June 24, 1969 V. D. ROOSA 3,451,626

NONLEAK-OFF FUEL INJECTION NOZZLE

Filed Jan. 13, 1967

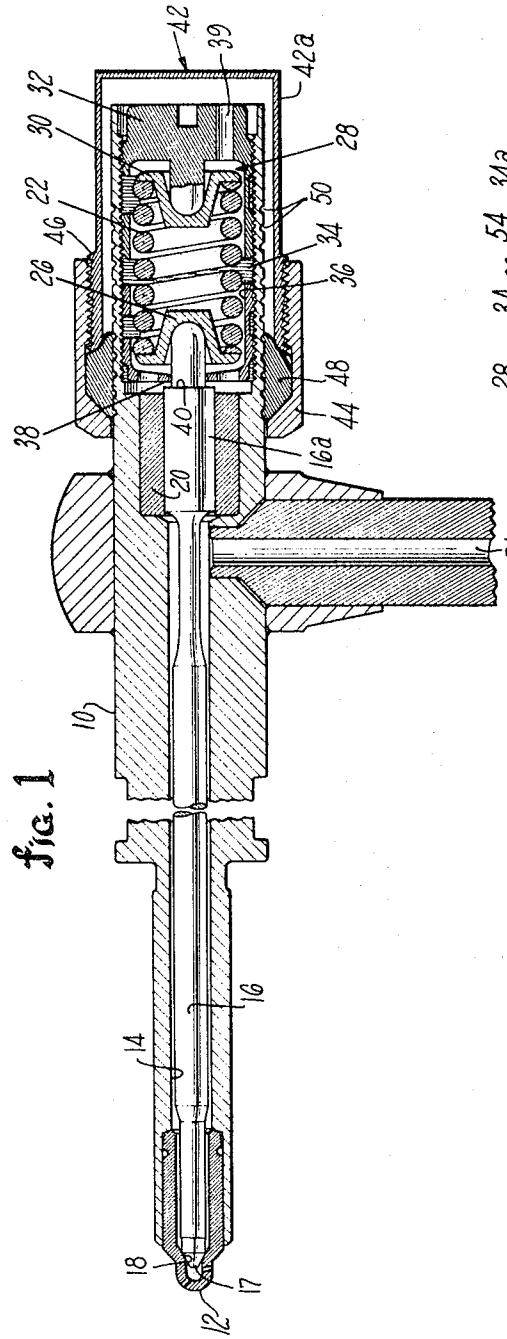


Fig. 1

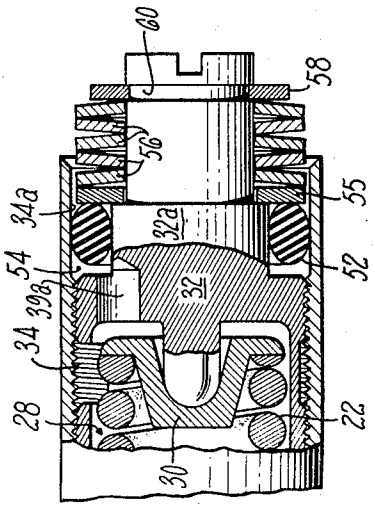


Fig. 2

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United States Patent Office 3,451,626
Patented June 24, 1969

3,451,626

NONLEAK-OFF FUEL INJECTION NOZZLE

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Filed Jan. 13, 1967, Ser. No. 609,174
Int. Cl. B05b 1/30
U.S. Cl. 239—533 6 Claims

ABSTRACT OF THE DISCLOSURE

A fuel injection nozzle for internal combustion engines having a guided inwardly opening pressure operated valve in a first chamber in the valve and a second chamber separated from the first chamber by the guide with the second chamber being sealed to prevent leakage and constructed to accommodate the volume of fuel in the spring chamber displaced by the valve when it is lifted from the valve seat.

This invention relates to fuel injection nozzles for internal combustion engines and more particularly to an improvement on the nozzle described in my prior Patent 3,224,684 issued Dec. 21, 1965 and entitled "Fuel Injection Nozzle."

