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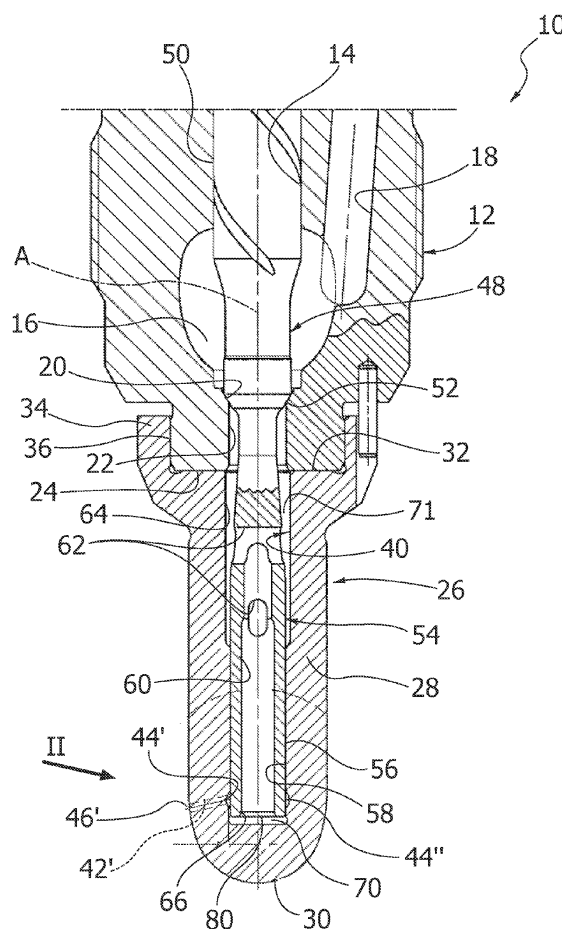
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(54) **A fuel injector for internal combustion engines**

(57) A fuel injector for internal combustion engines, comprising:

- a valve guide (12) having a longitudinal guide bore (14) and a chamber (16) provided with a valve seat (20), said chamber (26) being connected to a fuel supply duct (18);
- an atomizer (26) fixed at a lower end of said valve guide (12), the atomizer (26) having a longitudinal bore (40) in flow connection with said chamber (26) through said valve seat (20), the atomizer having a plurality of nozzle bores (42', 42'') having inner openings (44', 44'') facing into said longitudinal bore (40); and
- an axially movable spindle (48) having a valve portion (52) cooperating with said valve seat (20) and a cut-off element (54) extending into said longitudinal bore (40) of the atomizer (26), the cut-off element (54) having a cylindrical sealing portion (56) in sealing contact with a cylindrical sealing surface (58) of said longitudinal bore (40) and a central duct (60) establishing a fluid connection between an upper region (64) and a lower region (70) of said longitudinal bore (40).

FIG. 1



Description

Background of the invention

[0001] The present invention relates to a fuel injector for internal combustion engines. The invention relates in particular to a fuel injector for large two-stroke internal combustion engines, such as diesel engines for naval propulsion.

[0002] More specifically, the present invention relates to a fuel injector according to the preamble of claim 1, comprising a housing, a valve guide fixed at the lower end of the housing, an atomizer fixed at a lower end of the valve guide and provided with a plurality of nozzle bores, a spindle having a valve portion cooperating with a valve seat of the valve guide, and a cut-off element extending into a longitudinal bore of the atomizer to reduce the volume in fluid connection with the nozzle bores when the spindle is in a closed position.

Description of the Related Art

[0003] W02008/071187 discloses a fuel injector according to the preamble of claim 1, wherein the inlet openings of the nozzle bores of the atomizer are arranged in a first row and in a second row axially spaced apart and separated from each other by a cylindrical sealing portion. A cut-off element extending into a longitudinal bore of the atomizer has a first cylindrical section arranged to open and close the lower row of inlet openings and a second cylindrical section cooperating with a secondary valve seat for closing off the upper row of inlet openings when the valve spindle is closed.

[0004] When the valve spindle is open, the lower row of inlet openings is supplied by fuel flowing through a central duct of the cut-off element and the upper row of inlet openings is supplied by fuel flowing in an annular passage defined between the inner wall of the atomizer bore and the outer surface of the cut-off element.

[0005] EP-A-1380750 discloses a fuel injector comprising a nozzle body provided with first and second outlet openings for fuel and a valve needle slidable within a valve needle bore defined in the nozzle body. The valve needle bore is shaped to define a seating with which the valve needle is engageable to control fuel flow to a chamber. The valve needle is provided with a flow passage communicating with the chamber and a first annular recess communicating with the first outlet opening. Movement of the valve needle away from the seating into a first fuel injecting position causes the chamber to communicate with the first annular recess to permit fuel delivery through the first outlet opening and movement of the valve needle away from the seating into a second fuel injecting position causes fuel in the chamber to flow through the flow passage for delivery through the second outlet opening.

