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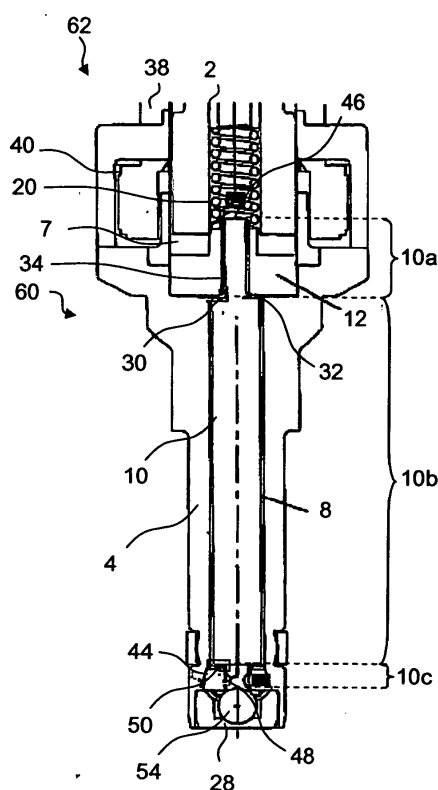
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(54) **Injection valve**

(57) Injection valve (62) comprising an injector body (38) with a central longitudinal axis (L) and a first cavity (7). The injection valve (62) also comprises a valve body (4), a valve needle (10), an armature (12) and an actuation unit (4). The valve body (4) comprises a second cavity (8). The valve needle (10) is axially movable in the second cavity (8) and comprises a first radial surface (30). The armature (12) is decoupled from the valve needle (10) and is axially movable at least partially within the first cavity (7) and comprises a radial armature surface (32). The first radial surface (30) and the radial armature surface (32) are facing each other and feature a contact area (50) of a predetermined size if the valve needle (10) is in a predetermined axial position. The actuator unit (40) is operable to magnetically actuate the armature (12) to move axially.

dle (10) and is axially movable at least partially within the first cavity (7) and comprises a radial armature surface (32). The first radial surface (30) and the radial armature surface (32) are facing each other and feature a contact area (50) of a predetermined size if the valve needle (10) is in a predetermined axial position. The actuator unit (40) is operable to magnetically actuate the armature (12) to move axially.

FIG 1



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

[0004] These objects are achieved by the features of the independent claim. Advantageous embodiments of the invention are given in the sub-claims.

[0005] 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.

[0006] 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.

[0007] 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.

[0008] 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.

[0009] 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.

[0010] 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.

[0011] 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.

[0012] In a further advantageous embodiment of the invention, 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] In a further advantageous embodiment of the invention, the valve needle comprises a recess featuring a hydraulical 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.

[0014] In a further advantageous embodiment of the invention, 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.

[0015] 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.

[0016] 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.

[0017] 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.

[0018] Elements of the same design and function that appear in different illustrations are identified by the same reference character.

[0019] 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.

[0020] 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.

[0021] 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

cal 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.

[0022] 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.

[0023] 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.

[0024] 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.

[0025] 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.

[0026] 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.

[0027] 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.

[0028] 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.

[0029] 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.

[0030] 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.

[0031] 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).

[0032] 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 (50) 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.

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 claim 1 or 2, whereas the valve body (4) comprises a fluid outlet portion (44) which is closed to prevent the fluid injection or which 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.

4. 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 a fluid inlet portion with the fluid outlet portion (44), whereas the fluid inlet portion is operable to provide fluid under a predetermined hydraulic pressure.

5. Injection valve (62) according to one of the preceding claims, whereas

- 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). 5

6. 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). 10

7. Injection valve (62) according to one of the preceding claims, whereas the first radial surface (30) and the armature surface (32) are planar. 15

