



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
23.06.2010 Bulletin 2010/25

(51) Int Cl.:
E21D 20/02 (2006.01) E21D 21/00 (2006.01)

(21) Application number: **09425508.0**

(22) Date of filing: **14.12.2009**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
AL BA RS

(71) Applicant: **Giamundo Aniello, Anna**
80063 Piano di Sorrento (NA) (IT)

(72) Inventor: **Maddaluno, Giona**
80067 Sorrento (NA) (IT)

(74) Representative: **Fiammenghi-Domenighetti, Delfina et al**
Via Quattro Fontane 31
00184 Roma (IT)

(30) Priority: **19.12.2008 IT RM20080682**

(54) **Tunnel reinforcement tubular device of non-polluting material**

(57) The invention concerns a tubular device made of fiberglass-reinforced plastic provided with internal longitudinal channels used both for inserting the hardenable

fluid (cement mortar, grout or other) under pressure and for the exit of the same at the end of the reinforcement hole filling operation (8).

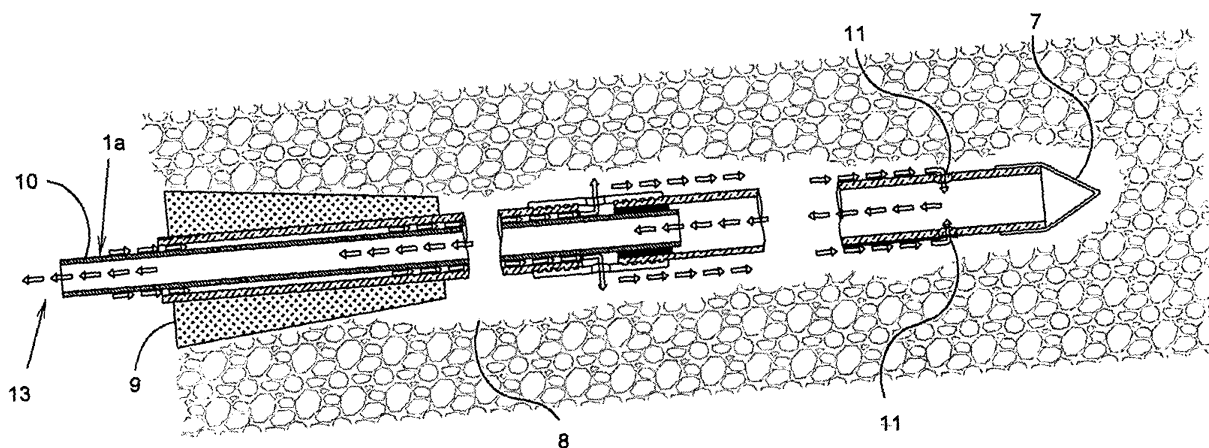


Fig. 1a

DescriptionState of the art

[0001] The present invention regards a device and a related process for the reinforcement of the excavation face of a tunnel.

Prior art

[0002] During the full section excavation of a tunnel, one of the by now consolidated techniques consists of pre-reinforcing the face. In substance, holes are made, a fiberglass-reinforced plastic reinforcement element is inserted, and grout is injected. In detail, there are substantially four types of reinforcement techniques:

- a) reinforcement of the advance core and cavity borders;
- b) reinforcement of the advance core and pre-reinforcement of the borders;
- c) radial riveting ahead of the face (for which the so-called "jet grouting" technique is excluded);
- d) radial riveting from the pilot tunnel.

For the injection in the single holes of the reinforcement work, cementations, low-pressure injections or jet grouting are used.

Specifically, the relative operating modes are the following:

i) Cementation:

- i1) Perforation
- i2) Insertion in the hole of the fiberglass-reinforced plastic element provided with suitable centering devices
- i3) Hole mouth caulking with quick-setting cement mixtures
- i4) Cementing the hole through a PVC or PE tube

ii) Low-pressure injection:

- ii1) Perforation
- ii2) Insertion in the hole of the fiberglass-reinforced plastic element provided with suitable centering devices
- ii3) Hole mouth caulking with quick-setting cement mixtures
- ii4) Cementing, with mortar coating of the hole through a PVC or PE tube
- ii5) Selective low-pressure injection (20 ÷ 50 bar).

The standard tubes also allow the low-pressure injection of grouts and/or cement mortars through valves. For high-pressure injections, the tubes must be obtained by employing a suitable orientation of

the reinforcement (hp series for burst pressures up to 100 bar).

i) Jet Grouting:

- iii1) Obtainment of jet grouted column
- iii2) Insertion in the hole of the fiberglass-reinforced plastic bar provided with suitable spacers, so as to center it in the hole itself.

[0003] As seen, apart from the jet grouting case, the injection techniques always provide for the aid of polyvinylchloride (PVC) tubes or polyethylene (PE) tubes, or tubes made of other thermoplastic materials.

