Aug. 3, 1948. S. W. GILBERT 2,446,469

CONTROL APPARATUS FOR INTERNAL-COMBUSTION ENGINES

Filed May 12, 1945 2 Sheets-Sheet 1

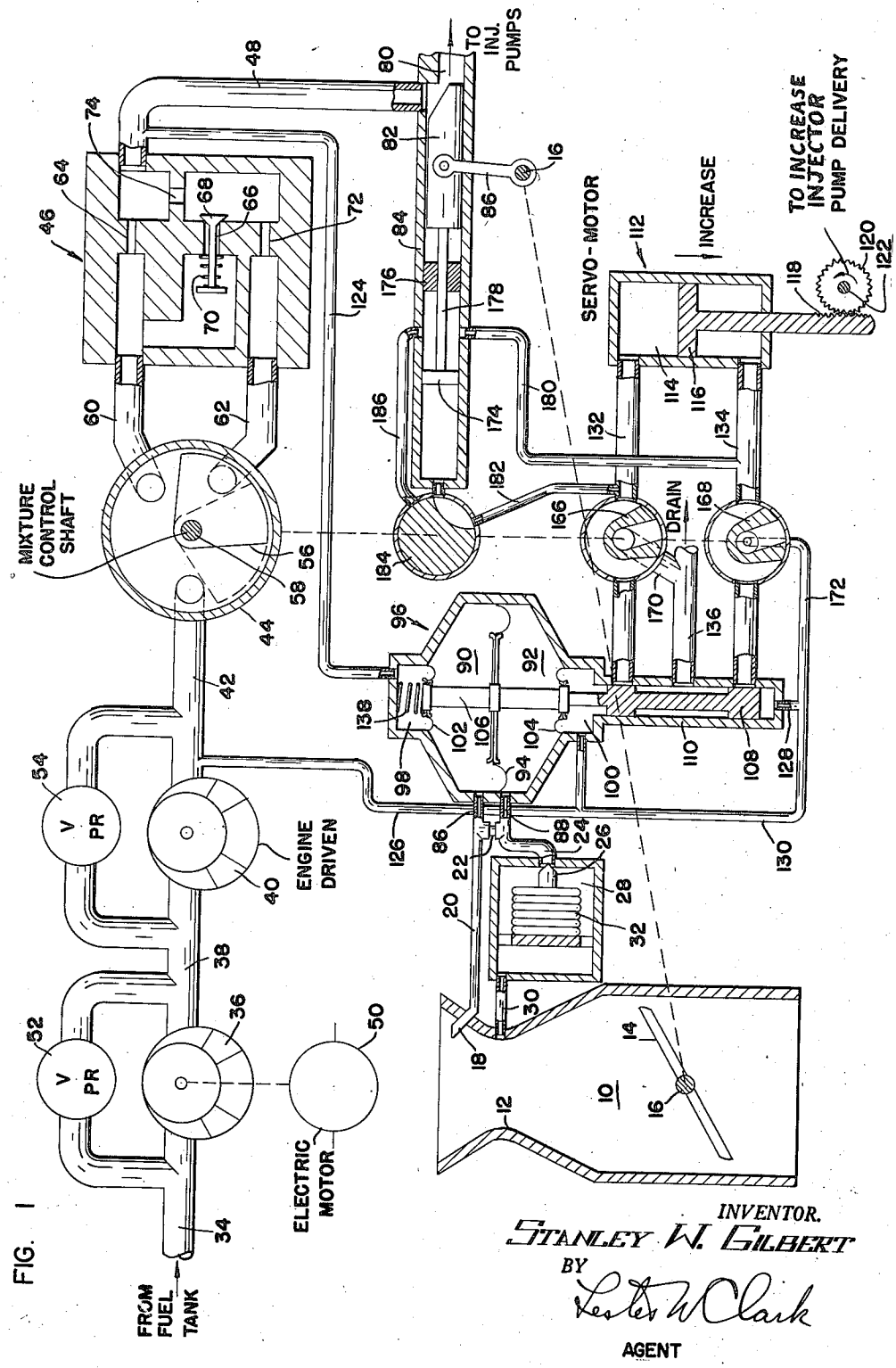


FIG. 1

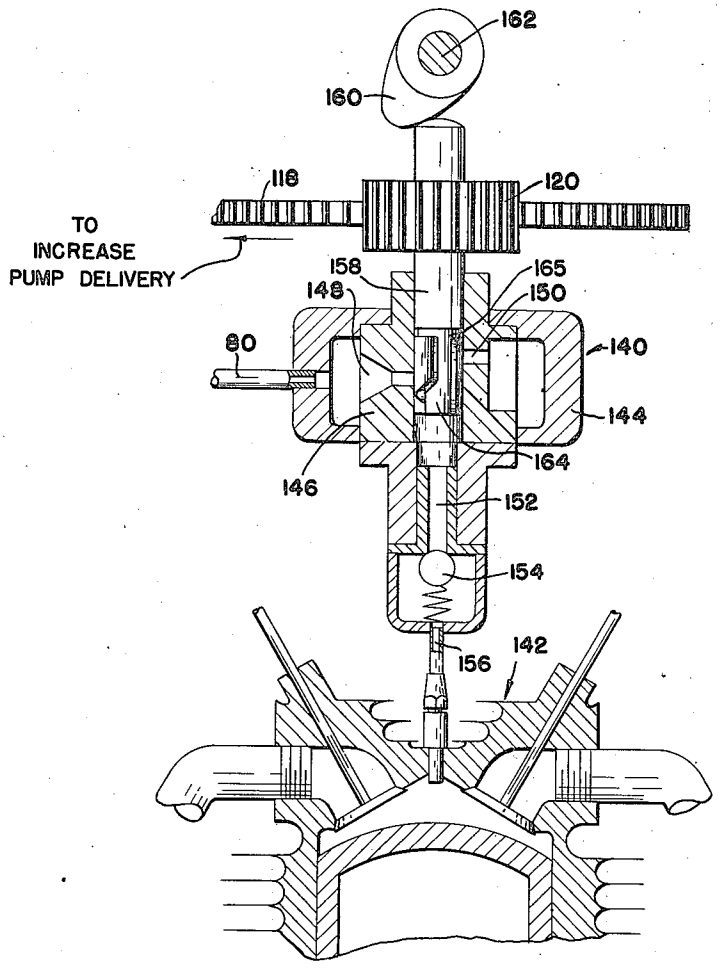
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CONTROL APPARATUS FOR INTERNAL-COMBUSTION ENGINES

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FIG. 2



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2,446,469

CONTROL APPARATUS FOR INTERNAL-COMBUSTION ENGINES

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Application May 12, 1945, Serial No. 593,415

17 Claims. (Cl. 123—119)

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The present invention relates to fuel supply systems for internal combustion engines. While it is illustrated as applied to a system of the type in which fuel is injected directly into the combustion chamber of the engine without first being mixed with air, some of the features of my invention may be used in other types of systems. The invention is especially adapted for use with engines of the spark ignition type, although its utility is not limited to such engines.

Such direct injection systems commonly use a set of injector pumps, one for each cylinder of the engine, and means are provided to control simultaneously the capacity per stroke of all the pumps so as to regulate the quantity of fuel delivered to the combustion chamber at each stroke of the engine. Alternatively, each injector pump may deliver fuel into the intake manifold just outside one of the cylinder intake ports.

It has been proposed to operate the pump capacity control mechanism in accordance with the flow of air thru the air induction system of the engine, in such a manner as to maintain the fuel-to-air ratio within suitable limits. In such fuel supply systems, difficulty has been encountered in controlling the pump capacity when the rate of flow of air thru the induction system is relatively low. Under such conditions, the force produced by the device which meters the air flow is rather small, and the control of the pump capacity by this small force tends to be erratic.

Other difficulties have been encountered in such systems with respect to the control of the pump capacity when it is desired to shut down the engine. Under such conditions, the air flow responsive means tends to maintain the pump at a substantial capacity as long as the engine operates, while the best method of stopping the engine is to cut off the flow of fuel thru the pump before the engine comes to rest, so that no unburned fuel remains in the cylinders of the engine.

