April 30, 1957 R. L. SHALLENBERG ET AL 2,790,432

FUEL INJECTION PUMP

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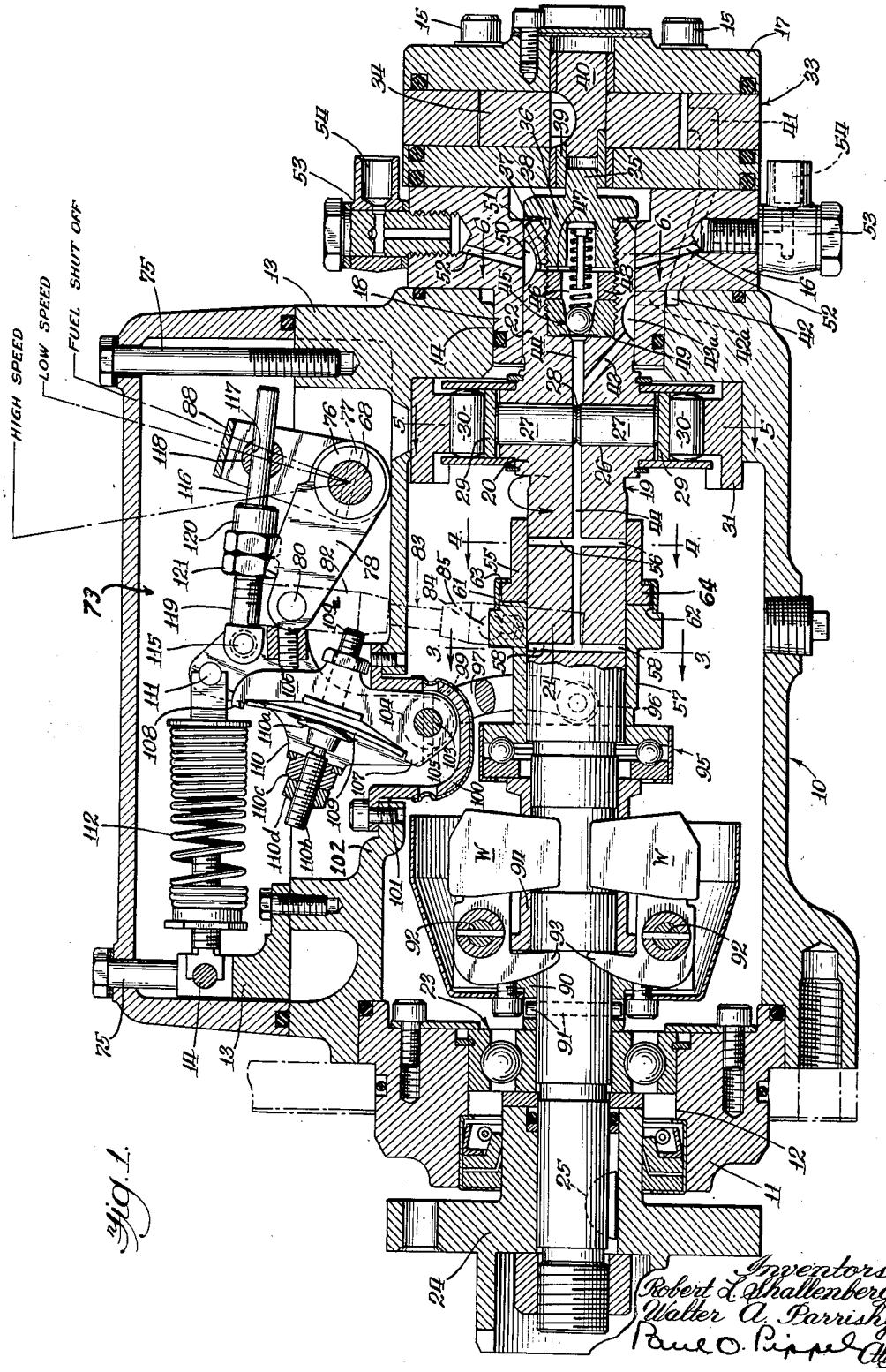


Fig. 1.

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Fig. 2.

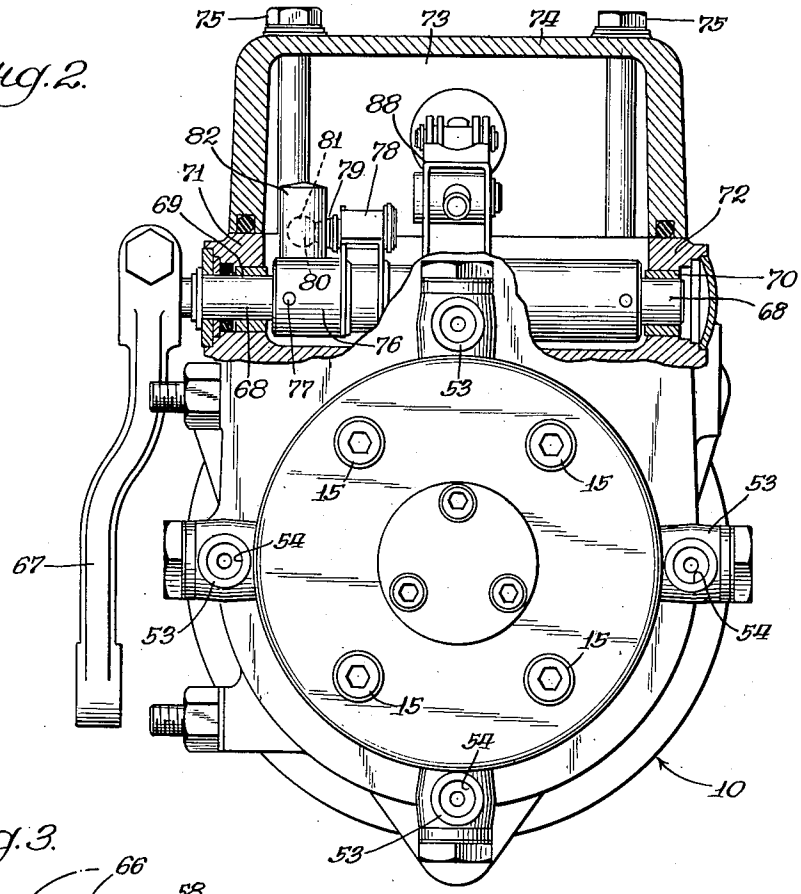


Fig. 3.

