(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 419 014 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **90308315.2**

(51) Int. Cl.5: **F02M 59/36**

(22) Date of filing: **30.07.90**

(30) Priority: **12.08.89 GB 8918432**

(43) Date of publication of application:
27.03.91 Bulletin 91/13

(84) Designated Contracting States:
DE ES FR GB IT

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(54) Fuel injection system.

(57) A fuel injection system for supplying fuel to an internal combustion engine includes a cam actuated fuel pump 10 which is connected by a pipe line 11 to a fuel injection nozzle 12. A spill valve 13 is located adjacent the nozzle and when opened while the pump is delivering fuel, terminates flow of fuel through the nozzle.

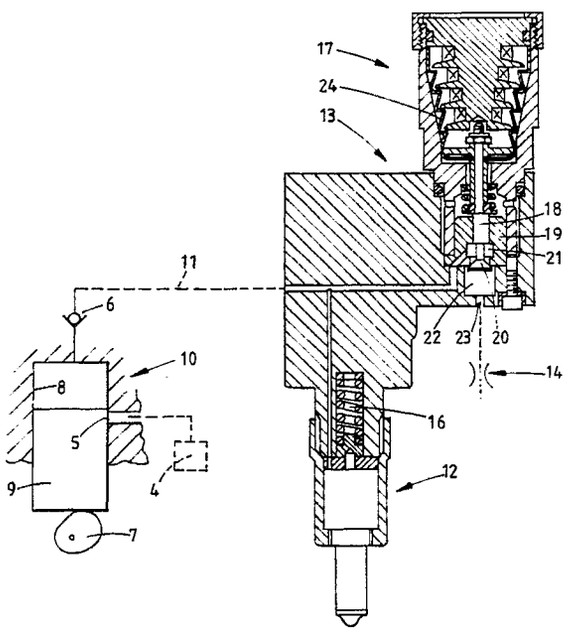

FIG.1.

EP 0 419 014 A1

FUEL INJECTION SYSTEM

This invention relates to a fuel injection system for supplying fuel to an internal combustion engine and of the kind comprising a high pressure fuel pump including a cam actuated pumping plunger, the cam being driven in use by the associated engine, a fuel injection nozzle positioned to direct fuel into a combustion chamber of the engine and mounted remote from the pump and connected thereto by a high pressure pipe line, and a spill valve operable to spill fuel delivered by the pump during a working stroke of the plunger thereby to terminate delivery of fuel through the injection nozzle to the engine.

Such systems are well known in the art and it is the usual practice to provide the spill valve in the pump. However, with the spill valve in this position termination of the flow of fuel through the injection nozzle does not always occur in the desired precise manner due to the fact that the pipe line has a significant effect in modulating and changing the rate of pressure change at the injection nozzle relative to the rate achieved at the pump.

The object of the present invention is to provide a system of the kind specified in a simple and convenient form.

According to the invention in a fuel injection system of the kind specified the spill valve is positioned adjacent the fuel injection nozzle.

In the accompanying drawings:-

Figure 1 is a diagrammatic representation of one example of a fuel injection system in accordance with the invention, and

Figure 2 is a view similar to Figure 1 showing a modified system.

Referring to Figure 1 of the drawings the fuel injection system comprises a high pressure fuel pump 10 having an outlet which is connected through a delivery valve 6, by a high pressure pipe line 11 to the inlet of a fuel injection nozzle 12. The pump includes a pumping plunger 9 which is movable inwardly in a bore 8 by means of a cam 7. As shown the cam is a rotary cam but it can be a fixed cam such as is found in a distributor type of pump. Fuel is supplied to the bore 8 when a filling port 5 connected to a source 4 of fuel under pressure is covered by the plunger during the initial portion of its inward movement. The nozzle in use, is positioned to direct fuel into a combustion space of an associated engine and the pump 10 is mounted on the engine at a position remote from the nozzle. The injection nozzle 12 is also of conventional form having a fuel pressure actuated valve member which is moved by the fuel pressure to move the valve member against the action of a spring 16 to allow fuel flow through an outlet.

