

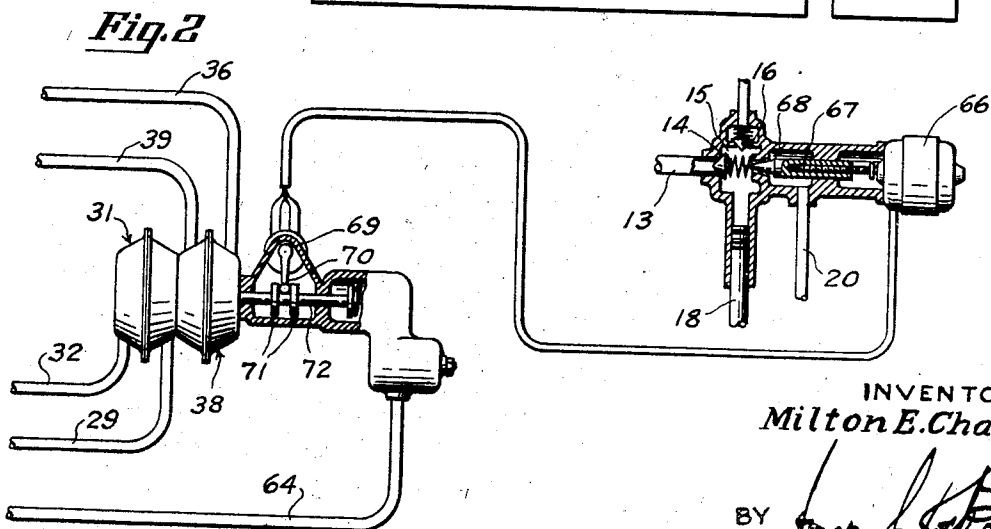
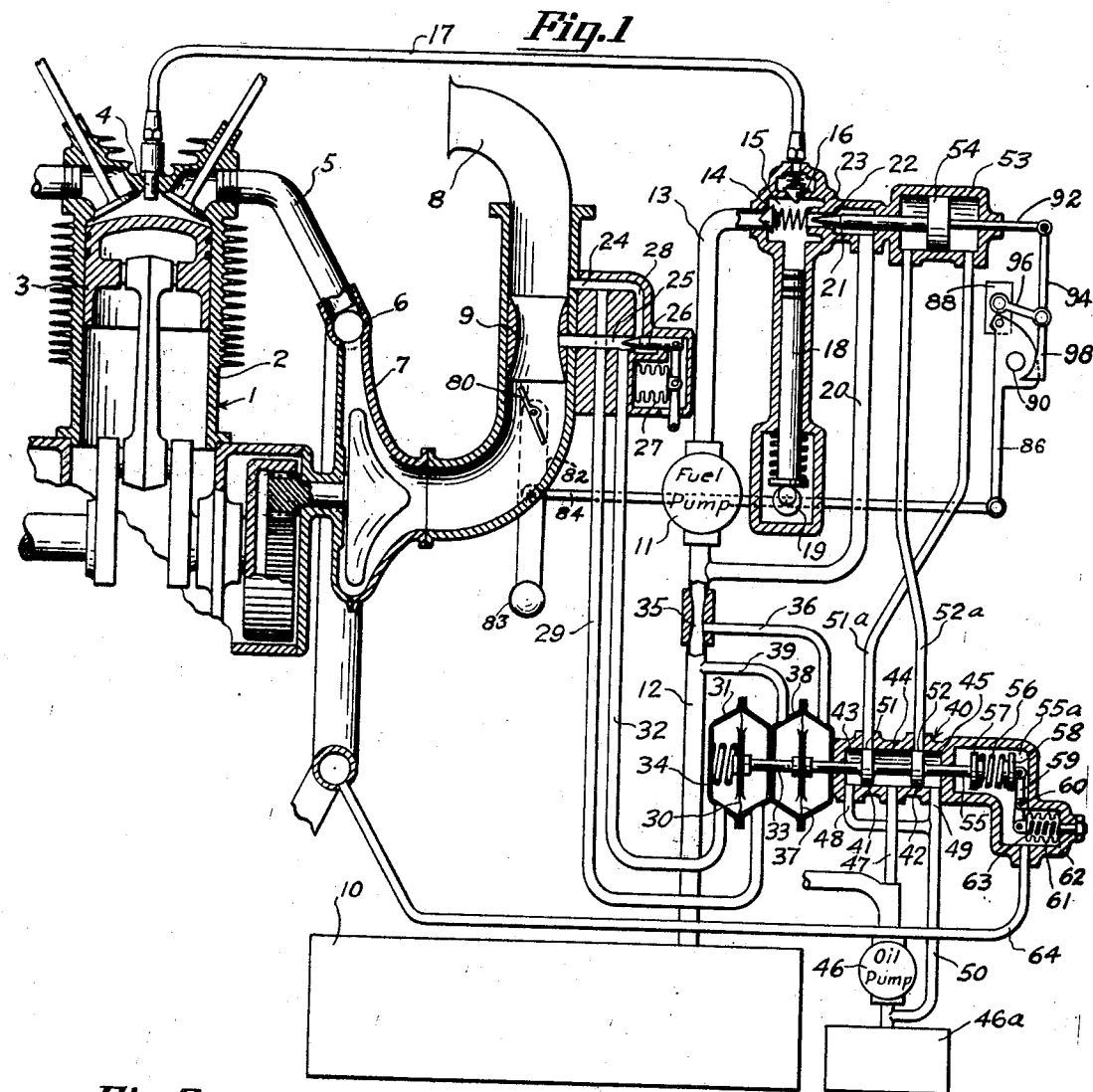
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FUEL INJECTOR CONTROL MECHANISM

