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FUEL INJECTOR

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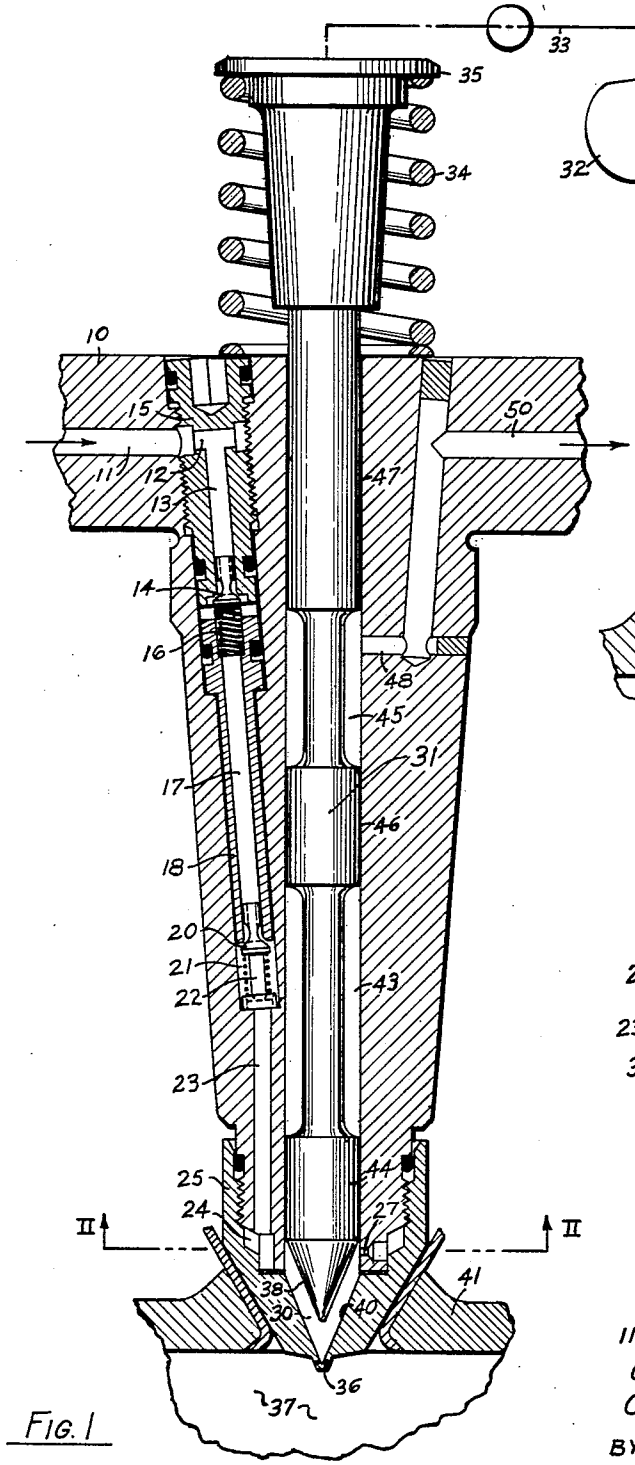


FIG. 1

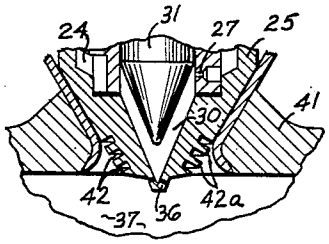


FIG. 3

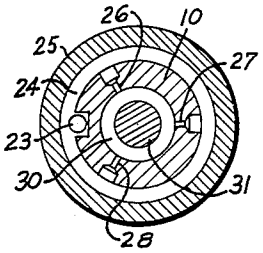


FIG. 2

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FUEL INJECTOR

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This invention relates to improvements in fuel injectors used in compression-ignition internal combustion engines.

