(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
02 November 2017 (02.11.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/187219 A1

(51) International Patent Classification:
E21D 21/00 (2006.01)

(21) International Application Number:
PCT/IB2016/001480

(22) International Filing Date:
26 September 2016 (26.09.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PV 2016-244 28 April 2016 (28.04.2016) CZ

(71) Applicant: **DSI UNDERGROUND IP HOLDINGS LUXEMBOURG SARL** [LU/LU]; 26B, boulevar Royal, 2446 Luxembourg (LU).

(72) Inventor: **CHROBÁK, Vladimír**; 739 12 Čeladná 149 (CZ).

(74) Agent: **SOUKUP, Petr**; Videňská 8, 772 00 Olomouc (CZ).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** EXPANDABLE ROCK BOLT WITH INDICATOR OF CLAMPING

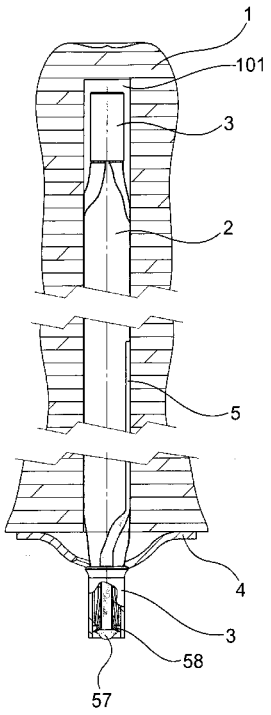

FIG. 1

(57) **Abstract:** An expandable rock bolt which is formed with a expansion body (2) whose transversal cross section has a deformed shape which forms on the surface at least one lengthwise groove (21) whose ends are procured with caps (3) with a filling component on an inlet side and an end component on an outlet side, where the essence of the invention is that it is equipped with at least one indicator (5) of clamping which is formed with a hollow tube (51) which is made of elastically compressible material and which is placed on the wall of the expansion body (2) along which is the indicator (5) taken out on the visible side for the staff whereas at least in a part of an internal cavity (512) of the tube (51) of the indicator (5) is placed indication medium.

WO 2017/187219 A1

Expandable rock bolt with indicator of clamping

Art Domain

This invention concerns design solution of an expandable rock bolt with an indicator of its clamping in the borehole which is designed not only for provision and reinforcement of consistency of the rock especially during driving of tunnels, mine corridors and chambers but also for stabilisation of rock walls, slopes and dikes or for formation of suspension reinforcement especially for tunnel and mine works with possible use in civil engineering.

Present Prior Art

For stabilisation and reinforcement of rock environment are used various types of rock bolts or anchors whose construction and material design differs in dependence on kind of rock. Among the most commonly used types are hydraulic expandable bolts which are procured with a tubular expansion tube which is procured on its both ends with end parts and whose surface is lengthwise in one or several lines deformed. These bolts are pushed into a beforehand drilled opening and subsequently is, into an expansion tube, forced a pressure medium whereby there comes to its expansion in the borehole, to formation of a frictional force of the tube of the bolt toward the wall of the borehole and thereby to its clamping.

An exemplary design of a hydraulic expandable bolt of this type is known from the file CZ 25706 U1 where is described a rock bolt which includes a tubular expansion tube whose transversal cross section has a deformed shape which forms on the surface of the tube at least one lengthwise groove and which is on its both ends finished with transitional annular caps in which are non-demountable fixed an outlet valve and an inlet valve. Yet this design does not enable any indication of expansion of the bolt and its clamping in the borehole. In the file WO2013173901 is described an expandable rock

bolt with a tubular expansion tube whose lengthwise cross section has a deformed shape which forms on the surface of the tube one lengthwise groove. The expansion tube is on its both ends finished with fixed tubular end parts and it is enlaced with at least one lengthwise adjustable sleeve which is fixable in any position. Yet in this design there is not described pressure control in the bolt and also not detection of its expansion or its correct clamping in the rock. In the file WO2004099570 is described a method for installation of expandable rock bolts by the help of pressurized of beforehand defined pressure by the help of a device with a control system which ensures keeping of the pressure for a certain time period and it is equipped with signalisation of efficiency of performed process or its failure. This design does enable pressure control in the bolt but there is not ensured detection of proper expansion and clamping in the borehole. In the file JP2005232761 is solved method of metering of generation of transversal tension of an expansion tube of a bolt inside of drill by the help of electric tensiometers which are connected to a detection unit. This design demands more complicated electronic equipment and does not provide information concerning perfect clamping of the bolt in the borehole. In the file WO2015176081 is described visual detection of filling of drill with medium by the help of an indication element which is part of a vent tube through which goes away air from gradually filled drill and which enables air passage but does not enable passage of viscous material. After filling of the drill with the viscous material is then the indication element pushed out from the vent tube which is visually noticed. This design is not possible to use for hydraulic expandable bolts. The file WO2009066246 solves detection of achievement of defined pressure in tubular expansion tube of expandable bolt with an indicator in its front end part which is after achievement of defined pressure pushed out from the end part which is visually noticed. This design indicates only pressure inside of the bolt but it does not enable indication of expansion of the bolt. In the file ZA200506692 is described similar design of pressure indication in tubular expansion tube of expandable bolt as in above mentioned file WO2009066246. Likewise, in this case is not possible to detect expansion of the bolt and its perfect clamping in the borehole.

The aim of presented invention is modification of expandable rock bolt design which ensures its perfect functionality and check of its anchorage with indication of perfect clamping in the borehole.

Essence of the invention

Defined goal is reached with invention which is an expandable rock bolt which is formed with a tubular expansion body whose transversal cross section has a deformed shape which forms on the surface at least one lengthwise groove and whose ends are procured with caps with a filling component on its inlet side and an end component on its outlet side wherein the essence of the invention is that the bolt is procured with at least one indicator of clamping which is formed with a hollow tube which is made of an elastically compressible material and which is placed in the wall of the expansion body along which is the indicator taken out on the visible side for the staff whereas at least in part on the internal cavity of the tube of the indicator is placed indication medium.

In an advantageous design is the indicator of clamping formed with a tube whose inner end is sealed with a stopper and in whose internal cavity is placed a tubular capsule which is made of easily destructible material and is on its both ends sealed with stanching sealing and it is filled with indication medium whereas in the end entry part of the internal cavity of the tube is fixed a porous element.