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FUEL INJECTOR CONTROL MECHANISM

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My invention relates to fuel injector control mechanism.

It has among its objects to provide an improved control mechanism adapted to use in internal combustion engines equipped with fuel injectors, and, more particularly, to control such engines used on airplanes or the like. A further object of my invention is to provide such an improved controlling mechanism wherein the quantity of fuel delivered through the injectors to the engine is so controlled as to vary as a function of air flow. A further object of my invention is to provide improved injector controlling servo-mechanism controlled as aforesaid and controlling the by-passing of fuel around the fuel injector pump to vary the quantity of fuel delivered to the injectors. Other objects of my invention are to provide such an improved system especially adapted to use in connection with supercharged engines and wherein the operation of a servo-mechanism is automatically controlled in an improved manner in accordance with variations in the operation of the engine. These and other objects and advantages of my improvements will, however, hereinafter more fully appear.

In the accompanying drawing, I have shown for purposes of illustration two embodiments which my invention may assume in practice.

In this drawing,

Figure 1 is a diagrammatic view of a supercharged airplane engine equipped with my improvements, the same being shown, for simplicity of illustration, applied to a single cylinder of the engine, and

Fig. 2 is a similar diagrammatic view of a modified form of the servo-mechanism.

In the illustrative embodiment in Figure 1, I have shown an airplane engine, generally indicated at 1, including a plurality of cylinders, one of which is shown for illustrative purposes at 2 having a piston 3 movable therein, with fuel being supplied to the cylinder through an injector nozzle 4 and air through a connection 5 from a manifold 6 connected to a supercharger 7 which, in turn, receives its air supply from a scoop 8 through an air venturi 9, while my improved controlling mechanism controls the fuel supply to the injector nozzle 4 in accordance with variations in air flow as hereinafter described.

The fuel is supplied to the injector 4 from a tank 10 by a constant pressure fuel transfer pump 11, suitably connected to said tank through an inlet pipe 12, while the pump 11 delivers through a discharge pipe 13 and a check valve 14 into a

chamber 15 which communicates through a check valve 16 with a pipe 17 delivering to the injector 4. As shown, an injector pump 18 acts upon the fuel in the chamber 15 to deliver the same to the injector at the desired pressure through the check valve 16, this pump 18 being operated by a suitable eccentric 19 on the engine 1. Further, a by-pass 20 is provided between the chamber 15 and the inlet of the pump 11, and the flow through this by-pass 20 is automatically varied as hereinafter described by an injector controlling valve 21, herein a needle valve longitudinally adjustable relative to a tapered seat 22 in the wall of casing 23 enclosing the chamber 15 and opposite check valve 14.