Object and Summary of the Invention

[0006] Future requirements and restrictions concerning emissions, in particular of NOx and HC-particles etc., demand injection devices for 2-Stroke engines with variable dosage capabilities to optimise the heat release by variable opening and closing of the injection holes with zero sack volume, which is highly responsible for HC emissions.

[0007] The object of the present invention is to provide a new sliding injection valve combined with a needle which slides within the atomiser and controls the opening and closing of the injection holes directly without additional volume between nozzle holes and valve wall, capable of providing variable dosage capabilities by means of stepwise opening of the injection holes of the atomizer.

[0008] In accordance with the present invention, this object is achieved by a fuel injector as defined in the appended claims.

Brief Description of the Drawings

[0009] Further characteristics and advantages of the present invention will become clear in the course of the detailed description which follows, given purely by way of non-limiting example, with reference to the annexed drawings, wherein:

- figure 1 is an axial cross-section of the end portion of a first embodiment of an injector according to the present invention,
- figures 2, 3 and 4 are axial cross-sections showing the part indicated by the arrow II in figure 1 in three different positions,
- figure 5 is an axial cross-section of the end portion of a second embodiment of an injector according to the present invention,
- figures 6, 7 and 8 are axial cross-sections showing the part indicated by the arrow VI in figure 1 in three different positions, and
- figures 9, 10 and 11 are axial cross-sections showing an alternative embodiment of the part indicated by the arrow VI in figure 1 in three different positions.

Description of Preferred Embodiments

[0010] Referring to figure 1, the reference number 10 indicates the end portion of a fuel injector for diesel engines according to the present invention. The injector 10 is intended to be mounted into an elongated cavity formed in the head of the engine.

[0011] The injector 10 comprises a valve guide 12 having a longitudinal guide bore 14. A chamber 16 is formed at the lower end of the guide bore 14. The chamber 16 is in flow connection with a fuel supply duct 18.

[0012] A conical valve seat 20 is provided at the bottom end of the chamber 16 of the valve guide 12. A short duct 22 extends downwardly of the valve seat 20 and opens

on a front face 24 of the valve guide 12.

[0013] An atomizer 26 is fixed at a lower end of the valve guide 12. The atomizer 26 has a cylindrical body 28 made of or coated by a corrosion-resistant material. The body 28 has a closed bottom end 30. An upper front face 32 of the atomizer 26 frontally abuts the front face 24 of the valve guide 12. A circular upper flange 34 of the atomizer 26 engages a bottom cylindrical surface 36 of the guide valve 12. A vertical pin 38 engages mutually facing openings of the valve guide 12 and of the atomizer 26 to set the atomizer 26 in a fixed angular position with respect to the valve guide 12. The atomizer 26 is fixed to the valve guide 12 by means of a retaining element (not shown).

[0014] In the following description and in the claims the terms like "upper", "lower", "above", "below", and similar, refer to the position of normal use of the injector 10, where the injector 10 is oriented vertically, with the atomizer 26 at the bottom.

[0015] The atomizer 26 has a longitudinal bore 40 closed at its bottom end. The upper end of the longitudinal bore 40 is in flow connection with the chamber 16 through the short duct 22 and the valve seat 20. A plurality of nozzle bores 42', 42" is formed through the cylindrical body 28. The nozzle bores 42', 42" have respective inner openings 44', 44" facing into the longitudinal bore 40 and outer openings 46', 46" open on the outer surface of the atomizer 26.

[0016] With reference to figure 1, a spindle 48 is displaceable into the valve guide 12 along a direction coincident with the longitudinal axis A of the spindle 48. The spindle 48 has a cylindrical portion 50 which slidably engages the longitudinal guide bore 14 of the valve guide 12. The spindle 48 has a conical valve portion 52 which cooperates with the conical valve seat 20 of the valve guide 12.

[0017] The spindle 48 is controlled by an electric actuator (not shown) which moves the spindle between a closed position (shown in figure 1), a first open position and a second open position.

[0018] The spindle 48 comprises a cut-off element 54 which extends coaxially below the valve portion 52 and into the longitudinal bore 40 of the atomizer 26. The cut-off element 54 is fixed to or integrally formed with the remaining part of the spindle 48.

