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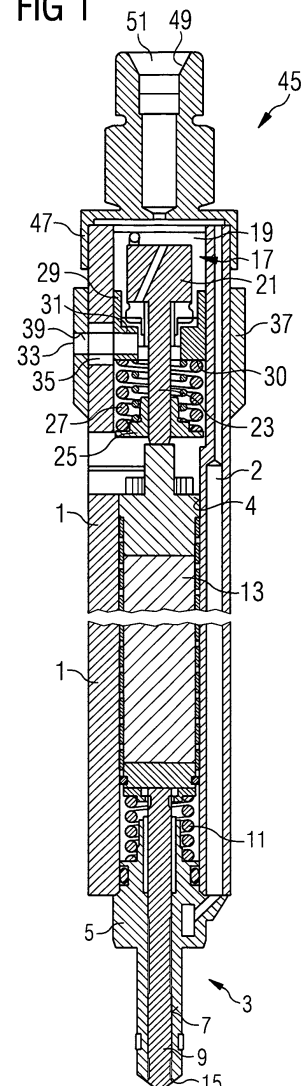
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(54) Fluid injector and method for manufacturing a fluid injector

(57) A fluid injector has a housing (1) comprising a housing recess (4) and a fluid duct (2) both extending from one axial end of the housing (1) into the housing. An actuator unit (13) is taken in the housing recess (4). A thermal compensator unit (17) taken in the housing recess. An inlet fitting (45) comprises a fluid supply connecting part (49) for connecting the fluid injector to a fluid supply. The inlet fitting (45) is designed and fixed to the housing (1) such that it sealingly closes the housing at the one axial end of the housing (1).

FIG 1



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Description

[0001] The invention relates to a fluid injector, in particular a fluid injector for metering fuel to a combustion chamber of an internal combustion engine. Fuel injectors are in widespread use, in particular for internal combustion engines where they may be arranged in order to dose the fluid into the intake manifold of the internal combustion engine or directly into the combustion chamber of a cylinder of the internal combustion engine. The invention further relates to a method for manufacturing a fluid injector.

[0002] In order to meet stringent regulations concerning exhaust emissions of internal combustion engines, fluid injectors need to be designed such that they are adapted to dose fluid very precisely. In this respect, more and more fluid injectors are equipped with piezoelectric actuators.

[0003] In order to enhance the combustion process in view of the creation of unwanted emissions, the respective fluid injector may be suited to dose fluid under very high pressure. The pressure may be, in the case of a gasoline engine, for example, in the range of up to 200 bar and in case of a Diesel engine, in the range of up to 2000 bar.

[0004] According to a first aspect of the invention, it is the object to create a fluid injector, which enables to be manufactured in a simple way. According to a further aspect of the invention, it is the object to create a method for manufacturing a fluid injector which is simple.

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

[0006] The invention is distinguished according to a first aspect by a fluid injector with a housing comprising a housing recess and a fluid duct both extending from one axial end of the housing into the housing. The fluid injector further comprises an actuator unit taken in the housing recess, a thermal compensator unit taken in the housing recess, and an inlet fitting. The inlet fitting comprises a fluid supply connecting part for connecting the fluid injector to a fluid supply. In that way it communicates with the fluid duct. The inlet fitting is designed and fixed to the housing such that it sealingly closes the housing at the one axial end of the housing. The fluid injector enables to be manufactured by only a few separate parts. The inlet fitting serves a double function of enabling a connection to a fluid supply and also forming a closing for the housing recess protecting the thermal compensator and the actuator from the environment of the fluid injector. In that way, it enables a cost effective manufacturing of the fluid injector.

[0007] According to an advantageous embodiment of the first aspect, the inlet fitting comprises a cup shaped part being fixed to the housing for closing the housing recess at the one axial end of the housing. This enables a reliable fixation of the inlet fitting to the housing even with very high fluid pressures being applied to the inlet

fitting and the fluid duct.

[0008] According to a further preferred embodiment of the first aspect, the thermal compensator unit is mechanically coupled to an internal ring body arranged in the housing recess and influencing depending on its axial position in the housing recess a characteristic of the thermal compensator unit.

