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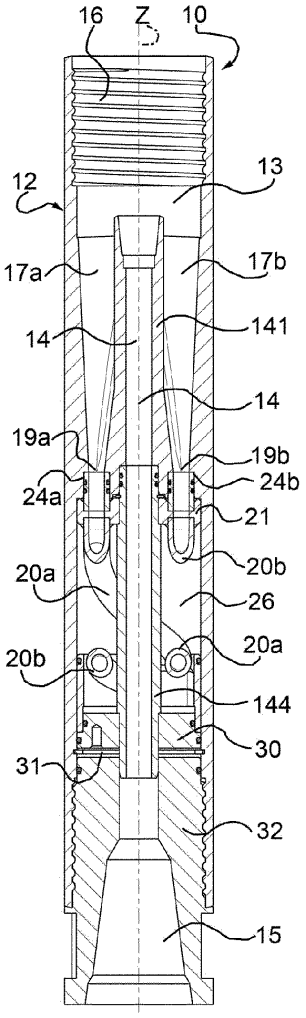
(54) Injection head for injecting consolidating pressurized fluid mixtures into the ground

(57) The injection head (10) includes a cylindrical outer body (12) defining a central, longitudinal axis (z) with an upper inlet (13) for receiving fluids from a string of tubular rods. One or more helical ducts (20a, 20b) impart to the fluids a helical motion around the axis (z) towards respective outlet side nozzles (11). Respective gradually downwardly tapered duct sections (17a, 17b) are interposed between the upper inlet (13) and the helical ducts (20a, 20b). The tapered ducts (17a, 17b) have straight geometric axes and are connected to the respective helical ducts at locations (19a, 19b) axially offset from the central axis (z) and near the periphery of the body (12).

Fig. 2



EP 2 463 443 A1

Description

[0001] The present invention relates to a high-efficiency injection head for injecting consolidating pressurized fluid mixtures into the ground in order to form consolidated soil portions.

[0002] It is known, in jet grouting methods, that the injection head (commonly referred to as a "monitor") is fixed in the proximity of the lower end of a string of tubular rods which is rotated and withdrawn towards the surface. The monitor has radial nozzles of small dimensions, through which consolidating fluid mixtures are injected into the ground.

[0003] The consolidating mixtures are fed to the monitor through a relatively wide duct inside the rods. In the monitor, the fluid is diverted orthogonally from the vertical, axial direction to a transverse direction, generally a radial direction or a secant direction, in narrower ducts to the nozzles. An abrupt change in direction, associated with a simultaneous variation in the duct cross section, creates a highly turbulent motion in the flow. This brings about a high head loss, right in the proximity of the outlet from the nozzles, where the velocity of the flow is at a maximum. The high outlet turbulence prevents the flow from leaving the nozzles in an ordered manner, or rather with the velocity vector of the single particle of fluid oriented according to the main axis of each nozzle and with the maximum energy.

[0004] In the jet grouting sector, there is a need to minimize the head loss of the fluid within the monitor in order to maximize the kinetic energy of the fluid leaving the nozzles and therefore increase the radius of the column of consolidated soil.

[0005] Monitors have been proposed having inner ducts which are configured in different ways so as to divert the consolidating mixture from a vertical, upper duct, which communicates with the tubular rod directly above, to the side nozzles. Provision is generally made of one or more curved ducts which convey the fluid streams along a path having a gradual change in direction, thereby reducing turbulence. US-A-5228809 discloses a monitor with an inner duct of constant cross section and regular curvature, the median axis of which lies in a vertical plane and extends from an upper, eccentric or peripheral position with respect to the central, vertical axis of the monitor to an obliquely inclined side nozzle. EP-1396585-B1 provides a gradually tapered, variable curvature inner duct, the median axis of which lies in a vertical plane and extends from an upper, central position, aligned with the central, vertical axis of the monitor, to an obliquely inclined side nozzle. The monitor described in EP-1231326-B1 has one or more helical inner ducts of a regularly tapered variable cross section for conveying the flow from the area of the central axis of the monitor to one or more side nozzles.