Furthermore it is advantageous when position of the tubular capsule in the internal cavity is kept with a spacer which is inserted between the front face of the tubular capsule and the porous element and when entry part of the internal cavity of the tube is procured with a lens-end which is made of transparent material and it is fixed to the tube by the help of a fixator and the lens-end is shaped like a lens.

In other advantageous designs is the indicator of clamping formed with tube whose inner end is firmly sealed and whose internal cavity is divided by a partition into

two parts or is the indicator of clamping formed with tube whose inner end is firmly sealed and in whose internal cavity is placed set of capsules which are made of easily destructible material and whose position in the internal cavity is kept with a plug.

For particular types of bolts is advantageous when the indicator of clamping is equipped with an extension tube which is in the tube fixed by the help of a bung and which is in its end part procured with the lens-end which is made of transparent material and which is fixed to the extension tube by the help of the fixator.

And finally it is advantageous when the indication medium consists of coloured liquid medium or a single-base or multi-base chemical compound or gel or pasta or foam or powder.

With presented invention is reached new and higher efficiency in the fact that with new structural modification is ensured transmission of information concerning perfect clamping of the bolt in the borehole whereby is basically eliminated possibility of imperfect anchorage owing to any factors arisen during realization of the borehole, placement of the bolt into the borehole and expansion of its body.

Description of figures in enclosed drawings

Particular examples of design of the invention are schematically illustrated in enclosed drawings where:

Fig. 1 is a view of in-rock clamped rock bolt after expansion of tubular body and after deformation of the indicator,

Fig. 2 is a longitudal section of the rock bolt from the fig. 1 which is inserted in the borehole and illustrated in the state before expansion of the tubular body,

Fig. 3 is a longitudal section of basic design of the indicator of clamping,

Fig. 4 is a longitudal section of an alternative design of the indicator of clamping from the fig.3 which is formed without a lens-end,

Fig. 5 is a longitudal section of an alternative design of the indicator of clamping from the fig.3 which is modified for use of mastic as indication medium,

Fig. 6 is a longitudal section of an alternative design of the indicator of clamping which is equipped with an extension tube,

Fig. 7 is a longitudal section of an alternative design of the indicator of clamping with use of indication medium in the form of polyurethane capsules,

Fig. 8 is a longitudal section of lower part of the rock bolt with illustrated cross section of the expansion body with an alternative placement of the indicator of clamping and its side outlet through an inlet neck of the bolt,

Fig. 9 is a longitudal section of lower part of the bolt with an alternative placement and side outlet of the indicator of clamping with the extension tube from fig.6,

Fig. 10a) and fig.10b) are front and side views of the rock bolt with a thread extension which is placed deep in the borehole and which is procured with the indicator of clamping with the extension tube which is placed along the body of the bolt,

Fig. 11 is a longitudal section of the rock bolt with inserted alternative design of the indicator of clamping with polyurethane capsules according to the fig.7,

Fig. 12 to fig. 20 illustrate alternative cross sections of the expansion body of the rock bolt with illustration of possible placement of one or more indicators.

The drawings illustrate presented invention and consequently described examples of particular design but they do not in any case anyhow limit extend of the protection stated in the definition yet only clarify essence of the invention.

Examples of lay out of the invention

The rock bolt according to the invention which is designed for clamping in the borehole 101 of a rock massif 1 is formed in its basic design according to the fig.1 with a expansion body 2 whose cross section has deformed shape, for instance C -profile, trefoil, quatrefoil, sixfoil, star with various number of tails, teardrop etc. as it is illustrated in fig. 12 to fig. 20 which forms on the surface at least one lengthwise groove 21. The

expansion body 2 is on its both ends procured with firmly fixed, preferably welded, transitional annular end caps 3 which are formed in the shape of an annulus and are recessed with a non-illustrated inlet valve and an outlet valve of standard design. The caps 3 of the bolt are then equipped with other non-illustrated structural and technological elements which can be according to the type of the bolt a filling head or a drilling head and a drilling bit. In the lower part of the expansion body 2 is then on its surface freely displaceable embedded a cover washer 4 which can be spherically shaped as it is obvious from fig.1, fig. 2, and fig. 8, or it can be flat as it is illustrated in fig. 9.

An integral part of the bolt is a clamping indicator 5 which is in its basic design which is illustrated in fig. 3 formed with a hollow tube 51 made of compressible material for example plastic, metal of non-metal foil, whose inner end 511 is firmly sealed, for example glued, with a stopper 52. In an internal cavity 512 of the tube 51 is placed a capsule 53 which is filled with unmarked indication medium which is made of easily destructible material preferably from glass and which is on its both ends sealed with stanching sealing 54. Position of the capsule 53 is in selected part of the internal cavity 512 kept with a rod spacer 55 which is inserted between a non-illustrated front part of the capsule 53 and a porous element 56 which is fixed, for example glued, in the end entry part of the internal cavity 512 of the tube 51 and it is formed from material which enables passage of indication medium. The entry part of the internal cavity 512 of the tube 51 is then procured with a lens-end 57 which is shaped preferably like a lens and is made of transparent material and is fixed to the tube 51 by the help of a fixator 58 which is formed for example from a shrink wrap. Whole indicator 5 is then embedded in a lengthwise groove 21 on the wall of the expansion body 2 where it is placed in the way that the end part of the tube 51 of the indicator 5 which is procured with the lens-end 57 stands-out out from the end cap 3 in the way that the lens-end 57 is visible.

When the rock bolt is used the indicator 5 is inserted into the lengthwise groove 21 on the wall of the expansion body 2 of the rock bolt in the way for the end part of its tube 51 to stand out from the lower end cap 3 and to be visible. After insertion into the

borehole 101 is the bolt connected to a non-illustrated source of high pressure hydraulic medium which is led into the cavity of the expansion body 2 whereby this expansion body 2 starts to expand transversally and to fill cross section of the borehole 101. Due to expansion of the expansion body 2 is the tube 51 of the indicator 5 gradually deformed and consequently there comes to destruction of the capsule 53 from which starts to run out the indication medium which runs down through the internal cavity 512, leaks through the porous element 56 into the space of the lens-end 57 and whereby is transmitted information about filling-up of the borehole 101 with the expansion body 2 of the bolt and its perfect clamping in a rock massif 1.