[0004] The material constituted by the debris obtained during the excavation of the already reinforced excavation face, i.e. the so-called "spoil", therefore contains materials that are currently considered polluting, since they are of instable chemical nature. Therefore, the trend of related laws on the matter is to prohibit the use of the spoil (containing the thermoplastic materials of the injection tubes) for all the construction work, even in the execution of the road embankments. It follows that the spoil must be deposited in suitable dumps for polluting material, which involves very high costs. Therefore, one object of the present invention is that of providing a device and a process for reinforcing the excavation face in a tunnel which does not provide for the use of polluting material, such as thermoplastic material (e.g. PVC or PE), obtaining a reinforcement that is identical or even of improved quality with respect to the preceding art.

[0005] With regard to the device, the objects of the invention are obtained by means of a tubular device made of stable, non-polluting material, preferably fiberglass-reinforced plastic, to be used in the reinforcement techniques of the excavation face in a tunnel, whose characteristics are specified in claim 1. The dependent device claims regard several specific and/or particularly advantageous embodiments.

[0006] With regard to the process, the objects of the present invention are obtained by means of a process of reinforcement of the excavation face in a tunnel having the characteristics contained in claim 10.

[0007] According to the present invention, a tubular device is provided that is (nearly) entirely made of fiberglass-reinforced plastic, which preferably has two longitudinal channels inside the device, i.e. incorporated inside the same. The first channel has a hole mouth side opening, and the second has a hole bottom side opening. The internal channels do not communicate with each other, and at their opposite ends lead towards the outside (at the mouth of the reinforcement hole in the mounting position of the tubular device of the invention). According to the tilt of the reinforcement hole, the grout (or the like) is injected under pressure into the first internal longitudinal channel or into the second internal longitudinal channel. When the reinforcement hole is completely filled, the grout (or the like) exits from the second internal longitudinal channel or from the first internal longitudinal chan-

nel (process claim 10).

[0008] The tubular device of the present invention can remain inside the hole as a reinforcement of the hardened cement mixture. It does not comprise unstable polluting materials and is therefore acceptable by current laws. In addition, it also allows verifying that the hole is completely filled with grout.

[0009] Preferably, as indicated in the dependent device claims, the tubular device has a first tubular section in double-tube form (two coaxial tubes) which defines an "external jacket" and an "internal tube".

[0010] The external jacket will act as the first internal longitudinal channel, while the internal tube will act as the second internal longitudinal channel. This embodiment type (currently considered the preferred embodiment), illustrated in the following detailed part of the description, offers particular advantages in terms of simplification of the production process of the tubular device of the present invention.

Brief description of the drawings

[0011] The present invention will now be described only as a non-limiting example, with reference to the enclosed drawings, which show a particular, non-binding embodiment of the present invention in which:

FIGURE 1a illustrates the device and the technique of the present invention, in the case of reinforcement of an upward-tilted hole;

FIGURE 1b illustrates the device and technique of the present invention, in the case of reinforcement of a downward-tilted hole;

FIGURE 2a shows a detail of Fig. 1a;

FIGURE 2b shows a detail of Fig. 1b;

FIGURE 3 is a cross section view (section A-A of Fig. 4b) of the device of the present invention;

FIGURE 4a is an exploded and longitudinal section view (section B-B, Fig. 4b) of the central part of the device of the present invention, shown in assembled state in Figs. 2a and 2b;

FIGURE 4b is an exploded side view of the central part of the device of the present invention, entirely analogous to the view of Fig. 4a.

Detailed description of the preferred embodiment

[0012] The present invention will now be described by examining its particular characteristics, which would allow a man skilled in the art of the field to actuate it. Other details, which are known and considered to be obvious for a man skilled in the art, will be omitted from the de-

scription.

[0013] In the following part of the description, the term "fiberglass-reinforced plastic" will be frequently used. Nevertheless, since the invention could be applied by using another equally stable and non-polluting material, with mechanical/physical properties similar to those of fiberglass-reinforced plastic, below (except in the claims) the term fiberglass-reinforced plastic signifies a stable, non-polluting chemical material which could be employed, due to its mechanical qualities similar to fiberglass-reinforced plastic (lightness, strength etc.), in place of actual fiberglass-reinforced plastic.

[0014] In its preferred, non-limiting or non-binding embodiment shown in the figures, the device comprises:

- a tubular fiberglass-reinforced plastic element, constituted by a first tubular section made of fiberglass-reinforced plastic 1a and by a second tubular section made of fiberglass-reinforced plastic 1b, constituting separate pieces but connected together via coupling or interference by means of a collar 2, preferably made of fiberglass-reinforced plastic.

The pressure-insertion of the collar 2 between the two tubular sections 1a, 1b ensures the watertight seal between the respective walls of these two sections 1a, 1b in contact with the same collar 2;

- an external sleeve 3 (Figs. 2a and 2b), preferably metal, having two female threads 4a, 4b which are engaged with the male threads 5a, 5b, respectively, of the tubular sections 1a and 1b; this sleeve 3 has, for example, four transverse holes 6 for the passage of the grout or the like situated at angular distances of 90° around the circumference of the sleeve 3;
- a (seal) closure element, or cap 7 (see Figs. 1a, 1b) which covers the "distal" part (i.e. hole 8 bottom side) of the device of the invention when inserted in the reinforcement hole 8, or better yet which closes the second tubular fiberglass-reinforced plastic section 1b; this cap 7 could be made of metal and among other things serves to prevent the accidental entrance of soil or the like into the tubular element 1a+1b, especially into the second tubular fiberglass-reinforced plastic section 1b.