[0006] Italian patent application TO2010A000613, not yet published on the filing/priority date of the present application, describes a monitor having helical inner ducts which each connect the upper inlet of the monitor to a respective outlet side nozzle. Each helical duct is gradually tapered three-dimensionally towards the nozzle and has a central helical line of a constant radius; the pitch of the helix gradually decreases from the upper inlet to the outlet nozzle. Although this monitor has a high efficiency, it has a somewhat complex shape which requires expensive production processes inasmuch as the helical ducts have to respect precise geometrical demands; use is made of three-dimensional numerical control machines or production is carried out by fusion.

[0007] It is an object of the present invention to provide a monitor which is able to reconcile the need to achieve an excellent result in terms of high efficiency (thus avoiding abrupt variations in cross section and in direction of the flow within the monitor) with the need to simplify the design and reduce the costs for producing the monitor.

[0008] These and other objects and advantages, which will be understood more fully from the text which follows, are achieved according to the present invention by an injection head or monitor as defined in Claim 1. Preferred embodiments of the invention are defined in the dependent claims, the content of which should be regarded as an integral and complementary part of the present description.

[0009] A preferred but non-limiting embodiment of the invention will now be described with reference to the appended drawings, in which:

Figure 1 is a sectional view according to a vertical plane parallel to the central, longitudinal axis of a monitor according to a preferred embodiment of the invention;

Figure 2 is a view in axial section of the monitor shown in Figure 1;

Figure 3 is a partial perspective view of the monitor shown in section in Figure 2;

Figures 4 to 10 show the outer body of the monitor shown in Figures 1 to 3;

Figure 4 is a top view of the outer body of the monitor shown in Figures 1-3;

Figure 5 is a view in axial section along line A-A in Figure 4;

Figure 6 is a sectional view along line A1-A1 in Figure 4;

Figure 7 is a sectional view along line A2-A2 in Figure 4;

Figure 8 is a sectional view along line A3-A3 in Figure 4;

Figure 9 is a partial perspective view of the body shown in section along line B-B in Figure 4;

Figure 10 is a partial perspective view of the body shown in section along line A-A in Figure 4;

Figures 11 and 12 are perspective views, from different angles, of a subassembly which is inserted in the outer body shown in Figures 4-10; and

Figure 13 is an elevated view, partially in section according to a vertical plane parallel to the central,

vertical axis of the subassembly shown in Figures 11 and 12.

[0010] Before illustrating in detail an embodiment of the invention, it must be remembered that this is not limited, in terms of its application, to the details and to the configuration of the components mentioned in the description or shown in the drawings. The invention may be implemented in various ways. It must be understood that the phrases and terms which are used here purely for descriptive purposes must not be regarded as having a limiting effect. The use of terms and expressions such as "vertical", "transverse", "upstream" or "downstream" is interpreted in relation to the appended drawings or in relation to the direction of the flow of fluid mixture, or in relation to a generic condition of use in which the monitor produces a vertical column of consolidated soil.

[0011] With reference to the drawings, an injection head or monitor is denoted in its entirety by 10, said injection head or monitor serving to deliver a pressurized jet of a consolidating fluid mixture, usually a cement mixture, through one or more side nozzles 11 in order to break up the surrounding ground and consolidate it. The monitor comprises an externally cylindrical body 12, having an internal cavity which runs in the longitudinal direction and has a variable shape, as described hereinbelow.

[0012] The upper end of the monitor 10 can be connected, by means of an upper thread 16, to a string of tubular rods (not shown) in order to move the monitor in the vertical and rotate it about the central, longitudinal axis z for carrying out a jet grouting process.