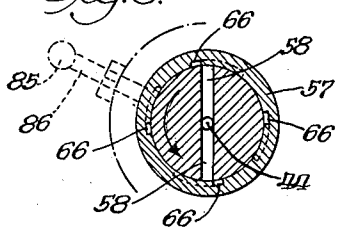


Fig. 4.

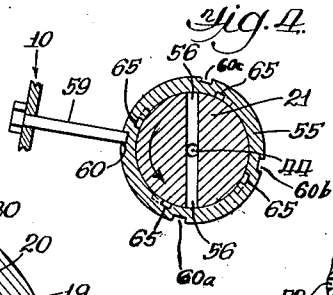


Fig. 6.

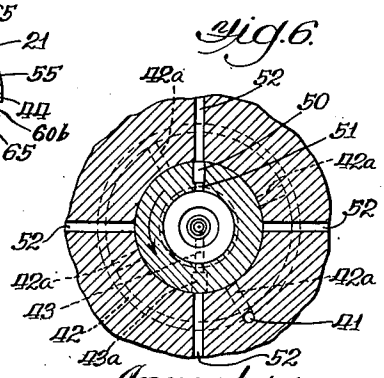
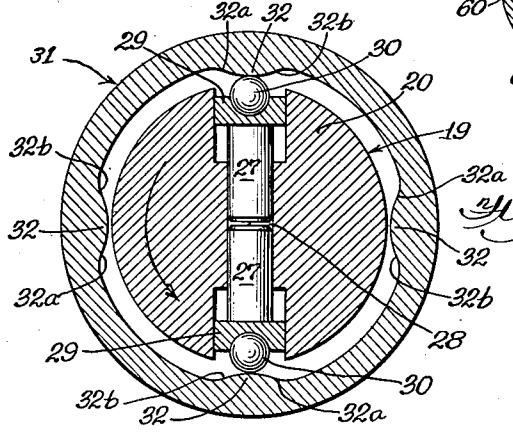


Fig. 5.



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FUEL INJECTION PUMP

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Application December 17, 1954, Serial No. 475,979
9 Claims. (Cl. 123—139)

This invention relates to fuel pumps for multicylinder internal combustion engines and more particularly concerns a pump having a rotor structure with a high pressure distributor port which successively registers with fuel line ports respectively communicating with the combustion chambers of the engine, the rotor structure also containing a pumping portion which delivers a measured quantity of fuel under pressure to the distributor port concurrently with each registration thereof with a fuel line port, and the rotor structure also including a metering and timing portion in control of the pump portion to determine the quantities of fuel delivered and the time that the delivery commences. This invention is an improvement over U. S. Patent 1,772,828 to F. Egersdorfer.

An important object of this invention is the provision of a fuel injection pump of the above character wherein the fuel distributing portion of the rotor structure is at one end of the pumping portion and the fuel metering and timing portion is at the other end of the pumping portion. This arrangement improves the space factor of the parts of the pump inasmuch as the pulsating chamber of the pump can communicate in opposite axial directions respectively with the distributing portion and the metering and timing portion, and manual and speed responsive control means for the metering and timing portion of the rotor structure can be assembled with respect thereto without interference with or from parts of the distributing portion.

A further object is the provision of a rotor structure wherein the pumping portion contains a transverse bore for radially opposed pistons actuated by an internally lobed annular cam surrounding the pump portion of the rotor structure.

A further object of this invention is the position of a pump rotor structure wherein the pump chamber communicates with the distributor portion and with the metering and timing portion by an axial bore which has a radially opening spill port controlled by an internal groove within a sleeve about the rotor structure to communicate with this port and allow the spilling of fuel therefrom after a selectable interval of pump stroke to terminate fuel delivery and thus effect metering under high pressure, and the axial bore within the rotor structure also having a timing port controlled by a similar sleeve of which the internal groove is adjustable with this sleeve to terminate registration of the timing port therewith at selectable times to determine when bypass of fluid therethrough from the pump shall cease and pumping stroke of the pump become effective for developing injection pressure within the fuel.

A further object is the provision of metering and timing sleeves of the aforesaid character wherein the internal grooves are directed helically about the axis of the rotor to adapt the sleeves to respectively change the quantity of fuel pumped and the timing of the pumping responsively to change in the axial positions of these sleeves as well as the rotative position of the metering sleeve.

The above and other desirable objects inherent in and encompassed by the invention are eluciated in the ensuing specification, the appended claims and the annexed drawings, wherein:

Fig. 1 is a sectional view taken through the casing of a preferred embodiment of the invention, the view being longitudinally of the pump rotor structure and showing parts in section other than the casing, and portions of some parts being broken away for clarity;

Fig. 2 is an end view of the pump looking at the end disposed to the right in Fig. 1, there being a portion of the upper part of the casing broken away to expose parts of the control shaft and linkage for the pump;

Fig. 3 is a transverse sectional view taken at the line 3—3 of Fig. 1 through the metering portion of the rotor structure and through the fuel metering sleeve encircling this portion of the rotor structure, the view also illustrating in dot dash lines an arm extending radially from the sleeve and rigidly assembled therewith for imparting manual rotative adjustment to the sleeve;

Fig. 4 is a view taken similarly to Fig. 3 through the timing ports and timing sleeve of the pump, this view being at the position indicated by the line 4—4 in Fig. 1;

Fig. 5 is a transverse sectional view taken on the line 5—5 of Fig. 1 through the pump portion of the rotary structure and through a fixed annular cam internally lobed for operating pistons of the pump;

Fig. 6 is a transverse sectional view taken at the section indicated by the line 6—6 in Fig. 1 through the distributor portion of the pump.

