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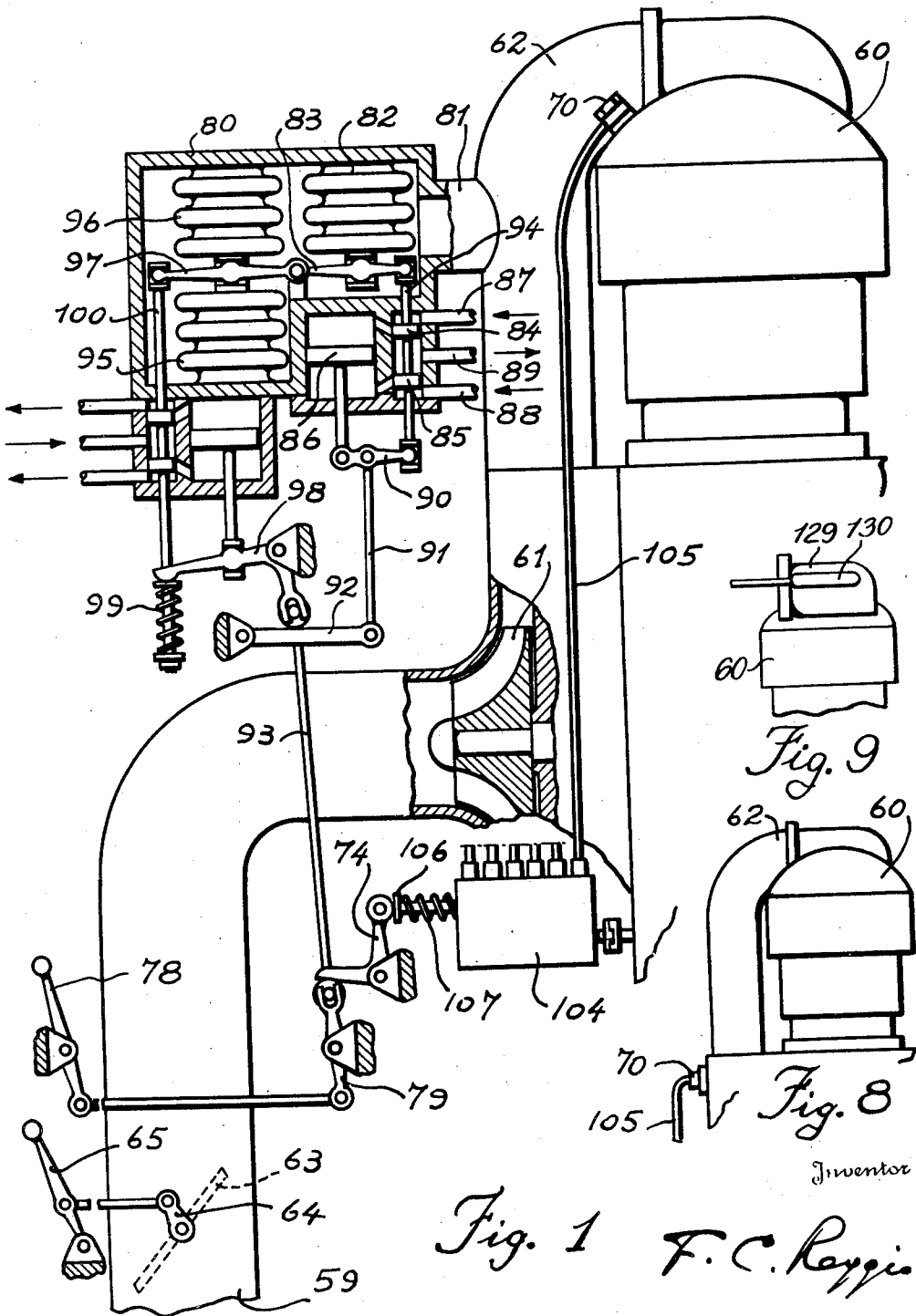
F. C. REGGIO

2,435,902

FUEL METERING DEVICE

Filed June 28, 1947

2 Sheets-Sheet 1



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FUEL METERING DEVICE

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2 Sheets-Sheet 2

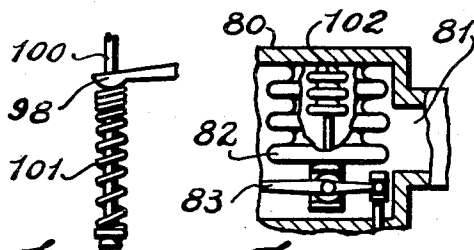


Fig. 2. Fig. 3

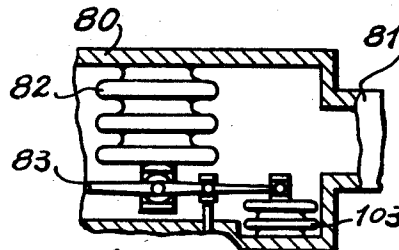


Fig. 4.