[0019] The lower end of the cut-off element 54 has a cylindrical sealing portion 56 which engages with sealing contact a cylindrical sealing surface 58 of the longitudinal bore 40. The cut-off element 54 has a central duct 60 which is in flow connection through transverse holes 62 with an upper region 64 of the longitudinal bore 40 located above the cylindrical sealing surface 58. The central duct 60 is also in flow connection through a bottom opening 66 with a lower region 70 of the longitudinal bore 40 located below the lower cylindrical sealing surface 58.

[0020] In the upper region 64 of the longitudinal bore 40 an annular duct 71 is defined between an inner surface of the longitudinal bore 40 and an outer surface of the

cut-off element 54. The transverse holes 62 of the cut-off element 54 are in flow connection with the annular duct 71.

[0021] Figures 2, 3 and 4 show the cut-off element in the positions corresponding, respectively, to the closed position, first open position and second open position of the spindle 48.

[0022] The inner openings 44', 44" of the nozzle bores 42', 42" are aligned or substantially aligned to each other in a circumferential direction. The inner openings are divided in a first group 44' and a second group 44". The first group includes at least one inner opening 44' positioned in a shallow recess 72 elongated in the longitudinal direction A and formed on the cylindrical sealing surface 58 of the longitudinal bore 40. The or each recess 72 has a lower edge extending below the respective inner opening 44'. The inner openings of the second group are open on the cylindrical sealing surface 58. When more recesses 72 are provided, the axial length of such recesses 72 can be different, as shown in figures 2-4.

[0023] In the closed position of figure 2 the lower edge of the cylindrical sealing portion 56 of the cut-off element 54 extends below the lower edges of the recesses 72. In this position the cylindrical sealing portion 56 of the cut-off element 54 closes fluid communication between all the inner openings 44', 44" and the lower region 70 or the annular duct 71.

[0024] In the first open position of figure 3 the lower edge of the cylindrical sealing portion 56 of the cut-off element 54 extends across at least one of the recesses 72 and below the lower edges of the inner openings 44', 44". In this position there is fluid communication between the lower region 70 and the partially uncovered recesses 72. Fuel under pressure passes through the central duct 60 and is injected through the nozzle bores 42' which communicate with the partially uncovered recesses 72.

[0025] In the second open position of figure 4 the lower edge of the cylindrical sealing portion 56 of the cut-off element 54 extends above the upper edges of the inner openings 44', 44". In this position all the nozzle bores 42 are in fluid communication with the lower region 70. All the nozzle bores 42', 42" are simultaneously supplied with pressurised fuel.

[0026] A second embodiment is shown in figure 5. The elements corresponding to the ones previously described are indicated by the same reference numbers.

[0027] In the second embodiment at least two of the nozzle bores 42', 42" have respective inner openings 44', 44" and outer openings 46', 46" spaced apart from each other in a direction parallel to the longitudinal axis A. The inner openings 44', 44" are formed on the cylindrical sealing surface 58 of the atomizer 26. The cylindrical sealing portion 56 of the cut-off element has an annular groove 74 which separates from each other an upper sealing portion 76 and a lower sealing portion 78 which cooperate in sealing contact with the cylindrical sealing surface 58 of the longitudinal bore 40.

[0028] In the closed position shown in figure 6 the lower

sealing portion 78 is positioned below the lower inner opening 44' and the upper sealing portion is positioned at least partially above the upper inner opening 44". In this position all the nozzle bores 42' 42" are closed.

[0029] In the first open position shown in figure 7 the lower sealing portion 78 is positioned between the lower and upper inner openings 44', 44" and the upper sealing portion is positioned at least partially above the upper inner opening 44" and in sealing contact with the cylindrical sealing surface 58. In this position fuel under pressure passes through the central duct 60 and is injected through the lower nozzle bores 42', which communicate with the lower region 70.

[0030] In the second open position shown in figure 8 the lower sealing portion 78 is positioned between the lower and upper inner openings 44', 44" and the upper sealing portion is positioned above the cylindrical sealing surface 58. The annular groove 74 is positioned between the upper inner opening 44" and the upper edge of the cylindrical sealing surface 58. In this position fuel under pressure passes through the central duct 60 and is injected through the lower nozzle bores 42', which communicate with the lower region 70. Fuel under pressure also passes in the annular duct 71 and is injected through the upper nozzle bores 42".

[0031] An alternative arrangement is shown in figures 9, 10 and 11. Also in this case there are provided at least two nozzle bores 42', 42" with respective inner openings 44', 44" and outer openings 46', 46" spaced apart from each other in a direction parallel to the longitudinal axis A. The cut-off element 54 has a cylindrical sealing portion 56 which is in continuous sealing contact with the cylindrical sealing surface 58 of the longitudinal bore 40 up to its lower edge 80.

