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(54) **Injection valve**

Einspritzventil

Soupape d'injection

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(73) Proprietor: **Continental Automotive GmbH
30165 Hannover (DE)**

(72) Inventor: **Izzo, Ivano
56124 Pisa (IT)**

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**EP-A1- 1 801 409 EP-A1- 2 123 899
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Description

[0001] The invention relates to an injection valve.

[0002] Injection valves 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. Injection valves may accommodate an actuator for actuating a needle of the injection valve, which may, for example, be an electromagnetic actuator.

[0003] EP 2 123 899 A1 describes a fuel injector comprising an injector body with at least one spray aperture.

[0004] EP 1 801 409 A1 describes a fuel injector with an armature that comprises an upper armature part and a lower armature part, each armature part being independently moveably guided on a pintle.

[0005] WO 02/12712 A1 describes a fuel injection valve for fuel injection systems of internal combustion engines, having a solenoid coil and an armature.

[0006] WO 00/79120 A1 describes a fuel injection valve for fuel injections systems of internal combustion engines, comprising a magnetic coil, an armature which can be impinged upon by the magnetic coil in the direction of lift counter to the action of a return spring, in addition to a valve needle which is connected to a valve closing body.

[0007] DE 3408012 A1 describes an electromagnetic injection valve.

[0008] The object of the invention is to create an injection valve which permits fast actuations.

[0009] These objects are achieved by the features of the independent claim. Advantageous embodiments of the invention are given in the sub-claims.

[0010] The invention is distinguished by an injection valve comprising an injector body with a central longitudinal axis and a first cavity. The injector valve also comprises a valve body, a valve needle, an armature and an actuation unit. The valve body is fixedly coupled with the injector body and comprises a second cavity. The valve needle is axially movable in the second cavity and comprises a first radial surface and prevents a fluid injection in a closing position and permits the fluid injection in further positions. The armature is mechanically decoupled from the valve needle and is axially movable at least partially within the first cavity. The armature comprises a radial armature surface. The first radial surface and the radial armature surface are facing each other and contact each other on a contact area of a predetermined size if the valve needle is in a predetermined axial position. The actuator unit is operable to magnetically actuate the armature to move axially.

[0011] The valve needle comprises a first, a second and a third hollow-cylindrical portion. The hollow-cylindrical portions are hydraulically coupled to each other. The second hollow-cylindrical portion has a larger radial diameter than the first and third hollow-cylindrical portion. The first hollow-cylindrical portion comprises a first orifice

which opens into a fluid inlet portion being operable to provide fluid. The third hollow-cylindrical portion comprises a second orifice which opens into the fluid outlet portion. An outer wall of a transition passage from the first to the second hollow-cylindrical portion at least partially represents the first radial surface of the valve needle. An outer wall of a transition passage from the second to the third hollow-cylindrical portion at least partially represents the second radial surface of the valve needle. Such hollow space represents the hydraulic conduit. Furthermore, such valve needle contributes to reducing its mass and by this contributes to reducing the required size of the contact area.

[0012] The valve body comprises a fluid outlet portion which is closed to prevent the fluid injection or which is opened to permit the fluid injection dependent on an axial position of the valve needle. The fluid outlet portion is operable to be filled with fluid. The valve needle comprises a second radial surface being axially positioned in the fluid outlet portion in such a way that a predetermined hydraulic force acts on the second radial surface in a direction away from the closing position. This supports the axial movement of the valve needle away from the closing position.

[0013] The mechanically decoupling of the armature from the valve needle means that both components are not fixedly coupled to each other. This contributes to reducing a mass inertia that the armature exerts against a magnetic force resulting from the actuation of the actuation unit. This allows to accordingly reducing a transition time between the closing and further positions of the valve needle. Furthermore, this has the advantage that the injection valve contributes to performing multiple injections of the fluid per time unit, in particular per operation cycle of a combustion engine, also at high rotational speed.

[0014] The first radial surface of the valve needle and the radial armature surface are preferably perpendicularly aligned to the longitudinal axis and both surfaces overlap. At least in the closing position the both overlapping surfaces are in contact to each other and feature the contact area of the predetermined size. The contact between both surfaces may also comprise a fluid layer.

