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(71) Applicant: **CONTINENTAL AUTOMOTIVE GMBH** [DE/DE]; Vahrenwalder Straße 9, 30165 Hannover (DE).

(72) Inventors: **FILIPPI, Stefano**; Via del Poderino 26, 57014 Castel' Anselmo Collesalvetti (IT). **GRANDI, Mauro**; Via della Scopaia Nr. 36, 57128 Livorno (IT). **LENZI, Francesco**; Via Muratori 29, 57128 Livorno (IT). **POLIDORI, Valerio**; Via Grecia 35, 57128 Livorno (IT).

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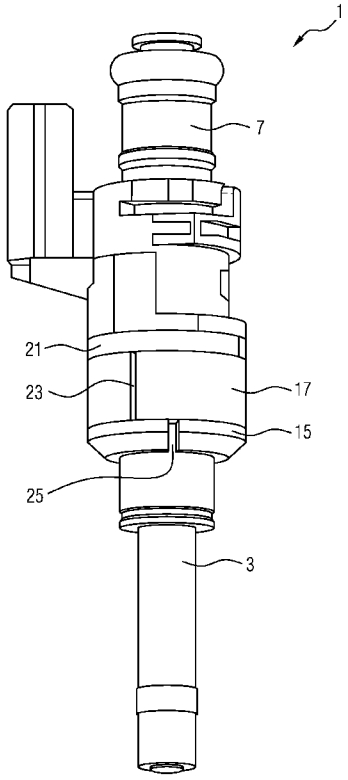
[Continued on next page]

(54) Title: ELECTROMAGNETIC INJECTION VALVE AND METHOD FOR ASSEMBLING AN ELECTROMAGNETIC INJECTION VALVE

FIG 2



(57) Abstract: An electromagnetic injection valve (1) is disclosed. It comprises an inlet tube (7), a valve body (3) comprising a cavity, in which a valve needle is axially moveable, a housing part (17) surrounding an electromagnetic actuator unit (9) of the injection valve (1) for moving the valve needle, an upper magnetic ring (13) press-fitted with the inlet tube (7) or the valve body (3) and a lower magnetic ring (15) press-fitted with the valve body (3). The housing part (17) and/or the lower magnetic ring (15) comprise at least one cut (23, 25) which extends in axial direction. Further, a method for assembling an electromagnetic injection valve is disclosed.

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Description

ELECTROMAGNETIC INJECTION VALVE AND METHOD FOR ASSEMBLING AN ELECTROMAGNETIC INJECTION VALVE

The present invention relates to an electromagnetic injection valve, particularly a solenoid type fluid injection valve for automotive applications. Furthermore, it relates to a method for assembling an electromagnetic injection valve.

A valve assembly for a fluid injection valve comprises a valve body comprising a cavity with a fluid inlet portion and a fluid outlet portion and a valve needle axially moveable in the cavity. The valve needle prevents a fluid flow through the fluid outlet portion in a closing position and releases the fluid flow through the fluid outlet portion in further positions. The valve needle may be actuated by an electromagnetic actuation unit.

DE 103 12 319 A1 discloses an injection valve with a lower magnetic ring to improve the performance of an electromagnetic valve.

In this type of injection valve, the housing is often manufactured by machining in order to create a pocket for the coil and to fit an inlet tube and a valve body. The material used for the housing has an impact on the magnetic performance of the injection valve, especially in conditions, where it operates with a high fuel pressure. However, the choice of material used for the housing also has a severe influence on the costs of the injection valve.

Furthermore, the existence of air gaps between parts which are penetrated by the magnetic flux also influences the magnetic performance.

It is an object of the present invention to provide an injection valve with a high magnetic performance, which may be manufactured at relatively low cost. Furthermore, a method for assembling an injection valve is provided.

These objects are achieved by means of an injection valve and a method for assembling an injection valve according to the independent claims.

Advantageous embodiments and developments are objects of the dependent claims.

According to a first aspect of the invention, an electromagnetic injection valve is disclosed. In this context, an electromagnetic injection valve is in particular a fluid injection valve, e.g. a fuel injection valve, which comprises an electromagnetic actuator unit.

