United States Patent

Romann et al.

[15] **3,680,794**

[45] **Aug. 1, 1972**

[54] **ELECTROMAGNETICALLY OPERATED FUEL INJECTION VALVE**

[72] Inventors: **Peter Romann**, Stuttgart; **Heinrich Knapp**, Leonberg-Silberberg; **Paul Fussner**, Sindelfingen, all of Germany

[73] Assignee: **Robert Bosch GmbH**, Stuttgart, Germany

[22] Filed: **July 26, 1971**

[21] Appl. No.: **166,211**

[30] **Foreign Application Priority Data**

Aug. 4, 1970 Germany ..... P 20 38 646.3

[52] **U.S. Cl.** **239/585**

[51] **Int. Cl.** **B05b 1/30**

[58] **Field of Search** 239/583, 584, 585

[56] **References Cited**

UNITED STATES PATENTS

1,252,254	1/1918	Fisher	239/584
1,664,616	4/1928	French	239/585

FOREIGN PATENTS OR APPLICATIONS

1,282,158	12/1961	France	239/585
150,638	7/1955	Sweden	239/585

Primary Examiner—M. Henson Wood, Jr.
Assistant Examiner—Edwin D. Grant
Attorney—Michael S. Striker

[57] **ABSTRACT**

An electromagnetically operated fuel injection valve wherein the orifice of the injection nozzle discharges fuel into an atomizing chamber having an outlet which is co-axial with the orifice and is in direct communication with the intake manifold of an internal combustion engine. The chamber is defined by a cylindrical inner sleeve having one or more tangential openings for admission of air which atomizes the fuel in the chamber prior to entry into the manifold. The quantity of air admitted by way of the opening or openings amounts to between one-third and one-half of the quantity required by the engine during idling. The inner sleeve is surrounded by an outer sleeve which defines therewith an air-filled compartment in communication with the opening or openings of the inner sleeve.

