(19) Europäisches Patentamt
European Patent Office
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(11) EP 2 025 923 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
18.02.2009 Bulletin 2009/08

(21) Application number: **07015380.4**

(22) Date of filing: **06.08.2007**

(51) Int Cl.:
F02M 61/12 *(2006.01)* ***F02M 61/16*** *(2006.01)*
F02M 65/00 *(2006.01)* ***F02M 61/18*** *(2006.01)*

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

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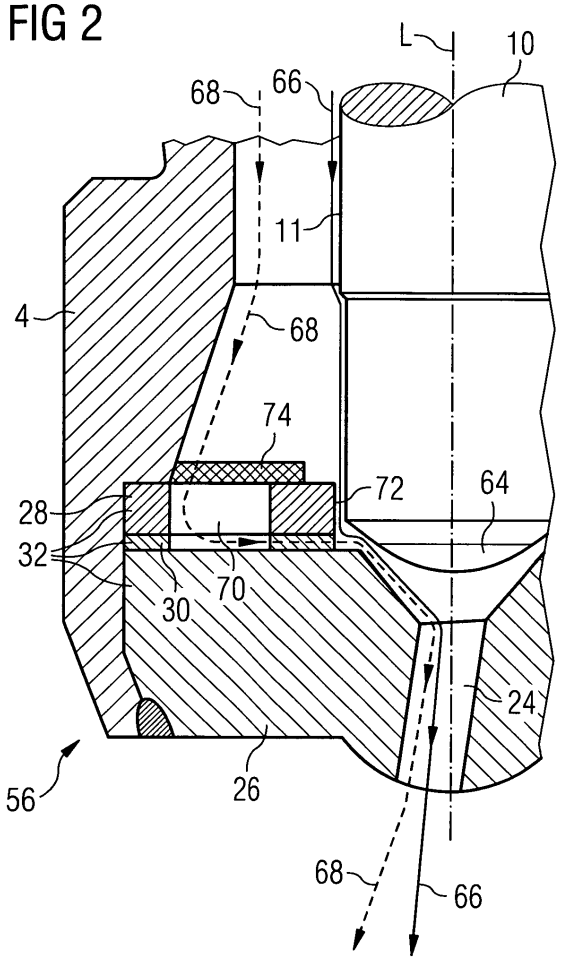
Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) Method for determining a set of a valve needle and a valve seat assembly of an injection valve

(57) The method is carried out with a valve assembly shell (56) comprising a valve body (4) with a cavity (8) having a fluid inlet portion (42) and a fluid outlet portion (44), and a valve seat assembly (32) with a seat plate (26) and a guiding element (28) for guiding the valve needle (10). The valve needle (10) is axially movable in the cavity (24), the valve needle (10) prevents a fluid flow through the fluid outlet portion (44) in a closing position and releases the fluid flow through the fluid outlet portion (44) in further positions, and the valve needle (10) and the valve seat assembly (32) are designed to enable a fluid flow between the fluid inlet portion (42) and the fluid outlet portion (44) following a first flow path (66) through a gap (74) between the valve needle (10) and the guiding element (28) and a second flow path (68) through the valve seat assembly (32).

FIG 2



EP 2 025 923 A1

Description

[0001] The invention relates to a method for determining the capability of a valve needle and a valve seat assembly to control a desired flow rate in an injection valve, and a method for determining a set of a valve needle and a valve seat assembly of an injection valve to obtain a desired flow rate of the injection valve.

[0002] Injection valves are in wide spread use, in particular for internal combustion engines where they may be arranged in order to dose the fluid into an intake manifold of the internal combustion engine or directly into the combustion chamber of a cylinder of the internal combustion engine.

[0003] Injection valves are manufactured in various forms in order to satisfy the various needs for the various combustion engines. Therefore, for example, their length, their diameter and also various elements of the injection valve being responsible for the way the fluid is dosed may vary in a wide range. In addition to that, injection valves may accommodate an actuator for actuating a needle of the injection valve, which may, for example, be an electromagnetic actuator or piezo electric actuator.

[0004] In order to enhance the combustion process in view of the creation of unwanted emissions, the respective injection valve may be suited to dose fluids under very high pressures. The pressures may be in case of a gasoline engine, for example, in the range of up to 200 bar and in the case of diesel engines in the range of up to 2000 bar.

