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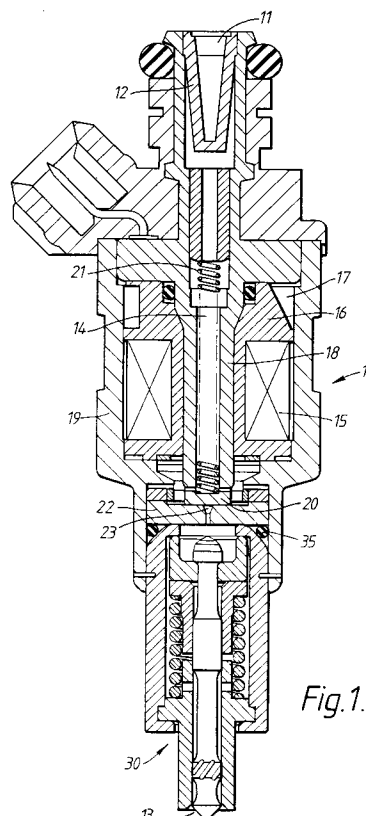
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Ickenham Uxbridge Middlesex UB10 8BZ(GB)(54) **Fuel injector.**

(57) A direct injection fuel injector has a fuel conduit 14, a fuel inlet 11 and a fuel outlet 13. An electromagnetically-controlled plate valve 20 regulates a flow of fuel along conduit 14 and a further valve including a needle valve member 36 allows fuel to exit the conduit via the outlet provided the differential pressure across the further valve exceeds a predetermined amount. The further valve member is effective to close the outlet in response to the pressure developed during compression in the combustion chamber.

*Fig.1.***EP 0 463 730 A1**

This invention relates to fuel injectors, particularly direct injection fuel injectors; that is to say, fuel injectors suitable for injecting fuel directly into the combustion chamber of an engine.

The invention has particular, though not exclusive, application to engines fuelled by petrol or methanols.

There is an increasing need for direct injection fuel injectors capable of accurately regulating the flow of fuel supplied to the combustion chamber. Such fuel injectors would enable greater fuel economy and would also reduce the emission of pollutants, particularly carbon dioxide.

Electronically-controlled fuel injectors are known. However, they do not operate satisfactorily at the high combustion pressures encountered in the combustion chamber of an engine and therefore cannot be used as direct injection fuel injectors.

It is an object of the present invention to provide a direct injection fuel injector which substantially alleviates the afore-mentioned problems.

According to the invention there is provided a fuel injector suitable for direct injection of fuel into the combustion chamber of an engine, comprising a fuel conduit having an inlet by which fuel can be admitted to the conduit and an outlet by which fuel can exit the conduit and being characterised by an electromagnetically-controlled valve for regulating a flow of fuel along the conduit and a further valve, positioned downstream of the electromagnetically-controlled valve, for enabling fuel to exit the conduit through the outlet provided the pressure upstream of the further valve exceeds the pressure downstream of the further valve by at least a pre-determined amount.

The further valve is operable to close off the outlet and prevents fuel injection from taking place during combustion.

A direct injection fuel injector, as defined, is particularly versatile in that the flow of fuel to the combustion chamber can be accurately metered by applying a suitable electrical control signal to the electromagnet of the electromagnetically-controlled valve.

The control signal may be a pulsed control signal; for example, a variable width, fixed frequency signal, a variable frequency, fixed width signal or a combination of these.

In a preferred embodiment the electromagnetically-controlled valve is an electromagnetically-controlled plate valve.

Preferably, the fuel injector has a nozzle providing said outlet and the further valve comprises a valve member displaceable between a first position in which the valve member co-operates with the nozzle to close the outlet and prevent fuel from exiting the fuel conduit and a second position in

which fuel can exit the conduit through the outlet.

In a preferred embodiment of the invention, the nozzle comprises a tubular sleeve and the valve member is an outwardly-opening valve member which is axially displaceable relative to the tubular sleeve between the first and second positions.

The valve member may be a needle-type valve member, and the further valve may include resilient means, for example a coil spring, for urging the valve member towards the first position.

The valve member may have a ribbed formation for assisting in axial alignment of the valve member in the tubular sleeve and to impart a swirling motion to fuel passing along the fuel conduit towards the outlet.

A direct injection fuel injector in accordance with the invention is now described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a longitudinal sectional view through the fuel injector; and

Figure 2 shows, on an enlarged scale, a detailed longitudinal sectional view through an outlet nozzle of the fuel injector of Figure 1.

Referring now to Figure 1, the fuel injector comprises a housing 10 having a fuel inlet 11, in which is fitted a filter 12, and a fuel outlet 13, the inlet and the outlet being connected by a conduit 14 formed within the housing.