10 Claims, 2 Drawing Figures

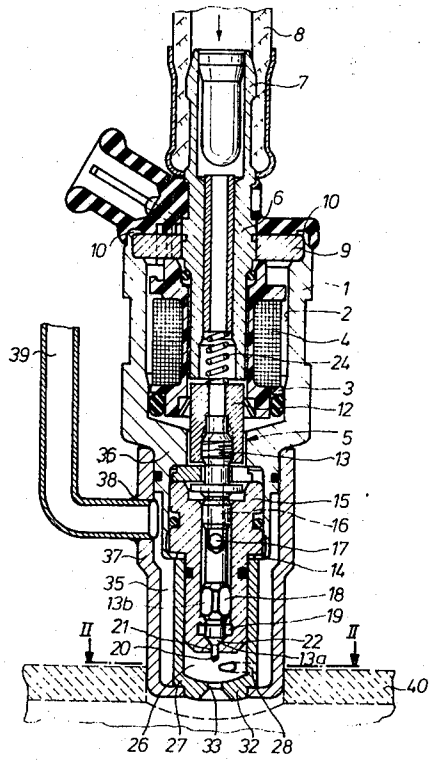


Fig.1

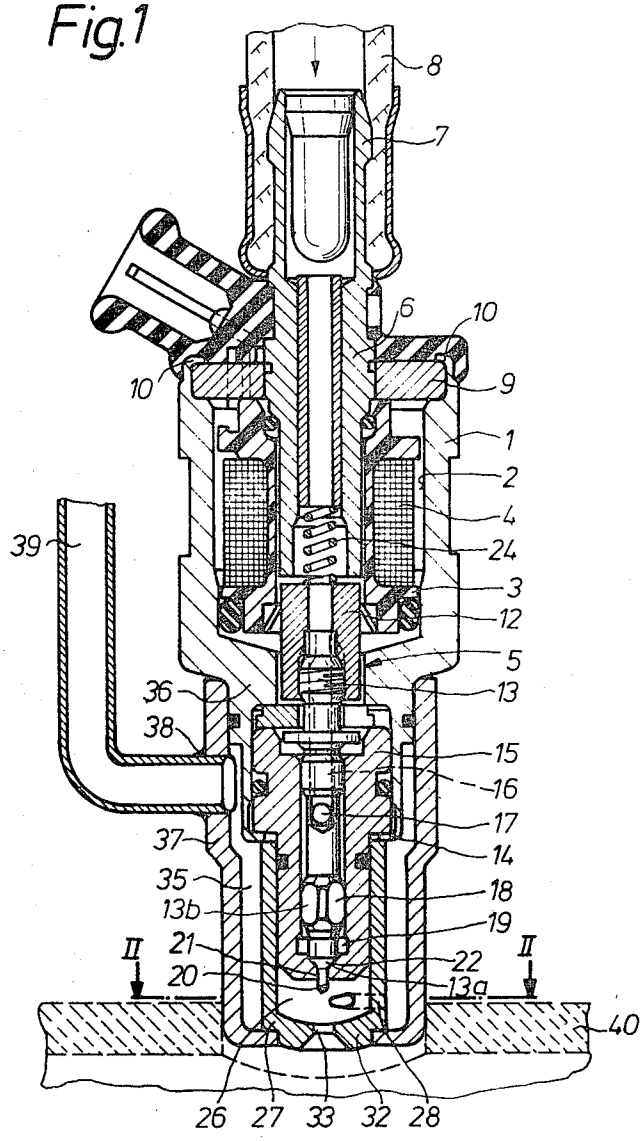
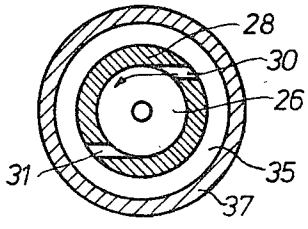


Fig.2



INVENTORS
Peter ROMANN
Heinrich KNAPP
Paul FÜSSNER

By
Michael S. Striker
their ATTORNEY

ELECTROMAGNETICALLY OPERATED FUEL INJECTION VALVE

BACKGROUND OF THE INVENTION

The present invention relates to improvements in electromagnetically operated fuel injection valves for use in internal combustion engines, and more particularly to improvements in valves which are designed to inject metered quantities of atomized fuel into the intake manifolds or suction manifolds of internal combustion engines. Still more particularly, the invention relates to improvements in fuel injection valves serving to inject fuel which is maintained at a relatively low pressure into the intake manifold of an internal combustion engine in such a way that the length of intervals during which the valve remains open determines the quantity of atomized fuel which is admitted into the intake manifold.

The presently known fuel injection valves which serve to admit atomized fuel into the intake manifold of an internal combustion engine normally comprise a valve member which is reciprocable by a spring and by an electromagnet in such a way that the spring tends to maintain the valve member in its closed or sealing position but yields in response to energization of the electromagnet to admit into the intake manifold fuel in such quantities as are determined by the length of the interval during which the electromagnet remains energized. The valve member is secured to a reciprocable armature of the electromagnet which further comprises a fixed soft iron core and a winding surrounding the core. A portion of the valve body normally consists of soft iron to define a portion of the closed path for magnetic force lines when the electromagnet is energized. As a rule, the length of intervals of injection of fuel into the manifold is extremely short, normally in the range of one or more milliseconds. Each energization of the electromagnet entails a movement of the valve member to its opening position in that a portion of the valve member is lifted off a seat in the nozzle of the valve body whereby the orifice of the nozzle discharges a stream of fuel into the intake manifold. The length of intervals of fuel injection is preferably controlled by electrical or electronic control means so as to be a function of several factors which are indicative of the momentary operating condition and requirements of the internal combustion engine.

It was found that the quantity of deleterious combustion products is reduced if the fuel enters the intake manifold in finely atomized condition. Thus, satisfactory atomization of injected fuel will result in a substantial reduction of the quantity of undesirable combustion products.

