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(54) **Fuel injection nozzle.**

(57) An inwardly opening fuel injection nozzle has a valve member which is biased into contact with a seating 15 by a spring 30. The force of the spring is transmitted to the valve member by a piston 22 slidable in a cylinder 21 formed in the valve member. A restrictor 27 communicates fuel under pressure from an inlet 26 to act on a surface 20 of the valve member to lift the valve member from the seating to allow the fuel flowing through the restrictor to flow through an outlet orifice 17. The piston 22 is also subject to the pressure downstream of the restrictor and when the pressure attains a predetermined value the piston moves relative to the valve member to uncover a port 28 which by-passes the restrictor to allow unrestricted flow of fuel through the outlet orifice.

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FUEL INJECTION NOZZLE

This invention relates to a fuel injection nozzle for supplying fuel to an internal combustion engine, the nozzle being of the so called inwardly opening type and comprising a valve member slidable in a bore in a nozzle body and resiliently biased into contact with a seating to prevent flow of fuel from an inlet to an outlet orifice, resilient means for biasing the valve member into contact with the seating and the valve member defining a surface against which fuel under pressure can act to lift the valve member from the seating.

Such nozzles are well known in the art, and it is also known with such nozzles to so construct the nozzle that the initial flow of fuel through the outlet orifice takes place at a restricted rate. This has been achieved by allowing a limited movement of the valve member away from the seating or to form a small gap between the valve member and the seating which provides a restricted flow of fuel. In order to provide restriction the flow area of the gap between the valve member and the seating must be less than the effective flow area of the orifice. The result is that the lift of the valve member away from the seating must be very small. One form of nozzle incorporates two springs one of which opposes the initial movement of the valve member, the other spring being brought into operation after the initial movement so that continued movement of the valve member is against the action of both springs. Another form of nozzle has a single spring only but the initial movement of the valve member is assisted by the fuel pressure acting on a piston which can only move by a limited amount. The construction of such nozzles requires a high degree of accuracy and furthermore the adjustment of the nozzles to precisely set the limited lift of the valve member is time consuming.

The object of the invention is to provide a fuel injection nozzle of the kind specified in which the initial flow of fuel through the outlet orifice is restricted.

According to the invention a fuel injection nozzle of the kind specified comprises a restrictor through which fuel under pressure from said inlet can act on said surface to lift the valve member from the seating thereby to allow fuel flow through said outlet orifice by way of said restrictor, and valve means operable when the pressure of fuel at said inlet increases to a predetermined value, to by pass said restrictor.

One example of a fuel injection nozzle in accordance with the invention will now be described with reference to the accompanying drawing which is a part sectional side elevation of a part of the fuel injection nozzle.

Referring to the drawing the fuel injection nozzle comprises a nozzle body 10 of stepped form the wider end of which is secured to an elongated tubular nozzle holder 11 by means of the conventional form of screw threaded cap nut 12. A spacer member 13 is interposed between the holder 11 and the nozzle body. Formed in the nozzle body is a blind bore 14 which opens onto the wider end of the body and at the closed end of the bore there is defined a seating 15 downstream of which is located a "sac" volume 16 from which extends an outlet orifice 17. Slidable within the bore 14 is a valve member 18 which is of stepped form. The narrower end of the valve member is shaped for cooperation with the seating and it defines with the bore an annular space 19. The wider portion of the valve member is a sliding fit within the bore and an inclined surface 20 is defined between the wider and narrower portions of the valve member, the surface 20 being exposed to the fuel pressure within the space 19. In the wider portion of the valve member there is formed an axial drilling 21 in which is slidably mounted a piston 22. The inner end portion of the piston is of reduced diameter and is engagable with the base wall of the drilling. The reduced diameter portion of the piston and the drilling define a further annular space 23 which is in constant communication with the annular space 19 by way of drillings 24 formed in the valve member. Moreover, an annular inlet chamber 25 is defined in the bore 14 about the valve member and the inlet chamber communicates by way of a passage 26 which extends within the valve body, the distance piece 13 and the holder, with a fuel inlet not shown and which in use is connected to an outlet of a high pressure fuel injection pump.

The inlet chamber 25 is in constant communication with the further annular space 23 by way of a restrictor 27 formed in the wall of the valve member and also formed in the wall of the valve member is at least one port 28 which as will be described, can connect the inlet chamber with the further annular space 23. In the closed position of the valve member as shown, the port 28 is covered by the piston 22. Preferably a number of ports 28 are provided which are spaced about the valve member in order to balance the forces due to fuel pressure.

Formed in the distance piece 13 is an opening through which extends the reduced end portion of a spring abutment 29 upon which is mounted one end of a coiled compression spring 30 the other end of which is engaged with a fixed abutment secured within the holder. The reduced end of the abutment 29 is engageable with the piston 22.

In the closed position of the valve member as shown, the valve member is urged into contact with the seating 15 by the spring 30 the force exerted by which is transmitted to the valve member by way of the spring abutment and the piston.