[0015] If for example the actuation unit is energized, a magnetic force is acting on the armature. By this, the armature axially moves away from the closing position with a predetermined velocity. If the velocity is high enough, the axial movement of the armature results in suction force acting on the valve needle. Due to the suction force, the valve needle axially moves away from the closing position.

[0016] The size of the contact area is typically dependent from the velocity of the armature. That means, the higher the size of the contact area between the first radial surface and the radial armature surface, the lower the required velocity to establish the suction force.

[0017] Another advantage of such injection valve is a reduction of mechanical shocks (bouncing) involving the

moveable parts due to mechanical damping resulting from hydraulic mediation of contact forces.

[0018] In an advantageous embodiment of the invention, the first radial surface and the radial armature surface contact each other if the valve needle is in the closing position. By this, the armature contributes to pushing the valve needle on a valve needle seat to reliably prevent the fluid injection.

[0019] In a further advantageous embodiment of the invention, the valve needle comprises a recess featuring a hydraulic conduit to fill the fluid outlet portion with fluid. This has the advantage that the hydraulic conduit reduces a mass of the valve needle. The mass of the valve needle also has influence on the size of the contact area. That means, the lower the mass of the valve needle, the smaller the required size of the contact area to move the valve needle axially.

[0020] In a further advantageous embodiment of the invention, the armature comprises an axial armature recess which at least partially takes in the first hollow-cylindrical portion of the valve needle. The first hollow-cylindrical portion serves to guide the axial movement of the armature. This guiding feature does not establish an axial coupling of the armature and the valve needle.

[0021] In a further advantageous embodiment of the invention, the first radial surface and the armature surface are planar. This results in a high suction force acting on the valve needle and contributes to reducing the size of the contact area.

[0022] Exemplary embodiments of the invention are explained in the following with the aid of schematic drawings. These are as follows:

Fig. 1 a valve assembly,

Fig. 2a-2f sections of an injection valve.

[0023] Elements of the same design and function that appear in different illustrations are identified by the same reference character.

[0024] An injection valve 62 (Fig 2) may be used as a fuel injection valve for a combustion chamber of an internal combustion engine and comprises a valve assembly 60 and an actuator unit 40. The injection valve 62 comprises an injector body 38 with a first cavity 7 and a central longitudinal axis L. The first cavity 7 may be hydraulically coupled with a fluid inlet portion being operable to provide fluid under high pressure, for example, under the pressure of about 200 bar in the case of a gasoline engine or of more than 2000 bar in the case of a diesel engine. An armature 12 is arranged within the first cavity 7 and is operable to axially move therein.

[0025] The valve assembly 60 comprises a valve body 4 with a second cavity 8 which is axially led through the valve body 4. The valve body 4 is mechanically coupled to the injector body 38. The valve assembly 60 further comprises a valve needle 10 taken in by the second cavity 8. The valve needle 10 preferably comprises a sphere

54. On one of the free ends of the second cavity 8 of the valve body 4 a fluid outlet portion 44 is formed which is closed or opened depending on an axial position of the valve needle 10. In a closing position of the valve needle 10, the sphere 54 rests sealingly on a valve needle seat 28 thereby preventing a fluid injection through at least one injection nozzle in the valve body 4. The injection nozzle may be for example an injection hole, but it may also be of some other type suitable for dosing fluid. In further positions of the valve needle 10, the sphere 54 does not rest on the valve needle seat 28 and permits the fluid injection through the injection nozzle.

[0026] The valve needle 10 further comprises a first, a second and a third hollow-cylindrical portion 10a, 10b, 10c. The second hollow-cylindrical portion 10b has a larger radial diameter than the first and third hollow-cylindrical portion 10a, 10c. A first radial surface 30 of the valve needle 10 is formed by an outer wall of a transition passage between the first and second hollow-cylindrical portion 10a, 10b. A second radial surface 50 of the valve needle 10 in the area of the fluid outlet portion 44 is formed by an outer wall of a transition passage between the second and third hollow-cylindrical portion 10b, 10c. The hollow-cylindrical portions 10a, 10b, 10c are hydraulically coupled to each other. The first hollow-cylindrical portion 10a comprises a first orifice 46 and the third hollow-cylindrical portion 10c comprises a second orifice 48. The first orifice 46 opens into a fluid inlet portion which is operable to provide fluid under a predetermined hydraulic pressure, in particular high hydraulic pressure, and the second orifice 48 opens into the fluid outlet portion 44.