[0005] The object of the invention is to create a method for determining the capability of a valve needle and a valve seat assembly to control a desired flow rate in an injection valve, and a method for determining a set of a valve needle and a valve seat assembly of an injection valve to obtain a desired flow rate of the injection valve which facilitates to obtain a reliable and precise function of the injection valve.

[0006] These objects are achieved by the features of the independent claims.

[0007] According to a first aspect the invention is distinguished by a method for determining the capability of a valve needle to control a desired flow rate in an injection valve, the method being carried out with a valve assembly shell comprising a valve body including a central longitudinal axis, the valve body comprising a cavity with a fluid inlet portion and a fluid outlet portion, and a valve seat assembly with a seat plate and a guiding element for guiding the valve needle, the valve needle being axially movable in the cavity, the valve needle preventing a fluid flow through the fluid outlet portion in a closing position and releasing the fluid flow through the fluid outlet portion in further positions, and the valve needle and the valve seat assembly being designed to enable a fluid flow between the fluid inlet portion and the fluid outlet portion following a first flow path through a gap between the valve needle and the guiding element of the valve seat assembly and a second flow path through the valve seat assembly. The method comprises the following steps:

inserting the valve needle into the cavity of the valve body of the valve assembly shell, coupling the valve assembly shell with a fluid supply, operating the valve needle under a given set of operating conditions, thereby releasing the fluid flow through the fluid outlet portion, preventing a fluid flow through the second flow path and enabling a fluid flow through the first flow path, measuring the fluid flow through the fluid outlet portion under the given set of operating conditions, and removing the valve needle from the cavity of the valve body of the valve assembly shell.

[0008] This has he advantage, that a reliable selection of suitable valve needles for injection valves is possible. The selection of the valve needles for the injection valves is based on a functional test method and a decision based on a geometrical selection of the valve needles can be avoided. Consequently, the number of rejected valve needles can be kept small. Thus, low costs for the injection valve and a small risk of a failure of the injection valve can be obtained. Finally, the valve needles can be assigned to flow rate classes according to the determined flow rates.

[0009] According to a second aspect the invention is distinguished by a method for determining the capability of a valve seat assembly to control a desired flow rate in an injection valve, the method being carried out with a valve sub-assembly comprising a valve body including a central longitudinal axis, the valve body comprising a cavity with a fluid inlet portion and a fluid outlet portion, and a valve needle being axially movable in the cavity, the valve needle preventing a fluid flow through the fluid outlet portion in a closing position and releasing the fluid flow through the fluid outlet portion in further positions, the valve seat assembly comprising a seat plate, a guiding element for guiding the valve needle and a fluid flow directing element, and the valve needle and the valve seat assembly being designed to enable a fluid flow between the fluid inlet portion and the fluid outlet portion following a first flow path between the valve needle and the valve seat assembly and a second flow path through the valve seat assembly. The method comprises the following steps: coupling the valve seat assembly with the valve sub-assembly, coupling the valve sub-assembly with a fluid supply, operating the valve needle under a given set of operating conditions, thereby releasing the fluid flow through the fluid outlet portion, preventing a fluid flow through the first flow path and enabling a fluid flow through the second flow path, and measuring the fluid flow through the fluid outlet portion under a given set of operating conditions, and removing the valve seat assembly from the valve sub-assembly.

[0010] This has the advantage, that a reliable selection of suitable valve seat assemblies with seat plate, guiding

element and fluid flow directing element for injection valves is possible. The selection of the valve seat assemblies for the injection valves is based on a functional test method and a decision based on a geometrical selection of the seat plate, the guiding element and the fluid flow directing element can be avoided. Consequently, the number of rejected valve seat assemblies can be kept small. Thus, low costs for the injection valve and a small risk of a failure of the injection valve can be obtained. Finally, the valve seat assemblies can be assigned to flow rate classes according to the determined flow rates.

[0011] According to a third aspect the invention is distinguished by a method for determining a set of a valve needle and a valve seat assembly of an injection valve to obtain a desired flow rate of the injection valve. The method comprises the following steps: determining a fluid flow of the valve needle in accordance with the method according to the first aspect of the invention, determining a fluid flow of the valve seat assembly in accordance with the method according to the second aspect of the invention, and selecting a combination of the valve needle according to the determined fluid flow of the valve needle and the valve seat assembly according to the determined fluid flow of the valve seat assembly to obtain the desired flow rate of the injection valve.