Cooperating with this injector control valve 21 is improved controlling mechanism therefor controlled by the air flow through the air scoop 8 and air venturi 9 to the supercharger 7. Herein, this mechanism includes a pipe 24 connected to the scoop 8 and a pipe 25 connected to the throat of the air venturi 9. As shown, a valve 26 controlled by an aneroid 27 is also connected in a by-pass 28 connecting the pipes 24 and 25 in such manner as to compensate for variations in altitude. The pipe 24 connected to the scoop is also connected by a pipe 29 leading to one side of a diaphragm 30 in a closed casing 31, while a pipe 32 leads from the pipe 25 and the Venturi throat, to the opposite side of the diaphragm 30 in the casing 31. As shown, a valve stem 33 is connected to the diaphragm 30 and a coil spring 34 normally biases this diaphragm and valve stem to the right. Thus, it will be apparent that as the air flow to the supercharger 7 and engine manifold 6 varies, the pressures in the throat of the venturi 9 and scoop 8 will be transmitted to opposite sides of the spring loaded diaphragm 30 in such manner as to adjust the valve stem 33 in accordance with variations in the differential of throat and scoop pressures.

Operatively associated with the mechanism including the air controlled diaphragm 30 is also fuel pressure controlled diaphragm mechanism. As shown, a venturi 35 is provided in the fuel inlet pipe 12 leading to the fuel pump 11, and a pipe 36 leads from the throat of this venturi to one side of a fuel pressure controlled diaphragm 37 in a closed casing 38, corresponding to the casing 31, while a pipe 39 is also connected to the fuel inlet pipe 12 on the inlet side of the venturi 35 and leads to the opposite side of the diaphragm 37.

Operatively connected to the valve stem 33 is an improved cooperating servo-mechanism, gener-

ally indicated at 40, and controlling the injector control valve 21. This mechanism includes a suitable casing having a chamber therein subdivided by a pair of spaced spools 41 and 42 on the stem 33 into three chambers 43, 44 and 45. As shown, oil under pressure is delivered by a suitable oil pump 46 from a suitable supply 46a and supplied through an oil inlet 47 into the middle chamber 44 between the spools 41 and 42, while return passages 48 and 49 lead from the chambers 43 and 45, respectively, to a common return passage 50 to the intake side of the pump 46. Outlet ports 51 and 52 having pipes 51a, 52a leading therefrom are also controlled by the spools 41 and 42, and one of these pipes 51a communicates with a cylinder 53 on one side of a piston 54 carrying the injector controlling valve 21, while the other pipe 52a delivers to said cylinder on the opposite side of the piston 54.

Thus, as the valve stem 33 is adjusted to the left upon an increase in air flow through the air venturi 9, the spools 41, 42 will be moved to the left relative to the ports 51, 52 in the servo-mechanism 40, and oil will be supplied from the pump 46 through the inlet 47 and the port 51 to the pipe 51a to move the piston 54 to the left and thereby tend to close the injector control valve 21, while the oil on the opposite side of the piston 54 will be free to return through the pipe 52a to port 52 and chamber 45, and, through the passages 49 and 50, to the inlet side of the pump 46.

On the other hand, a decrease in the air flow causes a reduction in the pressure differential on the opposite sides of diaphragm 30, and a consequent movement of the spools 41 and 42 to the right, thereby connecting the outlet of oil pump 46 thru inlet 47, chamber 44, port 52 and pipe 52a to cylinder 53 at the left of piston 54. At the same time, the cylinder at the right of piston 54 is vented thru pipe 51a, port 51, chamber 43, and passages 48 and 50 to the inlet side of pump 46. The piston 54 therefore moves to the right, opening the by-pass valve 21, and decreasing the quantity of fuel flowing to the engine.

It will, accordingly, be evident that the injector control valve 21 will be moved to the left, i. e., to reduce the amount of fuel discharged from the chamber 15 through the by-pass 20, and returned to the inlet side of the fuel pump 11 and thereby increase the flow to the injector 4, whenever the air flow to the engine increases in such manner as to cause the air diaphragm 30 to be moved to the left. Similarly, when the air flow decreases, the valve 21 will be opened to increase the fuel flow through the by-pass 20 and accordingly increase the amount of by-passed fuel and reduce the fuel supply to the injector 4.