Described design of the bolt and the indicator 5 is not only possible design according to the invention, but as it is clear from fig. 4 entry part of the internal cavity 512 of the tube 51 does not have to be equipped with the lens-end 57, but it can be finished only with the porous element 56. As an indication medium can be used any coloured liquid medium for example a spirit colour or a luminescent colour or the indicator 5 can be filled with suitable single-base or multi-base chemical compound, gel, pasta, foam or powder. In case of use of non-liquid indication medium this does not have to be inserted into the capsule 53, but certain part of the internal cavity 512 of the tube 51 of the indicator 5 which is separated by a partition 513 can be directly filled with it as is it evident form fig. 5. For different types of the bolts whose exemplar designs are illustrated in fig. 8 to fig. 10 is then possible to equip the indicator 5 with an extension tube 59 which is in the tube 51 fixed by the help of a bung 591 as is it illustrated in fig.6. This modification enables outlet of the indication medium from the internal cavity 512 sideways, along the expansion body 2 of the bolt namely through a filling neck according to the fig. 8 or out of the filling neck according to the fig. 9, possibly next to the expansion body 2 according to the fig.10a) and 10b). And last but not least in the internal cavity 512 of the tube 51 does not have to be inserted one big capsule 53 but it can be replaced with a set of capsules 53 as is it clear from the fig.7 and fig. 11. Position of the capsule 53 in the internal cavity 512 does not have to be kept with a spacer 55 this can be replaced with a plug 6 as is it also clear from fig.7. And as is it visible in fig.12 to fig. 20 it is possible to use, for particular types of deformed expansion

bodies 2 for indication of proper expansion of the bolt in a non-homogenous rock massif 1, more than one for example two or three indicators 5 which are inserted into various lengthwise grooves 21 of the expansion body 2 of the bolt.

Industrial usability

The expandable rock bolt according to the invention is designed not only for stabilisation and reinforcement of consistency of rock mass especially during boring of tunnels, mine corridors and chambers but also for stabilisation of rock walls, slopes and dykes in the form of grouting with expected use in mines for mining of coal or ores or for various applications in civil engineering.

PATENT CLAIMS

1. An expandable rock bolt which is formed with an expansion body (2) whose transversal cross section has a deformed shape which forms on the surface at least one lengthwise groove (21) and whose ends are procured with caps (3) with a filling component on an inlet side and an end component on an outlet side, **wherein** it is equipped with at least one indicator (5) of clamping which is formed with a hollow tube (51) which is made of an elastically compressible material and which is placed on the wall of the expansion body (2) along which is the indicator (5) taken out on the visible side for the staff whereas at least in a part of an internal cavity (512) of the tube (51) of the indicator (5) is placed indication medium.

2. The expandable rock bolt according to the claim 1, **wherein** the indicator (5) of clamping is formed with the tube (51) whose inner end (511) is firmly sealed with a stopper (52) and in whose internal cavity (512) is placed a capsule (53) which is made of easily destructible material and it is on both ends sealed with stanching sealing (54) and it is filled with the indication medium whereas in an end entry part of the internal cavity (512) of the tube (51) is fixed a porous element (56).

3. The expandable rock bolt according to the claim 2, **wherein** the position of the capsule (53) in the internal cavity (512) is kept with a spacer (55) which is inserted between the front face of the capsule (53) and the porous element (56).

4. The expandable rock bolt according to the claim 2 or 3, **wherein** the entry part of the internal cavity (512) of the tube (51) is procured with a lens-end (57) which is made of transparent material and which is fixed to the tube (51) by the help of a fixator (58).

5. The expandable rock bolt according to the claim 4, **wherein** the lens-end (57) is shaped like a lens.

6. The expandable rock bolt according to the claim 1, **wherein** the indicator (5) of clamping is formed with the tube (51) whose inner end (511) is firmly sealed and whose internal cavity (512) is divided by a partition (513) into two parts.

7. The expandable rock bolt according to the claim 1, **wherein** the indicator (5) of clamping is formed with the tube (51) whose inner end (511) is firmly sealed and in whose internal cavity (512) is placed set of capsules (53) which are made of an easily destructible material and whose position in the internal cavity (512) is kept with a plug (6).

8. The expandable rock bolt according to any claim 1 to 3, 6 or 7, **wherein** the indicator (5) of clamping is equipped with an extension tube (59) which is in the tube (51) fixed by the help of a bung (591) and which is in the end part procured with the lens-end (57) which is made of transparent material and which is fixed to the extension tube (59) by the help of a fixator (58).

9. The expandable rock bolt according to any claim 1 to 8, **wherein** the indication medium consists of coloured liquid medium or single-base or multi-base chemical compound or gel or pasta or foam or powder.