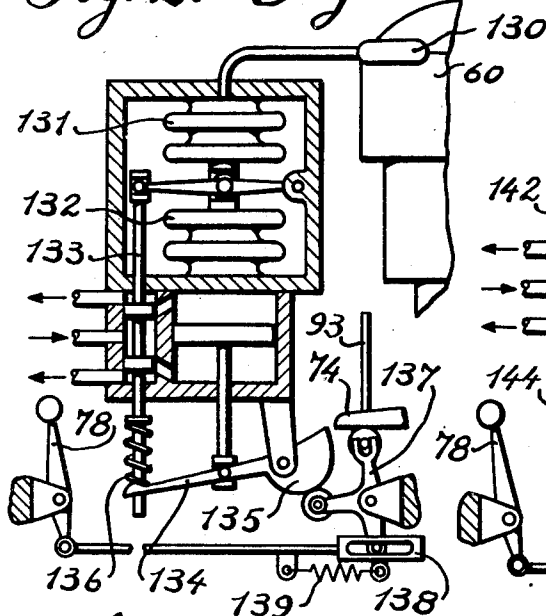


Fig. 5.

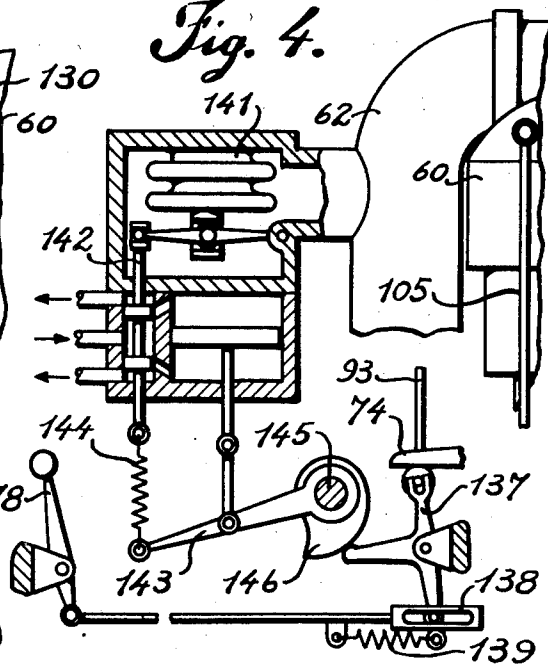


Fig. 6.

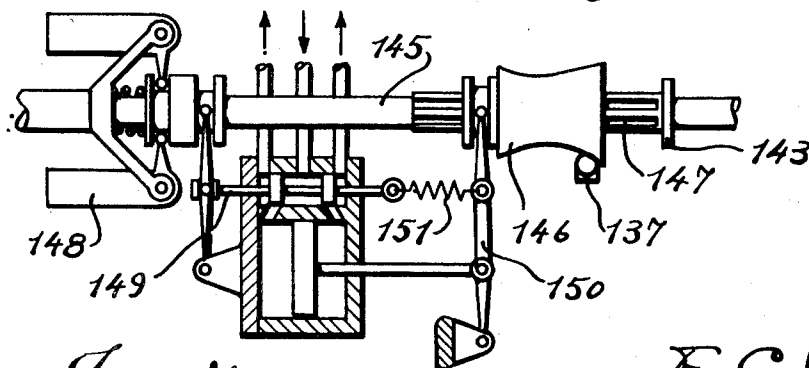


Fig. 7.

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UNITED STATES PATENT OFFICE

2,435,902

FUEL METERING DEVICE

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71 Claims. (Cl. 123—119)

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This invention relates to fuel metering devices for combustion engines, and more particularly to devices for automatically controlling the engine supply of liquid fuel, or the relative proportions of the fuel and air composing the engine combustible mixture. The present application is a division of my patent application Serial No. 254,355, filed February 3, 1939, now abandoned.

An object of the invention is to provide improved devices of the type indicated.

Another object is to provide improved devices for automatically controlling the engine fuel flow or the engine fuel/air ratio in response to changes in engine operating conditions.

Further objects of the invention will be apparent from the following description, taken in connection with the appended drawings, in which:

Figure 1 is a diagrammatic sectional view of a device embodying the invention;

Figure 2 is a fragmentary view of a modified form of spring which may be substituted for the corresponding spring shown in Figure 1;

Figures 3 and 4 are fragmentary sectional views showing the interior of one of the bellows of Figure 1, and a modified arrangement of the bellows, respectively;

Figure 5 is a fragmentary diagrammatic sectional view of another modified form of the invention;

Figures 6 and 7 are fragmentary diagrammatic sectional views of another modified form of the invention;

Figure 8 is a fragmentary view of still another modified form of the invention; and

Figure 9 is a fragmentary view of a further modified form of the invention.