[0012] This has the advantage, that a simple determination of appropriate combinations of valve needles and valve seat assemblies obtained by the two methods for determining the capability of valve needles and valve seat assemblies to control desired flow rates is possible. It is possible to achieve a fitting combination of valve needles and valve seat assemblies to obtain a given flow rate of the injection valve. Furthermore, valve needles and valve seat assemblies of specific flow rate classes can be matched in a desired manner. Consequently, the number of rejected injection valves can be kept small. Thus, low costs for the injection valve and a small risk of a failure of the injection valve can be obtained.

[0013] Exemplary embodiments of the invention are explained in the following with the aid of schematic drawings. These are as follows:

Figure 1 an injection valve with a valve assembly in a longitudinal section view,

Figure 2 section II of the valve assembly of the injection valve according to figure 1 in a longitudinal section view according to a first operating condition, and

Figure 3 section II of the valve assembly of the injection valve according to figure 1 in a longitudinal section view according to a second operating condition.

[0014] Elements of the same design and function that appear in different illustrations are identified by the same reference character.

[0015] An injection valve 62, that is in particular suitable for dosing fuel to an internal combustion engine, comprises an inlet tube 2, a housing 6 and a valve assembly 60.

[0016] The valve assembly 60 comprises a valve body 4 with a central longitudinal axis L and a cavity 8, which takes in a valve needle 10 and preferably a part of an armature 12. The valve needle 10 has a surface 11 and a seat part 64 (figure 2). In the inlet tube 2 a recess 16 is provided which further extends to a recess 18 of the armature 12. A spring 14 is arranged in the recess 16 of the inlet tube 2 and/or the recess 18 of the armature 12. Preferably, it rests on a spring seat being formed by an anti-bounce disc 20. By this the spring 14 is mechanically coupled to the needle 10. An adjusting tube 22 is provided in the recess 16 of the inlet tube 2. The adjusting tube 22 forms a further seat for the spring 14 and may be axially moved during the manufacturing process of the fluid injection valve in order to preload the spring 14 in a desired way.

[0017] In a closing position of the needle 10 it sealingly rests on a seat plate 26 by this preventing a fluid flow through at least one injection nozzle 24. The injection nozzle 24 may be, for example, an injection hole. However, it may also be of some other type suitable for dosing fluid. The seat plate 26 is separate from the valve body 4. In addition to that a lower guide 28 for guiding the needle 10 is provided. The lower guide 28 further comprises an orifice 70 for guiding the fluid flow.

[0018] Additionally, a fluid flow directing element 30 is provided which is arranged in the cavity 8 between the lower guide 28 and the seat plate 26. Preferably, the fluid flow directing element 30 has the shape of a cylindrical disk.

[0019] The seat plate 26, the lower guide 28 and the fluid flow directing element 30 are forming a valve seat assembly 32.

[0020] The injection valve 62 is provided with an actuator unit, that comprises preferably an electromagnetic actuator, comprising a coil 36, which is preferably overmolded. A valve body shell 38, the armature 12 and the inlet tube 2 are forming an electromagnetic circuit. The actuator unit may, however, also comprise another type of actuator, which is known to a person skilled in the art for that purpose. Such an actuator may be, for example, a piezoelectric actuator.

[0021] A fluid inlet portion 42 is provided in the valve body 4 which communicates with a fluid outlet portion 44 which is a part of the cavity 8 near the seat plate 26.

[0022] In the following, the function of the injection valve 10 is described:

[0023] The fluid is led from the fluid inlet portion 42 to the fluid outlet portion 44. The axial position of the valve needle 10, which determines whether the fluid outlet portion 44 is opened or closed for a fluid flow, depends on the force balance between the spring 14 and the forces applied to the valve needle 10 by the actuator unit with the coil 36.

[0024] The fluid flows through the fluid outlet portion 44 can be described with flow paths, in particular with a first flow path 66 and a second flow path 68.

[0025] The fluid flow on the first flow path 66 is following the surface 11 of the valve needle 10.

[0026] As can be seen in figure 2, the first flow path 66 enters a gap 72 between the valve needle 10 and the lower guide 28 near the surface 11 of the valve needle 10. This fluid flow is leaving the injection nozzle 24 in axial direction.

