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FUEL INJECTOR

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Fig. 1

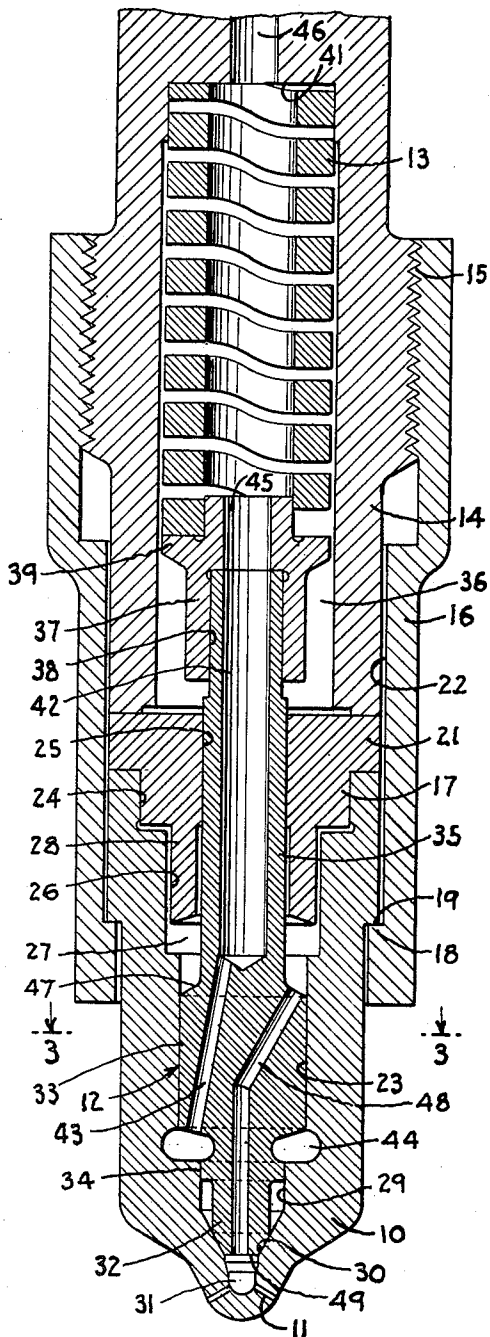


Fig. 2

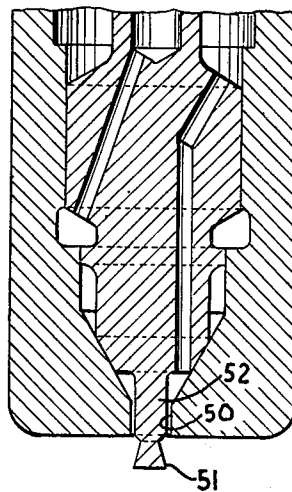
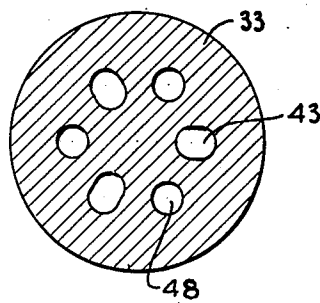


Fig. 3



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FUEL INJECTOR

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12 Claims. (Cl. 299—107.5)

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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. The instant invention is an improvement on the invention disclosed in my copending application Serial No. 216,200 filed March 17, 1951.

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, when the valve has opened by a predetermined fraction of its total movement, a condition of hydraulic balance of the valve is established. This balanced condition will permit the conventional spring loading means rapidly to seat the valve and the fuel supply pressure almost immediately 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 and a shoulder thereon so that, after a predetermined amount of valve movement in its opening direction, communication is established between the valve lifting pressure chamber and the equalizing chamber.

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.

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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 present invention is an improvement upon the injector covered by applicant's copending application Serial No. 216,220 filed March 17, 1951.

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 conjunction 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 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 counterbore 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.