[0009] An external ring body is arranged on the outside of the housing and is mechanically coupled to the internal ring body in such a way that the respective axial positions of the internal and external ring body correlate to each other. This enables to influence the characteristic after mounting the thermal compensator unit in the housing without needing access for a tool directly in the side of the recess. In that way, a simple and precise calibration of the fluid injector is enabled. This further enables the precise calibration and at the same time to use the inlet fitting for sealingly closing the housing recess at the one axial end of the housing. It is to be noted, however, that this aspect of the invention and its further preferred embodiments may also be incorporated in a further type of fluid injector with an inlet fitting not being designed for fixing the housing such that it sealingly closes the housing recess. Instead a closing part for closing the housing recess may then be provided. The inlet fitting then is designed for communicating with the fluid duct.

[0010] According to a further preferred embodiment of the first aspect, the thermal compensator unit comprises a piston with a rod. The rod is movable relative to the housing and comprises a first spring seat. The thermal compensator unit further comprises a thermal compensator spring, resting with one free end on the first spring seat. The internal ring body forms a second spring seat for the thermal compensator spring. This may ensure a simple and robust fluid injector.

[0011] According to a further preferred embodiment of the first aspect, the internal ring body is mechanically coupled to the external ring body by a calibration pin radially extending through a housing radial recess in the housing. This enables a simple to manufacture fluid injector, with a precise calibration being possible.

[0012] In this respect, it is advantageous if the calibration pin is coupled to the internal ring and/or the external ring by a press fit connection. This is simple to manufacture and therefore may result in low cost but enables a robust connection.

[0013] According to a second aspect, the invention is distinguished by a method for manufacturing the fluid injector according to the first aspect of the invention. The method comprises assembling the actuator unit and the thermal compensator unit and the internal ring in the housing recess. Further, it comprises assembling the inlet fitting on the housing, covering the housing recess and the fluid duct at the one axial end of the housing. It further comprises sealingly fixing the inlet fitting to the housing such that it sealingly closes the housing at the one axial end of the housing. The advantages of the method for manufacturing the fluid injector correspond

to the advantages of the first aspect of the invention and its preferred embodiments.

[0014] According to a preferred embodiment of the method for manufacturing the fluid injector, it comprises sealingly fixing the inlet fitting to the housing by laser welding. This has the advantage of enabling a very localized but extremely well sealing fixation of the inlet fitting.

[0015] According to a further preferred embodiment of the method, it comprises after assembling the actuator and the thermal compensator unit and the internal ring in the housing recess steps of:

- assembling the external ring body to the housing on the outside of the housing,
- mechanically coupling the external ring body to the internal ring body in such a way that the respective axial positions of the internal and external ring body correlate to each other,
- varying the axial position of the external ring body for calibrating the fluid injector in view of a given characteristic of the thermal compensator unit, and
- fixing the external ring to the housing, preventing further axial movement of the external ring after the calibration has been finished.

[0016] Exemplary embodiments of the invention are explained in the following with the aid of schematic drawings. Exemplary embodiments of the invention are explained in the following with the aid of schematic drawings. These are as follows:

FIG. 1 a fluid injector and

FIG. 2 a flowchart for manufacturing the fluid injector.

[0017] Elements of the same design and function that occur in different illustrations are identified by the same reference character.

[0018] A fluid injector may be embodied as a fuel injector, that is suitable for injecting fuel into a gasoline engine or that may be suitable for injecting fuel in a Diesel engine. The fluid injector comprises a housing 1 and a valve body 3. The valve body 3 comprises a cartridge 5 with a cartridge recess 7 and a needle 9, that is inserted into the cartridge recess 7 and is guided in an area of a guide formed in the cartridge recess 7. The needle 9 is of an outward opening type but it may also be of an inward opening type. The needle is pushed in its closing position by a return spring 11 if no further forces act on the needle. The return spring 11 exerts a force on the needle 9 in the closing direction of the needle 9.

[0019] The fuel injector is preferably located in a cylinder head of an internal combustion engine and provides the combustion chamber with fluid.

[0020] The housing 1 comprises a fluid duct 2, which may preferably be manufactured as a borehole. It further comprises a housing recess 4. The housing recess 4 and

the fluid duct 2 both extend from one axial end of the housing into the housing. The one axial end of the housing 1 is the one facing away from the nozzle 15. The fluid duct 2 extends through the housing 1 and communicates with the nozzle 15. An actuator unit 13 is arranged in the housing recess 4 and is coupled to the needle 9. Preferably, the actuator unit 13 is a piezoelectric actuator unit. Then, it comprises a stack of piezoelectric elements, which are pretensioned by a tube spring and held in-between a first and a second end cap.

