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(54) **Electromagnetic actuator assembly for a fluid injection valve**

(57) An electromagnetic actuator assembly for a fluid injection valve is disclosed. It comprises a first coil (14), a valve needle (22) being arranged axially moveable along a longitudinal axis (L) of the actuator assembly, and an armature (16) being arranged axially moveable along the longitudinal axis and being mechanically coupled to the valve needle (22). A second coil (28) is mechanically coupled to the armature (16). The first and the second coil form a transformer. Further, a valve assembly and a fluid injection valve are disclosed.

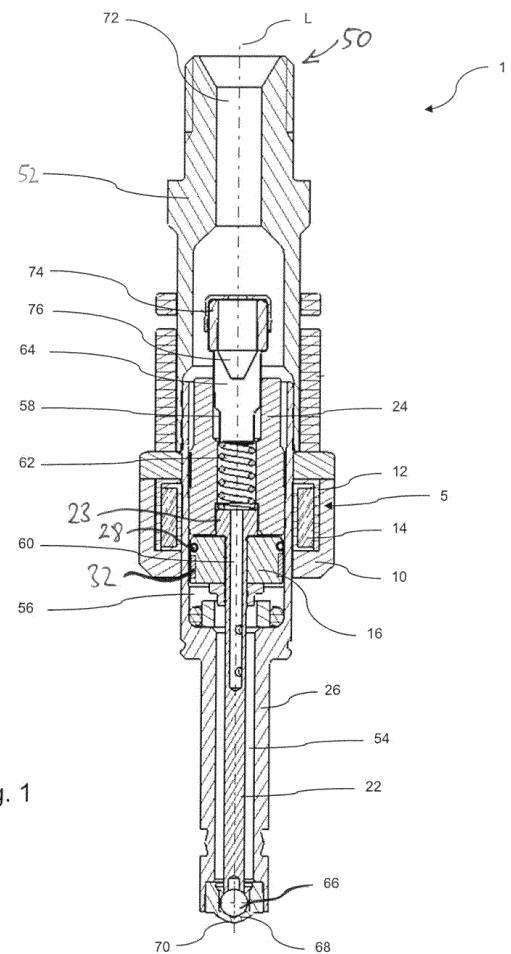


Fig. 1

Description

[0001] The invention relates to an electromagnetic actuator assembly for a fluid injection valve, comprising a first coil, a valve needle and an armature. The valve needle is arranged axially moveable along a predetermined axis of the fluid injector. The armature is arranged axially moveable along the predetermined axis and being mechanically coupled to the valve needle.

[0002] Fluid injectors are in widespread use, in particular for internal combustion engines where they may be arranged in order to dose 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] In order to enhance the combustion process in view of the creation of unwanted emissions, the respective fluid injector has to 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 500 bar and in the case of diesel engines in the range of up to 2000 bar. Due to always more stringent requirements, the solenoid injector must be controllable in order to deliver very small fuel quantities. In particular, this is true for solenoid injectors under so called ballistic operating mode.

[0004] EP 2 221 468 A1 discloses a fluid injector comprising a housing with a cavity and a coil being arranged in the cavity. A valve needle is arranged axially moveable along a predetermined axis of the fluid injector. An armature is arranged axially moveable along the predetermined axis and is mechanically coupled to the valve needle. A reluctance element is designed to have a permeability which is much smaller than the permeability of the housing and is arranged such that a magnetic circuit comprising the housing and the armature also comprises the reluctance element.

[0005] It is an object of the present invention to provide an electromagnetic actuator assembly for a fluid injector which enables a particularly fast, reliable and/or efficient fluid injection.

[0006] This object is achieved by an electromagnetic actuator assembly having the features of independent claim 1. Advantageous embodiments and developments of the actuator assembly are given in the dependent claims.

[0007] According to a first aspect, an electromagnetic actuator assembly for a fluid injection valve is disclosed. According to a second aspect, a valve assembly for the fluid injection valve is disclosed. The valve assembly may comprise the actuator assembly or some individual constituent parts of the actuator assembly, such as a valve needle. According to a third aspect, a fluid injection valve is disclosed which comprises the valve assembly and/or the actuator assembly.

[0008] The actuator assembly comprises a first coil. In an expedient embodiment, the valve assembly comprises a valve body with a cavity which extends from a fluid inlet end to a fluid outlet end of the valve body. The first coil may expediently be arranged outside of the valve body. In particular, it extends circumferentially around a portion of the valve body. Preferably, the fluid injection valve comprises a housing which surrounds the valve body and in which the first coil is arranged.

