March 23, 1948. T. PEDERSEN 2,438,251

ENGINE FUEL SUPPLY MEANS

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FIG. 1.

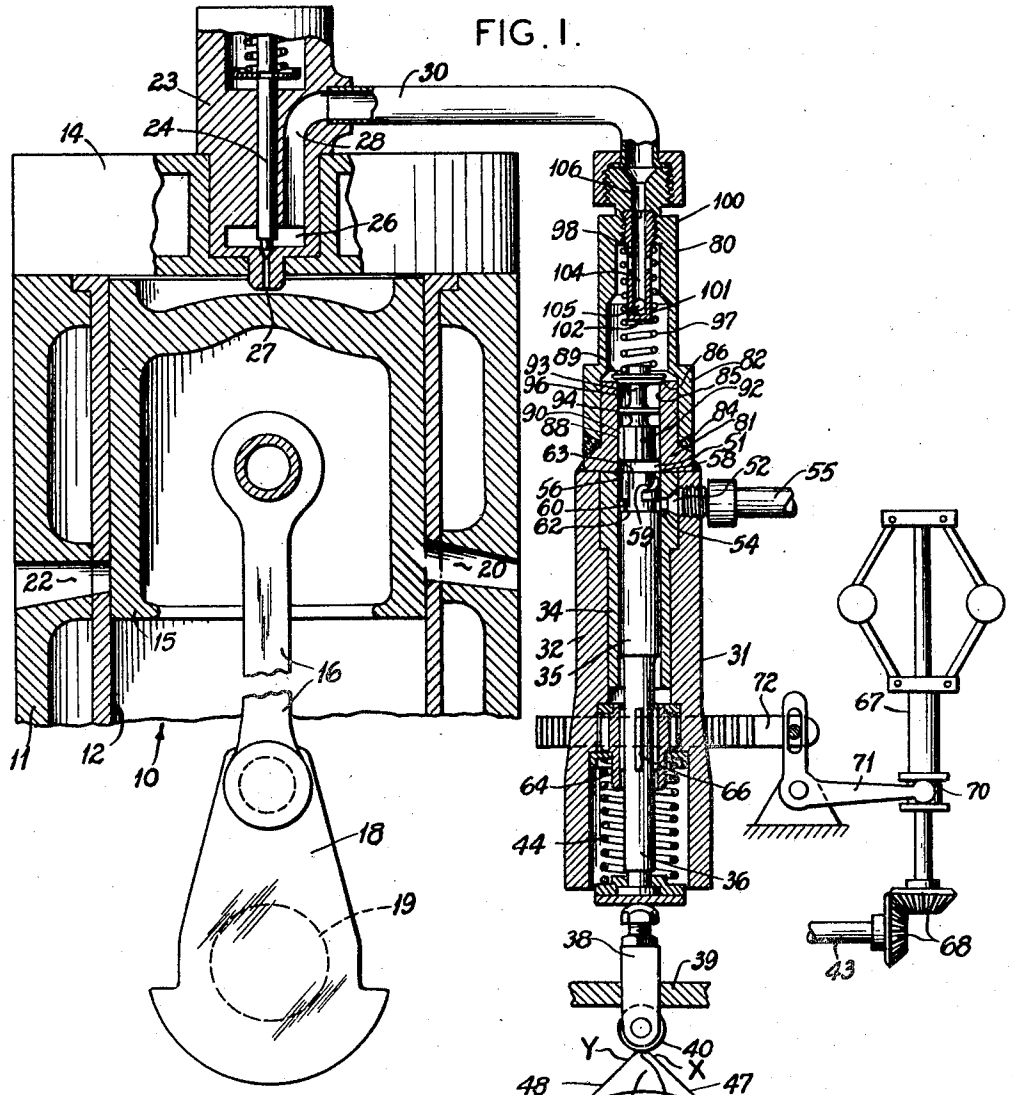
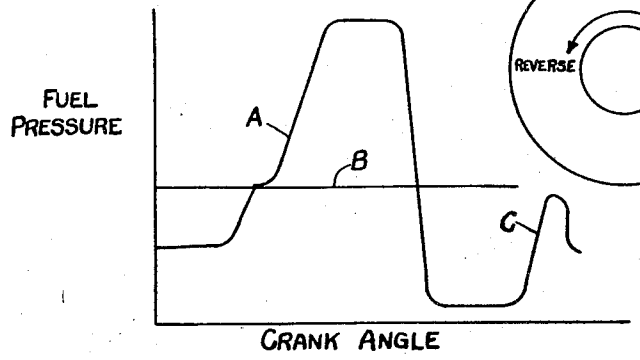


FIG. 2.