Whenever the piston 54 starts to move the valve 21 in either direction, the motion continues until the valve stem 33 is restored to its normal position wherein ports 51 and 52 are closed. This does not occur until the fuel flow is changed by an amount such that the new fuel differential pressure acting on diaphragm 37 balances the new air differential pressure acting on diaphragm 30.

Cooperating with the above described servo-mechanism further to control the position of the spools 41 and 42 is mechanism controlled by the pressure in the manifold 6. As shown, an extension 55 is provided on the right hand end of the valve stem 33 and extends into an end aneroid chamber 55a, while a coiled spring 56 acts be-

tween an abutment 57 on the extension 55 and an abutment 58 on a vertical lever 59 pivoted at 60 in the chamber 55a. An aneroid 61 is also connected at one end to the opposite end of the lever 59 and has its opposite end fixed to the casing 62, while a coiled spring 63 inside the aneroid normally expands the latter. As shown, a pipe 64 connects the chamber 55a with the manifold. Thus, as the air flow to the engine increases and the pressure increases in the manifold 6, whenever the bellows 61 collapses sufficiently to overcome the spring 63, the upper end of lever 59 will be swung to the left to impart a further movement of the stem 55 to the left and thereby enrich the mixture; while upon a decrease in pressure in the manifold, the aneroid expands, thereby causing a movement of stem 55 to the right, in a fuel flow decreasing direction. When the bellows 61 expands far enough so that the upper end of lever 59 is stopped by the casing 62, the valve stem 55 is then placed wholly under the control of diaphragms 30 and 37.

In the operation of the complete device, the variations in air flow to the supercharger 7 will cause adjustment of the air diaphragm 30 as a function of the differential of throat and scoop pressures in the air venturi 9, while the fuel diaphragm 37 will act to balance the air diaphragm 30 due to its connection to the throat and scoop of the fuel venturi 35. With the spools 41 and 42 movable with the valve stem 33, oil flow from the inlet 47 will be controlled by the diaphragms 30 and 37 and spools 41, 42, in such manner as to adjust the injector control valve 21 to open or close the by-pass 20, and, as a result, decrease or increase the quantity of fuel delivered by the injector pump 18 through the pipe 17 to the injector nozzle 4. Thus, the fuel supplied by the injector nozzle 4 to the cylinder 2 will be varied as a function of the quantity of air being delivered to the cylinder throughout the normal operation of the engine. When, however, the pressure in the manifold 6 increases, as, for example, during overload, the pressure therein will be transmitted through pipe 64 to aneroid 61, and a further movement of the spools 41, 42 in the same direction will be effected as a result of the increase in air flow, in such manner as thereby further to enrich the mixture automatically as a function of the increase in pressure in the manifold.

A throttle 80 is located in the air induction system downstream from the venturi 9. The throttle 80 rotates on a shaft which also carries an arm 82, manually operable by means of a suitable handle 83. Arm 82 is pivotally attached to a link 84 whose opposite end is pivoted on an arm 86. The arm 86 is pivotally mounted on a fixed support 88. The arm 86 carries near its upper end a pin 90.

A rod 92 is attached to the piston 54 and extends to the outside of cylinder 53. The outer end of rod 92 is pivotally connected to a link 94, which is pivoted at an intermediate point on an arm 96 whose opposite end is attached to the fixed support 88. The lower end of link 94 carries a cam 98 which cooperates with the pin 90.

When the parts are in the positions shown in the drawing, the throttle is somewhat more than half open, and the pin 90 has been moved to a position where it is not in the path of motion of cam 98. As the throttle is moved toward closed position, the arms 82 and 86 are moved counterclockwise, carrying the pin 90 to the right. As the motion of pin 90 to the right continues, a

position is reached where it engages cam 98 and forces the link 94 to rotate in a counterclockwise direction, thereby moving the piston 54 and valve 21 to the left, or in a valve closing direction. This closing movement of valve 21 causes an increased discharge of fuel to the engine by the pump 18 and hence results in an enrichment of the mixture of fuel and air supplied to the engine.