[0009] Further, the actuator assembly comprises a valve needle which is arranged axially moveable along a longitudinal axis of the actuator assembly. In particular, the longitudinal axis also represents a longitudinal central axis of the valve body and of the fluid injection valve. The valve needle may be received in the cavity. Expediently, the valve needle may cooperate with a valve seat of the valve assembly for controlling fluid flow through an injection nozzle of the fluid injection valve. In particular, the valve needle is in mechanical contact with the valve seat in a closing position to prevent fluid flow through the injection nozzle and is axially displaceable away from the closing position for enabling fluid flow through the injection nozzle.

[0010] In addition, the actuator assembly comprises an armature which is arranged axially moveable along the longitudinal axis. The armature is mechanically coupled to the valve needle, in particular for displacing the valve needle away from the closing position. The armature can be fixed to the valve needle. Alternatively, the armature is axially displaceable relative to the valve needle and the valve needle comprises an armature retainer for limiting the axial play between the valve needle and the armature. In this case, the armature is operable to engage with the armature retainer for displacing the valve needle away from the closing position. Expediently, the armature may be arranged in the cavity of the valve body.

[0011] The actuator assembly furthermore comprises a second coil which is mechanically coupled to the armature. The second coil may expediently be arranged in the cavity of the valve body. The first and the second coil in particular form a transformer.

[0012] The first coil is in particular operable to generate a magnetic field which exerts an inductive force acting on the armature in longitudinal direction. By means of the second coil, the actuator assembly is in particular operable to generate a Lorentz-force when a flux variation is generated by the first coil, in addition to the inductive force.

[0013] As a result, a dynamic magnetic force that magnifies (boosts or bucks) the inductive force between poles in transient events is achievable which in particular uses a Lorentz volumetric effect to improve the opening and/or the closing behavior of the actuator assembly.

[0014] Therefore, the electromagnetic actuator has a particularly advantageous dynamic behavior of the magnetic force.

[0015] As a further advantage, during a stationary activation of the actuator assembly the current through the first coil is constant to maintain the injector and valve, respectively, open. Hence, no additional Lorentz-force is present in the

system due to a missing flux variation. Instead, only the inductive force of the first coil a result of the stationary magnetic flux attracting the armature to a stationary pole piece of the assembly is present as in conventional actuators.

[0016] In a preferred embodiment, the second coil is comprised by a closed electrical circuit. In one embodiment, the closed electrical circuit has a first section and a second section, the second section comprising the second coil. The first section is shaped and arranged such that a current flowing through the first section, together with the magnetic field of the first coil, generates a Lorentz force in a direction along the longitudinal axis. The second section is in particular shaped and arranged such that a variation of the magnetic field of the first coil induces a current through the second section and thus through the closed electrical circuit and in particular through its first section.

[0017] In a preferred embodiment, the second section- in particular the second coil - axially overlaps the first coil, in particular completely axially overlaps the first coil. The first section preferably projects axially beyond the first coil or is axially spaced apart from the first coil. The current in both the first and second sections may be directed circumferentially around the longitudinal axis by means of the shape of the first and second section, respectively.

[0018] The second coil preferably completely overlaps the armature in axial direction. In other words, the second coil preferably does not project axially beyond the armature. With advantage, the armature may represent a core for the second coil in this case. In one advantageous development, the armature comprises a magnetic material such as a ferritic steel. Particularly good magnetic properties are achievable in this way. The second coil is preferably spaced apart from the valve needle and in particular also from the valve body.

[0019] According to one embodiment, the second coil comprises one or more turns. The more turns the second coil has the better is the coupling between the first and the second coil and, as such, the amount of the additional Lorentz-force. However, it is to be understood that a single turn is sufficient to improve response time of the actuator assembly while providing a cost-effective and robust design.

[0020] According to a further embodiment, the second coil surrounds the armature such that a central axis of the second coil is parallel or coaxial to the longitudinal axis of the actuator assembly. The central axis of a coil is in this context in particular the axis of the coil around which the turn(s) of the coil is/are wound. The first coil and the second coil preferably have parallel or coaxial central axes, the central axes being in particular parallel or coaxial with the longitudinal axis.