A second smaller bore 29 extends downwardly to an inwardly tapered or conical portion 30 which functions as a seating surface for the valve and also has a fluid passage leading from said bore to sac hole 31 from which orifices 11 extend.

Valve 12 has a head 32 spaced from bore 29, a cylindrical guide body 33, a collar portion 34 larger in diameter than the head, and connecting the head and body, and a stem 35. Collar 34 is a fluid sealing fit in bore 29 and guide body 33 forms a fluid sealing fit with bore 23. Collar 34 is shown larger than head 32 although it is obvious that any expedient that will require the valve to lift a predetermined distance before passing fuel to the seat will perform equally well. The preferred execution also shows the top of collar 34 as flush, when the valve is closed, with the bottom of chamber 44 although it may, if desired, extend above or below the bottom of the chamber providing there is a fluid sealing fit between the collar and bore 29 so that the valve must travel a predetermined fraction of its total movement before fluid is permitted entry to the sac hole 31. 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 in nozzle 10 between the collar portion 34 and the guide body 33 of the valve. 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, collar, 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, the build up of fluid pressure in pressure chamber 44 acting on the differential diameters of 33 and 34 creates an axial force which starts to lift the valve. No fuel can escape from the pressure chamber, however, until valve collar 34 is withdrawn axially from bore 29. In other words, the valve must move inwardly a distance equal to the axial length of collar 34, in the preferred form shown, before any fuel can pass the collar. When the collar clears bore 29 and moves into the pressure chamber 44, fuel immediately issues through the clearance between head 32 and bore 29 into sac hole 31 whence it will pass through spray orifices 11 into the power cylinder. The throttling effect produced by the orifices results in an 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 then acts to seat the valve, fuel flow through the orifices 11 ceases and the pressure in the sac hole drops; the pressure in ducts 48 and chamber 27 also drops and hydraulic unbalance is re-established and the cycle is then 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.

Further, the collar 34 is dimensioned to insure that the valve will open a predetermined or definite distance before fluid enters balancing ducts 48 to hydraulically balance the valve. The result is a clear-cut chattering of the valve and a succession of individually small injections during a single fuel supply stroke of the 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 of 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

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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, a fuel pressure chamber, and a valve seat therein; a valve reciprocable in the nozzle separating the chambers and having a fuel pressure surface exposed to the central chamber; a spring normally urging the valve axially toward its seated position; fuel transmission means supplying the fuel pressure chamber; fuel pressure balancing means connecting the chambers; and means on the valve to delay delivery of fuel from the pressure chamber to the valve seat until the valve has been lifted a predetermined distance off its seat thereby to hydraulically balance the valve after it has moved a predetermined distance from its seat so that the spring will rapidly 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 valve seat in the nozzle; a central chamber defined by the bushing, the valve, and the nozzle; a fuel pressure chamber in the nozzle; means to supply fuel to the fuel pressure chamber; duct means to connect the fuel pressure chamber and the central chamber; and means on the valve to delay delivery of the fuel past the seat from the fuel pressure chamber until the valve has been lifted a predetermined distance off its seat thereby to equalize the pressure in said chambers after a predetermined movement of the valve.
6. An inwardly opening differential type fuel injector comprising a nozzle holder; a nozzle; a valve guide bushing disposed between the nozzle holder and the nozzle and seated on the latter to close an open end thereof; a reciprocable valve having a stem extending through the bushing; a valve seat in the nozzle; a spring normally urging the valve to seated position; a central chamber defined by the nozzle, the bushing, and the valve; a fuel pressure chamber between the nozzle and the valve; fuel transmission means supplying the fuel pressure chamber; means on the valve to delay fuel delivery past the valve seat from the pressure chamber until the valve has been lifted a predetermined distance; and fuel pressure balancing means connecting the chambers when the valve has been lifted said predetermined distance thereby 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, a fuel pressure chamber, valve guiding and sealing means between the

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chambers, and a valve seat; a valve reciprocable in the nozzle and having a main body portion in a fluid sealing fit with the nozzle guide means, said valve also having a head with seating means thereon, a first portion of said head being spaced from the guide means below the fuel pressure chamber and a second portion of said head below the fuel pressure chamber having a fluid sealing fit with said guide means; a first pressure area on said valve body portion exposed to the central chamber; a second pressure area on said body portion exposed to the fuel pressure chamber, said second pressure 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 has been lifted a predetermined distance from its seat 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.