[0027] As can be seen in figure 3, the second flow path 68 through the orifice 70 of the lower guide 28 represents the fluid flow distanced from the surface 11 of the valve needle 10. The fluid flow on the flow path 68 is passing the fluid flow directing element 30 thereby obtaining a radial velocity component of the fluid flow.

[0028] In the following, the method for determining the capability of the valve needle and the valve seat assembly to control a desired flow rate in the injection valve, and the method for determining a set of the valve needle and the valve seat assembly of the injection valve to obtain a desired flow rate of the injection valve are described in detail:

[0029] The method for determining the capability of the valve needle 10 to control a desired flow rate in the injection valve 62 is carried out in the following manner (see figure 2):

[0030] The valve body 4 and the valve seat assembly 32 are forming a valve assembly shell 56 which is used as a measuring device. The valve needle 10 which is to be measured is inserted into the cavity 8 of the valve body 4 of the valve assembly shell 56. The valve assembly shell 56 is coupled with the fluid supply. A fluid flow through the fluid outlet portion 44 is released. The fluid may be a gas or a liquid. The fluid flow through the first flow path 66 is enabled and the fluid flow through the second flow path 68 is prevented by a first fluid flow blocking device 74. Alternatively, the valve assembly shell 56 and the first fluid flow blocking device 74 are forming a one-piece master part. The valve needle 10 is operated under determined operating conditions. Furthermore, the fluid flow through the fluid outlet portion 44 is measured under the determined operating conditions. Finally, after having measured the fluid flow through the fluid outlet portion 44, the valve needle 10 is removed from the cavity 8 of the valve body 4 of the valve assembly shell 56.

[0031] The method for determining the capability of the valve seat assembly 32 to control a desired flow rate in the injection valve 62 is carried out in the following way (see figure 3):

[0032] The valve body 4 and the valve needle 10 are forming a valve sub-assembly 58 which is used as a measuring device. The valve seat assembly 32 which is to be measured is inserted into the valve sub-assembly 58. The valve sub-assembly 58 is coupled with the fluid supply. The fluid flow is released through the fluid outlet portion 44. The fluid may be a gas or a liquid. The fluid flow through the second flow path 68 is enabled and the fluid flow through the first flow path 66 is prevented by a second fluid flow blocking device 76. The valve needle 10 is operated under a certain set of operating conditions. The fluid flow through the fluid outlet portion 44 is determined under the certain set of operating conditions. Finally, the valve seat assembly 32 is removed from the valve sub-assembly 58.

[0033] In a further step, a combination of the valve needle 10 according to the determined fluid flow of the valve needle 10 and the valve seat assembly 32 according to the determined fluid flow of the valve seat assembly 32 is selected to form a couple of the valve needle 10 and the valve seat assembly 32 to obtain the required flow rate of the injection valve 62.

Claims

1. Method for determining the capability of a valve needle (10) to control a desired flow rate in an injection valve (62),
the method being carried out with a valve assembly shell (56) comprising

   - a valve body (4) including a central longitudinal axis (L), the valve body (4) comprising a cavity (8) with a fluid inlet portion (42) and a fluid outlet portion (44), and
   - a valve seat assembly (32) with a seat plate (26) and a guiding element (28) for guiding the valve needle (10),

   the valve needle (10) being axially movable in the cavity (24), the valve needle (10) preventing a fluid flow through the fluid outlet portion (44) in a closing position and releasing the fluid flow through the fluid outlet portion (44) in further positions, and the valve needle (10) and the valve seat assembly (32) being designed to enable a fluid flow between the fluid inlet portion (42) and the fluid outlet portion (44) following a first flow path (66) through a gap (74) between the valve needle (10) and the guiding element (28) of the valve seat assembly (32) and a second flow path (68) through the valve seat assembly (32),
   the method comprising the following steps:

   - inserting the valve needle (10) into the cavity (8) of the valve body (4) of the valve assembly shell (56),
   - coupling the valve assembly shell (56) with a fluid supply,
   - operating the valve needle (10) under a given set of operating conditions, thereby releasing the fluid flow through the fluid outlet portion (44), preventing a fluid flow through the second flow path (68) and enabling a fluid flow through the first flow path (66),
   - measuring the fluid flow through the fluid outlet

portion (44) under the given set of operating conditions, and
- removing the valve needle (10) from the cavity (8) of the valve body (4) of the valve assembly shell (56).

