

March 23, 1971

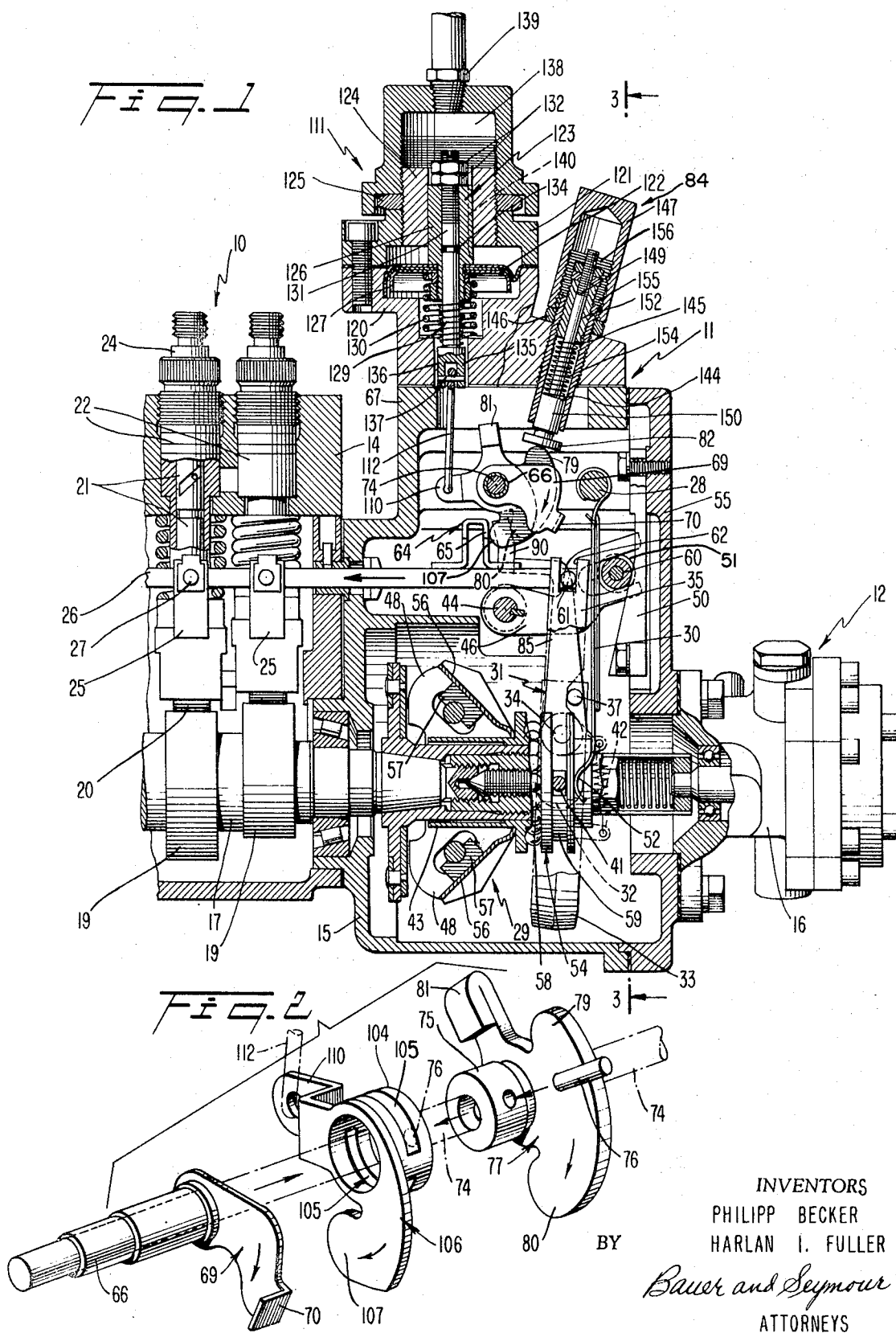
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FUEL INJECTION PUMP

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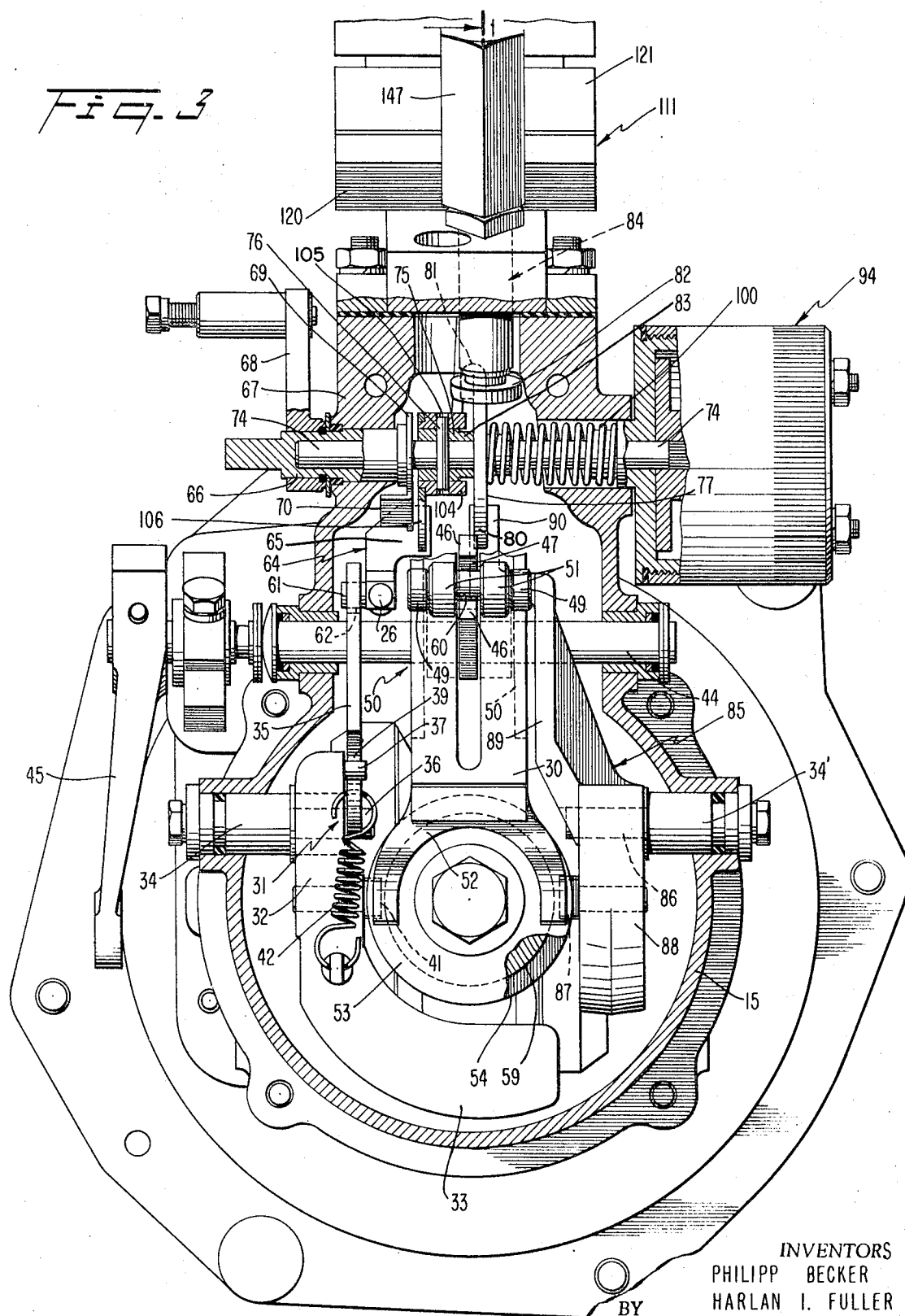
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Fig. 3