In order to avoid dependence upon the air induction system for stopping the effective action of the pumps, it has been proposed to provide a separately acting means for this purpose, such a means being shown in the copending application of Leighton Lee II, Serial No. 534,043, filed May 4, 1944, now issued as Patent No. 2,402,332, dated June 18, 1946, which is assigned to the assignee of the present application.

The mechanism disclosed in the aforesaid Lee patent serves to mechanically actuate the fluid motor which controls the pump mechanism in such a way as to adjust the pump mechanism for no delivery. Such mechanical actuation of the

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fluid motor is effected selectively either by the throttle mechanism when the throttle is moved to closed position, or by the mixture control valve mechanism when the valve is moved to its fuel cutoff position.

One of the objects of the present invention is to provide a system of the general character disclosed in the Lee patent, wherein upon movement of the mixture control valve to cutoff position, the means, such as the fluid motor, for changing the rate of fuel supply to the engine is removed from its normal control by the air induction system and is hydraulically actuated independently thereof.

Another object of the invention is to provide a system of the character described wherein there is a means, such as an accelerating pump, operated upon rapid movement of the throttle mechanism, such as accompanies acceleration or deceleration of the engine, for hydraulically actuating the means for changing the rate of fuel supply.

A further object is to provide, in a fuel supply system for an internal combustion engine, improved means for actuating an idle control device and an acceleration control device in response to movements of the throttle.

Other objects and advantages of the present invention will be apparent from a consideration of the appended specification, claims and drawings, in which:

Figure 1 represents, somewhat diagrammatically, a fuel supply system for an internal combustion engine, of the type to which my invention is applicable, and

Figure 2 illustrates, somewhat diagrammatically, one of the injector pumps with a portion of an adjacent engine cylinder.

There is shown in Figure 1 a passage 10 for air flowing to an internal combustion engine. This passage 10 includes a venturi portion 12 which produces a differential pressure varying with the square of the velocity of the air flowing thru the passage. The flow of air thru the passage 10 is controlled by a throttle 14 fixed on a shaft 16 for rotation therewith.

