

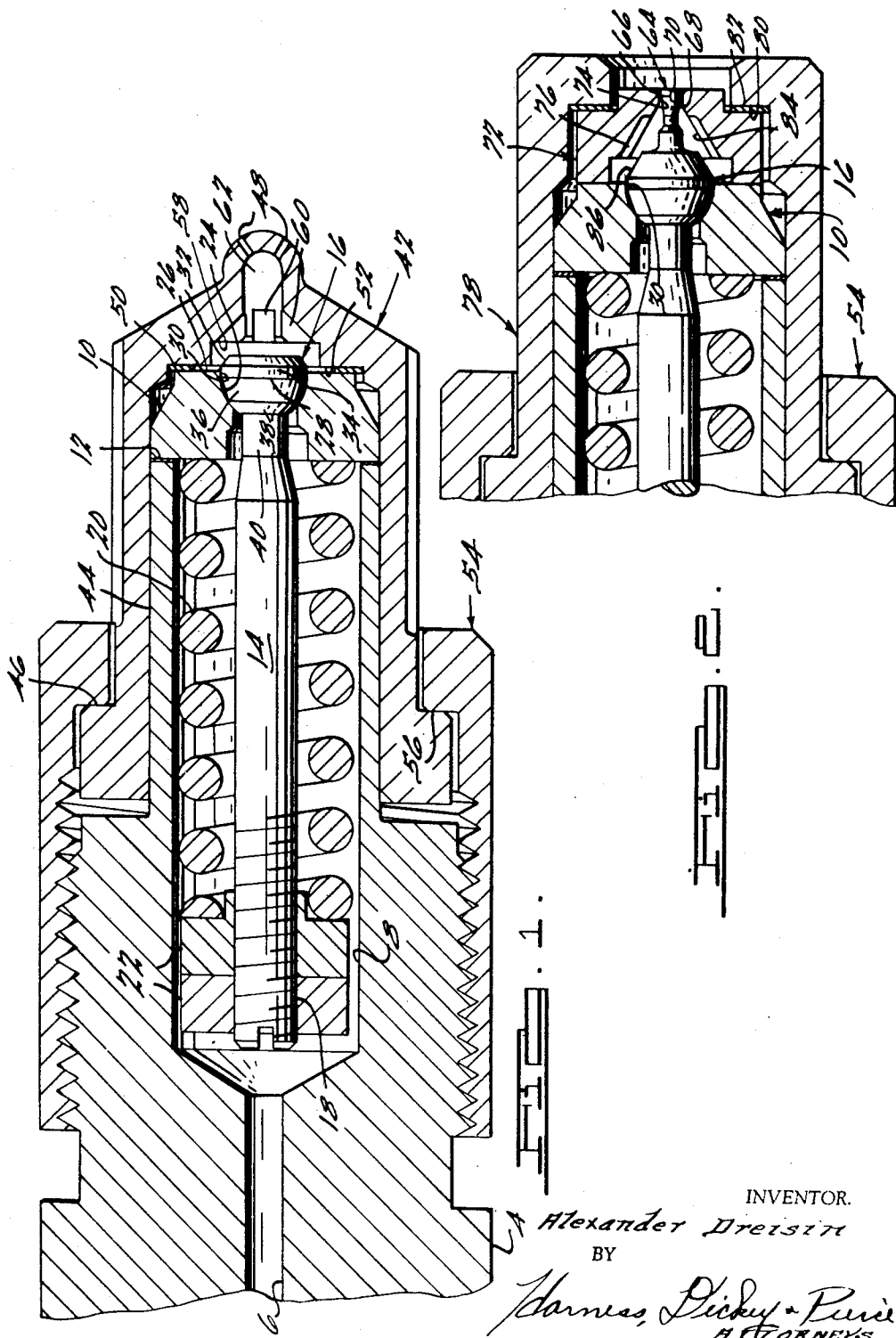
Sept. 6, 1960

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2,951,647

INJECTION NOZZLE

Filed Feb. 6, 1957



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2,951,647

INJECTION NOZZLE

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Filed Feb. 6, 1957, Ser. No. 638,639

6 Claims. (Cl. 239—453)

The present invention relates to hydraulically operated fuel injection nozzles for internal combustion engines and, more particularly, to an outwardly opening fuel injection nozzle which incorporates a differential area principle of operation without requiring the valve stem to be guided.

