

Nov. 5, 1946.

M. E. CHANDLER

2,410,774

FUEL INJECTION METERING MECHANISM

Filed July 22, 1942

2 Sheets-Sheet 1

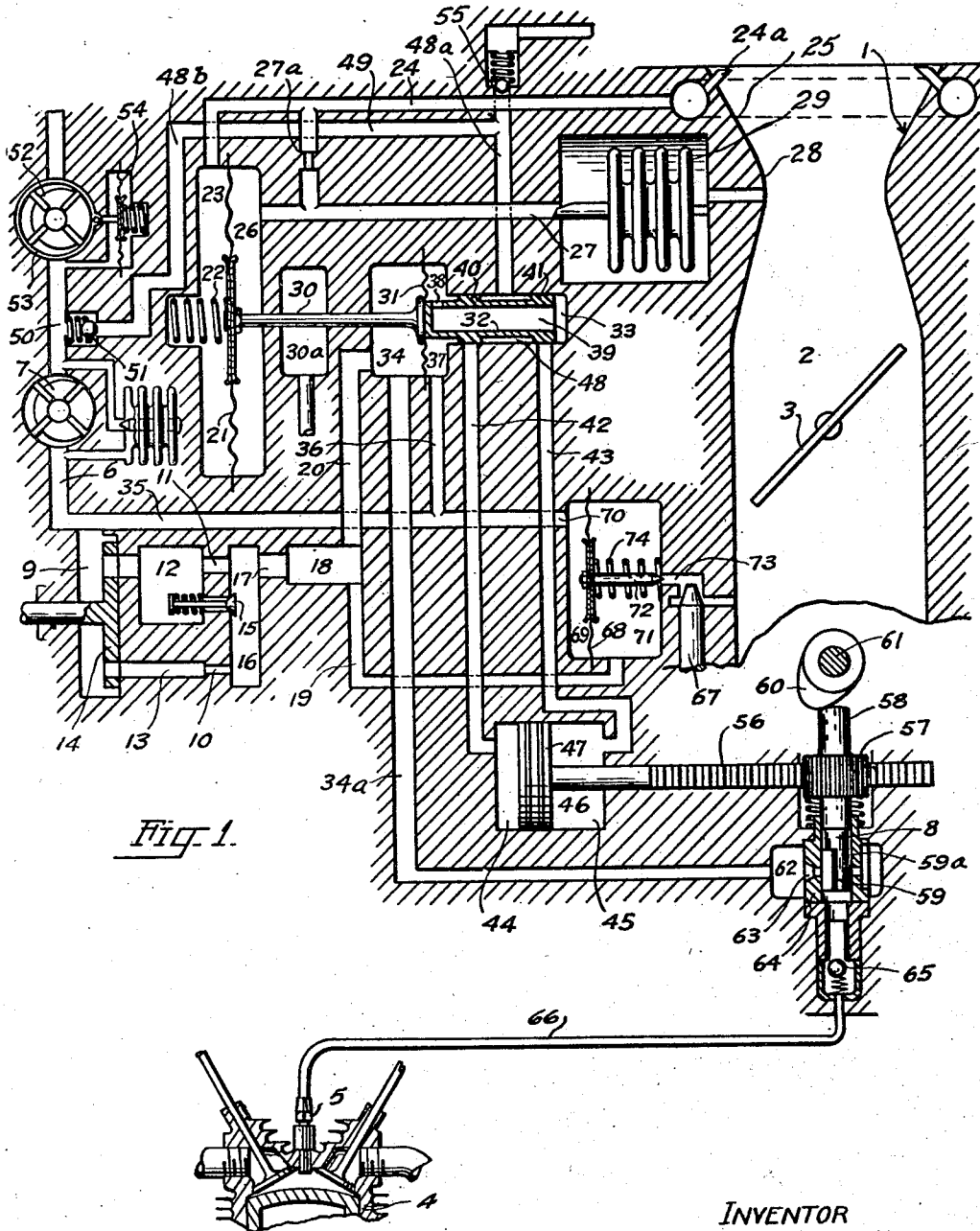


Fig. 1

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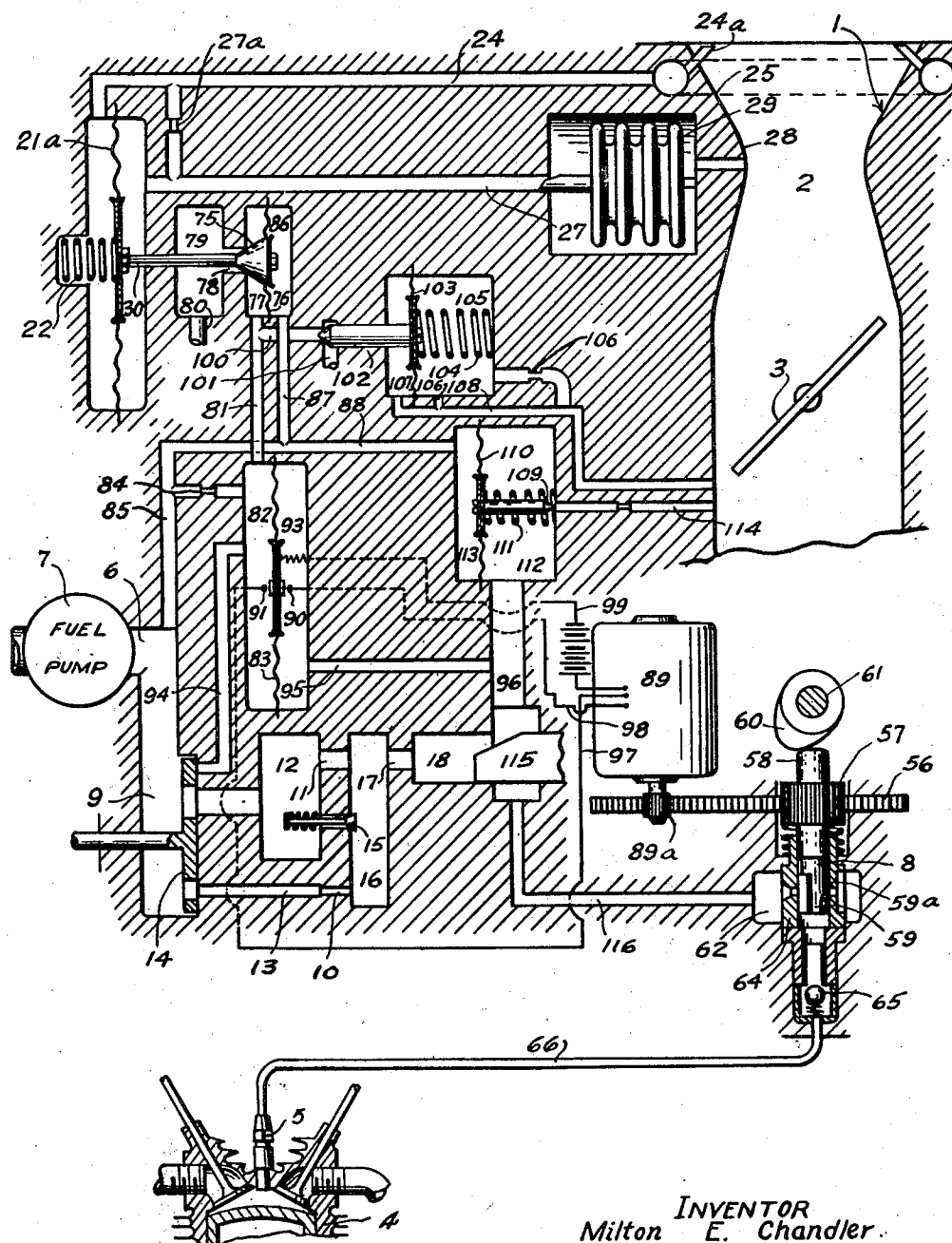


Fig. 2

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2,410,774

FUEL INJECTION METERING MECHANISM

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Application July 22, 1942, Serial No. 451,875

16 Claims. (Cl. 123—140)

1

My invention relates to fuel injection metering mechanism.

It has among its objects to provide an improved fuel injection metering mechanism and, more particularly, to provide such a mechanism which, while not limited thereto, is especially adapted to use in connection with airplane engines. A further object of my invention is to provide such an improved mechanism of the usual type wherein the quantity of fuel injected into the engine cylinders is maintained a function of air flow, but wherein it is made possible to eliminate all need for providing another source of hydraulic pressure other than the fuel. Still another object is to provide an improved structure making it possible to utilize the pressure of the fuel supplied by the fuel pump while obtaining the desired control of the quantity of fuel delivered by the injectors throughout the operation of the engine. A still further object of my invention is to provide such improved controlling mechanism especially adapted to use in connection with such a fuel pump and including improved reversible controlling mechanism adapted to vary the operation of a standard form of injector pump in response to variations in air flow. These and other objects and advantages of my improvements will, however, hereinafter more fully appear.

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

In these drawings:

Figure 1 is a diagrammatic view of one form of my improved mechanism, and

Fig. 2 is a like diagrammatic view of a modified construction.

In the illustrative construction of Figure 1, I have shown an air meter, generally indicated at 1, and delivering air through an air passage 2, controlled by a throttle 3, to any usual engine having usual cylinders, one of which is indicated at 4 and to which fuel is delivered through an injector nozzle 5, while improved controlling mechanism is provided whereby the fuel delivered under pressure from a fuel pump 7 is controlled in such manner that the quantity of fuel delivered by a usual injector pump 8 to the injector nozzle 5 is varied throughout the operation of the engine as a function of the air flow through the air meter 1, all as hereinafter more fully described.