[0015] It is observed that the component 9 constitutes the already-known hole 8 mouth caulking made with quick-setting mortars or possibly constituted by a cap made of expanded molded PE. The component 9 ensures the watertight seal with the wall of the mouth of the hole 8 (as in the prior art) and with the cylindrical external wall of the end (hole mouth side) of the first tubular fiberglass-reinforced plastic section 1a. The component 9 can therefore be considered as not making up part of the tubular device of the present invention.

[0016] In addition, it is observed that the volume occupied by the components 3, 7 that are not made of fiberglass-reinforced plastic is in reality negligible with respect to the overall volume involved (the tubular device of the

invention could even reach 18-20 meters length). Therefore, for practical purposes the device of the invention can be considered as being entirely composed of fiberglass-reinforced plastic.

[0017] The specific structure (in this preferred embodiment of the invention) will now be described of the two tubular sections 1a, 1b of the tubular device according to the present invention.

[0018] Of course, the first tubular fiberglass-reinforced plastic section 1a extends from the screwing zone in the metal sleeve 3 up to (and beyond) the mouth of the hole 8, while the second tubular fiberglass-reinforced plastic section 1b extends from its screwing zone in the other side of the sleeve 3 up to the cap 7.

[0019] The first tubular fiberglass-reinforced plastic section 1a is actually formed by two coaxial fiberglass-reinforced plastic tubes 10, 10' (see cross section of Fig. 3), connected with each other so as to form a single piece, as indicated. The internal tube 10 extends a certain distance beyond the edge (distal end) of the external tube 10' whose end (as said) is threaded. On the other hand, the internal tube 10 is smooth. From the production standpoint of the first tubular section 1a, this could be obtained by means of molding of a whole fiberglass-reinforced plastic tube having the structure indicated in Fig. 3, and by means of turning one end of the same until the internal projecting tube 10 appears completely smooth.

[0020] The second tubular fiberglass-reinforced plastic section 1b is instead constituted by a simple tube 12 made of fiberglass-reinforced plastic, i.e. without internal tube, but with one end provided with the aforesaid male thread 5b.

[0021] It will now be described how the device of the present invention can be used in the reinforcement of the excavation face of a tunnel.

Case (a): Tilt of the hole 8 directed upward starting from the mouth of the hole 8 itself (case related to Figures 1a and 2a):

[0022] The grout or the like, whose reinforcement will be constituted at the conclusion of the work by the tubular device of the invention, is pressure-inserted into the related hole 8 made in the face of the tunnel through the so-called "jacket" of the tubular device, i.e. between the two tubes 10, 10'. Once it has exited from the external tube 10' and reached the sleeve 3, its transverse holes 6 and the seal collar 2, the grout inevitably diverges and exits from the transverse holes 6. Then, as indicated by the arrows (which show the path of the grout in a very simplified but effective manner), the same begins to rise until it reaches the zone of the hole bottom. Since the pressure of the (grout) fluid between the wall of the hole 8 and the external wall of the tubular device continues to grow, this fluid is obliged to re-enter the device through the transverse holes 11 (indicated in Fig. 1a) entirely analogous to the holes 6, which are made on the wall of the second tubular fiberglass-reinforced plastic section

1b, near the bottom of the hole 8. As indicated in Figs. 1a, 2a, the fluid, returning into the tube 12 constituting the second tubular fiberglass-reinforced plastic section 1b, once again descends towards the mouth of the hole 8 by passing through the internal tube 10 of the first tubular section 1a. Once the fluid has exited (at the point indicated by the arrow 13 in Fig. 1a), one will be certain that the reinforcement hole 8 has been completely filled with grout or the like and the tubular device of the invention will remain inside as its reinforcement.

[0023] Thus, the device of the present invention will simultaneously act as a means for carrying out the injection of the grout or the like in the hole 8, as a means for verifying the complete filling of the hole 8 with the grout and as a means of fiberglass-reinforced plastic reinforcement (such material being stable and ecologically acceptable).

[0024] These three functions, integrated in one single object, constitute the true strength of the invention. The spoil deriving from the excavation following the reinforcement can therefore be reused for other construction works and in any case will not have to be deposited in a suitable dump for polluting materials.

Case (b): Tilt of the hole 8 directed downward starting from the mouth of the hole 8 itself (case related to Figures 1b and 2b):

[0025] In this case, the grout is injected directly into the internal tube 10 (rather than between the tubes 10, 10'), before exiting from the transverse holes 11 of the second tubular section. The grout descends by gravity towards the bottom of the hole 8 but then, once this bottom is filled, it rises towards the mouth of the hole 8 according to the path indicated by the arrows. It then enters into the "jacket" of the tubular device of the invention, i.e. into the air space between the two tubes 10, 10' of the first tubular section 1a, after having entered into the sleeve 3 through its transverse holes 6 (see Fig. 2b in particular). Indeed, since - once the grout has exited from the holes 11 - the pressure of the grout situated between the wall of the hole 8 and the external wall of the tubular device would continue to increase, the grout is obliged to re-enter the device (as in the preceding case a), this time through the holes 6 (rather than 11). It is observed that each of the two injection methods (case a and case b) are specific for a particular tilt of the hole 8. The method of case a) is also applicable when the hole 8 is horizontal or substantially so.