The pressure differential set up by the venturi 12 produces a flow of air thru a secondary air passage extending from an impact tube 18 thru a conduit 20, a short transverse conduit 22 having a restricted opening therethru, a conduit 24, past a valve 26 into a chamber 28 and thence thru a conduit 30 to the throat of venturi 12.

The pressure differential between the ends of the secondary air passage may be divided into

two component drops, one appearing across the restriction at 22 and the other across the valve 26. The valve 26 is operated by a bellows 32 located in the chamber 28. The bellows 32 is preferably filled with a fluid having a suitable coefficient of thermal expansion, so that the valve 26 is moved in accordance with changes in the pressure and temperature of the air in the chamber 28. The pressure differential appearing across restriction 22 is thereby controlled both as a function of the velocity and the density of the flowing air so that pressure differential is a measure of the mass of air flowing thru the passage 10 per unit time.

The fuel flowing to the engine comes from a tank (not shown) and passes thru a conduit 34, a boost pump 36, a conduit 38, a pump 40, a conduit 42, a mixture control 44, a jet system generally indicated at 46, and a conduit 48 to the injector pumps, one of which is shown in Figure 2.

The pump 36 is driven by an electric motor indicated schematically at 50. The discharge pressure of pump 36 is controlled by a pressure relief valve 52. Pump 40 is preferably driven by the engine and its discharge pressure is controlled by a pressure relief valve 54.

The mixture control 44 includes a disc valve 56 fixed on a shaft 58. The disc valve 56 controls the flow of fuel thru a pair of conduits 60 and 62 which connect the mixture control 44 to the jet system 46. When the valve 56 is in the position shown in full lines in Figure 1, the mixture control is said to be in its "lean" position, since the fuel can then flow to the jet system only thru the conduit 60. When the valve 56 is in the position illustrated in dotted lines, the mixture control is said to be in its "rich" position, since the fuel can then flow thru both conduits 60 and 62 to the jet system 46. It may be seen that the valve 56 can be moved to a position wherein it cuts off the flow of fuel thru both the conduits 60 and 62. The mixture control is then said to be in its "cutoff" position.

When the mixture control is in its lean position, fuel can flow to the engine only thru a fixed jet or orifice 64 and a parallel jet 66 controlled by a valve 68 biased closed by a spring 70. When the mixture control is in its rich position, fuel can also flow thru a fixed jet 72. The flow thru the jets 66 and 72 also passes thru another fixed jet 74.

The function of the jet system is to control the fuel flow as a function of the pressure differential across the jet system. When the mixture control is in its lean position, a given pressure differential indicates a certain rate of fuel flow. When the mixture control is in its rich position, the cross-sectional area open to the fuel flow is increased so that the same pressure differential as before produces an increased fuel flow. Since the pressure differential across the jet system is controlled by the air flow, as hereinafter explained, it may be seen that the mixture control may be used to select different fuel-to-air ratios for different flight conditions. The jet 66 and the valve 68 controlling it are provided to increase the fuel flow whenever the pressure differential across the jets exceeds a predetermined value, thereby producing an increase in the fuel-to-air ratio at high power outputs.

The conduit 48 is connected with a conduit 80 leading to the injection pumps, and flow of the fuel into the conduit 80 is controlled by an idle valve piston 82 movable in a cylinder 84. The piston 82 loosely fits the cylinder, or has a flat or groove along one side, so that fuel may flow

freely past it as it moves. The valve piston is movable by a lever 86 operated by the throttle shaft 16. The lever is shown as carried directly by the shaft 16, but it will be understood that it may be mounted on any shaft movable in unison with the shaft 16. The end of the valve piston 82 is so shaped, and the movement of the valve is so timed with the throttle 14, that the flow of fuel to the conduit 80 is substantially reduced as the throttle approaches its closed position and substantially increased as the throttle leaves its closed position. When the throttle has moved away from its closed position by a substantial amount, e. g., when it has rotated 20 degrees, the idle valve 82 is so far retracted that it does not affect the fuel flow as the throttle moves farther toward open position.

The pressure differential appearing across the restriction at 22 is applied thru a pair of conduits 86 and 88 to chambers 90 and 92, respectively, located on opposite sides of a diaphragm 94 in a pressure meter generally indicated at 96. The pressure meter 96 also includes chambers 98 and 100. The chamber 98 is separated from the chamber 90 by a diaphragm 102 and the chamber 100 is separated from the chamber 92 by a diaphragm 104.

The diaphragms 94, 102, and 104 are connected to the stem 106 of a valve piston 108 which is movable in a cylinder 110 to control the flow of fuel to a pressure operated means for changing the rate of fuel supply from the fuel conduit to the engine. Preferably and as shown, this means is a servo motor or fluid motor 112 which serves to change the capacity of a variable capacity injector pump mechanism as hereinafter described. The motor 112 includes a cylinder 114 enclosing a piston 116 connected to move a rack 118 cooperating with a gear 120 mounted on a shaft 122. The gear 120 is connected to suitable mechanism for controlling the capacity of the said injector pump mechanism.