In this particular embodiment, the fuel inlet is coupled to a constant pressure fuel supply (not shown), and is intended to be fitted directly to the engine's combustion chamber so that the fuel outlet lies within the chamber.

The passage of fuel through the fuel injector is regulated by an electromagnetically-controlled valve comprising an electromagnet including a solenoid coil 15 supported on a coil former 16. The coil former is located inside an annular cavity 17 defined by concentric parts 18 and 19 of the housing 10. Both parts 18 and 19 are made of a magnetisable material, thus providing a magnetic circuit round the solenoid coil 15. The electromagnetically-controlled valve further includes a valve plate 20, also made of a magnetisable material, which is urged by a coil spring 21 into contact with a valve seat in the form of a disc 22 in which is formed an aperture 23. The valve plate 20, when in the position shown in Figure 1, blocks the aperture 23 in disc 22, thereby preventing the flow of fuel from the fuel inlet 11, through conduit 14, to the fuel outlet 13.

Upon energisation of the solenoid coil 15, the valve plate 20 is magnetically attracted towards the adjacent end face of part 18 thus unblocking the aperture 23 in the disc 22.

Upon de-energisation of the solenoid coil 15 the valve plate 20 is returned by the action of the

coil spring 21 into contact with the disc 22, thereby blocking the flow of fuel through the aperture.

The flow of fuel through the aperture 23 can be accurately metered by suitably energising the electromagnetically-controlled valve. To that end, the solenoid coil 15 may be supplied with a pulsed control signal which regulates the time intervals during which the solenoid coil is energised (and fuel is able to flow through aperture 23) and the time intervals during which the solenoid coil is de-energised (and fuel is prevented from flowing through the aperture 23).

The pulsed control signal may be a variable width, fixed frequency signal or a variable frequency, fixed width signal or a combination of these.

The fuel injector has an outlet nozzle 30 which is located downstream of the electromagnetically-controlled valve and incorporates a second valve for exercising further control over the flow of fuel.

The outlet nozzle, shown in greater detail in Figure 2, has a sleeve 31 fixed to part 19 by welding, for example, and a coaxial sleeve 32 having a flange 33 which is fixed within an annular groove 34 formed in sleeve 31 at the downstream end thereof.

The upstream end of sleeve 31 is folded inwardly, as shown in Figure 1, whereby to abut disc 22, and an O-ring 35 provides a fluid-tight seal between these abutting parts.

The second valve, incorporated in nozzle 30, has a needle-type valve member 36 which is axially displaceable relative to sleeves 31 and 32. The valve member 36 is maintained in substantial axial alignment with sleeves 31 and 32 by a collar 37 fixed round the upstream end 38 of valve member 36 and by a cylindrical part 39 of the valve member which is a close fit within the bore of a further flanged sleeve 40 and that of sleeve 32.

The collar 37 and the further sleeve 40 can both slide axially relative to sleeve 31 and a further coil spring 41, acting directly on sleeve 40, urges the valve member 36 towards the normally-closed position - the position shown in Figures 1 and 2.

The end 42 of sleeve 32 is formed with a conical valve seat 43 formed around the fuel outlet 13 and, in the normally-closed position, a tapered end surface of the valve member 36 bears against the valve seat 43, as shown, and prevents fuel from exiting the conduit 14 through outlet 13.

Provided the differential pressure across the second valve is sufficient to overcome the force exerted by the coil spring and cylinder pressure, the valve member will be displaced, in the direction of arrow A in Figure 2, enabling fuel to exit the conduit 14 through the fuel outlet 13. The fuel flows around the collar 37 and sleeve 40, through a cross-bore 44 in sleeve 32 and along a channel 45

therein to the outlet 13.

A ribbed formation 46 on the valve member 36 also assists alignment of the valve member in the bore of sleeve 32 and allows fuel to pass along channel 45 to the outlet 13. The ribs of the formation slope relative to the longitudinal axis of the valve member. This reduces wear on the sleeve and also imparts a swirling motion to fuel passing along conduit 45. The latter assists atomisation of the fuel at the outlet.

Before combustion takes place in the combustion chamber, the pressure developed during compression (typically about 10 bar) acts on the downstream end of the valve member 36 (which is within the combustion chamber) assisting its return to the normally-closed position and forming a positive seal, thereby blocking a flow of fuel through the fuel outlet and preventing fuel injection during combustion.

The described fuel injector has particular, though not exclusive, application to petrol engines.

In a typical application, the fuel inlet 11 would be connected to a fuel supply line delivering fuel at a constant pressure, typically in the range 6-10 bar. At such pressures, the fuel would exit the fuel outlet as a spray suitable for ignition in the combustion chamber.