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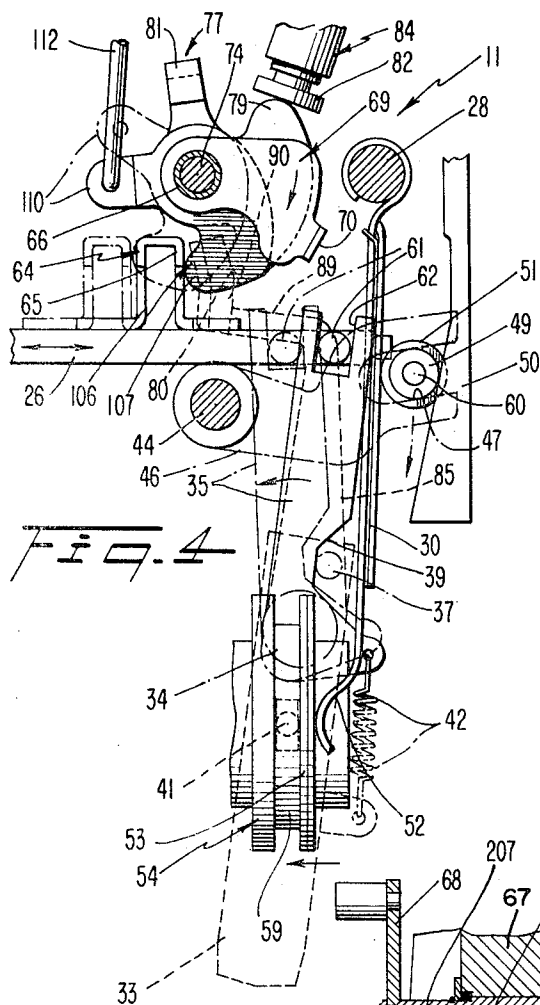
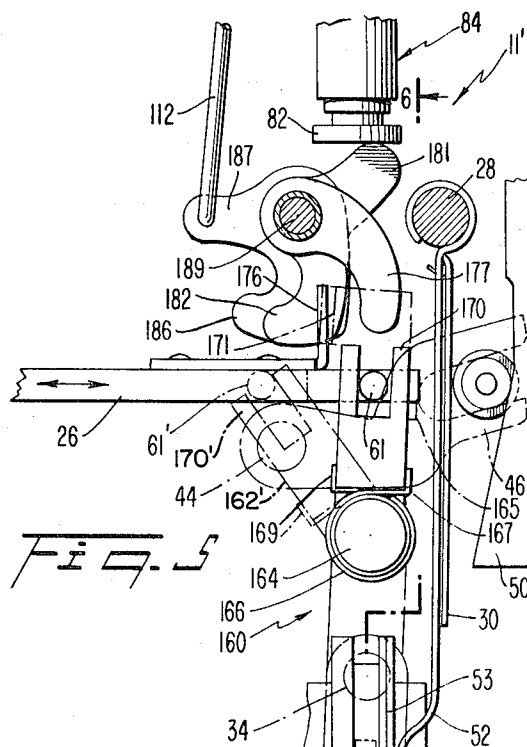
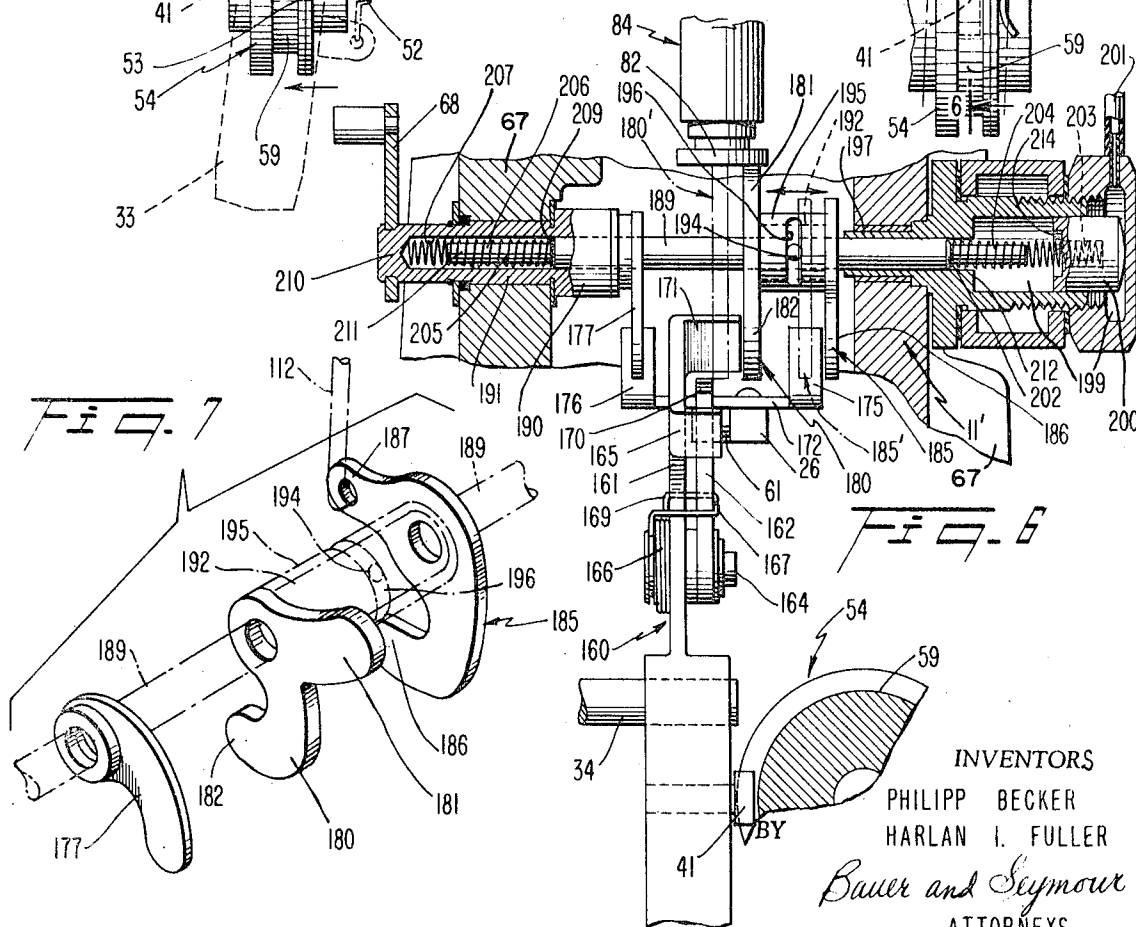
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FUEL INJECTION PUMP

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21 Claims

ABSTRACT OF THE DISCLOSURE

A fuel injection pump for an engine wherein the rate of fuel delivery is determined by a governor acting upon a movable pump controlling member in opposition to a heavy spring variably tensioned by the engine throttle. The pump includes a jointed lever interposed between the movable member and the pump control rod, the jointed lever being rigid in the fuel quantity increasing direction and foldable in the other, fuel quantity-decreasing direction against the opposition of a small spring. A second, rigid lever, connected to move synchronously with the jointed lever, cooperates with a maximum fuel stop lever and a boost rack control lever. In a first disclosed embodiment, the jointed lever and the rigid lever are separate, but both are driven by the movable member. In a second disclosed embodiment, the jointed lever is formed in part of a portion of the rigid lever.

