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FUEL INJECTION MEANS FOR INTERNAL COMBUSTION ENGINES

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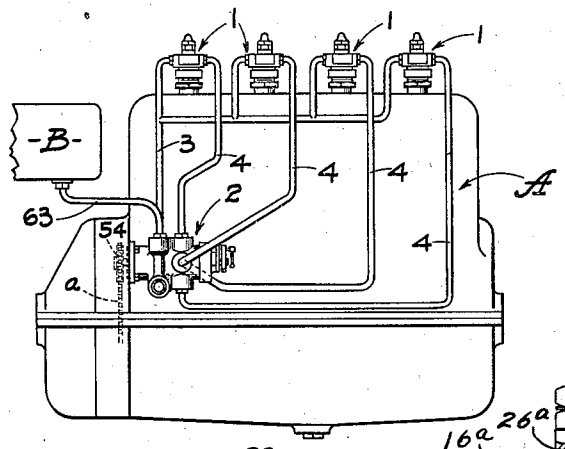



FIG. 1.

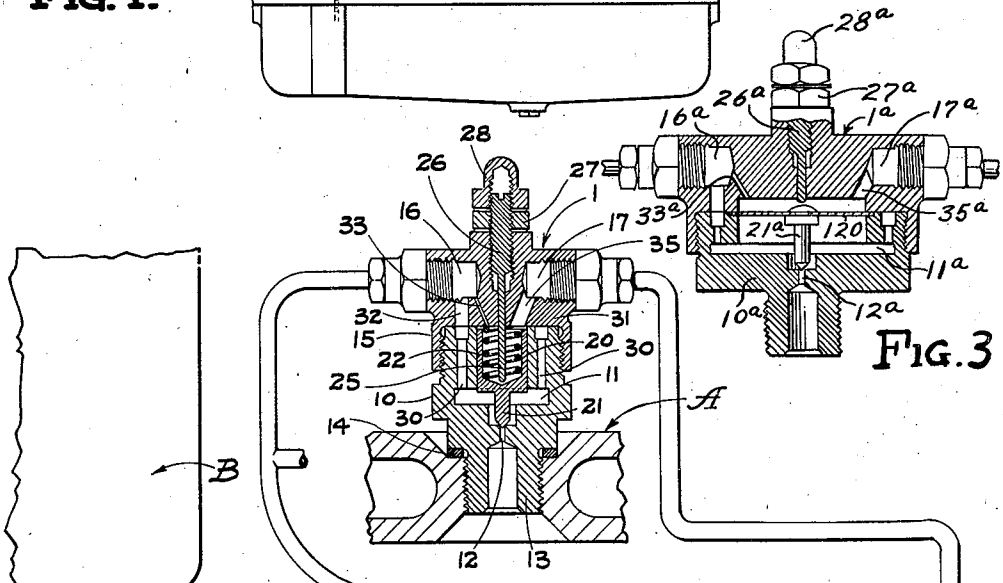



FIG. 3

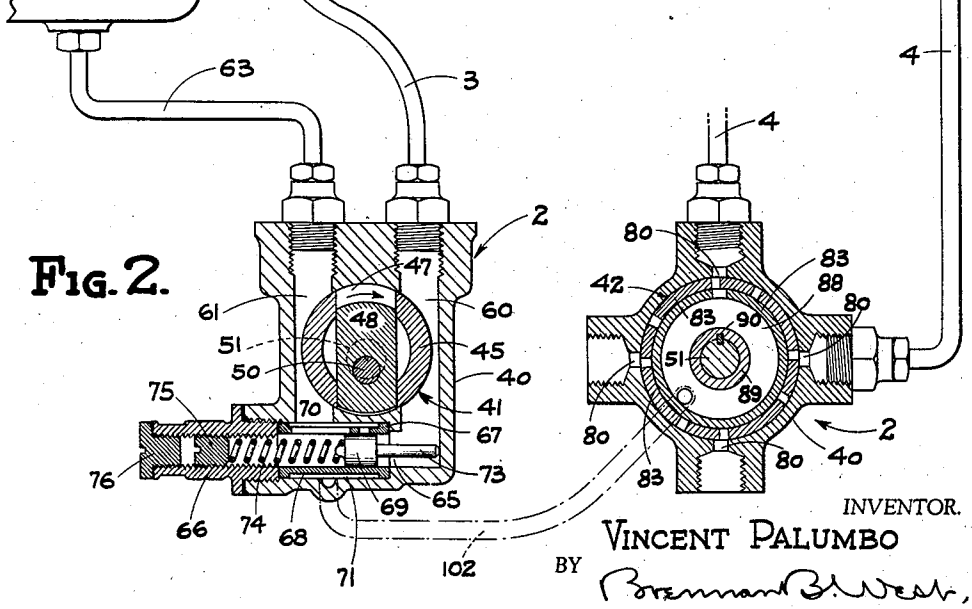



FIG. 2.

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## FUEL INJECTION MEANS FOR INTERNAL COMBUSTION ENGINES

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6 Claims. (Cl. 299—107.2)

This invention relates to improved fuel injection means for internal combustion engines.

Among the objects of the invention are to provide a fuel injector that is relatively simple yet highly efficient and wherein the valve that governs the fuel injection is actuated and controlled by fuel pressure; to provide an injector of the aforesaid character in which the valve is biased toward closed position and is operated by a pressure fluid actuator means that may consist of a piston, a diaphragm, or the equivalent, and whose opposite sides are exposed, respectively, to a valve opening working space and to a valve closing working space, the first mentioned of which spaces, along with the fuel passage, is constantly in free communication with a high pressure part of the fuel system, while the second mentioned space is in constant but restrained communication through a restricted passageway or bleeder port with the same high pressure part of the system thereby to permit attainment of a balanced pressure on both sides of the actuator means so as to allow the valve to close, the pressure in the valve closing working space being subject to intermittent relief; and to provide a fuel injector of the foregoing nature that is intended to be individual to an engine cylinder and which includes an adjustment whereby the action of its valve may be regulated according to the peculiarities of the cylinder whose fuel supply it controls to the end that, in a multiple cylinder engine, maximum smoothness of operation and efficiency may be realized.