Two problems which have faced builders of diesel or compression-ignition engines for many years are those of a "steamy-white" smoke exhausted upon starting the engine and of excessive "sooty" smoke exhausted when the engine is operating under a load. While there are other contributory causes of these undesirable exhaust smokes, a major related cause is that of insufficient preparation of the fuel charge before it is burned in the combustion chamber. This lack of fuel preparation results in "quenched" combustion in a cold engine immediately after starting and in delayed ignition when the engine is working under load.

It is, therefore, one object of the invention to provide an injector structure which better prepares the fuel charge in the plunger chamber of a mechanically actuated injector and thus materially reduce the starting smoke and the exhaust smoke under load which normally occurs in a diesel engine.

Another problem arises from the fact that diesel engines which utilize a mechanically actuated injector plunger located adjacent to the combustion chamber must provide additional means to lubricate the plunger if such an engine is used in vehicular service. During a vehicle's coasting and braking cycle, the fuel flow to the injector should be stopped. However, in commercial use to date, no engine equipped with this type of injector can operate for a practical length of time without the injector plunger sticking in its bore if the fuel flow from the pump is completely shut off.

Another object of the present invention is to enable all fuel to be shut off to mechanically operated injectors without resultant sticking or scoring of injector plungers whenever the load is rotating the engine. This is accomplished by the use of lubrication reservoirs which provide the necessary lubrication for sufficiently long periods of time, such as during a long coast down a mountain grade.

Other objects and advantages of the invention will become apparent from the following description and the accompanying drawings in which:

FIG. 1 is a view in cross section of an injector embodying the principles of the invention, showing multi-delivery ports, lubrication bands and a double check valve construction;

FIG. 2 is a view in section taken on the line II—II of FIG. 1 showing the arrangement of the multi-delivery fuel ports leading into the plunger chamber;

FIG. 3 is a fragmentary view in section of a modified form of the invention in which the part of the injector which protrudes into the combustion chamber has a structure that provides more rapid heating of the fuel charge in the plunger chamber.

In FIG. 1 a fuel charge, preferably from a positive displacement type of supply pump, enters an injector body **10** through a fuel conduit **11** and flows through a cross port **12** and an axial passage to a check valve **14** located in its guide piece **15**. A spring **16** serves to keep the valve **14** seated except when the fuel charge, under pressure, is passing through. The charge of metered fuel then enters an axial passage **17** in a lower check valve tube **18** and opens a lower valve **20** against

the pressure of a spring **21** until the valve **20** hits a stop piece **22**. The charge continues down a drilled passage **23** into the body **10** and into an annular groove **24** formed by reliefs in an injector cup **25** and the body **10**. The charge finally is distributed through delivery ports **26, 27, 28** located circumferentially in the housing **10** and leading into a plunger chamber **30** formed by the retraction of a plunger **31** away from its seat in the cup **25**. The plunger **31** is actuated by an engine driven cam **32** through a rocker lever **33** (shown schematically). A plunger spring **34**, acting against its retainer **35**, provides the force to retract the plunger **31**. With the fuel charge deposited in the chamber **30**, the plunger **31** is driven downward near the end of the compression stroke by the cam **32** and in doing so drives the fuel in the chamber **30** through small spray nozzles **36** and into a combustion chamber **37**.

The significance of the multi-feed ports **26, 27, 28** will now become apparent. The fuel is forced through these ports under enough pressure so that a plurality of sprays are formed which impinge on a retracted conical surface **38** of the plunger **31**. The tip **38**, since it is in the path of the hot air entering from the combustion chamber **37** through the spray nozzles **36** during the end of the compression stroke, heats up much faster upon starting the engine than its mating surface **40** on the cup **25**. The injector cup **25** transfers to a cylinder head **41** and then into the cooling water much of its heat until the entire engine structure surrounding the combustion chamber approaches the normal operating temperatures. Thus the fuel upon entering the chamber **30** should strike the hotter tip **38** rather than the colder wall **40** if the fastest charge heating is to be obtained.

