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# (54) Electromagnetic fuel injector with hydraulic damping

(57) An electromagnetic fuel injector (1) provided with: a tubular body (4) which has a feeding duct (5); an injection nozzle (3) which is regulated by an injection valve (7) provided with a mobile needle (15); and an electromagnetic actuator (6) which has a coil (8), a fixed magnetic pole (10) located inside the tubular body (4), and a mobile anchor (11) located inside the tubular body (4), integral with the needle (15) of the injection valve (7) and adapted to be magnetically attracted by the magnetic pole when the coil (8) is energized; at least one portion of the anchor (11) has at least one central through hole which allows the fuel to flow towards the injection nozzle (3) and through the anchor (11); and the magnetic pole (10) has a number of side passage ducts (20), which are obtained at the external side surface of the magnetic pole (10) and allow the fuel to flow towards the injection nozzle (3) and through the magnetic pole (10).

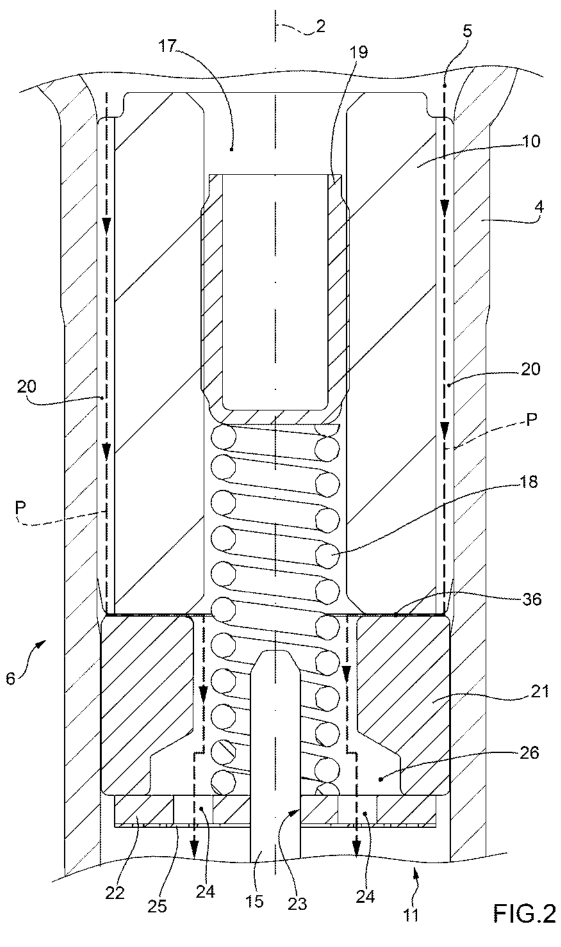


FIG.2

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## Description

TECHNICAL FIELD

**[0001]** The present invention relates to an electromagnetic fuel injector.

PRIOR ART

**[0002]** Patent application EP1619384A2 describes an electromagnetic fuel injector comprising a cylindrical tubular body having a central feeding duct, which serves the function of fuel duct and terminates with an injection nozzle regulated by an injection valve controlled by an electromagnetic actuator. The injection valve is provided with a needle, which is rigidly connected to a mobile anchor of the electromagnetic actuator to be displaced by the action of the electromagnetic actuator between a closing position and an opening position of the injection nozzle, against the bias of a closing spring which tends to keep the needle in the closing position. The valve seat is defined by a sealing element, which is disc-shaped, fluid-tightly closes the bottom of the central duct of the supporting body, and is crossed by the injection nozzle.

**[0003]** The electromagnetic actuator comprises a coil, which is externally arranged about the tubular body, and a fixed magnetic pole, which is made of ferromagnetic material, is arranged within the tubular body at the coil and is adapted to magnetically attract the anchor. The magnetic pole is centrally perforated and has a central through hole fulfilling the task of allowing the fuel to flow towards the injection nozzle and through the magnetic pole. The closing spring is arranged inside the central hole and is compressed between a perforated striker body driven into the central hole and the anchor to push the anchor, and thus the needle integral with the anchor, towards the closing position of the injection nozzle.

**[0004]** Experimental tests have indicated that the driving time-injected fuel amount curve (i.e. the law which links the driving time to the injected fuel amount) of the above-described electromagnetic injector is quite linear and uniform on the whole, but has undesired irregularities (i.e. oscillations) at short driving times, and thus at small amounts of injected fuel; therefore, the above-described electromagnetic injector is not adapted to be used on small turbocharged engines (i.e. with a high specific power), where small amounts of fuel are to be injected at low rpm and/or small amounts of fuel need to be injected so as to obtain a series of pilot injections before a main injection.

**[0005]** The injection valve is normally closed due to the closing spring which biases the needle to the closing position, where the needle presses against a valve seat of the injection valve and the anchor is spaced from the magnetic pole. In order to open the injection valve, i.e. to move the needle from the closing position to the opening position, the coil of the electromagnetic actuator is energized so as to generate a magnetic field which attracts the anchor towards the magnetic pole against the elastic force exerted by the closing spring; during the step of opening, the stroke of the anchor stops when the anchor itself impacts against the magnetic pole. In other words, during the step of opening the injection valve, the anchor accumulates kinetic energy, which is then dissipated when the anchor strikes the magnetic pole. Upon the anchor striking the magnetic pole, the anchor tends to bounce back triggering some oscillations on the anchor position which are rapidly damped by the magnetic attraction force generated by the magnetic pole. If the injection valve is closed, i.e. the coil of the electromagnetic actuator is de-energized, the total closing time is relatively long in a first instant when the anchor is moving towards the magnetic pole because the anchor should invert its motion direction in order to move towards the closing position; if, instead, the injection valve is closed, i.e. the coil of the electromagnetic actuator is de-energized, the total closing time is relatively short in a second instant immediately after the first instant when the anchor is moving away from the magnetic pole after bouncing, because the anchor is already moving in the desired direction in order to move towards the closing position. Therefore, due to the anchor bouncing against the magnetic pole, minor variations of the injection time (i.e. of the time interval elapsing between the opening instant and the closing instant of the injector) may determine a considerable variation of the fuel amount which is injected when the injection time is short (i.e. before the oscillations of the anchor position which are generated by the anchor striking the magnetic pole have been completely damped).