Objects additional to the foregoing will appear as I proceed to describe the invention in detail by reference to the accompanying drawing wherein like reference characters designate corresponding parts throughout the several views. The detailed description, however, is not to be taken as limiting the invention to the structural features disclosed further than required by the terms of the claims appended hereto.

In the drawing, Fig. 1 represents a side elevation of a multiple cylinder internal combustion engine, each cylinder of which is equipped with my improved fuel injector; Fig. 2 is a diagrammatic representation of a system wherein the injector, a pump and a selector-relief valve are shown in section; and Fig. 3 shows a modified form of the injector in central section.

For illustrative purposes I have shown my fuel injection means in association with a multiple cylinder engine, the same being of the four-cycle type. It will be understood that in other respects the engine may be of standard character having the usual ignition system, valve controlled inlet and exhaust ports, and means for supplying air in lieu of the ordinary gaseous mixture to the cylinders, such being omitted from the drawing. Communicating with each cylinder of the engine A is an injector designated generally by the reference numeral 1 and later to be described in detail. Mounted on a part of the engine is a unit 2 which, incidentally, incorporates a selector-relief valve, a throttle, and a pump. The mechanism of this unit is driven from a moving part of the engine, for example, the crank shaft, through a chain *a* or other means. The high pressure side of the pump communicates through a conduit 3 and its several branches with the supply sides or inlet passageways, and, as will later appear, with both valve working spaces, of the injectors, while conduits 4 establish communication between the relief sides or passageways of the injectors, and with their valve closing working spaces, and the distributor ports of the selector-relief valve.