SUMMARY OF THE INVENTION

An object of the invention is to provide a novel and improved valve for injection of fuel into the intake manifold or suction manifold of an internal combustion engine and to provide such valve with novel and improved means for enhancing the atomization of fuel prior to entry into the intake manifold.

Another object of the invention is to provide a fuel injection valve with simple, compact and reliable means for effecting a fine atomization of fuel which is being discharged by the orifice of the nozzle and is about to enter the intake manifold of the internal combustion engine.

A further object of the invention is to reduce the quantity of undesirable combustion products in internal combustion engines with manifold injection of atomized fuel.

An additional object of the invention is to provide a device for atomizing fuel which issues from the orifice of the nozzle in a valve for injection of atomized fuel into the intake manifold of an internal combustion engine.

The invention is embodied in an electromagnetically operated valve for injection of atomized fuel into the intake manifold of an internal combustion engine. The valve comprises a body including a nozzle which is provided with a fuel-discharging orifice, a valve member having a portion which is movable with reference to the orifice between an opening position and a sealing position, means for biasing the valve member and its portion to the sealing position, an electromagnet which is energizable to move the valve member and its portion to the opening position against the opposition of the biasing means whereby the orifice of the nozzle discharges a predetermined quantity of fuel which undergoes at least some atomization while leaving the interior of the nozzle, an enclosure connected with the valve body and defining an atomizing chamber which is outwardly adjacent to the orifice to receive a predetermined quantity of preferably partly atomized fuel in response to movement of the valve member and its portion to the opening position, an outlet provided in the enclosure for evacuation of atomized fluid and being in at least substantial axial alignment with and spaced from the orifice of the nozzle, one or more openings provided in the enclosure to supply to the chamber currents of air which atomizes the fuel entering the chamber by way of the orifice of the nozzle, such opening or openings being radially spaced from the orifice and extending substantially at right angles to the axis of the nozzle, and means for supplying to the opening or openings currents of air which flows substantially tangentially along the internal surface of the enclosure and effects a further atomization of partly atomized fuel which enters the chamber in response to movement of the valve member and its portion to the opening position. The finely atomized fuel leaves the chamber by way of the outlet in the enclosure and is admitted into the intake manifold of the internal combustion engine.

When the pressure of air in the intake manifold drops, the manifold draws air into the chamber by way of the opening or openings in the enclosure and such air effects a highly satisfactory atomization of fuel which is being admitted by way of the orifice in the nozzle of the fuel injection valve.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved fuel injection valve itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an axial sectional view of a fuel injection valve which embodies the invention, further showing a portion of the intake manifold; and

FIG. 2 is a transverse sectional view as seen in the direction of arrows from the line II—II of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The drawing illustrates an electromagnetically operated fuel injection valve which serves to admit sprays of finely atomized fuel into the intake manifold **40** of an internal combustion engine. The valve comprises a housing or body including a main portion **1** which consists of steel and has a central axial bore **2** receiving a spool-shaped plastic frame **3** for the winding **4** of an electromagnet. The lower end of the bore **2** communicates with a coaxial smaller-diameter bore **5** for the armature **12** of the electromagnet. The soft-iron core **6** of the electromagnet is surrounded by and extends upwardly beyond the frame **3** and beyond the main portion **1** of the valve body. The core **6** is coaxial with the armature **12** and serves as a means for admitting fuel to the axial passage **16** (shown by broken lines) of a reciprocable valve member **13** which is threadedly connected with the armature **12** and extends downwardly into a nozzle **15** which is sealingly received in the lower part of the main body portion **1** and is held therein by a bent-over flange **14** of the portion **1**. The upper end portion **7** of the soft iron core **6** extends beyond the body portion **1** and is sealingly connected with the discharge end of a fuel supplying conduit **8**. A ring **9** on the core **6** is fixedly held in the main body portion **1** by a bent-over flange **10**; this ring serves to guide the magnetic force lines from the core **6** into the main body portion **1**. The armature **12** is adjacent to the inner or lower end portion of the soft iron core **6**. The axial passage **16** of the valve member **13** communicates with a diametrically extending passage **17** which discharges fuel radially into the interior of the nozzle **15**. Such fuel flows along peripheral flats **18** provided on an enlarged portion **13*b*** of the valve member **13** and accumulates in a space **19** which is immediately adjacent to a fuel discharging orifice **21** provided in the end wall **20** of the nozzle **15**. The inner end of the orifice **21** is surrounded by a seat **22** for a conical sealing portion **13*a*** of the valve member **13**. The latter further comprises an end portion or pin **20** which is normally received in the orifice **21** to prevent the escape of fuel from the space **19**. The pin **20** is received in the orifice **21** with small radial clearance and is movable by the electromagnet including the armature **12** from the illustrated sealing position to a retracted or opening position to thereby admit a metered quantity of fuel from the space **19** into an atomizing chamber **26** which is immediately adjacent to the outer or discharge end of the orifice **21**. When the pin **20** is held by the electromagnet in the illustrated sealing position, the aforementioned conical portion **13*a*** of the valve member **13** is in sealing engagement with the seat **22** of the nozzle **15**. The conical portion **13*a*** of the valve member **13** is located between the enlarged portion **13*b*** and the pin **20**.