[0021] According to a further embodiment, the turn or turns of the second coil are arranged in a helical nut of the armature. Alternatively or additionally, the second coil is wound around a second cylindrical portion of the armature which has second outer diameter being smaller than a first outer diameter of a first cylindrical portion of the armature. The first and the second portions of the armature may be separate parts of ferromagnetic material which are coupled to each other. The first and the second portion of the armature may be made from one piece of ferromagnetic material. The ferromagnetic material is a ferritic steel in one embodiment.

[0022] According to a further embodiment, an outer diameter of the turn or turns which are wound around the second portion of the armature corresponds to the first outer diameter or is smaller than the first outer diameter. This makes sure that the armature with the second coil can move axially within a cylindrical recess of a - such as a recess of the pole piece without risking abrasive damage of the second coil. When the outer diameter of the turn(s) equals the first outer diameter, the Lorentz-force is maximized.

[0023] According to a further embodiment, ends of the second coil are electrically connected to a resistor. The resistor may be comprised by the first section of the electrical circuit or represent the first section of the electrical circuit. The resistor may be represented by a body of electrically conducting material, such as copper, circumferentially surrounding the first portion of the armature and having a disruption, such as a slot, extending in a direction of the longitudinal axis. The disruption may expediently extend over the full longitudinal extension of the body. In other words, the body may have the shape of a longitudinally slotted ring or cylinder shell. For example, the body is a layer of conductive material applied on the armature.

[0024] The electrical connections between the ends of the second coil and the body of electrically conducting material may be made by welding. By means of the electrically conducting body an electrical current flow orthogonal to the magnetic flux lines of the first coil is easily and reliably achievable.

[0025] According to a further embodiment, the body of electrically conducting material is electrically separated from the armature. For example, an electrical insulating layer is arranged radially between the body of electrically conducting material and the armature. In addition, the second coil is electrically separated from the armature, too.

[0026] According to a further embodiment, the second coil may be made from enameled wire such as enameled copper wire. However, other electrically conducting materials may be used instead of copper.

[0027] According to a further embodiment, the actuator assembly comprises a controlling unit connected to the first coil and being adapted to supply a current to the first coil to phase the flux variation of the first coil with a motion of the armature. As a result, the opening and closing transient with respect to the voltage polarity can be improved. This is supported by a low resistance connection between the second coil and the body of electrically conducting material to generate an electrical current circulation, into the same layer, in clockwise or counter-clockwise direction depending on the radial flux vector (from the inner to the outer side or vice versa) in order to add the dynamic force for boosting or not

the net force over the armature.

[0028] According to one aspect, the invention provides an actuator assembly for a fluid injection valve which has a second coil comprising at least one turn being wound around the armature of the assembly. The second coil (in the simplest form a single wire) is mounted around the armature. It may concatenate the magnetic flux. It produces an electrical current, preferably being fed into a body of electrically conducting material which is axially offset relative to the second coil. The current through the body of electrically conducting material flows basically orthogonal to the flux density vectors of the magnetic flux of the first coil in the region of the body. Thus, a dynamic magnetic force can be generated that magnifies, i.e. boosts or bucks, the inductive force between poles in transient events by means of using a Lorenz volumetric effect to improve the opening and the closing behaviors of the actuator assembly.

[0029] According to one aspect, a fluid injection valve with a valve assembly is specified. The valve assembly comprises a valve body and an actuator assembly according to one of the previously described embodiments. The valve body has a cavity which extends in longitudinal direction from a fluid inlet end to a fluid outlet end of the valve body. The first coil is arranged outside of the valve body and the second coil and the armature are arranged inside of the cavity of the valve body.

[0030] Exemplary embodiments of the invention will be explained in the following with the aid of schematic drawings.

[0031] In the figures:

Figure 1 shows a fluid injection valve with an electromagnetic actuator assembly according to an exemplary embodiment of the invention,

Figure 2 shows an enlarged view of a second embodiment of the actuator assembly according to the invention.

[0032] Elements of the same design and function that appear in different illustrations are identified by the same reference signs.

[0033] Figure 1 shows a longitudinal section view of a fluid injection valve 1 (Figure 1) according to a first exemplary embodiment. The fluid injection valve 1 is suited for dosing fluid, in particular fuel, into an internal combustion engine.

[0034] The fluid injection valve 1 has a longitudinal axis L and comprises an inlet tube 52 with a fuel connector 50, the fuel connector 50 being configured to mechanically and hydraulically couple the fluid injection valve 1 to a fluid reservoir (not shown), such as a fuel rail.

