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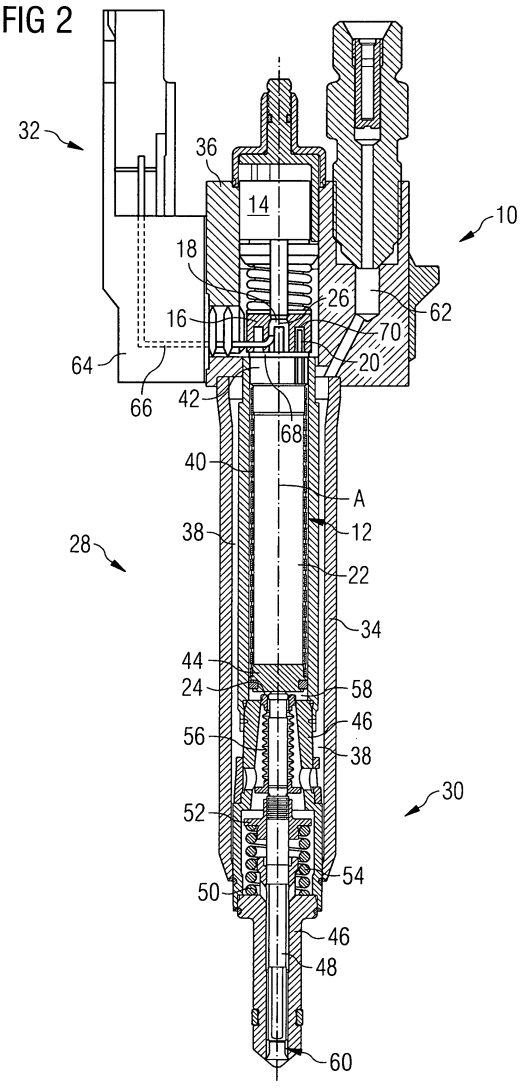
(54) Actuator arrangement and injection valve

(57) Actuator arrangement (10), comprising a solid state actuator unit (12) with a longitudinal axis (A) comprising electric pins (20) being electrically coupable to a power supply and a piston (18), wherein the solid state actuator unit (12) comprises a first axial end area (24) designed to act as drive side and a second axial end area (26) facing away from the first axial end area (24), a compensator unit (14) being arranged facing the second axial end area (26) of the solid state actuator unit (12) along the longitudinal axis (A) of the solid state actuator unit (12) and being in contact with the solid state actuator unit (12) via the piston (18), and a damping element (16) being designed and arranged in-between the compensator unit (14) and the solid state actuator unit (12) facing the second axial end area (26) of the solid state actuator unit (12), the damping element (16) being preloaded by the compensator unit (14) and the solid state actuator unit (12).

FIG 2



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Description

[0001] The invention relates to an actuator arrangement and injection valve.

[0002] Actuator arrangements are in wide spread use, in particular injection valves for instance for internal combustion engines comprise actuator arrangements, which comprise solid state actuator units. In order to inject fuel, the solid state actuator unit is energized so that a fluid flow through the fluid outlet portion of the injection valve is enabled.

[0003] In order to enhance the combustion process in view of the creation of unwanted emissions, the respective injection valve may be suited to dose fluids under very high pressures. The pressures may be in case of a gasoline engine, for example in a range of up to 200 bar or in the case of diesel engines in a range of up to 2,000 bar. In order to enable fast response times electric energy needs to be transmitted to or from the actuator arrangement in a very fast way.

[0004] The object of the invention is to create an actuator arrangement that is simply to be manufactured and which enables reliable operation.

[0005] This object is achieved by the features of the independent claims. Advantageous embodiments of the invention are given in the sub-claims.

[0006] According to a first aspect the invention is distinguished by an actuator arrangement, comprising a solid state actuator unit with a longitudinal axis comprising electric pins being electrically coupable to a power supply and a piston, wherein the solid state actuator unit comprises a first axial end area designed to act as drive side and a second axial end area facing away from the first axial end area, a compensator unit being arranged facing the second axial end area of the solid state actuator unit along the longitudinal axis of the solid state actuator unit and being in contact with the solid state actuator unit via the piston, and a damping element being designed and arranged in-between the compensator unit and the solid state actuator unit facing the second axial end area of the solid state actuator unit, the damping element being preloaded by the compensator unit and the solid state actuator unit.