**[0006]** In order to cancel or limit the anchor bouncing against the magnetic pole, interposing an element made of resilient (i.e. elastic) material between the anchor and the magnetic pole has been suggested, which element may be fixed either to the anchor or to the magnetic pole, and fulfils the task of limiting the bouncing when the anchor impacts against the magnetic pole. However, the element made of resilient material tends to rapidly wear due to the continuous anchor impacts against the magnetic pole and therefore such a constructional solution is not very effective. A possible solution to such a problem is increasing the thickness of the element made of resilient material so as to confer higher mechanical resistance and ability to withstand wear to the resilient material element itself. However, increasing the thickness of the element made of resilient material inevitably results in an increase of the size of the gap between the anchor and the magnetic pole (the resilient material is inevitably non-ferromagnetic), and therefore it obliges to increase the number of ampere-turns of the electromagnetic actuator, with a consequent increase of cost, weight, volume and electricity consumption of the electromagnetic actuator itself.

## DESCRIPTION OF THE INVENTION

**[0007]** It is the object of the present invention to provide an electromagnetic fuel injector, which injector is free from the above-described drawbacks while being easy and cost-effective to be manufactured.

**[0008]** According to the present invention, an electromagnetic fuel injector is provided as claimed in the appended claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** The present invention will now be described with reference to the accompanying drawings, which illustrate a non-limitative embodiment thereof, in which:

- figure 1 is a diagrammatic, side elevation sectional view of a fuel injector provided according to the present invention;
- figure 2 shows a part of an electromagnetic actuator of the injector in figure 1 on an enlarged scale;
- figure 3 shows a detail of figure 2 on an enlarged scale;
- figure 4 shows an injection valve of the injector in figure 1 on an enlarged scale;
- figure 5 shows a constructional variant of the electromagnetic actuator in figure 2 on an enlarged scale; and
- figure 6 shows a further constructional variant of the electromagnetic actuator in figure 2.

## PREFERRED EMBODIMENTS OF THE INVENTION

**[0010]** In figure 1, numeral 1 indicates as a whole a fuel injector, which substantially has a cylindrical symmetry about a longitudinal axis 2, and which is adapted to be controlled for injecting fuel from an injection nozzle 3. Injector 1 comprises a supporting body 4, which has a variable section, cylindrical tubular shape along the longitudinal axis 2, and a feeding duct 5 extending over the whole length of supporting body 4 itself to feed pressurized fuel towards injection nozzle 3. The supporting body 4 supports an electromagnetic actuator 6 at an upper portion thereof and an injection valve 7 at a lower portion thereof, which valve delimits the feeding duct 5 at the bottom; in use, the injection valve 7 is actuated by the electromagnetic actuator 6 to regulate the fuel flow through the injection nozzle 3, which is obtained at the injection valve 7 itself.

**[0011]** The electromagnetic actuator 6 comprises a coil 8, which is externally arranged about the tubular body 4 and is enclosed in a toroidal case 9 made of plastic material, and a fixed magnetic pole 10 which is made of ferromagnetic material and is arranged within the tubular body 4 at the coil 8. Furthermore, the electromagnetic actuator 7 comprises a mobile anchor 11, which has a cylindrical shape, is made of ferromagnetic material and is adapted to be magnetically attracted by the magnetic pole 10 when coil 8 is energized (i.e. when the current flows therethrough). Finally, the electromagnetic actuator 7 comprises a tubular magnetic armature 12, which is made of ferromagnetic material, is arranged outside the tubular body 4 and comprises an annular seat 13 for accommodating the coil 8 therein, and a magnetic washer 14 having an annular shape, which is made of ferromagnetic material and is arranged over the coil 8 to guide the opening of the magnetic flux about the coil 8 itself.

**[0012]** Anchor 11 forms part of a mobile plunger, which further comprises a shutter or needle 15, having an upper portion integral with anchor 11 and a lower portion cooperating with a valve seat 16 of the injection valve 7 to regulate the fuel flow through the injection nozzle 3 in a known manner.

**[0013]** The magnetic pole 10 is centrally perforated and has a central through hole 17, in which a closing spring 18 is partially accommodated, which spring biases the anchor 11 towards a closing position of the injection valve 7. In particular, a striker body 19 is driven into the central hole 17 of the magnetic pole 10 in a fixed position, which body is closed to seal the central hole 17 (i.e. to prevent the fuel from flowing through the central hole 17) and keeps the closing spring 18 compressed against the anchor 11. Moreover, the magnetic pole 10 comprises a number of side passage ducts 20 (only two of which are shown in figures 1 and 2), which are obtained at the external side surface of the magnetic pole 10, are externally delimited by the tubular body 4, and fulfill the task of allowing the fuel to flow along the feeding duct 5 towards the injection nozzle 3 and through the magnetic pole 10.

**[0014]** As shown in figure 2, anchor 11 consists of an annular element 21 and a discoidal element 22 which closes the annular element 21 at the bottom and has a central through hole 23 which receives an upper portion of the needle 15 and a plurality of side through holes 24 (only two of which are shown in figure 2), which allow the fuel to flow towards the injection nozzle 3. A central portion of the discoidal element 22 is suitably shaped so as to accommodate and keep a lower end of the closing spring 18 in place. Needle 15 is preferably made integral with the discoidal element 22 of anchor 11 by means of an annular welding. A debouncing device is connected to the lower face of the discoidal element 22 of anchor 11, which device is adapted to attenuate the bouncing of the needle 15 against the valve seat 16 when the needle 15 moves from the opening position to the closing position of the injection valve 7.

**[0015]** The annular element 21 of anchor 11 has a central through hole 26, which accommodates a lower portion of the closing spring 18 and allows the fuel to flow towards the injection nozzle 3 and through the anchor 11. The annular element 21 of anchor 11 has an external diameter close to (i.e. only slightly smaller than, and thus substantially identical to) the internal diameter of the corresponding portion of the feeding duct 5 of the supporting body 4; thereby, anchor 11 may slide with respect to the supporting body 4 along the longitudinal axis 2, but it may not perform any transversal movement to the longitudinal axis with respect to the supporting body 4. Furthermore, the fuel mostly flows through the central hole 26 of the annular element 21 and a small amount thereof does not flow laterally to the annular element 21 in the annular space between the external side surface of the annular element 21 and the internal surface of the tubular body 4.

**[0016]** An external, cylindrical side surface of the annular element 21 of anchor 11 and an upper annular surface of the annular element 21 of anchor 11 are preferably covered by a chrome coating (indicatively being 20-30 microns thick); chrome is a non-magnetic material, has a low sliding friction coefficient (less than half than steel), while having a high surface hardness. The function of the chrome coating on the upper annular surface of the annular element 21 of anchor 11 is to locally increase the surface hardness to better support possible impacts of anchor 11 against the magnetic pole 10 and to avoid magnetic sticking between the anchor 11 and the magnetic pole 10. The function of the chrome coating 47 on the external cylindrical surface 45 of the annular element 21 of anchor 11 is both to facilitate the sliding of the annular element 21 of anchor 11 with respect to the supporting body 4, and to uniform the side gap (while keeping a minimum gap between the annular element 21 of anchor 11 and the supporting body 4), so as to avoid magnetic sticking on the sides and to balance the radial magnetic forces.