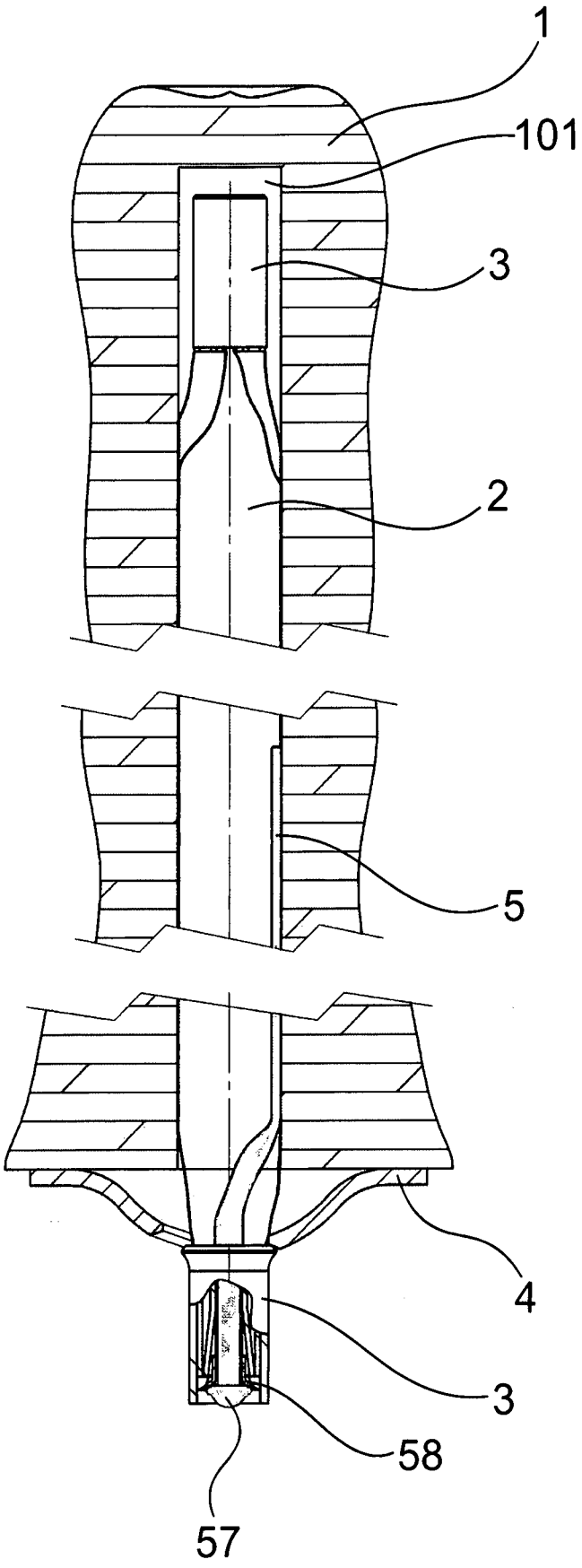

FIG. 1

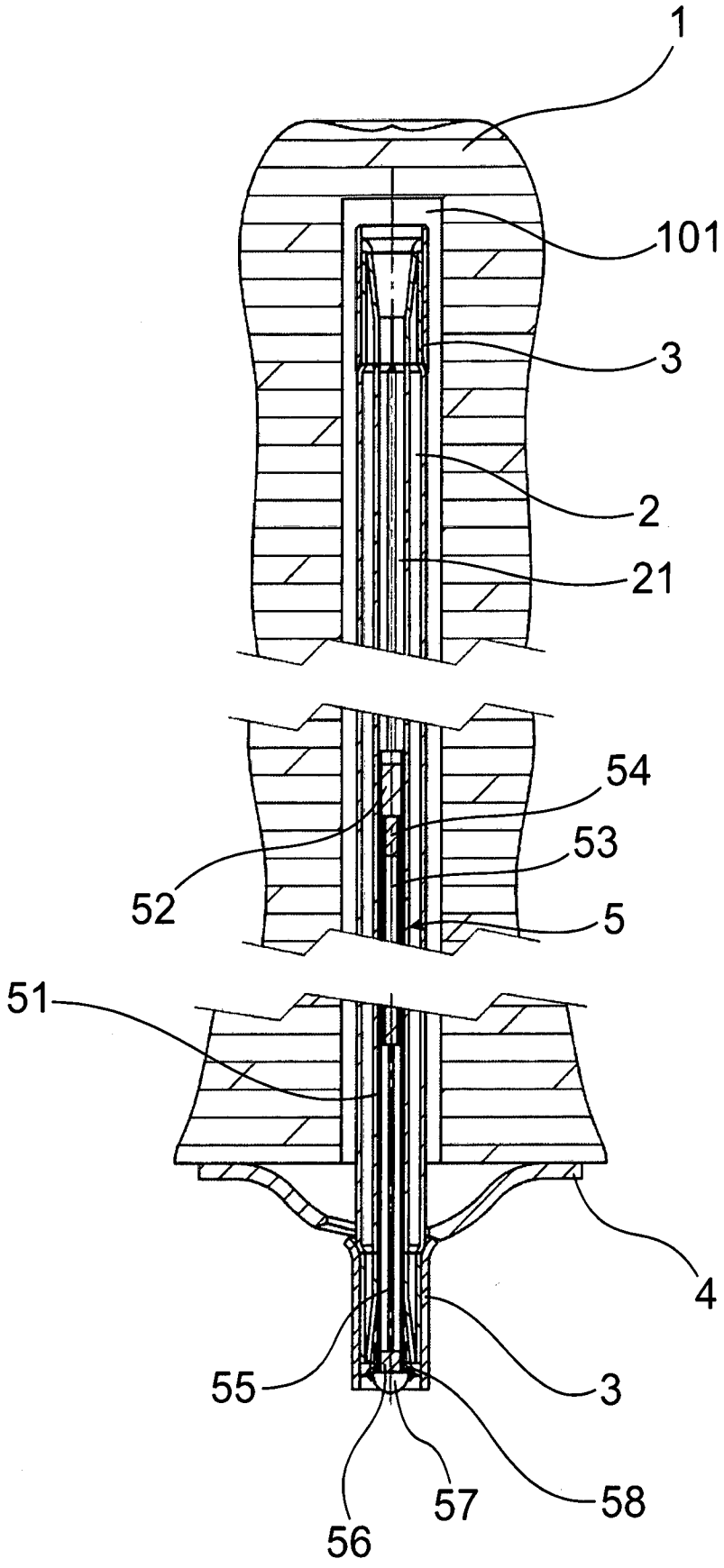

FIG. 2

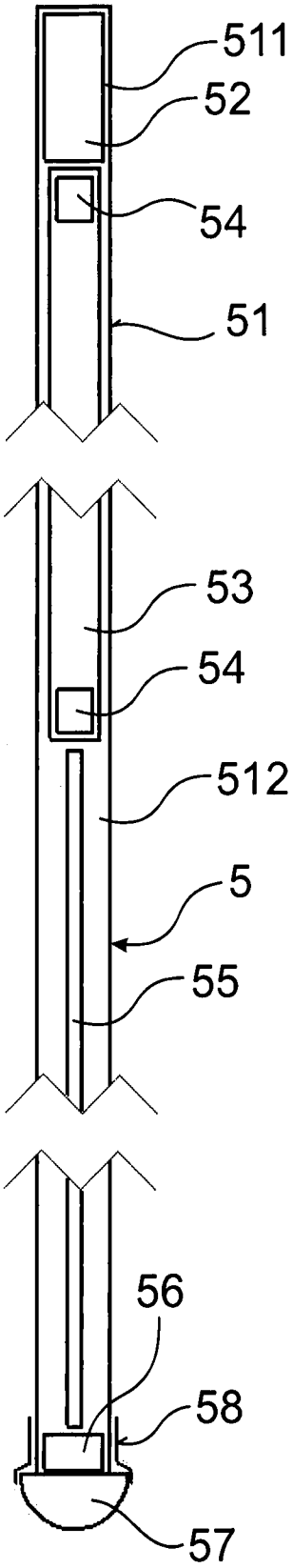

FIG.3

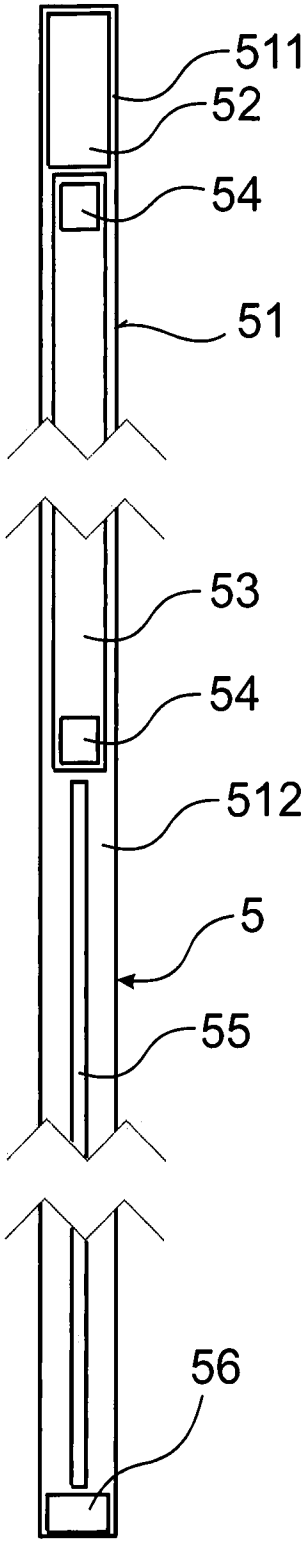

FIG. 4

