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FUEL INJECTOR

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Fig. 1.

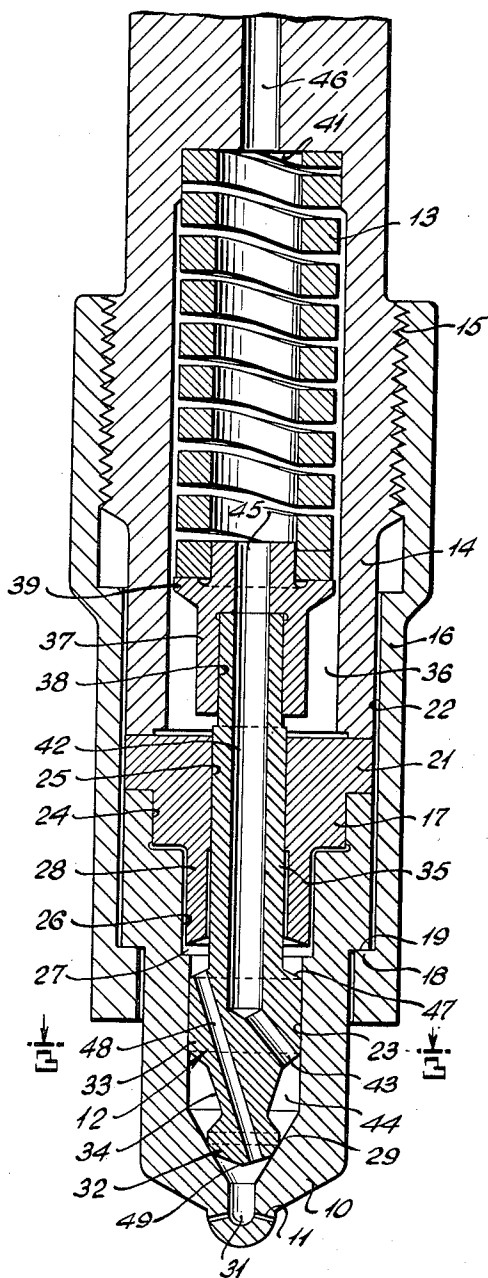


Fig. 2.

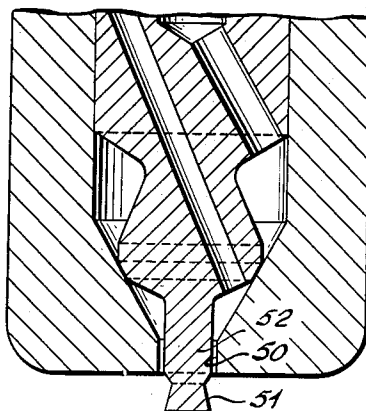
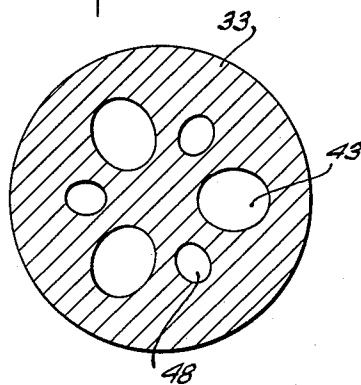


Fig. 3.



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## FUEL INJECTOR

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12 Claims. (Cl. 299—107.5)

1

2

This invention relates to fuel injectors for combustion engines, and particularly to an injector of the type having a spring loaded valve which opens inwardly in response to fuel pressure.

It is generally known that a fuel injector system which, during each supply stroke of the fuel pump, supplies a pilot or initial charge of fuel followed immediately by the main or bulk charge will promote more efficient and complete combustion.

The principal object of this invention is to retain the functional advantages of, but materially simplify, such a system by providing an injector which will supply a plurality of successive or transient charges during each supply stroke of the fuel pump. Such object is accomplished by constructing the injector with an inwardly opening valve so designed and so arranged in the nozzle that immediately after it is first opened during the fuel supply stroke, a condition of hydraulic balance of the valve is obtained. This balanced condition will permit the conventional spring loading means instantly to seat the valve and the fuel supply pressure instantly thereafter to unseat such valve again into a condition of hydraulic balance. The cycle is repeated a number of times during each supply stroke of the pump, at a rate in the order of five cycles per pump stroke. The hydraulic balancing is achieved by providing an equalizing chamber in the nozzle above the valve, and providing the valve with a duct therethrough so that communication is instantly established between the valve lifting pressure chamber and the equalizing chamber upon the opening of the valve.