**[0017]** As shown in figure 4, the valve seat 16 is defined by a sealing body 27, which is monolithic and comprises a disc-shaped plug element 28, which fluid-tightly closes the feeding duct 5 of the supporting body 4 at the bottom and is crossed by the injection nozzle 3. A guiding element 29 rises from the plug element 28, which guiding element has a tubular shape, accommodates the needle 15 therein for defining a lower guide of the needle 15 itself, and has an external diameter smaller than the internal diameter of the feeding duct 5 of the supporting body 4, so as to define an external annular duct 30 through which the pressurized fuel may flow.

**[0018]** Four feeding through holes 31 (only two of which are shown in figure 4) are obtained in the lower part of the guiding element 29, which holes lead towards the valve seat 16 to allow the pressurized fuel to flow towards the valve seat 16 itself. The feeding holes 31 may be either staggered with respect to the longitudinal axis 2 so as not to converge towards longitudinal axis 2 itself and to impress in use a vortex pattern to the respective fuel flows, or the feeding holes 31 may converge towards the longitudinal axis 2. As shown in figure 4, the feeding holes 31 are arranged slanted by an angle of 80° (more generally, from 70° to 90°) with the longitudinal axis 2; according to a different embodiment (not shown), the feeding holes 31 form an angle of 90° with the longitudinal axis 2.

**[0019]** Needle 15 ends with a substantially spherical shutter head 32, which is adapted to fluid-tightly rest against the valve seat 16; alternatively, the shutter head 32 could be essentially cylindrical and have the spherical abutting zone only. Furthermore, the shutter head 32 slidingly rests on an internal surface 33 of the guiding element 29 so as to be guided in its movement along the longitudinal axis 2. The injection nozzle 3 is defined by a plurality of injection through holes 34, which are obtained from an injection chamber 35 arranged downstream of the valve seat 16; for example, the injection chamber 35 could have a semi-spherical shape, a truncated conical shape, or even any other shape.

**[0020]** In use, when the electromagnetic actuator 6 is de-energized, anchor 11 is not attracted by the magnetic pole 10 and the elastic force of the closing spring 18 biases the anchor 11 downwards along with the needle 15; in this situation, the shutter head 32 of needle 15 is pressed against the valve seat 16 of the injection valve 7, thus isolating the injection nozzle 3 from the pressurized fuel. When the electromagnetic actuator 6 is energized, anchor 11 is magnetically attracted by the magnetic pole 10 against the elastic force of the closing spring 18 and anchor 11 is moved upwards along with needle 15 due to the magnetic attraction exerted by the magnetic pole 10 itself; in this situation, the shutter head 32 of needle 15 is raised with respect to the valve seat 16 of the injection valve 7 and the pressurized fuel may flow through injection nozzle 3.

**[0021]** In figures 2 and 3, the dashed line indicates the path P followed by the fuel to flow along the feeding duct 5 crossing the magnetic pole 10 and the anchor 11 of the electromagnetic actuator 6. It is apparent that the fuel flows through the passage ducts 20 along the path P, thus it flows through an annular meatus 36 defined between a lower surface 37 of the magnetic pole 10 and an upper surface 38 of the anchor 11 (i.e. of the annular element 21 of anchor 11), and finally flows through the central hole 26 of the annular element 21 of anchor 11 and through the side holes 24 of the discoidal element 22 of anchor 11.

**[0022]** Therefore, a certain amount of fuel exists in the annular meatus 36 defined between the lower surface 37 of the magnetic pole 10 and the upper surface 38 of the anchor 11 (i.e. of the annular element 21 of anchor 11); when the injection valve 7 is opened, the magnetic attraction of the magnetic pole 10 on the anchor 11 attracts the anchor 11, which thus moves towards the magnetic pole 10 by progressively reducing the axial size, and thus the fuel passage section, in the annular meatus 36. The progressive reduction of the fuel passage section in the annular meatus 36 determines a progressive increase of the fuel pressure inside the meatus 36 and thus determines a progressive increase of a force of hydraulic origin which pushes on the anchor 11 and opposes the approaching movement of anchor 11 to the magnetic pole 10.

**[0023]** As the anchor 11 approaches the magnetic pole 10, the strength of such a force of hydraulic origin increases, thus determining a progressive slow-down of the anchor 11. Therefore, two possible scenarios may occur according to the dimensioning of the various components in design: if the force of hydraulic origin is sufficiently strong, the sum of the force of hydraulic origin and of the elastic force generated by the closing spring 18 balances the magnetic force exerted by the magnetic pole 10 up to stop the anchor 11 in a balanced position in which the anchor 11 is close to the magnetic pole 10, but does not touch the magnetic pole 10 (in this case, the anchor 11 does not strike the magnetic pole 10, and therefore no oscillation is trigged due to the bouncing of anchor 11 against the magnetic pole 10); alternatively, if the force of hydraulic origin is not sufficiently strong, the sum of the force of hydraulic origin and of the elastic force generated by the closing spring 18 does not balance the magnetic force exerted by the magnetic pole 10 and thus the anchor 11 impacts in all cases against the magnetic pole 10, but the impact occurs at a very slow speed due to the slow-down determined by the force of hydraulic origin (in this case, anchor 11 strikes the magnetic pole 10 at a very slow speed and therefore no considerable oscillation is triggered due to the bouncing of anchor 11 against the magnetic pole 10).

**[0024]** It is worth noting that the two above-described scenarios may occur in the same injector 1 as the fuel feeding pressure varies: when the fuel feeding pressure is low (e.g. when the engine is idling), the force of hydraulic origin is also small and thus the anchor 11 may strike the magnetic pole 10 at a very slow speed due to the slow-down determined by the force of hydraulic origin; instead, when the fuel feeding pressure is high (e.g. when the engine is at top rpm), the force of hydraulic origin is also higher and thus the force of hydraulic origin stops the anchor 11 before the anchor 11 strikes the magnetic pole 10. In all cases, the objective of substantially eliminating the oscillations triggered on the position of anchor 11 upon the anchor 11 striking and subsequently bouncing against the magnetic pole 10 is achieved.

