June 28, 1949. R. C. GROVES 2,474,396

INJECTION PUMP

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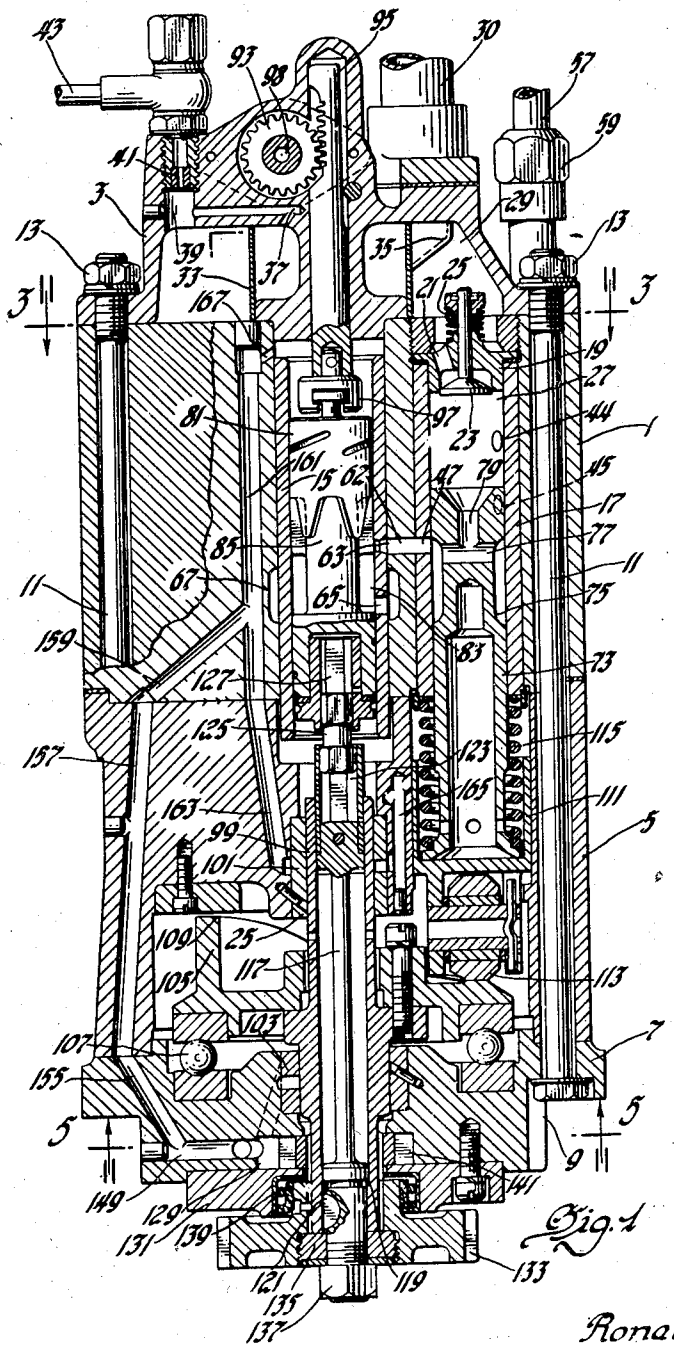


Fig. 1

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INJECTION PUMP

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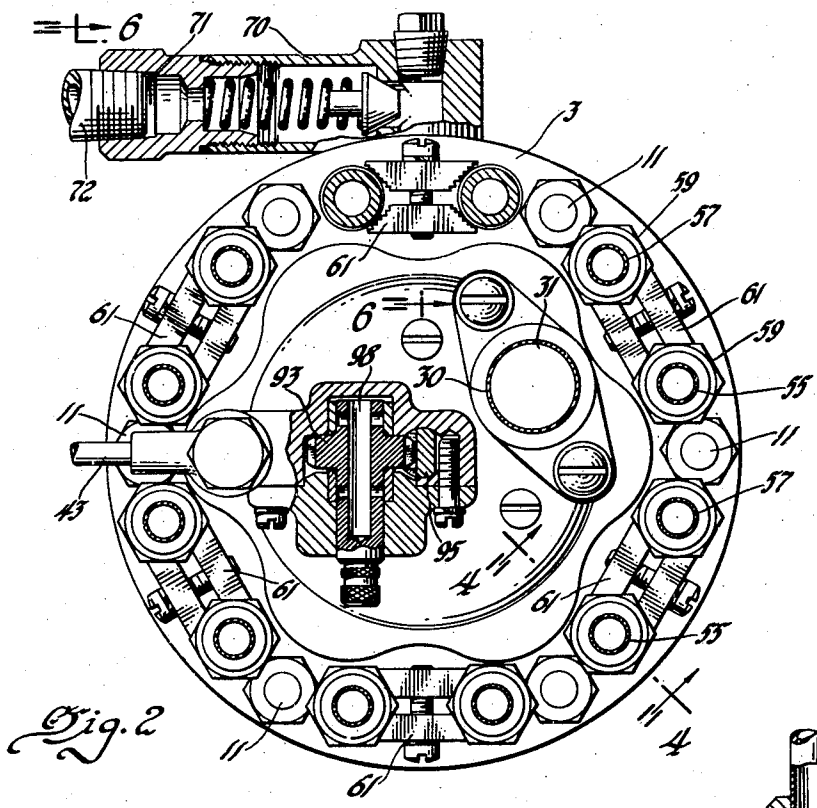