8. An inwardly opening differential type fuel injector comprising a nozzle holder; a nozzle having a central chamber, a fuel pressure chamber, a valve seat, and fuel outlet means; a valve arranged to reciprocate in the nozzle between the fuel pressure chamber and the central chamber, said valve having a first portion spaced from the nozzle below the pressure chamber and a second portion between the pressure chamber and the first portion forming a fluid sealing fit with the nozzle, said second portion having a dimension such that the valve must move inwardly a predetermined distance before fuel is admitted past the seat from the pressure chamber; a spring normally urging the valve to seated position, the volume of the 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 fuel pressure chamber, a first guide bore inwardly of the pressure chamber, a second guide bore outwardly of the pressure chamber, a valve seat, and a fuel outlet; a valve having a head with a seating surface cooperating with the valve seat, a cylindrical body reciprocable in the first guide bore, and a stem having a fuel passage communicating with the nozzle holder fuel passage, said valve head being spaced from the second guide bore below the pressure chamber and having a collar thereon forming a fluid sealing fit with the second guide bore between the spaced portion and the pressure chamber; a spring normally urging the valve to seated position; fuel duct means connecting the stem fuel passage and the pressure chamber; and a pressure balancing duct connecting the central chamber and the fuel pressure chamber when the valve has moved a predetermined distance from its seat to hydraulically balance the valve.

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

ing a valve seat therein; 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 between the valve and nozzle, said valve being also spaced from the nozzle below the pressure chamber, a collar on the valve between the spaced portion and the pressure chamber forming a fluid sealing fit with 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 the interior of the nozzle when the valve has been lifted a predetermined distance from said valve seat, and a valve moving pressure surface 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, a counterbore, a bore smaller than the axial bore, and a valve seat therein; a valve reciprocable in the nozzle bore, said valve having a reduced portion defining a fuel pressure chamber in the nozzle and a head spaced from the smaller bore, a collar on the head between the spaced portion and the pressure chamber forming a fluid sealing fit with the smaller bore; a member in the nozzle counterbore above the valve which, in conjunction with the nozzle and valve, defines a central chamber, the surface of the valve exposed to the central chamber being adapted to serve as a fuel pressure surface in which fluid pressure can exert an axial component of force; 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 off the valve seat 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 when the valve has moved a predetermined distance from its seat to permit fuel from the pres-

sure chamber to enter the central chamber through the space and said duct when said collar has moved into the pressure chamber thereby to hydraulically balance the valve.

12. An inwardly opening differential type fuel injector comprising a nozzle holder; a nozzle having valve guide means and a valve seat therein; a valve guide member seated on the nozzle holder and sealing off the inner end thereof; a valve reciprocable in the nozzle and having a main body, a head, and seating surface thereon, said valve main body separating the interior of the nozzle into a central chamber defined by said valve guide member, the valve, and the nozzle and a fuel pressure chamber defined by the valve and nozzle, said valve head having a first portion spaced from said guide means below the fuel pressure chamber and a second portion adjacent said first portion in fluid sealing fit with said guide means, whereby the valve must lift a predetermined distance from the seat to permit fuel from the pressure chamber to flow past said seat, and said valve body also having a first pressure area exposed to the central chamber and a second pressure area exposed to the fuel pressure chamber on which fuel can exert an axial component of force; 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 connecting the fuel pressure chamber with the central chamber when the valve has lifted said predetermined distance from its seat 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.

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