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ENGINE FUEL SUPPLY MEANS

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3 Claims. (Cl. 103—41)

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This invention relates to improvements in fuel supply means for internal combustion engines, and has particular reference to improved and greatly simplified fuel injecting mechanism for engines of reversible, solid fuel injection type.

The principal object of the invention is to provide for embodiment in engines of the character indicated, improved and simplified fuel injecting mechanism including a single-cam operated fuel pump of plunger type, which is operable equally in either direction of engine rotation, to deliver fuel under pressure and in regulated quantity, for cylinder injection, and where the improvements attained are such as to avoid any necessity for angular shift of the pump cam or other adjustments of the mechanism, in order to accommodate a change in the direction of engine rotation.

Another object resides in the provision as a part of the improved mechanism, of a plunger fuel pump of constant stroke character, embodying control means affording a variable beginning of fuel-pressure delivery by the pump, and pressure-delivery cutoff or release at a predetermined constant point in the plunger delivery stroke, whereby the timing of cylinder fuel injection relative to the engine piston compression stroke, and the quantity of fuel injected, may be closely controlled.

A further object is to provide in operative association with a fuel pump of the character indicated, adapted for fuel-delivery cut-off or release before the pump plunger attains the end of its delivery stroke, a pressure-operated control device operable responsively to fuel delivery from the pump, to open a fuel line between the pump and an injection valve at the engine cylinder, and to close the line upon delivery release at the pump, wherein the control device is adapted for receiving a predetermined portion of the fuel in said line and retaining such portion in isolation from the line and from the pump, this result being effected upon line closure by the device. In consequence thereof, the quantity of fuel remaining in the line following line closure by the control device, is so reduced as to render the secondary reflected fuel pressure wave occurring in the line at such time, ineffective to cause a re-opening of the cylinder injection valve, whereby there is prevented undesirable secondary injection or fuel dribble at the injection valve.

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Further objects and advantages afforded by the present improvements, will appear readily from the following description of a preferred embodiment of the invention as exemplified in the acompanying drawing, wherein:

Fig. 1 is a view in sectional elevation, of an engine cylinder and fuel injecting mechanism therefor, the latter embodying the improvements effected by the present invention, and being shown in somewhat enlarged section and in elevation as to the pump operating cam, for the sake of clarity of disclosure, the view also including in diagrammatic elevation, an engine operated governor control for the fuel pump, and

Fig. 2 illustrates graphically, the fuel pressures obtaining in the fuel injecting cycle.

The presently improved fuel injecting mechanism by preference is of unit character, and is applicable in particular, to single or multi-cylinder, reversible, engines of the two-cycle, solid fuel injection type. In the instance of engines having more than one cylinder, each cylinder preferably will have an injecting unit individual thereto, while regulation of the units to effect injection timing and fuel quantity control, may and preferably will be attained by means common to the several units and connected to an engine operated device, such as a governor responsive to engine speed and loading.

Referring now to Fig. 1 of the drawing by appropriate reference characters, the injecting mechanism is illustrated in application to an engine of the character indicated, being shown in association with a cylinder assembly thereof, indicated generally by the numeral 10. Although illustrated in part only, the assembly includes an engine frame or block 11 supporting a cylinder liner 12 and a cylinder head member 14. Disposed for reciprocation in the liner 12, is a piston 15 which is operatively connected through a connecting rod 16, with the crank 18 of the engine crankshaft 19. The block and cylinder liner are suitably apertured to provide scavenging air inlet and exhaust ports 20 and 22 respectively, located so as to be controlled by the piston 15, such being a common arrangement in two-cycle engines. Arranged centrally in the cylinder head member 14, is a fuel injection valve 23 of

a solid injection type, as of the spring loaded, needle valve character shown, wherein the needle valve element 24 is lifted by fuel under pressure received in valve chamber 26, to permit fuel injection to the cylinder through the nozzle 27. Delivery of fuel under pressure to valve chamber 26, is effected through valve passage 28 and a fuel line 30 connected thereto and leading from a fuel pump 31, the latter embodying features of the present invention as will appear hereinafter.

