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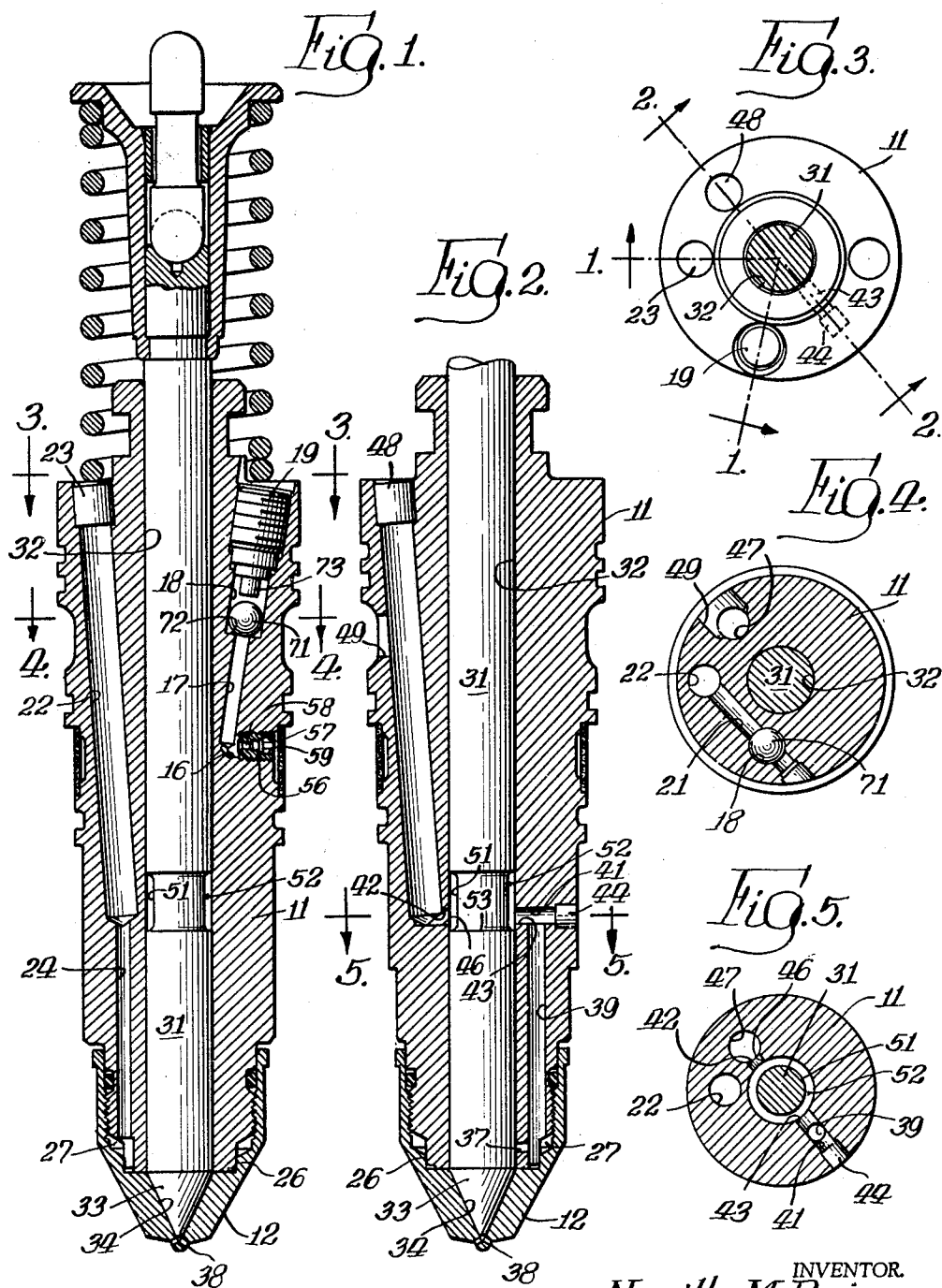
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3,146,949