The invention is in no way limited to use with reciprocating engines, but may be practiced in connection with any suitable thermal or combustion engine, such for example as the internal combustion turbine, the turbo-jet engine, the turbo-propeller engine, the pulse-jet, the ram-jet, the rocket engine.

Referring more specifically to the drawings, the arrangement disclosed in Figure 1 comprises an engine 60 having an induction passage 59 communicating with the inlet side of a supercharger or compressor 61 of any suitable type, which in turn leads to an induction pipe 62 and thence to the inlet port, not shown, of the engine. The passage 59 is controlled by a throttle valve 63 actuated through a lever 64.

A casing 80, communicating through a large duct 81 with the induction pipe 62, contains air at induction pressure and temperature. An evac-

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uated bellows 82 in said casing acts on lever 83 to operate rod 94 and pilot valve 84, 85 which controls admission of oil under pressure, usually led from the engine lubricating system through pipes 87 and 88 as indicated by the arrows, to opposite sides of piston 86. Low pressure oil is returned to the engine sump through line 89. A floating lever 90 is connected at its ends with rod 94 and piston 86, and at an intermediate point with rod 91 which is connected, through lever 92 and rod 93, with the horizontal arm of a bell-crank lever 74.

Also enclosed within casing 80 there is a bellows 95 which contains a definite weight of gas or other suitable fluid at constant volume. The high velocity of the air flow in the induction manifold 62 as well as the pulsations of pressure therein determine eddy currents and turbulence within the large and short conduit 81 and casing 80, thus causing an active thermic exchange, by conduction and convection, between the air flowing in the manifold 62 and the bellows 95. Furthermore the thermal capacity of the latter usually is, or may be made, extremely small. It follows that the fluid within bellows 95 is at all times maintained at the same temperature as the air in the pipe 62.

The absolute pressure within bellows 95 is therefore proportional to the absolute manifold or induction temperature. Bellows 95 and a similar and evacuated bellows 96 act against each other and on a lever 97 to operate rod 100 of a servo mechanism similar to the servo motor 86. Engine lubricating oil is led thereto and evacuated therefrom as indicated by the arrows. The pressure of the air in casing 80 acts in opposite directions on bellows 95 and 96, thereby balancing out the effect of any pressure change therein, so that the load transmitted to lever 97 by the two bellows is only dependent upon the induction or manifold temperature. The servo mechanism controlled by rod 100 acts on lever 98 to vary the operating distance of rod 93 from the fulcrum of lever 92. Spring 99 balances the load transmitted by the bellows to rod 100 and is designed so that the operating distance of rod 93 from the fulcrum of lever 92 is proportional to the actual absolute manifold temperature. Any temperature change in said induction manifold operates bellows 95 and in turn the servo mechanism to rotate lever 98 and vary the load of spring 99 until the balance of the rod 100 in its neutral position is re-established. Thus the load on rod 93 is proportional to the absolute pressure and inversely proportional to the absolute temperature in the induction pipe 62, and there-

fore is directly proportional to the air density therein.

A control lever 78 is adapted to modify the angular setting of lever 79 and in turn to alter the distance of the lower end of rod 93 from the fulcrum of lever 74.

The engine 60 is provided with a fuel feed, such for example as a conventional injection or metering pump 104 driven by the engine and comprising one or more pump elements connected by ducts or pipes 105 and nozzles 70 with the various engine cylinders. These nozzles 70 may be mounted in any suitable position, such as near the intake cylinder port or valve or inside the cylinder, as shown in Figure 1, or they may be mounted to inject fuel into the induction pipe 62 as shown in Figure 8.

The delivery of the engine fuel feed or metering pump is adjusted by axially displacing the control rod 106. This rod is biased by a spring 107 and is actuated by the upper arm of the bell-crank lever 74. The spring 107 is so designed as to exert on the control rod 106 a load which is proportional to the quantity of fuel delivered per cycle by the metering pump 104.

The device works as follows: The evacuated resilient bellows 82 exerts on the rod 94 an upward load proportional to the induction pressure. In normal operation the rod 94 with the control valves 84 and 85 is maintained in equilibrium in neutral position by a downward load of equal magnitude transmitted thereto from the calibrated spring 107 of the fuel metering pump 104. Thus, for a given adjustment of the temperature compensating lever 98 and manual control lever 78 the induction pressure and the load of the spring 107 (and in turn the engine fuel supply) are proportional. If now the pilot operates the engine throttle control lever 65 in a direction to decrease the engine air supply, or if the aircraft climbs to higher altitude, the induction pressure surrounding bellows 82 decreases, and with it decreases the upward load transmitted by the bellows to the rod 94, while the downward load transmitted thereto from the spring 107 remains unchanged.