Referring now to Fig. 1 the pump will be seen to comprise a casing generally indicated **10**. This casing has a left end wall **11** containing an opening **12**. A right end wall **13** of the casing has an opening **14** coaxial with the opening **12**. Four recess-headed cap screws **15** shown in Figs. 1 and 2 extend through and are employed for mounting a distributor head **16** and a gear pump casing **17** onto the exterior side of the end wall **13**. A tubular extension **18** of the distributor head **16** extends into the opening **14** of the end wall **13** wherein such extension is piloted.

A rotor structure **19** has an enlarged pumping portion **20**, a metering and timing portion **21** at the left end of the pumping portion **20**, and a distributing portion **22** at the opposite or right end of the pumping portion. The left end of the rotary structure is journalled in a ball bearing unit **23** mounted within the left end casing wall opening **12** whereas the right end portion of the rotor structure is journalled within the tubular extension **18** of the distributor head **16**. A sliding sealing relation exists between the cylindrical outer periphery of the distributor portion **22** of the rotor structure and the cylindrical inner periphery of the distributor head **16** and extension **18**. The rotor structure **19** is continuously driven by a drive shaft or coupling member **24** keyed at **25** to the left end of such structure.

The pumping portion of the rotor structure as illustrated in Figs. 1 and 5 includes a diametric bore **26** in which radially opposed pistons **27** are reciprocated in timed relation so as to be simultaneously moved toward one another into their most radially inward positions illustrated in Figs. 1 and 5 alternately with being simultaneously moved apart radially outwardly, so as to alternately contract and expand a pumping chamber **28** formed within the bore **26** between the opposed inner ends of these pistons. Each piston has an outer tappet **29** wherein there is journalled a roller **30** adapted to rotate about the inner periphery of an annular cam member **31** mounted non-rotatively within the casing **10**. There are four internal lobes **32** within the cam for causing the pistons **27** to perform four cycles of expansion and contraction of the pumping chamber **28** during each revolution of the rotor structure **19**.

Fuel is delivered to the pump through an inlet (not shown) to the fuel feed pump **33** including the above

mentioned casing 17 and pumping gears 34 of which one is shown in section in Fig. 1. This gear 34 shown in Fig. 1 is driven continuously with the main pump rotor structure 19 through a non-circular axial projection 35 of a screw plug 36 threaded at 37 into a threaded recess 38 in the right end of such rotor structure, thence through a tubular coupling member 39 and a hub member 40 for the gear 34. This feed pump including the gear 34 is adapted to deliver liquid fuel at a constant nominal pressure, 50 pounds per square inch, for example, into an inlet passage 41 which leads from the pump casing 17 through the distributor head 16 into an annular channel 42 formed in the outer face of the end wall 13 of the main casing 10. The inlet passage 41 is also shown in Fig. 6 as is the annular channel 42 and four radial passages 42*a* which lead inwardly from the channel 42 through the tubular hub of the distributor. These radial passage portions 42*a* are spaced apart 90° about the axis of the rotor structure and are successively communicated with by an outer end portion or port 43*a* of a radial inlet passage 43 in the rotor structure. Radial inlet passage 43 communicates with the pump chamber 28 through a portion of an axial rotor passage 44. The circumferential orientation of the radial inlet passages 42*a* with respect to the cam lobes 32 of the main pump is such that the inlet port 43*a* registers with a succeeding one of such passages 42*a* each time the pump chamber 28 is expanded pursuant to the tappet rollers descending a trailing profile portion 32*a* of the cam lobes 32; see Fig. 5. The roller tappets 30 force the pistons 27 together for contracting the pump chamber 28 each time these rollers ascend the approach profiles 32*b* of a pair of diametrically opposed cam lobes 32.

Normally during operation of the device, that is, when the device is set for delivering fuel, contraction of the pump chamber 28 forces fuel rightward through the passage 44 past a delivery check valve 45 into the chamber 46 of such valve which includes an annular groove-like space 47 between the inner end of the screw plug 36 and an opposed end of an annular ring 48 screwed into the threaded portion 37 against a valve seat member 49. An outlet port 50 of the distributor portion 22 communicates with radial outlets 52 of which there are four in number spaced equidistantly and radiating through the distributor head 16. These radial passages 52 communicate at their outer ends with couplings 53 of which each has a recess 54 for receiving the end of a respective fuel line leading to an engine upon which the device is adapted to be mounted. Couplings 53 all appear in Fig. 2. The radial passages 52 of the distributor head 16 as shown in Fig. 6 are so oriented circumferentially at the rotor axis with respect to the internal cam lobes 32 of the annular cam 31 that the distributor outlet port 50 registers with a respective one of such passages 52 during each contraction of the pumping chamber 28.

The metering and timing portion 21 of the rotor structure carries a timing sleeve 55 cooperative with ports 56 of the axial passage 44 to determine the time during the contraction period of the pump chamber 28 that fuel delivery commences past the delivery check valve 45 of the combustion chambers of the engine. A metering sleeve 57 controls the time that fuel can spill outwardly through a metering or spill port 58 to terminate delivery from the contracting pumping chamber 28 past the delivery valve 45 and thereby determine the quantity of fuel pumped attendant to each injection impulse. Timing sleeve 55 can move only axially of the rotor structure because of being constrained against rotation by a casing-mounted pin 59 which projects into an axial groove 60 in the outer periphery of such sleeve; see Fig. 4. Metering sleeve 57 is adapted to rotate as well as move axially on the rotor metering portion 21. A coupling band 61 for connecting the control sleeves 55 and 57 for axial movement in unison while permitting relative rotation by sleeve 57 is press fitted on a shoulder 62 of sleeve 57 and has an in-turned flange 63 hooking over flange 64 of the sleeve 55.