When fuel under pressure is supplied to the inlet the fuel pressure in the inlet chamber 25 and also the spaces 23 and 19 increases and the fuel pressure acting on the surface 20 generates a force acting to oppose the force exerted by the spring. When the force due to fuel pressure acting on the valve member is sufficient to overcome the force exerted by the spring, the valve member is lifted from its seating and a restricted flow of fuel takes place through the orifice 17 the restriction being due to the presence of the restrictor 27. The extent of movement of the valve member is limited by its abutment with the spacer member 13. The valve member can therefore be in the fully open position but by virtue of the presence of the restrictor 27, the flow through the outlet orifice 17 is at a restricted rate.

As the fuel pressure at the inlet continues to increase, the fuel pressure acting on the piston which is less than the pressure at the inlet due to the pressure drop across the restrictor 27, will increase until the force exerted by the spring is again overcome and the piston will move upwardly into contact with the spacer member. In so doing the ports 28 are uncovered and the restrictor 27 is then effectively bypassed so that fuel can now flow through the outlet orifice 17 at a substantially unrestricted rate. As the ports 28 are uncovered the pressure in the space 23 increases rapidly and the piston will therefore move quickly into contact with the spacer member. There is therefore a rapid transition between restricted and full flow. When the flow of fuel under pressure to the nozzle inlet ceases, the piston and valve member are returned to the position shown in the drawing by means of the coiled compression spring. It is anticipated that the piston 22 will first move downwardly to close off the ports 28 and may move into engagement with the valve member. The valve member will start its downward movement and during this time since the ports 28 are closed and the restrictor 27 is small fuel will flow through the outlet orifice 17. This flow of fuel will be at a reduced rate. Gas blow-back will be avoided and a sharp end of injection will be obtained. In addition the impact of the valve member on the seating will be reduced thereby reducing the impact stress.

The construction as described provides for restriction of the initial flow of fuel to the engine. Furthermore, the restriction is achieved using a fixed restrictor which is drilled or formed during the process of production of the nozzle. Once the nozzle has been assembled then apart from the

conventional adjustment of the nozzle opening pressure by adjusting the force exerted by the spring 30, no further adjustment is required and the complicated setting procedures of the prior art nozzles are therefore avoided.

In the construction as described the narrower portion of the piston engages the base wall of the drilling 21. This is the preferred way of constructing the nozzle since it provides a substantial bearing surface between the piston and the valve member. As an alternative, however, the opening in the distance piece may be enlarged so that whilst it still acts as a stop for the valve member, it can accommodate a piston which defines a step for engagement with the end of the valve member so that the spring force is transmitted to the valve member by way of the stepped portion of the piston.

Although as described the orifice 17 extends from the 'sac' volume 16 it may extend from a point immediately downstream of the seating 15 at a position where the valve member partly covers the entrance to the orifice and acts to control the flow of fuel through the orifice as the valve member moves away from the seating.

Claims

1. A fuel injection nozzle for supplying fuel to an internal combustion engine, the nozzle being of the inwardly opening type and comprising a valve member (18) slidable in a bore (14), resilient means (30) biasing the valve member (18) into contact with a seating (15) to prevent fuel flow through an outlet orifice (17) from an inlet (26), a surface (20) defined on the valve member and against which fuel under pressure can act to lift the valve member (18) from the seating (15) characterised by a restrictor (27) through which fuel under pressure from the inlet (26) can act on said surface (20) to lift the valve member from the seating (15) to allow fuel flow through said outlet orifice (17) by way of said restrictor (27) and valve means operable when the pressure of fuel at said inlet (26) increases to a predetermined value, to by-pass said restrictor (27).

2. A nozzle according to Claim 1 characterised in that said valve means includes a piston (22) and said piston is responsive to the fuel pressure downstream of said restrictor (27).

3. A nozzle according to Claim 2 characterised in that said piston (22) is slidable within a cylinder (21) formed in the valve member (18) said piston (22) acting to transmit the force exerted by said resilient means (30) to the valve member (18), and said by-pass being defined by a port (28) formed in the wall of said cylinder and which is uncovered

by the piston (22) after a predetermined relative movement of the valve member (18) and the piston (22).

4. A nozzle according to Claim 3 characterised by means (13) engageable by the valve member (18) to limit the movement of the valve member away from the seating (15). 5

5. A nozzle according to Claim 4 characterised in that the piston (22) has a reduced portion within the cylinder, said reduced portion being engageable with the end wall of the cylinder under the action of the resilient means (30). 10

6. A nozzle according to Claim 4 characterised in that said piston (22) defines a flange exterior of the cylinder said flange being engageable with the end of the valve member (18) under the action of the resilient means (30). 15

7. A nozzle according to Claim 5 or Claim 6 characterised in that the inner end of said cylinder (21) and the piston (22) define a space (23), passage means (24) connecting said space (23) with the bore (14), said restrictor (27) communicating with said space (23) and said port (28) communicating with said space (23) when the port is uncovered by the piston (22). 20 25

8. A nozzle according to Claim 7 characterised in that said restrictor (27) is formed in the wall of the valve member (18) and said restrictor and said port (28) communicate with a space (25) defined about the valve member (18), said space (25) communicating with said inlet (26). 30

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