Thus the bellows 82 expands, the rod 94 moves downward, and oil under pressure, admitted over piston 86, displaces the latter downward, causing counter-clockwise rotation of lever 74 and movement of the control rod 106 to the left, thereby decreasing the engine fuel supply. As the spring 107 expands, its load decreases and determines a corresponding decrease of the downward load applied to the rod 94. As a result the downward motion of the latter is stopped, and thereafter the rod 94 moves upwardly toward its neutral position. The downward movement of the piston 86 continues until the loads transmitted to the rod 94 by the spring 107 and by the induction pressure have once more equal magnitudes and rod 94 resumes its neutral position. Obviously, an increase of induction pressure, due either to a change of adjustment of the throttle control lever 65 or to a decrease of altitude, causes the device of Figure 1 to correspondingly increase the engine fuel supply. Induction pressure and fuel delivery per cycle thus vary proportionally.

As already stated, lever 97 actuated by bellows 95 and 96 exerts on rod 100 an upward load which is proportional to the induction temperature. In normal operation, that is to say when said temperature is constant, said load is balanced by the spring 99, and the rod 100 is in its neu-

tral position. An increase of induction temperature causes a proportional increase of pressure within bellows 95 and upward load applied to the rod 100. Bellows 95 expands, the rod 100 is lifted, and oil under pressure is led above the piston of the servomotor, thus causing lever 98 to rotate counter-clockwise, and gradually increasing the load of spring 99. This increase in the spring load causes the rod 100 to move downward toward its neutral position. Operation of the servomotor and rotation of lever 98 continue until rod 100 resumes its neutral position, the load of spring 99 having in the meantime assumed a value equal to the new upward load exerted on the rod 100 by the bellows and corresponding to the new value of the induction temperature; the result being that lever 98 assumes a new position of equilibrium in which the distance of rod 93 from the fulcrum of lever 92 has increased in proportion to the increase of absolute induction temperature.

Thus the load exerted by the rod 93 to the bell-crank lever 74 is proportional to the absolute pressure and inversely proportional to the absolute temperature in the induction pipe 62, and is therefore proportional to the air density therein.

The mixture control lever 78 is adapted to modify the distance of rod 93 from the fulcrum of lever 74 so as to vary the proportionality ratio between the air density in the induction pipe 62 and the fuel delivery per cycle.

If the air charge per cycle, or weight of air present in the engine cylinder during the compression and power strokes, is proportional to the induction density, then the mechanism shown in Figure 1 gives for each adjustment of the mixture control lever 78 a corresponding constant fuel/air ratio.

In certain engines it has been found that the air charge is inversely proportional not to the absolute induction pressure, but to the square root thereof. To automatically maintain in such engines a constant value of the fuel/air ratio for each position of the mixture control lever 78, the mechanism of Figure 1 may be modified by the adoption of a spring 101, shown in Figure 2, whose deflection within the designed limits is proportional to the square root of the load; such for example as a coil spring having uniform diameter and non-uniform pitch so designed that within the operating range the number of free coils is inversely proportional to the spring deflection, whereby the distance between rod 93 and the fulcrum of lever 92 is proportional (and thereby the load on rod 93 is inversely proportional) to the square root of the absolute temperature in the induction pipe 62.

In engines in which the air charge is found to be a still different function of the induction temperature, an automatically constant value of fuel/air ratio may be obtained either by providing resilient means 101 of suitable characteristic, or by establishing the suitable relation between rotation of lever 98 and distance of rod 93 from the fulcrum of lever 92 by means of a cam, substantially as shown in Figures 5 or 6.

It has further been observed that in certain engines, in particular those highly supercharged and having a large valve overlap, such as applied conveniently to injection engines wherein it is possible to secure scavenging of the combustion chamber without loss of fuel, the air charge or weight of air remaining in the engine cylinder during compression and power stroke is affected,

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for a given induction pressure, by the surrounding atmospheric, or exhaust, pressure. To correct such influences so that the load on rod 93 be proportional to the air charge a comparatively small bellows, whose interior communicates with the surrounding atmospheric pressure, may be added to the pressure responsive bellows 82 of Figure 1, either within the evacuated bellows 82 as indicated by numeral 102 in Figure 3, or on opposite side of lever 83, as indicated by numeral 103 in Figure 4, its size and position being determined in accordance with engine tests. With the arrangement shown in Figure 3, which is particularly suitable in connection with reciprocating engines, the engine fuel supply increases with the altitude. The arrangement shown in Figure 4, instead, causes the fuel supply to decrease as the altitude increases, and is suitable for securing proper barometric compensation in the fuel flow of aircraft gas turbine engines.

Thus the regulator 80 operates to control the engine fuel supply automatically in accordance with preselected functions of engine induction air pressure, induction air temperature and surrounding air pressure.

The interior of bellows 102 or 103 may be vented to the atmospheric pressure or the surrounding air pressure by any obvious means, such for instance as a passage provided in the wall of housing 80.

