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(56) Documents Cited:
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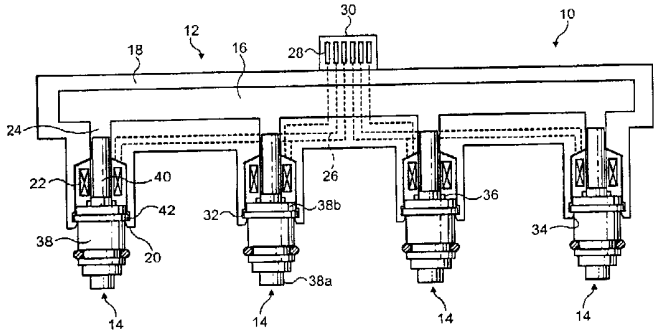
Other: EPODOC, JAPIO, WPI, OPTICS

(54) Abstract Title: **I.c. engine common rail fuel distribution system**

(57) The moulded fuel rail 12 is integrally moulded with (a) a plurality of actuation means for actuating the injection valves of respective fuel injectors 14, and (b) integrally moulded fuel outlet connectors 20 each having a groove 32 to engage by a snap-fit with an external rib 42 on the inlet end 38a of each injector valve unit 14. Each actuation means may be an electromagnetic coil 22 or a piezoelectric stack. A seal 36 may be provided in each connector 20. Each fuel injector valve unit 14 has a body 38 with a fuel inlet 40 and an external rib 42 adapted to be snap-fitted into a groove 32 in the outlet connector 20 of the fuel rail 12. The pressure of fuel supplied to the rail 12 is may be typically at least 300 bar and as high as 1000-2000 bar.



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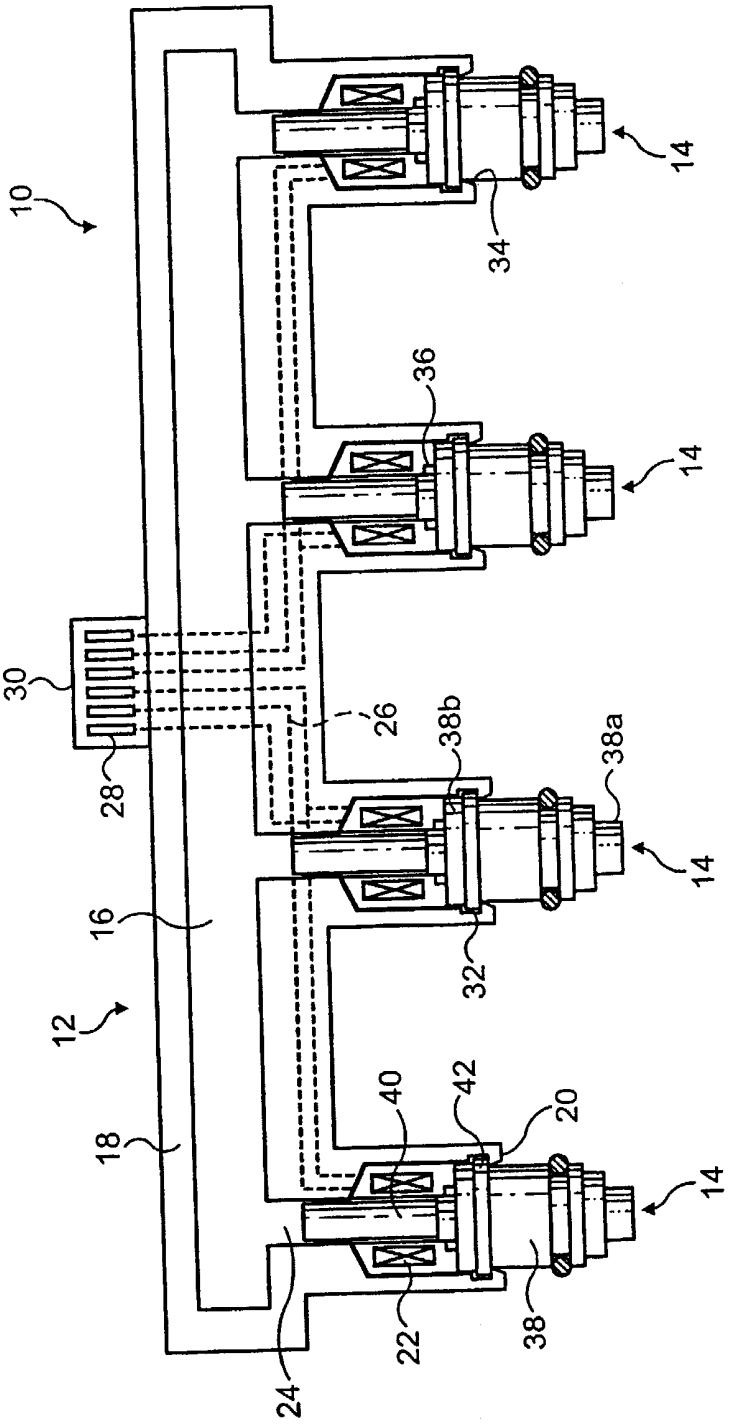
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FUEL DISTRIBUTION SYSTEM