When a current of requisite strength is caused to flow through the winding **4** of the electromagnet in the main body portion **1**, the armature **12** moves axially and away from the nozzle **15** against the opposition of a helical spring **24** which reacts against an internal shoulder in the soft-iron core **6** and normally urges the valve member **13** to its sealing position. Energization of the winding **4** results in movement of the conical portion **13*a*** away from the seat **22** so that a predetermined quantity of pressurized fuel can leave the space **19** in the nozzle **15** and flows through the orifice **21** to enter the atomizing chamber **26**. The fuel in the space **19** is assumed to be maintained at a pressure of two atmospheres above atmospheric pressure. If the pressure of fuel is substantially constant, the length of the interval of energization of the winding **4** determines the quantity of fuel which enters the atomizing chamber **26** in response to movement of the pin **20** on the valve member **13** to its opening position. The lifted pin **20** defines with the end wall of the nozzle **15** an annular duct for the flow of pressurized fuel into the atomizing chamber **26**. The fuel which enters the chamber **26** is being atomized at the annular edge on the lower end of the pin **20**.

The atomization of fuel in the chamber **26** is enhanced by currents of air admitted into the chamber **26** at one or more points which are radially spaced from the axis of the orifice **21**. In the illustrated embodiment, the chamber **26** is defined by an inner enclosure or sleeve **27** which is sealingly secured to and surrounds a portion of the nozzle **15**. The bottom end wall of the inner sleeve **27** has an outlet **33** which discharges finely atomized fuel directly into the intake manifold **40** of the internal combustion engine. The cylindrical wall **28** of the inner sleeve **27** has a preferably cylindrical internal surface which is coaxial with the orifice **21** and outlet **33** and is provided with one or more tangential air-admitting openings. As shown in FIG. 2, the cylindrical wall **28** has two openings **30, 31** which are disposed diametrically with reference to each other and discharge currents of air substantially tangentially of the internal surface of the sleeve **27**. If desired, the wall **28** can be provided with a single opening or with three or more preferably equidistant openings for admission of atomizing air. The outlet **33** is provided in the end wall **32** of the inner sleeve **27** and this end wall is surrounded by a ring-shaped inwardly extending collar on an outer enclosure or sleeve **37** which defines with the sleeve **27** an annular air-filled compartment **35**. The latter receives air from a supply pipe **39** which is brazed to the outer sleeve **37**, as at **38**. The diameter of the outlet **33** is substantially smaller than the internal diameter of the cylindrical wall **28**, i.e., substantially smaller than the diameter of the atomizing chamber **26** The outer sleeve **37** sealingly surrounds and is secured to a cylindrical part **36** of the main body portion **1**. The supply pipe **39** receives air from the air funnel (not shown) of the internal combustion engine. The intake manifold **40** sucks air from the compartment **35** by way of the openings **30, 31** and outlet **33** of the inner sleeve **27**.