The chamber 98 is connected by means of a conduit 124 to the conduit 48 in the fuel line on the downstream side of the jet system 46. The chamber 100 of the pressure meter 96 is connected by means of a conduit 126 to the conduit 42 in the fuel line on the upstream side of the jet system 46. The upper end of the valve cylinder 110 is connected directly with the chamber 100. A branch 128 of an extension 130 of the conduit 126 supplies fuel under pressure to the bottom of the valve cylinder 110. Two conduits 132 and 134 connect the cylinder 110 to the opposite ends of cylinder 114 of the servo motor 112. A conduit 136 serves as a drain and connects the valve cylinder 110 with a suitable low pressure point in the fuel line or elsewhere.

The fuel pressure differential across the jet system, which is a measure of the rate of flow of fuel to the engine, is applied to the chambers 98 and 100, with the high pressure in the chamber 100, so that this pressure differential acts upwardly on the valve piston 108 as viewed in Figure 1. The air pressure differential, which is a measure of the rate of flow of air to the engine, is applied to the diaphragm 94 so that it acts on the valve piston 108 in a downward direction as viewed in Figure 1.

When the fuel pressure differential is balanced with the air pressure differential, the valve piston 108 is at the position shown in the drawing. In this position of the valve piston, no fuel flows to either end of the cylinder 114 of servo motor 112.

If the amount of air flowing thru the passage

10 increases, the force acting downwardly on the diaphragm 94 increases, thereby moving the valve piston 108 downwardly, and opening the port to the conduit 132 so that fuel under pressure may flow from the chamber 100 into conduit 132 and the upper end of cylinder 114. At the same time, the lower end of cylinder 114 is connected thru the conduit 134 with the drain conduit 136. A pressure differential is thereby established across the piston 116, causing it to move downward, carrying the rack 118 with it and rotating the gear 120 in the counter-clockwise direction. The pump capacity regulating mechanism is so designed that rotation of gear 120 in the counter-clockwise direction increases the pump capacity, as indicated by the legend in the drawing and as hereinafter more fully described. The increase in the pump capacity causes a corresponding increase in the fuel flow, thereby increasing the pressure differential across the jet system so as to produce a force acting upwardly on the valve piston 108 to restore it to its neutral position.

In a similar manner, if the air flow decreases, the valve piston 108 is moved upwardly to admit fuel under high pressure to the lower end of cylinder 114 thru conduits 128 and 134, and to connect the upper end of cylinder 114 to the drain conduit 136 thru conduit 134. This produces a rotation of the injector pump capacity control shaft in the opposite, or capacity decreasing, direction.

When the valve piston 108 is in its neutral position, the piston 116 of the servo or fluid motor is held in whatever position it may then occupy, thus preventing any change in the capacity of the injector pumps.

It may be noted that the area of the surface of diaphragm 102 on which the pressure in chamber 98 acts downwardly is greater than the area on the surface of diaphragm 104 on which the pressure in chamber 100 acts upwardly, because of the presence of the valve stem in chamber 100. However, since the pressure in chamber 100 is communicated thru conduits 130 and 128 to the lower end of cylinder 110, where it acts upwardly on valve 108, it may be seen that the net area subject to the pressure in chamber 100 is equal to the area subject to the pressure in chamber 98.

When the air flow is small, as when the throttle 14 is near its closed position, the force applied to diaphragm 94 is small. An idle spring 138 is provided to bias the valve 108 in a fuel flow increasing direction. This spring is made light as compared to the force applied to the diaphragm 94 under engine power output conditions, so that its effect is then negligible. However, under idling conditions, it becomes the predominating force acting downwardly on valve 106. In effect, it operates to establish a definite, substantially constant pressure drop across idle valve 82 and jet system 46 in series. Since the restriction at valve 82 is then much smaller than that at jet 64, the flow is determined by the idle valve contour.

Referring particularly to Figure 2, one of the injection pumps is shown at 140, it being understood that there is a plurality of such pumps corresponding in number to the cylinders 142 of the engine. The pump 140 has a hollow outer body 144 to which fuel is supplied thru a branch of the fuel conduit 80. Positioned within the outer body 144 is an inner body 146 having ports 148 and 150 connecting a chamber in the outer body with a central bore or cylinder in the inner body. The bore in the inner body 146 is open at the bottom and communicates with a conduit 152 which in

turn communicates thru a self-closing ball check valve 154 with a conduit 156 leading to a nozzle which discharges directly into the motor cylinder 142. Mounted in the central bore for both longitudinal and rotative movement is a plunger 158 carrying, at its projecting upper end, the beforementioned gear 120 meshing with the rack 118. The plunger 158 is reciprocated by a cam 160 on a shaft 162 driven by the engine.

When the engine is in operation the shaft 162 with the several cams 160 thereon, is operated to move the plunger 158 of each injector pump downward concurrently with the suction stroke of each engine piston so as to deliver a charge of fuel to the engine cylinder. The plunger 158 has a contoured recess 164 formed therein which provides communication between the ports 148 and 150 and the cylinder ahead of plunger 158. The point in the travel of plunger 158 at which pumping starts is determined by the angular position of the plunger, which determines the point at which port 148 is closed by the helically contoured portion of recess 164. The plunger 158 is rotated by the rack 118 and the gear 120 thru the action of the servo motor as already described. When the servo motor piston 116 is in its uppermost position, as viewed in Figure 1, the port 148 is aligned with the vertical portion of recess 164, appearing at the center of plunger 158 in Figure 2, so that no pressure is built up by the downward stroke of plunger 158 and no fuel is injected thru valve 154 into the engine cylinder; as the piston 116 is moved downward, increased amounts of fuel are admitted into the injector pump and injected into the engine cylinder; and when the piston 116 is in its lowermost position the charge of fuel injected into the cylinder is at the maximum. The point in the stroke of plunger 158 at which pumping terminates is always the same, being established by the uncovering of port 150 by the annular groove 165 which communicates thru recess 164 with the cylinder ahead of plunger 158.

