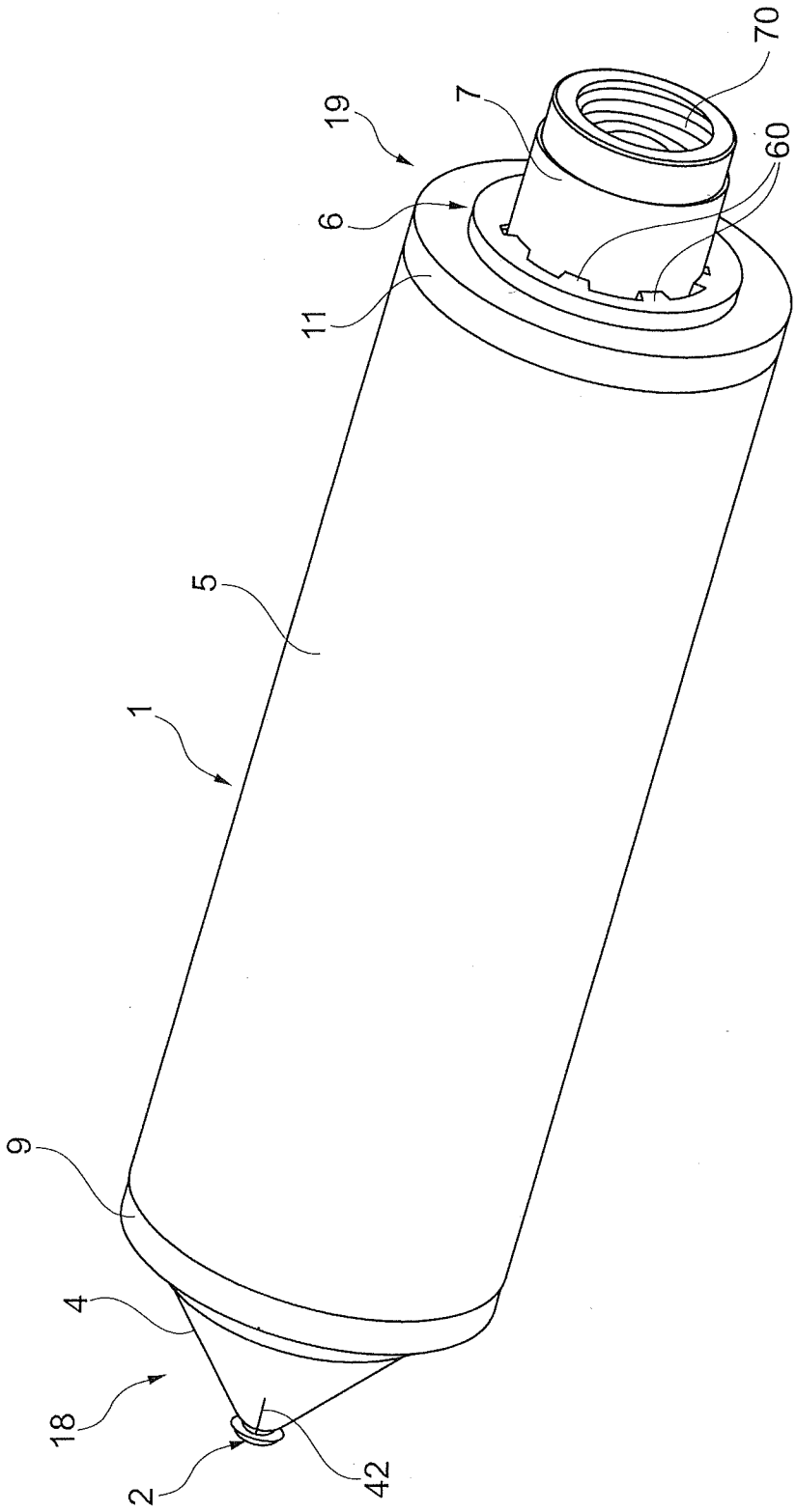

Fig. 1

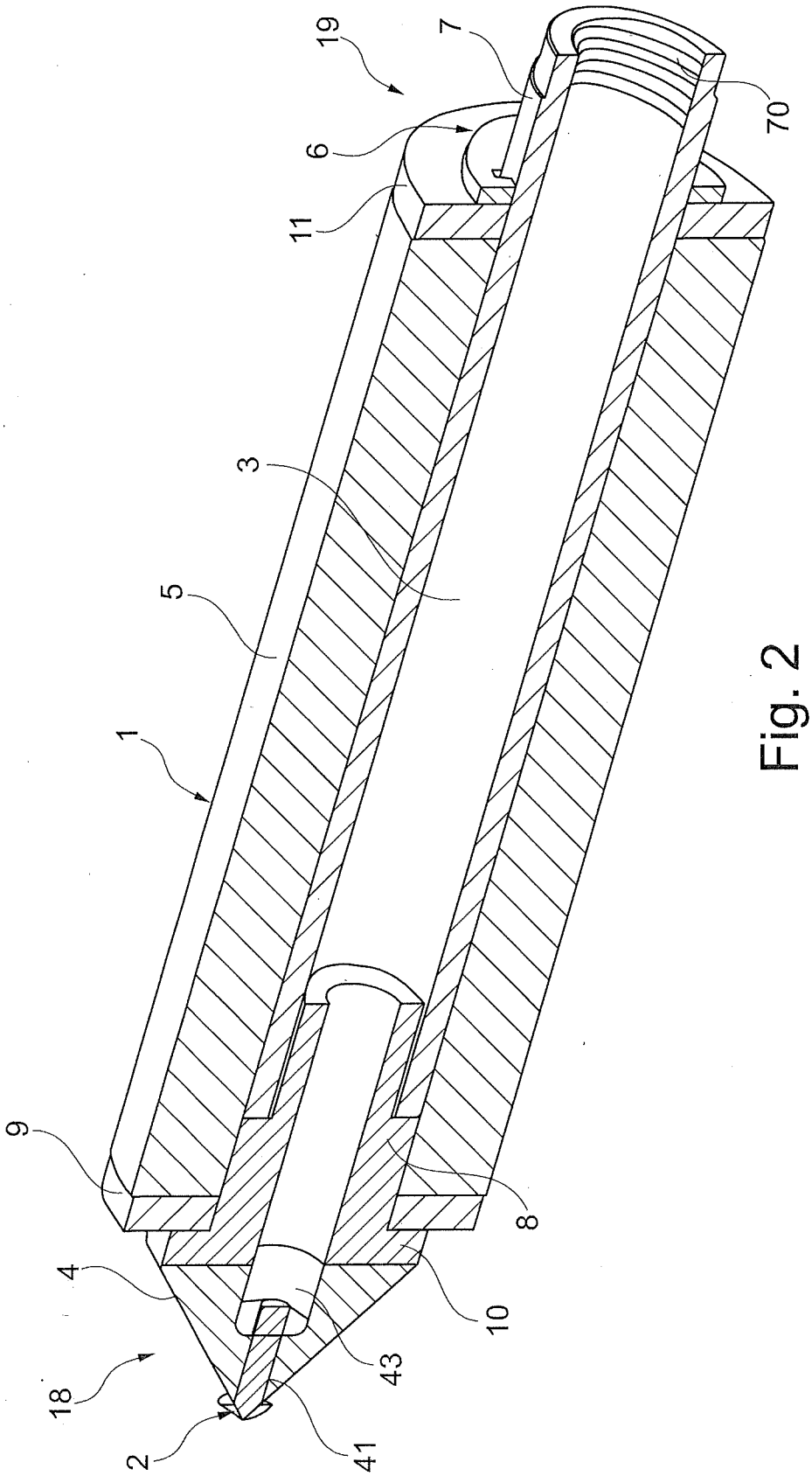

Fig. 2

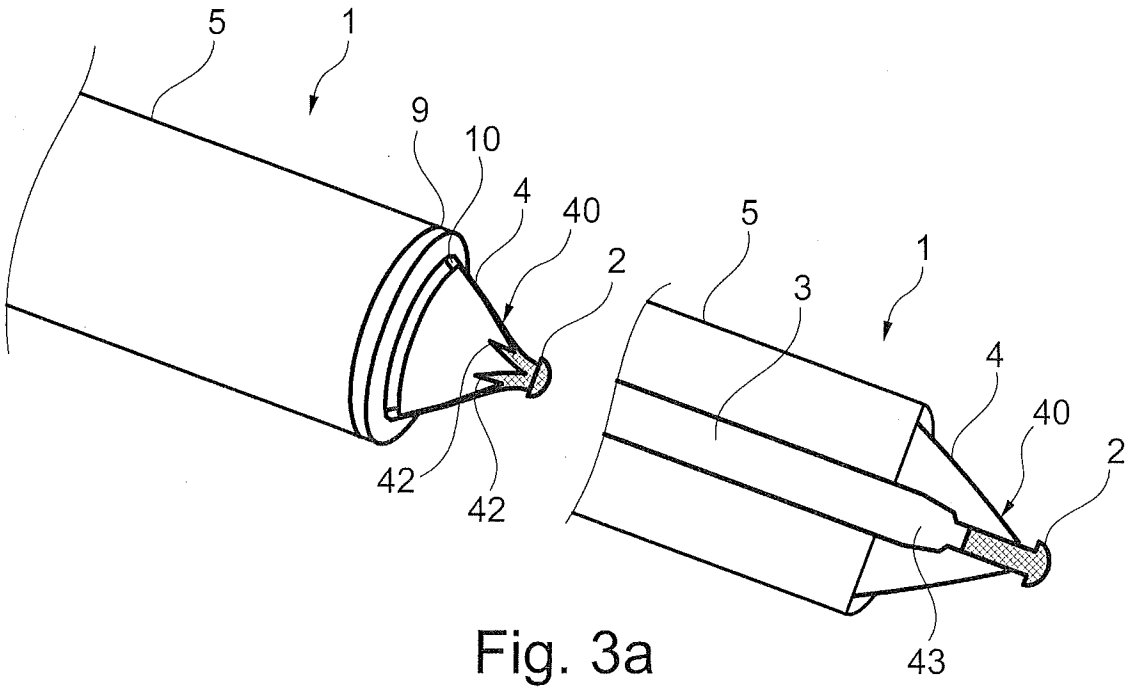

Fig. 3a

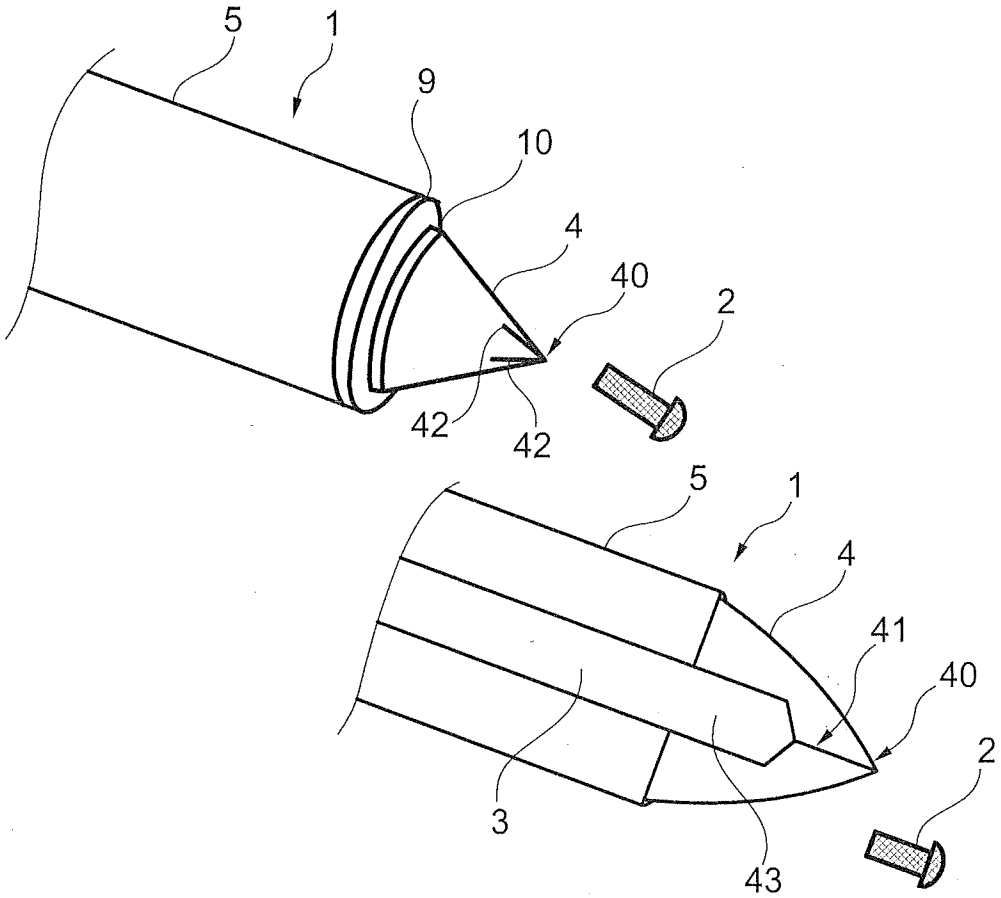

Fig. 3b

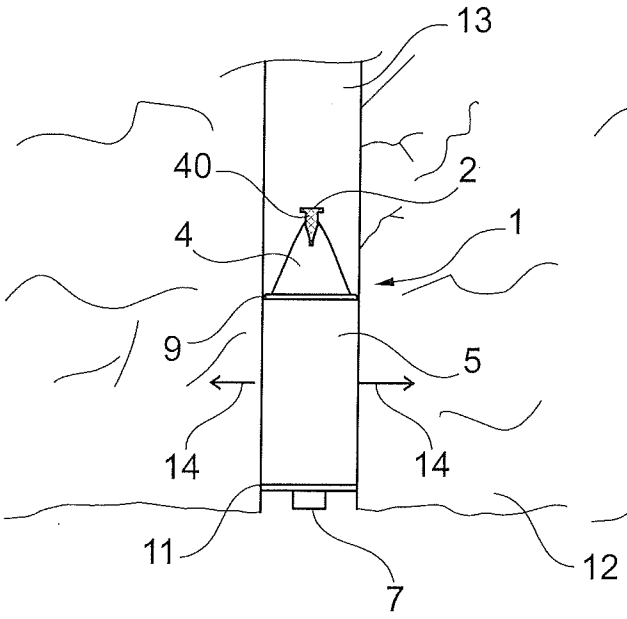

Fig. 4a