[0026] In other words, the method of case a) would not be applicable if the hole 8 is tilted downward, and the technique described in case b) could not be employed if the hole is tilted upward. Indeed, employing the method b) for a hole 8 directed upward, one would probably not be able to fill the entire bottom of the hole 8 (hole bottom side, or distal side) with grout. Likewise, employing the method a) for a hole tilted downward, it would probably not be possible to fill the entire side of the hole next to

the component 9 (hole mouth side, or proximal side) with grout.

[0027] In summary, in case a) there is a hole mouth side injection (the fluid material exits from the device at the sleeve 3 situated in proximal position) and a hole bottom side vent (the fluid material re-enters the device through the transverse holes 11 closest to the bottom of the hole 8). In case b), there is a hole bottom side injection (the fluid material exits from the device at the distal transverse holes 11) and a hole mouth side vent (the fluid material re-enters the device through the proximal transverse holes 6). It must be noted that the use of reinforcements made of composite material commonly indicated as fiberglass-reinforced plastic, intended for underground use, can be deemed consolidated practice.

[0028] In particular, in the making of tunnels, intensive applications of bars, tubes or integrated systems of various complexity (reinforcements coupled with injection vehicles or perforation and injection systems), they are used in techniques for improving the characteristics of the mass at the excavation core and at the borders of the cavity (ADECO-RS Method) or for radial riveting ahead of the face or from the pilot tunnel.

[0029] Nevertheless, the originality and specificity of the present invention lies in the fact that the "double-tube" reinforcement - as represented in the section of Fig. 3 - does not comprise thermoplastic materials, and in addition to acting as reinforcement it also allows verifying, due to the double passage, the completed filling of the hole 8 with the hardenable fluid filling material (grout or the like).

[0030] In general, the present invention is not limited to a round external section of the tubular device. The latter could have a square or generally polygonal shape, even if the round section is preferable.

[0031] In addition, in general additional vents (or injection holes) could be present, closer together in longitudinal direction (i.e. not only distributed on a plane transverse to the tubular device as in the preceding detailed description), hole bottom side and/or hole mouth side, respectively.

[0032] The present invention is therefore not limited to the exact configuration of the tubular device shown in the drawings and corresponding to the preferred embodiment of the invention. Indeed, it is extended to all those configurations which can be deemed easily inferable from the present concrete embodiment for an average man skilled in the art.

Claims

1. A tubular device to be used in the reinforcement techniques of the excavation face in a tunnel, **characterized in that** it is substantially entirely made of stable, non-polluting material, preferably fiberglass-reinforced plastic, and having a lateral wall, a first proximal end, or hole mouth side end, from which a

hardening fluid material is injected, and a second distal end, or hole bottom side end; the device also being **characterized in that** it has:

- at least one first internal longitudinal channel, which extends inside the tubular device, between one or more first openings situated at the proximal end, up to one or more proximal holes (6) which cross through the lateral wall of the tubular device in a zone that is far from the distal end,
- at least one second internal longitudinal channel, not intercommunicating with said first internal longitudinal channel, and which extends inside the tubular device from one or more second openings situated at the proximal end of the tubular device, up to one or more distal holes (11) which cross through the lateral wall of the tubular device in a zone that is close to its distal end, situated between the latter and the zone of said proximal holes (6);

wherein,

said first internal longitudinal channel communicates with the tubular device exterior only through said first openings and said one or more proximal holes (6), and

said second internal longitudinal channel communicates with the tubular device exterior only through said second openings and said one or more distal holes (11).

2. A tubular device according to claim 1, **characterized in that** it comprises a liquid seal closure cap (7) arranged at its distal end.
3. A tubular device according to claim 1 or 2, **characterized in that** it has a substantially round section.
4. A tubular device according to claim 1 or 2, **characterized in that** it has a substantially polygonal section.
5. A tubular device according to any one of the preceding claims, **characterized in that** it has a first tubular section (1a) and a second tubular section (1b), wherein the second tubular section (1b) consists of a simple tube (12) with free inner passage constituting a first part of said second internal longitudinal channel, while the first tubular section (1a) has a double-tube structure, since it is composed of an internal tube (10) and an external tube (10') coaxial thereto, wherein, in addition, said first internal longitudinal channel extends between the internal tube (10) and the external tube (10'), while the remaining part of the second internal longitudinal channel extends through the internal tube (10).