[0035] The fluid injection valve 1 further comprises a valve assembly with a valve needle 22, a seat element 68, at least one injection nozzle 70 and a valve body 26. The seat element 68 may be made as one part with the valve body 26 or may also be made as a separate part which is fixed to the valve body 26. The injection nozzle 70 may, for example, be an injection hole. It may, however, also be of some other type suitable for dosing fluid. Preferably, the injection nozzle 70 is comprised by the seat element 68.

[0036] In addition, the fluid injection valve 1 has an electromagnetic actuator assembly comprising a pole piece 24, a movable armature 16, and a first coil 14. The pole piece 24 is arranged within the valve body 26 and fixed to the valve body 26. The armature 16 is made from a ferromagnetic material such as a ferritic steel.

[0037] The valve needle 22 is mechanically coupled to the armature 16. More specifically, the armature 16 is displaceable relative to the valve needle 22 in reciprocating fashion along the longitudinal axis L. The valve needle 22 comprises an armature retainer 23 which limits the axial play of the armature 16 relative to the valve needle 22 in axial direction towards the pole piece 24. Therefore, the valve needle 22 is also regarded as a constituent part of the actuator assembly in the present context.

[0038] Further, the fluid injection valve 1 comprises a housing 10 surrounding the valve body 26. The housing may comprise a yoke of the electromagnetic actuator assembly and/or a plastic housing. The first coil 14 may be arranged in a cavity 12 of the housing and preferably overmolded with the plastic housing.

[0039] The valve body 26 has a cavity 54, 56 which extends from a fluid inlet end to a fluid outlet end of the valve body 26. A first portion of the cavity 54 takes in the valve needle 22. A second portion of the cavity 56 which communicates hydraulically with the first portion 54 takes in the armature 16.

[0040] The pole piece 24 has a central opening 58 which hydraulically communicates with a tubular portion 60 of the valve needle 22, so that the a fluid inlet 72 of the fuel connector 50 of the inlet tube is hydraulically connected to the injection nozzle 70 at the fluid outlet end of the valve body 26 via the central opening 58 of the pole piece 24, the tubular portion 60 of the valve needle 22 and the cavity 54, 56 of the valve body 26.

[0041] A spring 62 is arranged in the central opening 58 of the pole piece 52. Preferably, the spring 62 rests on a spring seat of the valve needle 22, the spring seat being comprised preferably by the armature retainer 23 of the valve needle 22. The spring 62 is in this way mechanically coupled to the valve needle 22. An adjusting tube 64 is arranged positionally fix in the central opening 58 of the pole piece 24. The adjusting tube 64 comprises a further seat for the spring 62 and may, during the manufacturing process of the fluid injection valve 1, be axially moved in order to preload the spring 20.

[0042] The valve needle 22 has a sealing element 66 at the end opposite of the armature retainer 23, i.e. at its needle tip. The sealing element 66 is, for example, in the shape of a ball. The sealing element 66 may be welded to a shaft of the valve needle 22.

[0043] In a closing position of the valve needle 22, the sealing element 66 sealingly rests on the seat element 68 and prevents in this way a fluid flow through the injection nozzle 28. The valve needle is axially displaceable away from the closing position to further positions, i.e. axially moveable out of contact with the seat element 68, for enabling fluid injection through the injection nozzle 70.

[0044] A filter element 74 is arranged in the adjusting tube 64. filter element 75 has a filter screen 76 through which the fluid must flow when flowing from the fluid inlet 72 to the at least one injection nozzle 70.

[0045] In addition to the first coil 14, the electromagnetic actuator assembly comprises a second coil 28. The second coil 28 which consists of one or more turns 30 is mechanically coupled to the armature 16. The second coil 28 surrounds the armature 16 such that a longitudinal axis of the second coil 28 is parallel to, in particular coincidental with, the longitudinal axis L of the fluid injection valve 1. The second coil 28, e.g. made from copper enameled wire, is electrically connected to a resistor which is represented by a body 32 of electrically conducting material and surrounding the armature 16. The electrically conducting material for example comprises or consists of copper. The body 32 has a disruption 34 extending in a direction of the longitudinal axis L, such that the body 32 has two opposite circumferential ends. In other words, the body 32 has a partly annular shape. For example, the body 32 is represented by a layer of the conducting material which is deposited circumferentially - more specifically: only partly circumferentially - around the armature. By means of the two circumferential ends and the coil ends of the second coil 28, the body 32 is connected in parallel to the second coil 28 so that a closed electric circuit is established. The second coil 28 and the circular body 32 are electrically insulated from the armature 16. This may be made by means of a thin insulation layer.