Fig. 2

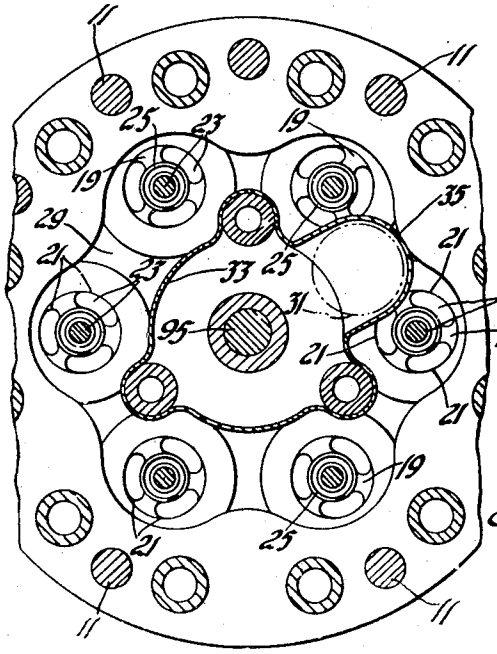


Fig. 3

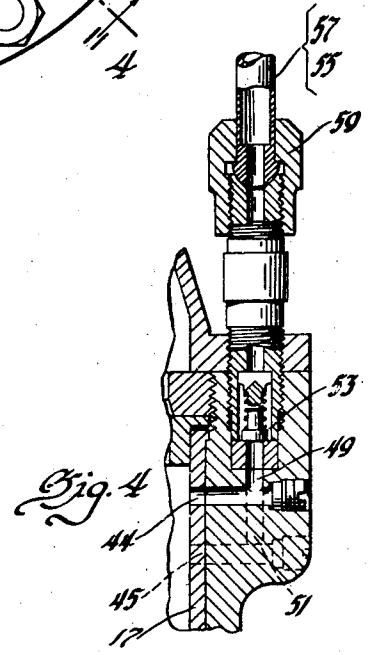


Fig. 4

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INJECTION PUMP

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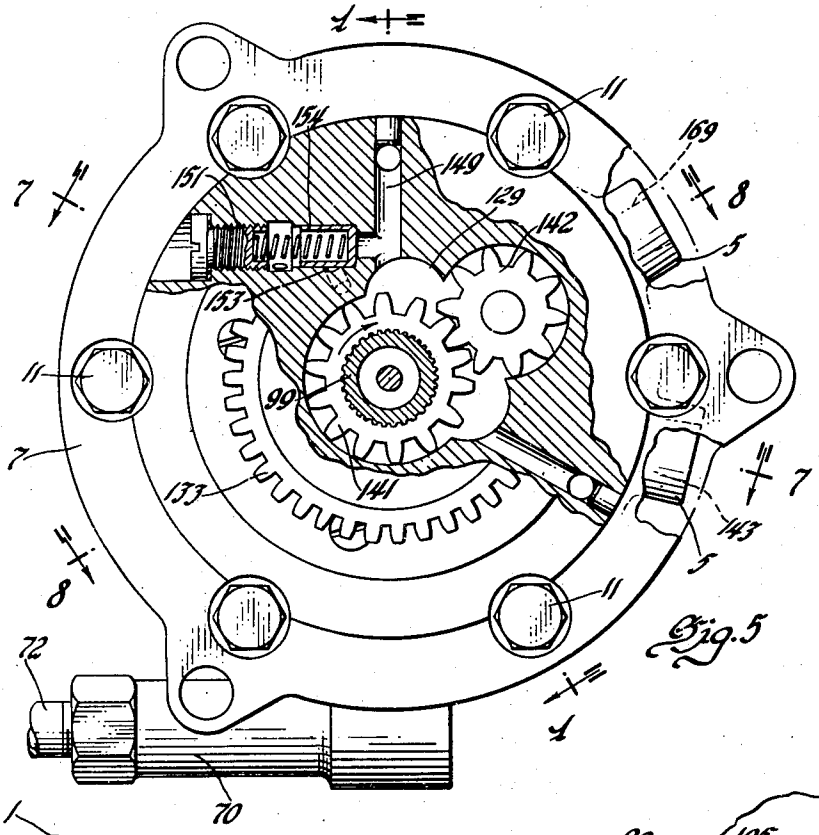