The invention relates to a fuel distribution system for use with an internal combustion engine, and is more particularly concerned with a so called common rail fuel injection system including a common rail which is sometimes referred to as an accumulator volume. In particular, but not exclusively, the invention relates to a fuel distribution system for use in a common rail fuel injection system for a compression ignition internal combustion engine. The invention also relates to a fuel injection system incorporating such a fuel distribution system.

In known common fuel rail injection systems, it is usual for fuel injectors of the system and the common rail to be separate components and for the injectors to be connected to the rail by means of clips. Each injector commonly includes an actuator arrangement having a solenoid or a stack of piezoelectric elements operable to control movement of a valve needle of an injection nozzle of the injector. The actuator arrangement is usually individually electrically connected to the engine wiring harness so as to allow actuator movement to be controlled between 'open' and 'closed' positions. This mode of construction suffers from the problems that the components are time consuming to assemble, and also that it results in a large amount of loose wiring within the engine compartment.

It is an object of a first aspect of the present invention to provide a fuel distribution system having simpler modes of assembly and installation than known systems.

According to said first aspect of the present invention, there is provided a fuel distribution system for distributing fuel to a plurality of fuel injectors, said system comprising:

(i) a body defining a plurality of connectors which are adapted to be connected with respective fuel injector valve units, and a fuel distribution passageway for distributing fuel to the connectors, and

(ii) a plurality of actuation means, each actuation means being associated with one of the connectors so that, in use, the respective fuel injector valve units are operatively connected to the actuation means;

wherein the connectors are integrally formed with the body.

Each valve unit conveniently forms part of one of the fuel injectors, each of which also includes an injection nozzle that is operable to control movement of an associated valve needle to control fuel injection to the engine. The injection nozzles need not, however, form part of the fuel distribution system of this aspect of the invention.

Preferably, the body is a moulded body which is preferably *in situ* moulded around the actuation means.

Preferably, each connector is arranged to receive its respective fuel injector valve unit in a snap-fit fashion.

Preferably also, the system includes a connector tab which is integrally formed with the body and which carries electrical terminals which are electrically connected with the actuation means. More preferably, the terminals and wiring connecting the terminals with the actuation means are *in situ* moulded within the body.

Preferably, said actuation means associated with the or each connector is positioned about an opening in the connector for receiving an armature of the respective fuel injector valve unit.

The armature may be coupled to a valve member associated with the respective valve unit. This valve member may be an injection nozzle valve needle or a valve member that is operable to control movement of an injection nozzle valve needle.

Each actuation means may comprise an electromagnetic coil or one or more piezoelectric elements.

The fuel distribution passageway may include a common fuel conduit or passage to define a "common rail". A plurality of branch passages may extend from the fuel passage, each for delivering fuel to an associated fuel injector valve unit. The common rail may be of linear form, may take the form of a linear array of fuel passages, each associated with a different one of the fuel injectors of the system, or may include a central hub having radially extending fuel passages, each for delivering fuel to a different one of said fuel injectors.

According to a second aspect of the present invention, there is provided a fuel injection system comprising a fuel distribution system according to said first aspect of the present invention, in combination with a plurality of fuel injectors, each fuel injector including a valve unit which is engaged with or adapted to be engaged with a respective one of the connectors of the fuel distribution system.

It will be understood that the body may be moulded so as to further define other features associated with fuel injection systems, for example, an air intake manifold.

In one embodiment, therefore, the fuel distribution system comprises;

(i) a body defining a plurality of connectors which are adapted to be connected with respective fuel injector valve units, and a fuel distribution passageway for distributing fuel to the connectors, and

(ii) a plurality of actuation means, each actuation means being associated with one of the connectors so that, in use, the respective fuel injector valve units are operatively connected to the actuation means;

wherein the connectors are integrally formed with the body and with an air intake manifold of the associated engine.