2. Method for determining the capability of a valve seat assembly (32) to control a desired flow rate in an injection valve (62),
the method being carried out with a valve sub-assembly (58) comprising

- a valve body (4) including a central longitudinal axis (L), the valve body (4) comprising a cavity (8) with a fluid inlet portion (42) and a fluid outlet portion (44), and
- a valve needle (10) being axially movable in the cavity (24), the valve needle (10) preventing a fluid flow through the fluid outlet portion (44) in a closing position and releasing the fluid flow through the fluid outlet portion (44) in further positions,

the valve seat assembly (32) comprising a seat plate (26), a guiding element (28) for guiding the valve needle (10) and a fluid flow directing element (30), and the valve needle (10) and the valve seat assembly (32) being designed to enable a fluid flow between the fluid inlet portion (42) and the fluid outlet portion (44) following a first flow path (66) between the valve needle (10) and the valve seat assembly (32) and a second flow path (68) through the valve seat assembly (32),
the method comprising the following steps:

- coupling the valve seat assembly (32) with the valve sub-assembly (58),
- coupling the valve sub-assembly (58) with a fluid supply,
- operating the valve needle (10) under a given set of operating conditions, thereby releasing the fluid flow through the fluid outlet portion (44), preventing a fluid flow through the first flow path (66) and enabling a fluid flow through the second flow path (68), and
- measuring the fluid flow through the fluid outlet portion (44) under a given set of operating conditions, and
- removing the valve seat assembly (32) from the valve sub-assembly (58).

3. Method for determining a set of a valve needle (10) and a valve seat assembly (32) of an injection valve (62) to obtain a desired flow rate of the injection valve (62),
the method comprising the following steps:

- determining a fluid flow of the valve needle (10) in accordance with the method of claim 1,
- determining a fluid flow of the valve seat assembly (32) in accordance with the method of claim 2, and
- selecting a combination of the valve needle (10) according to the determined fluid flow of the valve needle (10) and the valve seat assembly (32) according to the determined fluid flow of the valve seat assembly (32) to obtain the desired flow rate of the injection valve (62).

Amended claims in accordance with Rule 137(2) EPC.

1. Method for determining a set of a valve needle (10) and a valve seat assembly (32) of an injection valve (62) to obtain a desired flow rate of the injection valve (62), the method comprising the following steps:

- determining a fluid flow of the valve needle (10) with a first method being carried out with a valve assembly shell (56),
the valve assembly shell (56) comprising

- a valve body (4) including a central longitudinal axis (L), the valve body (4) comprising a cavity (8) with a fluid inlet portion (42) and a fluid outlet portion (44), and
- the valve seat assembly (32) with a seat plate (26) and a guiding element (28) for guiding the valve needle (10), the valve needle (10) being axially movable in the cavity (24), the valve needle (10) preventing a fluid flow through the fluid outlet portion (44) in a closing position and releasing the fluid flow through the fluid outlet portion (44) in further positions, and the valve needle (10) and the valve seat assembly (32) being designed to enable a fluid flow between the fluid inlet portion (42) and the fluid outlet portion (44) following a first flow path (66) through a gap (74) between the valve needle (10) and the guiding element (28) of the valve seat assembly (32) and a second flow path (68) through the valve seat assembly (32),

the first method comprising the following steps:

- inserting the valve needle (10) into the cavity (8) of the valve body (4) of the valve assembly shell (56),
- coupling the valve assembly shell (56) with a fluid supply,
- operating the valve needle (10) under a given set of operating conditions, thereby

releasing the fluid flow through the fluid outlet portion (44), preventing a fluid flow through the second flow path (68) and enabling a fluid flow through the first flow path (66),

- measuring the fluid flow through the fluid outlet portion (44) under the given set of operating conditions,
- assigning the valve needle (10) to a flow rate class according to the determined flow rate, and
- removing the valve needle (10) from the cavity (8) of the valve body (4) of the valve assembly shell (56),

- determining a fluid flow of the valve seat assembly (32) with a second method being carried out with a valve sub-assembly (58) comprising the valve body (4) and the valve needle (10), the second method comprising the following steps:

- coupling the valve seat assembly (32) with the valve sub-assembly (58),
- coupling the valve sub-assembly (58) with a fluid supply,
- operating the valve needle (10) under a given set of operating conditions, thereby releasing the fluid flow through the fluid outlet portion (44), preventing a fluid flow through the first flow path (66) and enabling a fluid flow through the second flow path (68), and
- measuring the fluid flow through the fluid outlet portion (44) under a given set of operating conditions,
- assigning the valve seat assembly (32) to a flow rate class according to the determined flow rate, and
- removing the valve seat assembly (32) from the valve sub-assembly (58),

and

- selecting a combination of one of a plurality of valve needles (10) of a flow rate class according to the determined fluid flow of the valve needle (10) and one of a plurality of valve seat assemblies (32) of a flow rate class according to the determined fluid flow of the valve seat assembly (32) to obtain the desired flow rate of the injection valve (62).