Referring more particularly to the controlling mechanism, it will be understood that the pump 7 is of any suitable standard type adapted to

2

maintain a constant delivery pressure. Herein, a branched connection 9 leads from the pipe 6 to usual jets 10 and 11 through separate parallel passages 12 and 13 respectively, the flow through which is controlled by a usual manual mixture control disc valve 14. Here also an automatic enrichment jet 15 is connected in parallel with the jets 10 and 11, and all three open into a fuel passage 16 communicating through a metering orifice 17 with a fuel passage 18 having branching passages 19 and 20, hereinafter referred to. Thus, it will be apparent that fuel will be supplied under pressure by the pump 7 through the several jets 10 and 11 and orifice 17 under the usual control of the manual mixture control valve 14, while under overload conditions the enrichment jet 15 will be automatically operated to enrich the mixture.

Cooperating to control the flow delivered into the fuel passage 18 in such manner as to maintain the flow through the injector nozzle 5 of each cylinder a function of the air flow through the air meter 1, is improved cooperating controlling mechanism, herein including a diaphragm 21. This diaphragm is normally biased to the right by an axial spring 22 and has one side 23 of the diaphragm connected through a passage 24 and suitable impact tubes 24a with the scoop 25 of the air meter, while the other side 26 of the diaphragm 21 is connected through suitable passage means 27 with the throat 28 of the air meter; a restricted connection 27a being provided between the air passages 24 and 27, and an aneroid operated valve 29 being provided to modify the action of the throat pressure on the diaphragm 21 in accordance with variations in altitude. As shown, this diaphragm 21 has a valve rod 30 connected thereto and passing through any suitable drain connected chamber 30a, while a second diaphragm 31, herein a fuel diaphragm and smaller than the diaphragm 21, is attached to the right hand end of this rod, and a double spool valve 32 is also carried by this rod 30 and reciprocable in a chamber 33. As shown, the branching fuel passage 20 communicates with a chamber 34 on one side of the diaphragm 31, while a passage 35 leads from the passage 6 and is connected by a passage 36 to a chamber 37 on the other side of the diaphragm 31. The diaphragm 21 is subjected to the differential of air pressures between the scoop 25 and throat 28 of the air meter, which differential is, in accordance with the well-known principles of Venturi meters, a measure of the quantity of air flowing to the engine. The diaphragm

3

31, on the other hand, is subjected to the pressure differential across the jets 10, 11, 15 and 17, which differential is a measure of the quantity of fuel passing thru the jets. When the quantity of fuel supplied to the engine is proportioned to the quantity of air supplied, the forces acting on the diaphragms 21 and 31 are balanced, and the valve 32 is in the position shown in the drawing. If for any reason the proportionate relationship between the quantities of fuel and air supplied to the engine is disturbed, the valve 32 is operated to control the fuel flow in a manner hereinafter described, to restore that proportionate relationship.

Herein, the spool valve 32 is utilized to control the operation of improved controlling mechanism for the injector pump 8 in such manner as to vary the fuel delivered to the cylinder through the injector nozzle 5 as a function of the quantity of air supplied through the air meter 1. As shown, fuel from the chamber 37 passes into a port 38 in the valve 32 and longitudinally of that valve through an axial passage 39 therein. Spaced lands 40 and 41 are provided on the valve 32 for controlling the flow of fuel through passages 42 and 43 which communicate with opposite ends 44 and 45 of a cylinder 46. Fuel under pressure may thereby be admitted to the cylinder 46 and such fuel acts upon a piston 47 in that cylinder which controls the operation of the injector pump 8, as hereinafter described. An annular outlet chamber 48 between the lands 40 and 41 communicates constantly with a drain passage 48a. When the valve 32 is moved to the right from the position shown in the drawings, fuel under pressure is supplied thru the passage 42 to the left end 44 of the cylinder 46, while the right end 45 of cylinder 46 is connected thru passage 43 and chamber 48 to the drain passage 48a. The piston 47 is then moved to the right by the pressure differential across it. Likewise, when the valve 32 moves to the left, the piston 47 is moved to the left.

The drain passage 48a is connected thru passages 49 and 48b and a check valve 51 to a passage 50 connected to the inlet of pump 7. It may be observed that in this manner the full pressure differential across pump 7 is made available for operating piston 47. A booster pump 52, which supplies fuel to the inlet side of pump 7, is illustrated as having an adjustable liner 53 operated by a spring biased diaphragm 54 subject to the discharge pressure of the pump 52. It will also be noted that a check valve 55 is connected to the fuel passage 48a in such manner as to provide an outlet to a suitable drain or tank. It will be understood that the pump 7 may be of the same type as the pump 52 or of the more conventional relief valve controlled type.

Whenever the booster pump 52 is operating, whether pump 7 is operating or not, the pressure of the fuel discharged by pump 52 closes check valve 51. Closure of check valve 51 causes pressure to build up in passage 48b until it is sufficient to open valve 55. When booster pump 52 is not operating, the fuel entering passage 48a flows thru passage 48b and check valve 51, which is opened due to the suction at the inlet side of pump 7. This suction is transmitted thru passage 48b to the check valve 55 where it acts to hold that valve closed.