The injection valve comprises an inlet tube and a valve body. The valve body has a longitudinal axis and comprises a cavity. A valve needle is arranged in the cavity in axially moveable fashion. The inlet tube and the valve body may hydraulically connect a fluid inlet end to a fluid outlet end of the injection valve. The fluid inlet end is preferably comprised by the inlet tube and the fluid outlet end is preferably comprised by the valve body.

The injection valve further comprises a housing part which surrounds an electromagnetic actuator unit of the injection valve. The electromagnetic actuator unit is configured for moving the valve needle.

An upper magnetic ring is press-fitted with the inlet tube or with the valve body. A lower magnetic ring is press-fitted with the valve body. The housing part is preferably positioned axially

between the upper magnetic ring and the lower magnetic ring.

Preferably, the upper magnetic ring is press-fitted with an external circumferential surface of the inlet tube or an external circumferential surface of the valve body and/or the lower magnetic ring press-fitted with the external circumferential surface of the valve body. In the present context, an "external circumferential surface" extends around the longitudinal axis and faces away from the longitudinal axis. Expediently, the external circumferential surfaces of fluid inlet tube and/or valve body are hydraulically separated from the cavity of the valve body.

The housing part and/or the lower magnetic ring comprise at least one cut which extends in axial direction. The cut preferably extends along the complete axial extension of the housing part or the lower magnetic ring, respectively.

By a cut extending in axial direction, it is understood that the cut extends essentially in axial direction, thereby preventing the build-up of eddy currents. A certain deviation from an axial direction does not make the cut ineffective and therefore is within the scope of the invention. For example, the cut extends parallel to the longitudinal axis or oblique to the longitudinal axis. In one development, the inclination angle of the cut with respect to the longitudinal axis is less than 45°, preferably less than 30°.

The prevention of eddy currents by means of the cut or the cuts has the advantage, that a high performance magnetic material can be used for the housing and/or the magnetic ring. Furthermore, the material for the housing could be chosen with regard to other properties, in particular cost or workability.

The injection valve has the further advantage that the press-fit of the lower magnetic ring with the valve body ensures that there

is no air gap between the lower magnetic ring and the valve body. Hence, magnetic performance is improved which makes it possible to operate the injection valve with fuel pressures of up to 250-500 bar.

According to an embodiment of the invention, the housing part is made from a magnetic material, in particular from a magnetic metal or alloy such as magnetic steel. In this way, the electromagnetic field of the actuator may be efficiently guided by the upper magnetic ring, the housing part and the lower magnetic ring.

Preferably, the housing part is manufactured of the magnetic material by a forming process. A forming process is understood to be a non-subtractive manufacturing process, for example rolling or deep-drawing, as opposed to machining processes, where a controlled material removal takes place.

This has the advantage, that suitable materials and/or processes are relatively cost-efficient and that the overall costs of the injection valve can be reduced.

According to an embodiment, the at least one cut in the housing part and/or the lower magnetic ring reaches entirely through the housing part and/or the lower magnetic ring, in particular in radial direction. In other words, the lower magnetic ring or the housing part, respectively, is in the shape of a slotted ring or a slotted sleeve. This has the advantage, that the part has a certain elasticity which can be advantageous with regard to the press-fit.

However, it can also be desirable not to have this elasticity. Therefore, in an alternative embodiment, the at least one cut in the housing part and/or the lower magnetic ring reaches only partially through the housing part and/or the lower magnetic

ring. In this case, the cut is made deep enough to substantially prevent the build-up of eddy currents. For example the radial extension of the cut is 50 % or more, in particular 70 % or more, of the radial extension of the housing part or the lower magnetic ring, respectively. The radial extension of the housing part or the lower magnetic ring is in this context to be understood as the distance between the inner circumferential surface and the outer circumferential surface of the portion of the housing part or the lower magnetic ring, respectively, which is provided with the cut. In other words, it is the respective wall thickness.

The housing part can be connected to the lower magnetic ring or made in one piece with the magnetic ring. According to one embodiment, however, the housing part has the shape of a hollow cylinder and the lower magnetic ring is separate from the housing part. In this case, the magnetic ring is a separate component and is mounted independently from the housing part.

This has the advantage that the press-fit of the lower magnetic ring can be carried out independently from any other mounting process, thereby taking particular care to close an air gap between the lower magnetic ring and the valve body.