The fluid motor 112 and the variable capacity injector pumps collectively constitute means for changing the rate of fuel supply to the engine, but it will be understood that the invention in its broader aspects is not necessarily limited to the particular means shown.

It is established practice to stop the engine by cutting off the fuel supply, this being done in the present instance by moving the mixture valve disc 56 in the counter-clockwise direction from the full line position shown in Figure 1, thus cutting off the flow of fuel thru both of the conduits 60 and 62. When this is done it is desirable to disconnect the fluid motor from the control of the pressure controlled valve 108, and it is highly preferable to also actuate the servo or fluid motor 112 in the direction to change the injector pump capacity to the minimum, that is to zero, so as to immediately stop all injection of fuel into the engine cylinders.

In order to accomplish the results described there are mounted on the mixture control shaft 58, or on another shaft connected to operate in unison therewith, two valve discs 166 and 168 forming parts of valves connected respectively in the conduits 132 and 134. When the valve disc 166 is rotated in the counter-clockwise direction synchronously with the valve disc 56, as the latter is moved to its cut-off position, the valve 166 serves to disconnect the conduit 132 from the valve 108 and to connect it with a branch conduit 170 communicating with the drain conduit 136. Simultaneously the valve disc 168 serves to dis-

connect the conduit 134 from the valve 108 and to connect it with a pressure conduit 172 which is an extension of the conduit 130. As the result of the movement of these valves, the fluid motor 112 is cut off from the control of the valve 103 and the full fuel pressure is communicated directly to the lower end of the cylinder 114 while pressure at the upper end thereof is relieved. The cylinder, therefore, moves upward very quickly and the injector pumps are adjusted to the positions in which there will be no injection of fuel. This ensures the cutting off of fuel thru the pumps before the engine comes to rest.

Under conditions of rapid acceleration and deceleration, the response of the control system thus far described to changes in the air flow may be too slow. Therefore, I have provided means to increase the injector pump delivery suddenly upon an opening movement of the throttle, and to decrease it suddenly upon a closing movement of the throttle. With this additional control feature, the engine can accelerate and decelerate more rapidly.

In accordance with the invention, fluid under pressure is supplied directly to the fluid motor 112 by an accelerator pump controlled by the throttle mechanism and separate from the valve 108. The accelerator pump includes an extension of cylinder 84 and a piston 174 movable therein. The two portions of the cylinder 84 are separated by a bushing 176 which forms a partition. The piston 174 is connected to move with the idle valve piston 82 by a rod 178 extending thru the bushing 176. A conduit 180 communicates with the cylinder 84 at the right of the piston 174 and also with the before-mentioned conduit 134. A conduit 182 communicates with the cylinder 84 at the left of the piston 174 and also with the before-mentioned conduit 132.

When the throttle 14 moves suddenly towards its closed position, the piston 174 is moved quickly toward the right thus forcing fuel thru the conduits 180 and 134 into the lower end of the cylinder 114. At the same time, fuel is drawn from above piston 116 thru conduits 132 and 182 into the left end of cylinder 84. The piston 116 is thereby forced upward to decrease the capacity of the injector pumps. Similarly when the throttle is moved suddenly toward its open position, the piston 174 is moved rapidly toward the left, thus forcing fuel thru the conduits 182 and 132 into the upper end of the cylinder 114, thus increasing the capacity of the injector pumps. It will be seen that this action is supplemental to the action of the valve 108, and that the said action will take place, even though the valve 108 may be partly open and tending to move the piston 116 to decrease or increase the capacity of the injector pumps.

If the throttle is moved slowly, the pressure created by movement of the accelerating pump is dissipated thru valve 108 without any appreciable effect on the injector pump capacity.

It will be understood that the throttle mechanism is frictionally held by any usual or suitable means in whatever position it may occupy, thus resisting any tendency for movement of the throttle mechanism by fluid pressure applied to the piston 174 during normal operation of the valve 108.

From the foregoing description it will be clear that the throttle controlled means for supplying fluid to the servo motor operates entirely independently of the means controlled by the Venturi pressure. Any sudden change in the throttle position, particularly to or from closed position, will cause a corresponding rapid movement of the servo motor.