[0046] The closed electric circuit has a first portion which comprises the body 32 and a second portion which comprises the second coil 28. The second portion, in particular the second coil 28 axially overlaps the first coil 14. The first portion projects axially beyond the first coil 14. In particular, the body 32 is axially spaced apart from the first coil 14.

[0047] The first and the second coils 14, 28 form a transformer such that, during a flux variation generated from the first coil 14, induces a current through second coil 28 which, by means of the electrical connection in the closed electric circuit also flows through the partly annular body 32. The current flowing through the body 32 generates - in addition to an inductive force which is generated by the first coil 14 - a Lorentz-force 14 acting on the armature 16 in longitudinal direction. This may result in an improved opening and the closing behavior of the fluid injector.

[0048] The function of the actuator assembly will be explained in more detail with help of an enlarged view of a second embodiment of the actuator assembly for a fluid injection valve 1 in Fig. 2.

[0049] The actuator assembly and the fluid injection valve 1 of the second embodiment correspond in general with those of the first embodiment. However, the armature 16 of Fig. 2 comprises a first portion 18 having a first outer diameter and a second portion 20 having a second outer diameter being smaller than the first outer diameter. By way of example, the second coil 28 comprises one turn 30 that surrounds the second portion 20 of the armature 16. The second coil 28 may comprise or consist of a wire, in particular an enameled copper wire. The second coil 28, i.e. the wire, is insulated from the armature 16 - in particular by the enameling with a lacquer.

[0050] The partly annular body 32 surrounds the first portion 18 of the armature 16. It has a disruption 34 extending in a direction parallel to the longitudinal axis L over the complete axial extent of the body 32. The opposite circumferential ends of the body 32 body 32 adjacent to the disruption 34 are connected with respective ends 36, 38 of the second coil 28 so as to act as resistor between the ends 36, 38 of the second coil 28. Between the circular body 32 and the armature 16 a thin insulating layer is provided to avoid electrical dispersion.

[0051] The second outer diameter is preferably selected such that an outer diameter of the second coil 28 equals the outer diameter of the body 32 arranged around the first portion 18.

[0052] It is possible to use the actuator assembly described above, for example, in dry condition or in wet condition as described in conjunction with Fig. 1. It may be advantageous to provide a protection over the electric conducting materials when the actuator assembly is used in wet condition.

[0053] The first coil 14, the second coil 28 and the partly annular body 32 are each arranged such that a current through the respective part is directed generally circumferentially around the longitudinal axis L. Applying a current to the first coil 14 results in a magnetic flux along a magnetic path MP of the actuator assembly. In an interior of the first coil 14, the magnetic flux MP is directed along the longitudinal axis L, while the magnetic field lines are bent away from the longitudinal axis L at the axial ends of the first coil 14 to close the magnetic path on the outside of the first coil 14. The second coil 28 is coaxially positioned in the interior of the first coil 14. Thus, the primary coil 14 and the second coil 28 are linked to function like a transformer so that a variation of the magnetic flux MP of the first coil 14 induces a current in the second coil 28.

[0054] The current flowing in the second coil is directed to the partly annular body 32 to close its loop. Since the partly annular body 32 is positioned axially spaced apart from the first coil 14, it is exposed to a radial component RF of the magnetic flux MP. Preferably, the body 32 axially overlaps a yoke of the actuator assembly at a position, where the yoke

guides the magnetic flux MP to be basically completely directed in radial direction. The direction of the current in the body 32 can be considered approximate orthogonal to the radial magnetic flux portion RF. Thus, the current through the body 32, together with the magnetic field corresponding to the radial magnetic flux portion RF generates a Lorentz force in direction along the longitudinal axis L.

[0055] More specifically, a Lorentz volumetric force f according to equation (1) may be generated in axial direction (i.e. in direction of the longitudinal axis L) according to the relation:

$$\vec{f} = \vec{J} \times \vec{B}_r \quad (1)$$

$$\vec{F} = \int_{vol} f dV \quad (2)$$

$$|\vec{F}| \approx 2\pi R K N i(t) B_r \quad (3)$$

where J is the current density vector of the second coil 28 (the current density vectors of the second coil 28 and of the body 32 have in particular the same direction or are antiparallel) and B_r is the magnetic radial flux vector related to the magnetic path MP.