Each of the control sleeves 55 and 57 has a sliding sealing fit at its inner periphery with the cylindrical outer periphery of the control or metering and timing portion 21 of the rotor structure excepting for that portion of the periphery of the control portion 21 which registers with internal grooves within the sleeves 55 and 57. Timing sleeve 55 has four generally axial helical grooves 65 within its inner periphery. Each of these grooves communicates with the right end of the sleeve 55 as viewed in Fig. 1 so that when any of the grooves is in registry with the timing ports 56 fuel can escape through these ports and the registered groove 65 to prevent the development of enough fuel pressure in the pump chamber 28 for forcing fuel past the delivery check valve 45. These internal grooves 65 are so oriented circumferentially of the rotor axis with respect to the cam lobes 32 of the piston pump that the timing ports 56 are in registration with a pair of the diametrically opposite grooves 65 when the pump chamber 28 begins contraction. Consequently injection cannot commence until the rotor has rotated far enough to carry the timing ports 56 out of registration with these timing grooves. Thus timing or the beginning of injection can be varied by moving the timing sleeve 55 axially. With the spiral grooves 65 having the direction of pitch illustrated in Fig. 4, axial movement of the timing sleeve 55 to the right as viewed in Fig. 1, while the rotor structure rotates in the direction indicated by the arrow in Fig. 4, will cause the timing ports 56 to depart from partial registration with the grooves 55 nearer the beginning of the compression or contraction phase of the pump chamber 28 and thus advance the timing. Axial adjustment of the timing sleeve 55 is under control of a governor device which will be explained later.

It will be noted there are four exterior axial grooves 60, 60*a*, 60*b*, and 60*c* in the timing sleeve 55. Each of these grooves is adapted to cooperate with the constraining pin 59 and they are selectively placeable in cooperative relation with the pin 59 attendant to retraction of such pin endwise and advancement thereof into any one of these grooves which is placed in registration thereof attendant to rotation of the sleeve 55 upon the rotor portion 21. The grooves 60, 60*a*, 60*b* and 60*c* are progressively spaced circumferentially of the sleeve 55 in a graduation of different amounts with respect to the location of the grooves 65 circumferentially of such sleeve. Therefore by placing different of these exterior grooves in cooperative relation with the pin 55 the timing range of the internal timing grooves 65 can be adjusted as desired.

The internal spiral grooves 66 of the metering sleeve 57 are so disposed circumferentially of the rotor structure axis, while this sleeve is set to cause fuel delivery by the piston pump, that such grooves are out of registration with the metering or spill ports 58 at the time the pumping chamber 28 commences its compression or contraction. At a later time during continuation of the contraction of the pumping chamber the ports 58 arrive in registry with a pair of diametrically opposite internal grooves 66 to allow the fuel to spill from the contracting pumping chamber outwardly through the ports 58 and the grooves 66 to the left end of the metering sleeve 57 as viewed in Fig. 1. This excess fuel simply spills into the pump casing 10. Thus the casing 10 acts as a sump for spilled fuel, and a conduit, not shown, leads from the casing 10 through a filter back to the inlet for the feed pump which includes the gear 34.

In Fig. 3 it will be noted that the spiral pitch of the metering grooves 66 is such that rocking adjustment of the sleeve 57 counterclockwise as viewed in Fig. 3 will cause the spill ports 58 to arrive in registry with the grooves 66 at a later time wherefore the pumping period of the piston pump is increased to cause a greater quantity

of fuel to be pumped for injection through the delivery passages 52 of the distributor 16. Thus by changing the rotative position of the metering sleeve 57 the quantity of fuel delivered by the piston pump for delivery to the combustion chambers can be selectively varied.

Also it will be noted in Fig. 3 that the spiral pitch of the metering grooves 66 is such that axial movement of this sleeve to the right as viewed in Fig. 1 will enable the spill ports 58 to arrive in registry with the grooves sooner and thereby correspondingly diminish the amount of fuel pumped per stroke of the pistons 27.

Manual rotative setting of the metering sleeve 57 is obtained by the use of a manually settable lever 67, Fig. 2, which is mounted non-rotatively upon a cross shaft 68. End portions of the shaft 68 are mounted within bearings 69 and 70 in opposite walls 71 and 72 of a control compartment on the upper side of the casing 10. A cover cap 74 of the compartment 73 is removably held in place by long cap screws 75. A sleeve 76 is held non-rotatively upon the cross shaft 68 by a pin 77. An arm 78 fixed upon the sleeve 76 has a cross pin 79 in its end portion remote from the sleeve 76, and this cross pin 79 has a spherical end portion 80 universally pivoted within a spherical socket 81 within a head 82 constituting the upper end portion of a turn-buckle-type link 83. Link 83 is indicated in phantom in Fig. 1 by dot dash lines. A similarly socketed lower end member 84 of the link 83 universally pivotally receives a spherical end portion 85 of an operating stem 86 anchored in and projecting radially outwardly from the metering sleeve 57. Rocking of the cross shaft 68 by the manually operated lever 67, Fig. 2 causes swinging of the arm 78, Fig. 1, to raise or lower the link 83 which is operable through the stem 86, Fig. 3, for selectively changing the rotative position of the metering sleeve 57 and thus changing the amount of fuel delivered by the piston pump to the engine combustion chambers.