Fig. 5

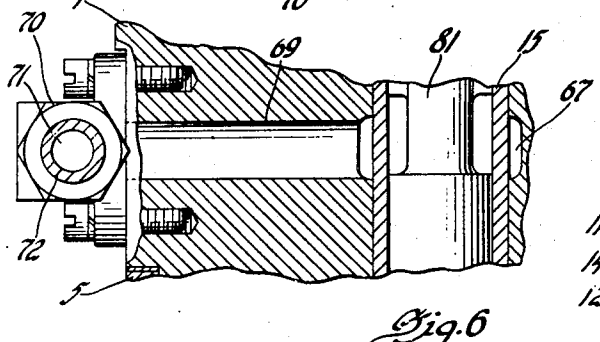


Fig. 6

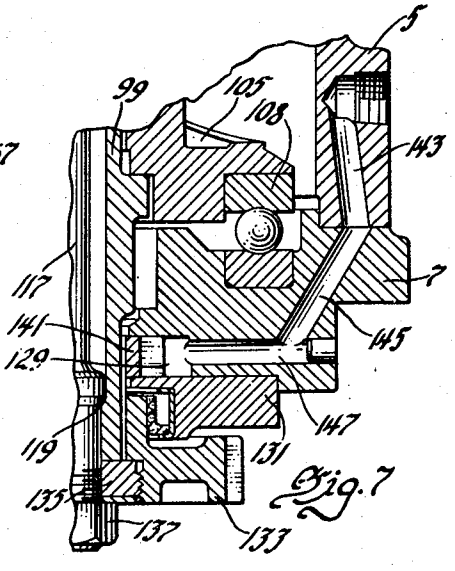


Fig. 7

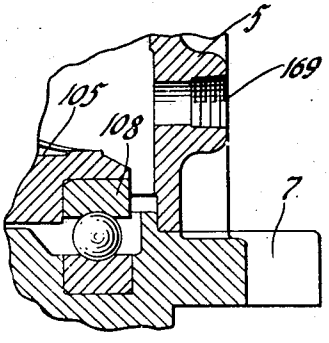


Fig. 8

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INJECTION PUMP

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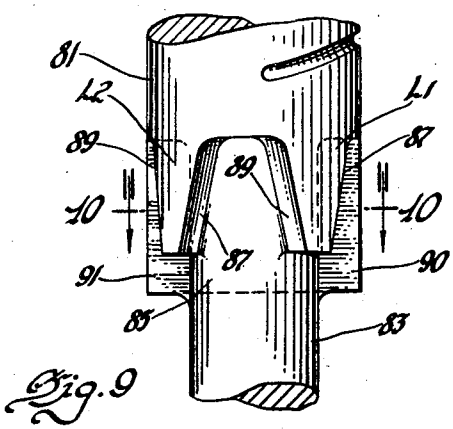


Fig. 9

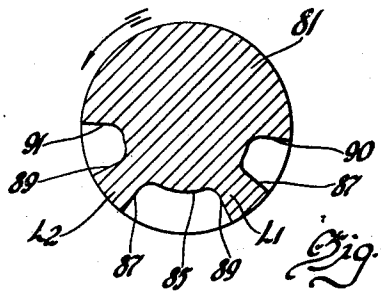


Fig. 10

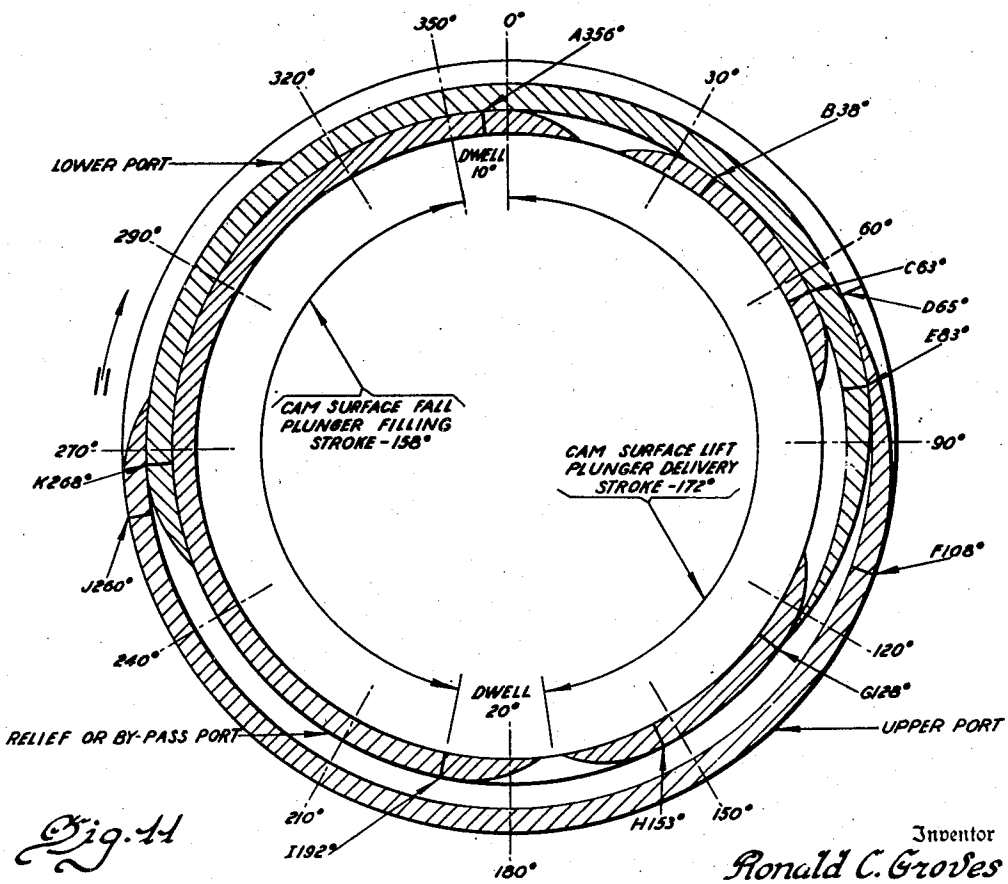


Fig. 11

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UNITED STATES PATENT OFFICE

2,474,396

INJECTION PUMP

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Application March 1, 1945, Serial No. 580,347

9 Claims. (Cl. 103—41)

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The present invention generally relates to fuel injection pumps for internal combustion engines and more particularly relates to multi-plunger pumps, each of which supplies fuel to more than one engine cylinder.

In conventional pumps of this type a valve operating in timed relation to the pump plungers cooperates with a common fuel inlet and relief passage to control the fuel entering and relief of pressure from each plunger pump. On account of the difference in fuel inlet and pressure relief flow velocities in the common passage and past the control surfaces of the control valve, part of the fuel and vapor discharged from one pump re-enters another pump with this arrangement. This prevents complete filling of the pumps with fuel and thereby prevents accurate metering of fuel to the engine cylinders supplied with fuel from each pump.