[0027] The armature 12 is not fixedly coupled to the valve needle 10 and comprises an armature recess 34 which at least partially takes in the first hollow-cylindrical portion 10a. By this, the first hollow-cylindrical portion 10a serves as an axial guiding element for the armature 12. The armature 12 further comprises a radial armature surface 32 which faces the first radial surface 30 of the valve needle 10.

[0028] A bias spring 20 is arranged inside the injector body 38 and preferably rests on an adjusting tube 2 of the injector body 38 which may be moved axially during the manufacturing process of the injection valve 62 in order to preload the bias spring 20 in a desired way. On the other side, the bias spring 20 rests on the armature 12.

[0029] The injection valve 62 is provided with a drive, which is preferably an electromagnetic drive, comprising for example an actuation unit 40. The actuation unit 40, the valve body 4 and the armature 12 may form an electromagnetic circuit.

[0030] If the valve needle 10 is in the closing position, the first radial surface 30 is typically in contact to the radial armature surface 32. The first radial surface 30 and the radial armature surface 32 are preferably planar and contact each other in a contact area 56 of a predetermined size.

[0031] If the actuation unit 40 is energized, a resulting

electromagnetic force F_m acts on the armature 12. The electromagnetic force F_m acts against a mechanical force F_s obtained from the bias spring 20. By appropriately energizing the actuation unit 40, the armature 12 may in that way be moved away from the closing position. After a predetermined time the actuation unit 40 may be de-energized again.

[0032] Fig. 2a to 2b show sections of the valve assembly 60 while being energized and de-energized by the actuation unit 40. As shown in Fig. 2a, the bias spring 20 exerts the mechanical force F_s onto the armature 12 which transfers it to the valve needle 10 by means of the contact area 56. In addition, a hydraulic force F_h acts on the sphere 54 to press it into the valve needle seat 28. Both, the mechanical and hydraulic force F_s , F_h permits the closing position of the valve needle 10.

[0033] As soon as the actuation unit 40 is energized, the armature 12 charges (Fig. 2b) and axially moves towards an impact face 24 of the inlet tube of the injection valve 62 by moving away from the first radial surface 30 of the valve needle 10 (Fig. 2c). That relative axial movement between the armature 12 and the valve needle 10 results in a pressure reduction in the space occurring between the radial armature surface 32 and the first radial surface 30 (Fig. 2c). Due to the pressure reduction a suction force results acting on the valve needle 10 towards an axial direction away from the closing position. In addition, the hydraulic force F_h acting on the second radial surface 50 of the valve needle 10 in the fluid outlet portion 44 supports an axial movement of the valve needle 10 away from the closing position (Fig. 2c and 2d). In conclusion, the valve needle 10 and its sphere 54 axially move away from the closing position and permit the fluid injection through the injection nozzle.

[0034] The suction force acting on the valve needle 10 is dependent on the size of the overlapping area of the first radial surface 30 and the radial armature surface 32 and on the velocity the armature 12 is axially moving towards the impact face 24.

[0035] Due to the high hydraulic pressure in the first cavity 7, the hydraulic pressure in the space between the first radial surface 30 and the radial armature surface 32 increases (Fig. 2e). This makes the valve needle 10 axially move towards the valve needle seat 28. This typically occurs independently from the current axial position of the armature 12.

[0036] At the same time, the actuation unit 40 may be de-energized. As soon as the mechanical force F_s overcomes a hydraulic sticking force occurring between the impact face 24 and the armature 12, the armature 12 begins to axially move towards the closing position (Fig. 2f).

[0037] The sphere 54 of the valve needle 10 may already rest in the valve needle seat 28 when the armature 12 impacts the first radial surface 30 of the valve needle 10. Alternatively, the bias spring 20 may be selected in such a way, that the armature 12 impacts the first radial surface 30 of the valve needle 10 while the valve needle

10 axially moves towards the valve needle seat 28.