**[0025]** In order to modify the balance of the three forces involved on the anchor 11 (i.e. the force of hydraulic origin generated by narrowing the meatus 36, the elastic force generated by the closing spring 18, and the magnetic force generated by the electromagnetic actuator 6), acting on the fuel feeding pressure (force of hydraulic origin generated by narrowing the meatus 36), on the constructional features of the closing spring 18, and on the constructional features of the electromagnetic actuator 6 is possible.

**[0026]** As previously mentioned, the external diameter of the annular element 21 of anchor 11 is close to (i.e. only slightly smaller than, thus substantially identical to) the internal diameter of the corresponding portion of the feeding duct 5 of the supporting body 4; thereby, anchor 11 may slide along the longitudinal axis 2 with respect to the supporting body 4. On the other hand, however, a small part of the fuel exiting from the side passage ducts 20 does not flow through the central hole 26 of the annular element 21 following the path P, but it flows by the side of the annular element 21 into the annular space between the external side surface of the annular element 21 and the internal surface of the tubular body 4; the fuel which does not flow through the central hole 26 of the annular element 21 following the path P, but flows laterally to the annular element 21 into the annular space between the external side surface of the annular element 21 and the internal surface of the tubular body 4, does not contribute to generating the force of hydraulic origin which acts on the anchor 11 to slow down the anchor 11 itself.

**[0027]** The side passage ducts 20 of the magnetic pole 10 may be provided according to the constructional variant shown in figure 5 in order to completely eliminate the flow of part of the fuel from the side of the annular element 21 into the annular space between the external side surface of the annular element 21 and the internal surface of the tubular body 4. In this case, each passage duct 20 has a lower portion 39 converging towards the longitudinal axis 2, so as to have an outlet 40 towards the annular meatus 36, which is moved and directed (i.e. oriented) towards the longitudinal axis 2, i.e. closer to the central hole 26 of the annular element 21 and further from the internal surface of the tubular body 4. Thereby, the fuel enters the annular meatus 36 closer to the central hole 26 of the annular element 21 and directed towards the central hole 26, and thus the amount of fuel flowing by the side of the annular element 21 into the annular space between the external side surface of the annular element 21 and the internal surface of the tubular body 4 is considerably reduced. In order to cause all the fuel to flow through the lower portions 39 of the passage ducts 20, the magnetic pole 10 comprises a lower annular expansion 41 which is arranged under the inlets 42 of the lower portions 39 and fulfils the task of sealing the duct. It is worth noting that, the magnetic pole 10 being fixed, at the lower annular expansion 41, the magnetic pole 10 may be interference-fitted or welded to the supporting body 4 to ensure an optimal sealing.

**[0028]** According to a further constructional variant shown in figure 6, each passage duct 20 is not obtained on the external wall of the magnetic pole 10, but is obtained inside the magnetic pole 10 by the side of the central hole 17. Thereby, the outlet 40 of each passage duct 20 is moved towards the longitudinal axis 2, i.e. closer to the central hole 26 of the annular element 21 and further from the internal surface of the tubular body 4, while the passage ducts 20 are straight (i.e. may be provided by means of a single mechanical drilling process of the magnetic pole 10). In the embodiment shown in figure 6, the passage ducts 20 are parallel to the longitudinal axis 2; according to a different embodiment (not shown), the passage ducts 20 are slanted so as to converge towards the longitudinal axis 2 at the outlets 40 so that, when exiting from the outlets 40, the fuel is directed towards the outlets 40.

**[0029]** The above-described injector 1 has many advantages.

**[0030]** Firstly, the above-described injector 1 is simple and cost-effective to be manufactured, because it has only a few constructional differences which are easy to be implemented as compared to a similar injector currently marketed.

**[0031]** Furthermore, the above-described injector 1 has a linear, uniform (i.e. without irregularities) driving time-injected fuel amount curve (i.e. the law which links the driving time to the injected fuel amount), even for short driving times, and thus for small amounts of injected fuel. Such a result is obtained by eliminating the oscillations triggered on the position of anchor 11 upon the anchor 11 striking and subsequently bouncing against the magnetic pole 10.

## Claims

**1.** Electromagnetic fuel injector (1) comprising:

a tubular body (4), which presents a feeding duct (5);
an injection nozzle (3), which is located at the end of the feeding duct (5) and id regulated by an injection valve (7) provided with a mobile needle (15); and
and electromagnetic actuator (6), which moves the needle (15) between a closing and an opening position of the injection valve (7) and comprises a coil (8), a fixed magnetic pole (10) located inside the tubular body (4) and a mobile anchor (11) located inside the tubular body (4), integral to the needle (15) of the injection valve (7) and magnetically attracted by the magnetic pole when the coil (8) is energized;
at least one portion of the anchor (11) facing the magnetic pole (10) comprises at least one central through hole (26), which allows the fuel to flow towards the injection nozzle (3) and through the anchor (11);
the electromagnetic fuel injector (1) is **characterized in that** the magnetic pole (10) comprises a number of side passage ducts (20), which are arranged around a longitudinal axis (2) and allow the fuel to flow towards the injection nozzle (3) and through the magnetic pole (10).

**2.** Electromagnetic fuel injector (1) according to claim 1, wherein the side passage ducts (20) are obtained in correspondence of the external side surface of the magnetic pole (10) and are externally delimitated by the tubular body (4).

**3.** Electromagnetic fuel injector (1) according to claim 2, wherein each side passage duct (20) presents a lower portion (39) converging towards the longitudinal axis (2), so that it presents an outlet (40) which is shifted towards the longitudinal axis (2).

**4.** Electromagnetic fuel injector (1) according to claim 3, wherein the magnetic pole (10) comprises a lower annular expansion (41), which is located beneath inlets (42) of the lower portions (39) of the passage ducts (20) and fulfils the task of sealing the passage.

**5.** Electromagnetic fuel injector (1) according to claim 1, wherein each passage duct (20) is obtained inside the magnetic pole (10) on the side of the longitudinal axis (2).

**6.** Electromagnetic fuel injector (1) according to one of the claims from 1 to 5, wherein an annular meatus (36), through which the fuel flows from the side passage ducts (20) of the magnetic pole (10) to the central hole (26) of the anchor (11), is defined between a lower surface (37) of the magnetic pole (10) and an upper surface (38) of the anchor (11).