The "surrounding air pressure" or "atmospheric pressure" which is referred to in the three preceding paragraphs and in number of claims, and to which pressure the interior of bellows 102 or 103 may be vented, is not necessarily the static atmospheric pressure. Where the engine is used in aircraft or other high-speed vehicle, said surrounding air pressure or atmospheric pressure existing in the immediate vicinity of the regulator 80 and actuating the bellows 102 or 103 may be affected by the forward speed of the aircraft or vehicle, due to the well-known ram effect which is dependent upon the arrangement of the air intake system and the velocity of the aircraft or vehicle, as is well known in the art.

It is to be clearly understood that while the fuel metering pump 104 described above and illustrated in Figure 1 of the drawings is a conventional multi-plunger variable-delivery fuel injection pump, the means for automatically controlling the fuel delivery or the fuel/air ratio according to the present invention may be applied to any suitable fuel supply system.

The device shown in Figure 1 may be used in combination with means for controlling the engine air supply, such as a control lever 65 operating the air throttle valve 63 as shown in Figure 1.

The arrangement described above in connection with Figure 1, in which the engine fuel flow or the fuel/air ratio can be adjusted only manually by the pilot or operator through the control lever 78 is not the most suitable in connection with aircraft engines. Accordingly, means responsive to one or more engine operative conditions, such for example as the induction manifold pressure or density, engine speed, atmospheric pressure, engine temperature, are provided for controlling said engine fuel supply or fuel/air ratio automatically.

Operation of the engine 60 with "best economy" mixture is possible over a certain range of power, beyond which the engine cannot safely be operated without resorting to some additional en-

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richment of the mixture to suppress over-heating and detonation. A temperature responsive element 130, shown in Figures 5 and 9, is mounted at a suitable point of the engine such as a cylinder head 60 or exhaust port 129 so as to be responsive to the combustion chamber or cylinder head temperature in the first case, or to the temperature of the combustion products or exhaust gases in the second case. This element 130 is connected with a bellows 131 placed to act against an evacuated bellows 132 so that changes in the pressure surrounding the bellows act in opposite directions on said two bellows and have no effect on their operation. Temperature changes about element 130 operate the bellows 131 and in turn the rod 133 of a servo mechanism, similar to those already described in detail, to control the angular adjustment of lever 134 and cam 135 and to vary the load of spring 136 acting on rod 133. An increase in temperature of element 130 lowers the rod 133 and in turn rotates lever 134 clockwise thereby increasing the load of spring 136 until the balance of rod 133 in its neutral position is re-established. Cam 135 is adapted to operate lever 137, having the same function as lever 79 previously described, so that for each value of the temperature of element 130 it determines a corresponding predetermined minimum possible value of the fuel/air ratio. Mixture control lever 78 and lever 137 are connected through a lost motion device such as an elongated slot 138 and a tension spring 139 whereby the lever 78, whatever its adjustment may be, does not oppose counterclockwise rotation of lever 137 when the latter is rotated by cam 135. It is thus clear that any desired relation between the temperature variations of element 130 and the corresponding changes of fuel/air mixture ratio which are automatically effected by means of the structure disclosed in connection with Figure 5 may be obtained by employing a cam 135 of appropriate design, whereby various operational requirements of engines of different types and of divergent characteristics may be met. Thus, while the cylinders of conventional air-cooled radial aircraft engines when operating under high load and speed are caused to run at lower temperature by providing richer fuel mixture, it is well known that in order to lower the temperature of a gas turbine engine it is necessary, instead, to decrease the fuel to air ratio of the combustible mixture thereof. It will therefore be appreciated that according to the invention the profile of cam 135 may either be so designed that expansion of the temperature responsive bellows 131 increases the fuel to air ratio where it is intended for use with a reciprocating engine; or, where it is intended for the control of a gas turbine engine, the cam 135 may be so designed as to decrease the engine fuel to air ratio, or fuel flow, upon increase in the temperature of element 130. As pointed out above, the device illustrated in Figure 1 may automatically vary the engine fuel supply per cycle in direct proportion to the air induction pressure and in inverse proportion to the absolute temperature thereof, the proportionality ratio, and in turn the fuel/air mixture ratio being determined by the effective length of the horizontal arm of the bell-crank lever 74, or in other words by the distance between rod 93 and the pivot of lever 74. It has also been set forth in the foregoing that such a device will operate correctly as stated with an engine in which the cylinder air charge varies proportion-

ally to the air induction density, but that in certain types of engines, for instance highly supercharged and air scavenged aircraft engines, the effective cylinder air charge is appreciably affected by changes of exhaust or surrounding atmospheric pressure, and may vary with the induction air absolute temperature according to a function of the latter substantially different from inverse proportionality, and that in combination with said latter engines devices partially modified according to Figures 2, 3 or 4 will therefore be more suitable.

