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R. F. FALBERG
FUEL INJECTION APPARATUS

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2 Sheets-Sheet 1

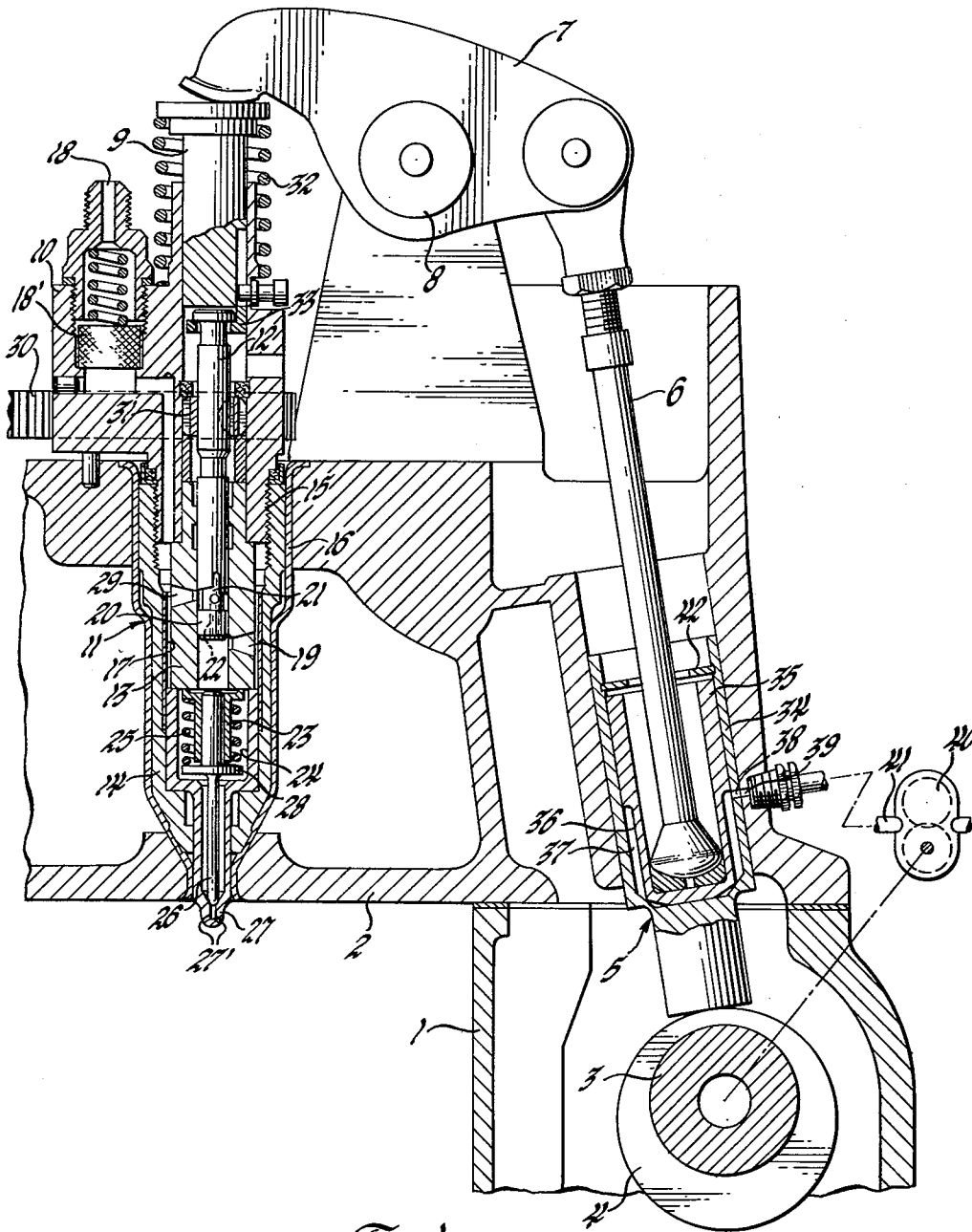


Fig. 1

INVENTOR.
Robert F. Falberg
BY
D. C. Thorpe
ATTORNEY

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R. F. FALBERG

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2 Sheets-Sheet 2

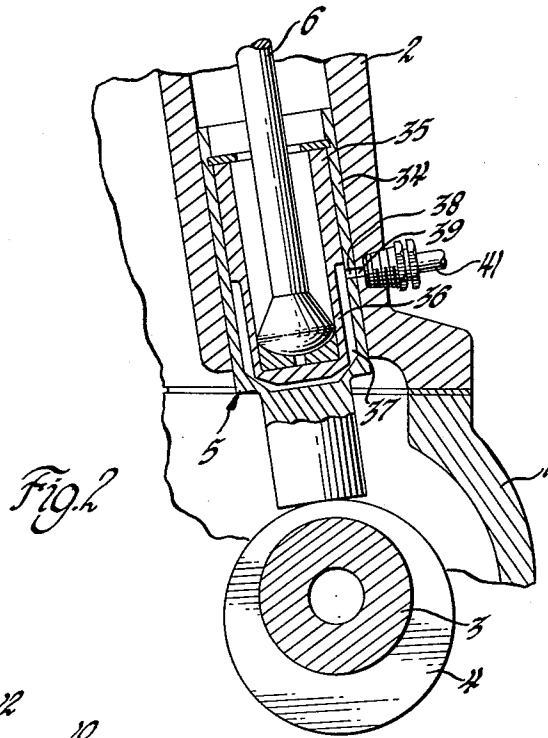


Fig. 2

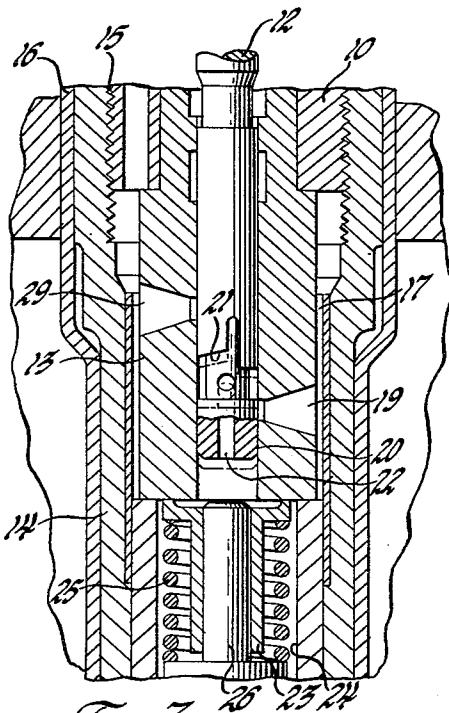


Fig. 3

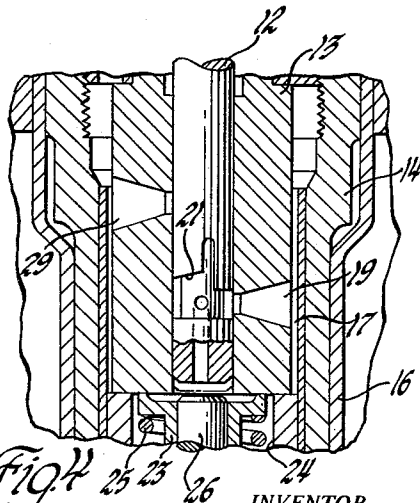


Fig. 4

INVENTOR.
Robert F. Falberg
BY
S. C. Sharpe
ATTORNEY

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FUEL INJECTION APPARATUS

Robert F. Falberg, Birmingham, Mich., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

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1 Claim. (Cl. 123-139)

This invention relates to fuel injection apparatus for internal combustion engines, and particularly to timing the injection for engines of the compression ignition type.