**7.** Electromagnetic fuel injector (1) according to claim 6, wherein, when in use, when the injection valve (7) is opened, the magnetic attraction (10) of the magnetic pole (10) on the anchor (11) attracts the anchor (11) which consequently moves towards the magnetic pole (10) reducing progressively the axial dimension and, therefore, the section for the fuel passage of the annular meatus (36); the progressive reduction of the section for the fuel passage of the annular meatus (36) determines a progressive increase in the fuel pressure inside the meatus (36) and, therefore, determines a progressive increase in a power of hydraulic origin which acts on the anchor (11) and contrasts the approach movement of the anchor (11) to the magnetic pole (10).

**8.** Electromagnetic fuel injector (1) according to one of the claims from 1 to 7, wherein at least one portion of the armature (11) facing the magnetic pole (10) presents an external diameter close to the internal diameter of the corresponding portion of the feeding duct (5) of the support body (4).

**9.** Electromagnetic fuel injector (1) according to claim 8, wherein the anchor (11) comprises:

annular element (21), which presents an external diameter close to the internal diameter of the corresponding portion of the feeding duct (5) of the support body (4) and comprises the central through hole (26) which allows the fuel to flow towards the injection nozzle (3) and through the anchor (11); and
a discoidal element (22), which closes inferiorly the annular element (21) and present a central through hole (23), which receives an upper portion of the needle (15), and a plurality of side through holes (24), which allow the fuel to flow towards the injection nozzle (3).

**10.** Electromagnetic fuel injector (1) according to claim 9, wherein a debouncing device (25) is connected to a lower surface of the discoidal element (22) of the anchor (11).

**11.** Electromagnetic fuel injector (1) according to claim 9 or 10, wherein an external cylindrical surface of the annular element (21) of the anchor (11) and an upper annular surface of the annular element (21) of the anchor (11) are covered by a layer of chrome.

**12.** Electromagnetic fuel injector (1) according to one of the claims from 1 to 11, wherein the magnetic pole (10) is centrally holed and presents a central through hole (17) in which a closing spring (18) is partially housed, which pushes the anchor (11) towards a closing position of the injection valve (7); a striker body (19), which is closed to seal the central hole (17) and keeps the closing spring (18) compressed against the anchor (11), is driven inside the central hole (17) of the magnetic pole (10) in a fixed position.

