

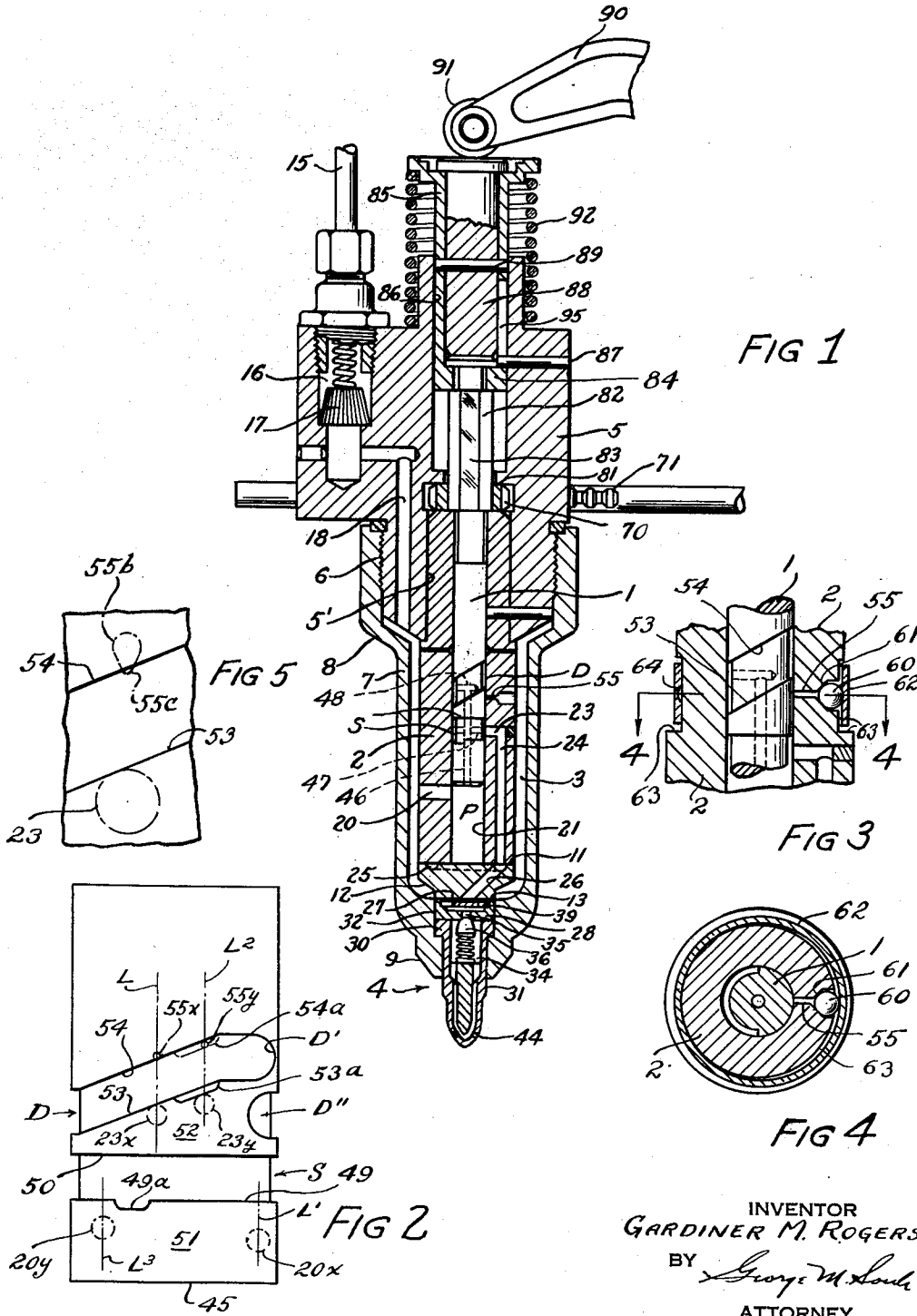
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FUEL INJECTOR

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## FUEL INJECTOR

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3 Claims. (Cl. 103—41)

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This invention relates to an improvement in fuel injectors for internal combustion engines, particularly of the diesel type.

The invention as illustrated herewith is embodied in a fuel injector pump having a plunger reciprocable in a cylinder and having valving lands separated to define a helix cavity which, in cooperation with lateral cylinder ports, is operable to vary the amount of fuel introduced during uniform length strokes of the plunger. In injector pumps of that class, pressure in the pressure chamber is usually built up to the point necessary for causing atomization of the fuel charge consequent upon the pressure chamber being sealed off from the supply port or ports. Such sealing off determines the beginning of the injection operation of the pump.