A second arm 88, projecting upwardly from the sleeve 76 and constrained against rotation relatively thereto has a center line projecting upwardly to a position designated "Low Speed" which indicates that the manual control lever 67 is at this time in a position causing the metering sleeve 57 to be in a rotative position causing the engine to operate at "Low Speed." Manual lever 67 can be operated for rotating the shaft 67, the sleeve 76 and the arm 88 to the position designated "Fuel Shut-off." Attendant to this setting the metering sleeve 57 will be rotated sufficiently far clockwise as viewed in Fig. 3 to cause the spill ports 58 to register with diametrically opposite of the grooves 66, at all axial positions of the sleeve 57, before the timing ports 56 have moved out of registry with the timing grooves 65 within the timing sleeve 55. Consequently when the control is adjusted into the "Fuel Shut-off" position the piston pump is effective for pumping fuel outwardly only through the spill ports 56 and 58 so that no fuel can be delivered past the delivery check valve 45. By adjusting the manual control lever 67 until the lever 88 is moved into the "High Speed" position, the metering sleeve 57 will be rotated sufficiently far counterclockwise, Fig. 3, that any axial position of the sleeve attained responsive to engine speeds not exceeding rated speed, sufficient fuel will be delivered by the piston pump for operating the engine at substantially rated load.

The speed and torque load upon an engine to which fuel is delivered by the present device is controlled by that portion of the device now to be described. A left end portion of the rotor structure 19 has an inertia weight carrier 90 mounted thereon and constrained for rotation therewith by a pin 91. Pivot pins 92 on the carrier 90 pivotally carry centrifugal weights W having respective toe portions 93 which bear against the left end of a sleeve 94, Fig. 1, to shift this sleeve rightward upon the rotor structure 19 attendant to the shaft rotating fast enough to cause the weights W to swing radially outwardly from the shaft or rotor structure. Axial force is transmitted from the sleeve 94 to the metering sleeve 57 through a ball bearing unit 95. A pair of rollers 96, one being shown in dotted lines in Fig. 1, are respectively upon the furcations of a forked lever 97, and these rollers 96 bear against a radial flange 98 of the metering sleeve 57, which flange also forms a race of the ball bearing unit 95. The upper end of the lever 97 projects through an opening 99 of a cup-like member 100 depending downwardly through an opening 101 in the upper wall 102 of the casing 10. This cup-like wall member 100 journals a shaft 103 upon which a hub 104 of the lever 97 is mounted and constrained against relative rotation by a pin 105. Also constrained for rotation with the hub 104 of the lever 97 is a torque spring holder member 106 having end portions 107, 108 between which a leaf spring 109 is suspended. An adjustable stop member 109*a* upon the spring holder 106 limits the distance the torque spring 109 may be bowed in the direction of bowing illustrated in Fig. 1.

A lever 110 shown partially behind the torque spring holder 106 in Fig. 1 is pivotally mounted at its lower end upon the shaft 103. The upper end of this lever carries a pin 111 through which this lever is adapted to exert compressive force against a helical governor spring 112 having its left end pivotally connected with a casing-mounted bracket 113 by a pivot connection 114. A second pivot pin, 115, in the upper end of the lever 110 pivotally mounts the left end of a rod 116 which projects slidably through a bore 117 of a cross pin 118 pivotally mounted in the lever 88. A threaded portion 119 of the rod 116 has an internally threaded stop member 120 mounted thereon for abutment against the cross pin 118 during certain conditions of operation, and the axial position of the stop member 120 upon the rod 116 is maintained by a lock nut 121.

Counterclockwise pivoting of the torque spring carrier 106 with the forked lever 97 and the shaft 103 carries a mid-portion of the torque spring 109 against a head 110*a* of a threaded stem 110*b* rotatively and axially adjustable within an internally threaded member 110*c* comprising an element of the lever 110 thus establishing a yieldable connection between the pivoted leaf spring carrier 106 and the lever 110. A lock nut 110*d* maintains the adjustment of the threaded stem 110*b*.

Operation of the apparatus

Rotor structure 19 is connected with the engine to which fuel is to be supplied by the apparatus by means of the drive shaft or coupling 24 so that the rotor structure will rotate at one-half crank shaft speed of a four cycle four cylinder internal combustion engine. A pump designed for an engine with a different number of cylinders would have a correspondingly different number of cam lobes 32 and fuel line delivery passages 52. Fuel is delivered under pressure to the combustion chambers of the four cylinder engine respectively through conduits (not shown) connected with the fuel outlet couplings 53, Figs. 1 and 2.

It will first be assumed the manual control for the pump has been set so the lever 88 occupies the "Low Speed" position shown in Fig. 1 and that the engine has just been started. The rotor 19 will be rotated in the direction indicated by the arrows associated therewith in Figs. 1, 3, 4, 5 and 6. In this manual setting the metering sleeve 57 will be advanced only slightly counterclockwise, Fig. 3, from the "Fuel Shut-off" position therefor. When the engine first starts the rotor structure 19 will be rotating at a very slow speed so the governor weights W will be in their radially inner positions illustrated in Fig. 1. Consequently, the control sleeves 55 and 57 will be near their leftmost settable positions illustrated in Fig. 1 so the metering spill ports 58 will register with the helical spill grooves 66 in the metering sleeve 57 sufficiently late during the contraction phases of the piston pump that considerable fuel will be delivered to the engine combustion chambers. This causes the engine

and the rotor structure **19** to accelerate rapidly until attaining a speed corresponding to the "Low Speed" at which the manual control has been set. At this time the metering sleeve **57** will have been moved far enough rightward by the governor weights W that the helical grooves **66** of this metering sleeve will be reached in registration by the metering ports **58** to diminish the amount of fuel delivered to the engine and prevent further acceleration thereof above the selected "Low Speed."