FUEL INJECTOR

Filed Oct. 16, 1961

2 Sheets-Sheet 1



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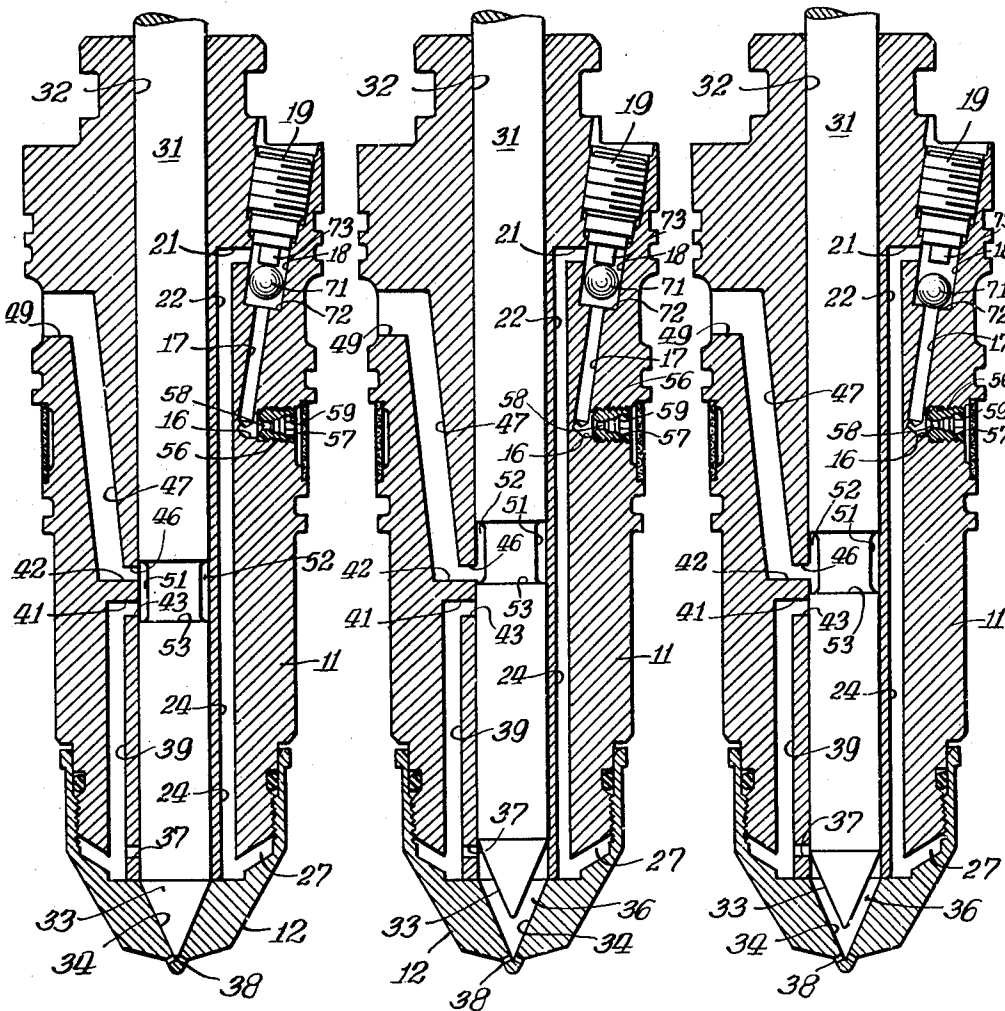
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2 Sheets-Sheet 2

Fig. 6.

Fig. 7.

Fig. 8.



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1

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FUEL INJECTOR

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This invention relates generally to means for supplying fuel to the cylinders of a multi-cylinder internal combustion engine, and more particularly to a fuel injector for a diesel engine.

Accordingly, it is a general object of the invention to provide a novel fuel injector for supplying accurately metered quantities of fuel to the respective cylinders of a multi-cylinder diesel-type internal combustion engine.

A specific object is to provide a novel fuel injector construction for use in a set of injectors in an internal combustion engine of the foregoing character, in which the injectors receive fuel from a common supply line and in which each injector is so constructed as to avoid improper functioning of the other injectors.

A further object is to provide a novel fuel injector construction which not only avoids improper functioning of the other injectors of the engine but also permits all injectors of the engine to function equally.

Other objects and advantages will become apparent from the following description taken in connection with the accompanying drawings in which:

FIGURE 1 is a longitudinal sectional view, taken along the line 1-1 of FIG. 3, and showing a fuel injector embodying the features of the present invention;

FIG. 2 is a view similar to FIG. 1, but taken along the line 2-2 of FIG. 3;

FIG. 3 is a transverse sectional view taken along the line 3-3 of FIG. 1;

FIG. 4 is another transverse sectional view taken along the line 4-4 of FIG. 1;

FIG. 5 is a transverse sectional view taken along the line 5-5 of FIG. 2; and

FIGS. 6, 7 and 8 are a series of semi-diagrammatic longitudinal sectional views of the injector, with the various passages thereof shown in the same plane for clarity, and showing the parts of the injector in various positions.

