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(71) Applicant: **Delphi Technologies IP Limited**
Saint Michael (BB)

(72) Inventors:
- **MACLANE, Stephen, Joseph**
  Gillingham, Kent ME8 0RU (GB)
- **HUTCHINS, Stephen**
  Gillingham, Kent ME8 0RU (GB)

(74) Representative: **Delphi France SAS**
c/o Delphi Technologies
Campus Saint Christophe
Bâtiment Galilée 2
10, avenue de l'Entreprise
95863 Cergy Pontoise Cedex (FR)

(54) PIEZO CONTROLLED INLET VALVE

(57) A pumping head (12) of a fuel injection equipment high pressure pump (10), comprising an inlet valve member (56) and, a piezoceramic actuator (72) fixed in the head body (42) and to the valve member.

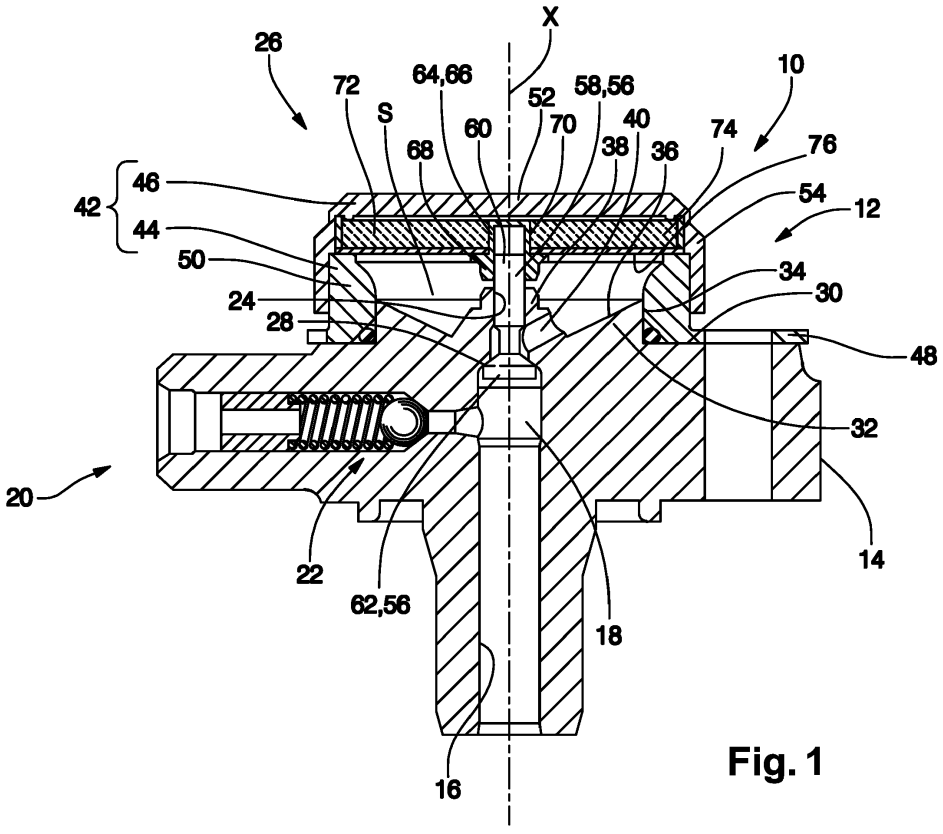

Fig. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to an inlet valve assembly of a high pressure fuel pump, said assembly having a piezo-controlled direct acting valve member.

BACKGROUND OF THE INVENTION

[0002] A direct injection equipment comprises a high pressure pump in which fuel received from a low pressure tank is pressurised prior to be delivered to a common rail and to injectors. The fuel in pressurised in a compression chamber which inlet is controlled by an inlet valve member that opens or closes under the influence of pressure difference between the upstream inlet conduit and said downstream compression chamber. Digital inlet valve (DIV) are added to limit the fuel entry in the compression chamber to the necessary volume demanded to be pressurised by the engine. A solenoid actuator may be added so that a magnetic armature cooperates with the valve member either to fully control the operation of the valve member or simply to speed-up the opening or to retard the closing, the valve member remaining generally passive. Such electro-valve are structurally large, complex and difficult to pilot.