6. A tubular device according to claim 5, **characterized in that** said first tubular section (1a) has a distal end as well as a proximal end corresponding with said proximal end of the tubular device, and said second tubular section (1b) has a proximal end as well as a distal end corresponding with said distal end of the tubular device, the proximal end of the second tubular section (1b) being connected, e.g. through screwing (4a, 4b, 5a, 5b), by means of a sleeve (3), to the distal end of the first tubular section (1a); wherein said sleeve (3) has said proximal holes (6) and said second tubular section (1b) has said distal holes (11). 5 10
7. A tubular device according to claim 6, **characterized in that:** 15
- the outer diameter of the first tubular section (1a) is equal to the outer diameter of the second tubular section (1b), while the outer diameter of said internal tube (10) is less than the inner diameter of the second tubular section (1b) constituting the simple tube (12); 20
 - the internal tube (10) projects beyond the external tube (10'), in the direction of the distal end of the tubular device, and is inserted for a determinate section within the second tubular section (1b); and 25
 - between the outer wall of the internal tube (10) and the inner wall of the simple tube (12), a collar (2) is inserted via interference which ensures a liquid seal closure. 30
8. A tubular device according to claim 7, **characterized in that** said collar (2) is made of fiberglass-reinforced plastic. 35
9. A tubular device according to claim 6 or 7, **characterized in that** said sleeve (3) is a metal sleeve. 40
10. A process for reinforcing the excavation face of a tunnel, comprising the following steps: 40
- after having made a perforation for obtaining a relative hole (8) on the wall of the excavation face, a tubular device in accordance with claim 1 is inserted into the hole (8), possibly with the aid of centering means; 45
 - the hole mouth caulking (9) is carried out, for example by means of quick-setting cement mixtures or by means of the insertion of a cap (9) made of expanded spongy material; 50
 - depending on the tilt of the hole (8), one proceeds in the following manner: 55
- a) if the hole (8) is horizontal or has a tilt directed upward starting from the mouth of the hole itself, then a hardening fluid mate-

rial (e.g. a cement mixture) is injected through said first internal longitudinal channel, from the first proximal opening(s), until said hardening fluid, passing through said proximal holes (6), exits from the tubular device before returning, once the entire hole (8) is filled, into the same tubular device through its distal holes (11), passing through the second internal longitudinal channel and finally exiting from the device through said one or more second openings situated at the proximal end;

b) if the hole (8) has a tilt directed downward starting from the mouth of the hole itself, then a hardening fluid material (e.g. a cement mixture) is injected through said second internal longitudinal channel, from the second proximal opening(s), until said hardening fluid, passing through said distal holes (11), exits from the tubular device before returning, once the entire hole (8) is filled, into the same tubular device through its proximal holes (6), then passing through the first internal longitudinal channel and finally exiting from the device through said one or more first openings situated at the proximal end.