An embodiment of a common rail fuel distribution system of the present invention will now be described, by way of example only, with reference to the accompanying drawing which is a schematic cross sectional representation of a

common rail fuel distribution system according to one aspect of the present invention.

Referring to the drawing, a common rail fuel distribution system 10 comprises a fuel rail 12 and a plurality of fuel injector valve units 14. Each fuel injector valve unit 14 forms part of a fuel injector unit, or fuel injector, that also includes an injection nozzle operable under the control of the valve unit 14 to control fuel injection to an associated engine cylinder or other combustion space. The nozzle of the injector may take one of a variety of forms familiar to those skilled in this art, and so for simplicity the structural details are not shown in the accompanying drawing.

The fuel rail 12 comprises a generally linear fuel conduit or passage 16 positioned within a body in the form of a linear moulded rail 18, the fuel conduit 16 being supplied, in use, with fuel from a high pressure fuel source (not shown), such as a high pressure pump, in a known manner. Typically, the pressure of fuel supplied to the fuel conduit 16 is at least 300 bar, and may be as high as between about 1000 and 2000 bar. The fuel conduit 16 and the moulded rail 18 have integrally formed fuel outlet connectors 20 formed therein. Each fuel outlet connector 20 is adapted to be connected with an associated one of the fuel injector valve units 14.

The moulded rail 18 is formed of an electrically insulating material (e.g. a temperature resistant resin or plastic) and has electromagnetic windings 22, forming part of an associated actuation means, integrally moulded therein. Each electromagnetic winding 22 is positioned within the moulded rail 18 in the

region of each of the connectors 20 so as to surround a bore 24 provided in the latter. Each connector bore 24 defines, at least in part, a branch passage from the fuel conduit 16 through which fuel is supplied from the conduit 16 to the valve unit 14. The moulded rail 18 is *in situ* moulded around copper wires 26 forming electrical connections with the respective windings 22 and leading to terminals 28 on a connector tab 30. The connector tab 30 is also integrally moulded with the rail 12 and allows connection of the windings 22 to an electronic valve control apparatus (not shown) which causes the windings 22 of the actuation means to be energised individually at the correct times and in the correct sequence in a known manner.

Each fuel injector valve unit 14 comprises a body 38 having a first end 38a adapted to have its associated injection nozzle (not shown) fitted thereto, and a second end 38b having a fuel inlet 40 and an external annular rib 42 adapted to be snap-fitted into the groove 32 in the fuel outlet connector 20. The fuel inlet 40 receives high pressure fuel through the branch passage defined by the bore 24 of the connector 20.

The connectors 20 terminate at their ends distal to the fuel conduit 16 in snap-fit connectors including annular grooves 32 in the walls of the connectors 20. The free end of each connector 20 has a flared lead in surface 34 and is axially split so as to facilitate deformation to permit snap-engagement of the valve unit 14 into the connectors 20. A seal 36, for example an O-ring, is provided in each connector 20 so that, when one of the valve units 14 is snap-engaged in the connector 20, a fluid-tight seal is formed therebetween to substantially prevent leakage of fuel.

Each valve unit 14 further includes an armature (not shown) that is movable with a valve member of the associated injector. The valve member is movable with the armature between first and second positions and the valve unit 14 is preferably configured such that, when the valve member is in the first position, fuel is able to flow from the fuel inlet 40, in use, through the injection nozzle to a nozzle outlet for injection to the associated engine cylinder. When the valve member is in the second position, fuel injection into the engine cylinder is prevented. Conveniently, the armature is disposed adjacent to the winding 22 so that when the latter is energised, the valve member is caused to move to the first position in which fuel injection occurs through the nozzle outlet.

In use, fuel is supplied to the common rail 12 from the high pressure fuel source (not shown) at a substantially constant pressure. When fuel is to be supplied to one of the fuel injectors (not shown) through its associated valve unit 14, the electromagnetic winding 22 associated with the fuel outlet connector 20 in which the valve unit 14 is located is energised by the electronic valve control apparatus. Energisation of the winding 22 results in the armature and its associated valve member being moved from its second position into its first position, thereby permitting fuel to be injected into the engine. De-energisation of the winding 22 results in the valve member moving to its second position to terminate the supply of fuel to the engine cylinder.

This cycle is repeatable for each valve unit 14 under the control of the electronic valve control apparatus associated with the common rail distribution system 10 and allows fuel to be injected by each fuel injector at the appropriate time in the cycle.