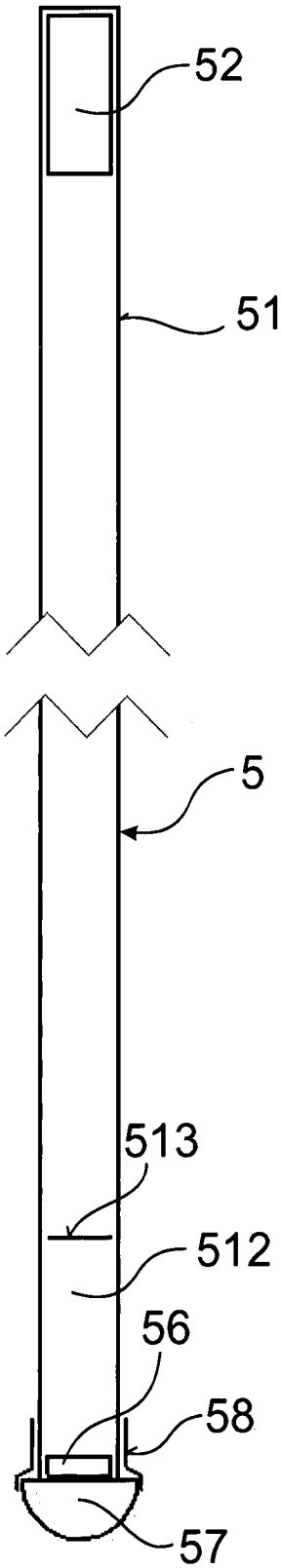

FIG. 5

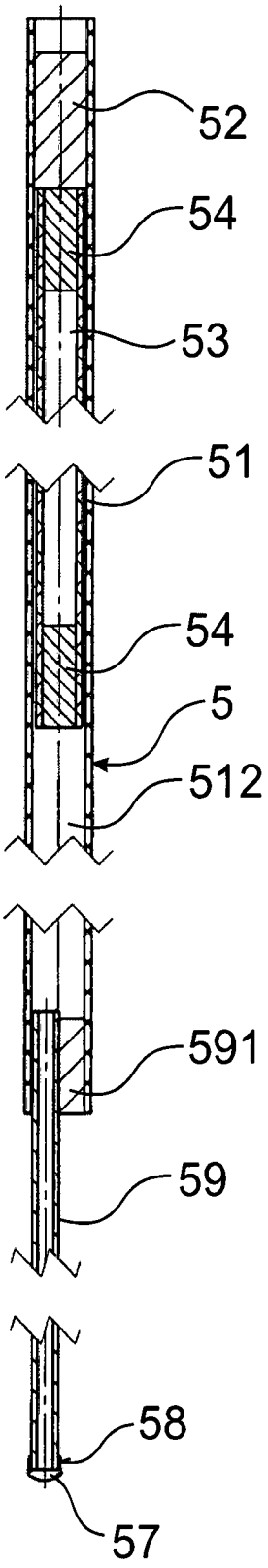

FIG. 6

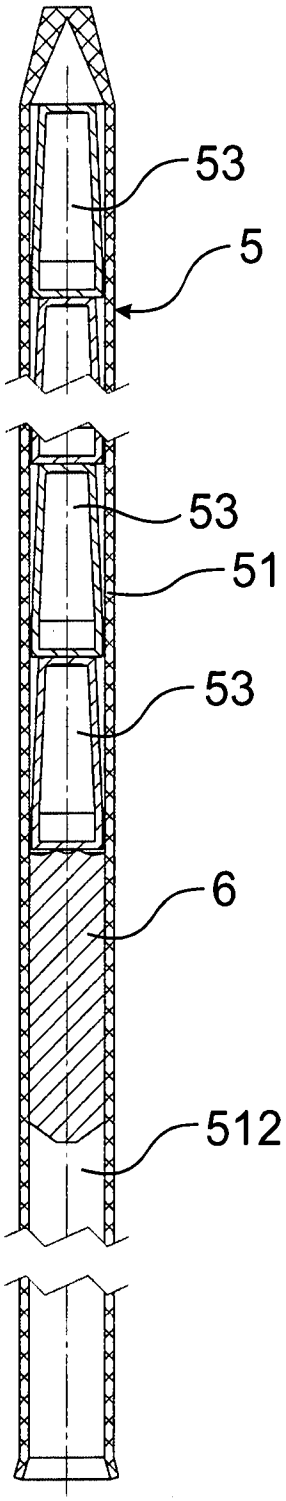

FIG. 7

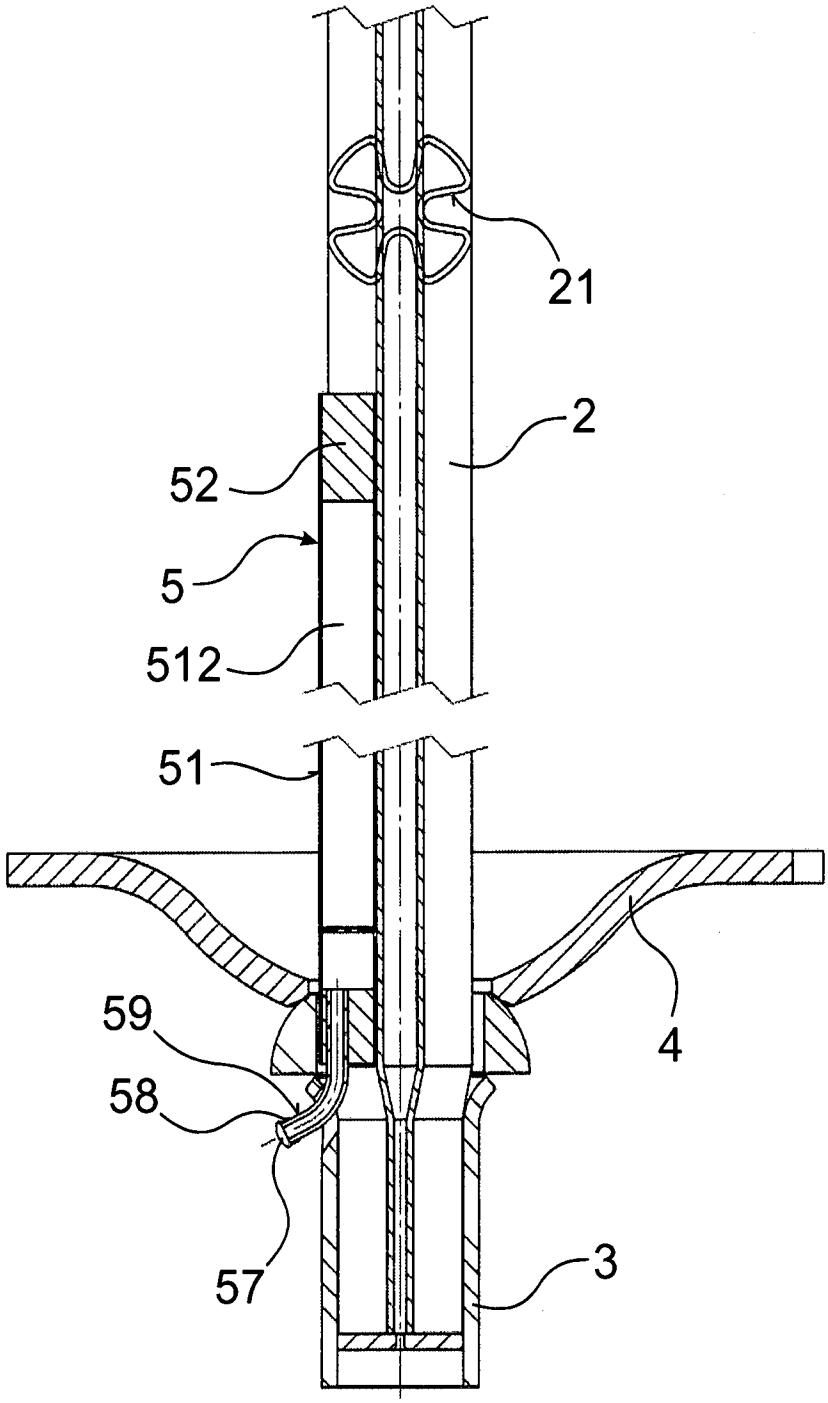

FIG. 8

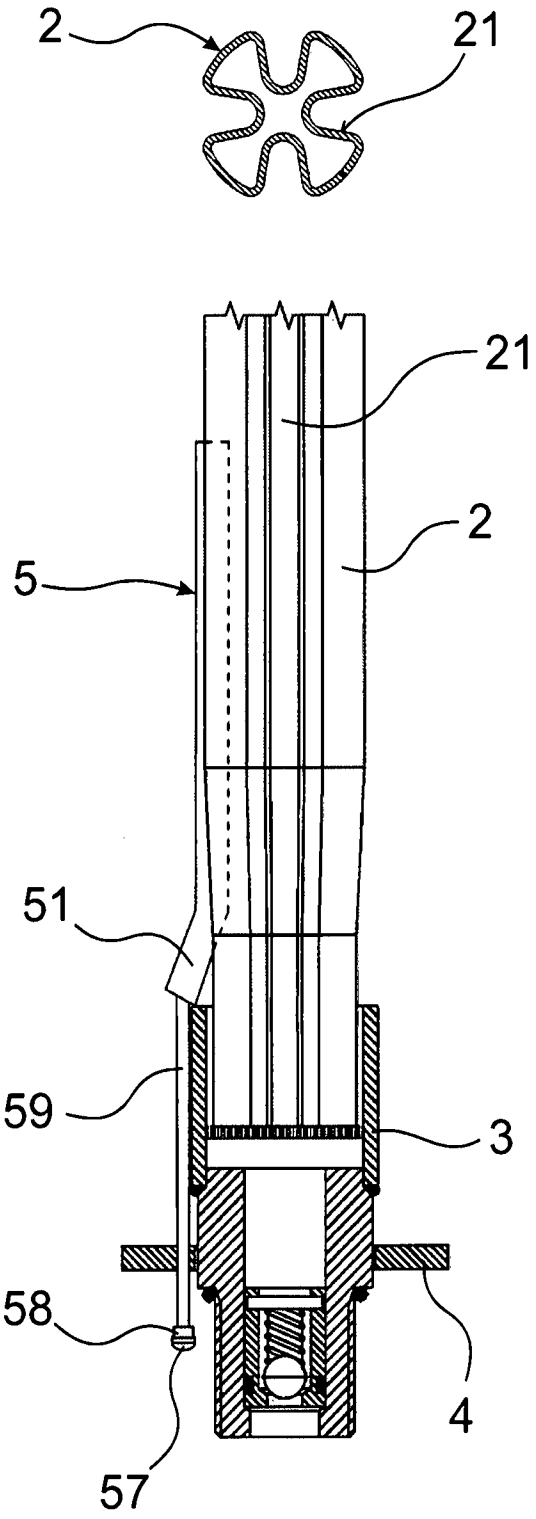