Fuel pumps such as that shown at 7 are usually driven by the engine, while booster pumps such as 52 are usually operated from a separate source of power, for example, an electric motor. The

4

booster pump is normally used only during starting, or when the main pump does not, for some reason, supply sufficient fuel. The check valve arrangement described above, which I provide for controlling the connections of the fluid drain from the servo-motor, permits the use of both pumps as a source of power for the servo-motor when both are operating, and the use of only the pump 7 as a source of power when that is the only one operating. The loss of the power required to force the servo-motor operating fuel thru the pump 52 when that pump is not being driven, is thereby eliminated, and the full pressure differential across pump 7 is available for operating piston 47.

The displacement of the injector pump 8 is controlled by the position of piston 47. As shown, the rod of the piston 47 has rack teeth 56 formed thereon which mesh with a substantially wider pinion 57 on the injector pump plunger 58. The pump illustrated is of the Bosch type and has its plunger 58 reciprocable in a cylinder 64. The plunger 58 is formed with a scroll 59a, and is provided with the usual cut away portion 59. The plunger is reciprocated by a cam 60 carried on a suitable engine driven shaft 61 and operating on the end of the plunger. As shown, the fuel chamber 34 adjacent the fuel diaphragm 31 is connected by a passage 34a in such manner as to deliver metered fuel to an inlet chamber 62 surrounding the injector pump and communicating through lateral inlet passages 63 with the pump cylinder 64. One of these inlet passages also serves as a relief port for the cylinder 64 when it is uncovered by the scroll on the cut away portion 59a near the end of the injection stroke. The exact point in the injection stroke at which the injection of fuel is cut off is thus determined by the angular position of the pump plunger 58. As usual in such pumps, fuel is also supplied from the pump cylinder 64 through a check valve 65 to a pipe 66 leading to the injector nozzle 5. Accordingly, as the piston 47 is moved in opposite directions in the cylinder 46 in response to variations in air flow, the plunger 58 is also rotated to vary the amount of fuel delivered from the pump cylinder 64 so that the quantity of fuel delivered by the pump also varies as a function of air flow.

I have also provided improved automatic control mechanism for use in idling. The same includes a spring biased diaphragm mechanism subject to metered and unmetered fuel pressures whereby the flow of fuel to a manually controlled idle valve 67 is automatically cut off as the throttle opens. As shown, this mechanism includes a diaphragm 68 having a chamber 69 at one side of the same communicating with the unmetered fuel in the passage 35 through a passage 70, while a chamber 71 on the opposite side of the diaphragm is supplied with metered fuel through the passage 19. A valve 72 is carried by the diaphragm and controls a passage 73 leading from the chamber 71 to the air passage 2, while a coiled spring 74 normally biases the valve to open position and the throttle connected idle valve 67 controls the flow from the passage 73 into the air passage at a point on the engine side of the throttle.

It has been found that with low power output and low engine speeds such as are encountered during idling, the operation of the fuel injector valves tends to be uneven and erratic. Furthermore, the pressure differential between chambers 23 and 26 cannot be depended upon as an accu-

rate measure of the quantity of air entering the engine. Therefore, I have provided the idle valve 67, the valve 72, and the spring 22 to control the fuel flow at such times.

The spring 22 acts on the valve 32 so as to maintain a minimum pressure differential between chambers 37 and 34. When the air pressure differential acting on diaphragm 21 is small, the spring 22 insures that the fuel pressure differential acting on diaphragm 21 never drops below that necessary to balance spring 22. The spring 74 is set to open valve 72 when the fuel pressure differential drops below a value slightly larger than the minimum maintained by spring 22.

When the valve 72 is open, the valve 67 predominates in the control of the quantity of fuel flowing to the engine. Altho fuel continues to flow thru the injector pumps 8, their operation is erratic at such times, while the valve 67 insures a minimum fuel flow, varying with throttle position.

In effect, the control of the fuel supply is transferred from the diaphragm 21 and the injector pumps 8 to the throttle operated valve 67 when the throttle is in the idling range.

In the operation of the complete mechanism, it will be apparent that as the quantity of air passing through the air meter 1 is varied, the spool valve 32 will be adjusted by its diaphragm mechanism including the diaphragms 31 and 21, in such manner as to move the piston 47 to increase or decrease the quantity of fuel delivered by the injector pump 8 through the injector nozzle 5. For example, if the air flow thru the passage 2 increases, the pressure differential between chambers 23 and 26 increases, causing a movement of valve 32 to the right. As previously described, this causes a following movement of piston 47 to the right, causing a rotation of the plunger 58 in a clockwise direction as viewed from the top. This moves the scroll 59a so that the injection of fuel is terminated at a later point in the stroke of plunger 58, thereby increasing the quantity of fuel supplied to the engine with each stroke of the plunger. The quantity of fuel flowing thru the jets is thereby increased, with a consequent reduction in pressure on the downstream side of the jets and in the chamber 34. The fuel pressure differential acting on the diaphragm 31 is thereby increased. As soon as this fuel pressure differential has increased sufficiently to balance the increase in the air pressure differential, the valve 32 is restored to its balanced position, and movement of piston 47 stops. In a similar manner, it may be seen that a decrease in air flow causes a movement of valve 32 to the left and a following movement of piston 47 to decrease the displacement of the pump 8 and decrease the fuel pressure differential acting on diaphragm 31 so as to restore valve 32 to its normal position.