[0056] By computing an integral (see equation (2)) within the volume of the body 32 a force F [N] in the direction of the longitudinal axis L is obtained. In equation (3) $i(t)$ is the current flow into the first coil 14, k is the overall coupling factor between the first and the second coils 14, 28, N is the first coil turn's number and B_r is the radial magnetic flux density.

[0057] The Lorentz force F is used for acting the armature 16 to boost (increase) or buck (decrease) the axial inductive force evoked by the first coil 14 during transient events, i.e. only when a flux variation is present. Depending to the sign of the flux variation in dependence of time, $d\Phi/dt$, it is possible to increase or decrease the attractive force generated by the first coil 14 using the dynamic current density J induces in the second coil 28. Varying $i(t)$, it is possible to obtain $J(t)$ as traditional transformer.

[0058] The effect of increasing or decreasing the inductive force can be phased with the motion direction of the armature 16 to improve the opening and closing transient with the appropriate copper connection with respect to the voltage polarity.

[0059] During a stationary activation $i(t)$ is constant which may in particular be the case for maintaining the injector open. As a result, no additional Lorentz force is acting on the armature 16. Instead, only the stationary magnetic flux (Φ) attracts the armature 16 to the pole piece 24 is present as it is at traditional actuators.

Claims

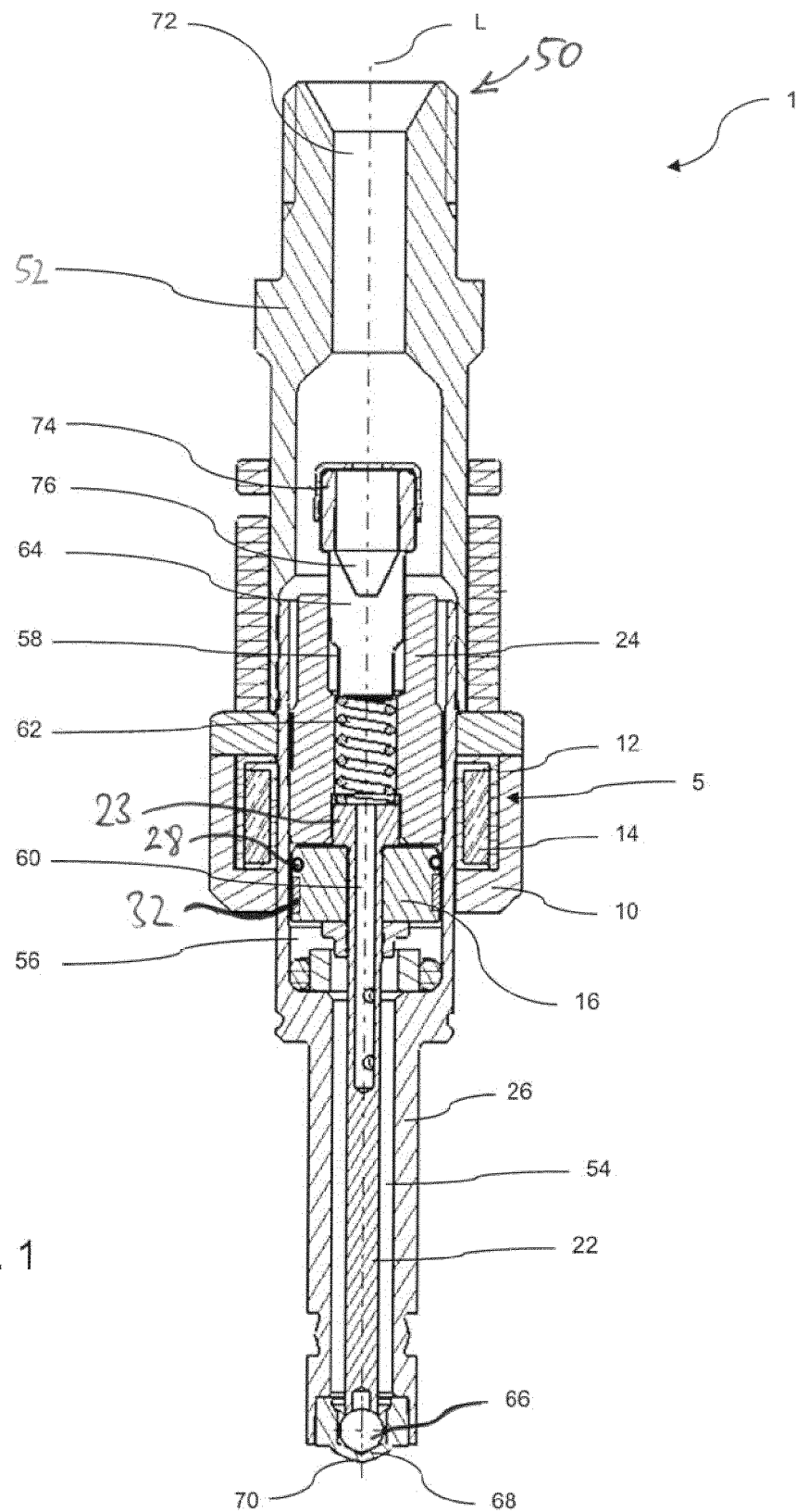
1. An electromagnetic actuator assembly for a fluid injection valve, comprising:

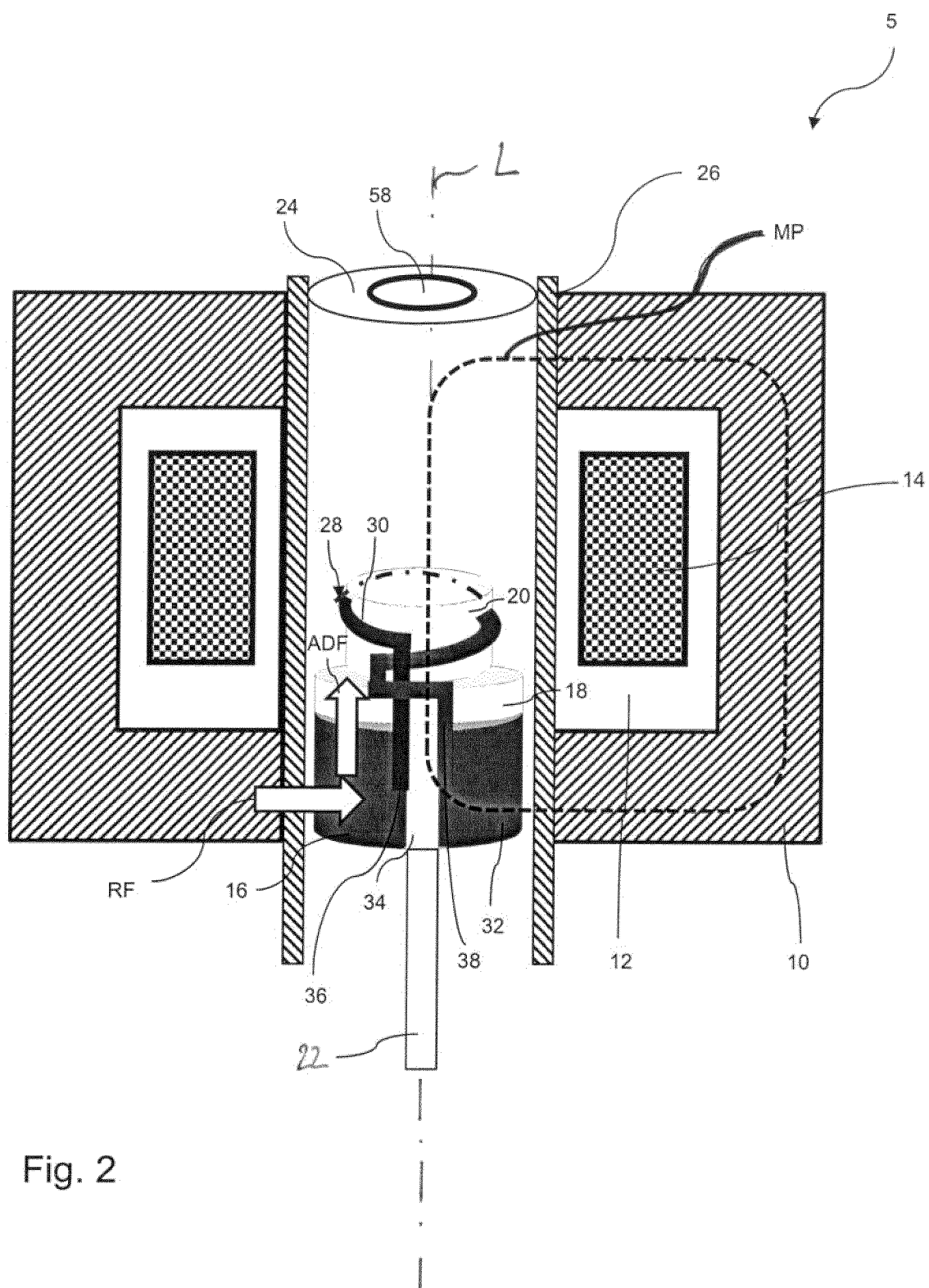
- a first coil (14);
- a valve needle (22) being arranged axially moveable along a longitudinal axis (L) of the actuator assembly;
- an armature (16) being arranged axially moveable along the longitudinal axis and being mechanically coupled to the valve needle (22);
- a second coil (28) being mechanically coupled to the armature (16), the first and the second coil forming a transformer.