This throttle control idle mechanism is provided to insure that the mixture will be sufficiently rich during idling to enable the engine to run smoothly.

In Fig. 2, I have shown a modified construction of servo-mechanism. This mechanism generally corresponds to that heretofore described, save that a reversible electric motor 66 is provided connected through any usual telescopic threaded connection 67 with an injector control valve 68 corresponding to the valve 21, while a reversing switch 69 has a control lever 70 disposed between spaced spools 71 on a valve stem 72 corresponding to the valve stem 33. The remainder of the mechanism being that heretofore described, it will be evident that this mechanism will function essentially similarly, with the reversing switch 69 operated as the valve stem 72 is moved reversely, and this switch 69 acting to reverse the motor 66 in such manner as thereby, through the threaded connection 67, to reversely operate the injector controlling valve 68 in the same sequence as heretofore.

It will be understood that in the use of my improved construction for airplane engines, I contemplate the provision of the usual ignition mechanism (not shown) in the cylinder. It will be evident, however, that if desired, the above described control mechanism may be used without such ignition mechanism in a usual Diesel installation.

While I have in this application described certain forms which my invention may assume in practice, it will be understood that the same are shown for purposes of illustration, and that the invention may be modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. In a fuel injector control mechanism, an air conduit, controlling means responsive to variations in the quantity of air flowing through said conduit, hydraulic control mechanism controlled by said controlling means, fuel injector mechanism including an injector pump having a valve for varying the delivery of said pump, means controlled by said hydraulic control mechanism for adjusting said valve to vary the delivery of said pump as a function of air flow, a throttle controlling the air flow through said conduit, and means controlled by said throttle for automatically varying the delivery of said pump during idling.

2. In a fuel injector control mechanism, an air conduit, controlling means responsive to variations in air flow through said conduit, fuel injector mechanism including an injector pump having a valve for varying the delivery of said pump, a reversible motor for reversely operating said valve, and means including a reversing switch for said motor reversely operated by said controlling means as the air flow through said conduit increases or decreases for operating said motor and actuating said valve to vary the delivery of said pump as a function of air flow.

3. In a fuel supply system for an internal com-

bustion engine, a first conduit for supplying combustion air to said engine, means for creating a first differential pressure indicative of the quantity of air flowing thru said conduit, a second conduit for supplying fuel to said engine, means for creating a second differential pressure indicative of the quantity of fuel flowing thru said second conduit, means for controlling the flow thru one of said conduits and thereby one of said differential pressures, motor means for operating said flow controlling means, a source of energy for said motor means, means for controlling the supply of energy to said motor means including a member having a normal position in which said motor means is stationary and effective upon movement from said normal position in opposite directions to cause operation of said motor means in opposite directions, first flexible diaphragm means responsive to said first pressure differential, second flexible diaphragm means responsive to said second pressure differential, and means connecting both said diaphragm means to said member so as to cause movement of said member when the forces acting on said diaphragm means are unbalanced, said member being effective when moved from said normal position to cause operation of said motor means in the proper direction to vary said one differential pressure until said diaphragms and member are returned to said normal position, so that said diaphragms remain in said normal position when the differential pressures are balanced, regardless of the position of said control means, and means responsive to the pressure in the intake manifold of said engine and effective when said intake manifold pressure exceeds a predetermined value to apply to said member a force opposed to that applied by said second diaphragm means so as to cause operation of said motor means in a direction to increase the ratio of fuel-to-air supplied to said engine.

4. In a fuel injection system for an internal combustion engine, a first conduit for supplying combustion air to said engine, means associated with said conduit for producing two unequal pressures whose difference is a measure of the rate of flow of air thru said conduit, a throttle for controlling the flow of air thru said conduit, injector pump means for delivering fuel at high pressure to the combustion chambers of said engine, a second conduit for conveying fuel to said injector pump means, a metering restriction in said second conduit for producing a differential pressure indicative of the quantity of fuel flowing therethru, means responsive to the difference between said air differential pressure and said fuel differential pressure for controlling the delivery of said injector pump means, and means controlled by said throttle for varying the delivery of said pump means during idling.