In the operation of inward opening pressure actuated fuel injection nozzles of the type contemplated by this invention, the plunger or valve is lifted from its seat by the pressure of fuel delivered to the nozzle from an associated high pressure charge pump which provides timed high pressure pulses of fuel to the nozzle. The discharge of fuel from the nozzle is effected by the pressure of the fuel acting on the valve to lift it from the valve seat in opposition to the force exerted by a biasing spring. The biasing spring is disposed in a spring chamber in the nozzle at the opposite end of the valve from the valve seat with the guide which mounts the valve for reciprocating movement separating the spring chamber from the high pressure fuel. Inherently, in such an arrangement leakage of the fuel between the guide and the valve takes place, and in the past it has been the practice to provide a leak-off system to return the leakage fuel from the spring chamber to the fuel tank. Such a leak-off system is disclosed in my prior Patent 2,829,004 issued Apr. 1, 1958, and entitled, "Leak-off Fuel Collecting System for Fuel Injection Engines."

A principal object of this invention is the provision of a fuel injection nozzle of the type described which does not require a leak-off collection system.

Another object of this invention is to provide a nozzle of the type described which is self-sufficient to accommodate leakage of fuel into the spring chamber.

A still further object of the invention is to provide a fuel injection nozzle which accommodates leakage of fuel into the spring chamber which is rugged and durable yet simplified in construction and low in cost.

It is another object to provide a fuel injection nozzle having a sealed spring chamber.

A still further object of the invention is to provide a fuel injection nozzle of the type described which facilitates fuel injection during the initial starting of an associated engine. Included in this object is the provision of an arrangement whereby the force biasing the valve against the valve seat is reduced during the initial starting of the engine.

Other objects will be in part obvious and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which is exemplified in the construction hereafter set forth, and the scope of the invention is indicated in the appended claims.

In the drawing:

FIG. 1 is a fragmentary cross-sectional view of a portion of a fuel injection nozzle embodying the present invention; and

FIG. 2 is a fragmentary cross-sectional view exemplifying a modified form of the present invention.

The exemplary nozzles shown in the drawing and embodying the present invention are generally similar to that illustrated in my Patent No. 3,224,684 and includes a generally elongated tubular body **10** having a discharge tip **12** at one end thereof and a central longitudinal bore **14** extending throughout its length. Located in the central bore **14** is a rod-like valve **16** having a conical tip **17** which cooperates with a conical valve seat **18** formed in the tip **12** to control the discharge of fuel from the nozzle body **10**. A valve guide **20** positioned in the bore **14** of the nozzle body at a position remote from the valve seat slidably mounts and aligns the valve **16** for rapid reciprocating movement of the valve under the influence of fuel pressure within the bore **14** acting against the bias of a spring **22**. The valve is provided with a fuel inlet **24** communicating with the bore **14** for the delivery of pulses of high pressure fuel to the bore **14** adjacent the guide **20** from an associated high pressure charge pump, not shown.

The upper end of the valve **16** engages a spring seat **26** located in a spring chamber **28** which is isolated from the bore **14** by the guide **20**, and the other end of the spring **22** is similarly provided with a second spring seat **30** which engages an adjustable stop **32** shown as being threadably received in the bore **34** of the spring chamber **28** to set the bias pressure of the spring holding the valve **16** against the valve seat **18**. A second stop **36** also is shown as being threadably received in bore **34** of spring chamber **28** to adjustably fix the lift of the valve **16** from the valve seat by the engagement between flange **38** thereof and shoulder **40** of the valve **16**.

When the nozzle has been assembled and placed in operation, timed pulses of fuel under high pressure are introduced into the nozzle through inlet **24** and act on the valve **16** to overcome the bias of spring **22** to lift the valve from the valve seat **18** and the discharge of fuel through the orifices in tip **12** takes place. When fuel pressure in the bore **14** is reduced after the pulse of fuel is discharged from the nozzle tip, the spring **22** exceeds the hydraulic pressure acting on the valve **16** and returns it to closed position.