[0013] The first upper section of the through cavity forms an inlet duct 13 with a large circular cross section, similar to the cross section of the tubular rods of the overlying string. Conveyed through the inlet duct 13 into the monitor are both the consolidating pressurized mixture to be delivered to the side injection nozzles and the drilling liquid which serves to lubricate a drilling tool or bit (not shown) mountable on the lower end of the monitor, where a downwardly open threaded chamber 15 is provided. The drilling liquid is conveyed through a central duct 14, coaxially inside the cylindrical body 12, from the upper inlet 13 to the lower threaded chamber 15, which is in fluid communication with the drilling tool. The top of the central duct 14 is associated with a valve (not shown), which is housed in the conical seat made in the top terminal section of the duct 14 and which serves to automatically obstruct said duct 14 when the consolidating mixture is injected.

[0014] Immediately downstream of the inlet duct 13, the cavity of the body 12 is subdivided into two duct sections 17a, 17b which are shaped as inverted half-cones, are side by side longitudinally and have respective straight or substantially straight axes. Each duct section 17a, 17b has a semicircular inlet section 18a, 18b (Figure 4) which tapers linearly downwards as far as a respective circular outlet section 19a, 19b, which is axially offset or near the periphery of the body 12 as far as possible.

[0015] In the embodiment shown, the ducts 17a, 17b are obtained from solid, in one piece with the body 12; according to an alternative embodiment (not shown), said ducts are made up of one or more metal inserts fitted in the cylindrical cavity of the body 12. In this example, said body 12 also forms a tubular portion 141 constituting the upper section of the central duct 14 for the drilling liquid. Two inner axial bulkheads 142, 143, formed in one piece with the body 12, connect the tubular portion 141 to the cylindrical outer wall of the body 12 in a stable manner and separate the tapered duct sections 17a, 17b.

[0016] The upper entrance of a respective rigid helical tube 20a, 20b which terminates in the nozzle 11 and imparts to the fluid running through it a helical motion around the longitudinal axis Z towards the nozzle engages next to each of the outlet sections 19a, 19b. Each helical tube is oriented vertically in the area in which it is connected to the respective duct 17a, 17b. In the area in which they are connected to the nozzles, the helical tubes are oriented horizontally in horizontal directions so as to form secants (i.e. in the direction of a chord) with respect to the circular transverse cross section of the cylindrical body 12. In this example, there are two nozzles for directing respective jets of consolidating mixture which are balanced with respect to the central axis and offset at an angle of 180 degrees.

[0017] As shown in Figures 11—13, in order to simplify the assembly and the precise hydraulic connection of the tubes 20 to the outlet sections 19 of the conical ducts 17, the upper ends of the helical tubes 20 are locked in an annular disc 21, which has a central through bore 22 for the central duct 14 and two diametrically opposite through bores 23a, 23b, in which the respective tubes 20a, 20b are locked. The tops of the tubes 20a, 20b are provided with outer sealing elements (O rings) which engage sealingly in respective widened cylindrical seats 24a, 24b, which are formed immediately downstream of the outlet sections 19a, 19b, in order to improve the tightness and the stability of the hydraulic connection.

[0018] The central tubular portion 141 terminates inferiorly at the level of the widened seats 24a, 24b, and therefore below this level the inner cavity of the body 12 forms a cylindrical chamber 26 which is delimited laterally by the cylindrical inner wall of the body 12.

[0019] At the bottom, the helical tubes 20a, 20b are connected to respective tubular inserts 27 which are made of a wear-resistant metal material and each of which is fixed in a secant through bore 28 of a bushing 29, the external diameter of which corresponds to the internal diameter of the chamber 26 and to the diameter of the annular disc 21.

[0020] Figures 11-13 independently show a rigid subassembly consisting of the tubes 20a, 20b locked at the top in the disc 21 and fixed inferiorly to the inserts 27 and to the bushing 29. Said subassembly is preassembled separately and then fitted from below as one piece in the chamber 26 of the body 12. The angular orientation assumed by the subassembly when the tubes 20a, 20b

engage in the widened seats 24a, 24b corresponds to the angular position of alignment of the axes of the tubular inserts 27 with the nozzle openings 11 made in the cylindrical outer wall of the body 12.