Higher speed for the engine is attainable by manual adjustment of the control lever **67**, Fig. 2, to rotate the control shaft **68**, Fig. 1, further counterclockwise toward the "High Speed" position a distance depending upon the desired speed of the engine. Such counterclockwise rotation of the control shaft **68** is operable through the arm **78**, the vertical control link **83**, and the arm **86**, Fig. 3, to effect counterclockwise rotation of the metering sleeve **57** as viewed in Fig. 3. This causes the metering ports **58** to arrive in registry with the spill grooves **66** at still a later time in each contraction phase of the piston pump, wherefore a greater quantity of fuel is delivered to the engine. When the engine attains the speed corresponding to the selected higher speed setting of the manual control, the corresponding faster rotating rotor structure **19** will have caused the governor weights W to have moved out far enough to shift the metering sleeve **57** far enough rightward, Fig. 1, that the internal spill grooves **66** of this metering sleeve will be registered with earlier by the metering ports **58** to prevent the delivery of fuel in an amount that would cause the engine to accelerate beyond this selected speed.

When it is desired to stop the engine the manual control lever **67**, Fig. 2, will be operated for rotating the control shaft **68**, Fig. 1, into the position causing the arm **88** to occupy the "Fuel Shut-off" position. This clockwise rocking of the arm **88** in Fig. 1 will lift the control link **83** for rotating the metering sleeve **57** sufficiently far clockwise, Fig. 3, that the metering ports **58** will register with the spill grooves **66** prior to the timing ports **56**, Fig. 4, moving out of registration with the timing spill grooves **65** of the timing sleeve **55**. Since all of the fuel pumped by the piston pump will then be able to spill outwardly through the timing ports **56** and metering ports **58**, no fuel will be delivered to the engine which will come to rest.

Considering again the condition of operation when the manual control lever **67** has been operated for rocking the control shaft **68**, Fig. 1, into a high speed position, the ensuing acceleration of the engine and of the rotor shaft **19** in attaining the selected high speed causes the governor weights W to move radially outwardly to assume a position correlated with this selected speed. As the weights W move outwardly and shift the sleeve **94** and the control sleeves **57** and **55** rightward, simultaneously the lever **97** is caused to pivot counterclockwise as viewed in Fig. 1. Counterclockwise movement of the lever **97** also causes counterclockwise movement of the shaft **103** and of the torque spring holder member **106** about the axis of the shaft **103**. This presses the torque spring **109** against the head **110***a* of the stem **110***b* mounted on the lever **110**, and thus tends to pivot the lever **110** counterclockwise about the axis of the shaft **103** against the force of the governor spring **112**. The force exerted by the spring **112** exceeds that necessary to bow the leaf spring **109** wherefore before counterclockwise pivoting of the lever **110** occurs the clockwise moving holder member **106** will first fully compress the leaf spring **109** against the stem head **110***a* to carry the mid portion of this leaf spring against the headed left end of the stop member **109***a*. After thus energizing the leaf torque spring **109**, further radial outward movement of the governor weights W and counterclockwise pivoting of the lever **97** and of the torque spring holder **106** will exert a force directly through the spring **109** against the head **110***a* to cause the lever **110** to pivot in unison with the lever **97** attendant to compressing the governor spring **112**. This counterclockwise pivoting of the lever **110** causes the rod **116** to slide axially within the bearing **117** of the pin **118** in the lever **88** to retract the stop member **120** from such pin **118**. This movement of the various parts movable with the forked lever **97** ceases when the governor spring **112** is compressed far enough to exert sufficient counterforce to balance the inertia force developed by the governor weights W attendant to attainment of the selected higher speed of the engine.

Now as load is applied to the engine it will tend to decelerate wherefore the force of the compressed governor spring **112** will prevail over the slightly diminished force exerted by the inertia weights W so that the levers **110** and **97** will be rocked clockwise about the shaft **103** to move the metering sleeve **57** leftward for increasing the amount of fuel fed to the engine and limiting the deceleration thereof. A further increase in load upon the engine will further diminish its speed and that of the governor to enable the spring **112** to further expand and move the metering sleeve **57** further leftward to additionally increase the fuel delivered to the engine and stabilize the same at a lower speed. When the engine attains a condition of being subjected to a load equal to its rated load the stop member **120** will abut against the cross shaft **118** in the arm **88** to prevent further expansion of the governor spring **112** so that any additional fuel fed to the engine in response to further deceleration thereof under overload conditions will be under control of the torque spring **109** which, it will be recalled, is in an energized compressed condition against the headed end of the stop member **109***a*. Abutment of the stop member **120** against the cross pin **118** prevents further rightward or clockwise movement of the arm **110** about the axis of the shaft **103**. However, the compressed spring **109** reacting against the stop member head **110***a* tends to pivot the spring holder **106** and the forked lever **97** clockwise about the shaft **103** and can effect a limited amount of such pivoting to move the metering sleeve **57** further leftward in response to deceleration of the engine attendant to assuming a maximum load condition requiring engine "lugging".

At slower engine speeds the timing sleeve **55** will be held in a more leftward position by the governor than at higher engine speeds. By examining Fig. 4 it will be seen that the timing spill grooves **65** are spiraled in the direction that when the timing sleeve is in the more leftward position of Fig. 1 the timing ports **56** will move out of registry therewith later and, therefore, cause the injection pressures to commence at a later time than when the sleeve is in a more rightward position corresponding to higher engine speed. Therefore, this sleeve is moved in accordance with governor speed to advance the timing or commencement of injection when the engine is running at higher speed. The desirability of such timing control is well recognized by those skilled in the art.