As hereinbefore described, the high pressure of the fuel within the bore **14** relative to that in spring chamber **28** during the injection of fuel from the nozzle inherently results in a small amount of leakage into the spring chamber **28** between the valve **16** and the guide **20**. The valve, in moving away from the valve seat causes its guide portion **16***a* to enter the spring chamber **28** to fill a portion thereof corresponding to the volume of the area of the guide portion **16***a* times the amount of lift of the valve from the valve seat. Since liquid fuel is relatively inelastic, it will be readily apparent that as the quantity of fuel leakage into the spring chamber **28** increases, the pressure in spring chamber **22** acting to aid the spring in holding the valve **16** against the valve seat increases. In addition, where the liquid fuel leakage into spring chamber **28** becomes sufficient to substantially fill the spring chamber, the pressure of the fuel in the spring chamber tends to increase drastically and ultimately, in conjunction with spring **22**, will prevent the proper lifting of the valve **16** unless the pressure in chamber **28** is relieved.

This invention provides an arrangement for accommodating the displacement of the valve **16** into the spring

chamber **28** during opening without the use of a leak-off return network connecting the spring chamber **28** with the fuel tank and without an undue increase in pressure in spring chamber **28**.

As shown in FIG. 1, an externally threaded closed cap **42** is positioned over the end of the nozzle body **10** and is sealed thereto by means of an apertured coupling nut **44** which threadably engages the threads **46** of the cap **42** to clamp a ferrule **48**, formed of a yieldable material such as a metal or plastic, which is shown as being deformed to enter the external recesses **50** provided on the outside of the nozzle body **10** under the clamping pressure of tightening the coupling nut **44** to the cap **42**.

While sealing the spring chamber **28** against the leakage of fuel, the cap **42** is so constructed as to accommodate the displacement of the fuel in the spring chamber **28** by the end of the valve guide **16***a* as the valve **16** lifts from the valve seat **18** without an undue increase of pressure in chamber **28**. A passage **39** is provided in the adjustable stop **32** to provide communication between the spring chamber **28** and the interior of the cap **42**. In practice, I have found that by making the peripheral wall **42***a* with a thickness of about 15–20 mils the wall **42***a* will bow outwardly to provide the additional capacity required by the displacement of the valve guide **16***a* entering the spring chamber so as to limit the pressure in the spring chamber **28** to a level which allows the desired movement of the valve **16** away from the valve seat **18** to allow the proper discharge of fuel through the nozzle tip **12**. For example, with a pressure in the bore **14** at the time of injection of, say, about 2800 p.s.i., this construction will limit the maximum pressure in the spring chamber to any desired value, say, 500 p.s.i.

Not only does this invention eliminate the need for a leak-off collection system from each nozzle and thereby simplify the layout of the fuel injection system by providing self-sufficient nozzles, but it also permits the use of a lower biasing pressure setting for spring **22** since the pressure in spring chamber **28** reaches a predictable level under steady state conditions. Such pressure assists the spring **22** in biasing the valve **16** toward the valve seat **18**. Because of this, the injection of fuel by the nozzle is facilitated during initial starting conditions when the engine is being cranked at low speeds. At such times, leakage past the guide **20** has not built up the pressure in the spring chamber **28** to its steady state value so that the combined biasing force of spring **22** and the pressure of the fuel in the spring chamber **28** is lower than under steady state conditions whereby a lower pressure in bore **14** will lift the valve **16** from the valve seat.

It will be understood that any pressure differential of the pressure in spring chamber **28** from that in bore **14** will tend to equalize between the intervals of high pressure pulses of fuel delivered by the associated charge pump. The discharge of fuel by the nozzle occurs over, say, a maximum of about 20° of crankshaft rotation of the associated engine and in a 4-cycle engine each nozzle discharges fuel once in every two revolutions of the engine, i.e., or 720° of crankshaft rotation. Accordingly, the pressure level of the fuel in spring chamber **28** may leak past the guide **20** back into bore **14** for about 97% of the time so as to stabilize the pressure in chamber **28** during operation to a pressure correlated with the inlet residual pressure in the bore **14**.

Referring now to FIG. 2, in which like numerals refer to like parts, a modified form of the invention is illustrated.

In this modified form of the invention, the peripheral wall **34** of the spring chamber **28** is provided with an unthreaded end extension **34***a*, and the stop nut **32** is provided with a mating longitudinal extension **32***a* concentrically disposed within the peripheral extension **34***a* to provide an annular recess or clearance **54** therebetween. A resilient O-ring **52**, formed of any suitable material such as a solid synthetic rubber, is positioned in the annular clearance **54** in engagement with the longitudinal extension **32***a* and the peripheral end extension **34***a* to provide a seal therebetween. The O-ring **52** is slidably movable in the annular clearance **54** and is biased in the direction of the spring chamber **28** by an axially movable ring **55** backed by a plurality of Belleville washers **56**. The stack of Belleville washers **56** are secured against longitudinal movement by a spring retaining ring **58** mounted in groove **60** of the longitudinal extension **32***a*.