Briefly described, the present invention relates to a novel fuel injector construction for use in a fuel supply system for a multi-cylinder internal combustion engine of the diesel type. Such a system is disclosed and claimed in my copending application Serial No. 72,440, filed November 29, 1960. An injector of the character contemplated herein has an elongated body and a fuel passage there-through for receiving a circulating flow of fuel. The fuel passage includes supply, intermediate, and return portions, and a feed hole connects the intermediate portion with a fuel chamber in the body adjacent the nozzle, to which metered quantities of fuel are supplied for injection into the cylinder. A reciprocally mounted plunger is provided in the injector body for injecting fuel from the fuel chamber into the cylinder of the engine, the plunger being movable in timed relation with the speed of the engine. Movement of the plunger also controls the circulating flow of fuel through the fuel passage and controls, in part, the quantity of fuel injected during the injection stroke of the plunger. Fuel is delivered under pressure to the inlet end of the supply portion of the fuel supply passage of each injector from a common supply line, the supply line being connected to a fuel supply unit or source of fuel under pressure. A portion of the fuel supplied to the injector is returned to the low-pressure side of the fuel supply unit by a common return line connected to the return portion of the fuel passage of each injector.

2

The fuel injector of the present invention includes a novel means for determining the amount of fuel entering the chamber in the injector for injection into the associated cylinder during each injection stroke of the plunger and for preventing passage of a pressure wave, resulting from combustion in the cylinder, into the common fuel supply and return lines to thereby prevent variations in the quantity of fuel injected by the other injectors.

With the present injector, fuel supplied thereto flows through the entire passage in the injector to the return line to purge the passage of air. The plunger then closes the return portion of the passage and flow control means in the supply passage, upstream of the feed hole controls the flow of fuel through the feed hole when the latter is open. Arresting means in the supply passage between the flow control means and feed hole prevents passage into the common supply line of a pressure wave resulting from the pressure in the cylinder. Thus, the provision of the arresting means effectively isolates each injector from the other injectors of the engine so that a pressure wave in any particular injector will not pass through the injector and into the common supply line to adversely affect the metering of fuel by other injectors.

The fuel injector of the present invention, as illustrated in FIGS. 1 and 2, comprises an elongated cylindrical body 11 having a nozzle 12 in the form of a tapered cup threaded onto the lower end thereof. The body 11 and cup 12 are adapted to be mounted in a vertical bore in the engine cylinder head (not shown). The body 11, in this instance, includes a series of concentric, varying diameter portions which engage complementally sized portions of the bore in the cylinder head to thus locate the injector in the head. A pair of vertically spaced longitudinal ducts are provided in the cylinder head, each intersecting the bores for all injectors at predetermined points, thus providing the common fuel supply and return lines for all injectors.

Each injector has a fuel passage therethrough, which in this instance, includes a supply portion, an intermediate portion and a return portion. Thus, as shown in FIG. 1, the supply portion of the fuel passage comprises a transverse bore 16 in the body 11 communicating with the common supply line in the cylinder head, the bore 16 being intersected at its inner end by a downwardly extending bore 17 from the upper end of the body 11. The upper end of the bore 17 is counterbored as at 18, the upper end thereof being closed by a plug 19. A second transverse bore 21 (FIG. 4) has one end thereof intersecting the counterbore 18 below the plug 19, and the other end of the bore 21 intersects a second downwardly extending bore 22 (FIGS. 1 and 4) in the body 11. The upper end of the bore 22 is plugged as at 23. The lower end of the bore 22 connects with a smaller bore 24 which extends downwardly to the lower end of the body 11. Thus, the supply portion of the fuel passage includes the transverse bore 16, the bore 17 and counterbore 18, the connecting transverse bore 21, the bore 22 and the connecting smaller bore 24. The lower end of the body 11 includes a reduced section 26 which, together with the nozzle 12, defines an annular space 27 therebetween, forming the intermediate portion of the fuel passage. The lower end of the bore 24 opens into the intermediate portion 27.