Fuel injection nozzles used today can be divided into two categories depending upon whether they open inwardly or outwardly. Inwardly opening nozzles readily lend themselves to a differential area principle of operation wherein a small area of the valve is subjected to the fluid pressure prior to its opening, and a larger area immediately thereafter. Exposing the larger area to the fluid pressure snaps the valve to its fully open position to permit the liquid fuel to discharge rapidly into a co-operating combustion chamber. The valve will also remain open to a lower value of pressure than the pressure required to open it because of the additional differential area exposed to fluid pressure in the open position. This latter characteristic will prevent the spurious reopening of the valve by the dynamic pressure waves accompanying the rise and fall of pressure in timed injection systems. Such reopening after the initial closing is very detrimental since it results in poor atomization of the fuel and leads to rapid carboning-up of the nozzle tip.

However, despite the foregoing advantages, inwardly opening valves in fuel injection nozzles have the disadvantage of requiring extremely close manufacturing tolerances, as well as, requiring a separate drain line for each injection nozzle. The close tolerances result from the necessity for guiding the valve stem concentrically with its conical seat in order to insure a high pressure seal. These disadvantages led the industry to search for a different type of nozzle which resulted in the development of the outwardly opening fuel injection nozzle. These nozzles represent a definite improvement over the inwardly opening nozzles in many respects, but do not readily lend themselves to the differential area principle of operation and require a positive guide to obtain a high pressure seal between the valve head and the seat.

Various attempts have been made to eliminate the foregoing disadvantages of outwardly opening injection nozzles with varying degrees of success and it is to this problem that the present invention is directed. The fuel injection nozzle embodied in the present invention provides a high pressure seal which is less expensive to machine, lends itself for use either as a pintle-type or a multiorifice-type nozzle, and incorporates the differential area principle of operation without requiring a guide for the valve stem. The latter represents a major improvement over prior art attempts to incorporate the differential area principle of operation into outwardly opening nozzles.

The present invention is comprised of an outwardly opening needle-type valve, maintained in abutting relation with a valve seat by an adjustable compression spring, and a nozzle housing having appropriate orifices. The

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valve seat has a truncated spherical recessed portion and a short cylindrical portion tangential to the truncated spherical portion at its greatest diameter. The valve head has spaced truncated spherical portions at its maximum diameter and adjacent the valve stem, and a frusto-conical or angular groove portion intermediate the spaced truncated spherical portions. In operation, a small area of the truncated spherical portion of the valve adjacent the stem is initially subjected to fluid pressure which will unseat the valve when the pressure exceeds a resisting force supplied by the aforesaid spring. As soon as the valve unseats, the major area of the truncated spherical valve head is exposed to the fluid pressure and the valve pops open rapidly in accordance with the differential area principle of operation. The aforesaid major truncated spherical portion of the valve and the cylindrical portion of the recess provide a throttling action which permits the differential area action to maintain at least until the valve opens.

Therefore, it is an object of this invention to provide an improved means for injecting liquid fuel into an internal combustion engine.

It is another object of this invention to provide an improved means for injecting liquid fuel into an internal combustion engine which is simple, ruggedly constructed, economical to build and easy to service.

It is a further object of the present invention to provide an improved means for injecting liquid fuel into an internal combustion engine which is easily assembled, eliminates the residual stress inherent in assembly, minimizes the effect of thermal distortion and wear, and obviates the necessity for extremely high tolerances.

It is a still further object of the invention to provide an outwardly opening valve which incorporates a hydraulic differential area principle of operation without requiring a guide for the valve stem; embodies a truncated spherical seat to insure a high pressure seal even under conditions of slight angular misalignment; eliminates the requirements of extreme concentricity in operating clearances; and is adaptable to either pintle-type or multi-orifice-type nozzles.

Other objects and features of novelty of the invention will become apparent when referring, for a better understanding of the invention, to the following description taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a cross-sectional view taken along the longitudinal axis of one end of a jet nozzle-type injector valve embodying the features of the present invention; and

Fig. 2 is a similar cross-sectional view of a pintle-nozzle-type injector valve.

Referring to Fig. 1, the present invention is comprised of a body 4 having an axially disposed passage 6 connecting pump means (not shown) with a chamber 8, also axially disposed in the body 4. A valve seat body 10 is in abutting relation with one end of the body 4 with a metal gasket 12 therebetween. A needle valve 14, having a valve head 16 and a threaded portion 18 at the opposite end thereof is maintained in abutting relation with the seat body 10 by a compression spring 20 disposed between the seat body 10 and two nuts 22 engaging the threads 18. The compression of the spring 20 may be varied by adjusting the nuts 22 on the threads 18.