Claims

1. Injection valve (62), comprising

- an injector body (38) with a central longitudinal axis (L) and a first cavity (7),
- a valve body (4) being fixedly coupled with the injector body (38) and comprising a second cavity (8),
- a valve needle (10) being axially movable in the second cavity (8) and comprising a first radial surface (30) and preventing a fluid injection in a closing position and permitting the fluid injection in further positions,
- an armature (12) being mechanically decoupled from the valve needle (10) and being axially movable at least partially within the first cavity (7) and comprising a radial armature surface (32), whereas the first radial surface (30) and the radial armature surface (32) are facing each other and contact each other on a contact area (56) of a predetermined size if the valve needle (10) is in a predetermined axial position,
- an actuator unit (40) being operable to magnetically actuate the armature (12) to move axially,
- a fluid inlet portion being operable to provide fluid under a predetermined hydraulic pressure

characterized in that

- the valve body (4) comprises a fluid outlet portion (44) which is closed to prevent the fluid injection or which is opened to permit the fluid injection dependent on an axial position of the valve needle (10) and which is operable to be filled with fluid, whereas the valve needle (10) comprises a second radial surface (50) being axially positioned in the fluid outlet portion (44) in such a way that a predetermined hydraulic force (F_h) acts on the second radial surface (50) in a direction away from the closing position,
- the valve needle (10) comprises a first hollow-cylindrical portion (10a), a second hollow-cylindrical portion (10b) and a third hollow-cylindrical portion (10c),
- the hollow-cylindrical portions (10a, 10b, 10c) are hydraulically coupled to each other,
- the second hollow-cylindrical portion (10b) has a larger radial diameter than the first and third hollow-cylindrical portion (10a, 10c),
- the first hollow-cylindrical portion (10a) comprises a first orifice (46) which opens into the fluid inlet portion and the third hollow-cylindrical portion (10c) comprises a second orifice (48) which opens into the fluid outlet portion (44),

- an outer wall of a transition passage from the first to the second hollow-cylindrical portion (10a, 10b) at least partially represents the first radial surface (30) of the valve needle (10),
 - an outer wall of a transition passage from the second to the third hollow-cylindrical portion (10b, 10c) at least partially represents the second radial surface (50) of the valve needle (10).
2. Injection valve (62) according to claim 1, whereas the first radial surface (30) and the radial armature surface (32) contact each other if the valve needle (10) is in the closing position.
 3. Injection valve (62) according to one of the preceding claims, whereas the valve needle (10) comprises a recess featuring a hydraulic conduit to hydraulically couple the fluid inlet portion with the fluid outlet portion (44).
 4. Injection valve (62) according to one of the preceding claims, whereas the armature (12) comprises an axial armature recess (34) which at least partially takes in the first hollow-cylindrical portion (10a) of the valve needle (10).
 5. Injection valve (62) according to one of the preceding claims, whereas the first radial surface (30) and the armature surface (32) are planar.

Patentansprüche

1. Einspritzventil (62) umfassend
 - einen Injektorkörper (38) mit einer zentralen Längsachse (L) und einem ersten Hohlraum (7),
 - einem Ventilkörper (4), der fest mit dem Injektorkörper (38) verbunden ist und einen zweiten Hohlraum (8) umfasst,
 - eine Ventilnadel (10), die axial in dem zweiten Hohlraum (8) bewegbar ist und eine erste radiale Oberfläche (30) umfasst und eine Fluid-Einspritzung in einer Schließposition vermeidet und die Fluid-Einspritzung in weiteren Positionen erlaubt,
 - eine Armatur (12) die mechanisch von der Ventilnadel (10) entkoppelt ist und zumindest teilweise innerhalb des ersten Hohlraumes (7) axial bewegbar ist und eine radiale Armatureoberfläche (32) umfasst, wobei die erste radiale Oberfläche (30) und die radiale Armatureoberfläche (32) einander zugewandt sind und sich gegenseitig an einer Kontaktfläche (56) von vorbestimmter Größe kontaktieren, wenn sich die Ventilnadel (10) in einer vorbestimmten axialen Position befindet,
 - eine Stellantriebseinheit (40), die betriebsfähig