The principal object of the present invention is to provide a large area fuel inlet passage having fuel directing and vapor separating means and a vent for the vapor separated, a plurality of pump cylinders each having a fuel inlet check valve connected to the inlet passage, separate delivery and by-pass or relief ports, a plunger cooperating successively with the delivery ports and a control valve rotatable in timed relation with the pump plungers and axially displaceable for cooperating with each of the cylinder relief ports in order to accurately control the amount of fuel delivered by each pump plunger to different engine working cylinders.

Another object is to provide a lubricating pump as part of the fuel pump assembly to supply oil to the pumps and pump operating means to properly lubricate the parts and prevent fuel leakage past certain parts thereby preventing wear of the parts and enabling them to operate at high speed even when gasoline is used as fuel.

Another object is to provide suitable lubricating and fuel sealing means to prevent leakage of fuel and dilution of the oil by the fuel.

The means by which these objects are accomplished and other features of the invention will become apparent by reference to the following detailed description and drawings illustrating one modification of the invention.

Figure 1 of the drawings is a reduced vertical sectional view of the pump assembly, taken substantially on line 1—1 of Figure 5 of the drawings, with parts broken away to show certain of the details of the invention to better advantage.

Figure 2 is an enlarged top plan view of the

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assembly with parts broken away to show certain details of the control elements.

Figure 3 is a partial enlarged transverse sectional view taken substantially on line 3—3 of Figure 1.

Figure 4 is a partial vertical sectional view taken substantially on line 4—4 of Figure 2.

Figure 5 is a partial enlarged transverse sectional view taken substantially on line 5—5 of Figure 1 with parts broken away.

Figure 6 is an enlarged vertical sectional view taken on line 6—6 of Figure 2.

Figure 7 is an enlarged vertical sectional view taken on line 7—7 of Figure 5 with parts broken away.

Figure 8 is a vertical sectional view taken on line 8—8 of Figure 5 with parts broken away.

Figure 9 is a partial enlarged view of the control valve shown in Figure 1.

Figure 10 is a sectional view taken on line 10—10 of Figure 9.

Figure 11 is a circular timing diagram showing the sequence of events taking place in one pump for one revolution of the pump operating means.

The pump assembly is best shown in Figure 1. The assembly includes a two-part housing comprising an upper cylindrical pump housing 1, provided with an upper cap or head 3 and a lower cylindrical housing 5 provided with a lower cap 7 having a mounting flange 9 for support on a suitable bracket, not shown, provided on an internal combustion engine. Suitable studs 11 are shown extending through longitudinal holes in the caps and housings with nuts 13 on one end to hold these parts together. Suitable gaskets are provided between the housings and caps to prevent entrance of dirt into and leakage of fuel and lubricant out of these parts.

The upper pump housing is provided with an axial bore in which a valve sleeve 15 is pressed and six fuel pump cylinder bores parallel to and spaced equidistant around the axial bore. A pump cylinder sleeve 17 is pressed in each of the cylinder bores. In the upper end of each pump cylinder bore an inlet valve cage 19 is secured. This cage, as best shown in Figures 1 and 3, is provided with three fuel inlet openings 21 of large area and a seat on which an inlet valve 23 is biased by means of a spring 25. The spring permits the valve to move off its seat so that fuel enters the pumping space 27 below the valve at relative low velocity when the pressure therein is reduced below that of the pressure in an annular fuel inlet cavity 29 provided in the upper housing cap 3 into which the openings 21 in each

of the valve cages open, as best shown in Figures 1 and 3. Fuel is supplied under pressure through a fuel supply pipe 30 connnected between a fuel inlet opening 31 in the cap 3, shown extending downwardly into the annular fuel inlet cavity 29, and a suitable fuel supply pump and fuel tank, not shown. A perforated baffle 33 of cylindrical shape provided with a deflecting lip 35 extending part way around the fuel inlet opening 31 is included in the cavity 29 to divide it into outer and inner annular portions. The deflecting lip 35 causes the entering fuel to be directed downwardly into the bottom of the inner annular cavity portion and the fuel and any vapor therein flows upwardly and outwardly through the perforations in the baffle to the upper extremity of the outer annular cavity portion thereby causing a separation of the vapor from the fuel. Suitable interconnected venting passages 37, 39 in the cap 3 are shown in Figure 1 opening into these two annular inlet cavity portions. A restricted venting orifice 41 is included in the venting passage 37 and a return pipe 43 is connected to this passage for continuous return of any vapor and fuel to the fuel tank.

Each pump cylinder sleeve 17, as best shown in Figures 1 and 4 is provided with two axial and angularly spaced high pressure fuel delivery ports 44, 45 near the top and a by-pass or relief port 47 below the delivery ports. Each of the delivery ports open into a separate delivery passage in the pump housing 1. These delivery passages are indicated by the numerals 49 and 51. An outwardly opening check valve 53 is included in each of these passages, as best shown in Figure 4. Separate delivery pipes 55, 57 are connected to each of the delivery passages by packing nuts 59 and clamps 61 engageable with pairs of these nuts are provided to prevent loosening thereof. Each of these two delivery pipes leads from each pump cylinder to separate fuel injectors, not shown, adapted to be mounted in different working cylinders of an internal combustion engine, not shown, for injecting fuel into the cylinder combustion chambers. The fuel by-pass or relief port 47 in each pump cylinder sleeve 17 is connected by separate radially inwardly directed passages 62. Each of these passages opens into one of six by-pass ports or relief ports 63 spaced circumferentially 60 degrees apart in the valve sleeve 15. The valve sleeve is also provided with a drain port 65 opening into an annular cavity 67 in the housing bore around this sleeve. A drain passage 69, shown in Figure 6, extends radially outwardly from the cavity 67 and a pressure relief valve 70 is connected to the outer end of the passage 67 to maintain a predetermined pressure in this passage. The pressure relief valve discharge opening 71, indicated in Figure 2, is connected by a return pipe 72 to the fuel tank.