In both the first and second embodiments, provision is made for temporarily disabling the maximum fuel stop lever when the engine is to be started, so that excess fuel may be supplied to the engine. In a third disclosed embodiment, the control rod for the engine is automatically moved to its excess fuel position when the engine stops, so that the control rod of the pump is in position for the re-starting of the engine.

This invention relates to a fuel injection pump adapted for use with an internal combustion engine, and more particularly relates to improved pump control mechanism. Such mechanism permits the control rod for the pump readily to be moved to its engine shut-off position, while providing for maximum fuel stop, torque back-up, and boost rack control functions of the pump. The pump of the invention also provides for the temporary disabling of the maximum fuel stop, whereby an excess of fuel may be supplied to the engine when it is to be started.

The invention has among its objects the provision of a fuel injection pump having an improved control mechanism therefor.

A further object of the invention lies in the provision of a fuel injection pump having a novel fuel quantity controlling mechanism which provides for the ready shutting down of the engine by the application of a small force to the mechanism.

Another object of the invention is the provision of fuel pump controlling mechanism of the type above indicated which additionally provides for a maximum fuel stop, a torque back-up, and a boost rack control.

A still further object of the invention lies in the provision, in a fuel injection pump of the above indicated type, of mechanism for disabling the maximum fuel stop to permit the pump to deliver excess fuel upon the starting of the engine.

The above and further objects and novel features of the invention will more fully appear from the following description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only, and are not intended as a definition of the limits of the invention.

In the drawings, wherein like reference characters refer to like parts throughout the several views,

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FIG. 1 is a view in vertical longitudinal axial section through a first illustrative embodiment of a pump in accordance with the invention, certain of the parts being shown in elevation, the control rod of the pump being shown in its normal maximum fuel position, the section being taken along the line 1—1 of FIG. 3 looking in the direction of the arrows;

FIG. 2 is an exploded view in perspective of the three levers in the control section of the pump of FIG. 1 which selectively determine the position of the control rod of the pump, the levers being shown in the positions which they occupy in FIG. 1;

FIG. 3 is a view in vertical transverse section through the control section of pump, the section being taken generally along the line 3—3 of FIG. 1 looking in the direction of the arrows, certain of the parts being shown in elevation;

FIG. 4 is a fragmentary view partially in vertical axial section and partially in elevation on an enlarged scale of the portion of the control section of the pump which includes the three levers which selectively determine the position of the control rod of the pump, the full line positions of the parts corresponding to those of FIG. 1, the control rod and certain of the other parts being shown in phantom lines in their fuel shut-off positions;

FIG. 5 is a fragmentary view, partially in vertical axial section and partially in elevation, and corresponding to FIG. 4, of the control section of a second embodiment of pump in accordance with the invention, the parts being shown in full lines in their engine-starting positions, the control rod and certain of the other parts being shown in phantom lines in their fuel shut-off positions;

FIG. 6 is a fragmentary view partially in transverse vertical section and partially in elevation of the control section of the pump of FIG. 5, the section being taken along the broken line 6—6 of FIG. 5 looking in the direction of the arrows, the parts being shown in engine-starting position; and

FIG. 7 is an exploded view in perspective on a reduced scale of the three levers in the control section of the pump of FIGS. 5 and 6, the levers being oriented as in FIG. 5.

GENERAL DESCRIPTION

As will be apparent from the above, two embodiments of fuel injector pump in accordance with the present invention are disclosed herein. The first such embodiment is disclosed in FIGS. 1—4, inclusive, whereas the second embodiment is disclosed in FIGS. 5—7, inclusive. Such two embodiments differ primarily in the construction of the levers which are interposed between the centrifugal governor 29 and the main throttle spring 30 of the pump, on the one hand, and the longitudinally reciprocable control rod 26 for the pump on the other. In the first embodiment two such separate and laterally displaced levers are employed, one of them 85 being rigid and the other 31 being a jointed lever which is yielding in one direction but is rigid in the other direction. In the second embodiment a rigid lever 160 is also employed, but a lever 162 forming a part of the second lever is pivotally mounted directly upon the rigid lever so as to be yieldable in one direction but rigid with respect thereto in the other direction. In both embodiments provision is made for shutting off the engine, an operation which requires the yielding of the jointed lever or pivotally mounted lever part in said one direction.

Also selectively acting upon the control rod in both disclosed embodiments of the pump are levers which determine the normal maximum fuel delivering position of the control rod, which provide a torque back-up control for the control rod, and a boost rack control for such rod. In the first embodiment there is provided means

whereby the maximum fuel stop lever and the boost rack control lever may be moved out of the path of wings on the rigid lever and control rod, respectively, prior to the starting of the engine so that the control rod may be moved to a position to provide an excess of fuel. In the second embodiment there is provided means whereby the maximum fuel stop lever and the boost rack control lever lie in their engine starting, excess fuel position when the engine is at rest and are moved into their normal position after the engine has started.

SPECIFIC DESCRIPTION

Turning now to FIGS. 1-4, inclusive, which illustrate the first embodiment of the pump, there is shown an in-line injector pump for a multi-cylinder engine. Such pump has a portion 10 which includes a plurality of aligned pump cylinders, a pump control portion 11 in which there is disposed mechanism for controlling the positioning of the common control rod 26 for the pistons in the pump cylinders, and a low pressure supply or transfer pump 12 which is driven by the main shaft 17 of the pump. The pump includes housing parts 14, 15, and 16 for the portions 10, 11, and 12, respectively, such housing portions being rigidly bolted together, as shown. The pump cylinders, all of which are of the same construction, are driven by the main shaft 17 which is drivingly connected to a shaft of the engine such as the cam shaft thereof. A plurality of cams 19, one for each pump cylinder, are rigidly mounted upon the shaft 17, there being cam followers 20 on the lower ends of the pistons 21 of the pump cylinders. The cams 19 are so oriented relative to each other on shaft 17 as to thrust the respective pistons 21 upwardly in their cylinder barrels 22 to deliver charges of fuel in the correct timed relationship through fuel delivery fittings 24 on the top of the pump cylinders to the respective cylinders of the engine.

Projecting laterally from the piston 21 of each of the pump cylinders there is an arm (not shown) which co-operates with a control fork 25, connected by conventional means 27 to the control rod 26 so that upon movement of the control rod longitudinally the pistons are turned simultaneously about their axes. The pistons 21 are provided with conventional helical slots which co-operate with spill ports (not shown), so that the angular position of the pistons about their axes determines the quantity of fuel which is injected by each stroke of the pump pistons. The horizontal positioning of the control rod 26, as above explained, is determined by the control mechanism, now to be described, in the portion 11 of the pump.

Mounted within the lower portion of the housing 15 upon the shaft 17 is a centrifugal governor 29. Such governor includes a reciprocable sleeve 43 mounted upon the shaft 17 and keyed thereto to rotate therewith, and two diametrically opposed brackets 48 affixed to such sleeve, the brackets having slotted sidewalls as shown. Shoes 57 on shafts mounted in the slots bear upon the inner surfaces of inclined rear walls 56 of the brackets 48, the shoes sliding along such walls as the sleeve 43 reciprocates. When the shaft 17 is at rest, the counterweights and shoes lie in their radially inner position and exert no force in an axial direction upon the sleeve 43. When the shaft 17 rotates, however, the counterweights and shoes tend to ride up the inclined surfaces of the rear walls 56 of the brackets and thus to thrust the sleeve 43 to the right. A thrust bearing 58 is interposed between the rear end of sleeve 43 and a collar 54 reciprocally mounted on shaft 17, as shown.