The operation of the diaphragm 21 will also be modified by the aneroid controlled valve 29 in accordance with variations in altitude, while during overload conditions the enrichment jet 15 will automatically operate to enrich the mixture in a usual manner. Also, should the main pump 7 be incapacitated for any reason, the booster pump 52 will hold the check valve 51 closed in such manner that the pressure of the fuel in the passage 48a leading from the spool valve 32 will then open the check valve 55 to establish communication to a suitable drain or tank. In idling, the automatic control of the metered fuel provided by the valve 72 will also function as pre-

viously described to control the flow past the manually operated idle valve 67.

In the modified construction shown in Fig. 2, the mechanism is generally similar to that heretofore described as regards the control of the injector pump and the variation of the quantity of fuel delivered thereby as a function of air flow. However, the control mechanism is modified in various respects and is of the electrical type. The diaphragm 21a corresponds to the diaphragm 21 and is provided with similar connections to the throat and scoop which need not be further described. Herein, however, the rod 30 carries a tapered valve 75 which is connected to a smaller fuel diaphragm 76 and controls the flow of fuel from a chamber 77 on one side of this diaphragm through a valve passage 78 into a chamber 79 having a suitable communicating drain 80 leading to a suitable tank, or, if desired, to the air passage 2. Herein, fuel is supplied to the chamber 77 through a passage 81 connected to one side 82 of a large fuel diaphragm 83 which in turn receives fuel through a restriction 84 from the pipe 85 leading from the outlet of the fuel pump 7. The opposite side 86 of the diaphragm 76 is connected through a passage 87 with an extension 88 of the passage 85. When the valve 75 is closed, it may be seen that no pressure differential exists across the diaphragm 76. As the air flow increases, the diaphragm 21a moves valve 75 in an opening direction, resulting in a decrease in pressure in chamber 77, since the fuel in that chamber is released thru valve 75. As soon as the valve has moved far enough so that the pressure differential acting on diaphragm 76 balances the air pressure differential acting on diaphragm 21a, the movement of the valve ceases. In this manner the pressure in chamber 77 is made to vary inversely as the quantity of air flowing thru the passage 2. This pressure is communicated to chamber 82 adjacent the diaphragm 83, where it acts to move diaphragm 83 to the left upon an increase in the quantity of air entering the engine. The chamber 93 on the opposite side of diaphragm 83 is connected thru the passages 95 and 96 to the main fuel line on the downstream side of the metering jets. The difference between the pressures in chambers 82 and 93 varies with the pressure differential across the jets, and therefore is a measure of the quantity of fuel flowing thru the jets. The force on diaphragm 83 due to this fuel pressure differential acts to the right when the quantity of fuel increases. The diaphragm 83 is positioned in accordance with the balance between two opposing forces, one indicative of the quantity of air entering the engine, and the other indicative of the quantity of fuel entering the engine.

The diaphragm 83 operates mechanism for controlling the operation of a reversible electric motor 89 which drives the rack 56 and thereby controls the volume of fuel delivered through the injector nozzle 5 to the engine cylinder 4. As diagrammatically shown, this diaphragm 83 controls the circuit connections for this motor. A stationary contact 91 is located in the chamber 82 on one side of the diaphragm 83 and another stationary contact 90 is located in the chamber 93 on the opposite side thereof. Altho these contacts have been shown, for convenience in drawing, inside the fuel filled chambers 82 and 93, it will be understood that these contacts will, in practice, preferably be disposed outside of these chambers in any well known manner. The contacts 91 and 90 are suitably connected to the

7

motor terminals by conductors 97 and 98 respectively and the diaphragm 83 is also connected to a motor terminal by a conductor 99. The current flow through the motor 89 will be automatically controlled in such manner as to control the pinion 57 of the injector pump 8 to vary the quantity of fuel supplied to the injector nozzle 5 as a function of air flow.

For example, when the air flow thru passage 2 decreases, the air differential pressure acting to the right on the diaphragm 21a decreases. Valve 75 then moves to the left until the pressure in chamber 77 is increased sufficiently so that the differential between the fuel pressures in chambers 86 and 77 is reduced to balance the reduction in the air differential pressure. The increased pressure in chamber 77 is communicated thru passage 81 to the chamber 82, where it moves diaphragm 83 to the right, causing engagement of contact 90 by the contact carried by diaphragm 83. An energizing circuit for motor 89 is thereby completed, which causes operation of motor 89 in a direction to move rack 56 to the left, thereby decreasing the displacement of injector pump 8. This decreases the quantity of fuel flowing thru the jets, and increases the pressure in passages 96 and 95 and chamber 93. This action continues until the pressure in chamber 93 has increased sufficiently to break the contact between the diaphragm-carried contact and stationary contact 90. When that contact is broken, the fuel flow will have been reduced to balance the reduction in the air differential pressure. In a similar manner, it may be seen that an increase in air flow causes a proportionate increase in fuel flow.