ist, die Armatur (12) magnetisch zu betätigen, sich axial zu bewegen,

- eine Fluid-Einlassstück, das betriebsfähig ist, Fluid unter einem vorbestimmten hydraulischen Druck bereit zu stellen, **dadurch gekennzeichnet, dass**
- der Ventilkörper (4) ein Fluid-Auslassstück (44) umfasst, welches geschlossen ist, um die Fluid-Einspritzung zu vermeiden, oder welches geöffnet ist, um die Fluid-Einspritzung abhängig von der axialen Position der Ventilnadel (10) zu erlauben, und welches betriebsbereit ist, mit Fluid gefüllt zu sein, wobei die Ventilnadel (10) eine zweite radiale Oberfläche (50) umfasst, die axial in einer Weise in dem Fluid-Auslassstück (44) positioniert ist, dass eine vorbestimmte hydraulische Kraft (Fh) auf die zweite radiale Oberfläche (50) in einer Richtung weg von der Schließposition wirkt,
- die Ventilnadel (10) ein erstes hohlzylindrisches Stück (10a), ein zweites hohlzylindrisches Stück (10b) und ein drittes hohlzylindrisches Stück (10c) umfasst,
- die hohlzylindrischen Stücke (10a, 10b, 10c) hydraulisch miteinander gekoppelt sind,
- das zweite hohlzylindrische Stück (10b) einen größeren radialen Durchmesser als das erste und dritte hohlzylindrische Stück (10a, 10c) aufweist,
- das erste hohlzylindrische Stück (10a) eine erste Öffnung (46) umfasst, welche sich in das Fluid-Einlassstück öffnet, und das dritte hohlzylindrische Stück (10c) eine zweite Öffnung (48) umfasst, welche sich in das Fluid-Auslassstück (44) öffnet,
- eine äußere Wand einer Übergangspassage von dem ersten zum zweiten hohlzylindrischen Stück (10a, 10b) mindestens teilweise die erste radiale Oberfläche (30) der Ventilnadel (10) darstellt,
- eine äußere Wand einer Übergangspassage von dem zweiten zum dritten hohlzylindrischen Stück (10b, 10c) mindestens teilweise die zweite radiale Oberfläche (50) der Ventilnadel (10) darstellt.

2. Einspritzventil (62) nach Anspruch 2, wobei die erste radiale Oberfläche (30) und die radiale Armatureoberfläche (32) einander kontaktieren, wenn die Ventilnadel (10) sich in der Schließposition befindet.
3. Einspritzventil (62) nach einem der vorangegangenen Ansprüche, wobei die Ventilnadel (10) eine Ausnehmung umfasst, die mit einer hydraulischen Leitung ausgestattet ist, um das Fluid-Einlassstück mit dem Fluid-Auslassstück (44) hydraulisch zu koppeln.

4. Einspritzventil (62) nach einem der vorangegangenen Ansprüchen, wobei die Armatur (12) eine axiale Armaturausnehmung (34) umfasst, die wenigstens teilweise das erste hohlzylindrische Stück (10a) der Ventilmadel (10) aufnimmt. 5
5. Einspritzventil (62) nach einem der vorangegangenen Ansprüchen, wobei die erste radiale Oberfläche (30) und die radiale Armaturoberfläche (32) eben sind. 10

Revendications

1. Soupape d'injection (62), comprenant : 15

- un corps d'injecteur (38) avec un axe longitudinal central (L) et une première cavité (7) ;
 - un corps de soupape (4) couplé de manière fixe au corps d'injecteur (38) et comprenant une seconde cavité (8) ; 20
 - un pointeau de soupape (10) axialement mobile dans la seconde cavité (8) et comprenant une première surface radiale (30) et empêchant une injection de fluide dans une position de fermeture et permettant l'injection de fluide dans les autres positions ; 25
 - un induit (12) mécaniquement découplé du pointeau de soupape (10) et axialement mobile au moins partiellement à l'intérieur de la première cavité (7) et comprenant une surface d'induit radiale (32), dans laquelle la première surface radiale (30) et la surface d'induit radiale (32) se font face l'une à l'autre et sont en contact l'une avec l'autre sur une zone de contact (56) d'une taille prédéterminée si le pointeau de soupape (10) se trouve dans une position axiale prédéterminée ; 30
 - une unité d'actionnement (40) fonctionnelle pour magnétiquement actionner l'induit (12) de façon à ce qu'il se déplace axialement ; 35
 - une partie entrée de fluide fonctionnelle pour fournir le fluide sous une pression hydraulique prédéterminée ; 40
- caractérisée en ce que :**
- le corps de soupape (4) comprend une partie sortie de fluide (44) qui est fermée pour empêcher l'injection de fluide ou qui est ouverte pour permettre l'injection de fluide en fonction d'une position axiale du pointeau de soupape (10) et qui est fonctionnel pour être rempli avec le fluide, dans laquelle le pointeau de soupape (10) comprend une seconde surface radiale (50) axialement positionnée dans la partie sortie de fluide (44) de telle sorte qu'une force hydraulique prédéterminée (F_h) agisse sur la seconde surface radiale (50) dans une direction en s'éloignant de la position de fermeture ; 45
 - le pointeau de soupape (10) comprend une 50