[0021] This is followed by the engagement of a central lower tube 144, which connects to the bottom of the tubular portion 141 and completes the central duct 14 for the drilling liquid. An annular lower disc 30, the diameter of which corresponds to that of the cylindrical inner chamber 26, hermetically closes the chamber 26 containing the subassembly formed by the bushing with the helical tubes and the upper disc. The lower disc is locked axially in the chamber 26 by means of a circlip 31, and thus constitutes an axial lower shoulder both for the above-mentioned subassembly and for the central lower tube 144. Finally, the lower threaded block 32 is fitted into the bottom of the body 12, said block having the threaded chamber 15 onto which the excavation tool (for example a triblade, a drilling bit or a tricone) is screwed.

[0022] The helical tubes 20a, 20b may advantageously be commercially available metal tubes which merely need to be twisted like a helix with a curvature such as to make them rest laterally against the inner surface of the cylindrical chamber. It will be seen that this configuration imparts to the helical tubes the maximum helical radius which can be contained in the cylindrical chamber 26, consequently minimizing the head losses.

[0023] Most of the monitors of the known type, as mentioned in the introduction, simultaneously impart to the fluid entering the monitor an acceleration and a variation in direction, simultaneously combining a gradual reduction in cross section and a diversion in accordance with a helical or else curved path. According to the present invention, however, the fluid is initially accelerated upstream without significantly diverting the flow. This is achieved by the conical duct sections having straight axes, which are relatively simple to design. The diversion from the vertical direction to the horizontal direction for leaving the nozzles is imparted more downstream, in an economical manner, by means of commercial cylindrical tubing of constant circular cross section. It is not necessary for the helical tubing to have a decreasing cross-sectional area, since the flows have already been accelerated in the ducts shaped like an inverted cone. It is important to note that the diversion of the flows takes place starting from (two) points which are as close as possible to the peripheral wall of the inner cavity of the monitor, i.e. at a long distance from the central axis. Proceeding from these eccentric positions, the radii of curvature of the ducts which convey the flows to the nozzles will become greater and, as a result, the ducts will produce smaller head losses compared to the monitors which draw the flow from the central area. It will be understood that the monitor of the present invention represents a compromise between design simplicity, limited costs and high performance.

[0024] The form, the dimensions and the design and operational details of the monitor can differ markedly from the embodiment described and illustrated in the appended drawings. In particular, the number of nozzles and consequently the number of ducts inside the monitor into which the flow entering the monitor is distributed may differ from two.

Claims

1. An injection head (10) for injecting consolidating pressurized fluid mixtures into the ground in order to form consolidated soil portions, the head including:

   - a cylindrical outer body (12) defining a central, longitudinal axis (z) and having an internal, longitudinally extending through cavity;
   - an upper inlet (13) for receiving fluids from a string of tubular rods mountable above the head;
   - at least one outlet side nozzle (11) lying in a plane perpendicular to or slanting with respect to the longitudinal axis (z);
   - at least one helical duct (20a, 20b) terminating in the nozzle (11) and imparting to the fluid running through it a helical motion around the longitudinal axis (z) towards the nozzle (11);

   characterized in that the head includes at least one gradually downwardly tapered duct section (17a, 17b) connecting the upper inlet (13) to the helical duct (20a, 20b), wherein the tapered duct (17a, 17b) has a substantially straight geometric axis and is connected to the helical duct at a location (19a, 19b) axially offset from the central, longitudinal axis (z) and near the periphery of the body (12).

2. An injection head according to claim 1, **characterized in that** the helical duct (20a, 20b) is formed by at least one tube of uniform cross section.

3. An injection head according to claim 1 or 2, comprising at least two of said outlet nozzles (11) and **characterized in that** the number of the helical ducts (20a, 20b) and the number of the tapered ducts (17a, 17b) correspond to the number of nozzles (11).