[0021] A thermal compensator unit 17 is arranged in the housing recess 4 on a side respective to the actuator unit 13 facing away from the nozzle 15. In an alternative embodiment, the thermal compensator unit 17 may, however, also be arranged on the side facing towards the nozzle 15.

[0022] In the embodiment according to FIG. 1, the thermal compensator unit 17 comprises a thermal compensator housing part 19, which is fixed to the housing 1 by welding, which is indicated by a small circle. The thermal compensator unit 17 further comprises a piston 21 with a rod 23 protruding towards the actuator unit 13. A first spring seat 25 is fixed to the rod 23 and serves as a seat for a thermal compensator spring 27 at one of its axial ends.

[0023] An internal ring body 29 is arranged in the housing recess 4 and forms a second spring seat 30 at the respective other axial end of the thermal compensator spring 27. The piston 21 is movable relative to the housing 1. The thermal compensator unit is designed to compensate different thermal expansion coefficients of the actuator unit 13 and the housing 1. It preferably comprises chambers filled with a hydraulic fluid which enable in combination with the piston 21 and dependent on the spring load applied to the thermal compensator spring 27 a compensation of these changes whereas it is designed such, that it behaves as a stiff body, if the actuator unit is controlled to expand. In this respect, it is to be noted, that the duration of the expansion of the actuator unit 13, correlating to an injection event of the fluid injector, is always for a very short duration of time. Therefore, an appropriately dimensioned throttle may be provided between respective chambers of a thermal compensator unit taking into consideration the time duration for the injection event and at the same time providing on a larger time scale a force pressure balance between respective chambers of the thermal compensator unit 7 and thereby setting the axial position of the piston 21 relative to the housing, in particular the location of the housing 1 where the thermal compensator housing part 19 is fixed to the housing.

[0024] The internal ring body 29 is mechanically coupled to an external ring 37. The external ring 37 is arranged on the outside of the housing 1 and is mechanically coupled to the internal ring body 29 in such a way that the respective axial positions of the internal ring body 29 and the external ring body 37 correlate to each other. It is to be noted, that the internal ring body 29 does not

need to have an exact ring shape. It is just formed in a way, that it is slidably movable along an inner wall of the housing recess 4 and that it forms the second spring seat 30. Also, the external ring body 37 may have a shape deviating from an exact ring shape. It may, for example, have a bushing form.

[0025] The internal ring body 29 is mechanically coupled to the external ring body 37 by a calibration pin 33, which protrudes radially from the internal ring to the external ring body 37. Further, the calibration pin 33 protrudes through a housing radial recess 35. The housing radial recess 35 preferably has an axial extension which is large enough to move the calibration ring during the manufacturing process of the fluid injector in an axial direction relative to the housing 1. Preferably, the calibration pin 33 is arranged in an internal ring radial recess 31 of the internal ring body 29 in a press fit connection. Preferably, the calibration ring 33 is arranged in an external ring recess 39 of the external ring body 37 also in a press fit connection. The external ring body 37 is fixed to the housing 1, preferably by laser welding. But it may also be fixed to the housing 1 by some other sort of connection known to the person skilled in the art for this purpose.

[0026] An inlet fitting 45 comprises a cup shaped part 47 covering an axial end area of the housing 1 at an axial end of the housing 1 facing away from the nozzle 15. The cup shaped part 47 is sealingly connected to the housing 1, for example, by laser welding also indicated by small circles. The inlet fitting 45 further comprises a fluid supply connecting part 49.

[0027] In its arrangement in the internal combustion engine, the fluid injector is coupled to a fluid supply, preferably being formed by a fuel rail via the fluid supply connecting part 49. Therefore, the fluid supply connecting part 49 comprises an inlet fitting recess 51, which extends through the fluid supply connecting part 49 in an axial direction. The inlet fitting recess 51 and the fluid duct 2 communicate with each other. The inlet fitting 45 closes the housing recess 4 and therefore protects the actuator unit 13 and also the thermal compensator unit 17 from influences from outside of the fluid injector.

[0028] In FIG. 2, an example is given how the fluid injector may be manufactured. In a step S1, the manufacturing process is started and the housing with the valve body 3 are already provided in a preassembled state.

[0029] In a step S3, the actuator unit 13 is inserted into the housing recess 4 and the thermal compensator unit 17 together with the internal ring body 29 are inserted into the housing recess 4.