Another object of the invention is to provide a fuel injector having a spring loaded valve of the inwardly opening type which will produce a rapid and clean cut-off of fuel injection because of a novel suction effect created in a novel nozzle chamber whose volume increases as the result of the closing movement of the valve, such chamber being in communication with the nozzle orifices by means of the duct through the valve.

A further object of the invention is to provide an injector having an inwardly opening valve which, when seated, will be urged more tightly to seated position by any fluid pressure thereafter applied to the discharge ends of the orifices. This is a departure from conventional construction in which the valve is urged toward open position by any such fluid pressure.

Still another object is to provide such an injector which will dispense with conventional costly

leak-off arrangements by permitting an eventual drain back to the orifices of any leakage escaping past the valve guiding fits.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of construction, combination of elements, and arrangement of parts which will be exemplified in the construction hereinafter set forth; and the scope of the application thereof will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a view in elevation taken through the axial center line of a fuel injector of the present invention.

Fig. 2 is a partial view similar to Fig. 1 showing the invention applied to a throttling pintle-type nozzle.

Fig. 3 is an enlarged cross section taken on line 3—3 of Fig. 1 showing one form of fuel duct arrangement. The nozzle is omitted for clarity.

Referring now to Fig. 1 of the drawings, there is shown a fuel injector having a nozzle 10 provided at its lower extremity with conventional orifices 11 to supply fuel to the power cylinder (not shown) of a combustion engine. A valve, generally indicated at 12, to control the flow of fuel supplied from a conventional pump (not shown) through the injector to the orifices, is normally biased to closed position by spring 13 and opens inwardly against the spring in response to fuel pressure in the manner hereinafter described. Nozzle holder 14 is threaded at 15 to receive a retaining nut 16 which serves to clamp nozzle 10 upwardly against a flanged valve guide bushing 17 arranged flush against the holder 14, the guide bushing having a pressure sealing fit with the nozzle and holder. Inwardly directed flange 18 of the retaining nut engages radial shoulder 19 of the nozzle so that the nozzle and bushing are clamped in rigid axial alignment with holder 14. It should be noted that flange 21 of bushing 17 and the upper portion of nozzle 10 are both spaced slightly from the inner wall 22 of nut 16 so that there will be no radial pressure on the bushing or the nozzle which might cause distortion.

Nozzle 10 has a valve guide bore 23 formed axially therein and at its upper end has a counter-bore 24 for locating the guide bushing. Axial bore 25 of the bushing is thus maintained in

coaxial relation with guide bore 23 to insure frictionless axial reciprocation of valve 12 therein. A second counterbore 26 may be formed in the nozzle adjacent guide bore 23 to provide therewith a chamber 27 for purposes later to be described. A skirt 28 of the bushing extends downwardly to substantially fill up the chamber 27, the purpose of this arrangement being later explained. Guide bore 23 is continued downwardly to an inwardly tapered or conical portion 29 which functions as a seat for the valve and also as a fluid passage leading from said bore to sac hole 31 from which orifices 11 extend.

Valve 12 has a head 32, a cylindrical guide body 33, a neck portion 34 connecting the head and body, and a stem 35. The valve is so arranged in the nozzle that stem 35 extends upwardly through guide bushing 17 into the spring chamber 36 formed in the nozzle holder. Supported upon the upper end of the valve stem 35 is spring seat member 37 which has a recess 38 at its lower end for positioning the seat member upon the valve stem. Seat member 37 is provided with an annular flange 39 which serves as a seat for spring 13. Spring 13 abuts against surface 41 and urges valve 12 downwardly against seat 29.

Valve 12 has a fuel duct 42 in the form of an axial passage extending through the full length of the stem into the valve body 33. A plurality of inclined ducts 43 (three, in the illustrative embodiment, as seen in Fig. 3, although it is obvious a different number may be used) extend downwardly and outwardly from the end of fuel duct 42 to establish communication between said duct and fuel pressure chamber 44 formed between the valve neck portion 34 and the walls of the guide bore 23 and conical portion or valve seat 29. Spring seat member 37 has an axial bore 45 registering with duct 42, and nozzle holder 14 also has an axial duct or passage 46 so that fuel from the pump system will be supplied through duct 46, spring chamber 36, bore 45, duct 42, and ducts 43 to chamber 44.