4. An injection head according to claim 2, **characterized in that** an upper portion of the or each helical tube (20a, 20b) is locked in a respective axially offset through bore (23a, 23b) formed in a disc (21) mounted in the cavity of the body (12), the disc having an outer edge in contact with a cylindrical surface of an inner chamber (26) of the body (12).

5. An injection head according to claim 2 or 4, **characterized in that** the top portion of the or each helical tube (20a, 20b) is sealingly engaged in a cylindrical seat (24a, 24b) constituting a widening of the lower section (19a, 19b) of the respective tapered duct

(17a, 17b).

6. An injection head according to any of the preceding claims, **characterized in that** the tapered ducts (17a, 17b) are integral with or secured to the outer body (12).

7. An injection head according to claim 6, **characterized in that** the tapered ducts (17a, 17b) are formed in one piece with the body (12).

8. An injection head according to claim 7, **characterized in that** the body (12) also forms a central, longitudinal tubular portion (141) forming at least an upper section of a duct (14) running coaxially to the center of the cylindrical body (12) from the upper inlet (13) to a bottom, downwardly open chamber (15).

9. An injection head according to claims 4, 7 and 8, **characterized in that** the disc (21) is an annular disc providing a central through bore (22) which accommodates a tube (144) or a tubular portion (141) being part of the outer body (12) and forming a section of the central duct (14).

10. An injection head according to claims 5 and 8, **characterized in that** the central tubular portion (141) has a lower end at the level of the widened cylindrical seats (24a, 24b) and below this level the body (12) forms a cylindrical chamber (26) which is delimited laterally by the cylindrical outer wall of the body (12).

11. An injection head according to any of the preceding claims as dependent on claim 2, **characterized in that** the helical tube or tubes (20a, 20b) are adjacent to the inner cylindrical surface of a cylindrical chamber (26) delimited laterally by the cylindrical outer wall of the body (12).

12. An injection head according to claims 2 and 11, **characterized in that** the helical tube or tubes (20a, 20b) have lower ends connected to a respective metal tubular insert (27) fixed in a through bore (28) of a bushing (29) the external diameter of which corresponds to the diameter of the chamber (26).

13. An injection head according to claims 2, 4 and 12, **characterized in that** the subassembly consisting of the helical tube or tubes (20a, 20b) connected inferiorly to the respective tubular insert (27), the bushing (29) and the annular disc (21) securing the upper parts of the helical tube or tubes constitutes a substantially rigid subassembly fitted into the chamber (26).

14. An injection head according to claim 1, **characterized in that** the tapered duct sections are shaped as inverted cone sectors.

15. An injection head according to claim 2, **characterized in that** the duct (17a, 17b) is tapered to accelerate the fluid passing through it and the duct (20a, 20b) has a constant transversal cross section for conveying the accelerated fluid down to the nozzle (11).

16. An injection head according to any of the preceding claims, **characterized in that** the at least one tapered duct section (17a, 17b) is upstream, whereas the helical duct (20a, 20b) is downstream of the respective tapered duct section (17a, 17b).