FIG 1

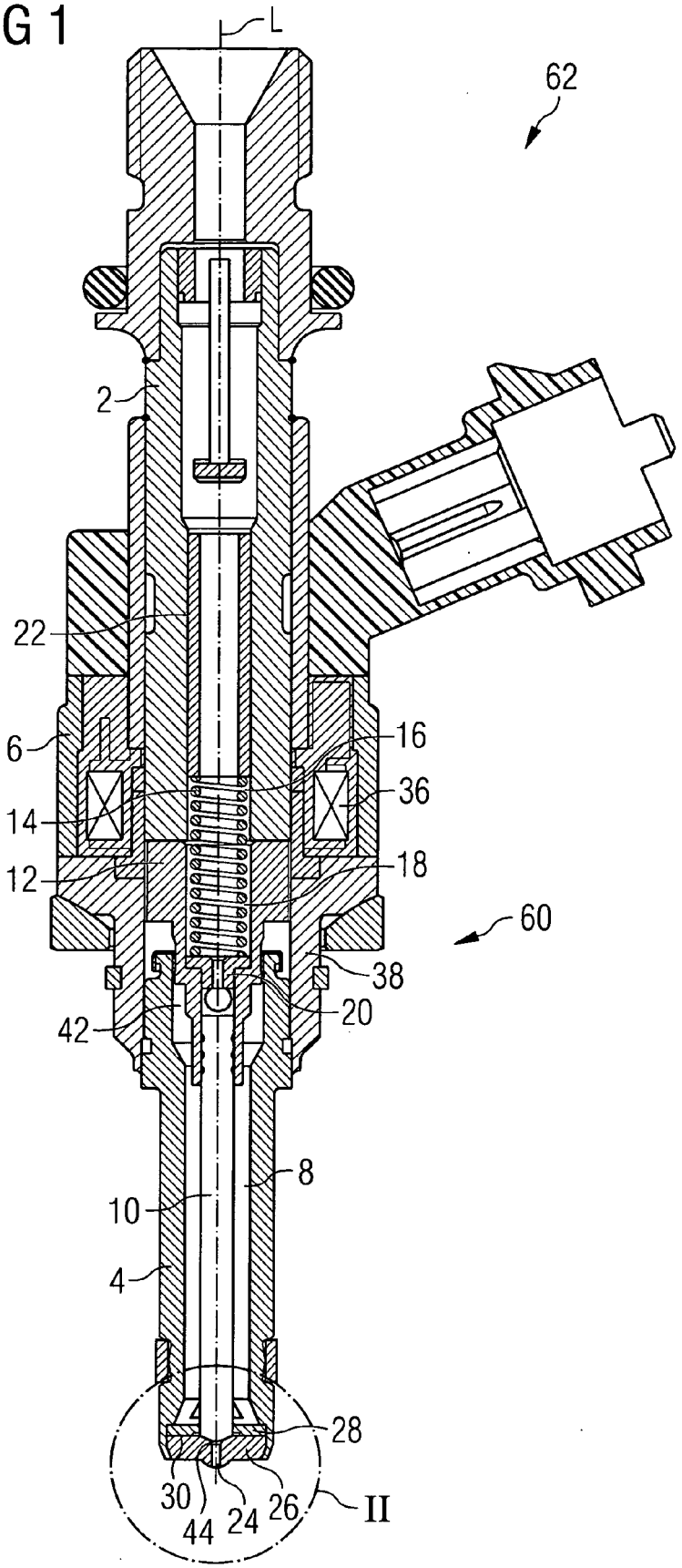


FIG 2