SUMMARY OF THE INVENTION

[0003] Accordingly, it is an object of the present invention to resolve the above mentioned problems in providing a pumping head of a fuel injection equipment high pressure pump, said pumping head comprising a body provided with a main bore extending along a main axis from a lower opening to an upper end partially defining a compression chamber wherein are arranged an outlet opening and an inlet opening forming an axial guiding bore extending through said body from a seat face surrounding the inlet opening in the bore to a top face of the body.

[0004] Advantageously, the pumping head further comprises an inlet valve assembly controlling said inlet opening an comprising an inlet valve body fixed atop the pumping head body thus defining an inner space, an inlet valve member having a head member defining a closing face cooperating with said seat face and, a stem member axially guided in said guiding bore and extending from said head member to an upper end protruding in said inner space and, a piezoceramic actuator fixed in said body and to said stem upper end.

[0005] Also, said piezoceramic actuator is a disc-like member provided with a central orifice, the outer edge of said disc-like member being fixed in the inlet valve body and, the stem upper end being fixed into the central orifice.

[0006] The pumping head further comprises a stem upper end cap member arranged atop the stem upper end and inside the central orifice of the piezoceramic member. It also comprises a flexible sealing membrane arranged in the inlet body inner space and preventing, in use, fuel to contact the piezoceramic disc.

[0007] Also, said membrane has an outer edge pinched between a face of the inlet valve body and the outer edge of the piezoceramic disc and, a central opening pinched between the stem upper end cap member and the piezoceramic disc.

[0008] Also, the inlet valve body comprises an annular member fixed on the pumping head body and defining the peripheral wall of the inner space and, a valve body cap member fixed on said annular member and closing said inner space.

[0009] Also, the disc membrane is arranged so its outer edge is against a top annular face of the annular member and the outer edge of said piezoceramic disc-like member, the valve body cap member covering the piezoceramic disc and being firmly tightened to the body annular member, thus pinching the piezoceramic disc and the membrane between the cover and the annular body member.

[0010] The pumping head further comprises electrical wires connected to the piezoceramic disc and extending outside the inlet valve body so that, in use, command signals may be sent from a command unit to said piezoceramic actuator.

[0011] The invention also extends to a high pressure fuel pump comprising a cambox and a pumping head as described above and wherein, in use, a camshaft rotates in the cambox imparting reciprocal displacements to a plunger guided in the main bore and varying the volume of the compression chamber.

[0012] It also extend to a fuel injection equipment comprising a high pressure pump as here above mentioned and a command unit connected to the inlet valve piezoceramic disc and adapted to send command signal for operating the inlet valve member.

[0013] The invention also extends to a method of controlling such fuel injection equipment, the method comprising the step of:

- energizing the piezoceramic disc so that the piezoceramic disc deforms forcing the inlet valve member to open.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The present invention is now described by way of example with reference to the accompanying drawing in which figure 1 is an axial section of a pumping head of a HP pump as per the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] A fuel injection equipment comprises a high pressure pump 10 that receives fuel at low pressure, pressurises it and delivers it to a common rail. The pump

10 has a pumping head 12 fixed on a cambox, not shown, the head 12 having a body 14 provided with a blind bore 16 which extends along a pumping axis X and in which, in use, reciprocates a plunger, not shown, that cooperates with a camshaft rotating in the cambox. Said bore 16 is open at a lower end of the head 12 to enable the plunger to extend in the cambox and, at the upper blind end, said bore 16 partially defines a compression chamber 18 in which radially opens an outlet channel 20 controlled by an outlet check valve 22 and, axially opens an inlet valve guiding bore 24 controlled by an inlet valve assembly 26. In the example embodiment of the figure, the inlet valve guiding bore 24 is coaxial to the bore 16 and it upwardly extends from a lower end opening in the blind end of the bore 16, said lower opening being surrounded by a seat face 28 defined on said end face of the bore to, an upper end opening on a top face 30 of the head body. From said pumping head top face 30 upwardly protrudes a cylindrical wall 32 having a right-angled triangle wall section defining an cylindrical outer face 34 and, a frustoconical inner face 36 downwardly pointing toward the head body 14, said cylindrical wall 32 axially extending about the pumping axis X. The pumping head top face 30 further comprises a conical member 38 axially upwardly protruding in the middle of said cylindrical wall 32, the inlet valve guiding bore 24 axially extending in said conical member 38 and opening at the top of it. The pumping head body 14 is further provided with a fuel inlet channel 40 drilled in said conical member 38 and extending from the top face 30 of the pumping head, in an area close to the base of said conical member 38, to an annular chamber defined in the inlet valve guiding bore 24 above said seat face 28.