Automatic "advancing" of the beginning of injection has heretofore been proposed which requires mechanism such as flyweights to move in proportion to engine speed. Such prior advancing mechanisms, however, have had the disadvantage of being very large and heavy in order to minimize effects of friction and to withstand the power required to drive the injection equipment. Also, such proportionate advance with engine speed is not essential, and it is one of the objects of this invention to simplify and minimize the size and weight of the apparatus by providing for only the required specific points of injection timing, i.e., one setting for engine speeds below that at which minimum fuel consumption occurs and one setting for speeds above this point. Such a two-point setting has been found sufficient for present day engines of the 0-2300 r.p.m. speed range, however, the principles of the invention would apply equally to higher speed engines as might require a third injection timing setting.

In accordance with the preferred embodiment of the invention a hydraulically extensible link is incorporated in the conventional follower which rides on the engine driven cam or eccentric to actuate the injector plunger. Another feature of the invention is the use of an engine driven pump such as the lubricating oil pressure pump to provide the fluid pressure to extend the two position follower automatically at the predetermined engine speed for which the timing of injection is to be advanced. In the follower, there is a piston or plunger element against which the oil pressure acts, and its effective area can be chosen so that it will move through a predetermined distance when the oil pressure corresponding to the desired engine speed is attained.

Other objects and advantages of the present invention will be more clearly understood from the following description, having reference to the drawings, wherein:

FIGURE 1 is a sectional view of a portion of the cylinder head and upper cylinder structure of an internal combustion engine and its fuel injection apparatus, showing the parts in their relative positions for operation at the "low speed" injection timing.

FIGURE 2 is a fragmentary view of the two position eccentric follower of FIGURE 1, but showing the parts in their relative positions for "high speed" injection timing.

FIGURE 3 is an enlarged fragmentary view of the fuel injector, showing the position of the plunger in solid lines at the end of its effective pumping stroke under conditions of "low speed" injection timing, and its corresponding position in broken outline under conditions of "high speed" injection timing.

FIGURE 4 is a view similar to FIGURE 3 except with the positions of the plunger at the actual end of its stroke, shown in solid and broken outline under conditions of "low speed" and "high speed" timing, respectively.

Referring now in detail to the drawings, and first to FIGURE 1, a combustion chamber structure for a compression ignition type engine is shown comprising a cylinder block 1 to which is attached the usual cylinder head 2. Suitably journaled in the block 1 is an engine driven shaft 3 with an eccentric 4 thereon. Extensible link means in the form of a two position follower 5 rides on

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the eccentric 4 and is slidably guided in the cylinder head 2 for actuating a push rod 6. The upper end of the push rod is, in turn, linked to a rocker 7 journaled on its shaft 8 and drivably engaging a slide piece 9 in the body 10 of a unit type fuel injector designated generally by the numeral 11. The slidepiece 9 transmits its movement to the injector plunger member 12. The lower end of this member 12 slidably reciprocates in a pump cylinder member 13 which is rigidly secured in the injector body 10 by a nut 14 threaded to the latter as at 15. Surrounding the nut 14 is a sleeve 16 which forms a passage through the cylinder head in which the injector is mounted so that the inner end of its spray tip 27 may discharge into the combustion chamber.