FIG. 9

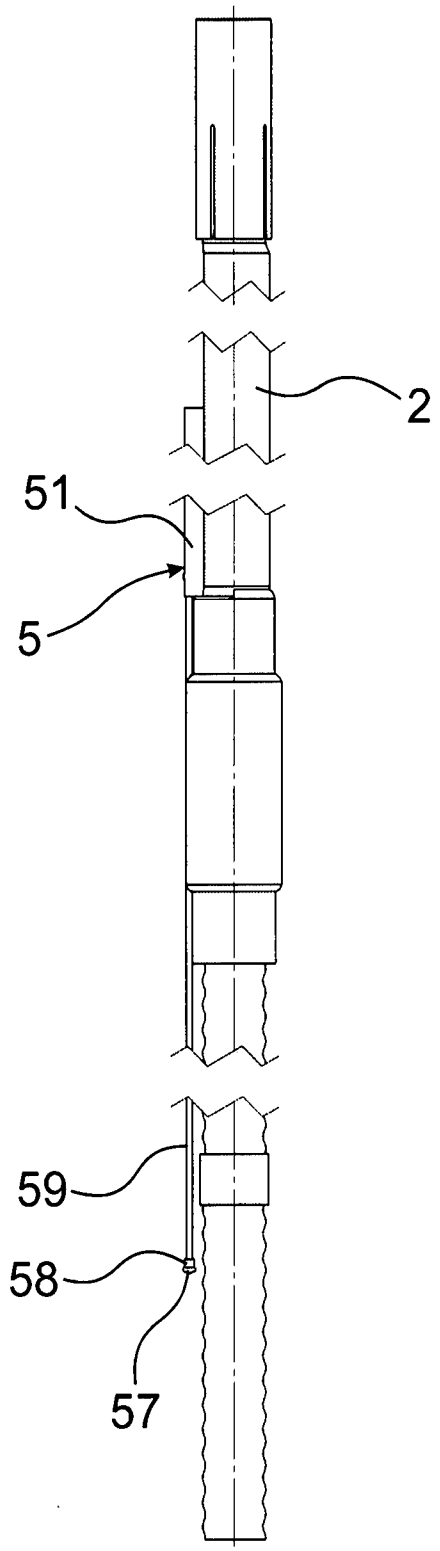

FIG. 10a

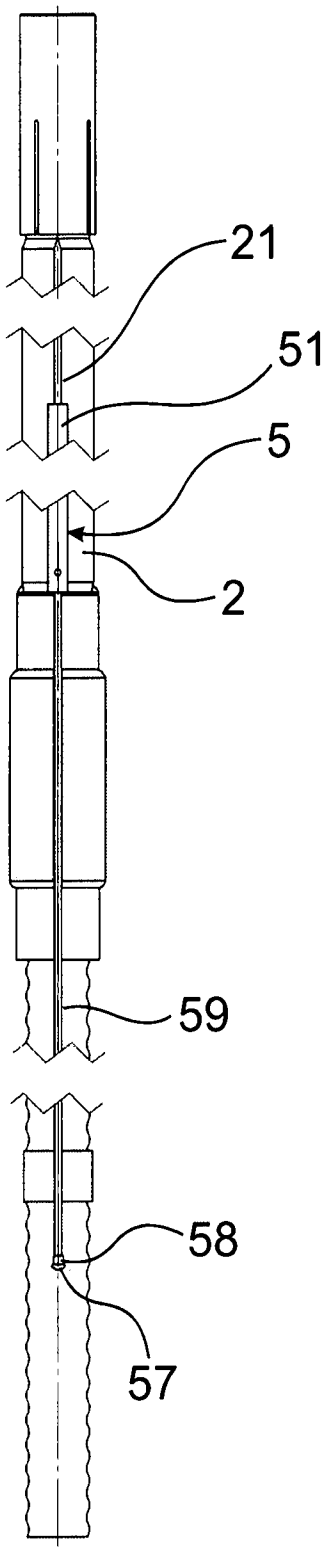

FIG. 10b

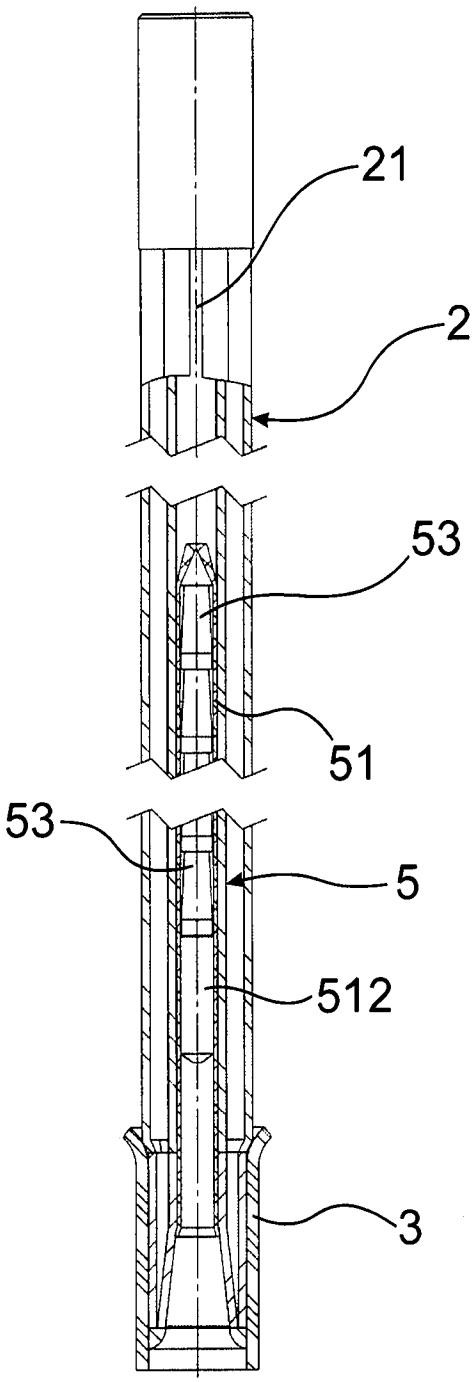

FIG. 11

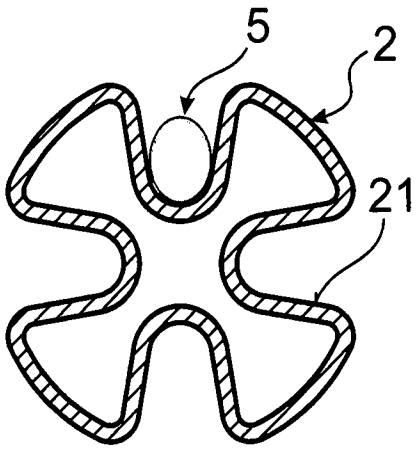