However, whether or not it includes any of said modifications, the device of Figure 1 is provided with manually actuatable control means 78 for adjusting the effective length of the horizontal arm of lever 74 to control the fuel/air ratio. In order to obtain a fuel/air mixture ratio that varies automatically as a predetermined function of engine operative conditions, lever 79 of the device represented in Figure 1 may be eliminated, and in substitution therefor there may be provided a lever 137 actuated by a cam having two distinct ways of reversible adjustment, for example a slidable and rotatable cam 146 as shown in Figures 6 and 7, there being provided means responsive to engine operative conditions for adjusting said cam in said two distinct ways, whereby the mixture ratio may automatically be caused to vary as a predetermined function of two independent variables, said function being dependent on the configuration of the cam.

The upper arm of lever 137 is connected with the lower end of rod 93, shown in Figure 1, for adjusting the effective length of lever 74, and has therefore the same function as the upper arm of lever 79. The lower arm of lever 137 has a lost-motion connection with a rod 138 which may be actuated by way of the manual control member 78 of Figure 1. A third, horizontally extending arm of lever 137 of Figures 6 and 7 is actuated by the cam 146 which may be axially and angularly adjusted by engine condition responsive devices, shown in Figures 7 and 6 as mechanisms responsive to the engine speed and to the manifold air pressure, respectively. The automatic mixture ratio control device may thus include the mechanism of Figure 1 minus lever 79, in combination with the structure represented in Figures 6 and 7.

Figure 6 shows means for automatically regulating the fuel/air ratio as a function of the induction or manifold pressure, assuming the mixture control lever 78 to be in "lean" adjustment with rod 138 in the position shown in the drawing, thus permitting contact between the horizontal arm of lever 137 and cam 146. A bellows 141, evacuated totally or in part and enclosed in a housing communicating with engine induction pipe 62, operates rod 142 of a servo mechanism similar to those already described, whereby an increase in induction pressure raises rod 142 and causes lever 143 to be rotated counter-clockwise until the increased load of tension spring 144 re-establishes the balance of rod 142 in its neutral position. Lever 143 is secured to an externally splined sleeve 147 rotatably mounted on an engine-driven shaft 145. The warped cam 146 is slidably but non-rotatably mounted on sleeve 147, so that the angular adjustment of the cam is dependent on the induction pressure. If the bellows 141 is not completely evacuated, it is actuated by changes of surrounding temperature, such as the induction or manifold temperature or whatever temper-

ature the bellows is subject to; and the angular adjustment of cam 146 is accordingly altered upon variations of said temperature. The axial adjustment of cam 146 is determined by speed responsive means such as a governor 148 driven from the engine through the shaft 145. This governor 148 controls rod 149 of a servo mechanism whereby an increase in engine speed displaces rod 149 to the left and thus causes the lever 150 to be rotated clockwise until the increased load of tension spring 151 re-establishes the balance of rod 149 in its neutral position. Cam 146 therefore determines for each value of induction pressure and engine speed a corresponding minimum possible value of fuel/air ratio. In the preferred embodiment specifically disclosed herein, which is intended for use with a reciprocating internal combustion aircraft engine, the form of the cam is such that in the cruising range of induction pressure and engine speed combinations, such minimum value corresponds to the "best economy" mixture, while for combinations of engine speed and induction pressure corresponding to higher power output the minimum possible value of fuel/air ratio will be higher than that corresponding to "best economy" mixture. Variation of fuel/air ratio as determined by cam 146 is obtained automatically if the mixture control lever 78 is adjusted for "lean" mixture, owing to the elongated slot 138 and spring 139, while further mixture enrichment may be obtained by rotating lever 78 counter-clockwise. Obviously, the structure disclosed in connection with Figure 5 for rotating the cam 135 with changes of temperature of the element 130 may be substituted for the structure shown in Figure 6 for rotating the cam 146, whereby the adjustment of the latter and in turn the engine fuel supply will vary in accordance with changes of engine speed and with variations in the temperature of element 130.

The foregoing embodiments of the invention have been described for purpose of illustration and not as a limitation of the scope of the invention. It is therefore to be expressly understood that the invention is not limited to the specific embodiments shown, but may be used in various engines having different characteristics and operational requirements, that various modifications may be made to suit said different engine operational requirements, and that other changes, substitutions, additions and omissions may be made in the construction arrangement and manner of operation of the parts without departing from the limits or scope of the invention as defined in the following claims.

Where the claims are directed to less than all of the elements of the complete system disclosed, they are intended to cover possible uses of the recited elements in installations which may lack the non-recited elements.

What I claim is:

1. In an engine fuel control mechanism, in combination with means responsive to the pressure and temperature of the engine induction air and means for varying the engine fuel supply, an operative connection between said first and second mentioned means for adjusting the engine fuel supply in proportion to the engine air supply, a lever of adjustable effective length in said operative connection for controlling the engine fuel-air mixture ratio, slidable and rotatable cam means having a warped surface for adjusting the effective length of said lever, and means responsive to engine operative conditions for axially and

angularly adjusting said cam means whereby the engine fuel-air ratio varies as a predetermined function of said engine operative conditions, said function being dependent on the configuration of said warped surface.