The pumping cylinder 13 is in the form of a bushing, and between it and the surrounding nut 14 is an annular fuel reservoir 17 which communicates with a fuel supply connection 18. A fuel inlet and bypass port 19 interconnects the interior of the pumping cylinder with the reservoir 17, and this port is traversed to close the same by the land means 20 on the plunger member during the pumping stroke. An external relief groove 21 on the plunger member is subsequently registerable with the port 19 during the pumping stroke, and this groove is in communication at all times with the lower or pumping end of the plunger member via a passage 22 in the latter. Accordingly, during each downward or pumping stroke, fuel is trapped in the pumping cylinder and sufficient pressure of the fuel therein is developed to unseat a spring biased check valve 23 which normally closes the outlet or lower end of the pumping cylinder 13. This check valve 23 is shown in the form of an annular sleeve which is disposed in an accumulator chamber 24 immediately below the pumping cylinder, and is biased closed by a compression spring 25. The spring 25 also acts to normally hold an ejection needle valve 26 seated in closed position against the lower end of the spray tip 27. The upper portion of the spray tip forms the accumulator chamber 24 which extends down around the reduced diameter lower portion of the needle valve 26 and thereby defines a fuel delivery connection between the pumping cylinder and the outlet orifices 27' in the lower end of the spray tip. Fuel pressure within the pumping cylinder acts against the upper end of the needle valve, which extends through the check valve 23 as shown. A flange 28 intermediate the ends of the needle valve serves to seat the spring 25, and when both the check valve and needle valve are in their closed positions this flange 28 is spaced slightly from the lower end of the check valve 23 as shown.

The particular injector illustrated also has an upper fuel inlet and bypass port 29 in the side of the cylinder member 13, and this is closed by the upper edge of the relief groove 21 during the downward stroke of the plunger member. Such closing of the port 29 occurs subsequent to the lower inlet and bypass port 19 being closed by the plunger land 20. Between such sequential closings of the ports 19 and 20 fuel is additionally bypassed from the lower end of the pumping cylinder via the plunger passage 22 and groove 21 through the port 29 to the reservoir 17. The amount of such additional bypassing of fuel as occurs through the upper port 29 determines the quantity of fuel trapped, and hence the pressure developed in the pumping cylinder (and in the accumulator chamber 24 after the check valve 23 opens), and consequently the length of time the check valve 24 remains open is likewise dependent on the time of closing of the upper port 29. This is regulatable by reason of the helical shape of the upper edge of the relief groove 21 and the fact that the plunger member may be adjustably rotated about its axis in the pumping cylinder to

vary the closing time for the port 20 relative to that of the port 19. Rotation of the plunger member for this purpose is adjustable by a rack gear 30 slidably guided in the injector body 10 and meshing with a pinion gear 31 keyed to the plunger member 12.

With the parts in their positions shown in FIGURE 1, fuel supplied from a suitable transfer pump (not shown) to the connection 18 passes through the fuel filter 18' and down through the injector body and nut 14 to the reservoir 17. From thence it may flow into the pumping cylinder via the side ports 19 and 20 and plunger groove 21 and passage 22, preparatory to the start of the injection cycle. Thus, with each lift stroke of the eccentric 4 the plunger member 12 moves downwardly to first close port 19 and thence port 29, trapping fuel in the pumping cylinder below the plunger member. As the pressure of this trapped fuel increases it causes the check valve 23 to open, allowing the fuel under pressure in the pumping cylinder to enter the accumulator chamber 24 (which also contains fuel under a residual pressure from a previous injection cycle). As the plunger member continues its downward movement the fuel pressure in both the pumping cylinder and the accumulator chamber continues to increase, but no opening of the needle valve 26 can occur because it is biased closed by the spring 25. When, however, the relief groove 21 on the plunger member starts (as shown in solid lines in FIGURE 3) to uncover the lower side port 19 a sudden pressure drop in the form of a sonic wave will travel from the relief groove 21 through the plunger member passage 22 and into the lower end of the pumping cylinder 13. This sudden pressure drop when felt by the check valve 23 will allow spring 25 to return check valve 23 to its seat, thereby trapping a desired amount of fuel under pressure in the accumulator chamber 24. The pressure of this fuel will thence act on the differential area that exists between the respectively larger and smaller diameter upper and lower portions of the needle valve 26 and cause it to raise this valve and uncover the spray tip orifices 27'. Fuel will then flow out of the spray tip orifices to the combustion chamber of the engine. When pressure of the fuel in the accumulator chamber 24 decreases sufficiently as the result of this injection the spring 25 will return the needle valve to its seat, terminating the injection.