A different type of injector belonging to the same general class is made the subject matter of my application Serial No. 608,588, filed August 2, 1945, which matured into Patent No. 2,590,575 on March 25, 1952. In that injector, a controlled or regulated high pressure is built up in the pressure chamber of the pump before the pressure chamber is communicated with a delivery port or duct leading to the atomizing nozzle, and maintained thereafter during the pressure stroke of the pump. Injection starts during maintenance of that controlled or regulated pressure, upon opening of the delivery port.

It will be apparent from the above discussion of said two types of injectors that, once the injection operation starts and assuming a uniform speed of operation of the pump at a given speed setting, the pressure applied to the fuel being introduced to the atomizing nozzle remains uniform and that pressure must be more or less limited so as not to be excessive at high speeds. The usual means for limiting the pressure is the making of the total injector nozzle orifice area large enough to relieve dangerous pressure conditions. Practically speaking, that means making the individual nozzle orifices larger than will result in good atomization at low speeds. If, instead, a considerably higher degree of fuel pressure were obtainable at the start of injection only, then at idling and cranking speeds, when the active portion of the pump stroke is short and the pump motion is relatively slow, good atomization could be secured even through fairly large atomizing orifices at the beginning of each effectively shortened stroke of the pump. The principal object hereof is to provide a simple means for obtaining an extremely high momentary pressure at the start of injection and the above indicated advantage thereof.

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While the present invention is not necessarily limited to the second discussed type of injector pump, that arrangement can be very easily adapted to obtain the principal advantages of the present improvement by conversion into a positive displacement injector. The means for obtaining the preliminary excess pressure (above the desired normal) may be either a small fixed or regulatable by-pass orifice communicated with the pressure chamber during the pressure stroke, but closed to communication therewith at the start of injection or a spring controlled, pressure-regulating by-pass valve so communicated initially but rendered inoperative at the start of injection. The by-pass orifice is closed substantially to seal the pump pressure chamber in a manner to place the operating mechanism under strain, thus storing energy therein as well as in the trapped fuel, and that energy is suddenly released against fuel between the pump and the nozzle at the beginning of the injection operation of the pump. Beginning of injection operation as referred to herein may mean either commencement of a preliminary injection of a small quantity of fuel to the engine cylinder ahead of a main charge or simply the beginning of a uniform injection operation comparable to such main charge.

A further and more specific object of the present invention is to provide a fuel injector pump of the class described above in which a momentary sharp pressure rise is accomplished on the fuel in the pressure chamber sufficient to place the injector mechanism and its operating means under strain within the elastic limits of the parts at the time injection begins, thus, by storing potential energy in said parts and the fuel in the chamber, making certain of obtaining good atomization at the nozzle at each stroke of the pump at all speed settings and particularly at idling or cranking speeds.

A further object is to provide an injector of the indicated class and in which injection commences with opening of a delivery port leading to the atomizing nozzle or its equivalent, which injector will operate as a positive displacement fuel-charge-metering injector pump apparatus with results superior to those of previously known positive displacement injector pumps.

A further specific object is to provide a reciprocating fuel injector pump in which a fuel adjusting helix cavity of the pump piston or plunger causes communication between the pump pressure chamber and a delivery port to start injection and wherein a relatively restricted by-pass orifice is communicated with the pressure

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chamber prior to the opening of said delivery port but is closed by a wall portion of the helix cavity substantially simultaneously with opening of the delivery port.

A concomitant object is to provide an injector pump operative as just described, wherein the by-pass orifice is of such character that it need not be fully closed prior to cracking of the delivery port in order to store up adequate potential energy in the injector mechanism and its operating means for producing an initial high pressure spray at start of injection.

Other objects and features of the invention will become apparent from the following description of the exemplary embodiments shown by the accompanying drawing, wherein:

Fig. 1 is a longitudinal central assembly sectional view of a unit injector incorporating the present invention in one form;

Fig. 2 is a development view of the injector pump plunger metering portion;

Fig. 3 is a fragmentary sectional view corresponding to Fig. 1, showing a pressure regulating valve associated with the restricted by-pass orifice heretofore discussed;

Fig. 4 is a sectional view taken as indicated on Fig. 3; and

Fig. 5 is a fragmentary development view showing a different form of pressure regulating by-pass from that shown by Fig. 2.