[0032] In the closed position shown in figure 9 the lower edge 80 of the cut-off element is positioned below the lower inner opening 44' and all the nozzle bore 42', 42" are closed.

[0033] In the first open position shown in figure 10 the lower edge 80 is positioned between the lower and upper inner openings 44', 44". In this position fuel under pressure passes through the central duct 60 and is injected through the lower nozzle bores 42', which communicate with the lower region 70.

[0034] In the second open position shown in figure 11 the lower edge 80 is positioned above the upper inner openings 44". In this position fuel under pressure passes through the central duct 60 and is injected through all the nozzle bores 42', 42", which communicate with the lower region 70.

[0035] The solutions according to the present invention allows to save fuel, to control injection rate and therefore to control the heat release in the combustion chamber, to reduce the NOx formation and to reduce the HC emissions.

[0036] The solutions described herein control directly the nozzle holes opening/closing and allow an easier control the injection cross-section (nozzle areas) de-

pending on the load or intended injection rate / heat release.

[0037] In the solution with nozzle bores in two or more lines, at low engine load the fuel will be injected through the holes in the first line, which contains at one or more injection holes. At higher loads the needle stroke has to be increased in a second (continuous) step to allow the injection also through the holes in the next (second) lines/stages. Through speed and step control of the needle stroke it is possible to control also the heat release at higher loads.

[0038] The solution with nozzle hole substantially on one line allows also easier design and better needle guide in the sliding area. In this case one or more injection holes are within a recess, which allows depending on the needle stroke to inject through the first holes. By further increasing the needle stroke it is possible to inject through all the bores. To have more flexibility, the recesses might be in different heights.

Claims

1. A fuel injector for internal combustion engines, comprising:

- a valve guide (12) having a longitudinal guide bore (14) and a chamber (16) provided with a valve seat (20), said chamber (26) being connected to a fuel supply duct (18);
- an atomizer (26) fixed at a lower end of said valve guide (12), the atomizer (26) having a longitudinal bore (40) in flow connection with said chamber (26) through said valve seat (20), the atomizer having a plurality of nozzle bores (42', 42") having inner openings (44', 44") facing into said longitudinal bore (40); and
- an axially movable spindle (48) having a valve portion (52) cooperating with said valve seat (20) and a cut-off element (54) extending into said longitudinal bore (40) of the atomizer (26), the cut-off element (54) having a cylindrical sealing portion (56) in sealing contact with a cylindrical sealing surface (58) of said longitudinal bore (40) and a central duct (60) establishing a fluid connection between an upper region (64) and a lower region (70) of said longitudinal bore (40) located, respectively, above and below said cylindrical sealing surface (58); and wherein in said upper region (64) an annular duct (71) is defined between an inner surface of the longitudinal bore (40) and an outer surface of the cut-off element (54);

characterized in that the spindle is movable between a closed position, a first open position and a second open position, wherein in the closed position of the spindle (48) said cylindrical sealing surface

(58) of said cut-off element (54) closes fluid communication between all said inner openings (44', 44") and said lower region (70) and said annular duct (71), wherein in said first open position a first group of inner openings (44') is in fluid communication with said lower region (70) and said cylindrical sealing surface (58) of said cut-off element (54) closes fluid communication between a second group of inner openings (44") and said lower region (70) or annular duct (71), and wherein in said second open position said first group of inner openings (44') is in fluid communication with said lower region (70) and said second group of inner openings (44") is in fluid communication with either said lower region (70) or with said annular duct (71).

2. A fuel injector according to claim 1, **characterized in that** said inner openings (44', 44") are aligned or substantially aligned to each other in a circumferential direction and that at least one inner opening (44') of said first group is positioned in a respective axially elongated recess (72) formed on said cylindrical sealing surface (58).
3. A fuel injector according to claim 1, **characterised in that** the nozzle bores (42', 42") of said first and second group have respective inner openings (44', 44") spaced apart from each other in a longitudinal direction (A).
4. A fuel injector according to claim 3, **characterized in that** said cylindrical sealing portion (56) of the cut-off element (54) has an annular groove (74) which separates from each other an upper and a lower sealing portion (76, 78), wherein in said closed position said lower sealing portion (78) is positioned below the lower edges of the first group of inner openings (42').
5. A fuel injector according to claim 3, **characterized in that** the cylindrical sealing portion (56) of the cut-off element (54) is in continuous sealing contact with the cylindrical sealing surface (58) of the longitudinal bore (40) up to a lower edge (80) of the cut-off element (54) and that in said closed position said lower edge (80) is positioned below the lower edges of the first group of inner openings (42').