Opposing the rearwardly directed thrust upon the sleeve 43 by the governor 29 is a heavy leaf spring 30 which is vertically centrally slotted at its upper end and is supported at such upper end upon a cross shaft 28 in the housing. The lower end of the leaf spring 30 is in the form of a yoke 52, the arms of which straddle the shaft 17 and are smoothly convexly curved to the left. Such

ends of the spring 30 bear upon a collar 54 which is mounted upon shaft 17 but is held from rotation therewith by reason of the engagement of the lower ends 52 of the spring 30 with thrust washers interposed between ends 52 of the spring and the rear end of collar 54. As above explained, the other end of the collar 54 is subjected to thrust by the governor sleeve 43 through the medium of the thrust ball bearing 58. The spring 30, which is variably tensioned by a throttle lever in a manner to be described, balances the thrust imposed on the collar 54 by the governor 29 so that under running conditions the longitudinal position of the collar 54 is determined by the throttle setting.

A throttle cross shaft 44 is provided with an external throttle lever 45, the cross shaft and lever being swung clockwise (FIG. 1) to increase the speed of the engine and counterclockwise to decrease the speed of the engine. Fixedly connected to the shaft 44 within the housing portion 15 is a lever arm 46, the outer free end of which extends through the central vertical slot in the upper end of the spring 30, as shown in FIG. 3. Such outer end of the lever 46 is longitudinally slotted at 47 to receive a cross shaft 60 which bears two spaced laterally inwardly larger rollers 51 and two smaller rollers 49 disposed laterally outwardly of their respective larger rollers 51. The larger rollers 51 ride upon the rear surfaces of the two upper portions of the leaf spring 30. The two smaller rollers 49 ride along two similar ramps 50 which are fixedly mounted upon the inner surface of the end cover 55 for the housing portion 15. It will be apparent that upon the turning of the shaft 44 clockwise (FIG. 1) the lever arm 46 carries the rollers 49 and 51 downwardly so that the portions of the spring 30 engaged by the rollers 51 are thrust to the left in an amount dictated by the ramps 50.

The collar 54 is directly connected to the control rod 26 by means of an articulated lever generally designated 31 which is located at the left in FIG. 3, lever 31 having a lower part 32 and an upper part 35 which is pivotally connected to the lower lever part at 36. The lower lever part 32 is pivotally connected to the housing 15 by a stub shaft 34 which extends inwardly from the housing into a bore in the lever part 32. The lower end of lever part 35 has a bore therein which accurately receives the inner end portion of a bushing in the housing 15 within which the inner end of stub shaft 34 is journaled. It will be apparent that in the construction shown the axis of the pivotal connection between the lower and upper lever parts 32 and 35 coincides with the axis of the stub shaft 34. In order that the oscillation of the lever 31 shall not per se affect the positioning of the control rod 26, the lower lever part 32 is provided with a counterweight 33 which is integral therewith.

The lower lever part 32 is connected to the thrust collar 54 by means of a shoe 41 which is pivotally mounted upon the lower lever part 32 in the horizontal plane of the longitudinal axis of the shaft 17. The shoe 41 accurately fits within an annular groove 59 in the thrust collar 54 so that reciprocation of the collar causes the lower lever part 32 to oscillate in opposite directions. The lever 31 is made rigid, when it pivots in a counterclockwise direction, by means of a transverse pin 37 which is mounted adjacent the upper end of the lower lever part 32, pin 37 being received within and abutting the bottom surface of a notch 39 in the rear edge of the upper lever part 35 when the lever 31 is straight as shown in FIG. 1. The parts 32 and 35 of the composite lever 31 are constantly urged toward their terminal straight line position by a small coil tension spring 42 which is connected between opposed rearwardly directed arms on the rear edges of the upper and lower lever parts 32, 35.

The upper end of the upper lever part 35 is connected to the control rod 26 for the pump through the medium of a cross pin 61 on rod 26, such cross pin being ac-

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curately received within a vertical slot 62 in the part 35. It will be apparent that the control rod 26 may be moved to the left (FIG. 1) and that the upper lever part 35 may be swung counterclockwise independent of the lower lever part 32 as required by such movement of the control rod, upon the application of a force directed to the left upon the control rod which is sufficient to overcome the opposition of the coil tension spring 42. Such force is much smaller than that which would be required if lever 31 were rigid, since in that case the opposition of the heavy leaf spring 30 would have to be overcome to permit the control rod 26 to the left to move to its shut-off position.

Engine shut-off

The engine is shut off when the control rod 26 is thrust sufficiently to the left to stop the injection of fuel to the engine cylinders. For this purpose there is provided a bracket 64 which is riveted to and extends upwardly from the control rod 26 adjacent the rear end of the latter, the bracket having a laterally inwardly extending wing 65 on its upper rear end. A transverse horizontal sleeve 66 is journaled in the upper portion 67 of the housing portion 15 as shown in FIGS. 1 and 3, there being an engine shut-off lever 68 fixed to the outer end of the sleeve. Internally of the housing portion 67 and generally rearwardly of the wing 65 there is a shut-off lever 69 which is affixed to the inner end of the sleeve 66. Lever 69 has a laterally outwardly extending wing 70 thereon which extends laterally into the path of the wing 65. The parts are so constructed and arranged that when the sleeve 66 is turned clockwise (FIG. 1) the wing 70 on the lever 69 engages the rear surface of the wing 65 on the bracket 64 and thrusts the bracket and the control rod 26 to which it is connected to the left to shut off the engine. As above noted, because the coil tension spring 42 presents only a small force which opposes the movement of the control rod 26 to the left, only a relatively small torque need be applied to the sleeve 66 in order to shut off the engine as described.

The maximum fuel stop

A rigid lever 85 which is shown most clearly in FIG. 3 is pivoted upon housing portion 15 intermediate its length upon a stub shaft 34' which is similar to and coaxial of the stub shaft 34 upon which the composite or jointed lever 31 is mounted. The lower end of lever 85 is of heavy section so as to serve as a counterweight therefor, there being a pivotally mounted shoe 87 which projects from the lower end of the lever 85 into the groove 59 in the thrust collar 54. Because of such manner of mounting of the lever 85 and its oscillation about the pivot pin 86 by axial movement of the collar 54, the lever 85 oscillates in the same direction and through the same angle as the lower lever part 32 of the lever 31. When the throttle shaft 44 is turned sufficiently clockwise (FIG. 1), the force exerted upon the leaf spring 30 is sufficient to overcome the opposition thereto exerted by the governor 29 and thus permits the levers 31 and 85 to be swung clockwise. In such direction of rotation, as we have seen, the lever 31 is maintained in its straight line position by spring 42, so that it then acts as a unit with the lever 85. Clockwise rotation of the levers 31 and 85 and thus travel of the control rod 26 to the right are stopped, however, when a wing 90 on the upper arm 89 of the lever 85 engages stop means now to be described.

A horizontal shaft 74, having its left-hand end (FIG. 3) journaled in the sleeve 66, extends to the right through the righthand wall of the housing portion 67 in which it is indirectly journaled. To provide for the escape of air between the inner end of the blind bore in sleeve 66 and the end of shaft 74 journaled therein, upon reciprocation of the shaft in a manner to be described, such end of the shaft may be flatted at one or more zones angularly thereabout. Affixed to the shaft 74

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to the right of the shut-off lever 69 by a cross pin 76 is a first or inner sleeve 75. The sleeve 75 thus moves with the shaft 74 both angularly about the axis of the shaft 76 and longitudinally thereof. The sleeve 75 extends to the right, there being a maximum fuel stop lever 77 rigidly connected to the smaller diametered right-hand end 83 of the sleeve 75.