As described hereinbefore, the volume of fuel injected into the combustion chamber can be accurately regulated by means of the control signal supplied to the electromagnet of the electromagnetically-controlled valve. This enables greater fuel economy to be achieved and also reduces the emission of pollutants, such as CO₂.

It will be appreciated that a fuel injector in accordance with the invention is suitable for use with liquid fuels other than petrol (e.g. methanols) and gaseous fuels.

Claims

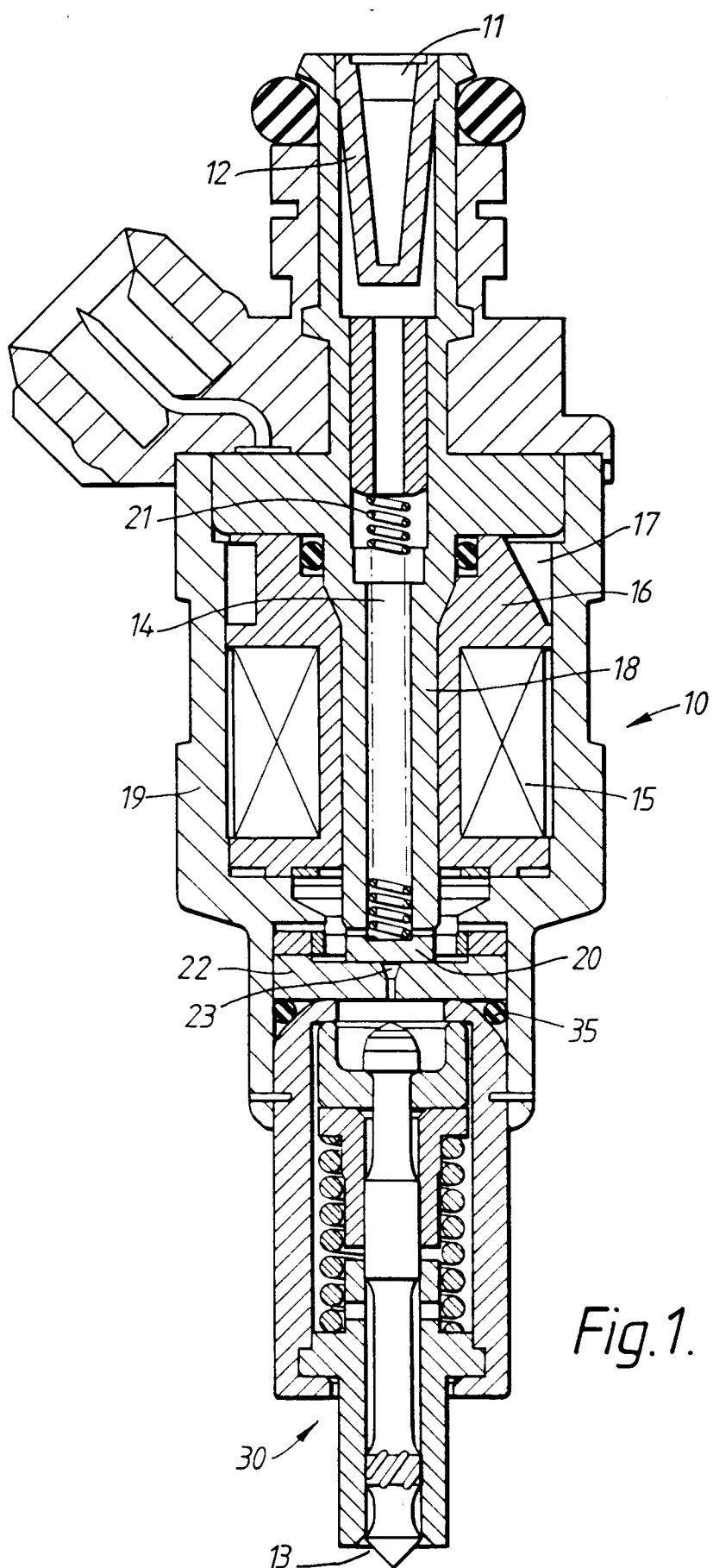
1. A fuel injector suitable for direct injection of fuel into the combustion chamber of an engine, comprising a fuel conduit (14) having an inlet (11) by which fuel can be admitted to the conduit (14) and an outlet (13) by which fuel can exit the conduit (14) and being characterised by an electromagnetically-controlled valve for regulating a flow of fuel along the conduit (14) and a further valve, positioned downstream of the electromagnetically-controlled valve, for enabling fuel to exit the conduit (14) through the outlet (13) provided the pressure upstream of the further valve exceeds the pressure downstream of the further valve by at least a predetermined amount.
2. A fuel injector as claimed in claim 1, charac-

terised in that the electromagnetically-controlled valve is an electromagnetically-controlled plate valve.