[0030] In a step S5, the inlet fitting is assembled on the housing covering the housing recess at the one axial end of the housing 1. Therefore, the inlet fitting 45 is preferably pushed with its cup shaped part 47 over the axial end area of the housing 1 facing away from the nozzle 15. The cup shaped part 47 then covers the cross-section of the housing recess 4 and also of the fluid duct 2. The inlet fitting is then sealingly fixed to the housing

1. This is preferably accomplished by laser welding. It may, however, also be accomplished by some other way of fixing it sealingly to the housing 1 known to the person skilled in the art taking into consideration that it must withstand the forces acting on the fixation due to the pressure of the fluid to be dosed in the pressure range the respective injection valve is designed to operate.

[0031] The manufacturing may then be finished in a step S7. It is preferred, however, that in a subsequent step S9, the fluid injector is calibrated, in particular that the thermal compensator is then calibrated. In order to make this calibration possible, the housing preferably has the housing radial recess 35. The external ring body 37 is pushed onto the housing 1 in step S3. Whether this is done before the inlet fitting 45 is pushed onto the housing 1 or after that depends on whether a maximum outer diameter of the inlet fitting 45 is larger than the outer diameter of the housing which is relevant for pushing the external ring body 37 on the housing 1.

[0032] In the preferred embodiment, however, the external ring body 37 is pushed onto the housing 1 prior to pushing the inlet fitting onto the housing 1. Preferably, also the calibration ring is assembled with the internal ring body 29 and the external ring body 37 prior to assembling the inlet fitting 45 and preferably even before the thermal compensator housing part 19 and the piston 21 are assembled in the housing recess 4. This enables to axially position the external ring body 37 precisely in order to insert the calibration pin 33 into the internal ring radial recess 31. Preferably, the calibration pin 33 is fixed in the internal ring radial recess 31 by a press fit connection. It is also preferably fixed in the external ring recess 39 by a press fit connection. It may, however, also be fixed in some other way known for being suitable to a person skilled in the art. For example, it may be fixed by a screw connection.

[0033] In the step S9, the inlet fitting is connected to a fluid supply and is supplied with fluid of a given pressure or a given pressure variation for the calibration process. The axial position of the external ring body 37 is then varied in order to obtain a given characteristic of the thermal compensator. For that purpose, the temperature of the fluid injector may also be varied during the calibration process and/or the amount of fuel to be dosed and/or actually dosed may be varied.

[0034] By varying the axial position of the internal ring body 29, a characteristic of the thermal compensator unit is influenced by setting the pretensioning force of the thermal compensator spring 27. In that way, also a calibration for the fluid dosing characteristic of the fluid injector may be set. The characteristic of the thermal compensator may therefore be representative for the characteristic of the fluid injector in view of fluid dosing.

[0035] After the calibration process has been finished, the external ring body 37 is kept in the respective axial position obtained during the calibration process and is fixed in this axial position by fixing it to the housing, e.g. by laser welding or some other sort of connection tech-

nique known to the person skilled in the art for this purpose in a step S11. After step S11, no further axial movement of the external ring body 37 is possible.