The injector 1, shown in detail in Fig. 2, comprises a body 10 enclosing a chamber 11 which I may term the valve opening working space and that is adapted to communicate through a relatively small outlet orifice or passage 12 with the interior of a cylinder of the engine A, the body 10 being shown as counterbored above and below said orifice. The orifice is shown as axial of an externally threaded boss 13 that is adapted to be screwed into a threaded aperture in the wall of the engine cylinder in much the manner of a spark plug, the joint between the body and wall being sealed by a gasket 14 that is compressed between a shoulder on the body and the adjacent part of the engine. Threaded onto the upper end of the body 10 is a cap 15 having an inlet passageway 16 and a relief passageway 17. Operating within a central axial bore or cylindrical chamber of the body 10 is an actuator means 20. In certain ones of the appended claims this actuator means is termed "pressure-responsive means" and, in the embodiment at present under consideration, the same is in the form of an open top hollow piston that carries at its lower closed end a needle-point valve 21 shown as integral with the actuator means. The actuator means is biased in a direction to engage the valve with a seat surrounding the inner end of the orifice 12 by a relatively light spring 22 that is confined between a part of the cap 15 and the bottom wall of the cavity of the actuator means 20. The extent to which the valve 21 may open is determined by a stop 25 formed by a pin-like extension of a screw 26 that extends through and

is threaded in the cap 15 and is adapted to be secured in any adjusted position by a lock nut 27. Applied to the screw above said nut is a sealing cap 28. The previously mentioned valve opening working space or chamber 11 communicates through holes 30 with an annular recess 31 in the top of the body 10, and a port 32 establishes free communication between the recess 31 and the inlet passageway 16 of the cap. Restrained communication (as distinguished from free communication above) between said passageway 16 and the space within the actuator means 20, which space I term the valve closing working space of the injector, is maintained through a restricted passage or bleeder port 33. Also communicating freely with said valve closing working space through a port 35 is the relief passageway 17 of the cap.

It will be apparent from the foregoing description that the injector valve 21, biased toward closed position by the spring 22, will remain closed as long as the pressure of the fuel in the valve opening and closing working spaces remains balanced, and that said valve will open the instant the pressure in the valve closing working space is relieved, this condition being brought about by permitting the pressure fluid (liquid fuel under pressure) to escape from the valve closing working space more freely than it can enter said space through the restricted passage or bleeder port 33.

I shall next describe the unit 2 which, as previously brought out, includes the pump, throttle and selector-relief valve. The casing 40 of said unit shown in section in two different planes in the diagram of Fig. 2 encloses a pump chamber 41, and a valve chamber 42. A pump rotor 45 has a working fit in the pump chamber 41, and extending diametrically through the rotor is a bore 47. A pump piston 48 is reciprocable within said bore, and has a bearing aperture within which a crank pin 50 operates, the latter being carried by a crankshaft 51. Attention is called to the fact that the axis of the crankshaft 51 is offset from that of the pump rotor, which fact is responsible for the extent of reciprocation of the pump piston 48, as will be obvious. Extending from and centrally of the outer end of the pump rotor is a stub shaft, having non-rotatably mounted on its outer end a gear 54, shown in Fig. 1 in dot-and-dash lines. It is the gear 54 wherewith the previously mentioned chain *a* engages to drive the pump and the selector-relief valve.

As appears from the transverse sectional view of the pump, which view constitutes a part of Fig. 2, the cylindrical portion of the pump chamber 41 wherein the rotor 45 operates opens into two compartments 60 and 61, the one designated 60 being the high pressure compartment, and the other, 61, being the lower pressure compartment. The former compartment communicates with the inlet passageway 16 of each of the injectors 1 through the branched conduit 3, while the latter compartment communicates through a conduit 63 with a source of liquid fuel supply, shown as a fuel tank B. To effect the result just described, the pump rotor 45 rotates in the direction indicated by the arrow associated with the rotor in Fig. 2.

The compartments 60 and 61 are adapted to communicate through a by-pass passageway 65 adjacent the bottom of the casing. Screwed into an extension of said passageway that opens through one side of the casing is the end of an internally threaded sleeve-like fitting 66; and shown as clamped between the inner end of said fitting and a shoulder 67 that surrounds the remote end of the by-pass passageway 65 is a thimble 68 within which a plunger valve 69 is adapted to reciprocate and control one or more ports 70 in the wall of the thimble which open into the low pressure compartment 61. As a means of providing free communication between the ports 70 and said chamber, regardless of the angular position of the thimble within the passageway, the thimble is turned down between its ends to a diameter less than that of the passageway, as indicated at 71 in Fig. 2. The plunger valve 69 is urged to closed position, in which it is stopped by the engagement of an extension 73 thereof with an opposed wall portion of the compartment 60, by a spring 74 that is compressed between the plunger valve and an adjusting screw 75 that operates within the threaded bore of the fitting 66, the outer end of which bore is closed by a screw plug 76.