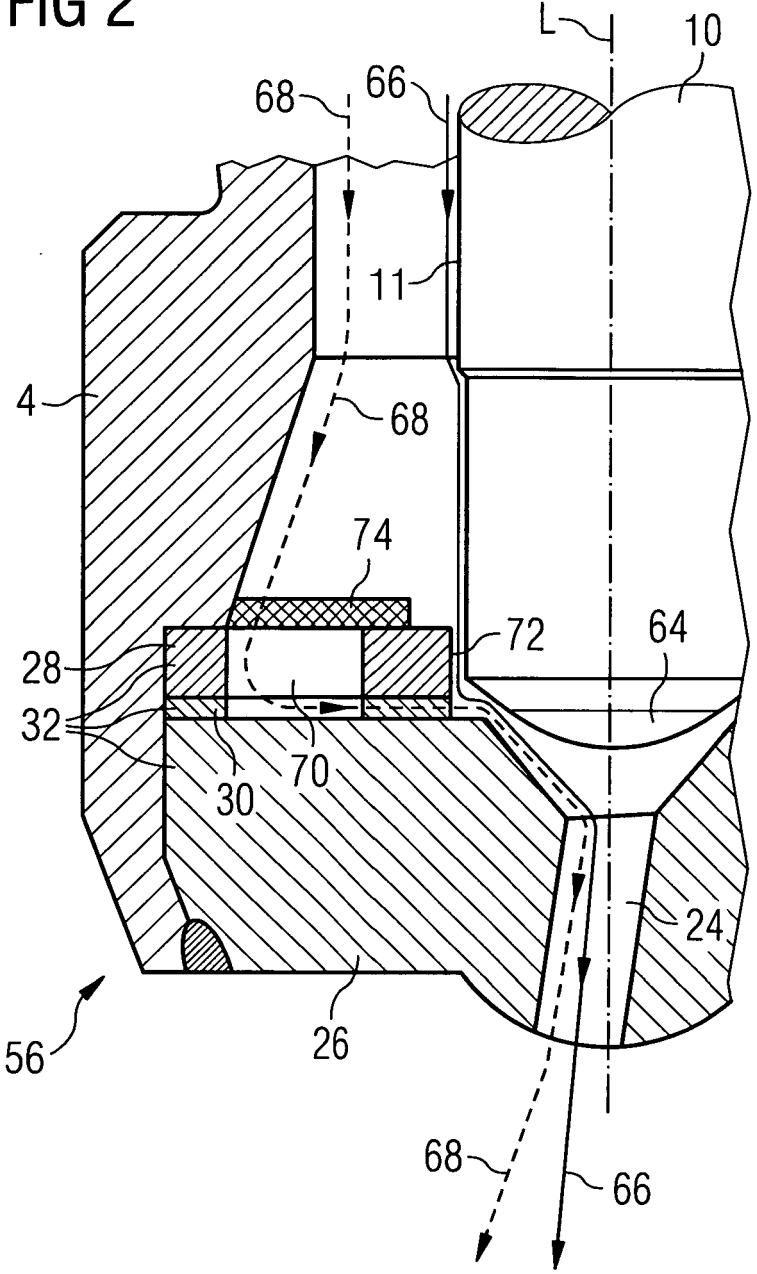
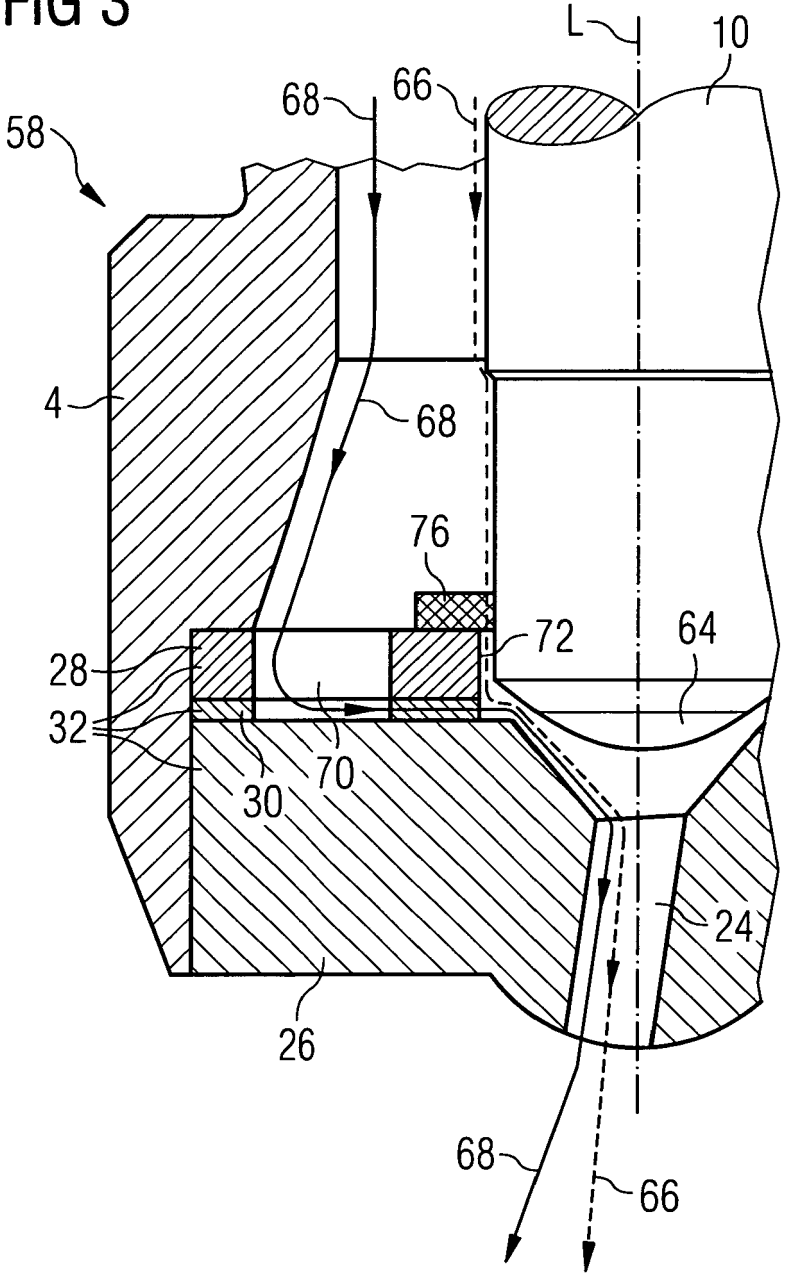