Having described a single preferred embodiment of the invention with the view of clearly and concisely illustrating the same we claim:

1. In a fuel metering pump; a rotor structure including a pump portion, a metering portion and a distributor portion, said pump portion having a pumping chamber and including means for alternately expanding and contracting such chamber a plurality of times attendant to each revolution of the rotor structure; port means for admitting fuel to the chamber during expansion thereof; means providing a plurality of fuel delivery passages associated with the distributor portion; the distributor portion having a port communicative with the pumping chamber, said port successively communicating with the delivery passages during rotation of the rotor and during respective contractions of the chamber; metering means comprising a spill port and a timing port in the metering portion of the rotor structure and communicating with the pump chamber independently of the port

means for admitting fuel to the chamber, spill port masking means associated with the metering portion and having spill channel means extending helically of the metering portion for registration with the spill port to facilitate the spilling of fuel from the pump chamber through such port during such registration, timing port masking means associated with the timing port for periodically masking such port during rotation of the rotor structure subsequent to each masking of the spill port by the spill port masking means and thereby initiate the creation of injection pressure of the fuel in the pumping chamber, the spill channel means being oriented circumferentially of the rotor structure to incur registration of the spill port therewith subsequent to commencement of each contraction of the pumping chamber; means for adjusting the spill port masking means axially of the rotor structure to change the time after commencement of pumping chamber contraction that registration of the spill port with the spill channel means occurs; and means operable for adjusting the spill port masking means rotatively of the rotor structure independently of adjustment of the timing port masking means for also changing the time after commencement of chamber contraction that registration of the spill port with the spill channel means occurs.

2. In a fuel metering pump; a rotor structure including a pump portion having a pumping chamber; means for alternately expanding and contracting said chamber a plurality of times attendant to each revolution of said structure; port means for admitting fuel to the chamber during each expansion thereof; the rotor structure having a distributor port communicative with the pumping chamber and revolvable attendant to rotation of said structure; means providing a plurality of fuel delivery passages successively communicative with the distributor port during rotation of the rotor and during respective contractions of the chamber; metering means comprising a spill port and a timing port in the rotor structure and revolved thereby attendant to rotor structure rotation, such spill port communicating with the pump chamber independently of the port means for admitting fuel to such chamber, a spill port masking sleeve journalled on the rotor structure and having internal spill channel means extending helically of the rotor structure axis for registration with the spill port to facilitate the spilling of fuel from the pump chamber through such port during such registration, timing port masking means associated with the timing port for periodically masking such port during rotation of the rotor structure subsequent to each masking of the spill port by the spill port masking sleeve and thereby initiate the creation of injection pressure of the fuel in the pumping chamber, the spill channel means being oriented circumferentially of the rotor structure to incur registration of the spill port therewith subsequent to commencement of each contraction of the pumping chamber, means for rotatively adjusting the spill port masking sleeve upon the rotor structure independently of adjustment of the timing port masking means to change the time after commencement of pump chamber contraction that registration of the spill port with the spill channel means occurs, and means for adjusting the masking sleeve axially of the rotor structure for also changing the time after commencement of chamber contraction that registration of the spill port with the spill channel means occurs.

3. In a fuel metering pump; a rotor structure including a pump portion having a pumping chamber; means for alternately expanding and contracting said chamber a plurality of times attendant to each revolution of said structure; means for admitting fuel to the chamber during each expansion thereof; the rotor structure having a distributor port communicative with the pumping chamber and revolvable attendant to rotation of said structure; means providing a plurality of fuel delivery passages successively communicative with the distributor port during rotation of the rotor and during respective contractions of the chamber; metering means comprising a spill port in the rotor structure and revolved thereby attendant to rotor structure rotation, said spill port being in addition to said means for admitting fuel to the chamber and spill port masking means adapted to uncover the port at selective intervals subsequent to each contraction of the pumping chamber; and timing means comprising a timing port in the rotor structure communicating with the pumping chamber and revolved attendant to rotor structure rotation, masking means for said timing port and having timing channel means extending axially of the rotor structure and with which the timing port registers at the beginning of each pumping chamber contraction to facilitate spilling of fuel from such chamber, the rotor structure revolving the timing port out of registration with the timing channel means during pumping chamber contraction to incur masking of the timing port by the timing port masking means and thus initiate fuel delivery through the distributor port, the timing port masking means being adjustable axially of the rotor structure, means for moving the timing port masking means axially of the rotor structure, and means for controlling the position of such timing port masking means rotatively of the rotor structure attendant to such axial moving thereof to vary the time the timing port revolves out of registration with the timing channel means and thus vary the time of initiating fuel delivery.

4. In a fuel metering pump; a rotor structure including a pump portion having a pumping chamber; means for alternately expanding and contracting said chamber a plurality of times attendant to each revolution of said structure; means for admitting fuel to the chamber during each expansion thereof; the rotor structure having a distributor port communicative with the pumping chamber and revolvable attendant to rotation of said structure; means providing a plurality of fuel delivery passages successively communicative with the distributor port during rotation of the rotor and during respective contractions of the chamber; the rotor structure also having a spill port and a timing port spaced apart axially thereof and opening radially outwardly of such structure, said ports being communicative with the pumping chamber; a spill port metering sleeve journalled on the rotor structure for masking the spill port but having internal spill channel means extending helically of the rotor structure axis for registration with the spill port to facilitate spilling of fuel from the pump chamber, the spill channel means being oriented circumferentially of the rotor structure to incur registration of the spill port therewith subsequent to commencement of each contraction of the pumping chamber, said sleeve being adjustable axially relatively to the rotor structure to change the time after commencement of the pumping chamber contraction that registration of the spill port with the spill channel means occurs and also being rotatively adjustable to change the time that such registration of the spill port with the spill channel means occurs; a timing sleeve mounted for axial adjustment on the rotor structure for masking the timing port but having internal timing channel means extending helically of the rotor structure axis for registration with the timing port to facilitate the spilling of fuel from the pumping chamber, the timing channel means being oriented circumferentially of the rotor structure to incur registration of the timing port therewith concurrently with commencement of each contraction of the pumping chamber, the rotor structure revolving the timing port out of registration with the timing channel means during pumping chamber contraction to incur masking of the timing port by the timing sleeve and thus initiate fuel delivery through the distributor port, adjustment of the timing sleeve axially of the rotor structure being operative to change the time that the timing port arrives in masking relation with the timing sleeve, means for constraining said sleeves for axial movement in unison while facilitat-

ing rotative adjustment of the metering sleeve relatively of the timing sleeve, means constraining the timing sleeve against rotative movement while facilitating axial adjustment thereof, manually settable means for selectively changing the rotative position of the metering sleeve, and means responsive to the rotational speed of the rotor structure for changing the axial position of said sleeves.

