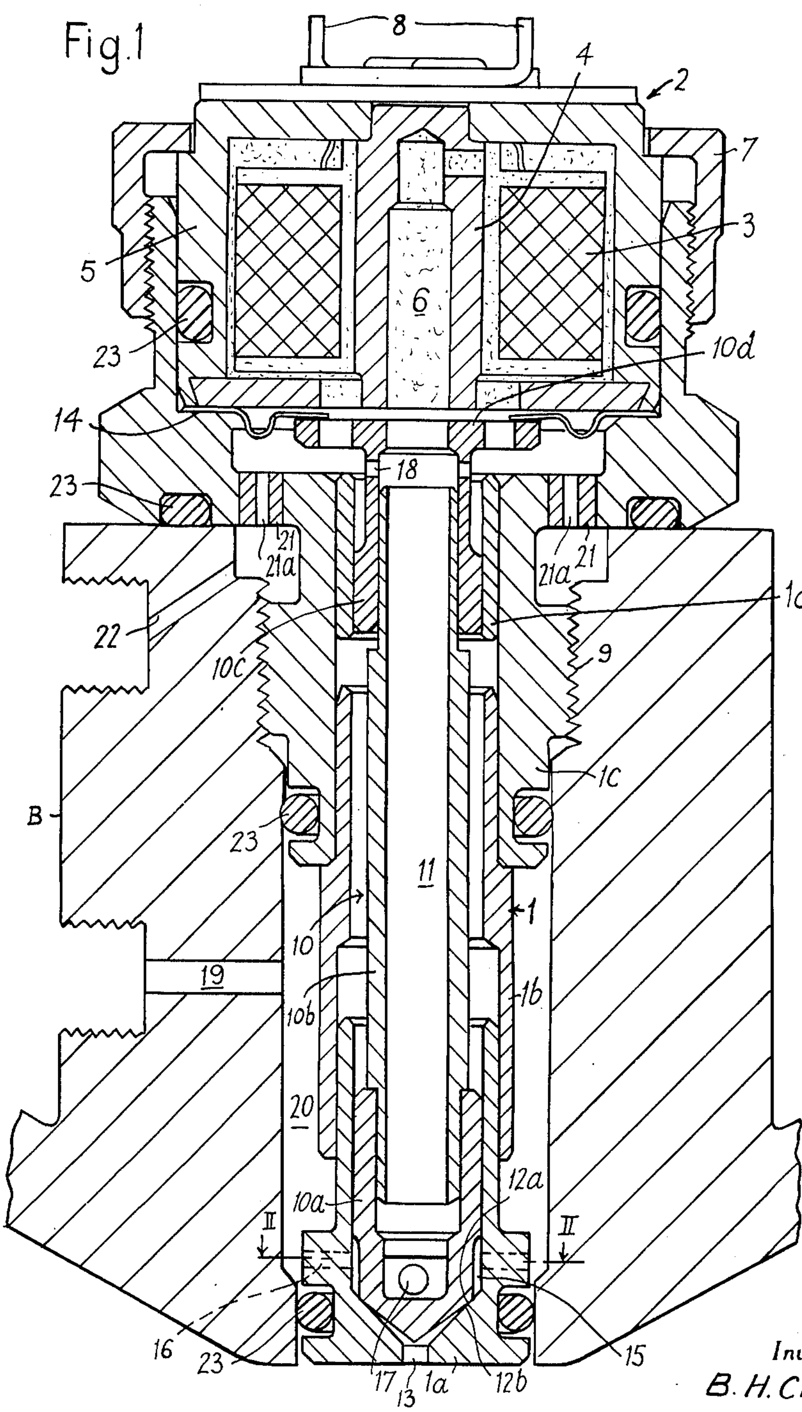
March 22, 1966 | B. H. CROFT | 3,241,768

FUEL INJECTION VALVES

Filed April 24, 1964 | 2 Sheets-Sheet 1

Fig.1



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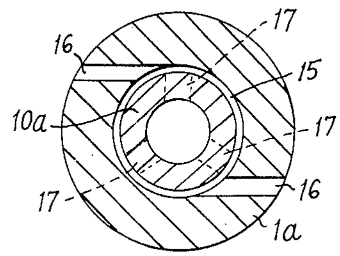

Fig.2

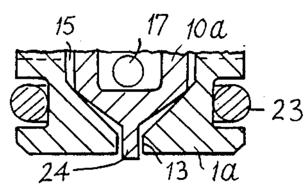

Fig.3

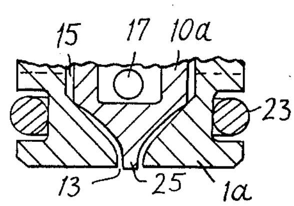

Fig.4

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FUEL INJECTION VALVES

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15 Claims. (Cl. 239—124)

The present invention relates to fuel injection valves for internal combustion engines.