Fuel pump 31 which as shown, is of a cam-driven plunger type, is comprised of a pump housing or frame assembly generally indicated by the numeral 32, providing a cylinder 34 within which reciprocates a pump plunger 35. The lower end 36 of the plunger engages a cam-follower guide 38 which is slidably supported by a portion 39 of the engine frame. Carried by guide 38 is a cam-follower or roller element 40 which rides upon the operating surface of a cam 42 on the engine camshaft 43, the latter being driven by suitable means (not shown) from the crankshaft 19. A spring 44 serves to maintain the plunger and guide 38 in engagement, and to assure retention of roller 40 in contact with the cam, whereby to afford positive plunger reciprocation by the cam. As shown, the cam 42 provides a single cam-projection 46 formed to have adjacent symmetrical operating faces 47 and 48 merging in a rounded tip or cam-peak 50. In consequence of the particular shape, the plunger 35 will have a constant stroke and of the same extent in either direction of cam rotation, this being attained for a purpose which will appear presently.

The upper section of the pump cylinder 34 constitutes a pump chamber 51, and arranged in a wall portion of the cylinder is a fuel passage 52 terminating in a fuel port 54 opening to the cylinder in the zone of chamber 51. Fuel is conducted to the passage 52 from a suitable source (not shown), through conduit 55. Controlling communication of the port 54 and pumping chamber 51, is a control device at the head end 56 of the plunger 35, the device preferably being formed as an integral part of the plunger head, and comprising a head recess 58 defining an angulate control edge 59, and an annular recess 60 therebelow defining a control edge 62 normal to the plunger axis. The recesses 58 and 60 are at all times open to each other through a connecting recess 63 directed longitudinally of the plunger, as shown. Thus it will readily appear from Fig. 1 that through angular or rotary displacement of the plunger 35, the angular or generally spiral control edge 59 will serve in the upstroke or fuel delivery stroke of the plunger, to cover or close port 54 at an earlier or later point in said plunger stroke, whereby the beginning of fuel pressure delivery by the pump, may be thus varied as desired.

The control edge 62 on the other hand, being normal to the plunger axis, will open the port 54 always at the same point in each delivery stroke of the plunger, and will thus establish direct communication between the port and the pumping chamber 51, through recess 60, passage 63 and recess 58. When the port is so opened, pump pressure delivery ceases, since the fuel ahead of the plunger then may return to the port 54 and fuel supply line. Thus from the foregoing description as to structure and function, of the control means integral with the plunger head portion 56, it will be observed that not only the beginning of pump pressure delivery may be controlled, as by varying the angular position of the plunger 35, but that by reason of pump delivery release at a constant point in the plunger delivery stroke, varying the beginning of pump delivery also determines in direct proportion, the quantity of fuel delivered by the pump.

Any suitable means may be employed to effect angular adjustment of the pump plunger, as to attain the foregoing result. As presently illustrated, a rotatable sleeve 64 longitudinally splined to the shank portion 66 of the pump plunger 35 so as to permit plunger reciprocation relative to the sleeve, is retained in the pump housing assembly against displacement longitudinally thereof, and when rotated, will produce a corresponding rotation of the plunger. Rotation of the sleeve 64 may be effected manually, or by preference and as is usual in fuel systems of this character, by automatic means, as an engine governor responsive to engine speed or loading. Such a governor is illustrated somewhat diagrammatically at 67 in Fig. 1, driven preferably from the engine camshaft 43 through bevel gearing 68. Movement of the governor-actuated member 70 is transmitted to rotation of pump sleeve 64 by a suitably positioned bellcrank 71 and a link 72, the link being adapted as a rack, to engage corresponding teeth on the sleeve 64. Thus as the governor responds to changing engine speed or loading, it will effect through the operating connection described, a corresponding rotation of the fuel pump plunger 35 to relate the plunger control edge 59 to the port 54 so as to determine an earlier or later beginning of pump delivery and the quantity of fuel delivered, whereby to adapt the fuel injection to changes in the engine speed or loading.