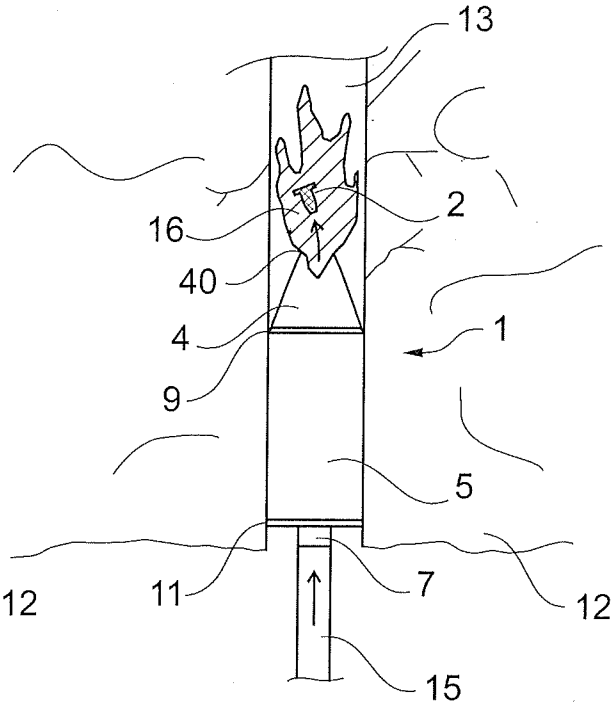

Fig. 4b

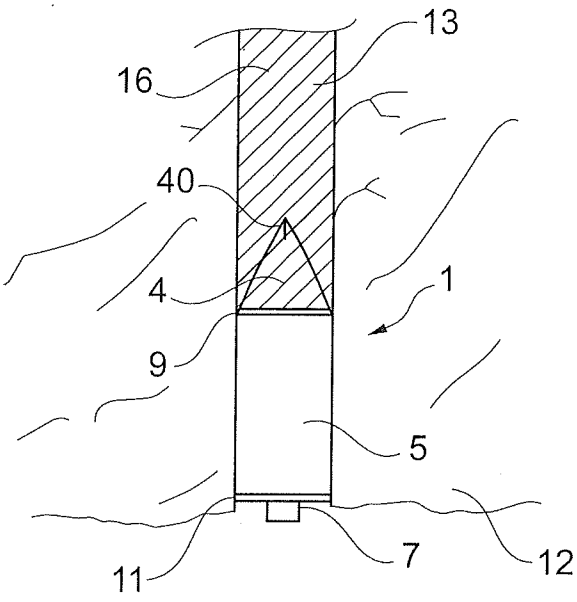

Fig. 4c

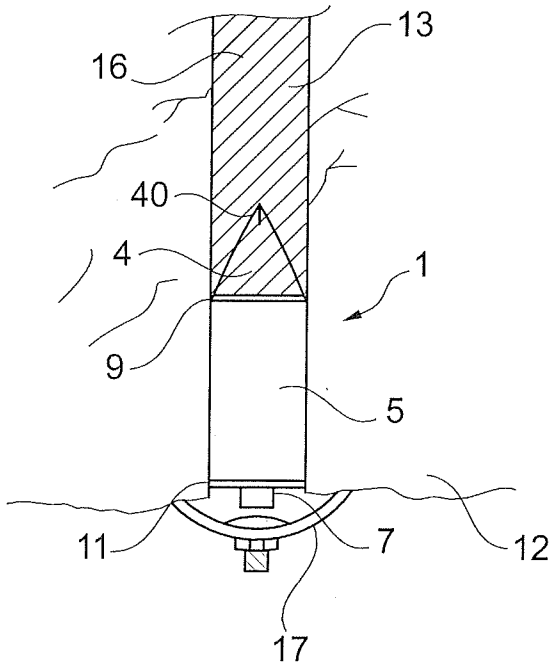

Fig. 4d

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2011/050474

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: E21B, E21D, F16K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2172629 A (EXXON PRODUCTION RESEARCH CO), 24 September 1986 (1986-09-24); whole document --	1-11
A	WO 9220901 A1 (KNUT NORDVALL BETONGTAETNING A), 26 November 1992 (1992-11-26); whole document --	1-11
A	DE 2838186 C2 (TRELLEBORG AB), 15 March 1979 (1979-03-15); whole document -- --------	1-11

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
17-08-2011	18-08-2011

Name and mailing address of the ISA/SE	Authorized officer
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Continuation of: second sheet

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E21D 9/00 (2006.01)
E21D 20/02 (2006.01)

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Cited literature, if any, will be enclosed in paper form.

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