In order to terminate delivery of fuel through the injection nozzle 12 there is provided a spill valve 13 the operation of which is controlled by an electro-magnetic actuator 17. The flow of current to the actuator 17 is determined by an electronic control system (not shown).

As shown in Figure 1 the spill valve 13 is mounted in the same body to which the nozzle is attached. However, the spill valve can form a separate component which would be located in close proximity to the nozzle. The spill valve includes a valve member 18 slidable in a bore in a valve body 19, the valve member defining a head 20 engageable with a seating defined by the body. Beneath the head the valve member and the body define a chamber 21 which is connected to the inlet of the nozzle. The valve member is biased by a spring to the open position in which fuel can flow from the chamber 21 into a further chamber 22 from which extends an outlet 23. The valve member 18 is coupled to the armature 24 of the actuator, the armature being of stepped form and the actuator also includes a stator 25 defining ribs presented to the steps defined by the armature. The stator also carries a plurality of windings and when the latter are supplied with electric current, the armature assumes the position shown in the drawing and the head 20 of the valve member is held in engagement with the seating to prevent flow of fuel between the inlet of the nozzle and the outlet 23.

The flow of fuel from the outlet 23 of the spill valve 13 is conveniently controlled by a back pressure control 14 which is shown as a simple restrictor. The control may be pressure relief valve or a spring controlled piston which can absorb the spilled fuel and also regulate the residual pressure in the pipe line.

In use, prior to the commencement of the working stroke of the plunger of the pump 10 the actuator 17 associated with the spill valve is energised in order to close the valve head 20 onto the seating and at the commencement of the working stroke of the plunger the fuel in the pipe line 11 will be pressurised and the valve member in the nozzle opened against the action of its spring to permit fuel flow to the engine. At a pre-determined point in the working stroke of the plunger the actuator is de-energised and the valve head of the spill valve is moved to the open position. When the valve head moves to the open position the pressure in the pipe line 11 adjacent the injection nozzle falls quickly thereby allowing the valve member in the nozzle to move quickly to the closed position. The pressure in the pipe line is controlled by the back

pressure control 14 which will restrict the rate at which the pressure can collapse and as stated, the control may be such that a residual pressure is maintained in the pipe line.

In the example of Figure 1 the quantity of fuel which is supplied to the associated engine may be varied by opening the spill valve at an appropriate instant in time following the commencement of delivery of fuel by the pump. Alternatively the spill valve may be opened at a pre-determined position of the plunger of the pump in its bore in which case the quantity of fuel is controlled by varying the length of the working stroke of the plunger using for example a helical groove on the plunger which controls the start of fuel delivery by the pump.

In the alternative arrangement which is illustrated in Figure 2, parts which have the same function as in the system of Figure 1 are assigned the same reference number. In Figure 2 it will be noted that there is an additional valve 15 and this valve is also actuated by an electro-magnetic actuator under the control of the electronic control system and in this case the valve 15 is closed by energising the associated actuator, to initiate the delivery of fuel through the injection nozzle. It is convenient for the closing movement of valve 15 to be assisted by the developing fuel pressure in the pipe line and for the opening movement of the valve 13 to be assisted by the fuel pressure in the pipeline. In this case therefore the valve 13 would be closed before the valve 15 in order to minimise the size of the actuator required. Alternatively the valves can be provided with balanced valve members.

In the arrangement shown in Figure 2 the quantity of fuel delivered to the associated engine is determined by the displacement of fuel which takes place when both valves are closed. If it is required to vary the timing of fuel delivery for a given quantity of fuel the time at which the actuators of the valves are de-energised must be altered by the same amount assuming of course that the cam which actuates the pump plunger has a constant rate. If the cam does not have a constant rate the shape of the cam must be taken into account by the associated control system and this can be achieved by the use of suitable maps. The resilience of the fuel column must also be taken into account it being understood that when fuel delivery takes place soon after the start of inward movement of the plunger there will be a greater volume of fuel in the system than when delivery takes place later in the inward stroke of the pump plunger.