Fig. 1

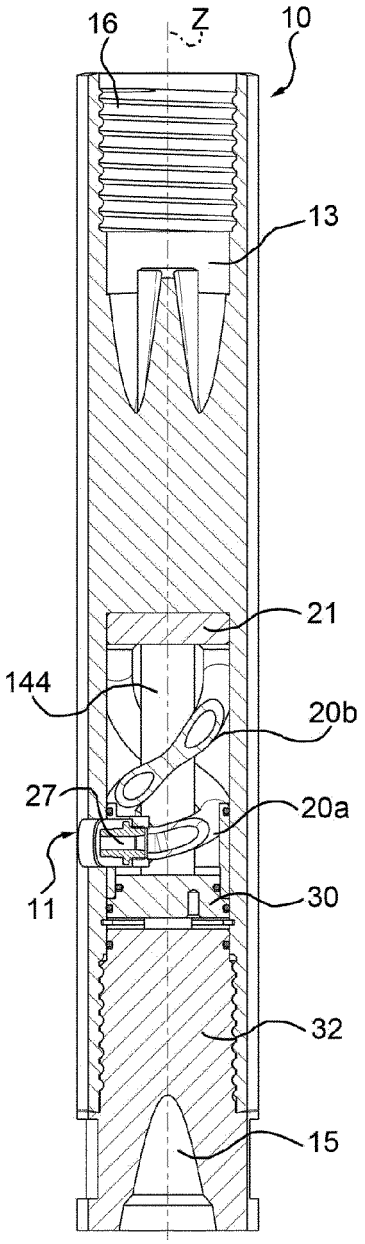


Fig. 2

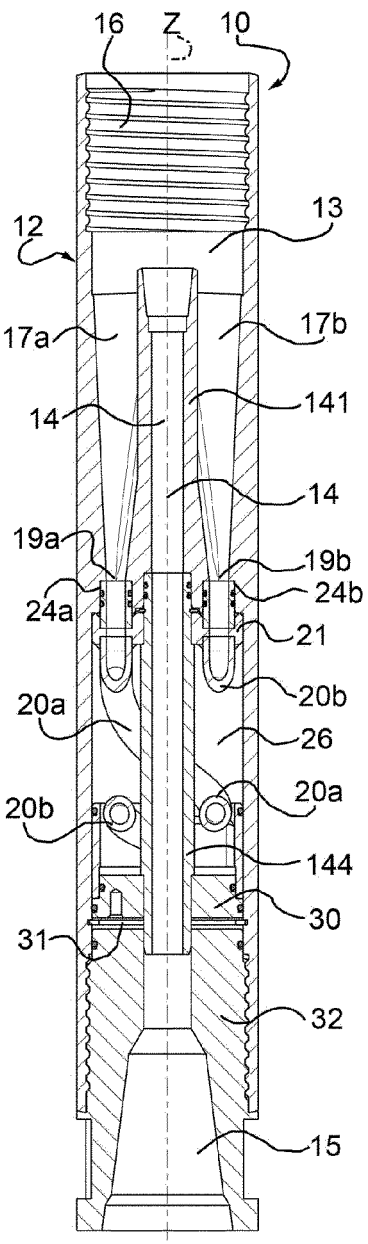
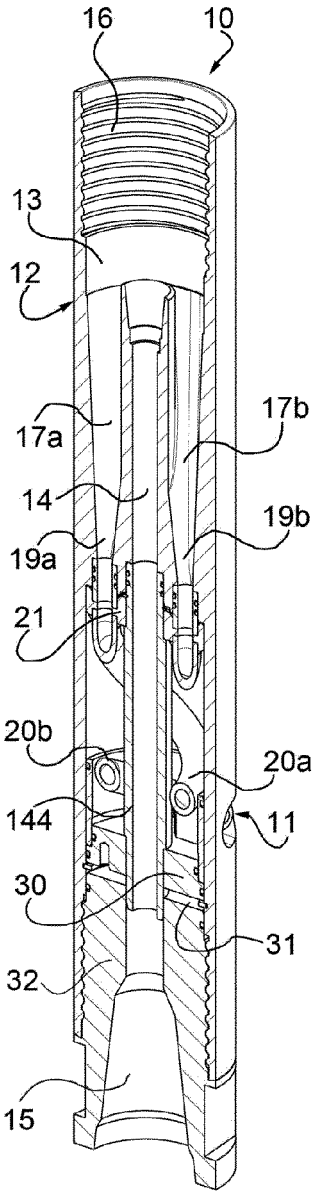