The purpose of the faster heating of the fuel charge in the chamber **30** is to vaporize as much of the charge as possible before it is injected into the combustion chamber **37**. For, the more it is vaporized, the sooner the charge will fire when injected. This reduces the ignition delay, which in a cold engine results in the white, foggy and acrid smelling exhaust and which in a hot engine contributes to the excessive black smoke under load. It must be added that a part of the preparation of the fuel charge is due to the mixing of the fuel in the plunger chamber **30** with the hot air coming in through the nozzles **36** just prior to the bottoming of the plunger **31** in the cup **25** at the end of the compression stroke. While three delivery ports **26, 27, 28** are shown at 120 degree intervals (FIG. 2) leading into the chamber **30**, the location and number of ports may vary with different engines and conditions. The reason that more than one, and usually more than two, ports are desirable is that the entire surface of the hot tip **38** should be utilized; and since the more orifices used, the smaller the percentage of fuel charge per orifice. Thus the heat transfer from the tip **38** to the fuel impinging on the tip will be more rapid.

FIG. 3 shows an additional method of providing faster warmup of the plunger chamber **30**. By cutting grooves **42** in the part of the cup **25** exposed to the combustion chamber **37**, fins **42a** are provided, and more surface area is in contact with the hot gases in the chamber **37**, and more heat is transferred to the inner surface **40** of the cup, thus heating up much more quickly. The heating fins **42a** and groves **42** perform their function most noticeably during the starting and warmup cycle. The application of additional heat to the inner surface **40** will contribute to more efficient operation under full load also. Currently used injector cups indicate by their shiny inner surface that the temperature inside the cup is under the ideal vaporization temperature. As the load requirements increase, the size of the fuel charge deposited in the chamber **30** also increases. The greater percentage of fuel

in the chamber tends to reduce the amount of possible charge vaporization by cooling the surfaces and thus to increase the ignition delay.

The multi-feed ports 26, 27, 28 also contribute materially to the better lubrication of the lower end of the cylindrical portion of the plunger 31. This lower zone is subject to the greatest heat and by providing lubrication with fuel to more than one point (as when the conventional single delivery port is used) the scoring or scuffing of the plunger in this area is substantially reduced.

A study of FIG. 1 indicates that the injector plunger 31 has two axially extending grooves or lubrication reservoirs located toward its lower end. A lower groove 43 is separated from the chamber 30 by a close-fitting shoulder 44 and from an upper groove 45 by a close-fitting shoulder 46. The upper groove 45 is also separated from the area above the injector body 10 by a shoulder 47. When the injector plunger 31 is driven downward to inject the previously deposited charge of fuel in the chamber 30 into the combustion chamber 37, extremely high hydraulic pressures are created in the chamber 30. A very small portion of this charge will be forced upward between the close-fitting shoulder 44 and its bore in the housing 10. (Also, since the length of seal between the bottom of the delivery ports 26, 27, 28 and the start of the conical surface 40 is short, another part of the charge would be forced into the annular conduit 24 and out of the injector if the check valve 20 were not employed. However, with good valves the only leakage is up the bore and not back through the feed ports.) Thus with each injection a little more fuel is forced upward past the shoulder 44 until the groove 43 is full of fuel. When the groove 43 is finally full, the pressure forces fuel past the shoulder 46 and into the upper groove 45. This groove 45 is open at all times to the conduit 48 which leads back to the fuel source (not shown) through an injector conduit 50. By groove 45 being held at substantially atmospheric pressure, no fuel oil will leak past shoulder 47 and into the engine where it could dilute the lubricating oil. The upper shoulder 47 is lubricated by engine lubricating oil at its upper end and by fuel oil at its lower end. There are, therefore, two bands of fuel oil serving to act as plunger lubricant reservoirs when the throttle is closed and the fuel from the supply pump is shut off, as whenever the engine is coasting. These bands 43 and 44 are deep enough to provide a reservoir of sufficient capacity to take care of plunger lubrication during the longest coast.