A feature of importance to the present improvements, is found in the location of the fuel release or cut-off edge 62 and recess 60 longitudially of the plunger. The recess and control edge are so positioned as to open port 54 and hence release further pump delivery in the manner described, during the delivery stroke of the plunger and before the latter attains the end of its stroke. The arrangement as herein provided is such that opening of port 54 by control edge 62, to release pump delivery, occurs during the plunger delivery stroke and, considering for example, clockwise rotation of the cam as viewed in Fig. 1, as the cam peak 50 approaches the follower-roller 40. More particularly, initial port opening is attained when the cam and roller are engaged on the relatively straight portion 47 of the cam projection, at about the point of merger between the straight portion and the rounded portion of the cam peak, as indicated at X on the cam. The advantage attained by this, will be readily understood from the fact that the degree of fuel atomization upon cylinder injection, is proportional to the velocity of the pump plunger during its pressure delivery stroke. The present cam-plunger relationship thus affords pump fuel delivery during a period of relatively high velocity lift of the plunger by the straight portion 47 of the cam projection, to assure the desired high degree of fuel atomization throughout the injection period, and effects a release of pump delivery just before the rounded cam peak 50 is brought to bear on the roller 40, when the rate of plunger lift rapidly decreases to zero.

The cam-actuated fuel pump mechanism of the character now described, is effective equally in either direction of engine rotation, without requiring angular displacement adjustment of the cam or other adjustment of the mechanism in order to condition the injecting mechanism for one or the other direction of engine rotation. This

is afforded by the described symmetrical formation of the cam, and further, by the relative operative positions of the cam and engine piston. As shown in Fig. 1, the cam is positioned on the camshaft, so that its peak 50 will engage the roller 40 to dispose the pump plunger 35 at the end of its lift or upstroke, when the engine piston 15 is at inner dead center. As a result, crankshaft rotation in either direction, will effect the same cycle of pump operation.

Referring briefly to the pump cycle and considering the same first upon clockwise or forward crankshaft and camshaft rotation (Fig. 1), during the period of roller engagement on the cam surface 74 of uniform radius, the pump plunger will remain stationary, as at outer dead center of its reciprocable movement, when the plunger control end 56 will be below the port 54. At this time, fuel delivered through supply pipe 55, and entering through port 54, fills the pumping chamber 51. Now as the cam surface 47 is brought to bear upon the follower-roller 40, the plunger will be thereby displaced upwardly in the pump cylinder, effecting first a closure of port 54 as the plunger control edge 59 passes thereover, and thence pressure-discharge of fuel from chamber 51 and through the fuel line 30 to the injection valve 23, for cylinder injection. During this phase of pump operation, the engine piston 15 is on its upward or compression stroke, approaching inner dead center position. Initial cylinder injection of fuel however, is regulated in accordance with the dictates of engine speed and loading as hereinbefore described, so as to occur at a time earlier or later in the approach of the piston 15 to its inner dead center position, this being attained through angular positioning of the pump-plunger by the engine-responsive governor, to dispose the angulate plunger control edge 59 relative to port 54 for closing the port earlier or later in the plunger upstroke.

At a predetermined constant point in the plunger upstroke, occurring when the cam point X engages the roller 40, the plunger control edge 62 will uncover the port 54 to the plunger recess 60, and thereby release further pump fuel-pressure delivery. The plunger then continues to the end of its stroke, as effected by the rounded cam-peak 50 acting on roller 40, and thereafter is returned to the opposite dead-center position under the influence of plunger-return spring 44, as the cam surface 74 rides under roller 40.

Reversal of crankshaft, and hence camshaft, rotation, as to effect counterclockwise rotation thereof as viewed in Fig. 1, will result in the same cycle of pump operation, the cam surface 48 now becoming effective to produce the plunger delivery stroke, with pump cut-off at cam-point Y. As will be observed, the point Y occupies the same relation with respect to cam surface 48, as does the point X with respect to cam surface 47. Thus as will now appear, in either forward or reverse engine rotation, the present improvements afford the same control as to timing of initial fuel injection and quantity of fuel injected.

A further element of the present invention is found in an improved fuel control device indicated generally at 80, arranged in the fuel delivery line 30 and preferably, mounted on and forming a part of the fuel pump assembly. The device as will hereinafter appear, is adapted for coaction with the fuel pump such as to open the fuel line 30 in response to pump fuel pressure delivery, and in response to cessation of pump delivery, not only to close line 30, but to effect a

predetermined reduction in the volume of fuel remaining in the line, so as to preclude secondary fuel injection or fuel dribble at the cylinder injection valve 23.