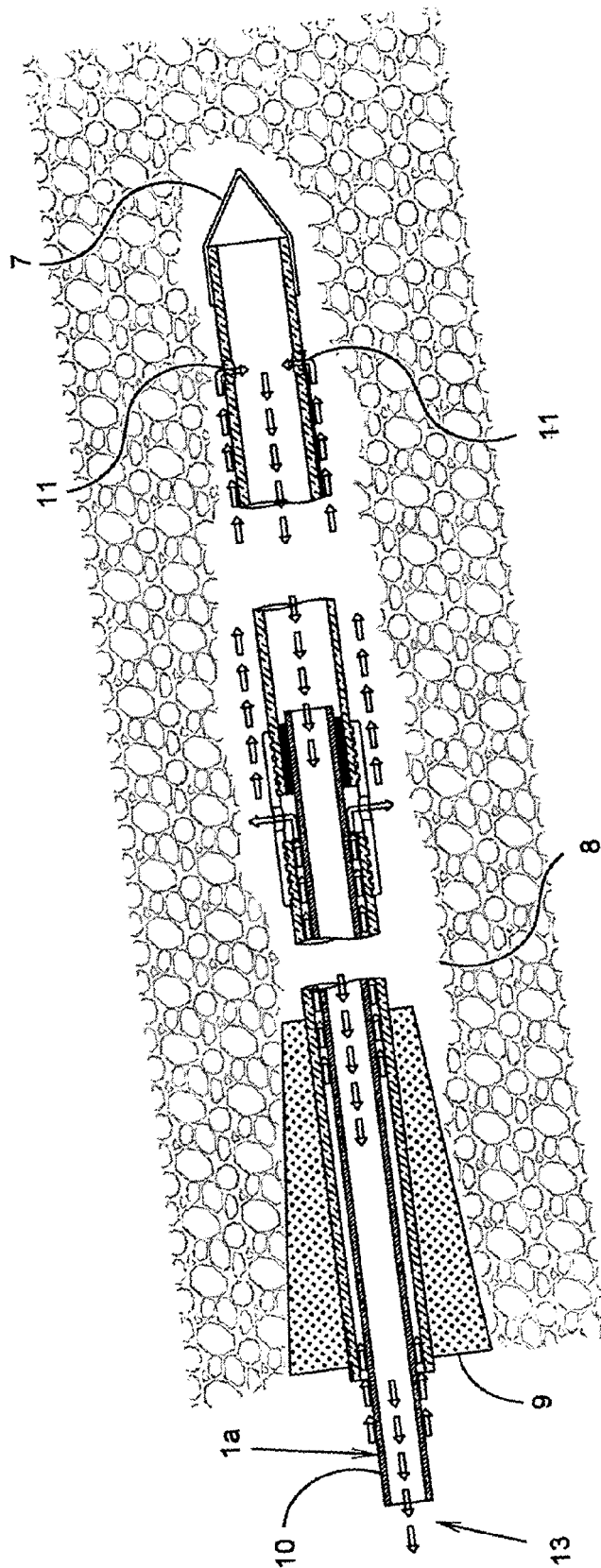


Fig. 1a

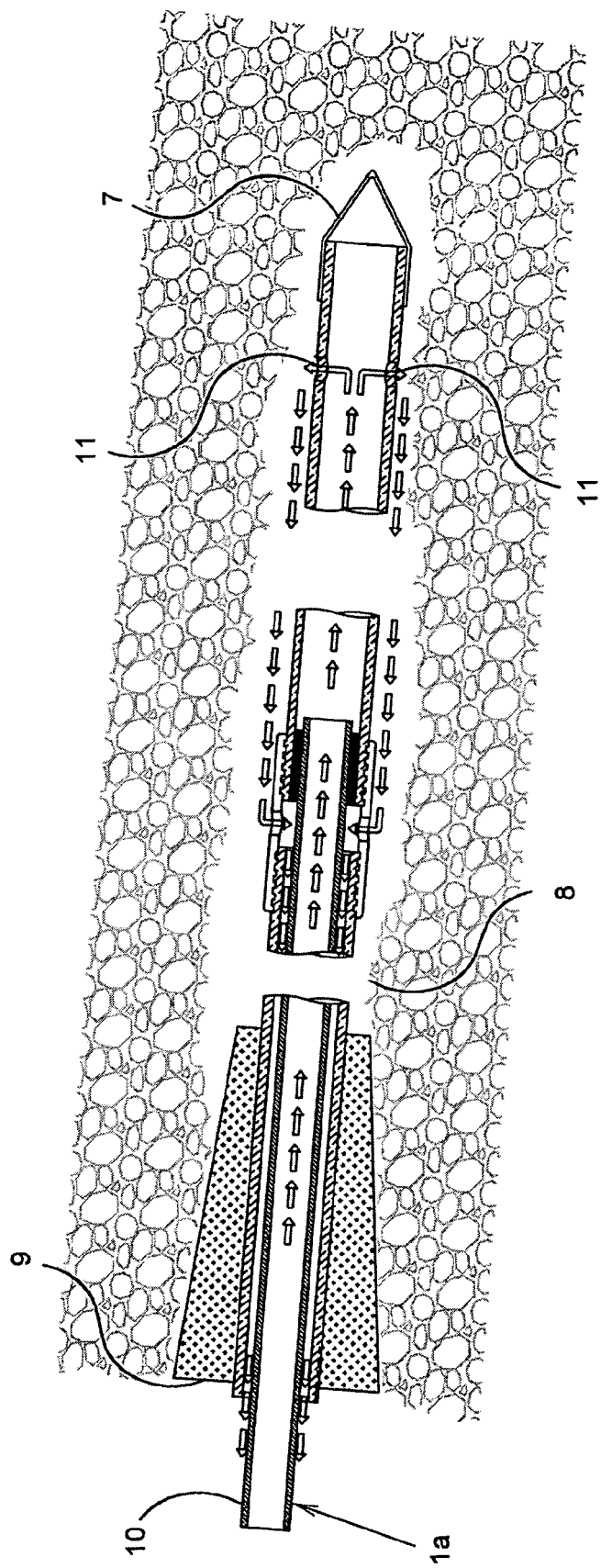


Fig. 1b

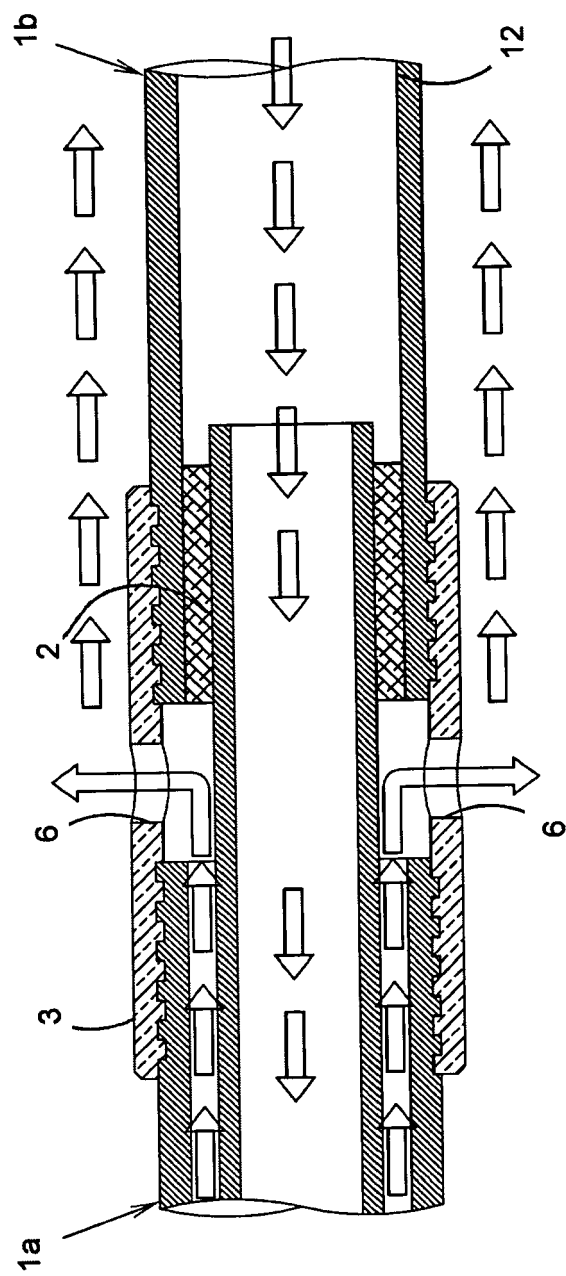


Fig. 2a

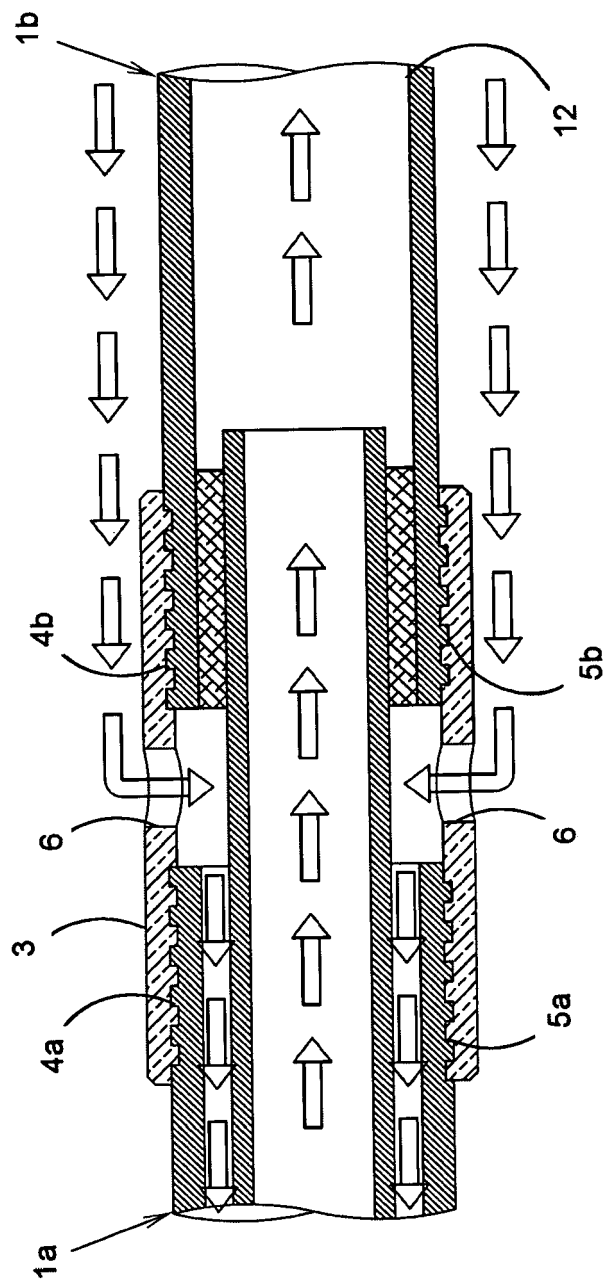


Fig. 2b

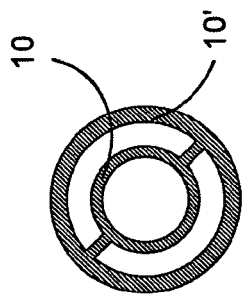


Fig. 3

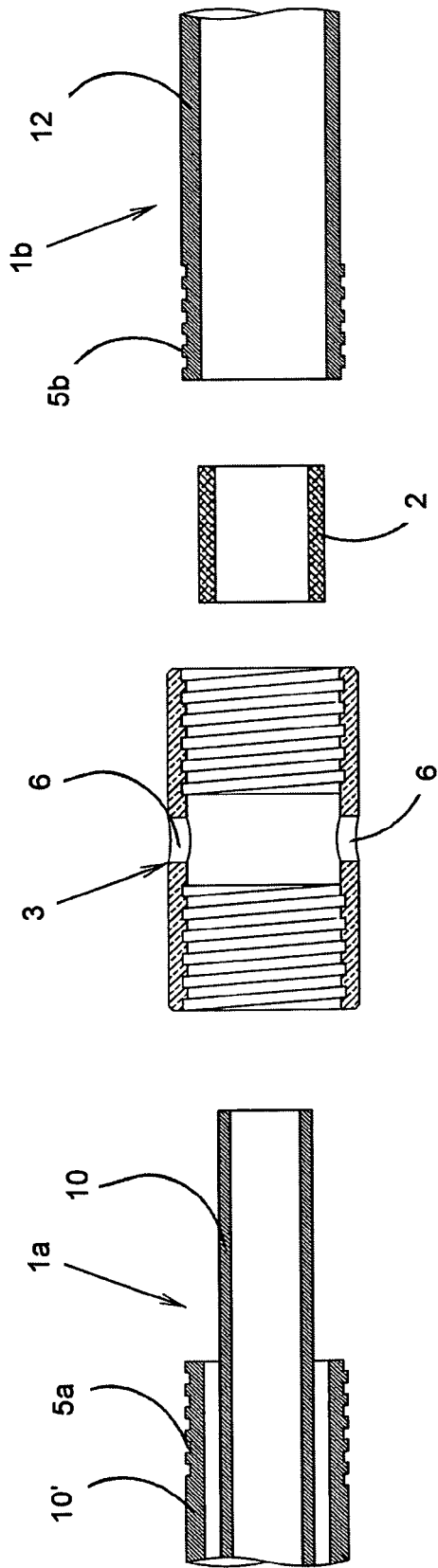


Fig. 4a

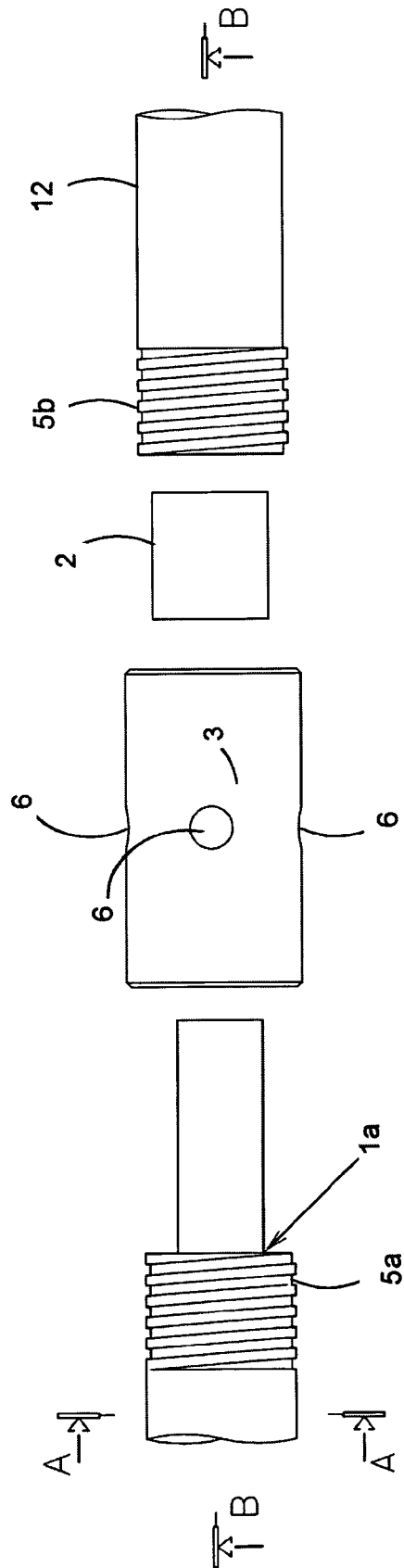


Fig. 4b



EUROPEAN SEARCH REPORT

Application Number
EP 09 42 5508

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 299 00 432 U1 (SCHRAN BERGBAU BAUMASCHINEN BO [DE]) 22 April 1999 (1999-04-22) * page 11, lines 4-32 *	1-4,10	INV. E21D20/02