It is desirable to prevent control of the servo motor by the throttle mechanism when the mixture control valve has been moved to cut off the fuel so as to stop the engine. In order that the servo motor may, under these circumstances, be free from control by the throttle mechanism and in order that the throttle mechanism may not be loaded by resistance offered by the piston 174, there is provided a means for by-passing the piston 174 when the mixture control valve is in the cutoff position. To this end there is provided a valve disc 184 which, in the position shown in Figure 1, serves to connect the left end of the cylinder 84 with the before-mentioned conduit 182. This valve is mounted on the mixture control shaft, or on a shaft movable in unison therewith, and when the mixture control shaft is moved to the position for cutting off fuel to the conduits 60 and 62 the valve disc 184 is moved counter-clockwise to a position wherein it closes the conduit 182 and establishes a connection between the left end of the cylinder 84 and a by-pass conduit 186 which extends to the cylinder 84 at the right side of the piston 174. With the valve disc 184 in the position last described, the piston is by-passed by the conduit 186 and can move freely in the cylinder. Thus, with the by-pass open, the piston 174 has no control of the servo motor, and the piston offers no resistance to movement of the throttle mechanism.

While I have shown and described certain preferred embodiments of my invention, other modifications thereof will readily occur to those skilled in the art, and I therefore intend my invention to be limited only by the appended claims.

I claim as my invention:

1. A fuel supply system for an internal combustion engine, comprising a passage including a venturi for air flowing to said engine for combustion purposes, a throttle for controlling the flow of air thru the passage, injector pump mechanism with changeable capacity for supplying fuel to said engine, fuel supply conduits leading to the pump mechanism, a mixture control valve in the fuel supply conduits movable to and from a cutoff position wherein it prevents the passage of fuel to the pump mechanism, a fluid motor for changing the capacity of said pump mechanism, means controlled by variations in air pressure differential at the venturi for supplying fluid to the fluid motor and for thereby changing the pump capacity, and means operable independently of the pressure controlled means and in unison with movement of the mixture control valve to cutoff position for supplying fluid to actuate the fluid motor to reduce the capacity of the pump mechanism to its minimum.

2. A fuel supply system for an internal combustion engine, comprising a passage including a venturi for air flowing to said engine for combustion purposes, a throttle for controlling the flow of air thru the passage, a conduit for fuel flowing to said engine, a mixture control valve in the fuel conduit movable to and from a cutoff position wherein it prevents the passage of fuel thru the said fuel conduit, fluid pressure operated means for changing the rate of supply of fuel from the fuel conduit to the engine, means controlled by variations in air pressure differential at the venturi for supplying fluid to operate the said means for changing the rate of fuel supply, and means operable upon movement of the mix-

ture control valve to cutoff position for preventing the supply of fluid by the pressure controlled means to the means for changing the rate of fuel supply.

3. A fuel supply system for an internal combustion engine, comprising a passage including a venturi for air flowing to said engine for combustion purposes, a throttle for controlling the flow of air thru the passage, injector pump mechanism with changeable capacity for supplying fuel to said engine, fuel supply conduits leading to the pump mechanism, a mixture control valve in the fuel supply conduits movable to and from a cutoff position wherein it prevents the passage of fuel to the pump mechanism, a fluid motor for changing the capacity of said pump mechanism, means controlled by variations in air pressure differential at the venturi for supplying fluid to the fluid motor and for thereby changing the pump capacity, and means operable upon movement of the mixture control valve to cutoff position for preventing the supply of fluid by the pressure controlled means to the fluid motor.

4. A fuel supply system for an internal combustion engine, comprising a passage including a venturi for air flowing to said engine for combustion purposes, a throttle for controlling the flow of air thru the passage, injector pump mechanism with changeable capacity for supplying fuel to said engine, fuel supply conduits leading to the pump mechanism, a mixture control valve in the fuel supply conduits movable to and from a cutoff position wherein it prevents the passage of fuel to the pump mechanism, a fluid motor for changing the capacity of said pump mechanism, means controlled by variations in air pressure differential at the venturi for supplying fluid to the fluid motor and for thereby changing the pump capacity, and means operable upon movement of the mixture control valve to cutoff position for disconnecting the fluid motor from control by the pressure controlled means and for supplying fluid to actuate the fluid motor to reduce the capacity of the pump mechanism to its minimum.

5. A fuel supply system for an internal combustion engine, comprising a passage including a venturi for air flowing to said engine for combustion purposes, a throttle for controlling the flow of air thru the passage, injector pump mechanism with changeable capacity for supplying fuel to said engine, fuel supply conduits leading to the pump mechanism, a mixture control valve in the fuel supply conduits movable to and from a cutoff position wherein it prevents the passage of fuel to the pump mechanism, a fluid motor for changing the capacity of said pump mechanism, a valve controlled by variations in air pressure differential at the venturi, two conduits adapted to be opened and closed by the last said valve for establishing high pressure and low pressure fluid connections to the fluid motor for thereby actuating it to change the pump capacity, two valves positioned respectively in the last said conduits, means operable upon movement of the mixture control valve to cutoff position for moving the last said valves to positions wherein they close the said two conduits, and a high pressure conduit connecting with one of the last said valves and serving when the valve is in its last said position to supply fluid to actuate the fluid motor in the direction to reduce the capacity of the pump mechanism to its minimum.