2. An engine fuel control mechanism including means responsive to the engine induction air pressure and temperature, fuel control means, an adjustable operative connection between said means, cam means reversibly adjustable in two distinct ways and having a warped surface for altering the adjustment of said operative connection, and means responsive to engine operative conditions for adjusting said cam means in said two ways.

3. An engine fuel control mechanism including fuel control means, means responsive to engine induction air pressure and temperature, adjustable means for operatively connecting said first and second mentioned means to keep the engine fuel supply substantially proportional to the engine air supply, cam means reversibly adjustable in two distinct ways and having a warped surface for altering the adjustment of said third mentioned means to vary the engine fuel-air ratio, means responsive to engine operative conditions for adjusting said cam means, and additional means whereby the engine fuel-air ratio may be altered independently of the adjustment of said cam means.

4. An engine fuel control device including fuel control means, means responsive to engine induction air pressure and temperature and surrounding atmospheric pressure, an operative connection between said first and second mentioned means for keeping the engine fuel supply proportional to the engine air supply regardless of changes of induction air pressure and temperature and surrounding atmospheric pressure, means for controlling the engine fuel-air ratio, and engine operative condition responsive means for adjusting said third mentioned means.

5. An engine fuel control device including, in combination with fuel control means and pressure and temperature responsive means connected with the engine air induction system for actuating said control means to vary the engine fuel supply substantially in proportion to the engine air supply, mixture control means for controlling the engine fuel-air ratio, cam means adjustable in two directions for actuating said mixture control means, and means for varying the adjustment of said cam means upon changes of engine speed and induction air pressure.

6. In an engine fuel control device having mixture ratio control means, cam means having two ways of adjustment and a warped surface for actuating said control means, and means for varying the adjustment of said cam means in said two ways with changes of engine speed and manifold air pressure and temperature.

7. In an engine fuel control device having fuel-air mixture ratio control means, means adjustable in two ways and having a controlling surface for actuating said control means, and means for varying the adjustment of said second mentioned means with changes of engine speed and manifold air pressure.

8. In combination with an engine having a fuel injection system and an air induction manifold, a fuel control mechanism including fuel control means, pressure and temperature responsive means connected with said manifold, warped cam means having two ways of adjustment, an operative connection including servo-motor means for

adjusting said fuel control means in dependence on the adjustment of said pressure and temperature responsive means, means for actuating said fuel control means in dependence upon the adjustment of said cam means, and additional means for varying the adjustment of said cam means in said two ways with changes of preselected engine operative conditions.

9. An engine fuel control device including means for controlling the engine fuel supply, and means operatively connected with said first mentioned means for actuating the latter to vary said engine fuel supply with changes of engine manifold air pressure and temperature, surrounding atmospheric pressure and engine speed.

10. In an engine fuel control mechanism, fuel control means, means responsive to engine induction air pressure and temperature and surrounding atmospheric pressure, an operative connection including servo motor means and lever means having an adjustable effective length between said second and first mentioned means to actuate the latter in a direction to increase the engine fuel supply with an increase of induction air pressure and with decrease of induction air temperature and surrounding atmospheric pressure whereby for a given adjustment of the effective length of said lever means the engine fuel-air ratio is kept constant regardless of variations of induction air conditions and altitude, while said ratio assumes different values for different adjustments of the effective length of said lever means, and means for varying the effective length of said lever means to control said ratio.

11. An engine fuel control mechanism including fuel control means, means responsive to engine induction air conditions substantially at the engine cylinder inlet ports and to the pressure surrounding the engine operatively connected with said control means for varying the engine fuel supply with changes of said induction air conditions and said pressure to keep the engine fuel supply substantially proportional to the engine air supply regardless of said changes, adjustable means in the operative connection between said first and second mentioned means for varying the ratio of proportionality between said fuel and air supplies whereby the engine fuel-air ratio is determined by the adjustment of said adjustable means, and means including a warped surface having two different orders of motion for automatically varying the adjustment of said adjustable means.

12. In an engine control device, fuel control means, servo motor means for actuating said control means to control the engine fuel supply, means responsive to changes of engine induction air pressure and surrounding pressure for causing controlling movement of said servo motor means to keep the engine fuel-air ratio independent of variations of said pressure, mixture control means for varying said ratio, a warped surface, means for adjusting said mixture control means from a variable point of said surface, and means for varying said point thereof with changes of preselected operative conditions.

13. Engine fuel injection control, including means responsive to engine induction air pressure and surrounding atmospheric pressure, fuel control means, an operative connection including servo-motor means and lever means having a variable effective length for increasing the engine fuel supply with an increase of induction air pressure and a decrease of surrounding pressure, and means responsive to the induction air tem-

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perature for varying the effective length of said lever means whereby said engine fuel supply increases with a decrease of said temperature.