A second passage 94 is provided for admitting fuel to the chamber 82 under certain conditions. The passage 94 is not restricted, and is controlled by the mixture control valve 14. When the mixture control valve is turned to a position wherein the passage 94 is open, fuel under high pressure is admitted to chamber 82, and the valve 75 no longer controls the pressure in chamber 82. The pressure in chamber 82 is thereby positively made higher than the pressure in chamber 93, and the switch contact 90 is engaged by the contact on diaphragm 91, and motor 89 is energized to drive the rack 56 in a fuel flow decreasing direction. In this manner, the valve 94 may be utilized as a manual control to completely cut off the flow thru the pump 8. The valve 14 may preferably be constructed so that the passage 94 is opened at the same time that the fuel flow thru the jets 10, 11 and 12 is cut off.

In this construction, an improved accelerating control mechanism is also provided. As shown, a passage 100 leads from the passage 81 and the flow through passage 100 to a suitable drain 101 is controlled by an accelerating control valve 102. The latter is carried by a diaphragm 103 and biased to closed position by a spring 104 in an air chamber 105. A small bleed 106 provides communication between chamber 105 and an air passage 108. A chamber 107 on the opposite side of the diaphragm communicates through the air passage 108 with the air passage 2 at a point on the engine side of the throttle 3. Thus, when the throttle 3 is suddenly opened, the pressure in passage 108 will be quickly built up and transmitted to the chamber 107 in such manner as thereby to move the diaphragm 103 to the right while compressing the spring 104. Accordingly, the accelerating control valve 102 will be moved to the right to permit flow from the passage 81

8

through the passage 100 to the drain 101 and accordingly reduce the pressure in the chamber 82 on one side of the fuel diaphragm 83 and thus through the contact 91, establish circuit connections causing the motor 89 to be rotated in such a direction as temporarily to increase the fuel flow through the injector nozzle 5. However, it will be apparent that this action will be only temporary since, due to the provision of the bleed 106, the pressure will gradually equalize on opposite sides of the diaphragm 103 so that the spring may thereupon again close the accelerating control valve 102.

Herein also improved means operative automatically during idling are also provided. These include an idling valve 109 carried on a diaphragm 110 which is biased toward open position of the valve by a spring 111. The chamber 112 on the side of the diaphragm 110 which carries the valve 109 is connected to fuel passage 96 so that metered fuel is supplied to this side of the diaphragm while the chamber 113 on the other side of the latter is connected to passage 88 and unmetered fuel is supplied to that side of the diaphragm. Thus, with the valve 109 controlling a passage 114 connected through a suitable restriction to the air passage 2 at a point on the engine side of the throttle 3, it will be apparent that when the throttle is moved to idling position, a flow of fuel through the passage 114 will be automatically provided. The idle valve 115 is operated by movement of the throttle, in the same manner as the idle valve 67 of Figure 1. This valve 115 controls the flow of fuel thru both the passages 96 and 116, but its closing movement is limited so that it cannot completely cut off the flow of fuel from the passage 18 into the passages 96 and 116.

In the operation of this mechanism, it will be apparent that the quantity of air flow through the passage 2 will control the injector pump 8 generally as in the modification of Figure 1, i. e. in such manner as to vary the quantity of fuel delivered to the cylinder as a function of air flow. Here, however, instead of hydraulic control means, the electrical control means provided will effect the desired reversals of the motor 89 to control the operation of the pump 8 as required. Moreover, the hydraulic connections which are provided are such as to enable the controlling fuel diaphragm 83 to have its action further modified as desired by the accelerating control mechanism provided, and also by the manually operated mixture controlling valve.

While I have in this application specifically described certain embodiments 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 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 output controlling means, pressure responsive switch means for controlling said motor

means, conduit means connecting the discharge of said fuel pump to said pressure responsive switch means, valve means for controlling the flow of fuel thru said conduit means independently of the pressure of the fuel discharged by said fuel pump, and means responsive to the quantity of air supplied to said engine for operating said valve means.

2. In a fuel supply system for an internal combustion engine, in combination, a conduit for supplying air to said engine for combustion purposes, a throttle for controlling the flow of air thru said conduit, an injector pump for delivering fuel directly to said engine, means responsive to the quantity of air flowing thru said conduit to control the delivery of said injector pump, means operative as an incident to a decrease in said quantity below a predetermined value to permit an additional flow of fuel to said conduit at a point spaced from said engine, and means responsive to the position of said throttle for controlling said additional flow.