FIG. 1

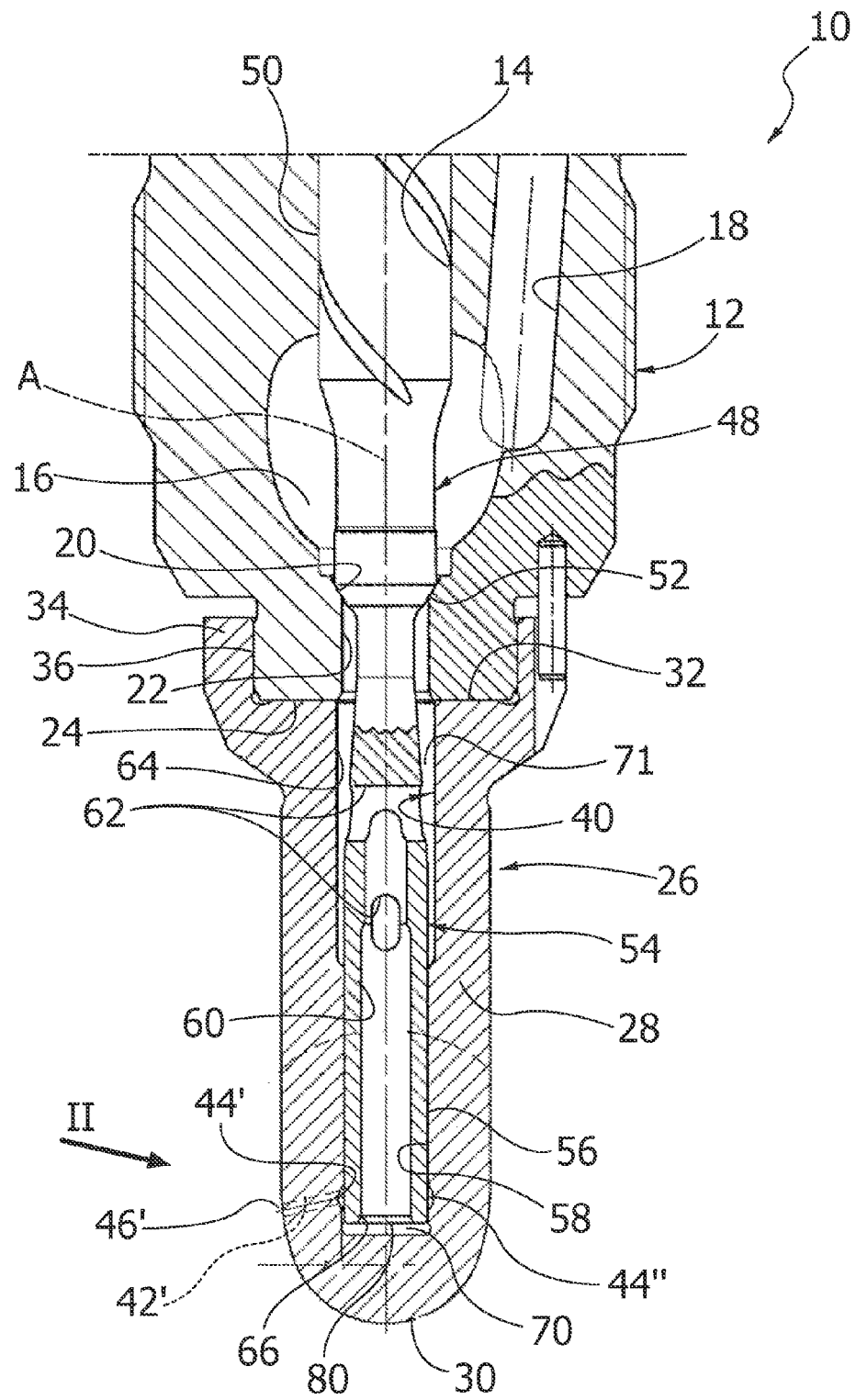


FIG. 2

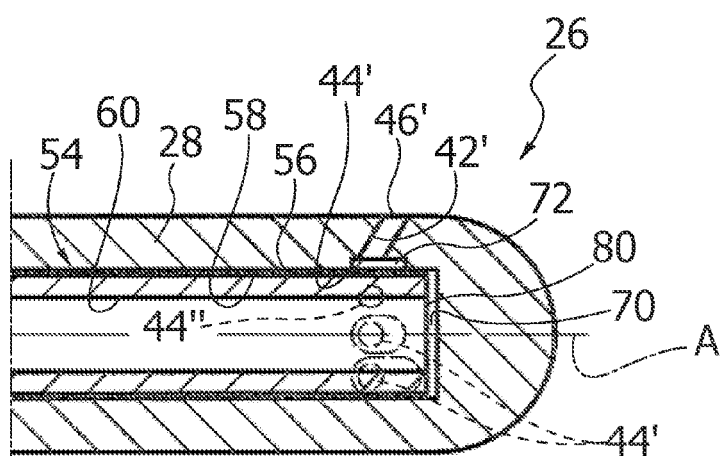


FIG. 3

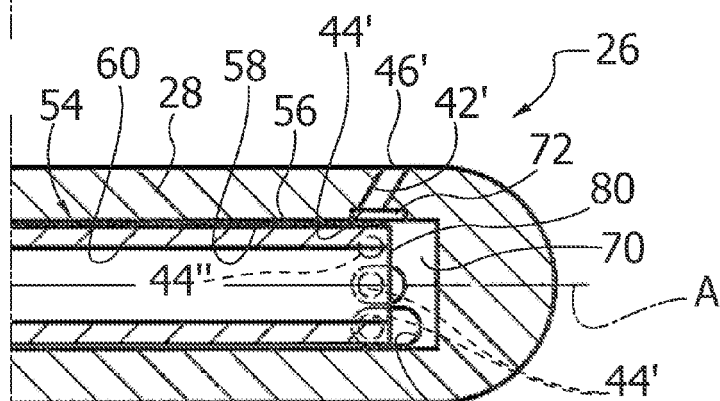


FIG. 4

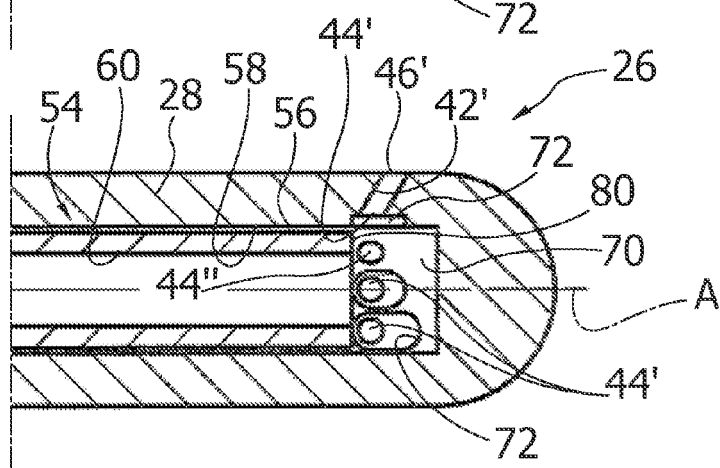


FIG. 5

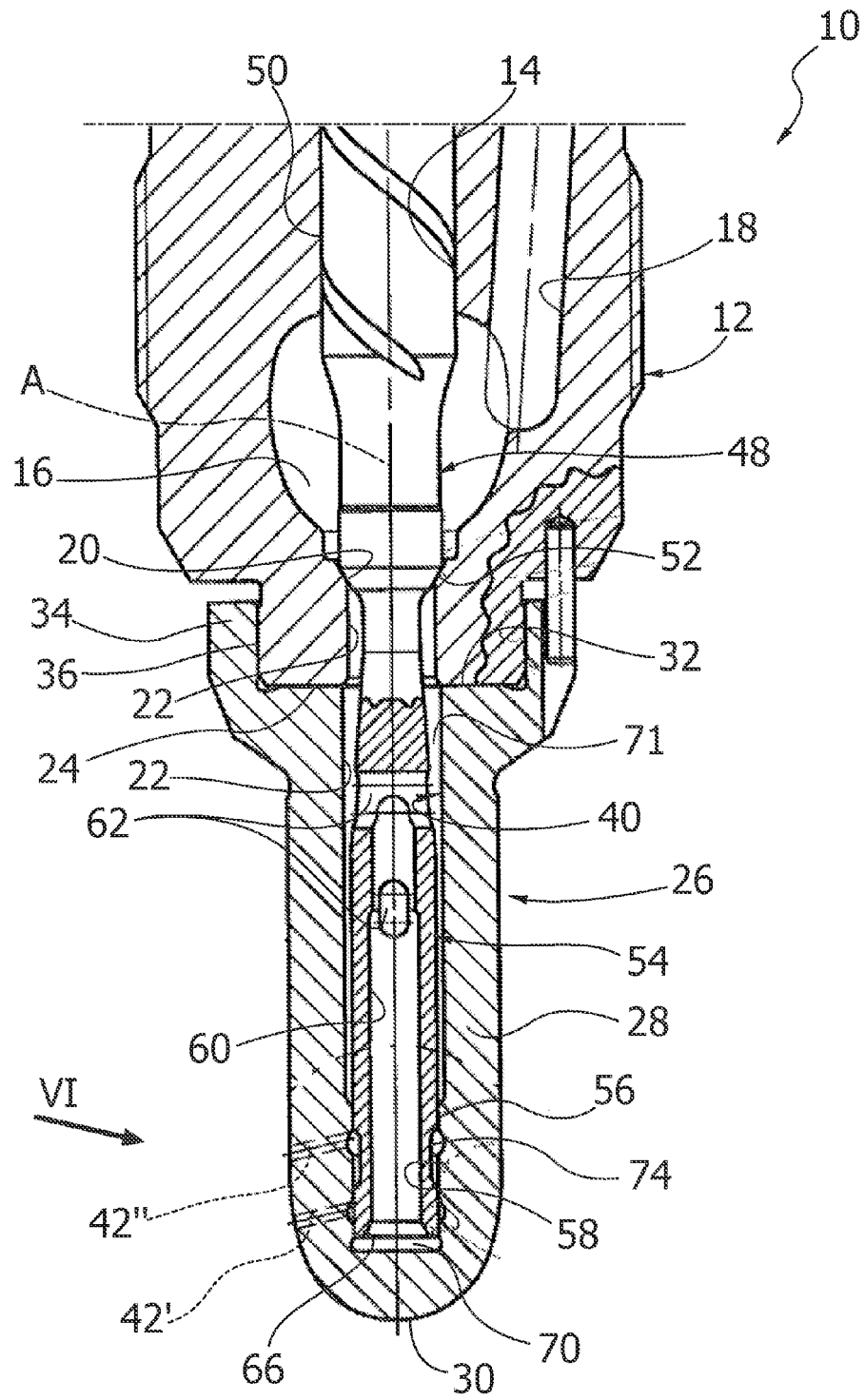


FIG. 6