In one embodiment, the lower magnetic ring is positioned on the valve body in such fashion that an upper side of the lower magnetic ring is in close contact with an underside of the housing part. The upper side of lower magnetic ring and the underside of the housing part are in particular mutually facing surfaces of the lower magnetic ring and the housing part, respectively, which in particular face in opposite directions of the longitudinal axis.

The housing part can be mounted before the lower magnetic ring and can be overmolded. Afterwards, the lower magnetic ring is mounted and press-fitted with the valve body, closing the air gap

between the lower magnetic ring and the valve body and at the same time making close contact between the upper side of the lower magnetic ring and the underside housing part.

In one embodiment, the electromagnetic actuator unit abuts the upper magnetic ring and the lower magnetic ring on opposite axial sides. In other words, the upper magnetic ring abuts a first axial side of the actuator unit and the lower magnetic ring abuts a second axial side of the actuator unit, remote from the first axial side. For example, the upper and lower magnetic rings abut a bobbin of the coil of the electromagnetic actuator unit on opposite axial sides of the bobbin. With advantage, an axial position of the electromagnetic actuator unit may be fixed by the upper and lower magnetic rings in this way.

According to a further aspect of the invention, a method for assembling an electromagnetic injection valve is specified. The injection valve comprises an inlet tube, a valve body having a longitudinal axis and comprising a cavity, in which a valve needle is axially moveable, and an electromagnetic actuator unit for moving the valve needle. In particular the method is a method for assembling the electromagnetic injection valve according to at least one of the previously described embodiments.

An upper magnetic ring is press-fitted with the inlet tube or the valve body, in particular with an external circumferential surface of the inlet tube or the valve body. A housing part is fitted surrounding the actuator unit and overmolded. A lower magnetic ring is press-fitted separately with the valve body, in particular with the external circumferential surface of the valve body. The housing part and/or the lower magnetic ring, respective are preferably provided with at least one cut which extends in axial direction.

This method has the advantage that it is cost-efficient and yields a high performance injection valve, which is suitable for high-pressure applications as well as for low pressure port fuel applications and/or direct or indirect gas applications.

According to an embodiment, the lower magnetic ring is press-fitted with the valve body in such a way that an upper side of the lower magnetic ring is in close contact with an underside of the housing part. With advantage, air gaps may be reduced or avoided in this way and the magnetic performance of the injection valve may be particularly good. In one embodiment, the upper magnetic ring is press-fitted with the valve body or the inlet tube in such a way that a lower side of the upper magnetic ring is in close contact with an upper side of the housing part the upper side facing away from the lower magnetic ring. With advantage, air gaps may be reduced or avoided in this way and the magnetic performance of the injection valve may be particularly good. In this context, "close contact" refers to direct mechanical contact, in particular full-area mechanical contact, of the respective parts.

In one embodiment, the upper magnetic ring and the lower magnetic ring are press-fitted onto the valve body - or onto the valve body and onto the inlet tube as the case may be - such that they abut opposite axial sides of the electromagnetic actuator unit - and in particular of the bobbin of the coil -, in particular in order to fix an axial position of the electromagnetic actuator unit.

Further advantages, advantageous embodiments and developments of the electromagnetic injection valve and the method for assembling the electromagnetic injection valve will become apparent from the exemplary embodiments which are described below in association with schematic figures.

Figure 1 shows an electromagnetic injection valve according to one embodiment of the invention in a side view which is partially cut open in longitudinal direction;

Figure 2 shows a perspective view of the electromagnetic injection valve according to figure 1 and

Figure 3 shows a detail of the electromagnetic injection valve according to figure 1.

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

The electromagnetic injection valve 1 shown in figures 1 to 3 is in particular suitable for dosing fuel to an internal combustion engine. However, the invention could be used in other types of electromagnetic injection valves, too.

The injection valve 1 comprises a valve body 3 having a central longitudinal axis 5 and an inlet tube 7. The valve body 5 and the inlet tube 7 comprise a cavity. The cavity is not visible in Fig. 1 which shows the valve body 3 and the inlet tube 7 only in a side view, not cut open. The cavity has a fluid outlet portion that communicates with a fluid inlet portion. The fluid inlet portion and the fluid outlet portion are in particular positioned at opposite axial ends of the injection valve 1, the fluid inlet portion being comprised by the inlet tube 7 and the fluid outlet portion being comprised by the valve body 3. In the cavity, a valve needle is axially moveable to seal and unseal the fluid outlet portion for controlling fluid flow out of the injection valve 1.