The device 80 in its presently preferred embodiment as shown, comprises casing sections 81 and 82 sealed by packing 84 at the telescoped ends thereof, the sections being held together and in assembly to the pump frame 32 by suitable means not here illustrated. Casing section 81 provides a central longitudinal bore 85 opening at its lower end to the pump chamber 51 and affording a bevelled valve seat 86 at its upper open end. Slidably received in bore 85 is a combined valve and control member 88 formed to provide a valve head 89 at the upper end, adapted for seating on valve seat 86, and a guide section 90 at the opposite end, of spider-like character providing longitudinal arms or vanes 92 closely slidably engaging the walls of the bore 85 along their longitudinal margins. Structurally interconnecting the valve head 89 and guide 90 is a centrally located stem 93 of predetermined, reduced diameter. The stem supports or has formed integrally thereof, a circular flange 94 adapted for close sliding contact at its periphery, with the walls of the valve bore 85. Flange 94 is spaced longitudinally from the inner ends of the guide vanes 92, and from the valve head 89 to a predetermined extent, so as to define with the valve head and interconnecting portion of the stem, an annular recess 96 of a predetermined capacity.

The control member 88 when fully received in the casing bore 85 to seat the valve head 89 on seat 86, is yieldably retained in such position by a valve spring 97 arranged in casing section 82, with its lower end bearing against valve head 89 and its opposite end against an internal casing seat 98 at the head or outer end 100 of casing 82. Extending longitudinally in the casing 82 and within the coils of spring 97, is a stop member 101 of tube-like form, supported at one end in the casing head portion 100, and which may be adjustable axially of the casing. The inner free end 102 of stop 101 serves as an abutment for the valve head 89 to limit the maximum opening movement of the control device 80. The bore 104 of stop member 101 communicates with the interior of casing 82 through ports 105, and with axial passage 106 in the casing head 100, the latter passage opening directly to the fuel line 30, as shown.

Describing now the operation of device 80, as pump 31 starts pressure-delivery of fuel from pumping chamber 51, the advancing fuel under pressure, will lift member 88 against the loading of spring 97, displacing the same to an extent sufficient to dispose the flange element 94 upwardly beyond the valve seat 86, thereby fully opening the valve bore 85 to the interior of casing section 82. Thus fuel then under high delivery pressure from pump 31, may pass into casing 82, through ports 105 and bore 104 of stop member 101, casing passage 106, and fuel line 30 to injection valve 23, for cylinder injection. When pump-delivery ceases, as upon opening of pump port 54 by the plunger control edge 62, the valve spring 97 then acts immediately to return the control member 88 to its closed position, as to seat valve head 89 on valve seat 86. At such time and because of the relatively rapid closing movement of member 88, there is retained in line 30 and in casing 82, a column of fuel under a certain residual pressure. Moreover, at the instant of closure of member 88, the column is under dis-

placement in the direction of the pump, so, when cut off, there results a reverse pressure-wave through the column toward the injection valve. If in a fuel line of this character, the volume of fuel comprising the trapped column, is sufficiently large, the resulting reflected pressure-wave may reach a pressure sufficient to produce secondary injection or fuel dribble at the injection valve, with consequences quite detrimental to proper and efficient engine operation. In the present system, the control device **80** functions with respect to the fuel column in line **30** and casing **82**, such as to effect a predetermined reduction in the volume thereof during the closing movement of member **88**. As will be observed from the drawing disclosure, the pump chamber **51** is closed to the casing **82** and line **30** therebeyond, when the member **88** is spring-displaced sufficiently to locate the control flange **94** in the upper end of casing bore **85**. Then as further closing movement of member **88** takes place, to the end of seating valve head **89** on valve seat **86**, the annular recess **96** open only to casing **82**, receives a portion of the fuel in the trapped column, and is completely filled at the instant the valve head engages valve seat **86**. Thus as the valve closes, there is removed from the fuel column a certain volume thereof as predetermined according to the capacity of recess **96**, so as to result in a corresponding decrease in the volume of fuel remaining in casing **82** and line **30**. As a result, the volume of trapped fuel is so reduced upon full-closure of member **88**, that the maximum pressure developed by the reflected pressure wave in the fuel column, will be less than the minimum fuel pressure required to open the injection valve **23**. Hence, secondary injection or fuel dribble at the injection valve is thus precluded.