In order to define a fuel chamber within the injector nozzle 12 from which fuel may be cyclically expelled into the cylinder, the injector includes an engine-operated elongated plunger 31 which is mounted for reciprocable movement in a central longitudinal bore 32 in the body 11. The lower end, indicated at 33, of the plunger 31 is tapered to fit a complementally tapered internal surface 34 in the nozzle 12 when the plunger is in its full down position as illustrated in FIGS. 1 and 2. Thus, when the plunger is

3

raised, as in FIGS. 7 and 8, a fuel chamber 36 is formed between the tapered lower end 33 of the plunger 31 and the tapered internal surface 34 of the nozzle 12.

In order to connect the intermediate portion 27 with the chamber 36, the injector body 11 is provided with a small transverse bore or feed hole 37 (FIG. 2). Thus, fuel flowing downwardly in the bore 24 and into the intermediate portion 27 may enter the fuel chamber 36 through the feed hole 37 when the latter is opened by upward movement of the plunger 31 in its bore 32. When the plunger 33 is in a full down position, as illustrated in FIGS. 1, 2 and 6, the tapered lower end 33 completely fills the chamber 36 so as to reduce its volume to zero. Any fuel in the chamber 36 will thus be injected through a plurality of small diverging holes or openings 38 at the lower end of the nozzle 12. The holes or openings 38 thus comprise a discharge outlet for fuel in the chamber 36.

In order to permit a circulating flow of fuel through the fuel passage in the injector to purge the passage of air or gaseous combustion products so that a solid flow of fuel is supplied to the chamber 36, a return portion of the fuel passage is provided. Such return portion in this instance comprises a longitudinal bore 39 in the body 11, which has its lower end connected to the intermediate portion 27 and at its upper end intersecting a transverse bore in the body 11. The transverse bore intersects and extends across the plunger bore 32 and thus comprises two sections, namely, sections 41 and 42. The first section 41 has its inner end 43 registering with the plunger bore 32 and its outer end plugged as at 44. The second section 42 has its inner end 46 registering with the plunger bore 32 and its outer end connected to the lower end of a second longitudinal bore 47 in the body 11. The upper end of the bore 47 is closed by a plug 48, and a short transverse passage 49 in the body 11 intersects the bore 47 intermediate its length and communicates with the common return line in the cylinder head.

In order to periodically connect the adjacent ends 43 and 46 of the sections 41 and 42 to complete the return portion of the fuel passage, the plunger 31 includes a portion 51 of reduced diameter defining an annular space 52 within the bore 32. Thus, when the annular space 52 registers with the adjacent ends 43 and 46 of the transverse bore, the annular space 52 completes the return portion of the fuel passage and a flow of fuel may be obtained therethrough. The return portion thus comprises the longitudinal bore 39, the sections 41 and 42, of the transverse bore, the annular space 52, the longitudinal bore 47, and the short transverse bore 49.

The position of the reduced portion 51 on the plunger 31 is such that the annular space 52 is brought into registry with the adjacent ends 43 and 46 of the sections 41 and 42, when the plunger 31 is in its full down position, as illustrated in FIGS. 2 and 6. A shoulder 53, formed by the reduced portion 51 at the lower end thereof, moves across the ends 43 and 46 of the sections 41 and 42 on upward movement of the plunger 31 to close them prior to the time that the feed hole 37 is opened upon continued upward movement of the plunger 31.

In order to supply a metered quantity of fuel for injection into the cylinder through the feed hole 37 when the latter is open and the return portion of the passage is closed, flow control means is provided, which in the present instance is located in the supply portion of the fuel passage at the inlet 16. Such flow control means comprises orifice means in the form of a plug 56 (FIG. 1) threaded into a counterbore 57 in the inlet 16, the plug 56 being provided with a metering orifice 58 therethrough for metering the fuel supplied to the chamber 27 and feed hole 47. The plug 56 includes a socket portion 59 adapted to receive a tool which facilitates installation or removal thereof, whereby another plug having a slightly different size orifice 58 may be employed to balance the injector with the other injectors of the engine.

4

With the foregoing construction, it will be apparent that accurately metered quantities of fuel will be injected into the cylinder during each stroke of the plunger 31 of the injector since an amount of fuel equivalent to that metered by the orifice 58 in the plug 56 will pass through the feed hole 37 into the chamber 36, the return portion of the passage being closed while metering occurs.