The particular configuration of valve 12 is not significant. It may assume a great variety of shapes which will enable it to act as a differential valve all as is familiar to those skilled in the art. A different shape as applied to a pintle type nozzle is shown in Fig. 2.

A plurality of ducts 48 (three, in the illustrative embodiment, of Fig. 3, although it is obvious a different number may be used) extend from the end face 49 of the valve through the head, neck, and body of the valve to shoulder 47 which defines a pressure surface in chamber 27. These ducts, which I prefer to call "balancing ducts," are essential features of the invention.

In operation, after the valve has been lifted by the differential pressure, fuel will pass valve seat 29 from the chamber 44 into sac hole 31, whence it will pass through spray orifices 11 into the power cylinder. A throttling effect is produced by the orifices with a resulting increase of fluid pressure in the sac hole, and such increase is communicated through balancing ducts 48 to chamber 27. The result is that the valve becomes substantially hydraulically balanced and the spring force alone will instantly act to urge the valve to its seated position. The cycle is then immediately repeated and the valve reopens in response to differential pressure. I wish it to be clearly understood that this action is repetitive and takes place in the order of five times per discharge stroke of the fuel pump.

It should be noted that each time the valve closes, there is an increase in the volume of chamber 27 and that a suction effect is thereby created. This suction has been found to be sufficient to cause fuel to flow upwardly into chamber 27 through the balancing ducts 48 from the sac hole, thereby eliminating dribbling from the orifices. It should also be here noted that the volume of chamber 27 can be adjusted by changing the length of the bushing skirt 28. Owing to the well-known compressibility of liquid fuels, adjustment of the volume of chamber 27 may be made effective in altering the natural frequency of the valve motion to meet differing requirements.

The arrangement of chamber 27 above the valve body with balancing ducts in communication therewith has another desirable characteristic. Any leakage upwardly past the valve body will be captured in the chamber whence it will be eventually returned to the sac hole through the balancing ducts. The necessity of leak-off tubing is thus avoided. In Fig. 2 I have shown the invention applied to a throttling pintle type nozzle wherein 50 is the throat, 52 is the pintle and 51 is the throttle. The operation of this type nozzle is the same as described for Fig. 1 and reference is made to that statement of operation.

While there have been hereinbefore described approved embodiments of this invention, it will be understood that many and various changes and modifications in form, arrangement of parts and details of construction thereof may be made without departing from the spirit of the invention, and that all such changes and modifications as fall within the scope of the appended claims are contemplated as a part of this invention.

What I claim is:

1. An inwardly opening differential type fuel injector comprising a nozzle holder; a nozzle having a central chamber and a fuel pressure chamber therein; a reciprocating valve in the nozzle separating the chambers and having a fuel pressure surface in the central chamber; a spring normally urging the valve to seated position; fuel transmission means leading to the fuel pressure chamber; and fuel pressure balancing means connecting the chambers when the valve is unseated thereby to hydraulically balance the valve so that the spring will seat the valve.

2. A fuel injector, according to claim 1, in which the fuel pressure balancing means passes through the valve.

3. A fuel injector, according to claim 1, in which the fuel transmission means leading to the fuel pressure chamber passes through the valve.

4. A fuel injector, according to claim 1, in which the fuel transmission means leading to the fuel pressure chamber and the fuel pressure balancing means pass through the valve.

5. An inwardly opening differential type fuel injector comprising a nozzle holder; a nozzle; a guide bushing between the holder and the nozzle; a spring loaded valve openable inwardly in response to fuel pressure; a central chamber defined by the bushing, the valve, and the nozzle; a fuel pressure chamber in the nozzle; means to conduct fuel to the fuel pressure chamber; and duct means to connect the fuel pressure chamber and the central chamber when the valve is unseated thereby to equalize the pressure in such chambers so that the spring will seat the valve.