3. In a fuel supply system for an internal combustion engine, in combination, a first conduit for conveying air to said engine for combustion purposes, a second conduit for conveying fuel to said engine, means for supplying fuel to said second conduit under superatmospheric pressure, means associated with said first conduit for producing two unequal pressures whose difference is a measure of the quantity of air flowing there-thru, a metering restriction in said second conduit, means for controlling the pressure differential across said restriction to control the flow of fuel there-thru, a third conduit supplied with fuel from said source and including a restriction, an expansible chamber connected to said third conduit and having a movable wall operatively connected to said pressure differential controlling means for positioning the same, valve means for controlling the flow of fluid thru said third conduit and thereby the pressure in said chamber and the position of said pressure differential controlling means, means subjected to said two unequal pressures for operating said valve means in accordance with the difference of said pressures, and manually operable means for controlling the pressure in said chamber so as to position said pressure differential controlling means in a fuel flow preventing position.

4. In a fuel supply system for an internal combustion engine, in combination, a first conduit for conveying air to said engine for combustion purposes, an injector pump for delivering fuel to said engine, a second conduit for conveying fuel to said injector pump, means for supplying fuel to said second conduit under superatmospheric pressure, means associated with said first conduit for producing two unequal pressures whose difference is a measure of the quantity of air flowing there-thru, means for controlling the quantity of fuel delivered to said engine by said injector pump, a third conduit supplied with fuel from said source and including a restriction, an expansible chamber connected to said third conduit and having a movable wall operatively connected to said fuel delivery controlling means for positioning the same, valve means for controlling the flow of fluid thru said third conduit and thereby the pressure in said chamber and the position of said movable wall, means subjected to said two unequal pressures for operating said valve means in accordance with the difference of said pressures, and manually operable means for controlling the pressure in said chamber so as to

position said pressure differential controlling means in a fuel flow preventing position.

5. In a fuel supply system for an internal combustion engine, in combination, a first conduit for conveying air to said engine for combustion purposes, an injector pump for delivering fuel to said engine, a second conduit for conveying fuel to said injector pump, means for supplying fuel to said second conduit under superatmospheric pressure, means associated with said first conduit for producing two unequal pressures whose difference is a measure of the quantity of air flowing there-thru, means for controlling the quantity of fuel delivered to said engine by said injector pump, a third conduit supplied with fuel from said source and including a restriction, an expansible chamber connected to said third conduit and having a movable wall operatively connected to said fuel delivery controlling means for positioning the same, valve means for controlling the flow of fluid thru said third conduit and thereby the pressure in said chamber and the position of said pressure differential controlling means, means subjected to said two unequal pressures for operating said valve means in accordance with the difference of said pressures, and means responsive to acceleration of said engine for additionally controlling the pressure in said chamber to move said fuel delivery controlling means in a fuel flow increasing direction.

6. In a fuel supply system for an internal combustion engine, in combination, a first conduit for conveying air to said engine for combustion purposes, a second conduit for conveying fuel to said engine, means for supplying fuel to said second conduit under superatmospheric pressure, means associated with said first conduit for producing two unequal pressures whose difference is a measure of the quantity of air flowing there-thru, a metering restriction in said second conduit, means for controlling the pressure differential across said restriction to control the flow of fuel there-thru, a third conduit supplied with fuel from said source and including a restriction, an expansible chamber connected to said third conduit and having a movable wall operatively connected to said pressure differential controlling means for positioning the same, said wall acting on said pressure differential controlling means in a fuel flow increasing direction in response to a decrease in pressure in said chamber, valve means for controlling the flow of fluid thru said third conduit and thereby the pressure in said chamber and the position of said pressure differential controlling means, a first diaphragm subjected to said two unequal pressures and connected to said valve means for operating said valve means in an opening direction in response to an increase in the difference of said pressures, and a second diaphragm subjected on one side to the pressure of the fuel on the upstream side of said metering restriction and on its other side to the pressure of the fuel in said chamber, said second diaphragm being connected to said valve means so as to operate said valve means in a closing direction in response to an increase in the difference in pressures acting on said second diaphragm.

7. In a fuel supply system for an internal combustion engine, in combination, a first conduit for conveying air to said engine for combustion purposes, a second conduit for conveying fuel to said engine, means for supplying fuel to said second conduit under superatmospheric pressure, means associated with said first conduit for pro-

11

ducing two unequal pressures whose difference is a measure of the quantity of air flowing there-thru, a metering restriction in said second conduit, means for controlling the pressure differential across said restriction to control the flow of fuel therethru, a third conduit supplied with fuel from said source and including a restriction, an expansible chamber connected to said third conduit and having a movable wall operatively connected to said pressure differential controlling means for positioning the same, valve means for controlling the flow of fluid thru said third conduit and thereby the pressure in said chamber and the position of said pressure differential controlling means, means subjected to said two unequal pressures for operating said valve means in accordance with the difference of said pressures, manually operable means for controlling the pressure in said chamber so as to position said pressure differential controlling means in a fuel flow preventing position, and means responsive to acceleration of said engine for additionally controlling the pressure in said chamber to move said pressure differential controlling means in a fuel flow increasing direction.