A pump plunger 73 is mounted for reciprocation in each cylinder sleeve 17. Each plunger, as best shown in Figure 1, is provided with an annular groove 75 which registers with the by-pass port 47 in each pump sleeve 17 for all positions of the plunger. Connecting diametral and axial passages 77, 79, provided in the plunger serve to connect the plunger groove with the pumping space 27 above the plunger. The plunger 73, as shown in Figure 1, is at the lower end of the filling stroke with the upper end thereof covering the lower fuel delivery port 45 in the pump cylinder 17. A rotary valve 81 in the sleeve 15 is driven in timed relation with the plungers 73 to prevent fuel flow through each by-pass port 47 at two points in the upward stroke of each plunger to cause delivery of fuel through the upper and lower delivery ports 44 and 45 successively and to open the by-pass port prior to and subsequent to each delivery to cause by-pass of fuel from and relief of pressure in each pumping chamber 27. The valve is movable axially in the sleeve to vary the duration of delivery and when moved to another position causes continuous by-pass and, therefore, no delivery from the pumping chambers.

The rotary valve 81, as best shown in Figures 1 and 9, is provided with an annular by-pass groove 83 in continuous register with the drain port 65 in the valve sleeve for all axial positions of the valve. As best shown in Figures 9 and 10 the valve is also provided with an undercut portion 85 adjacent the groove 83. This undercut portion extends 190° around the valve and the same depth of the groove 83, as best shown in Figures 9 and 10. Lands L1 and L2 are provided on the valve and are shown extending axially downward into the undercut portion 85. Each land is of identical shape, having inclined leading and trailing edges 87 and 89, respectively. The center lines of the lands L1 and L2 are spaced 90° apart. The center line of the leading land L1 is spaced 54½° behind the axial leading edge 90 of the undercut portion 85 and the axial trailing edge 91 of the undercut portion is spaced 51½° behind the trailing edge 89 of the trailing land L2. With the valve 81 in the uppermost position in the valve sleeve 15, as shown in Figure 1, the lower ends of the lands are flush with the upper edges of the relief ports 63 in the valve sleeve and these ports are not covered by the lands when the valve is rotated so that by-pass or relief of each pump cylinder is continuous for 196° of valve revolution so that no fuel is delivered by the plungers. This uppermost position of the valve is accordingly, the no fuel delivery or engine stop position of the valve. It will be evident that by moving the valve axially downwardly, the leading and trailing lands L1 and L2 will close off the by-pass ports each 90° of revolution of the valve. Due to the helical edges on the lands it will be evident that the farther the valve is moved downwardly in the valve sleeve the earlier the relief or by-pass ports in the sleeve are closed and, therefore, the earlier the start of fuel delivery by the pumps and also that the later the ports are opened or the later the fuel delivery ceases. In other words, the farther the valve is moved downwardly the greater the amount of fuel is delivered at two points in its lift or pumping stroke as determined by closure of the relief or by-pass port by the leading and trailing valve lands L1 and L2.

Axial movement of the valve 81 is accomplished by a gear 93 meshing with a rack 95 supported for movement in the cap 3. The rack is operably connected to the upper end of the valve 81 by a coupling 97 which permits rotation of the valve relative to the rock. The gear 93 is secured to a control shaft 98 rotatably mounted in the cap. The control shaft 98 is adapted to be connected to either the engine governor or to manual control means for varying the start and finish of fuel delivery from the pump and accordingly the amount of fuel delivery therefrom into the different engine cylinders connected to each pump.

The driving, lubricating and sealing means for the pump plungers, valve and operating means therefor is located in the lower housing 5. This means includes a hollow driving shaft 99 rotat-

ably mounted in bushings 101 and 103 supported in an axial bore in the lower housing 5 and cap 7. A cam plate 105 for operating the plungers 73 is secured to the shaft 99 and a ball thrust bearing 107 is placed between the cam plate 105 and lower cap 7. As will be subsequently described, the cam plate is provided with cam surface 109 having a 172° lift followed by a 20° dwell and a 158° fall followed by a 10° dwell for operating plunger cam followers 111. Each plunger cam follower is provided with a cam follower roller 113 and the plunger is slidably mounted in a bore in the lower housing 5 in alignment with a cylinder sleeve 17. A compression spring 115 is shown placed between the lower end of each cylinder sleeve and a shoulder on the lower end of each plunger 73 to urge it downwardly into contact with the lower end of a counterbore in each cam follower to hold the roller thereon in contact with the cam surface 109.

The valve 81 is driven in timed relation with the cam plate by a torsionally resilient shaft 117 located within the hollow shaft 99 and supported on an internal shoulder 119 therein and connected by means of a key 121 to the shaft 99.