Fig. 3



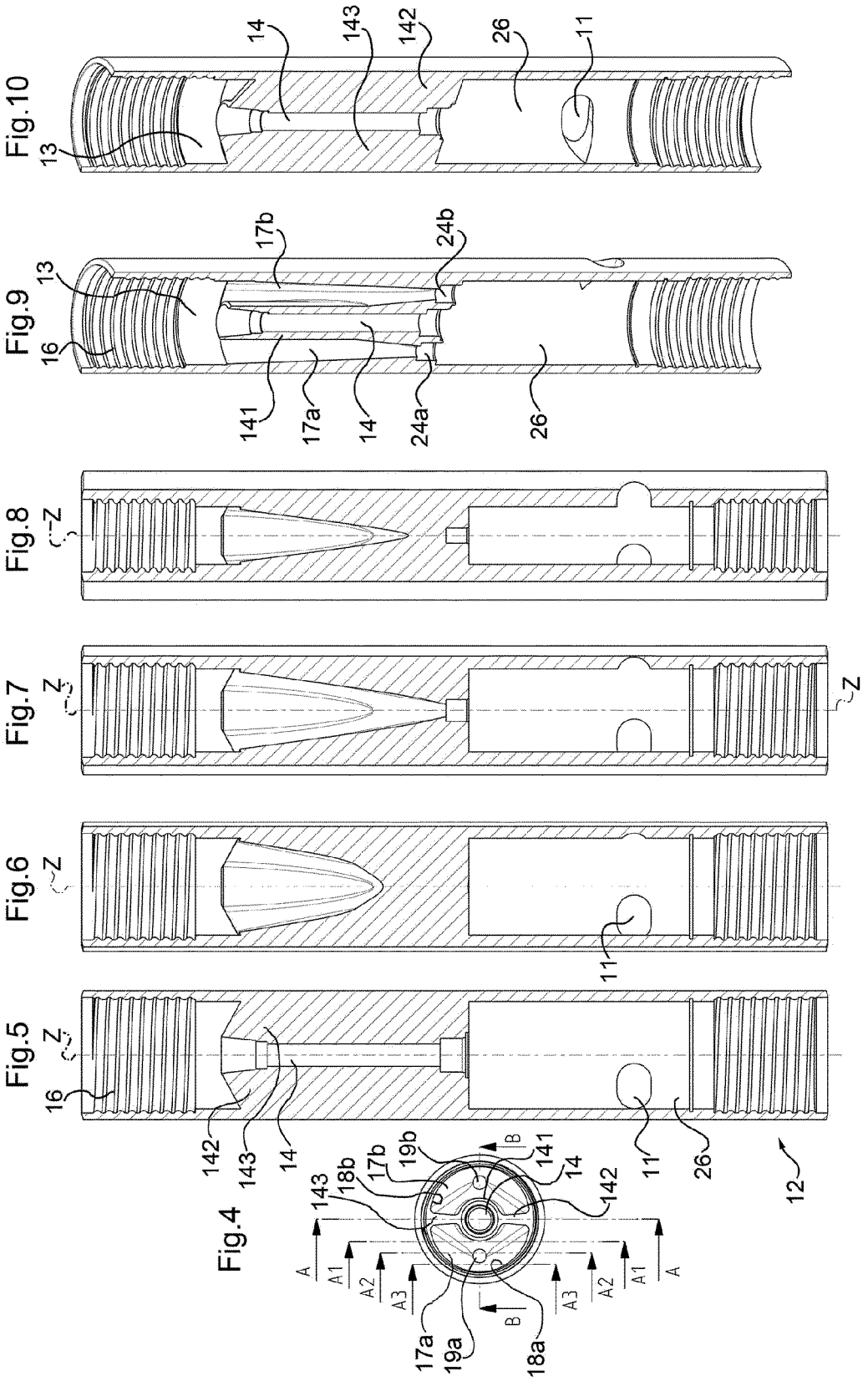


Fig.10
13
14
143
142
26
11
Fig.9
13
16
17b
24b
141
17a
14
24a
26
Fig.8
Z
Fig.7
Z
Z
Fig.6
Z
11
Fig.5
Z
16
142
143
14
11
26
12
Fig.4
143
18b
17b
19b
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17a
19a
18a
B
A3
A2
A1
A