It is apparent from the foregoing description that, as the pump rotor 45 is turned in the direction indicated by the arrow in Fig. 2, the pump piston 48 will be reciprocated within the bore 47 by reason of the eccentricity of the crank shaft 51 with respect to the axis of rotation of the pump rotor. In further explanation of this action it may be pointed out that as the rotor turns it will propel the crank pin 50 about an orbit concentric to the axis of the crankshaft, and since the shaft is offset with respect to the axis of the pump rotor, the pump piston will be caused to reciprocate within the pump bore.

As the pressure builds up within the compartment 60 above the resistance of the spring 74, it will force the plunger valve 69 along the bore of the thimble 68 until the adjacent port 70 is opened thereby to cause the fluid to circulate within the pump at the pressure determined by the strength of the spring 74, and as this factor may be varied by the adjustment of the screw 75, so may the maximum pressure of the fluid within the high pressure part of the system.

I shall now briefly describe the selector-relief valve. As shown in Fig. 2, a plurality of distributor ports 80 (four in the present case) open through the peripheral wall of the valve chamber 42. Said ports are shown as spaced 90° apart about said wall and each communicates through one of the conduits 4 with the relief passageway 17 of one of the injectors.

A suitable throttle is provided which involves segmental elements 83 that are disposed in spaced relation to one another about the peripheral wall of the valve chamber 42 and alternate ones thereof are stationary. One edge of each of the stationary elements 83 is disposed in substantially radial alignment with one side of one of the distributor ports 80. The other elements 83 are movable in unison, by suitable means (not shown, and constituting no part of the present invention) toward and from the stationary elements so as to alter the width of the gates constituted of the spaces between adjacent elements that register with the distributor ports 80.

The cylindrical body 88 of the selector-relief valve has a working fit within the segmental elements 83 of the throttle. The body 88 has a hub 89 mounted on the shaft 51 and held against turning with respect thereto by suitable means, as a key 90. In the peripheral wall of the valve body is a port 91 that sweeps past the gates of

the throttle that control the distributor ports 80 as the valve member is rotated by the shaft 51. The valve chamber 42—or, more accurately, the space within the valve body 88—communicates through a passageway 102, with the low pressure compartment 61 of the pump by way of the bypass passageway 65.

The manner in which the pump functions to maintain high pressure of the fuel within the compartment 60 thereof as well as in the portions of the system in open communication therewith, has already been described. It is obvious from the previous description that the fuel is constantly maintained at high pressure within the valve opening working space or chamber 11 of each of the injectors, where it has access to the adjacent side of the actuator means 20 of the valve 21, and such high pressure is also permitted to build up on the opposite side of the actuator means, i. e. in the valve closing working space, through the relatively small bleeder port 33. Under these conditions the valve is held closed by the spring 20. As the valve body 88 of the selector-relief valve rotates it will intermittently establish communication between the valve closing working space of each of the injectors 1 and the low pressure side of the system, it being remembered that the space within the valve body 88 communicates through the port 102 with the low pressure compartment 61 of the pump. The extent to which the valve 21 of each injector is allowed to open is determined by the adjustment of the stop 25, as previously explained; and the time the valve remains open is determined by the duration of the period of relief of the valve closing working space of the injector, the latter depending upon the adjustment of the throttle elements 83.

In the modified form of the injector, shown in Fig. 3, a diaphragm 120 constitutes the actuator means of the valve $21^a$ corresponding to the valve 21 of the previously described form. The remaining corresponding parts of the two forms are designated by like reference numerals, those associated with the modification shown in Fig. 3 being augmented by the exponent *a*. In the case of the modification, the resiliency of the diaphragm 120 is relied upon to close the valve $21^a$, although, if desired, a spring may be used to urge the diaphragm in a direction to close the valve.