FIG. 12

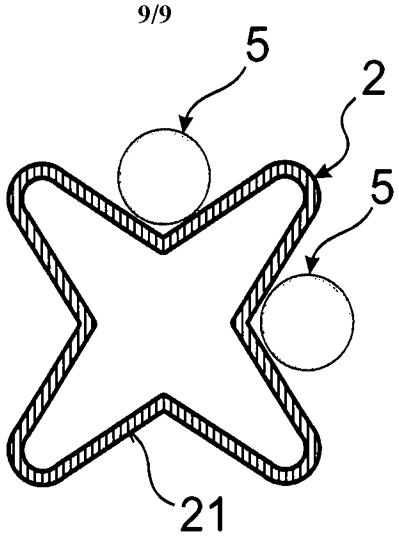

FIG. 13

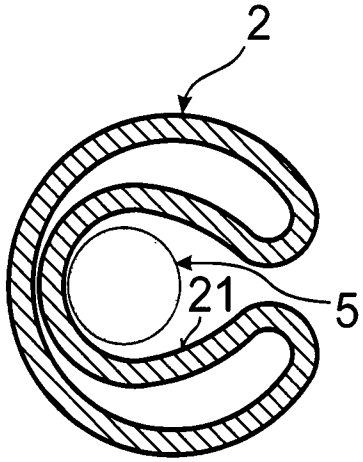

FIG. 14

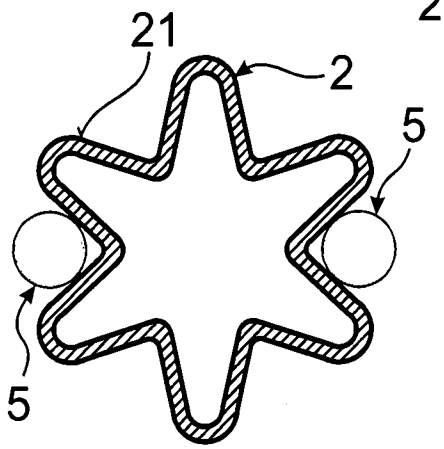

FIG. 15

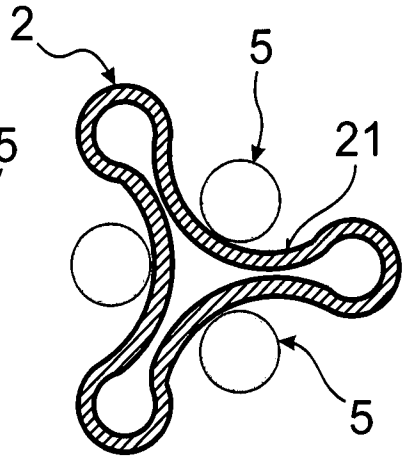