6. A fuel supply system for an internal combustion engine, comprising a passage including a

venturi therein for air flowing to said engine for combustion purposes, a throttle for controlling the flow of air thru the passage, injector pump mechanism with changeable capacity for supplying fuel to said engine, fuel supply conduits leading to the pump mechanism, a mixture control valve in the fuel supply conduits movable to and from a position wherein it cuts off the passage of fuel to the pump mechanism, a fluid motor for changing the capacity of said pump mechanism, means controlled by variations in air pressure differential at the venturi for supplying fluid to the fluid motor and for thereby changing the pump capacity, an accelerating pump connected to operate in unison with the throttle for supplying fluid to the fluid motor additional to that supplied by the pressure controlled means and for thereby changing the injector pump capacity, a by-pass conduit connecting opposite sides of the accelerating pump, a valve in the by-pass conduit, and means connecting the by-pass valve with the mixture control valve for closing the by-pass valve when the mixture control valve is in open position and for opening the by-pass valve when the mixture control valve is in cutoff position.

7. A fuel supply system for an internal combustion engine, comprising a passage including a venturi therein for air flowing to said engine for combustion purposes, a throttle for controlling the flow of air thru the passage, injector pump mechanism with changeable capacity for supplying fuel to said engine, fuel supply conduits leading to the pump mechanism, a mixture control valve in the fuel supply conduits movable to and from a cutoff position wherein it prevents the passage of fuel to the pump mechanism, a fluid motor for changing the capacity of said pump mechanism, means controlled by variations in air pressure differential at the venturi for supplying fluid to the fluid motor and for thereby changing the pump capacity, an accelerating pump connected to operate in unison with the throttle for supplying fluid to the fluid motor additional to that supplied by the pressure controlled means and for thereby changing the injector pump capacity, a by-pass conduit connecting opposite sides of the accelerating pump, a valve in the by-pass conduit, means operable in unison with the mixture control valve and serving when the said valve is moved to cutoff position to supply fluid to actuate the fluid motor to reduce the capacity of the pump mechanism to its minimum, and other means also operable in unison with the mixture control valve and serving when the said valve is moved to cutoff position to open the by-pass valve.

8. A fuel supply system for an internal combustion engine, comprising a passage including a venturi therein for air flowing to said engine for combustion purposes, a throttle for controlling the flow of air thru the passage, injector pump mechanism with changeable capacity for supplying fuel to said engine, fuel supply conduits leading to the pump mechanism, a mixture control valve in the fuel supply conduits movable to and from a cutoff position wherein it prevents the passage of fuel to the pump mechanism, a fluid motor for changing the capacity of said pump mechanism, means controlled by variations in air pressure differential at the venturi for supplying fluid to the fluid motor and for thereby changing the pump capacity, an accelerating pump connected to operate in unison with the throttle for supplying fluid to the fluid motor additional to

that supplied by the pressure controlled means and for thereby changing the injector pump capacity, a by-pass conduit connecting opposite sides of the accelerating pump, a valve in the by-pass conduit, means operable in unison with the mixture control valve and serving when the said valve is moved to cutoff position to cut off control of the fluid motor by the pressure controlled means, and other means also operable in unison with the mixture control valve and serving when the said valve is moved to cutoff position to open the by-pass valve.

9. A fuel supply system for an internal combustion engine, comprising a passage including a venturi therein for air flowing to said engine for combustion purposes, a throttle for controlling the flow of air thru the passage, injector pump mechanism with changeable capacity for supplying fuel to said engine, fuel supply conduits leading to the pump mechanism, a mixture control valve in the fuel supply conduits movable to and from a cutoff position wherein it prevents the passage of fuel to the pump mechanism, an idle valve in the fuel supply conduits operated by the throttle mechanism, a fluid motor for changing the capacity of said pump mechanism, means controlled by variations in air pressure differential at the venturi for supplying fluid to the fluid motor and for thereby changing the pump capacity, an accelerating pump operated by the idle valve for supplying fluid to the fluid motor additional to that supplied by the pressure controlled means and for thereby changing the injector pump capacity, a by-pass conduit connecting opposite sides of the accelerating pump, a valve in the by-pass conduit, means operable in unison with the mixture control valve and serving when the said valve is moved to cutoff position to cut off control of the fluid motor by the pressure controlled means, and other means also operable in unison with the mixture control valve and serving when the said valve is moved to cutoff position to open the by-pass valve.

10. A fuel supply system for an internal combustion engine, comprising a conduit for fuel flowing to said engine, a throttle for controlling the rate of flow of combustion air to said engine, an idle valve in the fuel conduit connected to said throttle for concurrent movement therewith and serving to restrict the passage of fuel to the engine when the throttle is near its closed position, pump means connected to said idle valve for concurrent movement therewith, said pump means being effective to discharge fuel whenever said throttle is moved in a direction to increase the engine power output, and means in fluid communication with said pump means for increasing the flow of fuel to said engine in response to a discharge of fuel by said pump means.

11. A fuel supply system for an internal combustion engine, comprising a conduit for fuel flowing to said engine, fuel pressure responsive means for controlling the rate of flow of fuel thru said conduit and effective upon an increase in said fuel pressure to increase the rate of fuel flow, a throttle for controlling the rate of flow of combustion air to said engine, an idle valve in the fuel conduit connected to said throttle for concurrent movement therewith and serving to restrict the passage of fuel to the engine when the throttle is near its closed position, pump means connected to said idle valve for concurrent movement therewith, said pump means being effective to discharge fuel whenever said throttle is moved in a direction to increase the engine power output, and means for conveying the fuel discharged by said pump means to said fuel pressure responsive means to increase the pressure therein and thereby to increase the fuel flow to said engine.