Claims

1. Fluid injector with a housing (1) comprising a housing recess (4) and a fluid duct (2) both extending from one axial end of the housing (1) into the housing (1),
 - an actuator unit (13) taken in the housing recess (4),
 - a thermal compensator unit (17) taken in the housing recess (4),
 - an inlet fitting (45) comprising a fluid supply connecting part (49) for connecting the fluid injector to a fluid supply, the inlet fitting (45) being designed and fixed to the housing (1) such that it sealingly closes the housing at the one axial end of the housing (1).
2. Fluid injector according to claim 1, with the inlet fitting (45) comprising a cup shaped part (47) being fixed to the housing (1) for closing the housing recess (4) at the one axial end of the housing (1).
3. Fluid injector according to one of the previous claims with the thermal compensator unit (17) being mechanically coupled to an internal ring body (29) arranged in the housing recess (4) and influencing depending on its axial position in the housing recess (4) a characteristic of the thermal compensator unit (17), an external ring body (37) being arranged on the outside of the housing (1) and being mechanically coupled to the internal ring body (29) in such a way that the respective axial positions of the internal and the external ring body (29, 37) correlate to each other.
4. Fluid injector according to claim 1, with a thermal compensator unit (17) comprising a piston (21) with a rod (23), the rod (23) being movable relative to the housing (1) and comprising a first spring seat (25), and the thermal compensator unit (17) further comprising a thermal compensator spring (27), resting with one free end on the first spring seat (25), and with the internal ring body (29) forming a second spring seat (30) for the thermal compensator spring (27).
5. Fluid injector according to one of the claims 3 or 4, with the internal ring body (29) being mechanically coupled to the external ring body (37) by a calibration pin (33) radially extending through a housing radial recess (35) in the housing (1).
6. Fluid injector according to claim 5, with the calibration pin (33) being coupled to the internal ring body (29) and/or the external ring body (37) by a press fit connection.
7. Method for manufacturing a fluid injector according to one of the previous claims comprising:
 - assembling the actuator unit (13) and the thermal compensator unit (17) and the internal ring body (29) in the housing recess (4),
 - assembling the inlet fitting (45) on the housing (1), covering the housing recess (4) and the fluid duct (2) at the one axial end of the housing (1), and
 - sealingly fixing the inlet fitting (45) to the housing (1) such that it sealingly closes the housing at the one axial end of the housing (1).
8. Method according to claim 7, comprising sealingly fixing the inlet fitting (45) to the housing (1) comprising laser welding.
9. Method according to one of the claims 7 or 8, comprising after assembling the actuator unit (13) and the thermal compensator unit (17) and the internal ring body (29) in the housing recess (4):
 - assembling the external ring to the housing on the outside of the housing,
 - mechanically coupling the external ring body (37) to the internal ring body (29) in such a way that the respective axial positions of the internal and external ring body (29, 37) correlate to each other,
 - varying the axial position of the external ring body (37) for calibrating the fluid injector in view of a given characteristic of the thermal compensator unit (17) and
 - fixing the external ring body (37) to the housing (1) preventing further axial movement of the external ring body (37) after the calibration has been finished.

FIG 1

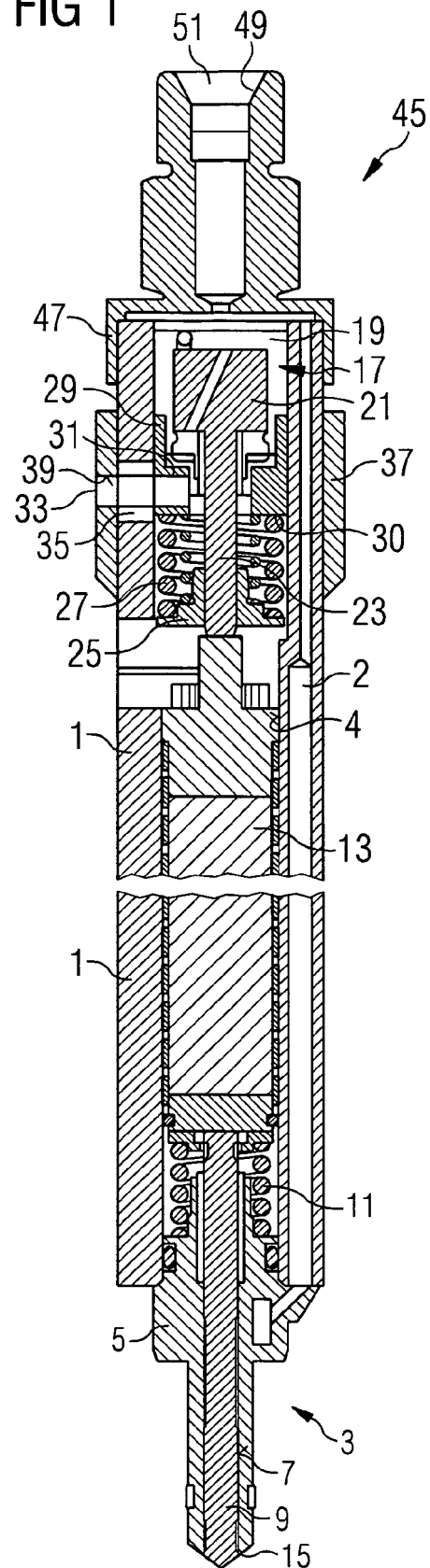
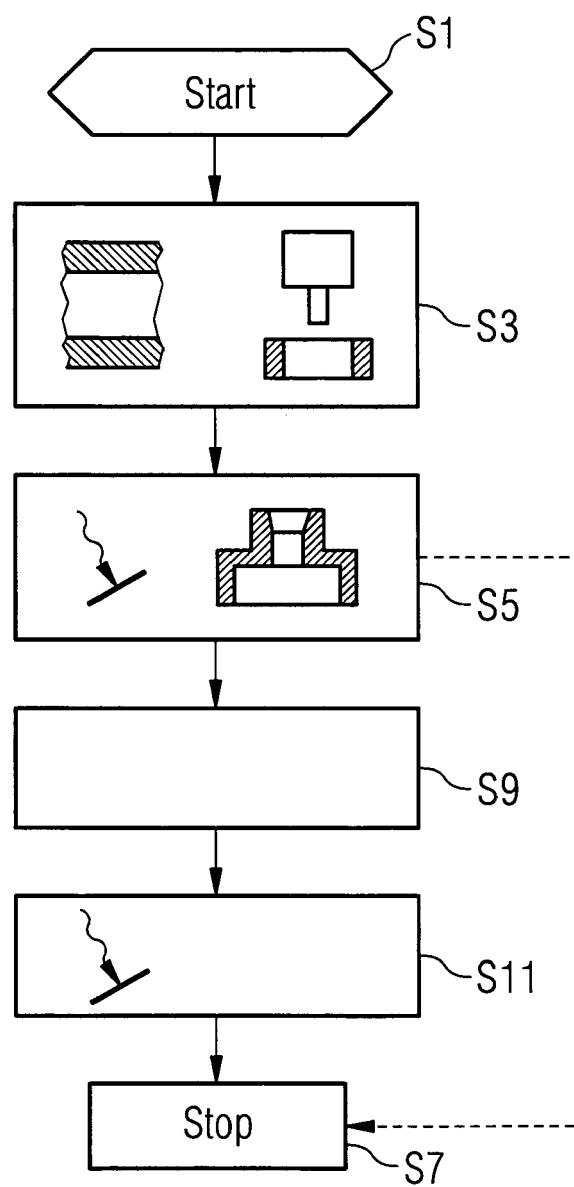