During the remainder of the lift stroke of the eccentric 4 continued downward movement of the plunger member will occur after its relief groove uncovers the port 19, as indicated (in solid lines) in FIGURE 4, but since the pumping chamber is vented to this port via the plunger passage 22 and groove 21, the check valve 23 will be maintained closed by its spring and such further plunger travel does not affect the injection. In any event, after the eccentric 4 has completed its lift stroke and during its return to the position shown in FIGURE 1 the follower 5 will be maintained in engagement with the eccentric by the plunger return spring 32 acting in compression between the injector body 10 and the slide piece 9. Corresponding return (upward) movement of the plunger 12 is likewise assured by its connection 33 with the lower end of the slide piece 9, to complete the cycle.

Referring to FIGURES 1 and 2, it will be seen that the extensible follower 5 comprises an outer cylinder element 34 whose lower end rides on the eccentric 4, and piston means in the form of a plunger element 35 which slidably fits the bore of the cylinder element 34. The plunger element 35 has the lower end of the push rod 6 seated therein for pivotal movement, and the lower outer periphery of this plunger element is of reduced cross section as indicated at 36 whereby a longitudinally expandible chamber 37 is formed between the elements

34 and 35. Fluid supply means for this chamber 37 is provided adjacent its upper end by a side port 38 extending through the cylinder element 34, which port registers with a fluid port 39 in the cylinder head 2 each time the follower is returned to its lowermost position shown in FIGURE 1. Fluid pressure means in the form of a suitable fluid pump 40, such as the engine driven lubricating oil pump, has its discharge side 41 connected to the port 39.

By properly selecting the effective area of the plunger element relative to the pressure developed by the engine driven pump 40 at the engine speed at which an injection timing advance is required, the plunger element 35 will be automatically elevated relative to the cylinder element 34 when this engine speed is reached. Such elevation will, in turn, raise the push rod and rotate the rocker 7 to shift the injector plunger member 12 to a position in advance of its corresponding position for engine operation at lower speeds. A suitable stop 42 for limiting such relative elevation of the follower plunger member 35 is provided in the form of a snap ring recessed in the upper end of the cylinder element 34 of the follower.

Accordingly, when the predetermined engine speed is reached at which the injection timing advance is to occur the uncovering of the fuel inlet and bypass port 19 by the injector plunger groove 21 will occur at an earlier point in the engine operating cycle, with the result that consequent venting of the pumping cylinder 13 and reclosing of the check valve 23 and opening of the injection needle valve will all occur earlier in the engine operating cycle. At reduced engine speed, the lubricating oil pressure in the follower chamber 37 will automatically reduce, allowing the injector plunger return spring 32 to return the follower parts to their relatively retracted position shown, retarding the beginning of injection for "low speed" operation.

While only a single preferred embodiment of the invention has been disclosed, it is appreciated that numerous minor changes in the construction and arrangement of the parts may be made without departing from the spirit and scope of the invention as hereinafter claimed.

I claim:

In fuel injection apparatus for internal combustion engines, a fuel injector including a pump cylinder having a fuel outlet and a fuel bypass port, a plunger movable in said cylinder in the direction to displace fuel through said outlet, said plunger having land means operable during said movement to initially block communication between said outlet and port and thence to reestablish said communication, a spring biased check valve controlling said outlet and openable to pass fuel displaced from the cylinder during said movement of the plunger while said port is blocked, an accumulator chamber receiving fuel passed by the check valve, said chamber having an outlet, a valve within the chamber normally closing said chamber outlet, said valve having fuel pressure responsive surfaces exposed to the fuel in said cylinder and the fuel in said chamber respectively, whereby said valve is held closed during plunger movement while said port is closed and is forced open by the fuel pressure in the chamber after said port is opened and said check valve closes, actuating means for said plunger including driving means adapted to be operated at a predetermined speed and an extensible link interconnecting said plunger and driving means, and means for extending said link whereby the timing of said port closing and reopening is advanced relative to the speed of said driving means.

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