In the form of the invention exemplified by FIG. 2, the displacement of fluid within the spring chamber **28** caused by the lifting of the valve **16** from the seat **18** is accompanied by an enlargement of the volume of the spring chamber **28** due to the longitudinal movement of the sealing O-ring **52** which is subjected to the pressure in chamber **28** through passage **39***a* as well as the opposing bias of the Belleville washers **56**. It will be readily apparent that this arrangement likewise automatically establishes a maximum pressure in the valve chamber **28** under conditions of equilibrium reached during operation in a manner similar to that of the emobdiment of FIG. 1.

Thus, it may be seen that the self-sufficient no leak-off nozzle design of this invention automatically accommodates for fuel leakage into the spring chamber without the use of a leak-off connection system for returning leakage fuel from each of the nozzles of an engine to the fuel tank in an organization which affords the additional advantages heretofore described.

As will be apparent to persons skilled in the art, various modifications and adaptations of the structure above-described will become readily apparent without departure from the spirit and scope of the invention, the scope of which is defined in the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a fuel injection nozzle for internal combustion engines having an inwardly opening pressure operated valve disposed in the bore of the nozzle body, an apertured guide spaced from the discharge end of the nozzle for mounting the valve for reciprocating movement toward and away from a valve seat and forming a wall of a first chamber for receiving fuel under pressure to open the valve, a second chamber in the nozzle body separated from said first chamber by said guide, and a spring in said second chamber for biasing the valve toward the valve seat, the improvement wherein a cap forms a closure for said second chamber, said cap having a peripheral wall dimensioned to bow outwardly to increase the volume of said second chamber when the valve is lifted from the valve seat.

2. A device as recited in claim **1** wherein the open end of said cap is threaded and surrounds the end of the nozzle body remote from the discharge end thereof, and an apertured mating coupling nut surrounding the nozzle body coacts with said cap to compress a yieldable ferrule disposed between the coupling nut and the cap into compressive engagement with said nozzle body to secure and seal the cap to the nozzle body.

3. In a fuel injection nozzle for internal combustion engines having an inwardly opening pressure operated valve disposed in the bore of the nozzle body, an apertured guide spaced from the discharge end of the nozzle for mounting the valve for reciprocating movement toward and away from a valve seat and forming a wall of a first chamber for receiving fuel under pressure to open the valve, a second chamber in the nozzle body separated from said first chamber by said guide, and a spring in said second chamber for biasing the valve toward the valve seat, the improvement wherein means are provided for sealing said second chamber to prevent leakage therefrom and for increasing the volume of said second chamber when the valve is lifted from the valve seat, said sealing means comprising a member having an outwardly extending shank disposed concentrically within a bore of the second chamber to define an annular recess therewith, an

axially movable seal positioned in said annular recess and engaging said shank and the wall of said bore, and resilient means biasing said seal in a direction to reduce the volume of said second chamber.

4. A device as recited in claim 3 wherein said seal comprises a resilient O-ring and said resilient means comprises a stack of Belleville washers.

5. A device as recited in claim 4 wherein said shank is provided with a shoulder for securing a seat for said Belleville washers.

6. In a fuel injection nozzle for internal combustion engines having an inwardly opening pressure operated valve disposed in the bore of the nozzle body, an apertured guide spaced from the discharge end of the nozzle for mounting the valve for reciprocating movement toward and away from a valve seat and forming a wall of a first chamber for receiving fuel under pressure to open the valve, a second chamber in the nozzle body separated from said first chamber by said guide, and a spring in said second chamber for biasing the valve toward the valve seat, the improvement wherein a cap telescopically engages the end of the nozzle body providing said second

chamber to form a closure therefor, said cap having a peripheral wall dimensioned to bow outwardly to increase the volume of said second chamber when the valve is lifted from the valve seat.

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U.S. Cl. X.R.

239—453