[0007] This has the advantage that undesired movements of the solid state actuator unit can be prevented and vibrations within the actuator arrangement can be limited due to the fact that the damping element is designed to dampen movements of the solid state actuator unit in the second axial end area. In particular, electric connections and resistance weldings between the electric pins of the solid state actuator unit and the power supply can be protected against undesired movements and vibrations. Moreover, the damping element within the actuator arrangement is simply to be manufactured. Also, the damping element can be mounted between the compensator unit and the solid state actuator unit to enable the correct arrangement. In addition to the compensator unit, the preloaded damping element may provide an axial preload force.

[0008] In an advantageous embodiment the damping element is preloaded with an axial preload force in the range of 10 N. By this, the damping of the actuator arrangement can be carried out especially reliable.

[0009] In a further advantageous embodiment the damping element comprises a silicon base. This has the advantage that the damping of the actuator arrangement is especially reliable.

[0010] In a further advantageous embodiment the damping element comprises a plastic. By this, the damping of the actuator arrangement can be carried out especially reliable. In addition, plastic can be processed fast and in that way contribute to a low production time for the actuator arrangement.

[0011] In a further advantageous embodiment the damping element comprises rubber. By this, the damping of the actuator arrangement can be carried out especially reliable. Also the rubber can be processed fast and in that way contribute to a low production time for the actuator arrangement.

[0012] According to a second aspect the invention is distinguished by an injection valve with a valve assembly within a recess of a housing body and an actuator arrangement of the first aspect of the invention, comprising a solid state actuator unit within the recess, wherein the solid state actuator unit is being designed for acting on the valve assembly.

[0013] Exemplary embodiments of the invention are explained in the following with the help of schematic drawings. These are as follows:

Figure 1, an actuator arrangement,

Figure 2, a specific actuator arrangement in an injection valve.

[0014] Elements of the same design and function that appear in different illustrations are identified by the same reference characters.

[0015] Figure 1 shows an actuator arrangement 10 comprising a solid state actuator unit 12, a compensator unit 14 and a damping element 16.

[0016] The solid state actuator unit 12 has a longitudinal axis A and comprises a piston 18 and electric pins 20 being electrically coupable to a power supply. For example, the electric pins 20 might be coupled by weldings, in particular resistance weldings, or soldered connections to an electric conductor 66 (figure 2), which is supplied with electric energy. In particular, injection valves for instance for internal combustion engines may comprise the actuator arrangement 10.

[0017] The solid state actuator unit 12 comprises a solid state actuator 22. The solid state actuator 22 changes its length in axial direction depending on a control signal applied to it such as electric energy supplied to it. The solid state actuator unit 12 is typically a piezo actuator unit. It may however also be any other solid state actuator

unit known to the person skilled in the art such as a magnetostrictive actuator unit.

[0018] The solid state actuator unit 12 comprises a first axial end area 24 designed to act as drive side and a second axial end area 26, which is facing away from the first axial end area 24, in particular facing the damping element 16. On the drive side of the solid state actuator unit 12 facing the first axial end area 24 optional actuating elements are arranged such as a valve needle or a rotor.

[0019] The compensator unit 14 is arranged facing the second axial end area 26 of the solid state actuator unit 12 along the longitudinal axis A of the solid state actuator unit 12 and is mechanically coupled to the piston 18 of the solid state actuator unit 12. The compensator unit 14 enables to set an axial preload force on the solid state actuator unit 12 via the piston 18 of the solid state actuator unit 12. In particular, the compensator unit 14 is a thermal compensator unit, which is enabled to compensate temperature changes.

[0020] The damping element 16 is arranged in-between the compensator unit 14 and the solid state actuator unit 12 facing the second axial end area 26 of the solid state actuator unit 12. The damping element 16 is preloaded by the compensator unit 14 and the solid state actuator unit 12. Typically, the damping element 16 is preloaded with an axial preload force in the range of 10 N.