FIG 2





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 02 7109

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 02/31344 A (SIEMENS AUTOMOTIVE CORPORATION) 18 April 2002 (2002-04-18) * abstract; figures 1,2 *	1,4,7,8	INV. F02M61/16 F02M51/06
X	US 6 422 482 B1 (STIER HUBERT ET AL) 23 July 2002 (2002-07-23) * abstract; figure 4 *	1,2,7	ADD. F02M63/00
X	EP 1 457 662 A (ROBERT BOSCH GMBH) 15 September 2004 (2004-09-15) * abstract; figures 1,2 *	1,7,8	
X	EP 1 256 711 A (MAGNETI MARELLI POWERTRAIN S.P.A) 13 November 2002 (2002-11-13) * abstract; figures 1,2 *	1,4,7	
X	EP 1 452 727 A (ROBERT BOSCH GMBH) 1 September 2004 (2004-09-01) * abstract; figures 1-3 *	1,7	
			TECHNICAL FIELDS SEARCHED (IPC)
			F02M
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		19 April 2006	Blanc, S
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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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 05 02 7109

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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19-04-2006

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 0231344	A	18-04-2002	EP 1325224 A1	09-07-2003
			EP 1325225 A1	09-07-2003
			EP 1325226 A1	09-07-2003
			EP 1325227 A1	09-07-2003
			EP 1325229 A1	09-07-2003
			JP 2004515672 T	27-05-2004
			JP 2004511700 T	15-04-2004
			JP 2004513278 T	30-04-2004
			JP 2004514083 T	13-05-2004
			JP 2004511701 T	15-04-2004
			WO 0231345 A1	18-04-2002
			WO 0231346 A1	18-04-2002
			WO 0231347 A1	18-04-2002
			WO 0231349 A1	18-04-2002
US 6422482	B1	23-07-2002	CZ 20002389 A3	14-03-2001
			WO 0025019 A1	04-05-2000
			DE 19849203 A1	27-04-2000
			EP 1045973 A1	25-10-2000
			JP 2002528673 T	03-09-2002
EP 1457662	A	15-09-2004	AT 316205 T	15-02-2006
			DE 10310297 A1	23-09-2004
EP 1256711	A	13-11-2002	BR 0201763 A	11-03-2003
			DE 60207482 D1	29-12-2005
			IT B020010280 A1	08-11-2002
			US 2003006300 A1	09-01-2003
EP 1452727	A	01-09-2004	NONE	