The upper end of the shaft 117 has a hexagonal socket 123 secured thereto and a stub shaft 125 having hexagonal portions thereon, which portions are engageable with the socket 123 on the shaft 117 and another hexagonal socket 127 secured in a recess in the lower end of the valve 81. The driving means for the valve comprising the resilient shaft and stub shaft and socket members provides a torsionally resilient cushion drive for the valve and permits misalignment between the valve and hollow shaft and also permits axial movement of the valve with respect to the stub shaft 125 and valve sleeve 15.

The lower end of the hollow shaft 99 is provided with external splines shown extending downwardly through a lubricating pump chamber 129 provided in the lower housing cap 7 and outwardly through an opening in a closure member 131 secured to the lower cap 7 and forming the lower face of the lubricating pump chamber. A driving gear 133 having an internal spline is slidable on the lower splined end of the shaft 99 and is held thereon by a nut 135 threaded in the gear and slidable over the lower threaded end of the resilient shaft 117 on which a nut 137 is threaded to hold the nut 135 in contact with the end of the shaft. An oil seal 139 is provided between a recess in the closure member and the outer surface of the hub of the driving gear to prevent oil leakage between these members.

The fuel pump and valve mechanism, described above, is oil pressure lubricated to prevent wear and to prevent fuel leakage and dilution of the lubricating oil. As best shown in Figure 5 an oil pump driving gear 141 is located in the lubricating pump chamber and splined on the driving shaft 99. The gear 141 meshes with a pump idling gear 142 rotatably mounted in the pump chamber 129. Connecting oil pressure supply inlet passages 143, 145 and 147 for the pump chamber 129 are provided in the lower housing, lower cap and closure member, respectively, as best shown in Figures 5 and 7. A pressure outlet passage 149 is provided in the lower cap leading from the pump chamber 129 and an adjustable pressure regulating valve 151 is connected to the outlet passage and is provided with a suitable by-pass passage 153, extending upwardly to the interior of the lower housing. The passage 153 is opened by the spring biased piston 154 to regulate the pressure in the outlet passage 149. Connecting lubricating supply passages in the lower cap and housing and upper cap indicated at 155, 157, 159, 161, 163 and 165 lead from the lubricating pump pressure outlet passage to holes in the shaft bushings 101 and 103 and to the side wall of each plunger 73 and to the space above the valve through a restricting orifice 167. The upper and lower end surfaces of the valve 81 are shown provided with external helical grooves for conveying oil from the ends of the valve toward the annular groove 83 in the valve. Leakage of oil from between the above parts falls by gravity on the cam follower guide rollers 113, cam plate 105 and thrust bearing 107. Excess oil in the interior of the housing is drained off through an overflow or outlet opening 169 in the housing, as best shown in Figure 8.

It has been found desirable to supply oil under pressure to the inlet passage 143 in the lower housing from the engine oil pump and to connect the overflow opening 169 to the engine sump.

The operation of the fuel injection pump is as follows: With the engine running fuel under pressure is supplied through the inlet pipe 30 to the fuel cavity 29 and is directed by means of the baffle 33 so that any vapor is separated from the fuel and the vapor and excess fuel is returned to the fuel tank through the return pipe 43 as previously described.

As previously explained the cam surface 109 on the cam plate 105 causes reciprocation of the plungers 73 and the valve 81 is connected to the cam plate by the torsionally resilient shaft 117 for rotation thereby.

The operation of each pump is the same and the events occurring in one revolution of the cam plate 105 and valve 81 occur at 60° intervals as the axes of the six pumps are spaced 60° apart around the valve. The operation of each pump will be better understood by reference to the timing diagram shown in Figure 11. At the 0° line on the diagram the plunger is at the bottom of its filling stroke and fuel has entered and completely filled the pumping space 27 above the plunger through the unseating of the fuel inlet valve 23 due to the reduction in pressure in the pumping chamber below that in the fuel cavity 29 in which any vapor therein is separated and returned to the tank. It will be noted that the plunger reached the bottom of the filling stroke at the start of the 10° dwell of the cam surface at the end of the fall of cam surface at the 350° line of the diagram and that the valve relief port 63 was opened at point A or 356° on the diagram by passage of the axial leading edge 90 of the valve 81 past the port 63. Following the diagram in the clockwise direction from the zero line, the lift of the cam surface causes upward movement of the plunger on the delivery stroke. As the by-pass or relief port 63 of the valve is opened at this time, fuel will be by-passed from the pumping chamber 27 through the pump cylinder by-pass or relief port 47, passage 62, valve sleeve by-pass or relief port 63 and past the relief portion 85 of the valve between the leading axial edge 90 and leading land on the valve and valve groove 83 and back to the fuel tank through the valve sleeve drain port 65, cavity 67 and passage 69, and past the pressure relief valve 70 to the fuel return pipe 72. By-pass of fuel from the pumping chamber continues until the leading inclined edge 87 of the leading valve land L1 closes off the cylinder sleeve by-pass or relief port 63. This occurs at point B or 38° on the diagram, with the valve in the lowest position corresponding to the maximum fuel delivery po-