première partie cylindrique creuse (10a), une deuxième partie cylindrique creuse (10b) et une troisième partie cylindrique creuse (10c) ;

- les parties cylindrique creuses (10a, 10b, 10c) sont hydrauliquement couplées les unes aux autres ;
- la deuxième partie cylindrique creuse (10b) présente un diamètre radial plus grand que celui des première et troisième parties cylindriques creuses (10a, 10c) ;
- la première partie cylindrique creuse (10a) comprend un premier orifice (46) qui s'ouvre dans la partie entrée de fluide et la troisième partie cylindrique creuse (10c) comprend un second orifice (48) qui s'ouvre dans la partie sortie de fluide (44) ;
- une paroi extérieure d'un passage de transition à partir de la première partie cylindrique creuse (10a) vers la deuxième partie cylindrique creuse (10b) représente au moins partiellement la première surface radiale (30) du pointeau de soupape (10) ;
- une paroi extérieure d'un passage de transition à partir de la deuxième partie cylindrique creuse (10b) vers la troisième partie cylindrique creuse (10c) représente au moins partiellement la seconde surface radiale (50) du pointeau de soupape (10).

2. Soupape d'injection (62) selon la revendication 1, dans laquelle la première surface radiale (30) et la surface d'induit radiale (32) sont en contact l'une avec l'autre si le pointeau de soupape (10) se trouve dans la position de fermeture. 35

3. Soupape d'injection (62) selon l'une quelconque des revendications précédentes, dans laquelle le pointeau de soupape (10) comprend un renforcement caractérisant un conduit hydraulique pour hydrauliquement coupler la partie entrée de fluide avec la partie sortie de fluide (44). 40

4. Soupape d'injection (62) selon l'une quelconque des revendications précédentes, dans laquelle l'induit (12) comprend un renforcement d'induit axial (34) qui rentre au moins partiellement dans la première partie cylindrique creuse (10a) du pointeau de soupape (10). 45

5. Soupape d'injection (62) selon l'une quelconque des revendications précédentes, dans laquelle la première surface radiale (30) et la surface d'induit (32) sont planes. 50