FIG 3



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PARTIAL EUROPEAN SEARCH REPORT

which under Rule 63 of the European Patent Convention shall be considered, for the purposes of subsequent proceedings, as the European search report

Application Number EP 07 01 5380

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 1 811 166 A (SIEMENS AG [DE]) 25 July 2007 (2007-07-25) * the whole document *	3	INV. F02M61/12 F02M61/16 F02M65/00
A	WO 02/33247 A (BOSCH GMBH ROBERT [DE]; DANTES GUENTER [DE]; NOWAK DETLEF [DE]; HEYSE) 25 April 2002 (2002-04-25) * abstract; figures *	3	F02M61/18
A	US 6 179 227 B1 (REN WEI-MIN [US] ET AL) 30 January 2001 (2001-01-30) * figure 2 *	3	

TECHNICAL FIELDS SEARCHED (IPC)

F02M

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC to such an extent that a meaningful search into the state of the art cannot be carried out, or can only be carried out partially, for these claims.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

2

Place of search	Date of completion of the search	Examiner
Munich	4 March 2008	LANDRISCINA, V

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

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INCOMPLETE SEARCH SHEET C

Application Number
EP 07 01 5380

Claim(s) searched completely:
3

Claim(s) not searched:
1,2

Reason for the limitation of the search:

Both claims 1 and 2 are directed to methods for determining the capability of an element (the needle and the seat assembly, respectively) of an injection valve to control a desired flow rate in the same injection valve. These methods consist in the measurement of the flow rate through the outlet portion of the valve in conditions (an internal path is blocked) which are different from those in which the valve normally works. As a consequence, the capability of controlling the flow rate in the injection valve cannot be determined by the methods as defined in either claim 1 or claim 2. This inconsistence imposes an undue burden on all those wishing to ascertain the scope of the claims, which is not in compliance with the clarity requirement of Article 84 EPC. The non-compliance with the substantive provisions is to such an extent, that a meaningful search of the whole claimed subject-matter of claims 1 and 2 could not be carried out (Rule 63 EPC and Guidelines B-VIII, 3).

The extent of the search was consequently limited to the subject-matter of claim 3.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 07 01 5380

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
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04-03-2008

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82