6. An inwardly opening differential type fuel injector comprising a nozzle holder; a nozzle hav-

5

ing a central chamber, valve guide means, a fuel pressure chamber, and a valve seat; a valve having a head with seating means thereon, and a body reciprocable in the guide means, said body having a pressure area in the central chamber and a pressure area in the fuel pressure chamber the latter area being adapted to open the valve in response to fuel pressure; a spring normally urging the valve to seated position; fuel transmission means leading through the nozzle holder and the valve into the fuel pressure chamber; and a duct through the valve body connecting the fuel pressure chamber with the central chamber when the valve is in unseated position thereby supplying fuel pressure against the valve pressure area in the central chamber to hydraulically balance the valve so that the spring will seat the valve.

7. An inwardly opening differential type fuel injector comprising a nozzle holder; a nozzle having a central chamber and fuel pressure chamber therein; a guide bushing disposed between the nozzle holder and the nozzle; a skirt extending from the bushing into the central chamber; a reciprocating valve extending through the bushing; a spring normally urging the valve to seated position; fuel transmission means leading to the fuel pressure chamber; and fuel pressure balancing means connecting the chambers when the valve is unseated thereby to hydraulically balance the valve so that the spring will seat the valve.

8. An inwardly opening differential type fuel injector comprising a nozzle holder; a nozzle having a central chamber, a fuel pressure chamber, and fuel outlet means; a reciprocating valve arranged in the nozzle between the fuel pressure chamber and the central chamber; a spring normally urging the valve to seated position, the volume of such central chamber increasing as the valve moves to seated position; fuel transmission means leading to the fuel pressure chamber; and a duct establishing communication between the fuel outlet means and the central chamber so that a suction effect upon the fuel outlet means will be produced as the volume of the central chamber is increased by the seating movement of the valve.

9. An inwardly opening differential type fuel injector comprising a nozzle holder having a fuel passage therethrough; a nozzle having a central chamber, a valve guide bore, a valve seat, and a fuel outlet; a valve having a head cooperating with the valve seat, a cylindrical body reciprocable in the guide bore, and a stem having a fuel passage communicating with the nozzle holder fuel passage; a spring normally urging the valve to seated position; a pressure chamber formed between the valve and the nozzle; fuel duct means connecting the stem fuel passage and the pressure chamber; and a pressure balancing duct connecting the central chamber and the pressure chamber when the valve is unseated thereby to hydraulically balance the valve.

6

10. An inwardly opening differential type fuel injector comprising a nozzle holder; a nozzle; means to hold the nozzle and nozzle holder in aligned relation; a spring loaded valve in the nozzle openable inwardly in response to fuel pressure; means to guide the valve for reciprocation within the nozzle and holder; a fuel pressure chamber in the nozzle; means to conduct fuel under pressure to the pressure chamber to open the valve; and a fuel duct connecting the pressure chamber with a valve-moving pressure surface whenever the valve is unseated, said duct serving to direct the fuel under pressure against said pressure surface where it will urge the valve towards closed position.

11. An inwardly opening differential type fuel injector comprising a nozzle holder; a nozzle having an axial bore and a counterbore therein; a valve reciprocable in the nozzle bore, said valve having a necked portion which in conjunction with the bore wall defines a fuel pressure chamber; an element in the nozzle counterbore above the valve which, in conjunction with the nozzle and valve, defines a central chamber, the surface of the nozzle exposed to the central chamber being adapted to serve as a fuel pressure surface; a spring normally urging the valve to seated position; fuel transmission means leading to the fuel pressure chamber and adapted to supply fuel to such chamber under pressure sufficient to lift the valve against the bias of the spring; and a duct extending through the valve adapted to permit the transfer of fuel under pressure from the pressure chamber to the central chamber whenever the valve is unseated thereby to hydraulically balance the valve.

12. An inwardly opening differential type fuel injector comprising a nozzle holder; a nozzle having a central chamber, a fuel pressure chamber, and a sac hole therein; a reciprocating valve in the nozzle which, when closed, separates the central chamber from the fuel pressure chamber and the fuel pressure chamber from the sac hole, said valve having a fuel pressure surface in the central chamber; a spring normally urging the valve to closed position; fuel transmission means leading to the fuel pressure chamber; and fuel pressure balancing means connecting the chambers when the fuel pressure chamber and the sac hole are in communication upon opening movement of the valve thereby to hydraulically balance the valve so that the spring will seat the valve.

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