Referring to Fig. 1 showing a unit type of injector pump mechanism, an engine-operated plunger piston 1 slidably fitting a pump cylinder 2, usually referred to in the art as a bushing, is reciprocated in a manner to receive fuel into a pressure chamber P of the cylinder from a fuel cavity or reservoir 3 through suitable supply port means during a suction stroke of the plunger and to deliver a charge of fuel to a combustion space of the engine through an atomizing nozzle mechanism generally shown at 4 during a pressure stroke of the plunger. The unit injector as shown herein includes a main body member 5 receiving, in a counterbore 5' of the body, a reduced diameter upper portion of the pump cylinder or bushing 2. The body 5 is threaded as at 6 for engagement with a sleeve-like nut 7 which enters the associated engine cylinder (not shown) as through the cylinder head water jacket and supports the nozzle mechanism 4 in communication with the combustion space of the cylinder. The sleeve-like nut 7 has a shoulder at 8 for engagement with a suitable gasket (not shown) around an opening in the cylinder head, and a reduced diameter portion 9 which fits a smaller bore in the cylinder head and is held therein by suitable means (not shown) which engages the body 5 and forces the shoulder 8 against the cylinder head.

The fuel cavity or reservoir 3 is formed as an annular space between the bushing 2 and sleeve-like nut 7, said space being generally sealed at its top end. The lower end face 11 of the bushing 2 abuts a coaxial base piece in the form of a recessed block 12. The base piece is one of a plurality of stacked centrally apertured injector nozzle assembly parts fixedly supported in and by the sleeve nut as is common practice.

The fuel cavity 3 is supplied with liquid fuel through a supply pipe 15 leading to a filter chamber 16 containing a filter unit 17, the outlet of the filter communicating with a supply duct 18 in the body 5 entering the upper end of the fuel cavity.

The bushing or pump cylinder block 2 has

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a single transverse bore 20 leading from the fuel supply cavity to the pressure chamber portion P of the cylinder bore 21 of the bushing just below the lower end of the plunger when the latter is in its raised position as shown in Fig. 1. The lower end of the cylinder 21 is closed by a central imperforate portion of the base piece or block 12. The single port 20 forms both a supply port and spill port cooperating with valving land and recess portions of the pump plunger. Above and (e. g.) diametrically opposite from the port 20 is a lateral fuel delivery port 23 intersecting a vertically extending or axial bore 24 which is open at its lower end only for communication with an annular trough or channel 25 on the top side of the block 12. The block 12 has an oblique duct 26 leading centrally of the assembly to a check valve chamber 27. The check valve chamber is formed in a circular valve body 28, one of the stacked parts mentioned, seated by engagement with the block 12 against an upper flanged portion 30 of a nozzle fitting 31, the lowermost of the stacked parts. The valve body 28 and said flange fit snugly in respective parts of a central through bore 32 in the lower reduced diameter portion of the sleeve nut 7.

The lower or reduced diameter main portion of the nozzle fitting 31 projects beyond the lower end of the sleeve nut. The nozzle fitting and valve body 28 have central communicating bores 34 and 35 respectively. The bore 34 contains a suitable main spring-closed check valve plug 36 which, between injection strokes of the plunger, closes the bore 35 against flow of fuel from the delivery duct toward the nozzle. In event the valve plug 36 refuses to close as by reason of accumulation of foreign matter on the valve seat, combustion pressure from the engine cylinder may force combustion gas or air back into the injector through the delivery duct; and to prevent that from occurring, the valve chamber 27 may be provided with an apertured check valve disc 39 which floats vertically in the chamber 27 and can be forced by such back pressure from the combustion space to seal against the lower flat face of the body 12 and close the delivery duct.

The mechanism for adjusting the plunger 1 for causing different amounts of fuel to be injected per stroke of the plunger may be conventional and includes, as shown, a gear 70 slidably keyed to the shank of the plunger 1 and a rack 71 in mesh with the gear and adjustable in the usual way as by a speed governor or other speed regulating means. The illustrated mechanism for reciprocating the plunger will be described later herein.