The lever 77 has an upper arm 79, a lower arm 80, and a bent over upper wing 81, such arms and wing being angularly displaced from each other as shown most clearly in FIG. 2. When the control rod 26 is moved to the right into its normally maximum fuel position, the wing or slat 90 on the upper end of the arm 89 of the rigid lever 85 engages the lower arm 80 of the lever 77 so as to rotate the lever counterclockwise (FIG. 1) into a position in which the upper arm 79 of such lever engages a stop 82 mounted upon a maximum fuel stop capsule 84 affixed to the housing portion 67 of the pump.

Engine starting control

When the engine is to be started it is required that an excess of fuel be supplied to it; in other words, it is necessary that the control rod 26 be moved further to the right than its normal maximum fuel position, above described, wherein it is stopped by lever 77 and stop 82. For this purpose, the first embodiment of the pump of the invention includes means whereby the maximum fuel stop lever 77 and the boost rack control lever 106, to be described, may be temporarily moved laterally out of the path of the wing 90 on the rigid lever 85 and the wing 65 on bracket 64 on control rod 26, respectively. Means is also provided for automatically restoring the maximum fuel stop lever 77 and the boost rack control lever 106 into the operative position of each shown in FIG. 3 after the engine has started.

The shaft 74, to which the sleeve 75 and the lever 77 are affixed is movable to the right (FIG. 3) so that the lower arm 80 of the lever 77 is then located out of the path of the wing 90. The armature (fragmentarily shown) of a solenoid 94 mounted upon the housing portion 67 is connected to the right-hand end of shaft 74. A coil compression spring 100 telescoped over the shaft 74 between the central portion of lever 77 and a shoulder on an inner sleeve portion of the solenoid housing constantly urges the shaft 74, the sleeve 75, and the lever 77 toward the left, that is, toward the position thereof shown in FIG. 3. When the solenoid 94 is energized, the armature thereof is impelled to the right to overcome the spring 100 and thus to move the shaft 74 and lever 77 to the right as described. When the solenoid is deenergized, the spring 100 thrusts such parts toward their normal, left-hand positions. Until the engine has started and picked up sufficient speed for the governor 29 to swing the rigid lever 85 sufficiently counterclockwise (FIG. 1), the left-hand edge of arm 80 of lever 77 engages the right-hand edge of wing 90 on the lever 85, thereby holding lever 77 in its engine-starting position. Thereafter the arm 80 of lever 77 snaps past the wing 90, and the parts resume their normal, engine-running positions.

The boost rack control

Under some conditions of operation, in the absence of the boost rack control now to be described, the injector pump would deliver fuel to the engine at a rate markedly in excess of the optimum stoichiometric fuel-air ratio. In other words, there would then be insufficient air to burn all the fuel, and severe smoking at the engine exhaust would result. The pump of the invention is provided with a boost rack control which prevents such undesirable condition.

Telescoped over the sleeve 75 is a second sleeve or hub 104 having two diametrically opposed slots 105 there-through which receiver the outer ends of the cross pin 76 through shaft 74 and the first sleeve 75. The sleeve 104 is thus free for rotation independently of the shaft 74

and sleeve 75 through an angle determined by the angular extent of the slots 105 in the sleeve 104. Fixedly attached to the left-hand end (FIG. 3) of sleeve 104 is a boost rack control lever 106 having a configuration most clearly shown in FIG. 2. Lever 106 has a first arm 107 thereon which selectively engages the wing 65 on bracket 64, and a second arm 110, the outer end of which is pivotally connected through a link 112 to the movable central piston-like member of a unit 111 which is responsive to the pressure of air delivered to the engine by a supercharger (not shown). As shown in FIG. 3, the arm 107 of the lever 106 is disposed in the path of the wing 65 on the bracket of the control rod 26 when the shaft 74 is disposed as shown in that figure. The lever 106 is of such configuration and the unit 111 so controls it that, after the engine has been started and the control levers have been returned to the position of FIG. 3, the boost rack control lever 106 functions effectively to stop further travel of the control rod 26 to the right (FIG. 1) past the position in which the wing 65 on bracket 64 engages the arm 107 of the lever in the terminal clockwise (FIG. 1) position of such lever until the engine receives intake air under at least a required predetermined pressure. Thereafter the lever 106 is swung counterclockwise out of operative position by the unit 111, the control rod 26 then being effectively stopped in its travel to the right by the maximum fuel stop lever 77, the stop 82, and the levers 85, 31.

The intake air pressure responsive unit 111

Unit 111 has a lower housing part 120 with a central lower chamber portion therewithin, part 120 being bolted to the upper end portion 67 of the housing portion 15 of control unit 11. Unit 111 has an upper housing part 121 having a lower chamber portion confronting that in part 120, the upper housing part 121 being secured to the lower housing part 120 as shown. Secured between the opposing faces of the housing parts 120, 121 and forming a seal therebetween is the radially outer edge of a flexible diaphragm 122 which, with a vertically reciprocable central member generally designated 123, functions as a piston.

Threaded within the upper housing part 121 is a bushing 124; the vertical positioning of the bushing 124 may thus be adjusted by turning the bushing in the housing part 121. The bushing 124 is sealed to the housing part 121 by an annular sealing member 125, as shown. A central sleeve member 126, forming a part of member 123, is reciprocable within the central bore in the bushing 124 and serves to guide the central reciprocable member 123 axially with respect to the bushing 124. Affixed to the lower smaller diametered end of the sleeve 126 is an inverted cup member 127 having a diameter somewhat less than that of the chamber within the housing parts 120, 121. Member 127 serves to support the main central portion of the flexible diaphragm 122 while permitting the diaphragm to form an upwardly open annular pleat between the member 127 and the wall of the chamber. A coil compression spring disposed between part 135 and the lower end of sleeve 126 urges shaft 131 downwardly so that the lower nut 132 constantly engages the upper end of sleeve 126. The member 127 and thus the sleeve 126 are constantly urged upwardly by the outer coil compression spring 130, the lower end of which engages the bottom of a counterbore in the housing part 120 and the upper end of which engages the inner central portion of the cup member 127.

A central rod member 131 is disposed within the central bore in the sleeve 126 and is sealed thereto by an O-ring 134 disposed in an annular groove on the rod. The rod 131 is adjusted vertically with respect to the sleeve 126 by means of adjusting nuts 132 on the threaded upper end of the rod, the lower of such nuts engaging the upper end surface of the sleeve 126. The rod 131 has an enlarged circular cylindrical portion 135 on the lower end

thereof, portion 135 being loosely received within bore 136 in the housing part 120. A cross or wrist pin 137 in the rod portion 135 loosely connects the upper end of the link 112 to the reciprocable member 123 of the unit 111, the connection between the link 112 and the member 135 being such as to permit the lateral shifting of the boost control rack lever 106 when the sleeves 75 and 104 are shifted preparatory to the starting of the engine.

An upper chamber 138 within the upper part 121 of the housing above bushing 124 of the unit 111 is provided with an air inlet fitting 139 which is connected to the outlet conduit of the supercharger of the engine, as above explained. The outer surface of the sleeve 126 is provided with at least one axially extended flat zone as indicated at 140 in FIG. 1, whereby air entering the upper chamber within the housing part 121 flows downwardly between the sleeve 126 and the bore in the bushing 124 so as to enter the lower chamber in the unit to act upon the upper surface of the diaphragm 122.