[0021] The electric pins 20 of the solid state actuator unit 12 can be arranged in optional direction, for instance in axial direction of the solid state actuator unit 12 or perpendicular to it. In particular, the electric pins 20 protrude in the damping element 16. In particular, the piston 18 of the solid state actuator unit 12 protrudes in the damping element 16.

[0022] The energizing of the solid state actuator unit 12 may cause undesired movements and vibrations within the actuator arrangement 10, which for example might stress weldings. By the damping element 16, which is mechanically coupled to the solid state actuator unit 12, undesired movements of the solid state actuator unit 12 can be prevented and vibrations within the second axial end area 24 of the actuator arrangement 10 can be limited. In particular, electric connections and resistance weldings between the electric pins 20 of the solid state actuator unit 12 and the power supply can be protected against undesired movements and vibrations. The damping element 16 may comprise for example a silicon base or a plastic such as rubber. Therefore, some kind of elasticity for damping may be provided. And by this, the damping element 16 is simply to be manufactured.

[0023] Figure 2 shows an injection valve 28 that may be used as a fuel injection valve for an internal combustion engine. The injection valve 28 comprises a valve assembly 30, the actuator arrangement 10 and a connector 32. The actuator arrangement 10 comprises the solid state actuator unit 12.

[0024] The injection valve 28 has a two-part housing body 34, 36 with a tubular shape with the central longitudinal axis A. The housing body 34, 36 of the injection valve 28 comprises a recess 38 which is axially led through the housing body 34, 36.

[0025] The solid state actuator unit 12 is arranged within the recess 38 of the housing body 34, 36 and comprises the electric pins 20 being electrically coupable to a power supply.

[0026] An actuator housing enclosing the solid state actuator 22 of the solid state actuator unit 12 may comprise a spring tube 40, a top cap 42 and a bottom cap 44. Part of the top cap 42 may form at least part of the second axial end area 26. Part of the bottom cap 44 may form at least part of the first axial end area 24 comprising the drive side of the solid state actuator unit 12. The solid state actuator unit 12 further comprises the piston 18, which is coupled to the top cap 42 or may in one piece form part of the top cap 42. It may apply an axial preload force on the solid state actuator unit 12.

[0027] The valve assembly 30 comprises a valve body 46 and a valve needle 48. The valve body 46 has a valve body spring rest 50 and the valve needle 48 comprises a valve needle spring rest 52, both spring rests 50, 52 supporting a spring 54 arranged between the valve body 46 and the valve needle 48. Between the valve needle 48 and the valve body 46 a bellow 56 is arranged, which is sealingly coupling the valve body 46 with the valve needle 48. By this a fluid flow between the recess 38 and a chamber 58 is prevented. Furthermore, the bellow 56 is formed and arranged in a way that the valve needle 48 is actuable by the solid state actuator unit 12.

[0028] A fluid outlet portion 60 is closed or open depending on the axial position of a valve needle 48. By changing its length, the solid state actuator 22 can exert a force to the valve needle 48. The force from the solid state actuator 22 being exerted to the valve needle 48 in an axial direction allows or prevents a fluid flow through the fluid outlet portion 60. Furthermore, the injection valve 28 has a fluid inlet portion 62, which is arranged in the housing body 34, 36 and which for instance is coupled to a not shown fuel connector. In this example, the fuel connector is designed to be connected to a high pressure fuel chamber of an internal combustion engine, the fuel is stored under high pressure, for example, under the pressure above 200 bar.

The valve assembly 30 is arranged in the injection valve 28 facing the first axial end area 24 on the drive side of the solid state actuator unit 12 in a part of the recess 38 of the housing body 34 of the injection valve 28 along the longitudinal axis A.

[0029] The compensator unit 14, which is in this example a thermal compensator unit, is arranged facing the second axial end area 26 of the solid state actuator unit 12 and facing the damping element 16 and is mechanically coupled to the piston 18 of the solid state actuator unit 12. In particular, the compensator unit 14 enables to set an axial preload force on the solid state actuator unit 12 via the piston 18 to compensate changes of the fluid flow through the fluid outlet portion 60 in the case of temperature changes of the injection valve 28.