The injection valve 1 furthermore comprises an electromagnetic actuator unit 9, which includes a coil 11, an upper magnetic ring

13 and a lower magnetic ring 15. The upper magnetic ring 13 and the lower magnetic ring may represent magnetic yokes of the actuator unit 9. Another part of the magnetic circuit is the housing part 17, which is penetrated by the magnetic flux.

The magnetic rings 13, 15 and the housing part 17, are made of a magnetic material. The valve body 3 and, in one embodiment, the inlet tube 7 may also be made of a magnetic material, at least in places. The magnetic material may be a ferromagnetic material. The magnetic circuit through the upper magnetic ring 13, the housing part 17, the lower magnetic ring 15, the valve body 3 and the inlet tube 7 preferably does not contain air gaps.

The upper magnetic ring 13 is press-fitted with an external peripheral surface 70 of the inlet tube 7 in a first region 19 indicated in figure 3. The upper magnetic ring 13 and the coil 11 are overmolded with a plastic overmolding 21 and the housing part 17 is embedded in the plastic overmolding 21, too.

The lower magnetic ring 15 is press-fitted with an external peripheral surface 30 of the valve body 3 in a second region 27 indicated in figure 3. In a third region 29, the upper side 31 of the lower magnetic ring 15 makes close contact with the underside 33 of the housing part 17. There is no radial air gap between the lower magnetic ring 15 and the valve body 3 due to the press-fit in the second region 27.

As shown in figure 2, the housing part 17 has a cut 23 extending in axial direction. The lower magnetic ring 15 also has a cut 25 extending in axial direction. The cuts 23 and 25 reach entirely through the housing part 17 and the lower magnetic ring 15, respectively, in radial and axial direction to prevent the build-up of eddy currents.

Patent Claims

1. Electromagnetic injection valve (1), comprising
   - an inlet tube (7),
   - a valve body (3) having a longitudinal axis (5) and comprising a cavity, in which a valve needle is axially moveable;
   - an upper magnetic ring (13) press-fitted with the inlet tube (7) or the valve body (3);
   - a lower magnetic ring (15) press-fitted with the valve body (3);
   - a housing part (17) surrounding an electromagnetic actuator unit (9) of the injection valve (1) for moving the valve needle;

   wherein
   - the lower magnetic ring (15) is positioned on the valve body (3) in such a way that an upper side (31) of the lower magnetic ring (15) is in close contact with an underside (33) of the housing part (17),
   - the electromagnetic actuator unit (9) abuts the upper magnetic ring (13) and the lower magnetic ring (15) on opposite axial sides, and
   - the housing part (17) and/or the lower magnetic ring (15) comprise at least one cut (23, 25) which extends in axial direction.

2. Electromagnetic injection valve (1) according to the previous claim, wherein the upper magnetic ring (13) is press-fitted with an external circumferential surface (70) of the inlet tube (7) or an external circumferential surface (30) of the valve body (3) and/or
   the lower magnetic ring (15) press-fitted with the external circumferential surface (30) of the valve body (3).

3. Electromagnetic injection valve (1) according to any of the previous claims, wherein the housing part (17) is positioned axially between the upper magnetic ring (13) and the lower magnetic ring (15).

4. Electromagnetic injection valve (1) according to any of the previous claims,
wherein the housing part (17) is made of a magnetic material.

5. Electromagnetic injection valve (1) according to any of the previous claims,
wherein the housing part (17) has the shape of a hollow cylinder and the lower magnetic ring (15) is separate from the housing part (17).

6. Electromagnetic injection valve (1) according to any of the previous claims,
wherein the at least one cut (23, 25) in the housing part (17) and/or the lower magnetic ring (15) reaches entirely through the housing part (17) and/or the lower magnetic ring (15) in radial direction.

7. Electromagnetic injection valve (1) according to any of claims 1 to 5,
wherein the at least one cut (23, 25) in the housing part (17) and/or the lower magnetic ring (15) reaches only partially through the housing part (17) and/or the lower magnetic ring (15) in radial direction.