[0016] The inlet valve assembly 26 has a body 42 comprising a main member 44 and a cap member 46, said main member 44 having a base 48, fixed on the top face 30 of the pumping head body and, an annular tubular portion 50 axially protruding from said base 48 and adjusted onto the outer face 34 of the cylindrical wall. Said tubular portion 40 is covered by the cap member 46 having a transverse wall 52 closing the inlet body tubular portion 50 and a peripheral wall 54 internally threaded and complementary engaged and tightened onto a male thread provided on the outer face of the inlet body tubular portion 50. As visible on the figure, the inlet valve body 42 and the top face 30 of the pumping head together define an inner space S in which opens the inlet valve guiding bore 24 and the fuel inlet channel 40.

[0017] Said inlet valve assembly 26 further comprises a poppet inlet valve member 56 having a stem 58 axially guided in the guiding bore 24 and extending between an upper end 60 protruding in the inner space S and a lower end protruding in the compression chamber 18, said lower end enlarging to form a head member 62 defining a closing face adapted to cooperate with the seat face 28 to seal said blind end of the bore.

[0018] The upper end 60 of the stem is covered by a cap member 64 defining a closed cylindrical portion 66 wherein said stem upper end 60 is inserted and, a crimping annular member 68 enabling to crimp said cap member 64 on the stem. The stem upper end 60 covered by said closed portion 66 of the cap are inserted in an orifice 70 centrally provided in a disc-like piezoceramic member 72 that transversally extends parallel to the transverse wall 52 of the cap toward an outer circular edge 74 that is between said body cap member 46 and the inlet body tubular portion 50. Moreover, a sealing flexible membrane 76 adapted to prevent fuel contact to the piezoceramic disc 72 is arranged in the inner space S, lying against the under face of said disc member 72, the membrane 76 having a peripheral area sandwiched between the disc member 72 and the inlet body tubular portion 50. Centrally, the membrane 76 is holed and fixed to the crimping annular member 68.

[0019] Not shown, the pumping head 12 and the inlet valve assembly 26 further comprise a fuel inlet conduit opening in the inner space S and enabling, in use, fuel to flow from a low pressure tank and to fill said inner space S and, electrical connection means, such as cables, wires and connectors, enabling to electrically connect said piezoceramic disc member 72 to an external command unit that will deliver relevant electrical command signals.

[0020] The operation of said pumping head 12 is now described focusing mainly on the moves of the inlet valve member.

[0021] In a first step the piezoceramic disc 72 is not energised, it does not receive electrical signals, and it remains in a neutral planar position. In said neutral position the inlet valve member is upwardly pulled sealing the fluid communication between the inlet channel and the compression chamber 18.

[0022] In a subsequent second step, the piezoceramic disc 72 is energized and, upon receiving such electrical signal, the disc deforms and centrally balloons, the outer edge 74 of the disc remaining pinched. As the disc 72 balloons, the disc central area downwardly moves pushing the inlet valve member 56 in an open position where the closing face of the head lifts away from the seat face 28 of the bore, enabling fuel passage in and out the compression chamber.

[0023] Thanks to said piezoceramic actuation of the inlet valve member, the opening and closing of the inlet is directly controlled, therefore, the inlet valve member can be opened or closed, earlier or later than it would naturally do under the sole influence of the pressure differences in the inner space S and in the compression chamber 18, this to optimise the filling of the compression chamber to the necessary quantity demanded by an engine.