sition. Upon closure of the port 63 in this manner the fuel trapped in the pumping space is then delivered under pressure by upward movement of the plunger through the upper cylinder delivery port 44 causing the check valve 53 in the delivery passages 44, 49 to be unseated and delivery of fuel through the pipe 57 to the fuel injector in one engine cylinder. Delivery and injection of fuel to this engine cylinder continues as long as the leading valve land L1 covers the relief or by-pass port in the valve sleeve. As shown in the diagram maximum fuel delivery through the upper cylinder port takes place with the valve in the lowest position in which the earliest start and latest finish of delivery or injection occurs. Upward movement of the valve retards the start and reduces the finish of delivery and no fuel is delivered when the valve lands are moved upwardly to prevent closure of the by-pass or relief port. For maximum fuel setting of the valve the trailing edge 89 of the leading valve land L1 starts to uncover the valve by-pass or relief port 63 at point C or 63° on the diagram to relieve the pressure in the pump chamber through the above described ports and passages in the valve, the high pressure being relieved to the fuel tank. It will be noted that maximum delivery of 25° of cam plate revolution is provided. Shortly after the opening of the by-pass port, at point D or 65° on the diagram, the plunger starts closing the upper delivery port 45 and at point E or 83° on the diagram starts opening the lower delivery port 44. Further upward movement of the plunger causes by-pass of fuel to the fuel tank until the plunger closes the upper delivery port at point F or 108° on the diagram and the inclined leading edge 87 of the valve trailing land then closes off the valve by-pass or relief port at point G or 128° on the diagram. This causes the fuel pressure to rise in the pumping chamber and the open lower delivery port to a value sufficient to unseat the check valve 53 in the delivery passages 44, 49 leading from the lower delivery port. Fuel is then delivered through this port and these passages through the plunger passages 77 and 79 and delivery pipe 55 to another engine cylinder fuel injector. With the valve in the maximum fuel position delivery through the lower delivery port also continues for 25° of revolution of the cam plate or until the inclined trailing edge 89 of the trailing land L2 starts to uncover the by-pass or relief port at point H or 153° line of the diagram. The pressure in the pump cylinder is accordingly relieved in the same manner as previously described and fuel delivery or injection to the second engine cylinder ceases.

On account of the 20° dwell following the lift of the cam surface the plunger is held in the upper end of the delivery stroke and is then caused to be moved downwardly on the filling stroke by the spring 115, due to the fall in the cam surface beginning at point I or 192° on the diagram, at which point the axial trailing edge 91 of the valve closes off the valve by-pass or relief port. The plunger in moving downwardly decreases the pressure in the pumping chamber below the value maintained in the fuel cavity and the fuel inlet valve 23 is accordingly unseated by this difference in pressure and fuel enters and completely fills the pump chamber. The filling stroke ends at the 0° mark on the diagram as previously explained and the upper delivery port is opened at point J or 260° and the lower delivery port is closed at point K or 268° on the diagram by this downward movement of the plunger on the filling stroke to complete the cycle.

I claim:

1. A fuel injection pump comprising a cylinder having an automatic fuel inlet valve, axially spaced delivery ports, and a fuel by-pass and relief port spaced axially therefrom, a plunger reciprocable in the cylinder and having a control surface adapted to open and close each delivery port each stroke of the plunger, and a valve operated in timed relation with said plunger and adapted to shut off said by-pass and relief port during the inlet stroke of the plunger to cause opening of the fuel inlet valve and to open and close the by-pass or relief port during the pumping stroke so that fuel is by-passed from the cylinder prior to and pressure is relieved subsequent to delivery of fuel through each delivery port at different points in the delivery stroke of the plunger.

2. A fuel injection pump comprising a cylinder having a fuel inlet check valve, delivery ports and a by-pass and relief port spaced apart axially, a plunger reciprocable in said cylinder and having a control surface adapted to uncover each delivery port each stroke, and a valve rotating in timed relation with said plunger having a control surface adapted to close off the by-pass and relief port during the inlet stroke of the plunger to cause opening of the inlet valve, said valve being axially movable relative to the by-pass and relief port and having lands provided with inclined edges adapted to open and close said port during the delivery stroke of the plunger in order to control the amount of fuel delivered through each delivery port.

3. A fuel injection pump including a fuel inlet cavity, inlet and return openings in the cavity and means in the cavity for directing and separating vapor from the entering fuel and for causing the vapor to pass out through the return opening, a pump cylinder having an inlet check valve connected to the cavity, said cylinder having a plurality of delivery ports and a relief port spaced apart axially, a plunger having a control surface adapted to open and close each delivery port each stroke of the plunger, a valve rotated in timed relation with said plunger and axially movable with respect to the relief port, said valve having a control surface adapted to close off the relief port during the inlet stroke of the plunger and valve lands having inclined leading and trailing edges adapted to be moved axially with respect to the relief port to close off said port for different intervals of time during the pumping stroke of the plunger so that the amount of fuel delivered through each delivery port may be accurately controlled.

4. A fuel injection pump including an inlet fuel cavity, a pressure supply connection and a vent connection to said cavity, fuel flow directing means in said cavity between said connections to cause separation of vapor from the entering fuel and to cause continuous venting of vapor from the upper portion of the cavity, a plurality of pump cylinders, a fuel inlet connection including an inlet check valve between the fuel inlet cavity and each cylinder, each cylinder having two delivery ports and a relief port spaced axially apart, a plunger reciprocable in each cylinder, each plunger having a relief groove communicating with the working face of the plunger, said groove registering with the relief port for all positions of the plunger and the surface between the groove and working face adapted to open and

close each delivery port each stroke of the plunger, means for reciprocating the plungers in timed relation, and a valve operating in timed relation with the plunger reciprocating means, said valve having control surfaces cooperating successively with each of the cylinder relief ports to cause closure of each during the inlet stroke of the plunger and to open and close each of said ports when each of the delivery ports of each cylinder is opened by movement of a respective plunger at different points in the delivery stroke in order to control delivery of fuel out of each cylinder delivery port.