5. In a fuel supply system for an internal combustion engine, a first conduit for supplying combustion air to said engine, means for creating a first differential pressure indicative of the quantity of air flowing thru said conduit, a second conduit for supplying fuel to said engine, means for creating a second differential pressure indicative of the quantity of fuel flowing thru said second conduit, means for controlling the flow thru one of said conduits and thereby one of said differential pressures, electrical motor means for operating said flow controlling means, a source of electrical energy for said motor means, means for controlling the supply of electrical energy to said motor means including a switch having a normal position in which said motor means

is stationary and effective upon movement from said normal position in opposite directions to close electrical circuits which cause operation of said motor means in opposite directions, first flexible diaphragm means responsive to said first pressure differential, second flexible diaphragm means responsive to said second pressure differential, and means connecting both said diaphragm means to said switch so as to cause movement of said switch when the forces acting on said diaphragm means are unbalanced, said switch being effective when moved from said normal position to cause operation of said motor means in the proper direction to vary said one differential pressure until said diaphragms and member are returned to said normal position, so that said diaphragms remain in said normal position when the differential pressures are balanced, regardless of the position of said control means, and means responsive to the pressure in the intake manifold of said engine and effective when said intake manifold pressure exceeds a predetermined value to apply to said switch a force opposed to that applied by said second diaphragm means so as to cause operation of said motor means in a direction to increase the ratio of fuel-to-air supplied to said engine.

6. In a fuel supply system for an internal combustion engine, a first conduit for supplying combustion air to said engine, means for creating a first differential pressure indicative of the quantity of air flowing thru said conduit, a second conduit for supplying fuel to said engine, means for creating a second differential pressure indicative of the quantity of fuel flowing thru said second conduit, means for controlling the flow thru one of said conduits and thereby one of said differential pressures, hydraulic motor means for operating said flow controlling means, a source of fluid under pressure for supplying energy to said motor means, means for controlling the supply of fluid to said motor means including a valve having a normal position in which said motor means is stationary and effective upon movement from said normal position in opposite directions to cause operation of said motor means in opposite directions, first flexible diaphragm means responsive to said first pressure differential, second flexible diaphragm means responsive to said second pressure differential, and means connecting both said diaphragm means to said valve so as to cause movement of said valve when the forces acting on said diaphragm means are unbalanced, said valve being effective when moved

from said normal position to cause operation of said motor means in the proper direction to vary said one differential pressure until said diaphragms and member are returned to said normal position, so that said diaphragms remain in said normal position when the differential pressures are balanced, regardless of the position of said control means, and means responsive to the pressure in the intake manifold of said engine and effective when said intake manifold pressure exceeds a predetermined value to apply to said valve a force opposed to that applied by said second diaphragm means so as to cause operation of said motor means in a direction to increase the ratio of fuel-to-air supplied to said engine.

7. In a fuel supply system for an internal combustion engine, a first conduit for supplying combustion air to said engine, means for creating a first differential pressure indicative of the quantity of air flowing thru said conduit, a second conduit for supplying fuel to said engine, means for creating a second differential pressure indicative of the quantity of fuel flowing thru said second conduit, means for controlling the flow thru one of said conduits and thereby one of said differential pressures, first diaphragm means responsive to said first pressure differential, second diaphragm means responsive to said second pressure differential, means connecting both said diaphragm means to said flow controlling means, said diaphragm means being effective to operate said flow controlling means to maintain a substantially constant fuel-to-air ratio, and means responsive to the pressure in the intake manifold of said engine and effective when said intake manifold pressure exceeds a predetermined value to apply to said valve a force opposed to that applied by said second diaphragm means so as to cause operation of said motor means in a direction to increase the ratio of fuel-to-air supplied to said engine.

8. In a fuel supply system for an internal combustion engine, in combination, means for conveying air to said engine for combustion purposes, an injector pump for delivering fuel to said engine, a fuel pump for supplying the inlet of said injector pump with fuel under superatmospheric pressure, means for controlling the quantity of fuel delivered to said engine by said injector pump, electrical motor means for driving said delivery controlling means, and means responsive to the quantity of air supplied to said engine for controlling said electrical motor means.

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