The diameters of the openings **30, 31** in the inner sleeve **27** are selected in such a way that these openings constitute effective restrictors for the inflow of air into the manifold **40** by way of the outlet **33**. In order to allow for a sufficiently wide range of adjustments when the engine including the intake manifold **40** is idling, the cross-sectional areas of the openings **30, 31** are dimensioned in such a way that these openings admit only a fraction of the air which is required by the engine during idling, preferably between one-third and

one-half of the air which is needed during such operation of the engine. It is clear, however, that the throttling of air flow into the intake manifold **40** by way of the outlet **33** of the inner sleeve **27** can be effected by one or more flow restrictors which are provided in another part of the valve, for example, in the supply pipe **39**.

It was found that the fuel which is admitted into the atomizing chamber **26** of the inner sleeve **27** undergoes particularly intensive atomization if the sleeve **27** is provided with two or more equidistant air admitting openings. The openings **30, 31** can but need not be located in a common plane which is normal to the axis of the nozzle **15**. Also, the axes of the openings **30, 31** can be located in planes which are inclined with reference to a plane that is normal to the axis of the nozzle **15**.

Satisfactory atomization of fuel which enters the intake manifold **40** is especially important when the engine is idling and also when the engine is operated at partial load. The aforediscussed dimensioning of openings **30, 31** so that they admit only a fraction of the total quantity of air which is needed for the operation of the engine during idling is desirable in order to insure that the idling operation of the engine can be regulated within a relatively wide range.

The details of the electrical or electronic control system which regulates the timing and the length of intervals of energization of the electromagnet in the main body portion **1** form no part of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of our contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended

1. In an electromagnetically operated valve for injection of fuel into the intake manifold of an internal combustion engine, a combination comprising a body including a nozzle having a fuel-discharging orifice; a valve member having a portion movable with reference to said orifice between an opening position and a sealing position; means for biasing said portion of said valve member to said sealing position; an enclosure connected with said body and defining an atomizing chamber outwardly adjacent to said orifice to receive a predetermined quantity of fuel in response to movement of said portion of said valve member to said opening position, said enclosure having an outlet for atomized fuel positioned in at least substantial axial alignment with and spaced from said orifice and at least one air-admitting opening extending substantially at right angles to the axis of and radially spaced from said orifice; and means for supplying to said opening a current of air to atomize the fuel which is admitted into said chamber by way of said orifice before the thus atomized fuel leaves said chamber by way of said outlet.

2. A combination as defined in claim **1**, wherein said outlet communicates with the intake manifold of the engine so that said opening admits into said chamber air in response to a drop in pressure in said manifold.

3. A combination as defined in claim **2**, wherein said enclosure is provided with a plurality of at least substantially equidistant air-admitting openings each of which is radially spaced from and extends substantially at right angles to the axis of said orifice.

4. A combination as defined in claim **2**, wherein the cross-sectional area of said opening is such that the quantity of air admitted by way of said opening is a fraction of the quantity required by the engine during idling.

5. A combination as defined in claim **4**, wherein the quantity of air admitted by way of said opening is between one-third and one-half of the quantity required by the engine during idling.

6. A combination as defined in claim **1**, wherein said enclosure has a substantially cylindrical internal surface and said opening is substantially tangential to said internal surface.

7. A combination as defined in claim **6**, wherein said internal surface is coaxial with said orifice and said outlet.

8. A combination as defined in claim **1**, wherein said air supplying means comprises a second enclosure surrounding said first mentioned enclosure and defining therewith an air-filled compartment communicating with said opening.

9. A combination as defined in claim **1**, wherein said enclosure extends directly into an opening of the intake manifold in the engine so that atomized fuel leaving said outlet enters the interior of such manifold.

10. A combination as defined in claim **1**, wherein said biasing means comprises a spring bearing against said valve member and reacting against said body, and further comprising electromagnet means provided in said body and energizable to move said portion to said opening position against the action of said spring.

* * * * *