8. In a fuel supply system for an internal combustion engine, 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, a booster pump for supplying the inlet of said fuel pump with fuel under superatmospheric pressure, means for controlling the quantity of fuel delivered to said engine by said injector pump, fluid motor means for operating said delivery controlling means, conduit means connecting the discharge of said fuel pump to said fluid motor means for supplying fuel to said motor means for use therein as a motive fluid, drain passage means for conveying fuel discharged from said motor means to the inlet of said fuel pump, and check valve means associated with said drain passage means and effective during operation of said booster pump to provide a different outlet for the fluid discharged from said motor means.

9. In a fuel supply system for an internal combustion engine, a fuel pump for delivering fuel to said engine under superatmospheric pressure, a booster pump for supplying the inlet of said fuel pump with fuel under superatmospheric pressure, fluid motor means, conduit means connecting the discharge of said fuel pump to said fluid motor means for supplying fuel to said motor means for use therein as a motive fluid, drain passage means for conveying fuel discharged from said motor means to the inlet of said fuel pump, and check valve means associated with said drain passage means and effective during operation of said booster pump to provide a different outlet for the fluid discharged from said motor means.

10. In a fuel supply system for an internal combustion engine, a conduit for supplying combustion air to said engine, a throttle for controlling the flow of air thru said conduit, an injector pump for delivering fuel directly to said engine, means responsive to the quantity of air flowing thru said conduit to control the delivery of said injector pump, and means operative as an incident to a decrease in said quantity below a predetermined value to produce a flow of fluid to said conduit at a point spaced from said engine.

11. A fuel supply system for an internal combustion engine, comprising a conduit for conveying combustion air to said engine, injector pump

12

means for delivering fuel to said engine, a fuel pump for supplying the inlet of said injector pump means with fuel under superatmospheric pressure, means for controlling the quantity of fuel delivered to said engine by said injector pump means, motor means for operating said delivery controlling means, means responsive to the rate of flow of air thru said conduit for controlling said motor means, and manually operable means for controlling said motor means to cause operation of said delivery controlling means in a fuel flow decreasing direction regardless of the magnitude of said rate of flow.

12. 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, means for controlling the quantity of fuel delivered to said engine by said injector pump, motor means for operating said delivery controlling means, means responsive to the quantity of air supplied to said engine for controlling said motor means, and means responsive to acceleration of said engine for additionally controlling said motor means to operate said delivery controlling means in a fuel flow increasing direction.

13. In a fuel supply system for an internal combustion engine, a fuel pump for delivering fuel to said engine under superatmospheric pressure, a booster pump for supplying the inlet of said fuel pump with fuel under superatmospheric pressure, fluid motor means, conduit means connecting the discharge of said fuel pump to said fluid motor means for supplying fuel to said motor means for use therein as a motive fluid, first drain passage means for conveying fuel discharged from said motor means to the inlet of said fuel pump, second drain passage means for conveying fuel discharged from said motor means to a different outlet, and valve means responsive to the fuel pressure at the outlet of one of said pumps for selectively opening said drain passage means.

14. A fuel supply system for an internal combustion engine, comprising a first conduit for conveying air for combustion purposes to said engine, means associated with said first conduit for producing two unequal air pressures whose difference is a measure of the rate of flow of air thru said conduit, means for supplying fuel under superatmospheric pressure, an injector pump for delivering fuel to said engine, a second conduit for conveying fuel from said fuel supply means to said injector pump, means for controlling the quantity of fuel delivered to said engine by said injector pump, an expansible chamber having a movable wall subject on its exterior surface to the fuel pressure in said second conduit, said wall being operatively connected to said injector pump delivery control means for positioning the same, a restricted inlet passage connecting the interior of said chamber to said second conduit, a restricted outlet passage connecting the interior of said chamber to a point maintained at a continuously lower pressure, pilot valve means for controlling one of said restricted passages, and means responsive to the difference of said air pressures for operating said pilot valve means.

15. A fuel supply system for an internal combustion engine, comprising injector pump mechanism for supplying fuel to said engine, means for controlling the delivery of said pump mechanism, motor means for operating said delivery control means, a fuel pump, a fuel conduit extending from said fuel pump to said injector pump mech-

13

anism, metering restriction means in said fuel conduit, valve means for varying the area of said restriction means, a manually movable control device for operating said valve means, a second control device responsive to the pressure differential across said metering restriction means, and means for selectively placing said manual control device or said second control device in control of said motor means.

16. A fuel supply system for an internal combustion engine, comprising injector pump mechanism for supplying fuel to said engine, means for controlling the delivery of said pump mechanism, motor means for operating said delivery

14

control means, a fuel pump, a fuel conduit extending from said fuel pump to said injector pump mechanism, metering restriction means in said fuel conduit, valve means for varying the area of said restriction means, a manually movable control device for operating said valve means, a passage for combustion air flowing to said engine, a second control device responsive to the rate of air flow thru said passage and to the fuel pressure differential across said metering restriction means, and means for selectively placing said manual control device or said second control device in control of said motor means.

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