Because of the fact that, when the feed hole 37 is open, the supply and intermediate portions are in communication with the fuel supply line, it will be apparent that a pressure wave from the associated cylinder may be transmitted through the intermediate and supply portions to the common supply line. The presence of such pressure waves in the common supply line may adversely affect the metering of fuel in adjacent injectors. While the plug 56 with its orifice 58 to a great extent will prevent such a pressure wave from passing therethrough, the present fuel injector includes additional means for positively preventing passage of such a pressure wave from the injector into the common supply line. Such means in this instance comprises arresting means in the form of a check valve mounted in the supply portion of the fuel passage of the injector, downstream of the plug 56. The valve in this instance comprises a ball 71 mounted in the counterbore 18 and adapted to seat on a shoulder 72 defined by the counterbore 18. The ball 71 will seat on the shoulder on travel of a pressure wave from the intermediate portion to close the bore 17. In order to prevent the ball 71 from obstructing the transverse bore 21, the plug 19 includes a stop 73 which limits the amount of travel of the ball 71 when the latter is unseated.

Thus, as will be apparent from FIG. 7, during the metering portion of an injection cycle, the return portion of the fuel passage is closed by movement of the reduced portion 51 of the plunger out of registry with the ends 43 and 46 of the first and second sections 41 and 42. Thus, the common return line which is connected to each injector, is closed to the other parts of the fuel passage. Consequently, a pressure wave from the fuel chamber 36 cannot pass into the return portion of the fuel passage, and, due to the presence of the ball 71, it is arrested before reaching the common fuel supply line. During metering of fuel by the plug 56, the return portion is closed so that an amount of fuel equivalent to that metered by the plug 56 will pass through the feed hole 37 and into the chamber 36 for injection into the cylinder.

I claim:

1. An injector for injecting fuel into a cylinder of a multi-cylinder internal combustion engine, comprising an injector body including a nozzle and having a fuel passage therethrough, said fuel passage being adapted to be connected at one end to a fuel supply line and at its other end to a fuel return line to provide a flow of fuel therethrough, said body also having a plunger bore therein, a reciprocable plunger mounted in said bore, said plunger and said bore having coacting means defining a portion of the fuel return, the lower end of said plunger and said nozzle together defining a fuel chamber separate from said fuel passage, said body also having a feed hole connecting said fuel passage with said fuel chamber adjacent the upper end of said chamber and adapted to be opened and closed by a portion of said plunger adjacent the lower end thereof, said plunger conforming in cross-section to said chamber and serving to evacuate said chamber when moving into closed position to force the contents of said chamber out through said nozzle, said plunger including a single means forming a part of said coacting means and located on the plunger above the lower end thereof, said single means closing said fuel return passage at said coacting means between said feed hole and said other end of said fuel passage when said plunger opens said feed hole, and opening said fuel passage at said coacting means between said feed hole and said other end of said fuel passage when said feed hole is closed by the plunger, and flow control means in said

5

fuel passage upstream of said feed hole for controlling the flow of fuel therethrough when said plunger both closes said fuel passage at said point and opens said feed hole to permit an amount of fuel to flow through said feed hole equivalent to that passing through said flow control means.

2. An injector according to claim 1 including arresting means in said fuel passage upstream of said feed hole for preventing a pressure wave from said chamber from passing into said supply line when said plunger opens said feed hole and closes said fuel passage between said feed hole and said other end of said fuel passage.

3. An injector according to claim 2, including flow control means mounted in said fuel passage upstream of said feed hole for controlling the flow of fuel through said feed hole when said plunger closes said fuel passage between said feed hole and said other end of said fuel passage and opens said feed hole to permit an amount of fuel to flow through said feed hole equivalent to that passing through said flow control means.

4. A fuel injector according to claim 3, in which said arresting means comprises a check valve adapted to close said fuel passage to prevent a pressure wave from said chamber from passing into said supply line when said

6

plunger opens said feed hole and closes said fuel passage between said feed hole and said other end of passage.

5. An injector according to claim 4, in which said check valve is located downstream from said flow control means.

6. An injector according to claim 1, in which said flow control means comprises orifice means mounted in said passage.

7. An injector according to claim 6, in which said orifice means comprises a plug having an orifice there-through removably mounted in said passage.

8. An injector according to claim 2, in which said fuel passage includes portions having separated openings into said plunger bore downstream of said feed hole, and said plunger has a reduced portion registering with said openings when said feed hole is closed, whereby a flow of fuel is maintained completely through said passage for purging the latter when said feed hole is closed.

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