The return line 50 leading back to the tank is important for still another reason. During the time of peak gas pressures in the combustion chamber 37, as on the power stroke of the engine, some of the gas is forced into the now collapsed chamber 30, the plunger 31 being held seated at this time. The check valve 20 and its back up valve 14 prevent any gas from entering the fuel supply conduits leading from the supply pump to the chamber 30. If gas bubbles enter these conduits, a very poorly operating engine will result, as explained in U.S. Patent No. 2,997,993. However, some of the gas will pass upward between the shoulder 44 and the bore wall of the housing 10, as did the small quantity of fuel during the time of injection. These bubbles of gas ultimately pass through the fuel in the groove 43, along the shoulder 46, in the groove 45 and on back to the vented fuel source (not shown) through the passages 48 and 50. These hot gas bubbles tend to take some of the lubricating film on shoulders 44 and 46 with them, thus making some means of additional lubrication even more essential. For this reason the loss of a part of the fuel charge during injection is not only tolerated but admittedly welcomed. During the coasting cycle, i.e., when the fuel supply to the injectors is cut off, the combustion chamber pressures are much lower, since no firing takes place, and as a result much smaller volumes of bubbles work their way up the plunger. In extremely long coasts the gases could carry away all of the lubrication supply in the bands 43, 45 but,

as with all fuel pumps, it is almost impossible to prevent some fuel from leaking from the pump when the throttle is closed. This slight seepage, therefore, enters the chamber 30 and keeps the surfaces 38 and 40 moist. The incoming "cooler" gas bubbles then force upward the slight amount of leakage fuel to help lubricate the shoulders 44 and 46, the leakage fuel also serving to replenish, or at least maintain, a lubrication supply in the bands 43 and 45.

To those skilled in the art to which this invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit and scope of the invention. The disclosures and the description herein are purely illustrative and are not intended to be in any sense limiting.

What is claimed is:

1. In a liquid fuel injection nozzle for the combustion chamber of an internal combustion engine, comprising a nozzle housing having a bore therein with a plunger chamber and seat at the inner end thereof and an orifice in said seat leading into said combustion chamber, a fuel injection plunger having a cylindrical inner end portion reciprocable in said bore adjacent said plunger chamber and having its lowermost end portion adapted to mate with said seat at the end of the injection stroke of said plunger in said plunger chamber and to provide an end wall of said plunger chamber when spaced thereabove, a liquid fuel passage in said housing adjacent said bore connected to a fuel supply, and a check valve means in said fuel passage;

the improvement comprising a liquid fuel charge dividing and distributing passage surrounding said bore adjacent the upper end of said plunger chamber, a plurality of circumferentially spaced spray orifice means providing communication between said charge dividing and distributing passage and said bore, each of said orifices extending radially of said bore to inject said fuel against a different circumferentially spaced heated area of said plunger end portion when said plunger is in a first predetermined portion of its stroke in said bore, and said plunger in a second predetermined portion of its stroke in said bore covering and closing off said orifices and the flow of fuel through said orifices thus serving to circumferentially lubricate said plunger during said second predetermined portion of its stroke, whereby to divide and increase the vaporization of each charge of liquid fuel delivered to said plunger chamber only when said plunger is in said first predetermined portion of its stroke.

2. A fuel injector mechanism for receiving fuel under pressure from a fuel source via a supply means and for injecting the fuel into an engine combustion chamber, including in combination:

(*a*) a housing having

a bore with a seat in its lower end and orifice means in said seat leading into said combustion chamber,

a fuel inlet passage connecting said supply means to the lower portion of said bore above said seat by means of a plurality of ports opening into said bore at different places around said bore, and

a fuel return passage leading from an upper portion of said bore back to said fuel source,