FIG 1

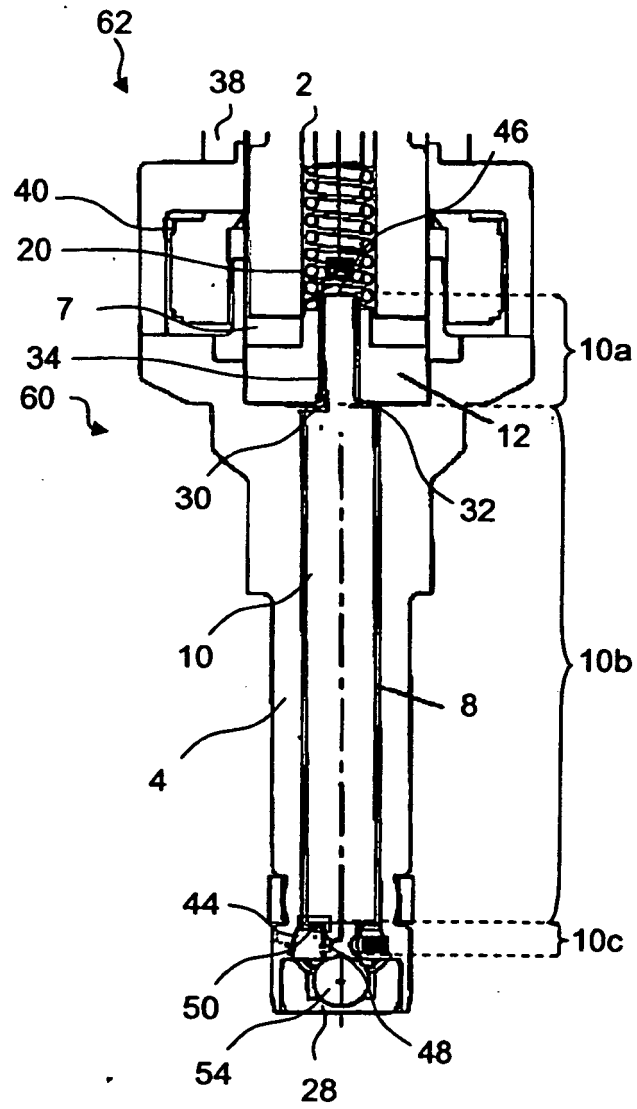


FIG 2a

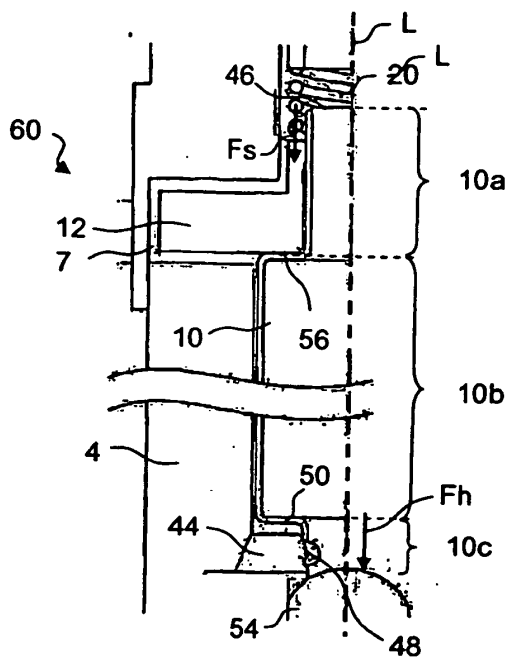


FIG 2b

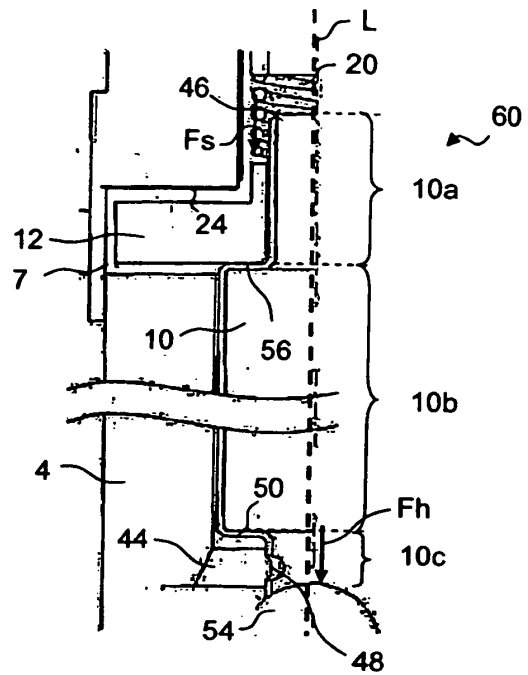


FIG 2c

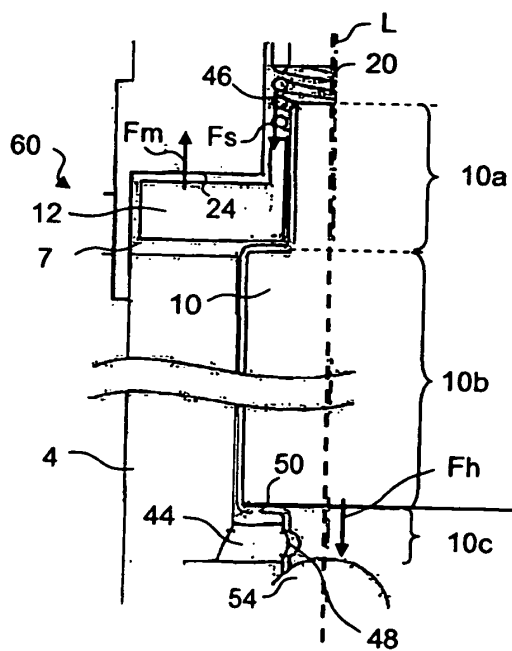


FIG 2d