FIG. 16

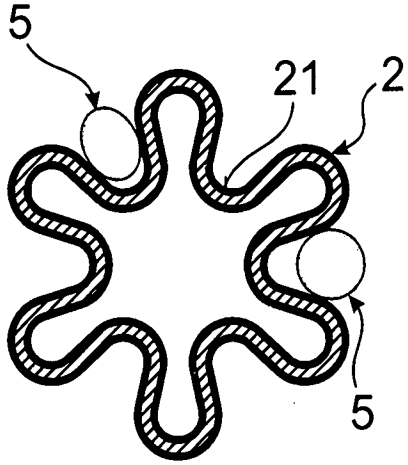

FIG. 17

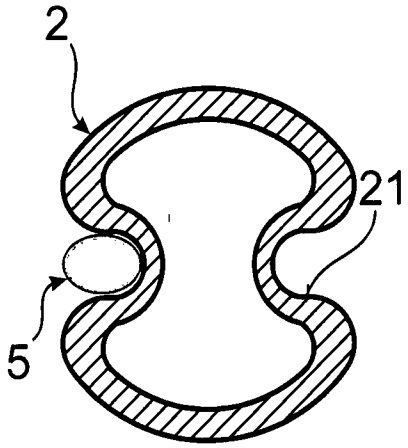

FIG. 18

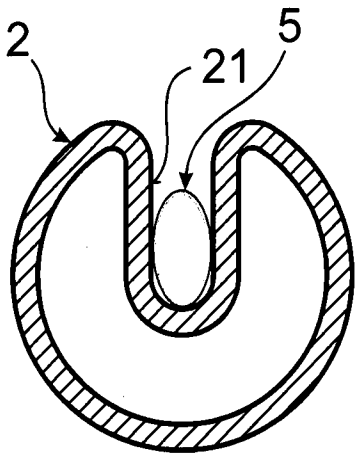

FIG. 19

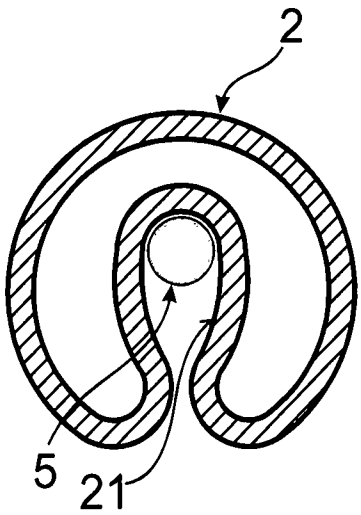

FIG. 20