LIST OF REFERENCES

[0024]

X pumping axis

S inner space

10 high pressure pump
12 pumping head
14 body of the pumping head
16 bore
18 compression chamber
20 outlet channel
22 outlet valve
24 inlet valve guiding bore
26 inlet valve assembly
28 seat face
30 top face of the pumping head
32 cylindrical wall
34 outer face
36 inner face
38 conical member
40 inlet channel
42 inlet valve body
44 main member of the inlet valve body
46 body cap member
48 body base of the main member
50 body tubular portion
52 transverse wall of the cap
54 peripheral wall of the cap
56 inlet valve member
58 stem
60 upper end of the stem
62 inlet valve head
64 cap member
66 closed portion
68 crimping annular member
70 orifice
72 piezoceramic disc
74 outer edge
76 membrane

Claims

1. Pumping head (12) of a fuel injection equipment high pressure pump (10), said pumping head (12) comprising a body (14) provided with a main bore (16) extending along a main axis (X) from a lower opening to an upper end partially defining a compression chamber (18) wherein are arranged an outlet opening and an inlet opening forming an axial guiding bore (24) extending through said body (14) from a seat face (28) surrounding the inlet opening in the bore to a top face (30) of the body and wherein,
the pumping head (12) further comprising an inlet valve assembly (26) controlling said inlet opening an comprising an inlet valve body (42) fixed atop the pumping head body thus defining an inner space (S), an inlet valve member (56) having a head member (62) defining a closing face cooperating with said seat face (28) and, a stem member (58) axially guided in said guiding bore (24) and extending from said head member (62) to an upper end (60) protruding in said inner space (S) and, a piezoceramic actuator (72) fixed in said body (42) and to said stem upper end (60).

2. Pumping head (12) as claimed in the preceding claim wherein said piezoceramic actuator (72) is a disc-like member provided with a central orifice (70), the outer edge (74) of said disc-like member being fixed in the inlet valve body (42) and, the stem upper end (60) being fixed into the central orifice (70).

3. Pumping head (12) as claimed in claim 2 further comprising a stem upper end cap member (64) arranged atop the stem upper end (60) and inside the central orifice (70) of the piezoceramic member.

4. Pumping head (12) as claimed in claim 3 further comprising a flexible sealing membrane (76) arranged in the inlet body inner space (S) and preventing, in use, fuel to contact the piezoceramic disc (72).

5. Pumping head (12) as claimed in claim 4 wherein said membrane (76) has an outer edge pinched between a face of the inlet valve body (42) and the outer edge of the piezoceramic disc (72) and, a central opening pinched between the stem upper end cap member (64) and the piezoceramic disc (72).

6. Pumping head (12) as claimed in any one of the preceding claims wherein the inlet valve body (42) comprises an annular member (44) fixed on the pumping head body and defining the peripheral wall of the inner space (S) and, a valve body cap member (46) fixed on said annular member (44) and closing said inner space (S).

7. Pumping head (12) as claimed in the combination of claims 5 and 6 wherein the disc membrane (76) is arranged so its outer edge is against a top annular face of the annular member (44) and the outer edge of said piezoceramic disc-like member (72), the valve body cap member (46) covering the piezoceramic disc (72) and being firmly tightened to the body annular member (44), thus pinching the piezoceramic disc and the membrane between the cover and the annular body member.

8. Pumping head (12) as claimed in any one of the preceding claims further comprising electrical wires connected to the piezoceramic disc (72) and extending outside the inlet valve body (42) so that, in use, command signals may be sent from a command unit to said piezoceramic actuator.

9. High pressure fuel pump (10) comprising a cambox and a pumping head (12) as claimed in any of the preceding claims and wherein, in use, a camshaft

rotates in the cambox imparting reciprocal displacements to a plunger guided in the main bore (16) and varying the volume of the compression chamber (18).

10. Fuel injection equipment comprising a high pressure pump (10) as claimed in claim 9 and a command unit connected to the inlet valve piezoceramic disc (72) and adapted to send command signal for operating the inlet valve member (56).

11. Method of controlling a fuel injection equipment as claimed in claim 10, the method comprising the step of:

- energizing the piezoceramic disc (72) so that the piezoceramic disc deforms forcing the inlet valve member (56) to open.