Having thus described my invention, what I claim is:

1. A fuel injector for internal combustion engines comprising a casing made up of two parts engaged in face-to-face relation, a recess in each of the mating faces of said parts, that of one part constituting a valve opening working space and that of the other a valve closing working space, a diaphragm disposed between the mating faces of said parts and separating said spaces, a fuel passage in the part having the valve opening working space that leads from said space and through which passage fuel is adapted to be delivered to the engine, a valve carried by the diaphragm for controlling the flow of fuel through said passage, means for connecting the two parts of the casing together, a fuel receiving passageway in the casing, the same having two branches, one of said branches communicating with the valve opening working space and the other branch, which is of much smaller flow capacity than the first mentioned branch, communicating with the valve closing working space, and a relief passageway in the casing, the same being of much larger flow capacity than the second mentioned branch and communicating with the valve closing working space.

2. A fuel injector for internal combustion engines comprising a casing provided with an inlet passageway and a relief passageway and a valve-controlled outlet orifice, a valve controlling said outlet orifice, pressure-responsive means additional to said valve for operating the latter, there being ports leading from the inlet and relief passageways to one side of the pressure-responsive means, the port leading from the relief passageway being relatively much larger in cross sectional area than the port leading from the inlet passageway, there being a working space within said casing on the opposite side of said pressure-responsive means, and a port leading from said inlet passageway to said working space and having a greater cross sectional area than that of the port leading from the inlet passageway to the first mentioned side of said pressure-responsive means.

3. In a fuel injector for internal combustion engines, the combination defined by claim 2 plus: means for supplying fuel under constant pressure to the fuel inlet passageway, and means for periodically relieving the pressure in the relief passageway, the pressure-responsive means being so arranged with respect to the outlet orifice that when the pressure on the side of said pressure-responsive means opposite said working space is relieved by said periodically operated pressure relief means, the valve is opened, and when the pressure is reestablished on said side of the pressure-responsive means, the valve is closed.

4. A fuel injector for internal combustion engines, the same comprising a casing, a fuel passage in the casing for the delivery of fuel to the engine, a valve opening working space enclosed by the casing and from which said passage leads, pressure-responsive means movable within the casing and having one of its sides exposed to said space, a valve fixedly attached to and movable with said pressure-responsive means for controlling the aforesaid fuel passage, a valve closing working space within the casing to which the opposite side of said pressure-responsive means is exposed, an inlet passageway in the casing that freely and constantly communicates with the valve opening working space, a bleeder port that is relatively much more restricted than said passageway through which said passageway constantly communicates with the valve closing working space, a relief passageway in the casing that is relatively much larger in cross sectional area than said bleeder port and that communicates freely and constantly with the valve closing working space, means for supplying fuel under constant pressure to the inlet passageway, and means for periodically relieving the pressure in the relief passageway, the pressure-responsive means being so arranged with respect to the fuel passage that when the pressure in the valve closing working space is relieved by said periodically operated pressure-relief means the valve is opened, and when the pressure is re-established in the valve closing working space, the valve is closed.

5. In a fuel injector for internal combustion engines, the combination defined by claim 4, plus: a spring serving to urge said valve toward closed position.

6. A fuel injector for internal combustion engines comprising a casing made up of two parts engaged in face-to-face relation, a cylindrical

chamber in the first of said parts that opens through the face thereof arranged for engagement with the second part, a valve opening working space in said first part into which the cylindrical chamber opens, a fuel passage in said first part leading from said space, a piston operating within the cylindrical chamber, a valve carried by the piston for controlling said fuel passage, means for connecting the two parts of the casing together, a fuel inlet passageway in the casing having two branches, one of said branches communicating with the valve opening working space and the other branch communicating with the cylindrical chamber on the side of the piston remote from said space, the first mentioned branch being relatively much larger in cross sectional area than the second mentioned branch, a relief passageway in the casing, the same being relatively much larger in cross sectional area than the said second mentioned branch of the inlet passageway and communicating with the same part of the cylindrical chamber as said second mentioned branch, means for supplying fuel under constant pressure to the fuel inlet passageway, and means for periodically relieving the pressure in the relief passageway, the piston being so arranged with respect to said fuel passage that when the pressure in the cylindrical chamber is relieved by said periodically operated pressure relief means, the valve is opened, and when the pressure is reestablished in said chamber, the valve is closed.

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