Referring further to the plunger 1, a development of which is shown by Fig. 2, the lower effective edge 45 of the plunger on the downward or pressure stroke thereof closes the supply port 20, thus establishing initial pressure in the chamber P and the helix cavities S and D which communicate constantly with the lower end of the cylinder bore through an axial bore 46 and lateral bores 47 and 48 respectively in the plunger. The cavity S (spill cavity) is defined in part of a lower control edge 49 and an upper edge 50, the cavity separating valve land or piston portions 51 and 52 of the plunger. The main delivery control helix cavity D in the land 52 is defined by an inclined lower helix edge 53 and an upper inclined control edge 54 parallel therewith. The edges 53 and 54 and the horizontal end portions D' and D'' of the delivery helix

cavity can all be formed in one operation by a single rotary milling cutter.

The delivery helix cavity preferably includes a preliminary injection helix relief portion 53a which is a very slight indentation of the land 52 adjoining the inclined edge portion 53 of the cavity at the idling and cranking speed portions only thereof. The preliminary injection helix cavity portion can of course extend along the entire inclined edge 53 if desired.

The restricted by-pass port, as shown in Figs. 1 and 2, is simply a small (e. g.) circular orifice 55 communicating the interior of the cylinder with the supply chamber 3. The by-pass port 55, although connected by the supply chamber, allows only a small quantity of fuel to escape therethrough, hence causes a rapid building up of pressure in the pressure chamber when, after closing of the supply port and before opening of the delivery port, it furnishes the only exit for fuel from the chamber. The by-pass port 55 is so located with reference to the delivery port 23 that the by-pass port closes at about the time the delivery port is opened by the helix edge 53 (or the preliminary injection helix cavity 53a) to start injection.

If the by-pass port 55 is directly above the delivery port 23 as shown, then a typical relationship of those two ports to the delivery helix cavity at the start of injection is as indicated at 23x and 55x, Fig. 2, along the line L. The corresponding position of the supply port 20 along line L' is shown at 20x on the development view, line L' being 180° removed from the common radial plane of the other two ports. Injection is terminated when the upper edge of the supply and spill port at 20x is uncovered by the descending edge 49 of the spill cavity S. A stop loop 49a is formed as part of the edge 49 for causing opening of the spill port 20 before the delivery port is opened by the portion D' of the delivery helix cavity.

The relative position of ports and plunger helix portions just described is intended as illustrative of a working speed position of the plunger with the engine operating under load.

An additional relative position of delivery port, by-pass port, spill port and plunger cavities is indicated diagrammatically in Fig. 2 at 23y, 55y (line L<sup>2</sup>) and 20y (line L<sup>3</sup>). In that relationship of ports and plunger cavities, pressure is preliminarily built up in the pressure chamber P as soon as the supply port 20 is cut off by the lower land 51 of the plunger because of the restricted nature of the by-pass port 55 as already explained. Preliminary injection starts when the upper edge of the delivery port, at 23y, is uncovered by the preliminary injection helix relief 53a and if the helix edge 54 is as shown in full lines, then the by-pass at 55y will still be open and no pronounced energy storing effect thereof will obtain in connection with the preliminary injection operation. Still assuming the full line illustration of helix edge 54, when the top edge of the delivery port 23 is uncovered by the main portion of the helix edge 53, the pressure control port 55 will be closed substantially simultaneously with commencement of main injection or slightly earlier so that a sufficiently sharp pressure rise in the pump pressure chamber P occurs to place the injector plunger and its operating mechanism under pronounced energy-storing strain.

An alternative preliminary injection helix arrangement is illustrated in Fig. 2 in broken lines.

The upper inclined edge 54 of the cavity D, for a distance coextensive with the preliminary helix relief cavity 53a, may be brought downwardly as illustrated at 54a. In that event, the by-pass port 55 will obviously be closed in the position 55y thereof as the delivery port 23 is opened for communication with the preliminary injection relief zone 53a of the delivery helix 53, and the full energy-storing effects of the port and helix relationships will obtain at preliminary injection.

Figs. 3 and 4 show the employment of a resiliently operated preliminary-pressure-establishing valve for the restricted by-pass aperture 55. The valve, as shown, is in the form of a metal ball 60 seated against the bottom of a counterbore 61 from which the orifice 55 extends inwardly into communication with the pump cylinder. The ball is normally held against the seat or bottom of the counterbore by an annular spring 62 surrounding the bushing 2 and operating in a suitable channeled guide 53 formed around the bushing. The spring is held somewhat eccentric to the guide by contact with the ball, and an inner peripheral smooth groove 64 is preferably formed in the spring for contact with the ball so as to hold the edges of the spring out of contact with the side walls of the channel, whereby the ring is free to turn progressively about the bushing. The controlled pressure established by the valve arrangement described depends upon the operating characteristics of the spring as more fully explained in my copending application.