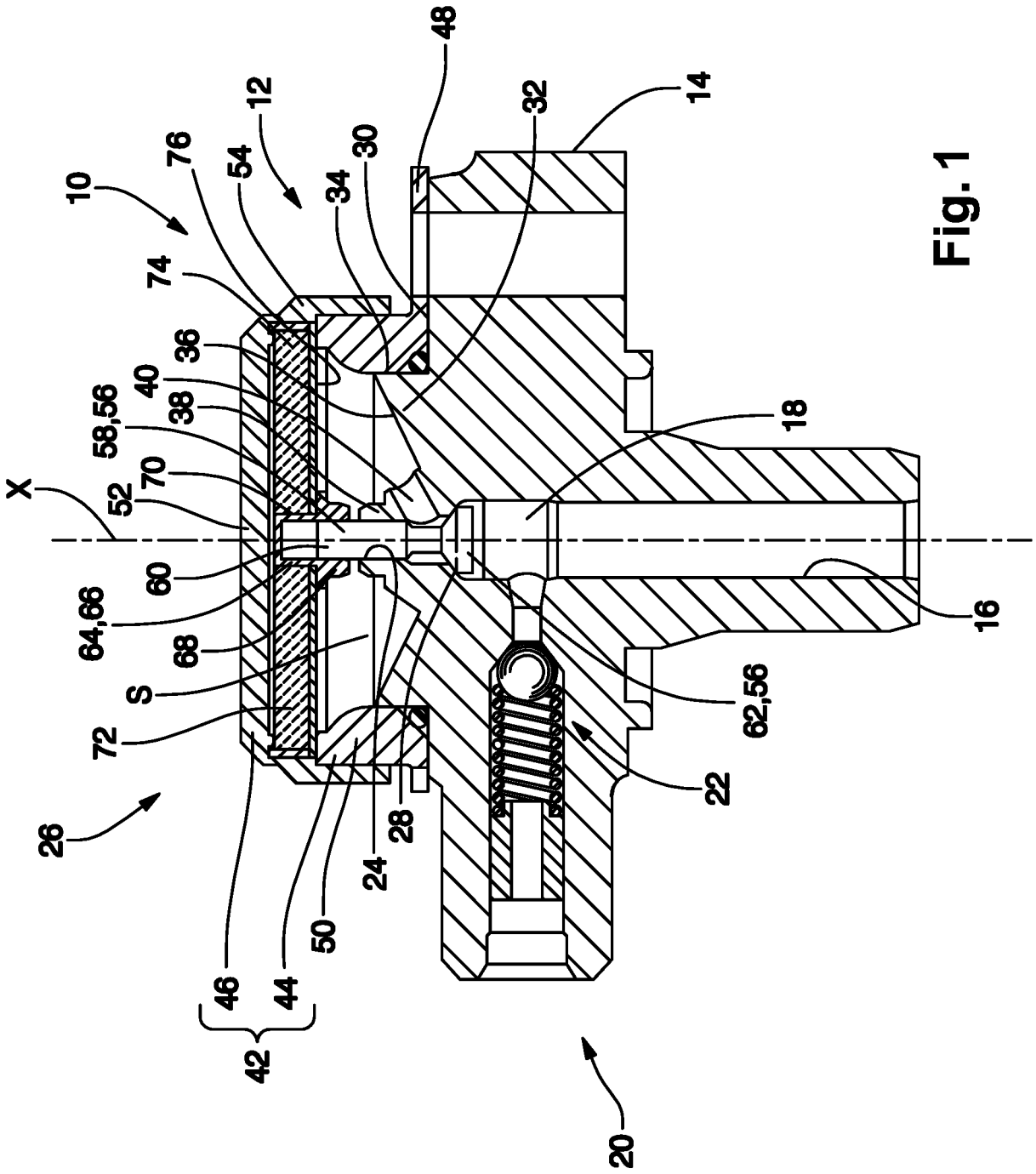
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Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 18 16 5539

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	DE 10 2012 218552 A1 (CONTINENTAL AUTOMOTIVE GMBH [DE]) 17 April 2014 (2014-04-17) * paragraph [0025] - paragraph [0028]; figure 1 * * abstract *	1	INV. F02M59/36
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X	DE 10 2008 018018 A1 (CONTINENTAL AUTOMOTIVE GMBH [DE]) 15 October 2009 (2009-10-15) * paragraphs [0023], [0034]; figure 2 * * abstract *	1	

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	6 July 2018	Hermens, Sjoerd

CATEGORY OF CITED DOCUMENTS

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82