It is an object of the present invention to provide an improved construction of electro-magnetically operated fuel injection valve.

The invention consists in an electro-magnetically operated fuel injection valve having a valve body which is adapted to be received within a cavity in a part of an engine, a valve stem located within the body and engaging a valve seating at one end and having an armature portion at its other end, wherein said armature is attractable by energisation of a solenoid to lift said one end of the valve stem from the seating to open the valve and allow fuel to flow through an outlet orifice, spring means for normally urging the valve stem into contact with the seating, a swirl chamber surrounding the valve stem upstream of the valve seating and at least one inlet port extending through the wall of the valve body and substantially tangential to the swirl chamber for feeding fuel to the swirl chamber.

Preferably the valve has a hollow valve stem and at least one port extending through the wall of the valve stem, so that when the valve is closed fuel can flow from the swirl chamber up inside the stem and through one or more return ports in the valve body back to the fuel supply for the valve. The port or ports through the wall of the valve stem and the tangential port or ports to the swirl chamber are non-aligned.

A restriction may be provided in the return port or ports to control the rate of flow and swirl velocity of the fuel in the swirl chamber.

The spring means advantageously consists of an annular non-magnetic spring which extends over the head or armature end of the valve stem and acts as a spacer preventing intimate contact between the head of the valve stem and the face of the solenoid, as well as serving to urge the opposite end of the valve stem against the seating when the solenoid is de-energised. The solenoid may be formed as a separate assembly which is detachably secured to the upper end of the valve body.

In order that the invention may be more fully understood, some embodiments thereof will now be described with reference to the accompanying drawings in which:

FIGURE 1 is a sectional view of one embodiment of electromagnetically operated fuel injection valve according to this invention,

FIGURE 2 is a section on the line **11—11** in FIGURE 1, and

FIGURES 3 and 4 show modified constructions.

Referring to FIGURES 1 and 2, the fuel injection valve is illustrated as mounted in a cavity in a boss B provided in the wall of the inlet manifold of an internal combustion engine. The valve comprises a valve body generally indicated at **1**, at the upper end of which is mounted a solenoid assembly **2** consisting of a coil **3** wound on an iron core **4**. The coil and core assembly are contained within a housing **5** and are encapsulated in a synthetic resin material **6**. The solenoid assembly is secured to the valve body by means of the screw-threaded retaining ring **7**. The electrical connections to the solenoid are made by means of two terminals **8** whereby they are independent of any electrical connection to the casing of the engine.

The valve body **1** consists of a lower portion **1***a* which may be made of a bronze, a central portion **1***b* which may be made of brass and an upper portion **1***c* which may also be made of brass. The top end of the upper portion **1***c* is enlarged to receive the solenoid assembly **2**. The three portions are secured together with an interference fit. The upper portion also carries an external screw thread **9** by means of which the valve body may be screwed into the cavity in the boss B; as well as an internal bronze guide sleeve **1***d*.

Within the valve body is arranged a valve stem **10** which has a central bore **11**. The stem consists of a lower portion **10***a* made of a plastic material, such as that known under the trade name Delrin, an intermediate portion **10***b* which may be made of aluminium and an upper armature portion **10***c* made of Swedish iron having an enlarged flat head **10***d*. These parts are also held together by an interference fit. The lower end of the valve stem is shaped to provide a seating surface **12***a* which engages with a seating surface **12***b* at the lower end of the valve body to close the valve. A central outlet orifice **13** is provided in the lower body portion **1***a*. An annular spring **14** of non-magnetic material is arranged at the upper end of the valve stem and extends from the outer part of portion **1***c* inwardly over the head **10***d* of the valve stem. This spring acts both to hold the seating **12***a* on the lower end of the valve stem engaged with the seating **12***b* and also acts as a spacer preventing intimate contact between the valve head **10***d* and the face of the solenoid. The air gap is accurately controlled by the thickness of the spring.