5. In a fuel metering pump; a rotor structure including a pump portion having a pumping chamber; means for alternately expanding and contracting said chamber a plurality of times attendant to each revolution of said structure; means for admitting fuel to the chamber during each expansion thereof; the rotor structure having a distributor port communicative with the pumping chamber and revolvable attendant to rotation of said structure; means providing a plurality of fuel delivery passages successively communicative with the distributor port during rotation of the rotor and during respective contractions of the chamber; metering means comprising a spill port in the rotor structure and revolved thereby attendant to rotor structure rotation, and port masking means adapted to uncover the port at selective intervals subsequent to each contraction of the pumping chamber; and timing means comprising timing port means which opens radially outwardly of the rotor structure and communicates with the pumping chamber, a timing port masking sleeve slidably mounted on the rotor structure and having internal timing groove means extending axially thereof and with which the timing port means communicatively registers at the beginning of each pumping chamber contraction to facilitate spilling of fuel from such chamber, the rotor structure revolving the timing port means out of registration with the timing groove means during pumping chamber contraction to incur masking of such port by such sleeve and thus initiate fuel delivery through the distributor port, means for axially moving the sleeve relatively to the rotor structure, and means for controlling the rotative position of the sleeve during such axial movement to change the relative position of the timing port means and timing groove means circumferentially of the rotor structure axis and correspondingly change the initiating time of fuel delivery.

6. In a fuel metering pump; a rotor structure including a pump portion, a metering portion and a distributor portion, said pump portion having a pumping chamber and including means for alternately expanding and contracting such chamber a plurality of times attendant to each revolution of the rotor structure; means for admitting fuel to the chamber during expansion thereof; means providing a plurality of fuel delivery passages associated with the distributor portion; the distributor portion having a port communicative with the pumping chamber; said port successively communicating with the delivery passages during rotation of the rotor and during respective contractions of the chamber; timing means comprising a timing port in the rotor structure metering portion and communicating with the pump chamber, and timing port masking means associated with the rotor structure metering portion and adjustively movable relatively thereto for masking the timing port during periods commencing at selectively different times after commencement of respective pump chamber contractions to initiate fuel delivery; metering means comprising a spill port in the metering portion of the rotor structure and communicating with the pump chamber, spill port masking means associated with the metering portion and having spill channel means extending helically of the metering portion for registration with the spill port to facilitate the spilling of fuel from the pump chamber through such port during such registration, the spill channel means being oriented circumferentially of the rotor structure to incur registration of the spill port therewith during respective masking periods of the timing port; means for adjusting the spill port masking means axially of the rotor structure to change the time after commencement of the timing port masking

periods that registration of the spill port with the spill channel means occurs; and means operable for adjusting the spill masking means rotatively of the rotor structure for also changing the time after timing port masking period commencement that registration of the spill port with the spill channel means occurs.

7. In a fuel metering pump; a rotor structure including a pump portion having a pumping chamber; means for alternately expanding and contracting said chamber a plurality of times attendant to each revolution of said structure; means for admitting fuel to the chamber during each expansion thereof; the rotor structure having a distributor port communicative with the pumping chamber and revolvable attendant to rotation of said structure; means providing a plurality of fuel delivery passages successively communicative with the distributor port during rotation of the rotor and during respective contractions of the chamber; timing means comprising a timing port in the rotor structure and communicating with the pump chamber, and timing port masking means associated with the rotor structure and adjustively movable relatively thereto for masking the timing port during periods commencing at selectively different times after commencement of respective pump chamber contractions to initiate fuel delivery; metering means comprising a spill port in the rotor structure and revolved thereby attendant to rotor structure rotation, a spill port masking sleeve journalled on the rotor structure and having internal spill channel means extending helically of the rotor structure axis for registration with the spill port to facilitate the spilling of fuel from the pump chamber through such port during such registration, the spill channel means being oriented circumferentially of the rotor structure to incur registration of the spill port therewith during respective masking periods of the timing port; means for adjusting the spill port masking means axially of the rotor structure to change the time after commencement of the timing port masking periods that registration of the spill port with the spill channel means occurs; and means operable for adjusting the spill masking means rotatively of the rotor structure for also changing the time after timing port masking period commencement that registration of the spill port with the spill channel means occurs.

8. The combination set forth in claim 3, wherein the timing channel means is in the form of a groove in the masking means that extends helically about the rotor structure, and the means for controlling the position of the timing port masking means rotatively of the rotor structure is adapted to constrain such masking means against rotation about the valve structure while accommodating movement of such masking means axially of the rotor structure.

9. The combination set forth in claim 3, wherein the timing port masking means and the spill port masking means are respective sleeves on the rotor structure whereon the spill port masking sleeve is axially movable and is also rotatively movable relatively to the timing port masking sleeve, said spill port masking sleeve being cooperable with the spill port to vary the spill time through the spill port attendant to either axial or rotative movement, means for concurrently axially moving the sleeves, and means for rotatively moving the spill port masking sleeve independently of movement of the timing port masking sleeve to attain quantity change in fuel delivery without altering the timing of such fuel delivery.

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