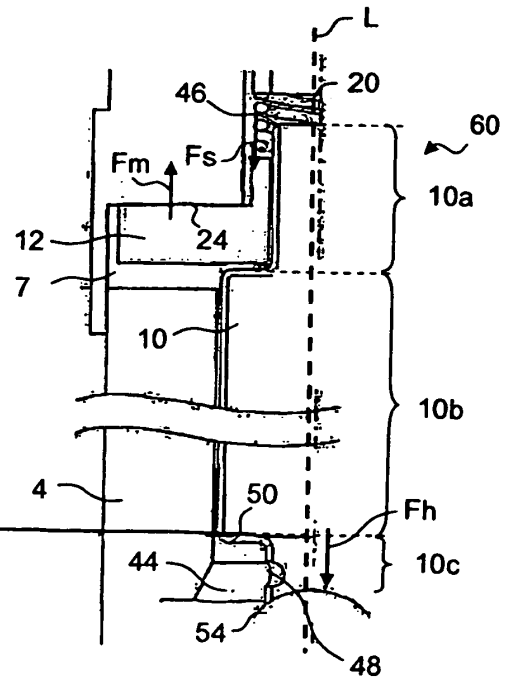


FIG 2e

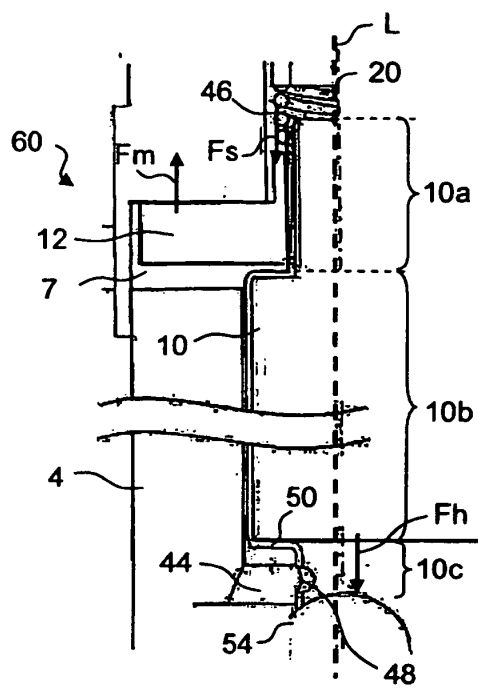
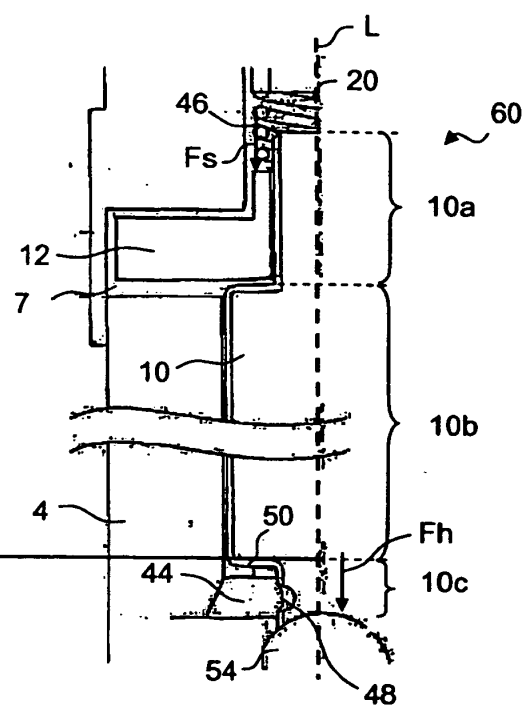


FIG 2f



REFERENCES CITED IN THE DESCRIPTION

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