X,P	EP 2 065 559 A (HILTI AG [LI]) 3 June 2009 (2009-06-03) * abstract *	1	ADD. E21D21/00
A	EP 1 939 394 A (MINOVA INTERNAT LTD [GB]) 2 July 2008 (2008-07-02) * abstract *	1-10	
A	US 2002/034424 A1 (LUDWIG WOLFGANG [DE] ET AL) 21 March 2002 (2002-03-21) * paragraph [0032] *	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			E21D
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 29 March 2010	Examiner Garrido Garcia, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

1
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 09 42 5508

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

29-03-2010

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
DE 29900432	U1	22-04-1999	NONE	

EP 2065559	A	03-06-2009	AU 2008246268 A1	18-06-2009
			CN 101446202 A	03-06-2009
			DE 102007057763 A1	04-06-2009
			US 2009142142 A1	04-06-2009
			ZA 200810155 A	26-08-2009

EP 1939394	A	02-07-2008	AT 458124 T	15-03-2010
			DE 102006059891 A1	26-06-2008
			EP 2096258 A2	02-09-2009
			US 2010003088 A1	07-01-2010

US 2002034424	A1	21-03-2002	AU 770677 B2	26-02-2004
			AU 2644501 A	11-10-2001
			CA 2342507 A1	10-10-2001
			CN 1317624 A	17-10-2001
			DE 10017763 A1	11-10-2001
			JP 2001349200 A	21-12-2001
			PL 346960 A1	22-10-2001
			ZA 200102830 A	08-10-2001