The coil compression spring 130 has such compressive value and rate that when the engine is provided with air from the supercharger at a pressure which equals or exceeds a predetermined value, the boost rack control lever 106 is swung counterclockwise (FIG. 1) into its terminal inoperative position, in which it can not cooperate with any of the parts which determine the longitudinal positioning of the control rod 26. At any time, however, during the operation of the engine after its initial starting when the supercharger air pressure falls below such predetermined value, the lever 106 comes into play so that it then forms the means which effectively determines the right-hand terminal position of the control rod. Under such condition, the rate at which fuel can be delivered to the engine is limited, so that improper combustion of the fuel is prevented. As above noted, the boost rack control lever 106 is moved to the right (FIG. 3) out of the path of the wing 65 on the bracket 64 on control rod 26 when the engine is to be started.

The torque back-up control capsule 84

The member 82 functions yieldably to stop the maximum fuel stop lever 77 when the engine is running and the parts are in the position generally shown in FIG. 1. The capsule 84 which mounts and controls the stop member 82 is so constructed that under conditions in which added torque from the engine is required and thus more fuel must be fed to the engine to prevent its slowing down unduly, the member 82 yields to permit further travel of the control rod 26 to the right beyond the position thereof shown in FIG. 1.

The member 82 is formed as an enlarged lower end of a plunger 144 which is reciprocally mounted within a sleeve 145 which is screw threaded into the part 120 of the upper housing. Sleeve 145 is held in adjusted position on such housing part by a lock nut 146. Turning of the sleeve 145 in the appropriate direction raises or lowers the sleeve so as to adjust the position of stop member 82 when the plunger 144 is in its normal, fully extended position. A cap 147 is preferably provided for unit 84, such cap being telescoped over the outer end of the sleeve 145 and the upper end of the plunger 144, as shown. The plunger 144 has a reduced diameter shank 149 which is guidingly received within a second, inner sleeve 152 which is threadedly mounted within the upper end of the first sleeve 145. The lower end 150 of the plunger 144, adjacent the member 82, which is of a larger diameter than shank 149, is guidingly received within the lower end of the sleeve 145; a coil compression spring 154 disposed between the shoulder at the junction between the parts 149 and 150 of the plunger and the lower end of the second, inner sleeve 152 constantly urges the plunger 144 toward its lower terminal position. The plunger 144 is stopped in such lower terminal position by lock nuts 156 on the shank 149, the lower one of such nuts

engaging the upper end of the sleeve 152 to stop the downward travel of the plunger. The inner sleeve 152 is held in vertically adjusted position in sleeve 145 by a lock nut 155. The plunger is stopped in its upward travel by engagement of the upper end of member 82 with the lower end of sleeve 145.

It will be seen that the three adjustments provided for the elements of the torque back-up capsule are independent of each other. Thus adjustment of the sleeve 145 determines the overall positioning of the capsule relative to the housing of the pump without affecting the length of travel of the plunger 144 or the force with which it is pretensioned or biased downwardly. The vertical adjustment of the second sleeve 152 determines the length of travel of the plunger without affecting the other two adjustments; the adjustment of the nuts 156 determines the degree of pretensioning of the plunger, also without affecting the other two adjustments.

The manner of operation of the device of
FIGS. 1 to 4, inclusive

When the engine is at rest the governor 29 exerts no force upon the thrust collar or reciprocable member 54; as a result the leaf spring 30 presses the lower ends of the jointed lever 31 and the rigid lever 85 to the left (FIG. 1) and thus the upper ends of such levers and the control rod 26 to the right. Lever 85 and thus control rod 26 are stopped by engagement of the slat or wing 90 on the rigid lever 85 with the lower arm 80 of the maximum fuel stop lever 77 and engagement of the upper arm 79 of lever 77 with the stop member 82.

When the engine is to be started, the solenoid 94 is energized so as to pull the shaft 74 to the right (FIG. 3), thereby removing the maximum fuel stop lever 77 from the path of the wing 90 on the rigid lever 85 and the boost rack control lever 106 from the path of the wing 65 on the bracket 64 on the control rod 26. The leaf spring 30 then thrusts the jointed lever 31 further clockwise (FIG. 1) and the control rod 26 to its fully extended, excess fuel position to the right. When lever 77 is moved laterally out of the path of wing 90 on lever 85, lever 77 rotates clockwise (FIG. 1) until arm 81 of lever 77 engages the forward edge of stop member 82. The engine is then started; as the engine picks up speed, the governor 29 exerts progressively increasing thrust to the right against collar 84 thereby to turn the lever 31 counterclockwise against the opposition of the leaf spring 30. When the engine has come up to a predetermined speed, the force exerted upon the levers 31, 85 by the governor 29 is sufficient to move them counterclockwise and the control rod 26 to the left to a position at which the wing 65 on the control rod 26 and the wing 90 on the rigid lever 85 snap past the respective boost control rack lever 106 and the lower arm 80 on the maximum fuel stop lever 77. The parts then return to the positions thereof shown in FIGS. 1 and 3.

The engine may be shut off at any time by use of the shut-off lever 68 so as to turn the sleeve 66 and the internal shut-off lever 69 so that the wing 70 and the latter thrusts the bracket 64 on control rod 26 to the left (FIG. 1) thereby "breaking" the jointed lever 31 and thrusting the control rod 26 to its fuel delivery shut-off position. If the pressure of the air delivered by the supercharger of the engine does not at least equal a predetermined value, indicating that insufficient air is available for the effective combustion of the fuel delivered, the pressure responsive unit 111 functions to thrust the arm of lever 106 against the bracket 64 of the control rod 26, thereby to limit the amount of fuel which can be delivered to the engine under such condition. When the engine speeds up to deliver air at a requisite rate thereto the lever 106 is removed from cooperation with the bracket 64 by the unit 111. The capsule 84 permits the stop 82 to yield from its normal extended position so as to deliver additional fuel to the engine as demanded by the position of the throttle

and thus the force exerted on the leaf spring 30 by the engine throttle.

The alternative device of FIGS. 5 to 7, inclusive

5 The fuel injection pump of the embodiment shown in FIGS. 5 to 7, inclusive, is similar in all respects to the pump of FIGS. 1 to 4, inclusive, with the exception of modifications therein in its control section, such section being here designated 11'. In such alternative embodiment 10 the jointed lever and the rigid lever are in effect combined at one side of the section 11', the two levers including a part at the lower end of each which is common to both of them. Further, the control section 11' is so constructed 15 and arranged that the maximum fuel stop and boost rack control levers are automatically shifted laterally to their engine-starting, excess fuel positions upon the stopping of the engine; upon the starting of the engine such levers are automatically shifted to their normal, engine-running positions. Parts which are the same in the second embodiment 20 as in the first are designated by the same reference characters.

The apparatus of FIGS. 5, 6, and 7 includes a long rigid lever 160 which is pivoted to the housing of the pump by a stub shaft 34 and which has a driving connection between its lower end and the collar or reciprocable member 54, such connection being provided by a shoe 41 pivotally 25 mounted on the lever and an annular groove 59 in the member 54 as in the first embodiment. The portion of the lever 160 above its pivotal mounting at stub shaft 34 is designated 161. Pivotaly mounted by a pin 164 upon portion 161 of lever 160 somewhat above shaft 34 is an upper short lever 162 which is disposed laterally inwardly (to the right in FIG. 6) of the portion 161 of lever 160. Lever 162 30 normally abuts a first, rear laterally inwardly extending wing 165 on the portion 161 of lever 160, in which position lever 162 lies generally parallel to portion 161 of lever 160. The terminal counterclockwise (FIG. 5) position of lever 162 relative to lever portion 161 is determined by engagement of the upper end of lever 162 with a second, 35 forward wing 171 on the upper end of lever portion 161. The lever 162 is normally held in engagement with wing 165 by a coil torque spring 166, one tang 167 of which overlies the rear edges of both lever 162 and lever portion 161, and a second tang 169 of which overlies the forward 40 edges of such members.