3. A fuel injector as claimed in claim 1 or claim 2, characterised by a nozzle (30) providing said outlet (13) and in that the further valve comprises a valve member (36) displaceable between a first position in which the valve member (36) co-operates with the nozzle (30) to close the outlet (13) and prevent fuel from exiting the fuel conduit (14) and a second position in which fuel can exit the conduit (14) through the outlet (13).
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4. A fuel injector as claimed in claim 3, characterised in that the nozzle (30) comprises a tubular sleeve (32) and the valve member (36) is an outwardly-opening valve member which is axially displaceable relative to the tubular sleeve (32) between the first and second positions.
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5. A fuel injector as claimed in claim 3 or claim 4, characterised in that the valve member (36) is a needle-type valve member.
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6. A fuel injector as claimed in any one of claims 3 to 5, characterised in that the further valve includes resilient means (41) for urging the valve member (36) towards the first position.
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7. A fuel injector as claimed in any one of claims 3 to 6, characterised in that the valve member (36) has a ribbed formation (46) for assisting in axial alignment of the valve member in the tubular sleeve (32) and to impart a swirling motion to fuel passing along the fuel conduit (14) towards the outlet (13).
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8. A fuel injector as claimed in any preceding claim, characterised in that the electromagnetically-controlled valve is energised with a pulsed control signal supplied to the electromagnet of the electromagnetically controlled valve.
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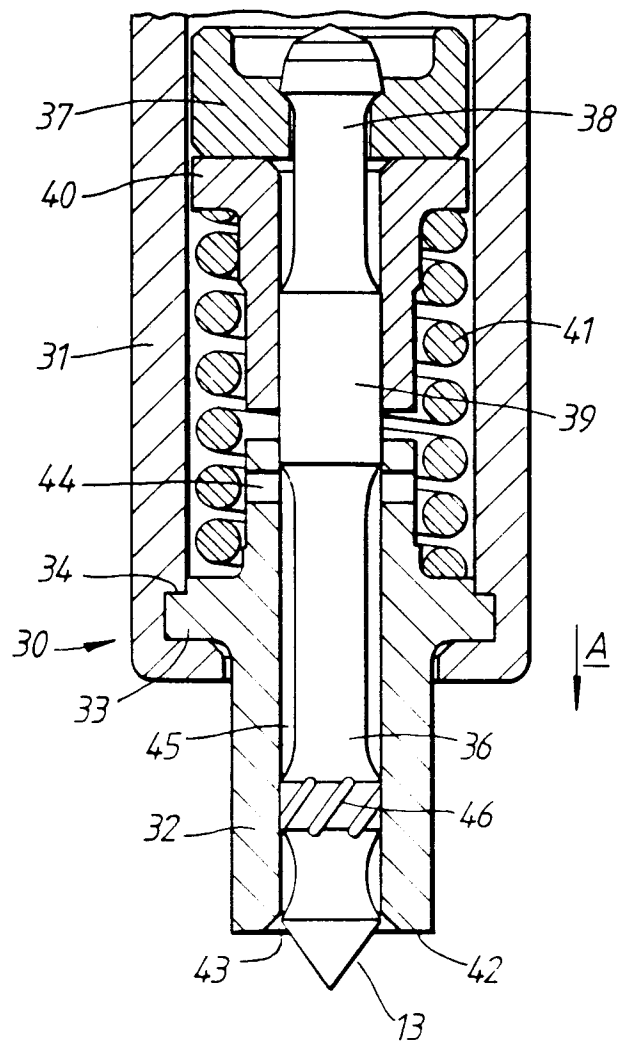


Fig.2.



European Patent
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EUROPEAN SEARCH REPORT

Application Number

DOCUMENTS CONSIDERED TO BE RELEVANT			EP 91304464.0
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. CL.5)
X	GB - A - 1 336 636 (ROTO DIESEL) * Totality; especially fig. 1-5 *	1-6, 8	F 02 M 51/06
Y	--	7	
Y	GB - A - 2 112 455 (LUCAS INDUSTRIES) * Totality; especially numeral 30 *	7	
X	DE - A1 - 3 151 368 (NISSAN MOTOR CO., LTD) * Fig. 2,3 * ----	1, 3, 6, 8	
			TECHNICAL FIELDS SEARCHED (Int. CL.5)
			F 02 M 51/00 F 02 M 61/00
The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 09-09-1991	Examiner PIPPAN
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	