It will be understood that a further embodiment can be envisaged in which the armature within the valve unit 14 takes the form of or includes a piezoelectric stack. In such an embodiment the actuator means includes electrical connectors for supplying a voltage across the piezoelectric stack.

The injection nozzle may be of a direct actuation type, in which the armature is mechanically coupled to a valve needle (the valve member) of the injection nozzle to control injection through the nozzle outlet. Alternatively the injection nozzle may include an hydraulic amplifier arrangement so that the actuator is operable to control fuel pressure within a control chamber, optionally through a differential piston arrangement. In the latter case the armature of the actuator arrangement may be coupled to a valve member which is actuable between its first and second positions to control fuel pressure within the control chamber. By controlling fuel pressure within the control chamber movement of an injection nozzle valve needle is controlled so as to control injection through the nozzle outlet.

In the embodiment shown in the accompanying drawing, the rail 12 is generally of linear form, including a linear fuel conduit 16 and laterally extending branch passages (defined at least in part by the bores 24 in the connectors 20). In an alternative embodiment the rail 12 may be of generally spherical form, with a plurality of radially extending branch passages, each supplying fuel to a respective one of the injectors.

CLAIMS

1. A fuel distribution system for distributing fuel to a plurality of fuel injectors, said system comprising:

(i) a body defining a plurality of connectors which are adapted to be connected with respective fuel injector valve units, and a fuel distribution passageway for distributing fuel to the connectors, and

(ii) a plurality of actuation means, each actuation means being associated with one of the connectors so that, in use, the respective fuel injector valve units are operatively connected to the actuation means;

wherein the connectors are integrally formed with the body.

2. A fuel distribution system according to Claim 1, wherein the body is a moulded body.

3. A fuel distribution system according to Claim 2, wherein the body is *in situ* moulded around the actuation means.

4. A fuel distribution system according to any one of Claims 1 to 3, wherein each connector is arranged to receive its respective fuel injector valve unit in a snap-fit fashion.

5. A fuel distribution system according to any one of Claims 1 to 4, wherein the system includes a connector tab which is integrally formed with the body and which carries electrical terminals which are electrically connected with the actuation means.

6. A fuel distribution system according to any one of Claims 1 to 5, wherein the terminals and wiring connecting the terminals with the actuation means are *in situ* moulded within the body.

7. A fuel distribution system according to any one of Claims 1 to 6, wherein said actuation means associated with the or each connector is positioned about an opening in the connector for receiving an armature of the respective fuel injector valve unit.

8. A fuel distribution system according to any one of Claims 1 to 7, wherein each actuation means is an electromagnetic coil.

9. A fuel distribution system according to any one of Claims 1 to 7, wherein each actuation means is one or more piezoelectric elements.

10. A fuel distribution system according to any one of Claims 1 to 9, wherein each actuation means is operable to control a valve needle of the associated fuel injector directly, said valve needle being movable to open and close a nozzle outlet.

11. A fuel distribution system according to any one of Claims 1 to 9, wherein each actuation means is operable to control movement of a valve member of the associated valve unit, and thereby to control movement of a valve needle of the associated fuel injector indirectly, said valve needle being movable to open and close a nozzle outlet.

12. A fuel injection system comprising a fuel distribution system according to any of Claims 1 to 11, in combination with a plurality of fuel injectors, each fuel injector including a valve unit which is engaged with or adapted to be engaged with a respective one of the connectors of the fuel distribution system.

13. A fuel injection system as claimed in Claim 12, for use in a compression ignition internal combustion engine.

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Application No: GB 0327305.9
Claims searched: 1 to 13

Examiner: John Twin
Date of search: 7 January 2004

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X	1,2,4,6 at least	WO 01/90567 A1	(Robert Bosch) - see eg figures 1, 4
X	1,2,4,6 at least	WO 97/21918 A1	(Robert Bosch) - see eg figure 1
X	1,2 at least	US 5743235	(Luedler) - see eg figure 11
X	1,2 at least	US 5616037	(Siemens Automotive) - see eg figure 5
X	1,2 at least	US 5598824	(Ford)
A		EP 0900933 A1	(Peugeot & Citroen)
A		US 5005878	(Robert Bosch) - note use of clip (10)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[W]:

F1B

Worldwide search of patent documents classified in the following areas of the IPC[7]:

F02M

The following online and other databases have been used in the preparation of this search report:

EPODOC, JAPIO, WPI, OPTICS