This result is illustrated graphically in Fig. 2, wherein the curve A represents the fuel pressure in the delivery line between the fuel pump and engine cylinder, as plotted against degrees of crank angle. The horizontal line B represents the minimum pressure necessary to effect opening of the injection valve **23**. As there shown, the fuel pressure increases rather abruptly upon pump pressure delivery, and continues at high injection pressure during the cylinder injection period, until the pump ceases pressure delivery, when the fuel pressure drops suddenly. The portion C of pressure curve A, indicates the rise and fall of the secondary, reflected pressure wave occurring in the trapped fuel column following full closure of the member **88** of control device **80**. It will be observed that the high point of this pressure wave approaches but does not reach the minimum opening pressure of the injection valve, this because the volume of the trapped fuel is so reduced as to preclude a greater pressure rise.

A further feature of the presently improved control device **80** is found in the retention in recess **96**, of the volume of fuel removed from the column in casing **82** and line **30** when the member **88** fully closes the line. Thus, upon the succeeding pressure delivery from pump chamber **51**, the fuel in recess **96** is returned to the fuel column ahead of the incoming fresh fuel from the pump, whereby to afford a full column of fuel in casing **82** and line **30** to the chamber **26** of injection valve **23** as the member **88** opens the line to pressure delivery from the pump.

Having now described the invention in a preferred embodiment thereof, it is to be understood that certain alterations in or modification of parts and their arrangement, may be made without departing from the spirit and intended scope of the invention, as defined by the appended claims.

I claim:

1. In a fuel pump assembly for an internal combustion engine, a plunger type fuel pump including a fuel delivery passage extending therefrom, said pump comprising a pump cylinder in communication with said delivery passage and having a fuel inlet port, a plunger reciprocable in the cylinder, means for rotating the plunger to control the angular position thereof in the cylinder, port-control means movable with said plunger and adapted to close said inlet port at a time in the fuel delivery stroke of the plunger determined by the angular position of the latter as controlled by said plunger rotating means, said port-control means further being adapted for opening said port to the pump cylinder during the delivery stroke of the plunger and before the latter attains the end of its delivery stroke, and a control valve in said fuel delivery passage adjacent said pump cylinder, displaceable from a closed position in response to fuel-pressure delivery by the pump, whereby to open said passage to the pump cylinder, said valve including means for receiving a portion of the fuel in said passage and retaining such fuel portion in isolation from the pump cylinder and from the passage beyond the valve, in the closed position of said valve.

2. In a fuel pump assembly for an internal combustion engine, a plunger type fuel pump including a fuel delivery passage extending therefrom, said pump comprising a pump cylinder in communication with said delivery passage and having a fuel inlet port, a plunger reciprocable in the cylinder, means for rotating the plunger to control the angular position thereof in the cylinder, port-control means movable with said plunger and adapted to close said inlet port at a time in the fuel delivery stroke of the plunger determined by the angular position of the latter as controlled by said plunger rotating means, said port-control means further being adapted for opening said port to the pump cylinder during the delivery stroke of the plunger at a predetermined point before the end of the delivery stroke, and a control valve in said fuel delivery passage adjacent said pump cylinder, displaceable from a closed position in response to fuel-pressure delivery by the pump, whereby to open said passage to the pump cylinder, said valve including means forming a chamber for receiving a portion of the fuel in said passage and retaining such fuel portion in isolation from the pump cylinder and from the passage beyond the valve, in the closed position of said valve.

3. In a fuel pump assembly for an internal combustion engine, a plunger type fuel pump including a fuel delivery passage extending therefrom, said pump comprising a pump cylinder in communication with said delivery passage and having a fuel inlet port, a plunger reciprocable in the cylinder, means for rotating the plunger to control the angular position thereof in the cylinder, port-control means on the plunger adapted for closing said inlet port at a time in the fuel delivery stroke of the plunger determined by the angular position of the latter as controlled by said plunger rotating means, said port-control means further being adapted for opening said port to the pump cylinder before the end of the plunger delivery stroke and at the same point in each delivery stroke independently of the angular position of the plunger in the cylinder, and a control valve in the delivery passage adjacent the pump

cylinder, including means normally biasing the valve to a passage-closing position, said valve being displaceable from said passage-closing position in response to fuel-pressure delivery by the pump, to open the passage to the pump cylinder, and said valve further providing a chamber for receiving a portion of the fuel in the passage and effective in the closed position of the valve, to isolate the fuel portion received in the chamber, from the pump cylinder and from the delivery passage beyond the valve.

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