Fig.13

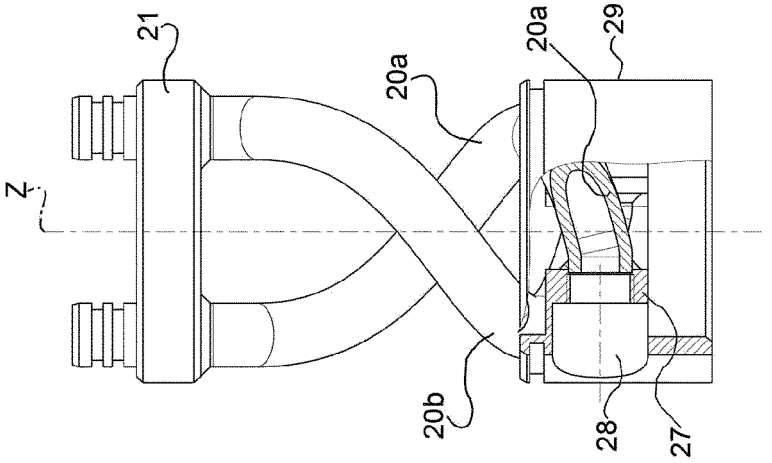


Fig.12

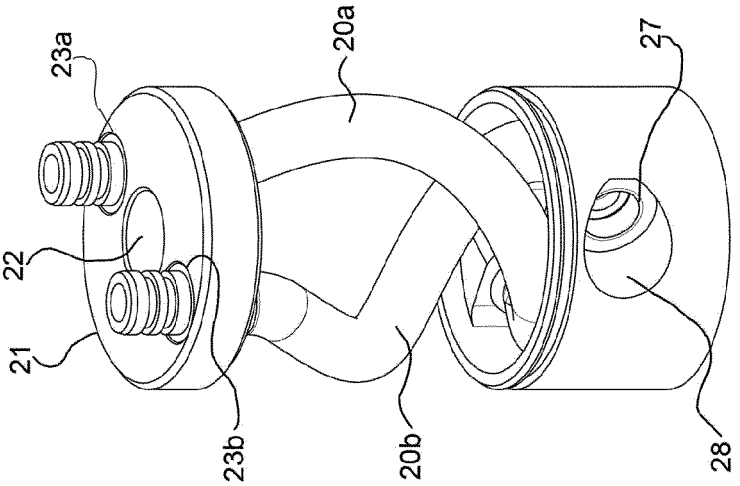
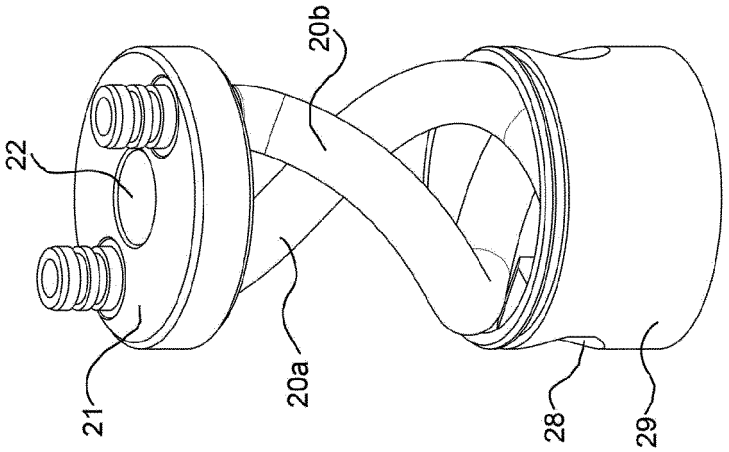


Fig.11



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EUROPEAN SEARCH REPORT

Application Number
EP 11 19 3013

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	10 April 2012	Geiger, Harald

CATEGORY OF CITED DOCUMENTS

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