12. A fuel supply system for an internal combustion engine, comprising a conduit for fuel flowing to said engine, a throttle for controlling the rate of flow of combustion air to said engine, a cylinder having a first port opening into an end thereof and a second port opening into the side thereof adjacent said end, connections between said conduit and said ports so that said cylinder forms a portion of said conduit, an idle valve piston movable in said cylinder to control the flow of fuel thru said ports, a connection between said throttle and said piston to cause concurrent movement thereof, said piston serving to restrict the passage of fuel thru said conduit when the throttle is near its closed position, pump means in the opposite end of said cylinder and movable concurrently with said piston, said pump means being effective to discharge fuel whenever said throttle is moved in a direction to increase the engine power output, and means in fluid communication with said pump means for increasing the flow of fuel to said engine in response to a discharge of fuel by said pump means.

13. A fuel supply system for an internal combustion engine, comprising a conduit for fuel flowing to said engine, fuel pressure responsive means for controlling the rate of flow of fuel thru said conduit and effective upon an increase in said fuel pressure to increase the rate of fuel flow, a cylinder having a first port opening into an end thereof and a second port opening into the side thereof adjacent said end, connections between said conduit and said ports so that said cylinder forms a portion of said conduit, an idle valve piston movable in said cylinder to control the flow of fuel thru said ports, a connection between said throttle and said piston to cause concurrent movement thereof, said piston serving to restrict the passage of fuel thru said conduit when the throttle is near its closed position, pump means in the opposite end of said cylinder and movable concurrently with said piston, said pump means being effective to discharge fuel whenever said throttle is moved in a direction to increase the engine power output, and means for conveying the fuel discharged by said pump means to said fuel pressure responsive means to increase the pressure therein and thereby to increase the fuel flow to said engine.

14. A fuel supply system for an internal combustion engine, comprising a conduit for fuel flowing to said engine, a valve in said conduit for shutting off the flow of fuel therethru, a pair of expansible fluid-containing chambers separated by a movable wall, means responsive to a discharge of fluid from one of said chambers upon a movement of said wall in one direction to increase the flow of fuel to said engine, means effective upon an increase in engine power output to move said wall in said one direction, a by-pass connection between said chambers, a valve controlling said by-pass, and means operable concurrently with the closing of said shut-off valve to open said by-pass valve so as to render said fuel flow increasing means unresponsive to movements of said wall.

15. A fuel supply system for an internal combustion engine, comprising a conduit for fuel flowing to said engine, a valve in said conduit for shutting off the flow of fuel therethru, a device for increasing the flow of fuel to said engine dur-

ing periods of increasing engine power output including a pair of expansible chambers separated by a movable wall, means responsive to a movement of said wall in one direction to increase the flow of fuel to said engine, and means effective upon an increase in engine power output to move said wall in said one direction, a by-pass connection between said chambers, a valve controlling said by-pass, said by-pass being effective when said valve is open to equalize the pressures in said chambers and thereby render said fuel flow increasing means ineffective to cause delivery of fuel to said engine, and means connecting said by-pass valve with said shut-off valve so that said by-pass valve is opened when said shut-off valve is closed.

16. A fuel supply system for an internal combustion engine, comprising a conduit for combustion air flowing to said engine, a throttle for controlling the flow of air thru said conduit, a conduit for fuel flowing to said engine, a valve in said conduit for shutting off the flow of fuel therethru, a device for increasing the flow of fuel to said engine during periods of increasing engine power output including a pair of expansible fuel-containing chambers separated by a movable wall, means connecting said wall to said throttle to cause movement of said wall in one direction and a consequent increase of pressure in one of said chambers upon movement of said throttle in a direction to increase engine power output, fluid pressure responsive means in fluid communication with said one chamber and effective upon an increase of pressure therein to cause delivery of additional fuel to said engine, a by-pass connection between said chambers, a valve controlling said by-pass connection, and means connecting said by-pass valve with said shut-off valve so that said by-pass valve is opened when said shut-off valve is closed, whereby movement of said throttle after said shut-off valve is closed will not cause a flow of fuel to said engine.

17. A fuel supply system for an internal combustion engine, comprising a conduit for combustion air flowing to said engine, a throttle for controlling the flow of air thru said conduit, a conduit for fuel flowing to said engine, a valve in said conduit for shutting off the flow of fuel therethru, a device for increasing the flow of fuel to said engine during periods of increasing engine power output including a pair of expansible fuel-containing chambers separated by a movable wall, means connecting said wall to said throttle to cause movement of said wall in one direction and a consequent increase of pressure in one of said chambers upon movement of said throttle in a direction to increase engine power output, fluid pressure responsive means for delivering additional fuel to said engine upon an increase in the fluid pressure supplied thereto, a passage connecting said one chamber with said pressure responsive means, a by-pass connection between said chambers, valve means controlling said by-pass connection and said passage, said valve means having a first position wherein said by-pass is closed and said passage is open and a second position wherein said by-pass is open and said passage is closed, and means connecting said valve means with said shut-off valve so that said valve means is moved to said second position when said shut-off valve is closed and to said first position when said shut-off valve is opened.

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