8. Method for assembling an electromagnetic injection valve (1) comprising an inlet tube (7), a valve body (3) comprising a cavity, in which a valve needle is axially moveable and an electromagnetic actuator unit (9) for moving the valve needle, wherein

- an upper magnetic ring (13) is press-fitted with the inlet tube (7) or the valve body (3);
- a housing part (17) is fitted surrounding the actuator unit (9) and overmolded,
- a lower magnetic ring (15) is press-fitted separately with the valve body (3) in such a way that an upper side (31) of the lower magnetic ring (15) is in close contact with an underside (33) of the housing part (17), and
- the upper magnetic ring (13) and the lower magnetic ring (15) are press-fitted onto the valve body (3) or onto the valve body (3) and the inlet tube (3) such that they abut opposite axial sides of the electromagnetic actuator unit (9) to fix an axial position of the electromagnetic actuator unit (9).

9. Method according to the previous claim, wherein the upper magnetic ring (13) is press-fitted with an external circumferential surface (70) of the inlet tube (7) or an external circumferential surface (30) of the valve body (3) and/or
the lower magnetic ring (15) press-fitted with the external circumferential surface (30) of the valve body (3).

10. Method according to claim 8 or 9,
wherein the upper magnetic ring (13) is press-fitted with the valve body (3) or the inlet tube (7) in such a way that a lower side of the upper magnetic ring (13) is in close contact with an upper side of the housing part (17), the upper side facing away from the lower magnetic ring (15).

11. Method according to one of claims 8 to 10,
wherein the housing part (17) and/or the lower magnetic ring (15) comprise at least one cut (23, 25) which extends in axial direction.