[0030] The injection valve 28 further comprises the connector 32 with a non-conductive connector body 64 in which an electric conductor 66 is arranged. Electric energy can be supplied to the electric conductor 66 of the connector 32. Furthermore, the solid state actuator unit 12 comprises an adapter 68 consisting of terminal elements 70. The electric conductor 66 of the connector 32 is electrically coupled to one of the terminal elements 70 of the adapter 68 which is electrically coupled to another of the terminal elements 70 which on its part is electrically coupled to the electric pins 20 of the solid state actuator 22. Consequently, electric energy can be simply supplied to the solid state actuator 22 via the connector 32.

[0031] The damping element 16 is arranged in-between the solid state actuator unit 12 and the compensator unit 14, wherein the damping element 16 may be conterminous to a spring rest of the compensator unit 14. In particular, the damping element 16 may be designed not to be conterminous to the housing body 36 of the injection valve 28. By this, the damping element 16 is arranged in-between the solid state actuator unit 12 and the compensator unit 14 without being in contact with further parts of the injection valve 28. In this case, especially reliable damping of undesired movements of the solid state actuator unit 12 and vibrations within the second axial end area 26 of the actuator arrangement 10 is accomplished.

[0032] Moreover, the damping element 16 may be prearranged in-between the compensator unit 14 and the solid state actuator unit 12 to enable the correct arrangement. In addition, the damping element 16 is preloaded by the compensator unit 14 and the solid state actuator unit 12 to provide an axial preload force. By this, especially reliable damping of undesired movements of the solid state actuator unit 12 and vibrations within the second axial end area 26 of the actuator arrangement 10 can be accomplished. Typically, the damping element 16 is preloaded with an axial preload force in the range of 10 N.

[0033] In the following, the function of the injection valve 28 will be described in detail:

[0034] The fluid is led from the fluid inlet portion 62 through the housing body 34, 36 to the fluid outlet portion 60.

[0035] The valve needle 48 prevents a fluid flow through the fluid outlet portion 60 in the valve body 46 in a closing position of the valve needle 48. Outside of the closing position of the valve needle 48, the valve needle 48 enables the fluid flow through the fluid outlet portion 60.

[0036] The solid state actuator 22 may change its axial length if it is energized. By changing its length the solid state actuator 22 may exert a force on the valve needle 48. The valve needle 48 is able to move in axial direction out of the closing position. Outside the closing position of the valve needle 48 there is a gap between the valve body 46 and the valve needle 48 at the first axial end area 24 of the injection valve 28 facing away from the solid state actuator 22. The spring 54 can force the valve needle 48 via the valve needle spring rest 52 towards the solid state actuator 22. In the case the solid state actuator 22 is de-energized, the solid state actuator 22 shortens its length. The spring 54 can force the valve needle 48 to move in axial direction in its closing position. It is depending on the force balance between the force on the valve needle 48 caused by the solid state actuator 22 and the force on the valve needle 48 caused by the spring 54 whether the valve needle 48 is in its closing position or not.

[0037] If the solid state actuator 22 is energized, undesired movements and vibrations can occur at the top cap 42 of the actuator housing. A rigidly coupling of the adapter 68 to the top cap 42 let the forces caused by the vibrations be transmitted directly from the top cap 42 of the actuator housing to the adapter 68. Thus, for example electric connections between the electric pins 20 of the solid state actuator unit 12 and the power supply may be stressed. By the damping element 16, undesired movements of the solid state actuator unit 12 can be prevented and vibrations within the second axial end area 26 of the actuator arrangement 10 can be limited, which enables reliable operation.

Claims

1. Actuator arrangement (10), comprising

- a solid state actuator unit (12) with a longitudinal axis (A) comprising electric pins (20) being electrically coupable to a power supply and a piston (18), wherein the solid state actuator unit (12) comprises a first axial end area (24) designed to act as drive side and a second axial end area (26) facing away from the first axial end area (24),
- a compensator unit (14) being arranged facing the second axial end area (26) of the solid state actuator unit (12) along the longitudinal axis (A) of the solid state actuator unit (12) and being in contact with the solid state actuator unit (12) via the piston (18), and
- a damping element (16) being designed and arranged in-between the compensator unit (14) and the solid state actuator unit (12) facing the second axial end area (26) of the solid state actuator unit (12), the damping element (16) being preloaded by the solid state actuator unit (12) and the compensator unit (14).