The valve head 16 has a chamfered end 32, common sphere portions 34 and 38, a frusto-conical or otherwise recessed portion 36, and a reduced cylindrical portion or stem 40. The valve seat body 10 has a cylindrical portion 30 having a close running fit with the major truncated spherical portion 34 of the valve head 16, and a truncated spherical recessed seat 24 of identical radius to that of truncated spherical portions 34 and 38 of the

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valve head 16. The spherically formed portion 34 is a portion of major diameter. In the preferred embodiment shown, the center of curvature of the recessed truncated spherical seat 24 is made sufficiently deep so that when the truncated spherical portion 38 seats thereagainst, the center of both of these truncated spherical portions is located below face 26 of the valve body 10. This permits the seal between the truncated spherical portion 38 and the recessed truncated spherical seat 24 to be broken before the annular clearance between the truncated spherical portion 34 and the cylindrical portion 30 enlarges. Consequently, a throttling action is maintained after the valve is unseated and permits the greater surface area of the truncated spherical portion 34 to be exposed to the fluid pressure whereby the valve is completely opened, thus achieving a differential area principle of operation.

A housing 42 fits over an extended cylindrical portion 44 of the body 4 and has an annular shoulder 46 at one end and orifices 48 at the other end thereof. A metal gasket 50 is disposed between the face 26 of the valve seat body 10 and an internal shoulder 52 of the housing 42. An internally threaded sleeve 54, having an annular internal shoulder 56, engages the external threads 18 of the body 4 to maintain the shoulder 56 in abutting relation with the shoulder 46. Tightening the sleeve 54 will also compress the metal gaskets 12 and 50 to complete the assembly.

The foregoing assembly is advantageous over other constructions because it permits the components to be tested and adjusted for leakage, initial and final opening pressures, flutter, and rate of fuel delivery, before proceeding with the assembly of the remainder of the injector (not shown). The sleeve 54 is preferably tightened on the body 4 with the axis of the assembly in a vertical position and, because of the allowance of considerable diametrical clearances between the bore of the housing 42 and the outer diameters of the seat body 10 and the extended cylindrical portion 44, and between the outer diameter of the housing 42 and the internal diameter of the sleeve 54, the internal components of the assembly are free to accommodate themselves to a lateral position without radial stress. Consequently, all strain occurring in the assembly is axial and the deleterious effects of lateral stresses on the functioning of the device are eliminated. In addition, because of the seat 24 being truncated spherical, a slight angular misalignment or swiveling of the valve 14 relative to the seat body 10 will not affect the high pressure seal, nor will it produce the lateral stresses which would be created if the conventional conical seat were used. By permitting the needle valve 14 to swivel as described above, it is apparent that the truncated spherical portion 38 is free to align itself exactly with the recessed truncated spherical seat to insure a good high-pressure seal therebetween without requiring that the stem of the needle valve 14 be carefully guided relative to the valve seat body 10 and the body 4 as would be the case if truncated conical seating surfaces were employed.

In operation, fluid under pressure passes through the passageway 6 into the chamber 8 and exerts a force against a first exposed surface of the truncated spherical portion 38 of the valve head 16. When the hydrostatic pressure is sufficiently increased to overcome the resistance of the spring 20, the valve begins to open separating the seating surface 38 from seating surface 24; however, due to the throttling effect between the cylindrical portion 30 and the truncated spherical surface 38 the fluid pressure is maintained long enough to permit the transverse area of the latter to be exposed to the high opening fluid pressure. Exposing this second and larger area to the fluid pressure causes the valve to lift very rapidly and provides the differential action analogous to that of an inwardly open nozzle. The momentum acquired by the valve 14 carries it further and, if the pressure wave is high enough and the flow persists for sufficient time, the valve head 16 will abut against inner face 58 of the housing 42 which

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will bring it to rest. Fluid then flows around the valve head 16, through coined passages 60, into cavity 62, and out through orifices 48.

Since the pressure at which the valve will close is less than that needed to open it, by virtue of the differential area principle, the valve 14 will remain open until the fluid pressure drops sufficiently to offset the area differential. When this occurs, the spring 20 will close the valve solidly and it will not flutter or reopen because the fluid is at the lower closing pressure which is below the pressure required to open the valve to insure that it will not flutter or reopen. Without this differential between opening and closing pressures, the dynamic pressure waves inherent in timed fuel injection systems would cause the valve to flutter and possibly reopen after the initial closing. As stated previously, such reopening results in poor atomization of the fuel and rapid carbon deposit on the nozzle tips which is very detrimental to engine performance.

It is customary to have the opening pressure for nozzles such as the present invention at rather high values, usually between 1600 and 3000 p.s.i., to facilitate atomization of the fuel. In currently used inwardly opening injection nozzles, extreme precision is required to sustain such pressures so that they may function under the vagaries of thermal distortion and the residual stresses of the component. Further, very slight amounts of wear cause them to operate erratically or fail entirely. The nozzle of the present invention requires no such degree of precision in manufacture and its method of assembly eliminates the creation of residual stresses and minimizes the effect of thermal distortion, as well as that of normal wear, on the efficiency of its operation.