5. A fuel injection pump comprising a housing having a fuel cavity provided with fuel inlet and return openings, means in the cavity for changing the direction of fuel flow between the cavity openings in order to cause separation of vapor from the fuel and passage of vapor outwardly through the return opening, a plurality of pump cylinders, each having an inlet check valve opening into the fuel cavity and separate delivery ports and a relief port spaced apart longitudinally, a plunger in each cylinder having a relief groove in continuous register with the relief port and communicating with the working face of the plunger, and a surface adjacent the working face, said surface and said groove cooperating with the delivery ports to cause each to be opened and closed each stroke of the plunger, means for reciprocating the plungers in timed relation, and a control valve rotatable in timed relation with the plungers and slidable axially in the housing, said valve having an undercut portion in register with a housing relief passage and control edges for opening and closing each of said cylinder relief ports when each of said delivery ports are opened to control the amount of fuel delivery therethrough.

6. A fuel injection pump comprising a housing having a fuel cavity provided with fuel supply and return openings and pump cylinder openings, an inlet check valve between each cylinder opening and the fuel cavity, a perforated baffle in the cavity for controlling the flow of fuel between the inlet and return openings in order to cause the separation of any vapor from the fuel and the passage of vapor outwardly through the return opening, each of said cylinder openings having axially spaced delivery ports and a relief port, a plunger in each cylinder having a control surface and relief groove adjacent the working face and passages extending from the groove and face, said surface and groove cooperating with the delivery ports to cause each to be opened and closed each stroke of the plunger, means for reciprocating the plungers in timed relation, a valve rotatable in timed relation with the plungers and capable of axial movement in said housing, said valve having an undercut portion with axial and inclined edges cooperating with each of said cylinder relief ports successively and with a relief passage in the housing when each of said cylinder delivery ports are opened by movement of each of said plungers on the delivery stroke to cause delivery of fuel through each of said cylinder delivery ports, and means for displacing said valve axially in the housing to present different portions of the inclined control edges to the cylinder relief ports in order to vary the start and finish of delivery and the amount of fuel delivered through each of said cylinder delivery ports.

7. A fuel injection pump comprising a housing having a fuel cavity provided with fuel supply and return openings and a plurality of pump cylinder openings leading therefrom, each cylinder opening having an inlet check valve therein, a perforated baffle in the cavity for directing the fuel in different directions to cause separation of any vapor from the fuel and the return of vapor and fuel through the return opening, each of said cylinder openings having a plurality of fuel delivery ports and a relief port spaced apart longitudinally, a plunger in each cylinder forming a pumping chamber adjacent the inlet valve and having a relief groove adjacent the working face of the plunger registering with the cylinder relief groove and passages between the groove and face whereby each delivery port is opened each stroke of the plunger to the pumping space, a relief valve, rotatable and slidable axially in the housing, having an undercut portion provided with axially leading and trailing edges and leading and trailing lands with inclined edges extending into the relief portion, said undercut valve portion communicating with a relief passage in the housing, including a pressure operated relief valve, said rotatable relief valve communicating successively with each of said cylinder relief ports when each of said delivery ports are opened to the cylinder pumping chamber, and means for moving said relief valve axially in the housing to cause the valve lands to close each of said cylinder relief ports for different intervals of time thereby controlling the start and finish of fuel delivery from each of said cylinder delivery ports.

8. A fuel injection pump comprising a housing having a fuel cavity provided with fuel supply and return openings and a plurality of cylinder openings, each cylinder opening having an inlet check valve therein, a baffle in the cavity for reversing the flow of fuel between the inlet and return openings to cause separation of vapor from the fuel and passage to vapor and fuel outwardly through the return opening, each cylinder opening having a plurality of delivery ports and a relief port spaced apart axially, a plunger in each cylinder forming a pumping space therein adjacent the inlet valve, each plunger having a relief groove adjacent the working face registering with a plunger relief port and passages between the groove and the face adjacent the pumping chamber so that each cylinder delivery port is opened to the pumping chamber each stroke, rotatable cam means for reciprocating the plungers in timed relation, a relief valve mounted for rotation and axial movement in said housing equidistant from each cylinder opening, torsionally resilient telescopic driving means between said cam means and said valve, said relief valve having an undercut portion with axial leading and trailing edges and leading and trailing lands with inclined edges extending into the undercut portion cooperating with a relief passage in the housing and each of said cylinder relief ports when each of said delivery ports are uncovered, and means for controlling the axial displacement of said relief valve to vary the amount of fuel delivered through each cylinder delivery port for different positions of the plunger on the delivery stroke.

9. A fuel injection pump comprising a housing including a fuel cavity provided with fuel supply and return passages, fuel delivery passages, a fuel relief passage including a pressure operated relief valve, a lubricating pump, and lubricating pressure passages including a pressure relief valve and lubricating leakage and supply passages, a plurality of cylinder openings including

inlet check valves communicating with the fuel cavity and delivery ports communicating with the delivery passages, and a relief port, a plunger in each cylinder cooperating with the delivery and relief ports, a relief valve rotatable and axially movable in the housing cooperating with the cylinder relief ports and a housing relief passage, means for driving the plungers, valve and lubricating pump in timed relation, control means for moving said relief valve axially to control fuel delivery from each pump cylinder delivery port, said lubricating pump supplying oil under pressure to each of said plungers, said valve and said valve control means, said valve having helical grooves for causing fuel and lubricant to be displaced toward the fuel relief opening in the housing and the oil leaking from said

plungers, valve and valve controlling means lubricating said driving means before entering said lubricating pump.

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