Surrounding the lower end of the valve stem is a swirl chamber **15** to which fuel is fed through two holes **16** drilled substantially tangential to the swirl chamber. Three ports or apertures **17** are provided in the lower end of the valve stem to allow fuel to flow up through the hollow bore **11** of this stem and out through apertures **18** in the portion **10***c* and the return ports **21** in the body portion **1***c*. The return ports may be provided with restrictions **21***a*.

Fuel is fed to the valve through the inlet connection **19** to a cavity **20** surrounding the valve body, and from thence through the holes **16** to the swirl chamber **15**. Return fuel flowing through the return ports **21** is returned to the fuel reservoir through the outlet connection **22**.

Sealing rings **23** are provided where shown to prevent leakage of fuel from the areas in which it is to be confined.

The operation of the fuel injection valve is as follows. When the valve stem is in the closed position with the seatings **12***a* and **12***b* in contact, no fuel flows through the orifice **13** to the engine manifold. However, the fuel will flow from the swirl chamber **15** through the bore **11** of the valve stem to the return fuel connection **22**, hence fuel is continually rotating in the swirl chamber **15**, which assists in providing good atomization during the initial stages of opening of the valve. When the valve is opened by energising the solenoid **2** and thus withdrawing the seating **12***a* at the lower end of the valve stem from the seating **12***b*, the fuel in the swirl chamber **15** flows through the central outlet orifice **13** with a swirling component as well as an axial velocity component. This swirling causes the fuel to be passed through the orifice **13** as a thin film clinging to the wall of the orifice and having a central air core. On emerging from this orifice, the fuel forms a conical sheet which is atomized as it passes through the air. The fuel flow ceases when the solenoid is deenergised and the valve closes under the action of spring **14**.

By adjusting the size of the restrictions **21***a* in the return ports **21**, the rate of flow of fuel through the swirl chamber and the swirl velocity can be controlled.

According to a further embodiment of the invention, the ports **17** and **21** may be omitted so that there is no return flow through the hollow stem of the valve. In such an embodiment the swirl chamber can be made sufficiently large so that the body of fuel contained therein still tends to swirl for a time after the valve has closed, whereby some of the swirling motion is still present when the valve opens again, to assist in the rapid build-up of the thin film of fuel through the outlet orifice **13**.

FIGURE 3 shows a modification wherein the lower end of the valve stem portion **10***a* is provided with a pin **24** projecting into the outlet orifice **13**. This serves to improve linearity of the valve operation by controlling the initial flow and also reduces the dead volume of fuel present between the seating surfaces and the orifice **13**, when the valve is closed, thereby preventing a large globule of fuel being fed from the valve when it first opens. The pin **24** can terminate either within the orifice, or beyond it as shown.

FIGURE 4 shows a modification in which the end of the valve stem portion **10***a* is shaped as at **25** to give a smoothly changing or constant flow area.

Fuel injection valves according to the present invention are simple to manufacture and possess the following advantages. The dual functions of fuel metering and fuel atomization are combined and the use of simple drilled holes is possible. Moreover the tangential holes **16** and the central orifice **13** combine to meter the fuel, and the fuel motion created by the tangential holes and the swirl chamber **15** produces the correct conditions for atomization from a single orifice. Hitherto these two functions have generally been separated and necessitated the use of very accurately machined components of complicated shapes. The use of simple drilled holes allows manufacturing tolerances to be relaxed compared with such prior constructions.

Whilst particular embodiments have been described, it will be understood that various modifications may be made without departing from the scope of this invention. Thus instead of employing the form of return spring **14** as shown, a coil spring may be located within the bore **11** of the stem of the valve. Also it will be clear that the number of tangential holes and ports may be varied from those shown.