2. Actuator arrangement (10) according to claim 1, wherein the damping element (16) is preloaded with an axial preload force in the range of 10 N.

3. Actuator arrangement (10) according to one of the

preceding claims, wherein the damping element (16) comprises a silicon base.

4. Actuator arrangement (10) according to one of the preceding claims, wherein the damping element (16) comprises a plastic.

5. Actuator arrangement (10) according to claim 4, wherein the plastic is rubber.

6. Injection valve (28) with a valve assembly (30) within a recess (38) of a housing body (34, 36) and an actuator arrangement (10) according to one of the preceding claims, comprising a solid state actuator unit (12) within the recess (38), wherein the solid state actuator unit (12) is being designed for acting on the valve assembly (30).

FIG 1

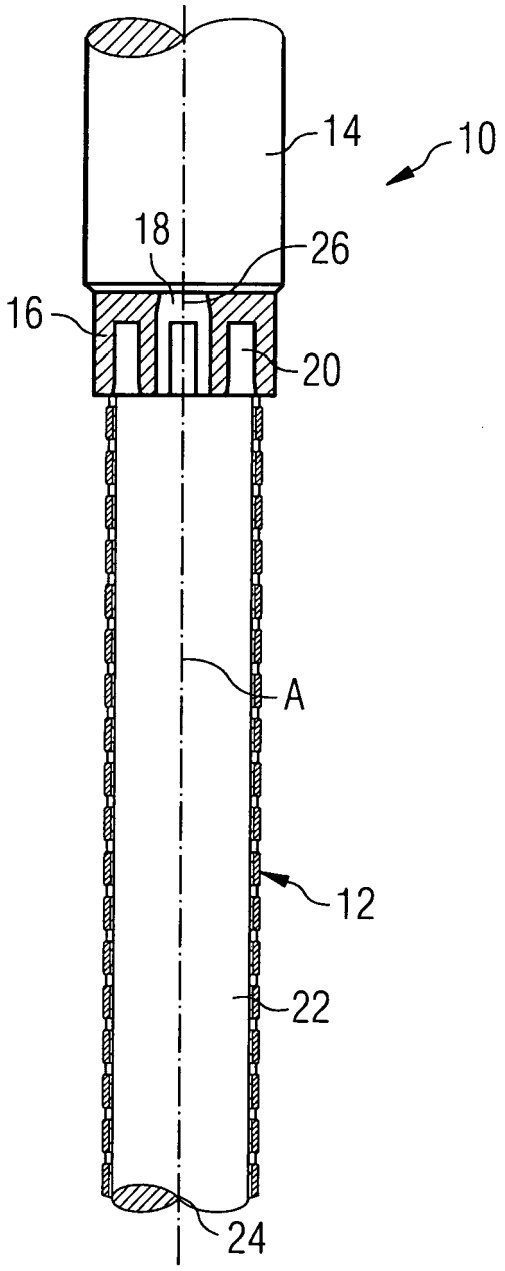
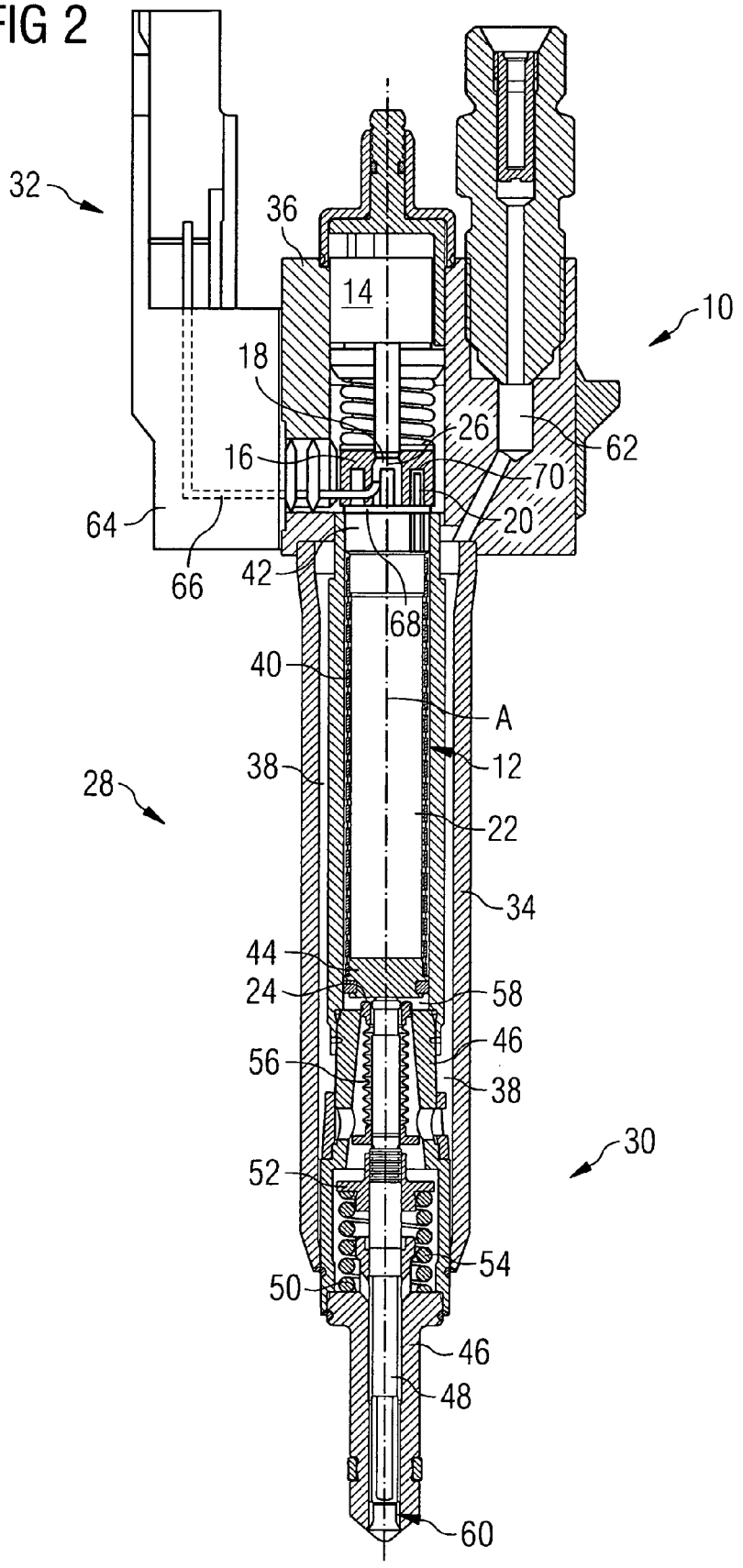