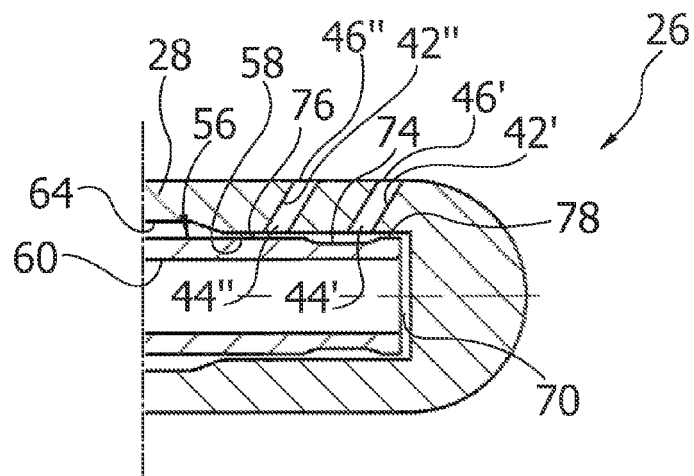


FIG. 7

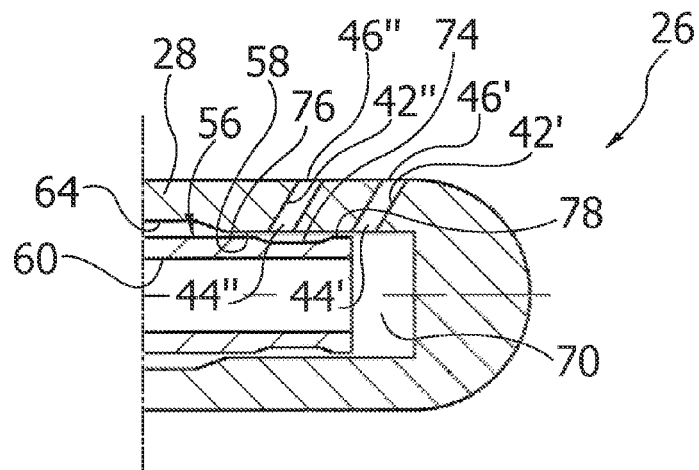


FIG. 8

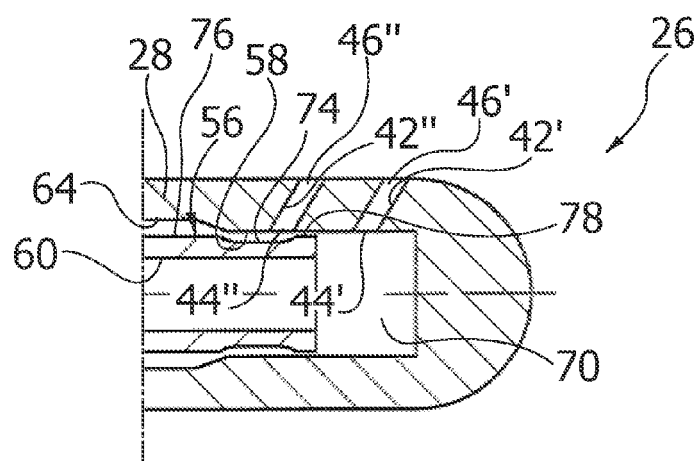


FIG. 9

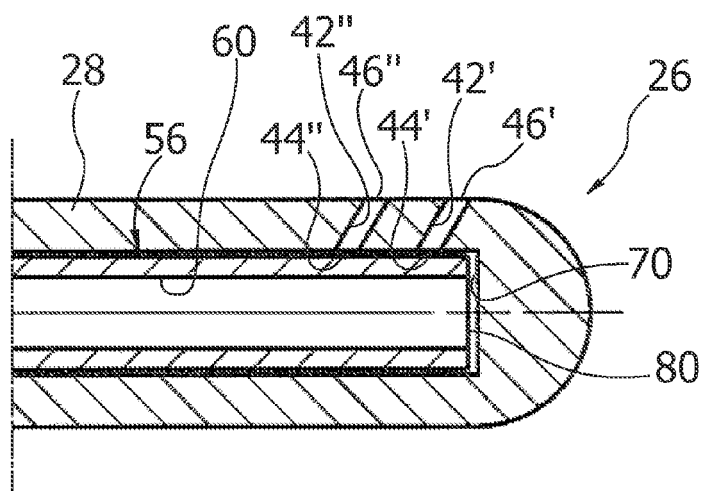


FIG. 10

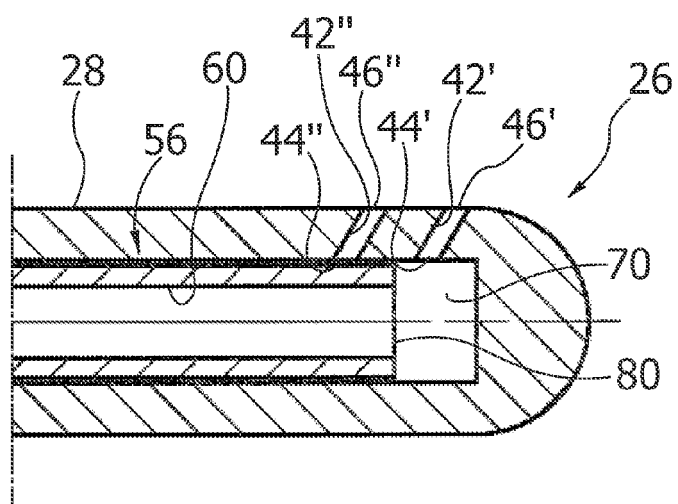
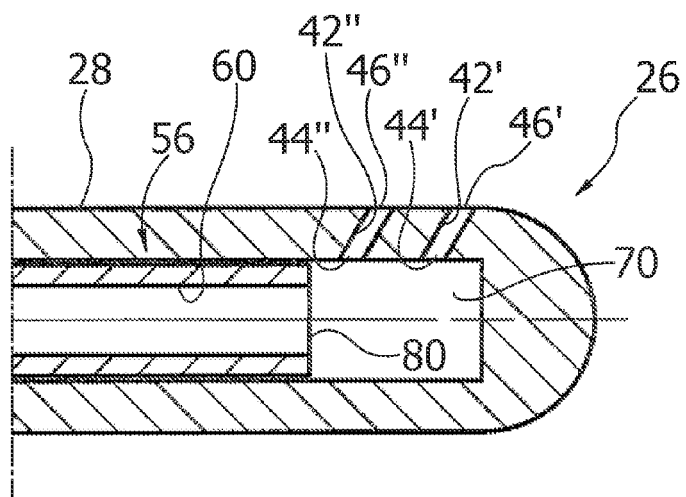


FIG. 11





EUROPEAN SEARCH REPORT

Application Number
EP 10 16 2498

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The present search report has been drawn up for all claims				TECHNICAL FIELDS SEARCHED (IPC)
				F02M
Place of search		Date of completion of the search	Examiner	
Munich		24 September 2010	Landriscina, V	
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 10 16 2498

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24-09-2010

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