The pressure control port does not have to be completely closed by the helix edge 54 or 54a when the delivery port opens in order to place the main parts of the injector unit and the operating mechanism therefor on the engine momentarily under pronounced strain. When a circular port is closed by a straight edge, the pressure in the space closed thereby necessarily rises very rapidly because of the manner in which the effective outlet opening diminishes. Such rapid acceleration characteristic may be altered by any suitable means. For example, as shown by Fig. 5, the entrance to the restricted by-pass port 55b is so shaped as by having an elongated and narrowed portion 55c that the final closing by the helix edge 54 will be the same as though a much smaller but circular pressure control port had been used. Alternatively and not requiring illustration, the edge of the port presented in closing relation to the helix edge 54 may be widened so that the rapidly rising pressure characteristic of a round opening cooperating with a straight closing edge would not obtain. In that event, it would be practically necessary to have the control by-pass port close immediately before the instant the delivery port opens in order safely to accomplish storing of energy in the mechanism as herein described.

For adjusting and operating the plunger 1, a conventional arrangement is shown. Fuel adjustment comprises the adjusting gear 70 and rack 71. The gear is supported between the top end of the bushing 2 and a shoulder 81 within the body. The gear is, in effect, splined to the upper end portion 82 of the plunger at a flat surface portion 83 thereof. For reciprocating the plunger, the top end thereof is engaged by an intumed flange 84 of a follower guide 85 slidable in a smooth bore 86 of the body 5 and held against rotation by a removable key pin 87 on said body 5, which pin also acts as a limit stop for the follower guide in a well known manner. Above the somewhat enlarged head portion of the plunger

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is a follower or tappet piece 88 secured to the follower as by a cross pin 89. The engine rocker arm 90, through a suitable roller 91, operates the plunger against the opposing force of a plunger return spring 92 around the follower and supported against the top face of the body 5.

I claim:

1. In a fuel injector pump, a valving and pumping plunger and a pump cylinder cooperating therewith to form a pressure chamber having inlet and outlet ports, means for reciprocating the plunger, a fuel delivery duct in the cylinder forming the principal outlet port and which is opened to the pressure chamber by a valving portion of the plunger during the pressure stroke thereof to start injection, a pressure-control, restricted fuel by-pass orifice in the cylinder wall communicating with the pressure chamber by another valving portion of the plunger, said second valving portion, operating immediately before the first mentioned valving portion operates to start injections substantially to seal the chamber against outlet of fuel therefrom whereby to produce a sharply increasing energy-storing pressure in the chamber.

2. A variable delivery fuel injector pump comprising a valving and pumping plunger and a pump cylinder cooperating therewith to form a pressure chamber having inlet and outlet ports, means for reciprocating the plunger, and a fuel delivery duct in the cylinder forming the principal outlet port and which is opened to the pressure chamber by a valving portion of the plunger during the pressure stroke thereof to start injection, combined with a relatively restricted pressure control fuel by-pass orifice in the cylinder wall communicating with the pressure chamber prior to start of injection and arranged to be closed by another valving portion of the plunger immediately before injection is started substantially to seal the chamber against outlet of fuel therefrom and produce thereby a sharply increasing pressure in the chamber.

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3. An engine fuel injector pump of the controlled pressure type and comprising a reciprocable valving plunger positively connected to a reciprocating mechanism of the engine for performance of a pressure stroke and having means for returning the plunger to effect its charging stroke, the plunger having valving cavity means providing axially spaced valving edges and the cylinder having a fuel delivery port and a restricted pressure control port respectively controlled by said edges, the pump having plunger operated valve port means connected with a pressure space between the plunger and cylinder to enable charging of the pump with fuel on the charging stroke; characterized in that said pressure control and delivery ports and their cooperating valving edges are so interrelated axially of the plunger that the pressure control port is opened during an initial part of the pressure stroke and then is sufficiently closed by the associated valving edge just prior to opening of the delivery port by its valving edge that substantially trapped fuel in the pressure space places said plunger and reciprocating mechanism under pronounced strain.

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