2. The actuator assembly according to the preceding claim, wherein

- the second coil (28) is comprised by a closed electrical circuit, the closed electrical circuit having a first section and a second section,
- the second section comprises the second coil (28) and the first section is shaped and arranged such that a current flowing through the first section, together with a magnetic field of the first coil, generates a Lorentz force in a direction along the longitudinal axis.

3. The actuator assembly according to the preceding claim, wherein the second section axially overlaps the first coil (14) and the first section projects axially beyond the first coil (14) or is axially spaced apart from the first coil (14).
- 5 4. The actuator assembly according to the preceding claim, wherein the first and second sections are shaped such that a current through the respective section is directed circumferentially around the longitudinal axis.
5. The actuator assembly according to one of the preceding claims, wherein the second coil (28) comprises one or more turns (30).
- 10 6. The actuator assembly according to one of the preceding claims, wherein the second coil (28) surrounds the armature such that a central axis of the second coil (28) is parallel to or coaxial with the longitudinal axis (L).
7. The actuator assembly according to one of the preceding claims, wherein the turn or turns of the second coil (28) are arranged in a helical nut of the armature (16).
- 15 8. The actuator assembly according to one of the preceding claims, wherein the armature (16) comprises a first cylindrical portion (18) which has a first outer diameter and a second cylindrical portion (20) which has a second outer diameter, the second outer diameter being smaller than the first outer diameter and the second coil (28) is wound around the second cylindrical portion (20) of the armature (16).
- 20 9. The actuator assembly according to the preceding claim, wherein an outer diameter of the turn or turns which are wound around the second portion (20) of the armature (16) corresponds to the first outer diameter.
- 25 10. The actuator assembly according to one of the preceding claims, wherein ends (36, 38) of the second coil are electrically connected to a resistor.
- 30 11. The actuator assembly according to claim 8 or 9, wherein ends (36, 38) of the second coil are electrically connected to a resistor and the resistor is represented by a body (32) of electrically conducting material circumferentially surrounding the first portion (18) of the armature (16) and having a disruption (34) extending in a direction of the longitudinal axis.
- 35 12. The actuator assembly according to claim 10 or 11, wherein the body (32) of electrically conducting material is electrically separated from the armature.
- 40 13. The actuator assembly according to one of the preceding claims, wherein the second coil (28) is made from enameled wire, in particular enameled copper wire, and the armature (16) comprises a magnetic material, in particular ferritic steel.
- 45 14. The actuator assembly according to one of the preceding claims, further comprising a controlling unit connected to the first coil (14) and being adapted to supply a current to the first coil (14) to phase a flux variation of the first coil (14) with a motion of the armature.
- 50 15. Fluid injection valve with a valve assembly which comprises a valve body (26) and an actuator assembly according to one of the preceding claims, the valve body (26) having a cavity (54, 56) which extends in longitudinal direction from a fluid inlet end to a fluid outlet end of the valve body, the first coil (14) being arranged outside of the valve body (26) and the second coil (28) and the armature (16) being arranged inside the cavity (54, 56) of the valve body (26).
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EUROPEAN SEARCH REPORT

Application Number
EP 14 15 8298

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		17 June 2014	Hermens, Sjoerd
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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 14 15 8298

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REFERENCES CITED IN THE DESCRIPTION

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