The upper end of the lever 162 is slotted to provide a yoke 170, the yoke accurately receiving a pin 61 (FIG. 5) which extends laterally from the control rod 26. As in the first embodiment, the axial position of the reciprocable member 54, under engine-running conditions, is determined by the resultant of the forces exerted thereon by the governor 29 and the leaf spring 30; the leaf spring is 45 adjustably tensioned, as in the embodiment of FIGS. 1 to 4, inclusive, by the turning of the throttle lever 46.

A bracket 172 is affixed to the upper surface of control rod 26 adjacent the rear end of the rod, as by being riveted thereto. Such bracket has horizontal portions which extend laterally in opposite directions, as shown in FIG. 6, there being an upstanding wing 175 on the outer end of the right-hand horizontal portion and an upstanding wing 176 on the outer end of the left-hand horizontal portion. An engine stop lever 177, a maximum fuel stop lever 180, and a boost rack control lever 185 selectively cooperate with wings 176, 171, and 175, respectively, after the 50 engine has been started. Before the engine has been started, the parts of the control section 11' are disposed as shown in FIG. 6, with the maximum fuel stop lever 180 and the boost rack control lever 185 moved laterally to the right out of the paths of wings 171 and 175, 55 respectively.

In FIG. 5, the control rod 26 is shown in full lines in its excess fuel position, into which the throttle spring 30 moves it when the engine is at rest and the levers 182 and 185 are disposed as shown in FIG. 6. When the control rod 26 is disposed in its left-hand terminal, fuel 60 65 70 75

shut-off position, the parts 61, 162, and 170 occupy the phantom line positions shown in FIG. 5 where they are designated by the same reference characters with an added prime. When the engine is running normally, the control rod 26 lies intermediate its excess fuel and fuel shut-off positions shown in FIG. 5, and the maximum fuel stop lever 180 and boost rack control lever 185 occupy the positions shown in phantom lines in FIG. 6 and designated by added primes, respectively. Such normal engine-running position of the control rod 26 is determined by engagement of one arm 182 of the maximum fuel stop lever 180 with the wing 171 on the lever portion 161 and the engagement of the second arm 181 of such lever with the stop member 82 of a torque back-up capsule similar to capsule 84 of the first embodiment. The engine is stopped by swinging an engine stop lever 177 into engagement with the wing 176, the lever 177 then thrusting the control rod 26 to the left into its shut-off position. In so doing the shut-off lever 177, acting through the wing 176, the bracket 172, the control rod 26, the cross pin 61 and the yoke 170 on lever 162, turns lever 162 counterclockwise (FIG. 5) with respect to lever 160 against the opposition of the coil torque spring 166.

The fuel shut-off lever 177 is affixed to the inner end of a horizontal transverse sleeve 190 which has its outer end portion 191 journaled in a bore in housing portion 67. Sleeve 190 is selectively turned by an external lever 68 affixed to the outer end of sleeve 190. The maximum fuel stop lever 180 is affixed to the left-hand (FIG. 6) end of a sleeve 192 which is mounted on a horizontal transverse shaft 189 and is fixedly secured thereto by a transverse pin 194 which extends through the shaft 189 and the sleeve 192. The shaft 189, which is journaled at the left in sleeve 190 and at the right within a sleeve 197 in housing portion 67, is selectively movable along its axis by means to be described to carry the levers 180, 185 from their full line to their phantom line position (FIG. 6) and vice versa.

The boost control rack lever 185 is affixed to an outer sleeve 195 which is telescoped over the sleeve 192 and journaled thereupon. Sleeve 195 has opposed elongated transverse slots 196 therethrough which receive the opposite ends of pin 194; the sleeve 195 and lever 185 affixed thereto move transversely with the shaft 189 but are free to rotate with respect thereto within the limit imposed by pin 194 and slots 196. The boost rack control lever 185 is under the control of an engine intake pressure responsive device (not shown) which may be the same as the above described unit 111 in the embodiment of FIGS. 1-4, inclusive. Lever 185, when in its normal engine-running position, is longitudinally aligned with the wing 175. When lever 185 in such position is operated, it is rotated by the pressure responsive device through lever arm 187 so that the lower arm 186 of the lever engages and thrusts the wing 175 forwardly.

The shaft 189, sleeves 192 and 195, and the levers 180 and 185 mounted on the respective sleeves are selectively moved along the axis of the shaft between the engine-starting, inoperative position of such levers and their operative, normal engine-running position by a means which, in the embodiment shown, is responsive to a phenomenon which indicates whether the engine is stopped or running. Such means includes a cylinder 199 mounted on housing part 67 and having a piston 200 reciprocable therein along a path coaxial of the shaft 189. The right-hand, outer end of cylinder 199 is provided with a conduit 201 which is connected to the delivery side of an oil pump, such as the transfer pump 12 of FIG. 1, driven by the engine. Interposed between the piston 200 and the right-hand end 202 of the shaft 189 is a first coil compression spring 204. A second coil compression spring 205 surrounds a reduced diameter left-hand end portion 206 of shaft 189 within a blind bore 207 in sleeve 190; spring 205 acts between a shoulder 209 on the shaft 189 and the closed end 210 of the bore

207 in sleeve 190. Engagement of the outer end 211 of portion 206 of the shaft and the end 210 of the bore stops the travel of the shaft and the levers 180 and 185 carried thereby with the levers in their operative positions, shown in phantom lines in FIG. 6.

As is apparent from the above, the control section 11' of FIGS. 5-7, inclusive, automatically disengages the maximum fuel stop lever 180 from wing 171 and allows the fuel pump control rod 26 to be moved into its excess fuel position by the throttle spring 30. Such action occurs when the engine is stopped (when the oil pump pressure is zero) or being cranked (oil pressure low). After the engine has started, and the engine lubricating oil pressure reaches a predetermined value (corresponding to a first predetermined engine speed) the piston 200 is thrust to the left (FIG. 6), and through the now partially compressed spring 204 exerts a sufficient thrust to the left upon shaft 189 to cause the shaft to start to move to the left against the opposition of spring 205. At a second, oil pressure, corresponding to a second, higher engine speed, the axial movement to the left of the shaft 189 is stopped by contact of the maximum fuel stop lever 180 with the right-hand edge of wing 171. Travel of the piston 200 to the left is stopped by engagement of the left-hand end surface 214 of the piston 200 with the left-hand end surface 212 of the cylinder. The spring 204, which when the piston lies in its left-hand terminal position is of greater compressive strength than the now partially compressed spring 205, limits the thrust which the piston 200 can impose upon the shaft 189 under high engine speed and thus high oil pressure conditions.

When the engine speed increases still further, the centrifugal governor acts to thrust the control rod 26 to the left (FIG. 5) against the opposition of throttle spring 30, so that the wing 171 on the upper portion 161 of lever 160 snaps past the arm 182 of the maximum fuel stop lever 180. The shaft 189 now moves into its left-hand terminal, normal engine-running, position, wherein the maximum fuel stop lever cooperates with the wing 171 and the yieldable stop 82.