I claim:

1. An electromagnetically operated fuel injection valve having a valve body which is adapted to be received within a cavity in a part of an engine, a valve stem located within the body and engaging a valve seating at one end and having an armature portion at its other end, a solenoid for attracting said armature to lift said one end of the valve stem from the seating to open the valve and allow fuel to flow through an outlet orifice, spring means for normally urging the valve stem into contact with the seating, a swirl chamber surrounding the valve stem upstream of the valve seating and at least one inlet port extending through the wall of the valve body and substantially tangential to the swirl chamber for feeding fuel to the swirl chamber.

2. A fuel injection valve as claimed in claim **1** in which the swirl chamber is located adjacent the valve seating.

3. A fuel injection valve as claimed in claim **1** having a hollow valve stem and at least one port extending through the wall of the valve stem so that when the valve is closed fuel can flow from the swirl chamber up inside the valve stem and through at least one return port in the valve body back to the fuel supply for the valve.

4. A fuel injection valve as claimed in claim **3**, in which the at least one return port in the valve body is provided with a restriction to control the rate of flow of fuel therethrough.

5. A fuel injection valve as claimed in claim **3**, in which the at least one port in the valve stem is non-aligned with the at least one tangential port to the swirl chamber.

6. A fuel injection valve as claimed in claim **1**, wherein the spring means consists of a non-magnetic spring which extends over the armature end of the valve stem and acts as a spacer preventing intimate contact between that end of the valve stem and the face of the solenoid as well as serving to urge the opposite end of the valve stem against the seating when the solenoid is de-energised.

7. A fuel injection valve as claimed in claim **1**, including an extension projecting from the lower end of the valve stem into the outlet orifice in the valve body.

8. A fuel injection valve as claimed in claim **1**, in which the valve body is provided with sealing means for forming fluid-tight joints between the valve body and the valve receiving cavity, when the valve is fitted in the cavity, in order to prevent leakage of fuel.

9. A fuel injection valve as claimed in claim **1**, in which the solenoid is formed as a separate assembly which is detachably secured to the upper end of the valve body.

10. A fuel injection valve as claimed in claim **9**, in which the electrical connections to the solenoid are made by means of terminal members attached to the solenoid and which are insulated from the valve body.

11. An electromagnetically operated fuel injection valve having a valve body which is adapted to be received within a cavity in a part of an engine, a hollow valve stem located within the body and engaging a valve seating at one end and having an armature portion at its other end, a solenoid for attracting said armature to lift said one end of the valve stem from the seating to open the valve and allow fuel to flow through an outlet orifice, non-magnetic spring means for normally urging the valve stem into contact with the seating, a swirl chamber surrounding the valve stem upstream of the valve seating, at least one inlet port extending through the wall of the valve body and substantially tangential to the swirl chamber for feeding fuel to the swirl chamber, and at least one port extending through the wall of the valve stem so that when the valve is closed fuel can flow from the swirl chamber up inside the valve stem and through at least one return port in the valve body back to the fuel supply for the valve.

12. A fuel injection valve as claimed in claim **11**, in which the at least one return port in the body is provided with a restriction to control the rate of flow of fuel therethrough.

13. An electromagnetically operated fuel injection valve having a valve body which is adapted to be received within a cavity in a part of an engine, a valve stem located within the body and engaging a valve seating at one end and having an armature portion at its other end, a solenoid mounted at the top of said valve body for attracting said armature to lift said one end of the valve stem from the seating to open the valve and allow fuel to flow through the outlet orifice, non-magnetic spring means acting on said armature portion for normally urging the valve stem into contact with the seating, a swirl chamber surrounding the valve stem upstream of the valve seating, a plurality of inlet ports extending through the wall of the valve body tangential to the swirl chamber for feeding fuel to the swirl chamber, and a plurality of ports extending through the wall of the valve stem so that when the valve is closed fuel can flow from the swirl chamber up inside the valve stem and through at least one return port in the valve body back to the fuel supply for the valve.

14. A fuel injection valve as claimed in claim **13**, in which the ports in the valve stem are non-aligned with the tangential ports in the swirl chamber.

15. A fuel injection valve as claimed in claim **13**, including an extension projecting from the lower end of the valve stem into the outlet orifice in the valve body.

References Cited by the Examiner

UNITED STATES PATENTS

1,323,778	12/1919	Lemp	239—585
2,315,172	3/1943	Voorheis	239—125
2,345,402	3/1944	Lubbock et al.	239—125

FOREIGN PATENTS

240,067	4/1946	Switzerland.

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