Referring to Fig. 2, an embodiment of the present invention is illustrated with a pintle-type valve. All of the components are identical to those already described with the exception that a pintle 64 having a cylindrical portion 66, a frusto-conical portion 68 and flats 70 is mounted on the valve head 16. A pintle plate 72, having a cylindrical orifice 74 and coined passages 76, is maintained in abutting relation with the valve seat body 10 by a housing 78 which is similar to the housing 42 of Fig. 1 with the exception that one end thereof is altered so as to provide an internal shoulder 80 for securing the pintle plate 72 in position. A metal gasket 82 is disposed between the pintle plate 72 and the internal shoulder 80.

The operation of the embodiment of Fig. 2 is similar to that of Fig. 1 with the exception that the pintle 64 modifies the pattern of the atomized spray and also may provide an additional throttling action during a portion of the lift. The passage area during the throttling portion of the lift is provided by the flats 70 until the cylindrical portion 66 clears the pintle plate 72 whereupon the conical portion 68 provides a larger passage area. Of course, appropriate grooves or other clearance means may be used in place of the flats 70 to further alter the atomization and spray pattern of the fuel.

In order to insure concentricity between the pintle 64 and the pintle plate orifice 74 in the fully open position, without the necessity of guiding the stem of the valve 14, the pintle plate 72 is provided with a frusto-conical countersink 84 which is concentric with the pintle plate orifice 74. The valve head 16 has a corresponding frusto-conical or chamfered surface 86 which is concentric with the pintle 64. At the full lift position, the frusto-conical surface 86 abuts against the frusto-conical countersink 84 to maintain concentricity between the pintle 64 and the orifice 74. When the valve head 16 is in this position, the fluid passes around the valve head by means of the coined passages 76.

The procedure for assembling the embodiment shown in Fig. 2 is the same as that for the embodiment shown in Fig. 1 with the exception that the pintle plate 72 is aligned with the rest of the assembly by the pintle 64. When the sleeve 54 is tightened on the body 4, the pintle

plate 72 and the other components of the assembly are free to assume positions of minimum lateral and radial strain as before.

What is claimed is:

1. In an outwardly opening fuel injection nozzle, a valve seat body having at one end a cylindrical bore portion terminating in a truncated spherically recessed seat which communicates with a passageway extending through the body to the other end thereof, and a valve having a stem fitting loosely within said passageway, a head presenting a spherically formed surface which cooperates with said seat to form a high pressure seal therewith and a spherically formed portion of major diameter in sliding and substantially fuel sealing relation to said bore portion to permit the fluid to operate on a larger portion of said valve head as said head moves from said seat before the fluid is expelled from said cylindrical bore portion, said spherically formed surface and portion lying on a common sphere.

2. In an outwardly opening fuel injection nozzle for internal combustion engines, a valve seat body having at one end a cylindrical bore portion terminating in a truncated spherically recessed seat which communicates with a passageway extending through the body to the other end thereof, and a valve having a stem fitting loosely within said passageway and having a head in complementary sealing engagement with said seat to expose a small portion of said head to the fluid in the passageway, said valve presenting a spherically formed portion of major diameter maintaining a running fit with said cylindrical bore portion during initial movement of said head from said seat, said spherically recessed seat and spherically formed portion lying on a common sphere when said head engages said seat.

3. In an outwardly opening fuel injection nozzle; a valve seat body part having a cylindrical bore portion at one end and a passageway in fluid fuel communication with said cylindrical bore portion and extending through said body part to the other end thereof; a valve having a stem fitting loosely within said passageway and having a head part presenting a spherical portion of major diameter forming a sliding fuel sealing fit with said cylindrical portion, the center of said spherical portion lying within said cylindrical bore portion during initial

opening movement of said valve; and cooperating seating surfaces formed on said parts, respectively, with an area of seating contact intermediate the cylindrical bore portion and passageway lying on the same sphere as said spherical portion and providing a high pressure seal for fuel in said passageway acting on a first area of said head part, one of said seating surfaces being spherically formed on the same radius as said spherical portion, said seating surfaces being separated upon said initial opening movement of said valve to expose an area of said head part greater than said first area to said fuel, and said cylindrical and spherical portions maintaining a sliding and substantially fuel sealing fit during said initial opening movement of said valve and said portions disengaging to permit expulsion of fuel upon further opening movement of said valve placing said center outside of said cylindrical bore portion.

4. The fuel injection nozzle defined in claim 3 wherein said one of said seating surfaces is formed on said head part.

5. The fuel injection nozzle defined in claim 3 and further comprising a wall on said body part intermediate said cylindrical bore portion and said seating surface on said body part disposed in spaced relation to said head part.

6. The fuel injection nozzle defined in claim 3 wherein both of said seating surfaces are spherically formed and said head part is spaced from said body part intermediate the seating surface and cylindrical bore portion of said body part.

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