Although a limited number of embodiments of the invention have been illustrated in the accompanying drawings and described in the foregoing specification, it is to be especially understood that various changes, such as in the relative dimensions of the parts, materials used, and the like, as well as the suggested manner of use of the apparatus of the invention, may be made therein without departing from the spirit and scope of the invention, as will now be apparent to those skilled in the art. Thus the shaft 189 in the control section 11' of the embodiment of FIGS. 5-7, inclusive, may be shifted manually or by solenoid means as in the first described embodiment, rather than by an oil pressure responsive means as shown. Further although it is preferred that the oil which actuates piston 200 be fuel from a transfer pump driven by the engine, the lubricating oil for the engine may be employed for this purpose, the conduit 201 then being connected to the output of the engine lubricating pump. Also, in the embodiment of FIGS. 1-4, inclusive, the levers 31 and 85 may be connected by a cross member which extends between and is integrally connected to the lower ends of such levers.

What is claimed is:

1. In a fuel injection pump for delivering fuel to an engine, said pump having a driven main shaft, and adjustable control member governing the quantity of fuel delivered by the pump at each fuel injecting cycle thereof, a centrifugal governor driven by the main shaft in synchronism therewith, a reciprocable member disposed to be urged in one direction by the governor with a force which increases in a predetermined manner upon increase of the speed of rotation of the main shaft of the pump, a throttle spring opposing the travel of the reciprocable member in said one direction, a throttle shaft for varying the force which the spring exerts upon the reciprocable

member, means operatively connecting the control member and the reciprocable member including means forming a first, jointed rod-like element having at least two pivotally connected parts, a portion of the first of which is connected to the reciprocable member and the second of which is connected to the control member, said jointed element being rigid in the direction in which the governor urges it to decrease the rate of fuel delivery by the pump and folding in the other direction, resilient means constantly urging the parts of the jointed element toward their rigid position relative to each other, and means for selectively thrusting the control member into its fuel shut-off position against the opposition of the said resilient means, the improvement which comprises a second, rigid rod-like element connected to the reciprocable member so as to move in the same direction as and in synchronism with the first part of the jointed element, and maximum fuel stop means cooperating with the second element for stopping the second element and thus the reciprocable member and the control member in a maximum fuel position of the control member.

2. A fuel injection pump according to claim 1, comprising means for selectively axially moving the maximum fuel stop means into and out of the path of the second element, said maximum fuel stop means when moved out of the path of the second element permitting movement of the control member to effect the delivery of excess fuel to the engine.

3. A fuel injection pump according to claim 1, wherein the maximum fuel stop means comprises a first, maximum fuel stop lever freely rotatable between limits, means for urging the first lever into the path of the second element, a stop member disposed to stop the rotation of the first lever by the second element, and means for selectively moving the first lever axially into and out of the path of the second element.

4. A fuel injection pump according to claim 3, comprising yieldable means for constantly urging the stop member toward an extended terminal position thereof, whereby when the throttle spring imposes a force upon the reciprocable member which is substantially greater than the force imposed thereon by the governor, the resultant force upon the reciprocable member causes the second, rigid element, acting through the first lever, to overcome the yieldable means, whereby to move the control member to effect the delivery of added fuel to satisfy the torque back-up requirements of the engine.

5. A fuel injection pump according to claim 4, wherein the yieldable means comprises a plunger including the stop member at its outer free end selectively engaged by the first lever, means for guiding the plunger for reciprocation along its axis, and resilient means for thrusting the plunger with the stop member toward its extended terminal position.

6. A fuel injection pump according to claim 5, comprising means for adjusting the outer terminal position of the plunger, means for adjusting the length of travel of the plunger between its outer and its inner terminal positions, and means for adjusting the force which the last-named resilient means exerts upon the plunger when the plunger is in its outer terminal position.

7. A fuel injection pump according to claim 6, wherein each of said three adjusting means adjusts its respective function independently of the functions of the other two adjusting means.

8. A fuel injection pump according to claim 3, comprising a second, boost rack control lever which selectively cooperates with the control member to stop the travel of the control member from further travel in a fuel delivery increasing direction beyond a predetermined position when the speed of the engine does not at least equal a predetermined desired value, said second lever being pivotally coaxial with and mounted for limited angular movement relative to said first lever.

9. A fuel injection pump according to claim 8, where-

in the second lever is selectively movable into the path of a part of the control member to stop the further travel of the control member in a fuel delivery increasing direction, and comprising means responsive to variations in engine speed to angularly move the second lever into the path of said part of the control member.

10. A fuel injection pump according to claim 9, comprising a supercharger for the engine and driven thereby, and wherein the means responsive to variations in engine speed comprises a pressure responsive means subjected to the output pressure of the supercharger.

11. A fuel injection pump according to claim 1, wherein the second, rigid element is separate from the first, jointed element and is separately connected to and driven by the reciprocable member.

12. A fuel injection pump according to claim 1, wherein the second, rigid element includes as a first portion thereof the portion of said first part of the jointed element which is connected to the reciprocable member, and further includes as a second portion thereof an extension rigidly connected to its said first portion, said extension cooperating with the maximum fuel stop means.

13. A fuel injection pump according to claim 1, wherein the means for selectively thrusting the control member into its fuel shut-off position against the opposition of said resilient means comprises a rotatable fuel shut-off lever selectively interposable into the path of a part affixed to the adjustable control member, and wherein the maximum fuel stop means comprises a maximum fuel stop lever mounted for limited pivotal and axial movements and being selectively interposable into the path of a portion of the second element.

14. A fuel injection pump according to claim 13, wherein the maximum fuel stop lever is axially movable between a first lateral position in which it is interposed in the path of said portion of the second, rigid element and a second lateral position in which it lies removed from the path of said portion of the second element.

15. A fuel injection pump according to claim 14, comprising yieldable means constantly urging the maximum fuel stop lever toward its first lateral position, and means for selectively moving the maximum fuel stop lever into its second lateral position.

16. A fuel injection pump according to claim 14, comprising yieldable means constantly urging the maximum fuel stop lever toward its second lateral position, and means for selectively moving the maximum fuel stop lever into its first lateral position.

17. A fuel injection pump according to claim 14, comprising a boost rack control lever mounted coaxially of the fuel shut-off and maximum fuel stop levers and selectively engaging a part affixed to the control member, and means responsive to the pressure of air delivered to the engine to move the boost rack control lever into the path of said last named part affixed to the control member so that the boost rack control lever functions to stop the movement of the control member in its fuel delivery increasing direction when said air pressure falls below a predetermined desired value.

18. A fuel injection pump according to claim 17, comprising means mounting the boost rack control lever for axial movement with the maximum fuel stop lever between first and second lateral positions, in its first lateral position the boost rack control lever being interposed in the path of said last-named part affixed to the control member, and in its second lateral position the boost rack control lever being removed from the path of said last-named part affixed to the control member, whereby when the boost rack control lever and the maximum fuel stop lever are moved into their second lateral positions the control member may be moved to its excess fuel position.

19. A fuel injection pump as defined in claim 1, wherein said maximum fuel stop means includes a lever pivotally mounted for limited axial and angular movements, and comprising means for yieldably urging said lever axially

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into the path of said second element, and means for selectively moving said lever out of said path.

20. A fuel injection pump as defined in claim 1, wherein said maximum fuel stop means includes a lever pivotally mounted for limited axial and angular movements, and comprising means for yieldably urging said lever axially out of the path of said second element, and means for selectively moving said lever into said path.

21. A fuel injection pump according to claim 9 comprising means for selectively moving said second lever axially out of the path of said part of the control member.

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