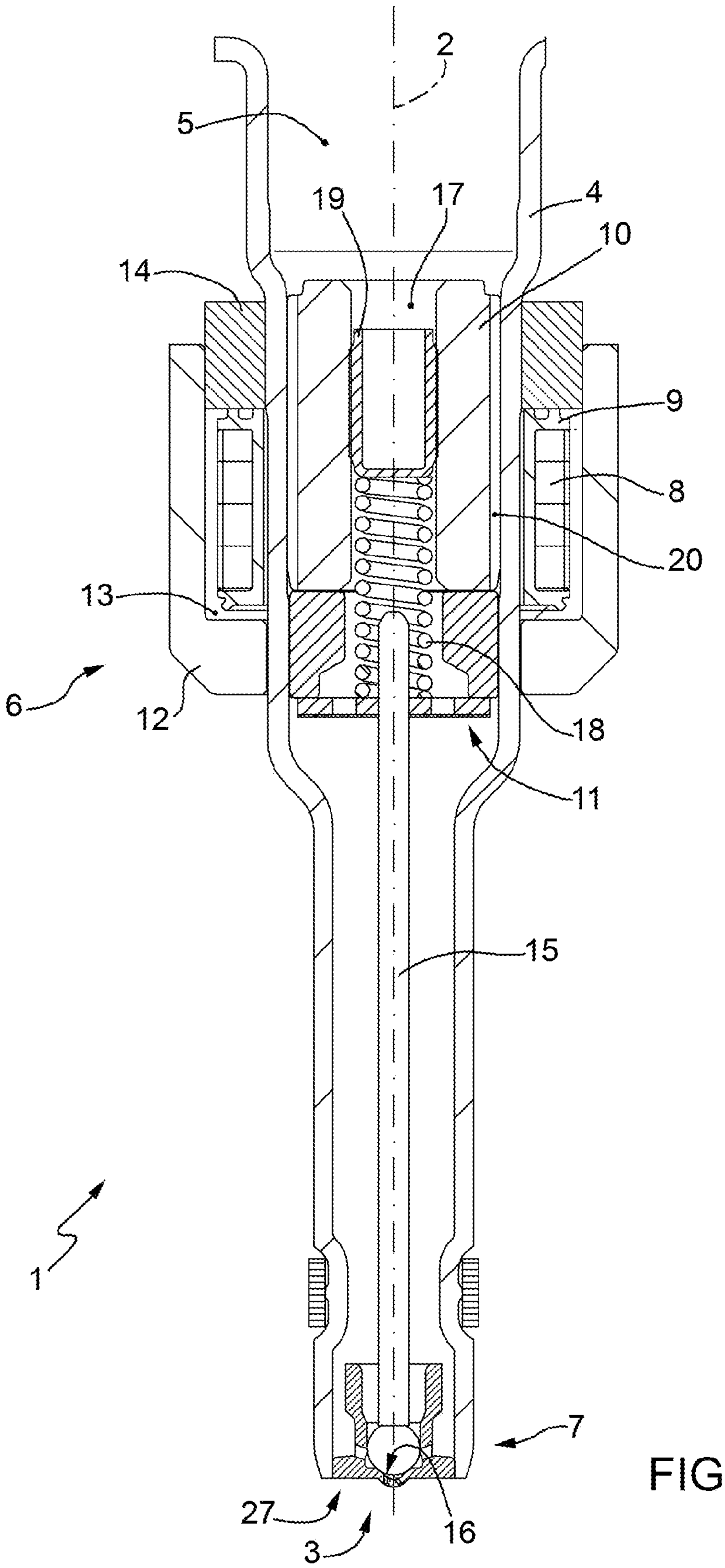


FIG.1

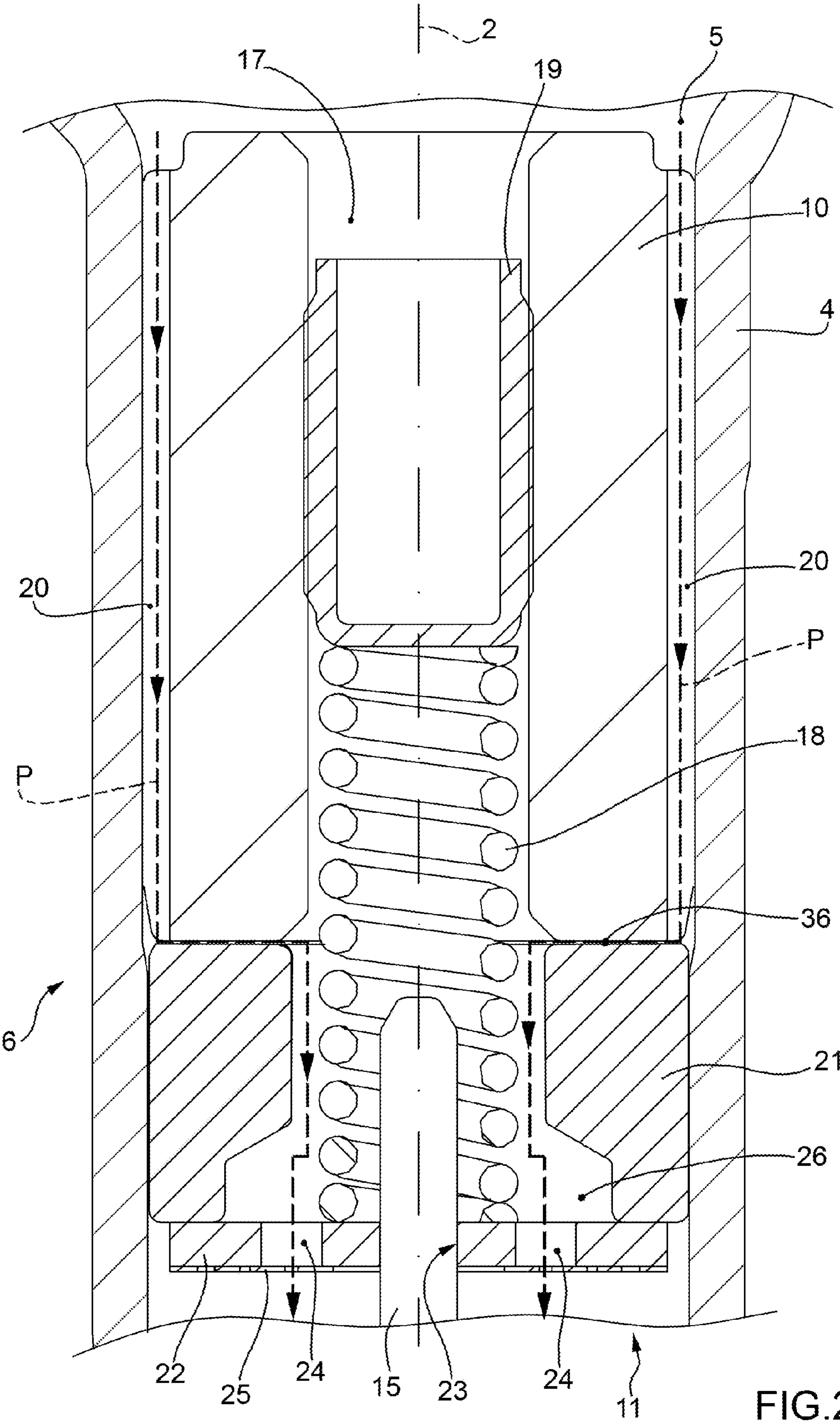


FIG.2

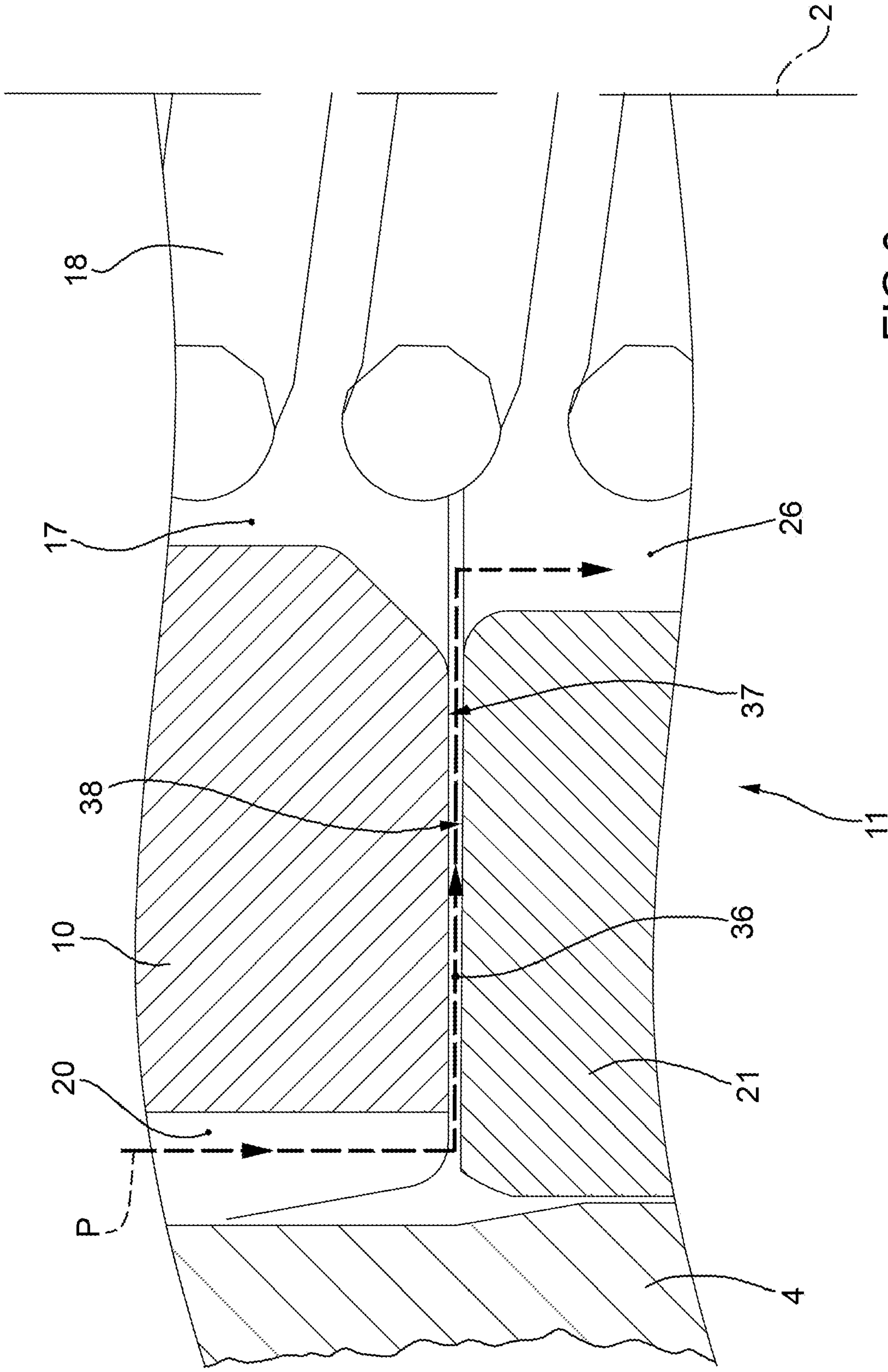


FIG.3

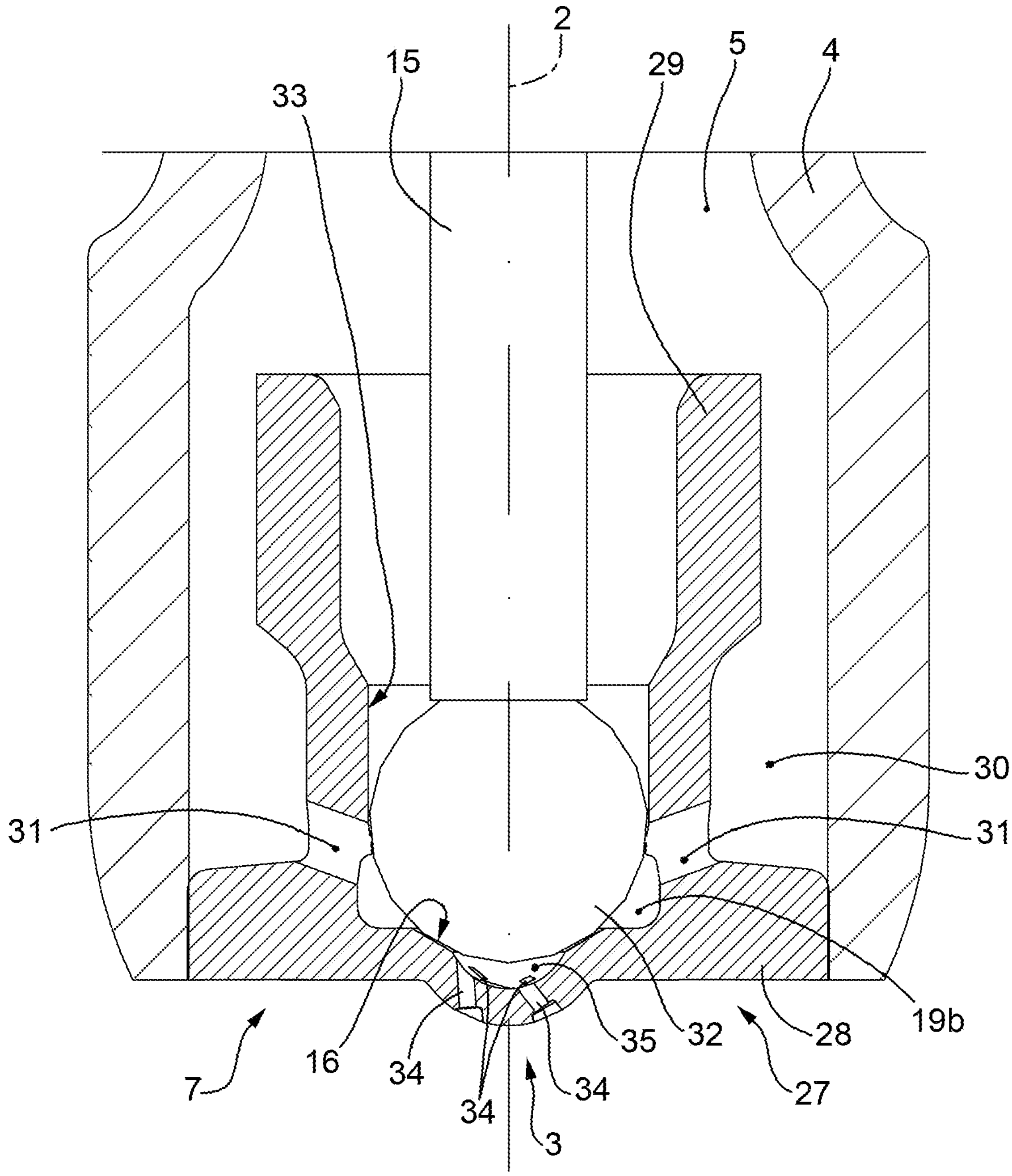


FIG.4

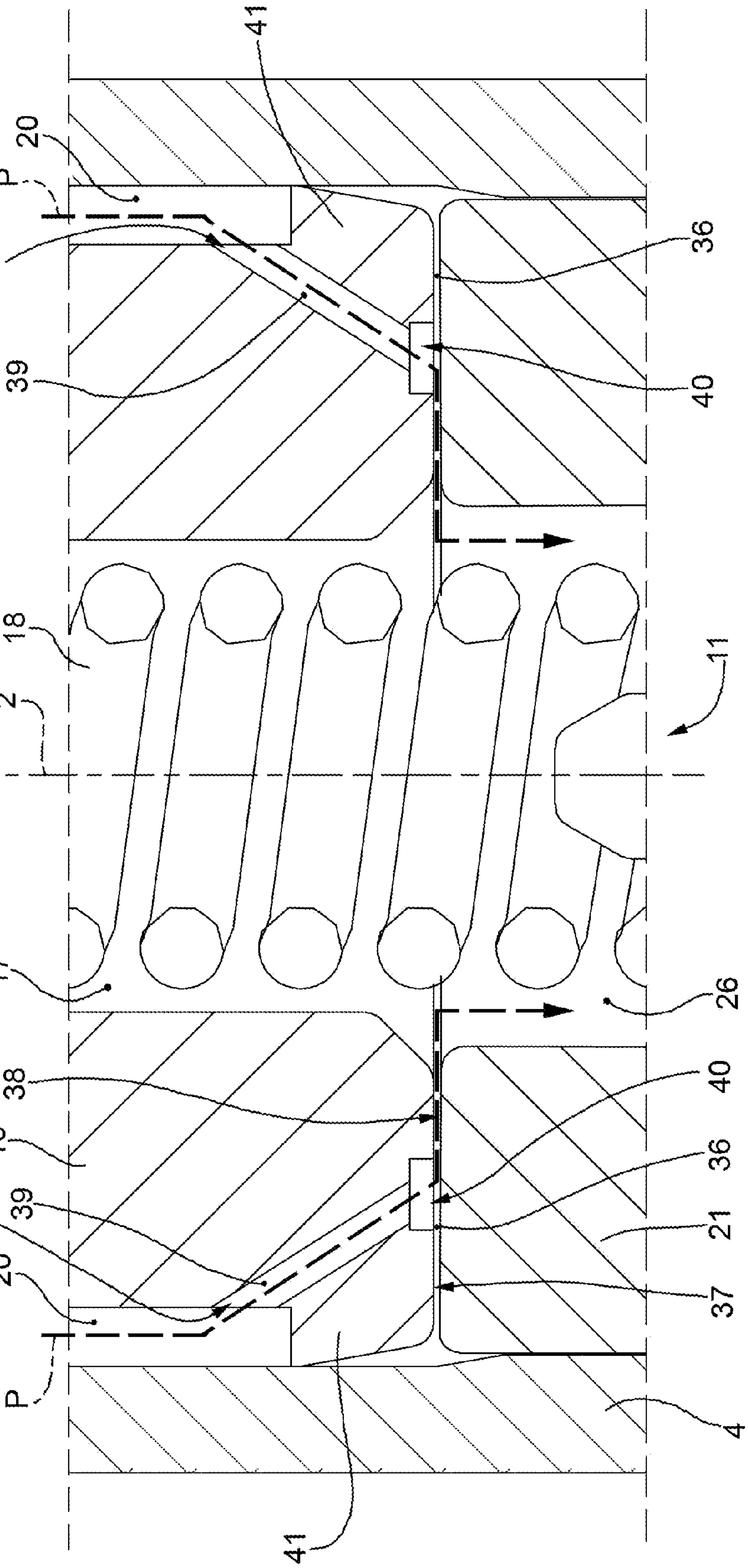


FIG.5

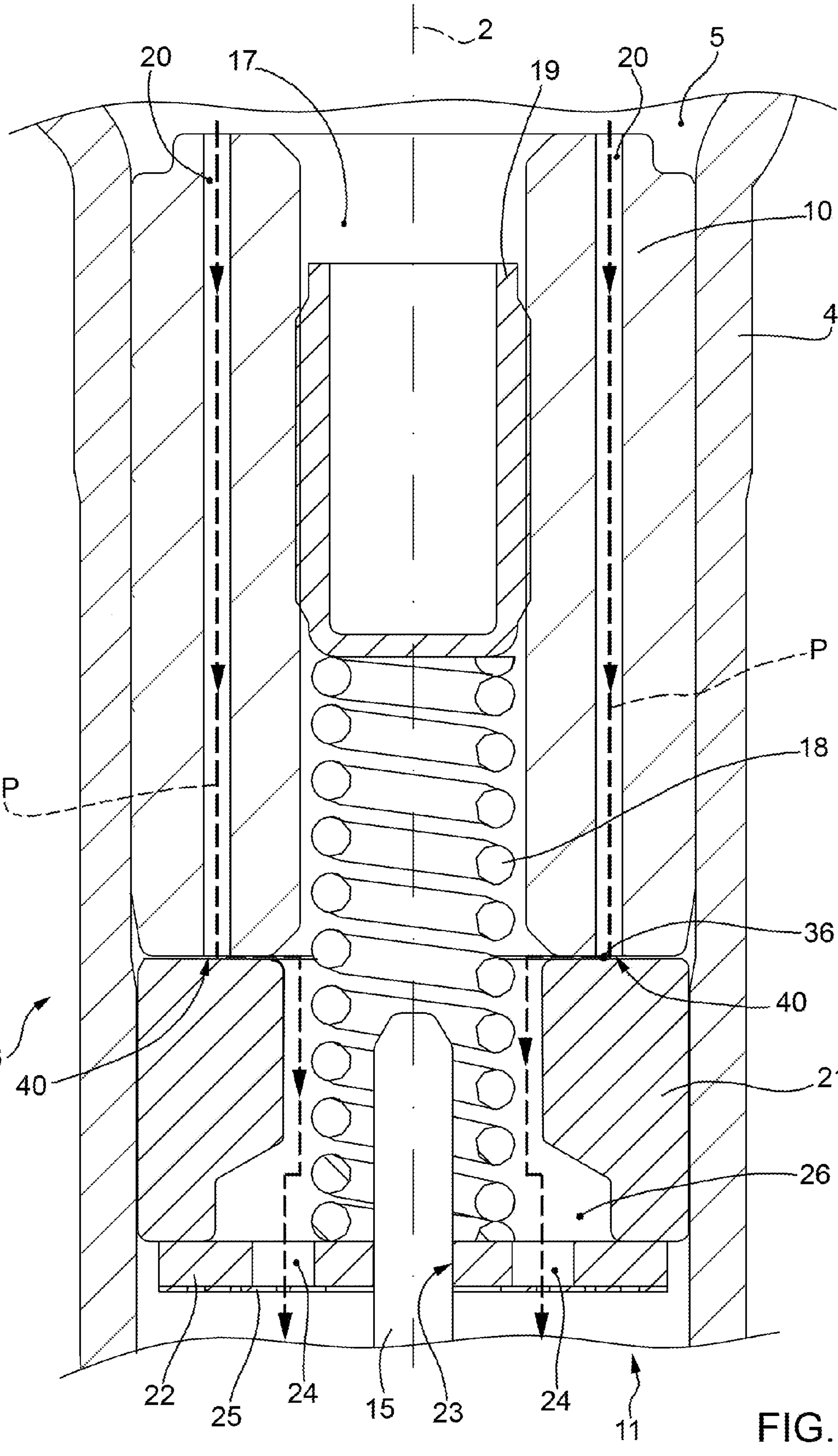


FIG.6

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# EUROPEAN SEARCH REPORT

Application Number
EP 10 16 2035

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X<br>Y | DE 10 2007 004870 A1 (BOSCH GMBH ROBERT [DE]) 7 August 2008 (2008-08-07)<br>* figures 1,2 *<br>----- | 1<br>2-12 | INV.<br>F02M51/06<br>F02M61/04<br>F02M61/10 |
| Y | DE 10 2004 056424 A1 (BOSCH GMBH ROBERT [DE]) 24 May 2006 (2006-05-24)<br>* figures 2,3,4 *<br>----- | 2-12 | |
| A,D | EP 1 619 384 A2 (MAGNETI MARELLI POWERTRAIN SPA [IT])<br>25 January 2006 (2006-01-25)<br>* figure 1 *<br>----- | 1 | |

TECHNICAL FIELDS SEARCHED (IPC)

F02M

The present search report has been drawn up for all claims

1

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 10 September 2010 | Morales Gonzalez, M |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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