FIG 2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EUROPEAN SEARCH REPORT

Application Number
EP 07 02 5217

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 1 741 922 A (BOSCH GMBH ROBERT [DE]) 10 January 2007 (2007-01-10) * paragraphs [0001], [0002], [0004], [0008], [0019], [0021], [0023] - [0026], [0037]; figure 1 * * abstract *	1	INV. H01L41/083 F02M51/06 F02M61/16
A	WO 02/40858 A (SIEMENS AG [DE]; VU NGOC TAM [DE]) 23 May 2002 (2002-05-23) * page 7, lines 5-30; figure 2a *	1	
A	EP 1 647 703 A (BOSCH GMBH ROBERT [DE]) 19 April 2006 (2006-04-19) * paragraphs [0031] - [0039]; figures 2,3 * * abstract *	1	
A	US 2002/134851 A1 (LORRAINE JACK [US] ET AL) 26 September 2002 (2002-09-26) * the whole document *	1	
			TECHNICAL FIELDS SEARCHED (IPC) F02M H01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	11 June 2008	Hermens, Sjoerd

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11-06-2008

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1741922 A	10-01-2007	DE 102005029976 A1	11-01-2007
WO 0240858 A	23-05-2002	DE 10057495 A1	29-05-2002
		EP 1336045 A1	20-08-2003
EP 1647703 A	19-04-2006	DE 102004050224 A1	20-04-2006
US 2002134851 A1	26-09-2002	NONE	

EPO FORM P0459

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