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FIG 1

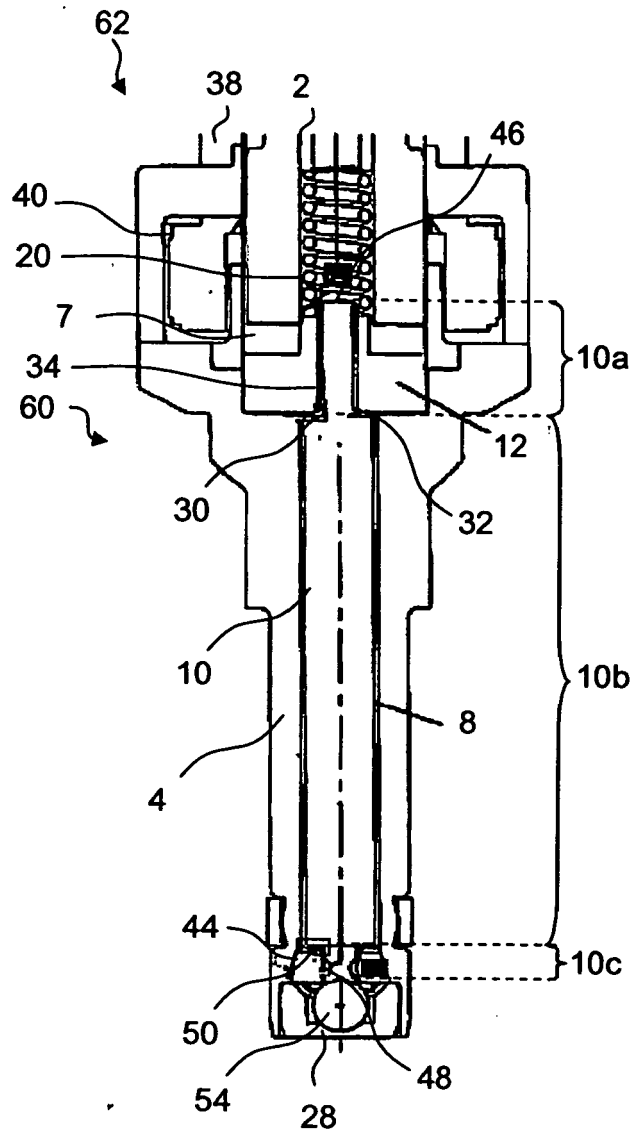


FIG 2a

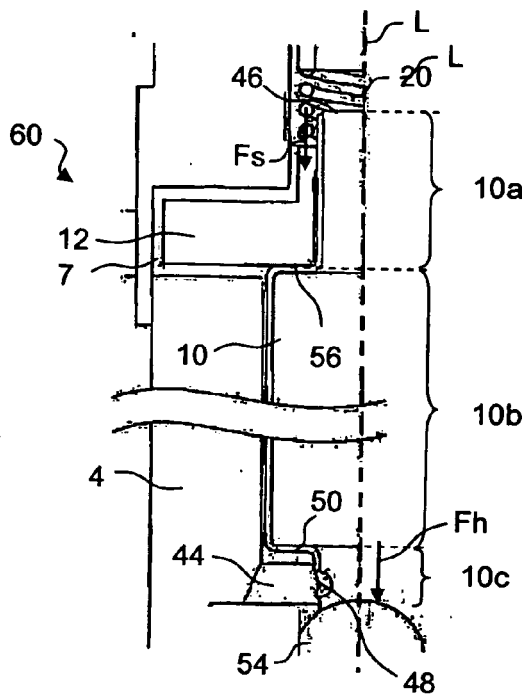


FIG 2b

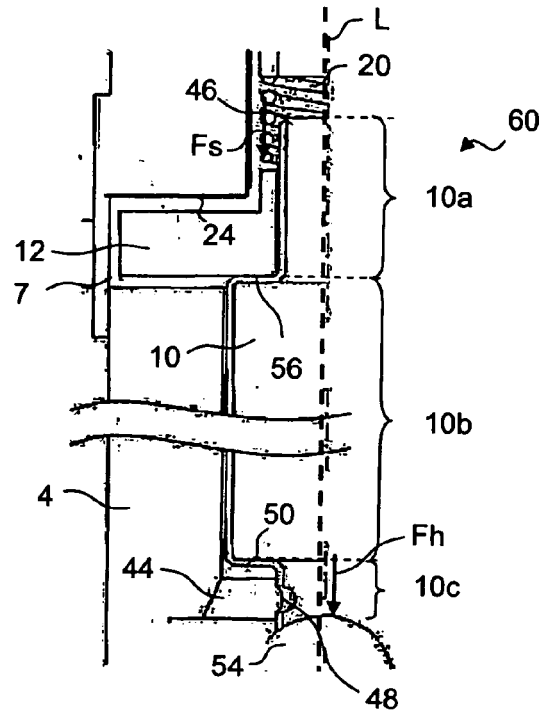


FIG 2c

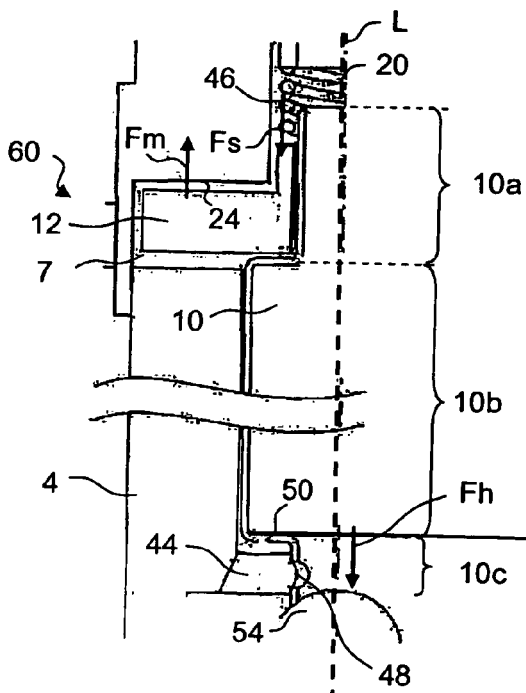


FIG 2d

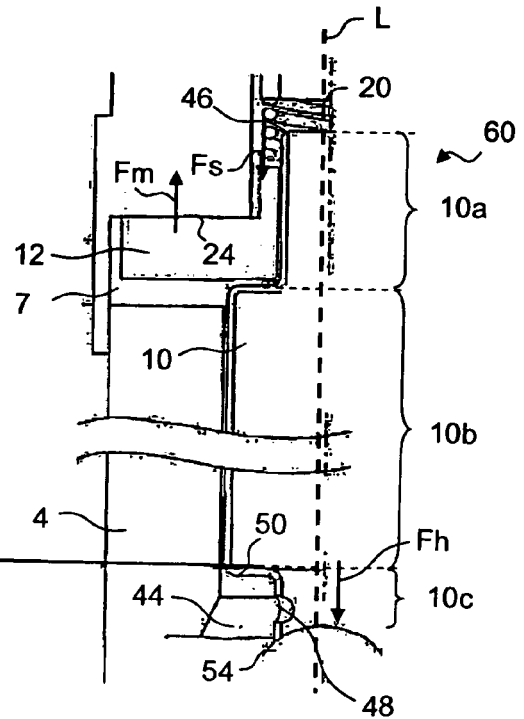


FIG 2e

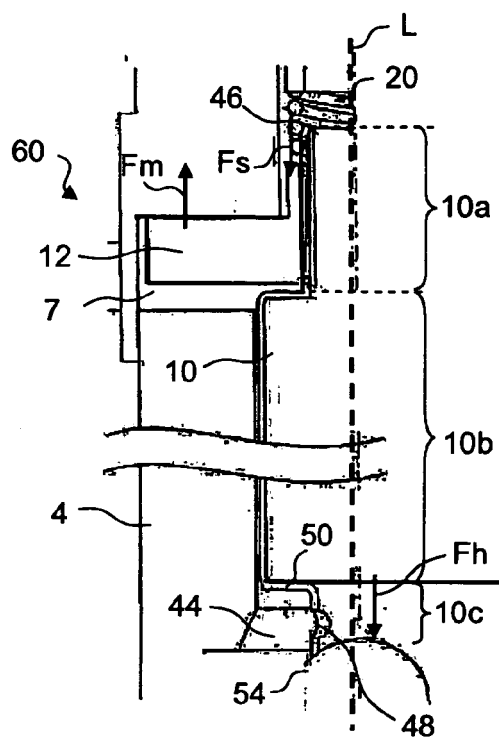
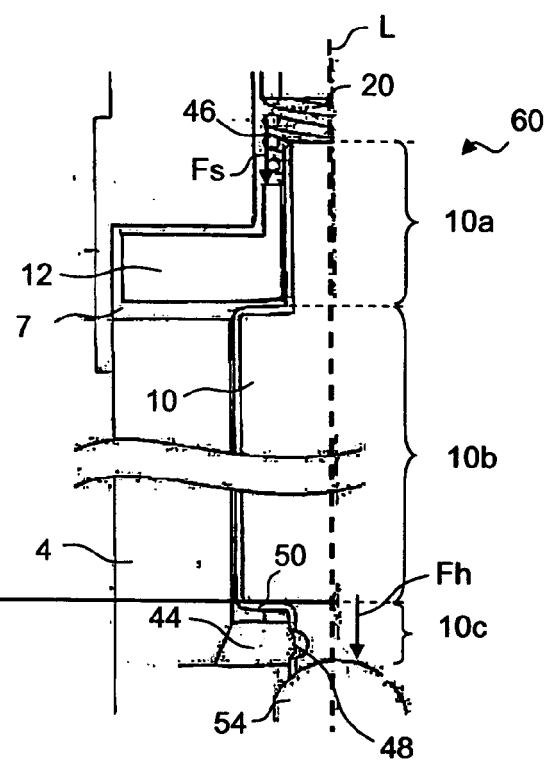


FIG 2f





EUROPEAN SEARCH REPORT

Application Number
EP 10 00 2172

DOCUMENTS CONSIDERED TO BE RELEVANT			
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A	* paragraph [0015] - paragraph [0046]; figures 1-4 *	5,6	
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A	* page 8, line 29 - page 9, line 37; figure 3 *	5	
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Place of search Munich		Date of completion of the search 7 September 2010	Examiner Kolland, Ulrich
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 10 00 2172

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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