FIG 1

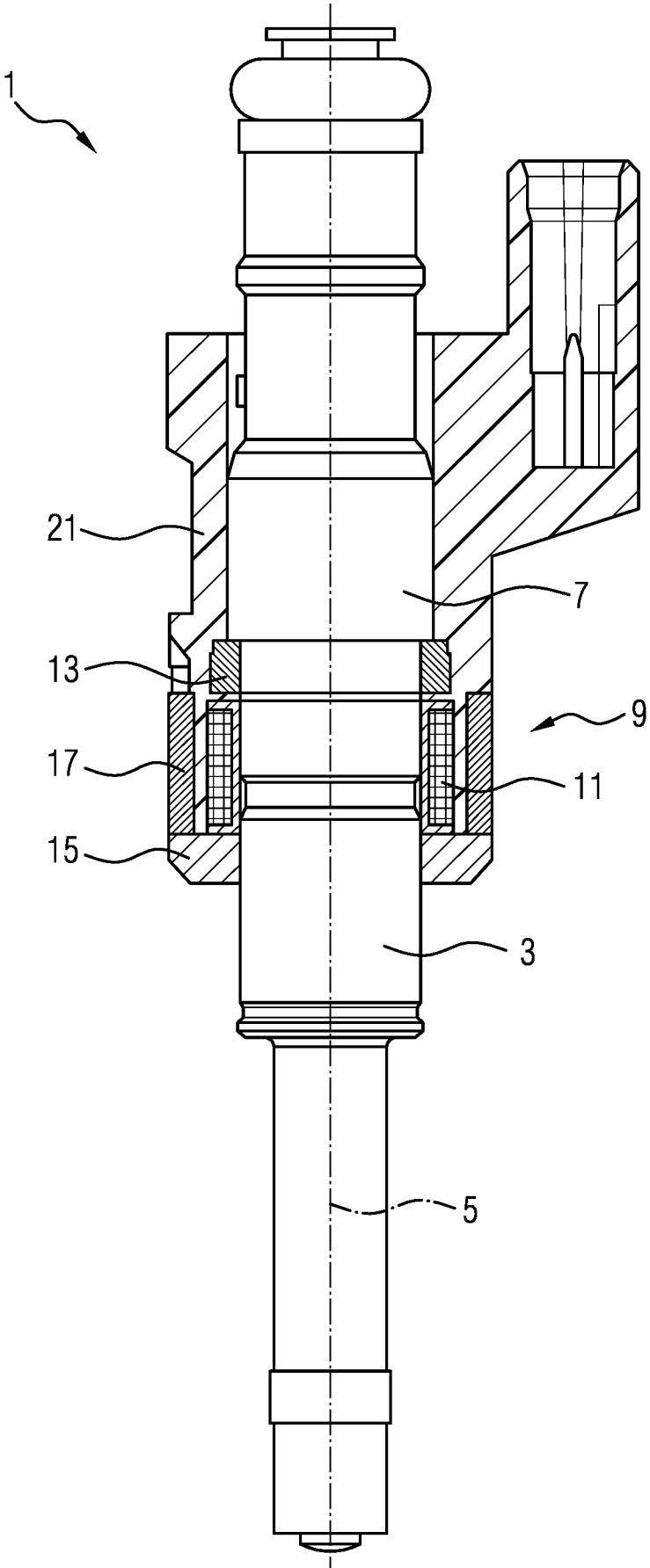


FIG 2

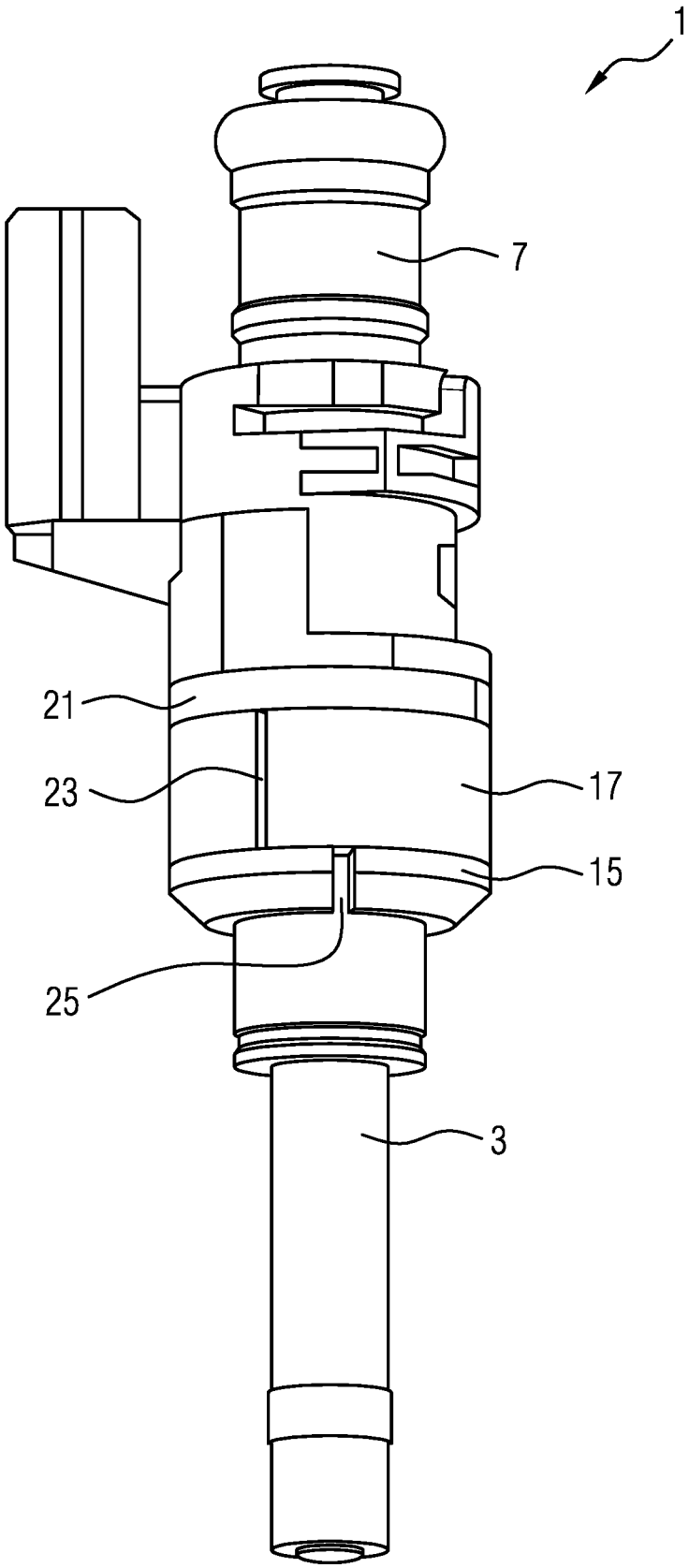
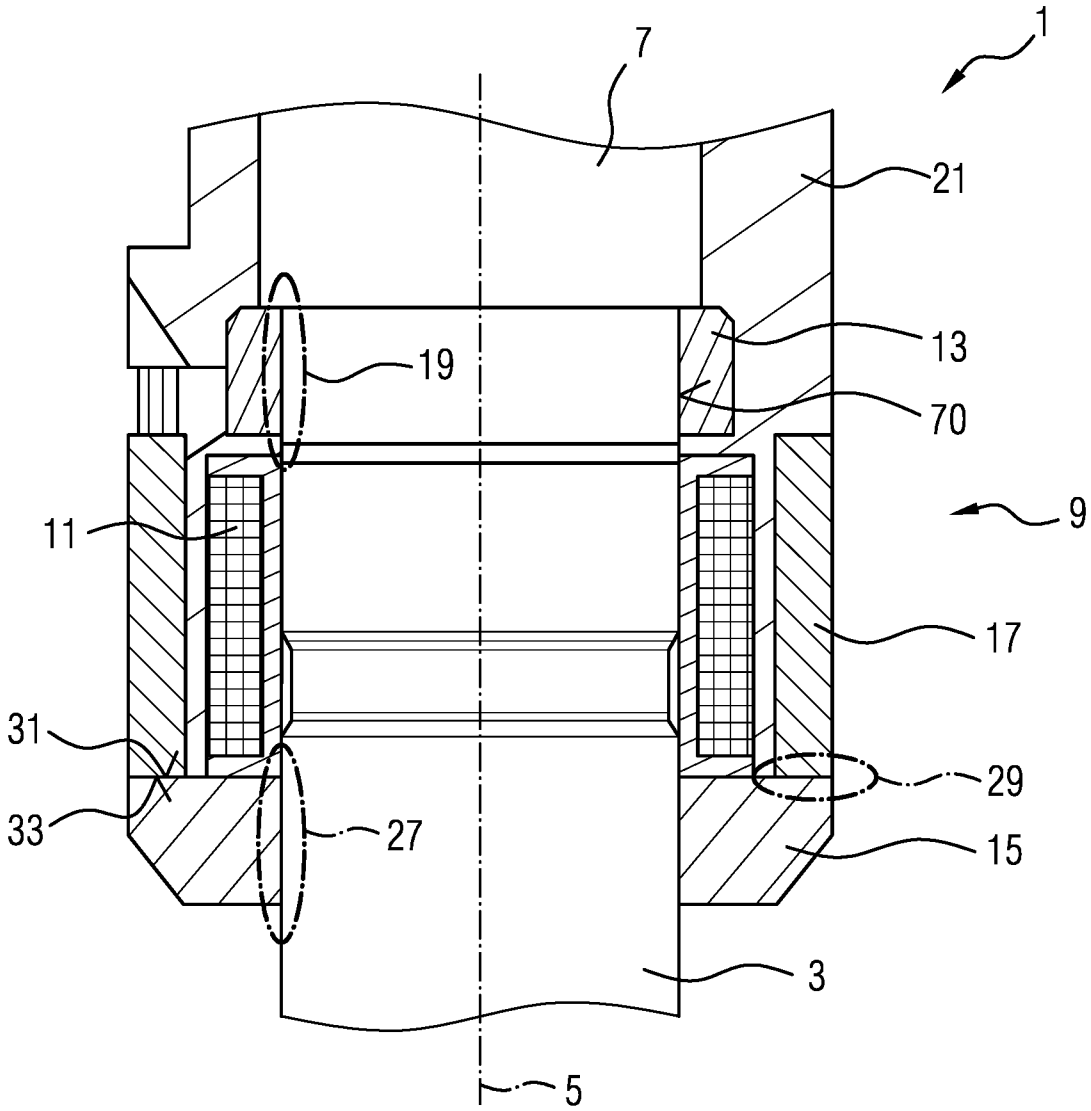


FIG 3



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/074135

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02M51/06
ADD. H01F7/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02M H01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	DE 103 12 319 A1 (VISTEON GLOBAL TECH INC [US]) 23 October 2003 (2003-10-23) cited in the application abstract; figures 2-4	1,3-8, 10,11
Y	DE 10 2012 209229 A1 (BOSCH GMBH ROBERT) 5 December 2013 (2013-12-05) paragraph [0009]; figure 4	1,3-8, 10,11
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A	US 2009/139491 A1 (JOSHI MANDAR A [US] ET AL) 4 June 2009 (2009-06-04) paragraph [0023]; figure 3	1,6-8,11

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 December 2016	17/01/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Godrie, Pierre

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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