Claims

1. A fuel injection system for supplying fuel to an internal combustion engine comprising a high pressure fuel pump (10) including a pumping plunger (9) actuated by an engine driven cam (7), a fuel injection nozzle (12) positioned to direct fuel into a combustion chamber of the engine and mounted remote from the pump (10) and connected thereto by a pipe line (11), and a spill valve (13) operable to spill fuel delivered by the pump (10) during a working stroke of the pumping plunger (9) thereby to terminate delivery of fuel through the injection nozzle to the engine characterised in that the spill valve (13) is positioned adjacent the fuel injection nozzle (12).

2. A system according to Claim 1, characterised by a back pressure control (14) for controlling the flow of fuel through an outlet (23) of the spill valve (13).

3. A system according to Claim 2 in which said control (14) comprises a restriction (14).

4. A system according to Claim 3 characterised in that said control (14) comprises a pressure relief valve.

5. A system according to Claim 1 characterised by a further spill valve (15) connected in parallel with the spill valve, said valves being operable to control the timing of fuel delivery and the ending of fuel delivery.

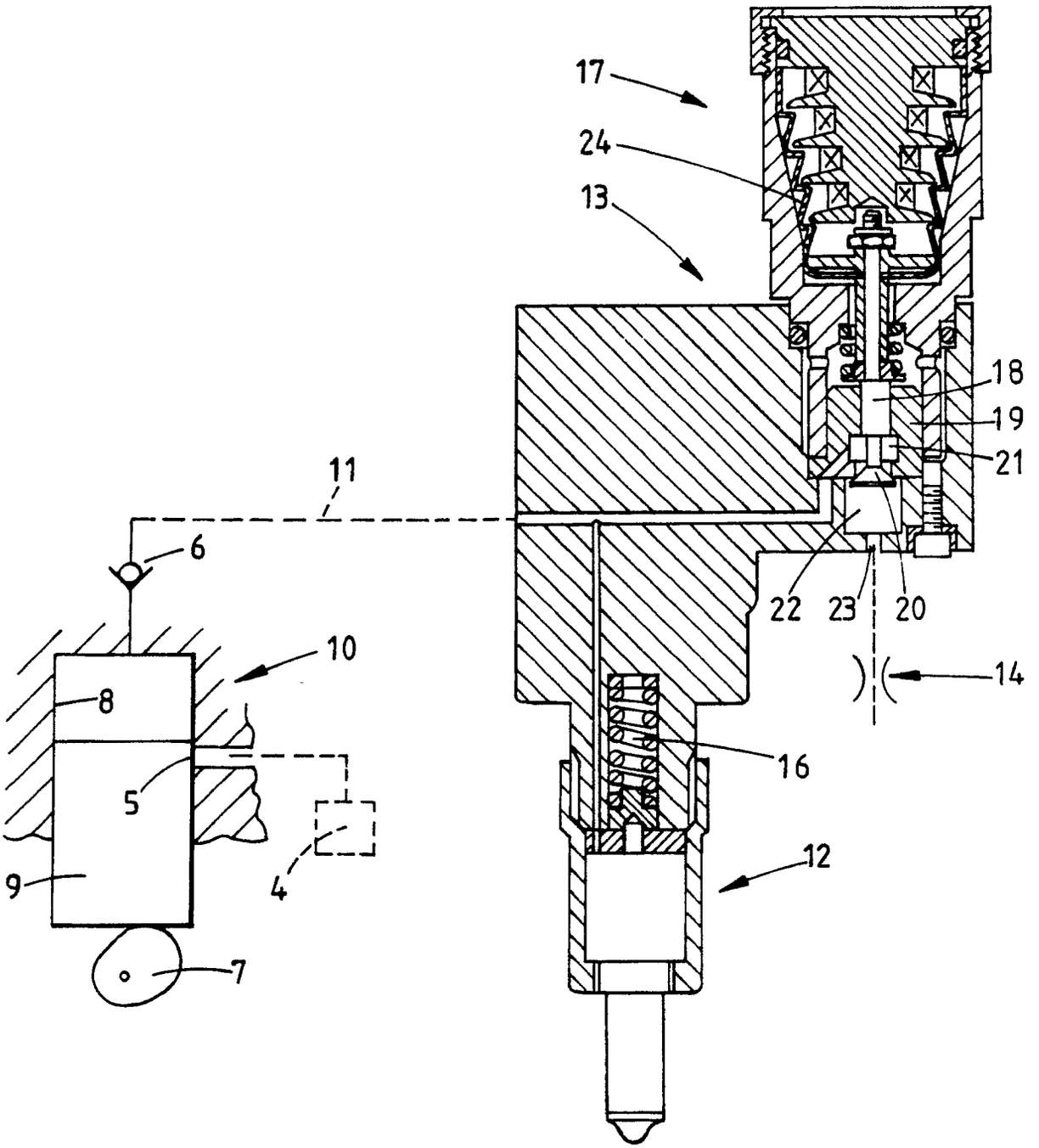

FIG.1.

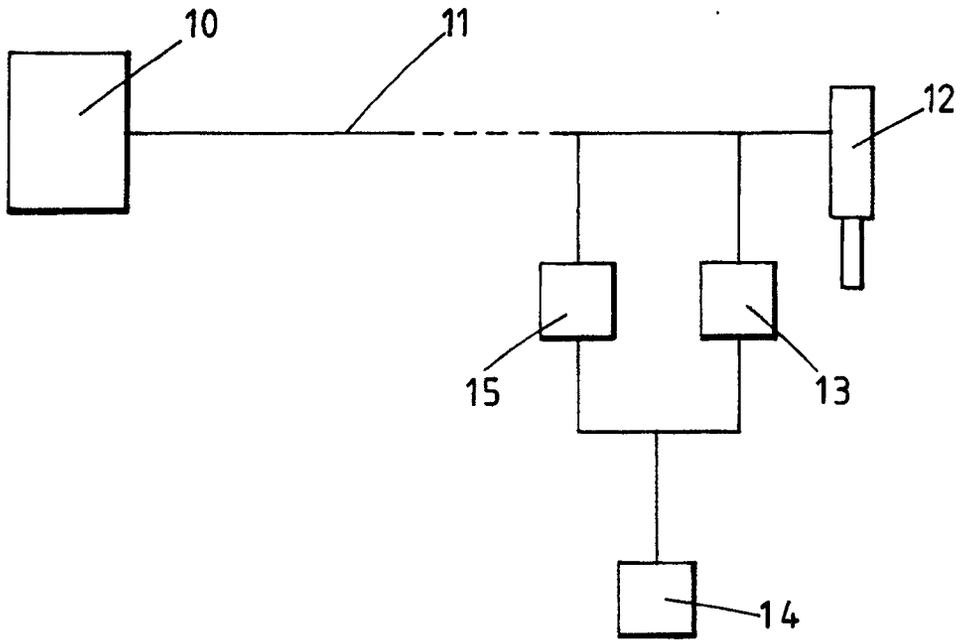

FIG.2.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 30 8315

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	FR-A-2 095 695 (KLOCKNER-HUMBOLDT DEUTZ AG) * Page 1, lines 1-6; page 3, lines 1-3,7-12; page 5, lines 8-33; figure 1 *	1,5	F 02 M 59/36
Y		2-4	
Y	SHIPBUILDING & MARINE ENGINEERING INT., vol. 104, no. 1253, November 1981, pages 473-476, London, GB; L. BRYCE: "Electronically-controlled fuel injection for medium-speed engines" * Page 473, left-hand column, figure: "Schematic arrangement of the fuel system for the electronically-controlled injection pump" *	2-4	
X	US-A-4 586 656 (WICH) * Column 3, line 40 - column 6, line 17; figures 1-3 *	1	
A	EP-A-0 178 427 (ROBERT BOSCH GmbH) * Page 11, lines 26-33; figure 1 *	4	
A	GB-A-2 125 116 (LUCAS)		TECHNICAL FIELDS SEARCHED (Int. Cl.5) F 02 M

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	11 December 90	KLINGER T.G.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same catagory
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
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