(*b*) a fuel-injection plunger reciprocating in said bore and having a lower end adapted to engage said seat at the lower end of its fuel-injection stroke and having a side wall portion above said lower end covering and thereby closing said delivery ports at said lower end of said stroke, said plunger when retracted from said seat uncovering said delivery ports and forming a plunger chamber between itself and said seat at the upper end of said stroke, said ports opening into said

plunger chamber, and opposite the lower end of said plunger when said plunger is at its upward extremity, to spray fuel onto the lower end of said plunger, and a plurality of grooves successively spaced from each other and from each end of said plunger by bore-engaging shoulders, the uppermost of said grooves being aligned with said fuel return passage during the full stroke of said plunger, said shoulders separating said grooves at all times from said plunger chamber and said fuel inlet passage,

(*c*) means engaging said fuel-injection plunger for reciprocating said fuel-injection plunger independently of the fuel being deposited in said plunger chamber, and

(*d*) check valve means in said fuel inlet passage for closing said passage during the downward fuel injection stroke of said plunger and keeping it closed while the lower end of said plunger is seated against said seat.

3. A fuel injector mechanism for receiving fuel under pressure from a fuel source via a supply means and for injecting the fuel into an engine combustion chamber, including in combination:

(*a*) a housing having

a bore with a seat in its lower end and orifice means in said seat leading into said combustion chamber,

a fuel inlet passage connecting said supply means to said bore only at the lower portion of said bore by port means there, and a completely separate fuel return passage leading from an upper portion of said bore back to said fuel source,

(*b*) a fuel-injection plunger reciprocating in said bore and having a lower end adapted to engage said seat at the lower end of its stroke and to provide a plunger chamber between itself and said seat at the upper end of said stroke, said port means opening into said plunger chamber,

a plurality of grooves successively spaced from each other and from each end of said plunger by bore-engaging shoulders, the uppermost of said grooves being aligned with said fuel return passage during the full stroke of said plunger, said shoulders separating said grooves at all times from said plunger chamber and said fuel inlet passage,

(*c*) means engaging said fuel-injection plunger for reciprocating said fuel-injection plunger independently of the fuel being deposited in said plunger chamber, and

(*d*) check valve means in said fuel inlet passage for closing said passage during the downward fuel-injection stroke of said plunger and keeping it closed while the lower end of said plunger is seated against said seat, whereby said grooves act as lubrication reservoirs to lubricate said fuel-injection plunger and said bore, and said return passage carries back to said fuel source the leakage of fuel and of gases from said combustion chamber which have passed between said shoulders and said housing bore.

4. A fuel injector for receiving fuel under pressure from a supply means and for injecting the fuel into an engine combustion chamber, including in combination:

(*a*) a housing having

a bore with a seat in its lower end and orifice means in said seat leading into said combustion chamber, and

a fuel inlet passage connecting said supply means to the lower portion of said bore by means of a plurality of delivery-ports spaced around and opening into said bore on a common plane,

(*b*) a plunger reciprocating in said bore and having a lower end adapted to engage said seat at the lower end of its stroke and to provide a plunger chamber between itself and said seat when said plunger is retracted from said seat, said delivery ports opening into said plunger chamber,

(*c*) check valve means in said fuel inlet passage for closing said passage during the downward stroke of said plunger and keeping it closed while the lower end of said plunger is seated against said seat, whereby, when said plunger is retracted and said fuel is delivered into said plunger chamber, said delivery ports distribute the fuel charge into a plurality of sprays that all impinge onto the lower end of said plunger that has been heated by hot gases that enter said orifice means from said combustion chamber in order to pre-heat said fuel charge before injection as well as to mix it somewhat with hot air in said chamber, and thereby to prepare it for injection through said orifice means into said combustion chamber, and

(*d*) said housing having a lower end portion beyond said seat projecting into said combustion chamber and having a finned outer surface exposing a substantial surface area to the hot gases in said combustion chamber, so that said seat and said plunger chamber are heated quickly upon the initial starting of the engine, and the cooling effect in the plunger, due to the larger volume of fuel per charge when the engine is operating under a load, is offset.

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