14. Engine fuel injection system including first means for increasing the engine fuel supply with increase of the engine manifold air pressure and with decrease of the engine manifold air temperature and surrounding air pressure, and additional engine operative condition responsive means for altering said supply independently of said first means.

15. An engine fuel supply system including fuel supply control means, induction air pressure and temperature responsive means for actuating said control means to increase said supply with increase of said pressure and decrease of said temperature, and engine operative temperature responsive means connected with said control means for enriching the combustible mixture for high values of the latter temperature.

16. Supercharged engine fuel injection system including supercharged air temperature and pressure responsive means for varying the fuel supply substantially in proportion to the engine air supply mixture control means for regulating the ratio between said fuel and air supplies, means for actuating said control means to vary said ratio, and additional means responsive to an operative temperature and connected with said control means to increase said fuel-air ratio for high values of the latter temperature.

17. An engine fuel supply device including fuel control means, engine induction pressure and temperature responsive means actuating said control means to increase the engine fuel supply upon increase of said pressure and upon decrease of said temperature, pressure responsive means actuating said control means to increase said supply upon decrease of atmospheric pressure, and means operatively connected with said control means to vary said supply independently of said pressure and temperature responsive means.

18. An engine fuel supply device including a fuel control means, first pressure responsive means actuating said control means to increase the engine fuel supply upon increase of engine manifold pressure, second pressure responsive means actuating said control means to increase the engine fuel supply upon decrease of the surrounding atmospheric pressure, and engine operative condition responsive means independent of said first and second pressure responsive means and operatively connected with said fuel control means.

19. An engine fuel supply device including a fuel control means, engine induction pressure and surrounding air pressure responsive means for actuating said control means to increase the engine fuel supply upon increase of said induction pressure and upon decrease of said air pressure, and means for actuating said control means with changes of engine speed.

20. A supercharged engine regulating device including fuel control means, supercharged air pressure and temperature responsive means actuating said control means to increase the engine fuel supply upon increase of said pressure and upon decrease of said temperature, pressure responsive means actuating said control means to increase said supply upon decrease of atmospheric pressure, and means for actuating said control means independently of said second and third mentioned means.

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21. A fuel control unit for an internal combustion engine having a supercharger and an engine driven pump adapted to supply a definite quantity of fuel for each revolution of the engine, control means for said pump comprising servo-motor means responsive to the pressure of the air supplied by said supercharger adapted to vary the fuel supply for every change in pressure and additional servo-motor means responsive to the R. P. M. of the engine and to the altitude for varying the quantity of fuel delivered by said pump for every change in speed and in altitude.

22. In a fuel metering system, an air passage; a source of pressure fuel supply; means automatically operative in response to pressure and temperature variations of the air flowing through said passage for varying the fuel supply to maintain a predetermined fuel-air ratio; manual means controlling the effect of said automatic means and adapted to provide a lean fuel-air mixture for normal operation; a supercharger connected with said passage; and means for rendering said manual means ineffective, to provide richer fuel-air mixture when the pressure developed by said supercharger and the engine speed attain high values.

23. In a fuel metering system, an air passage; a source of fuel supply; means automatically operative in response to variations in conditions of the air flowing through said passage for varying the fuel supply to maintain a predetermined fuel-air ratio; manual means controlling the effect of said automatic means and adapted to provide a lean fuel-air mixture for normal operation; and means responsive to an engine operative temperature for rendering said manual means ineffective and provide richer fuel-air mixture for high values of said temperature.

24. In a fuel metering device, an air passage; fuel supply means; means automatically operative in response to variations in conditions of the air flowing through said passage for varying the fuel supply to maintain a predetermined fuel-air ratio; manual means to control the effect of said automatic means for varying at will the richness of the mixture during normal operation; an air compressor connected with said passage; and means responsive to the pressure developed by said compressor and means which move with changes of engine speed for rendering said manual means ineffective and varying the fuel-air ratio.

25. In a fuel metering device, an air passage; fuel supply means; means automatically operative in response to variations in pressure and temperature of the air flowing through said passage for varying the fuel supply; manual means to control the effect of said automatic means for varying at will the richness of the mixture during normal operation; and means responsive to an engine operative temperature for rendering said manual means substantially ineffective and varying the fuel supply for predetermined changes of the latter temperature.

26. Fuel control means for an airplane engine charge forming device connected to a supercharger, manual means for controlling the fuel supply to provide a lean fuel-air mixture for normal operation, and engine speed and absolute pressure responsive means automatically operative upon attainment of predetermined engine speed and absolute pressure in the supercharger discharge for rendering said manual control

means inoperative, whereby a rich fuel-air mixture is provided when operating under high values of said speed and pressure.

27. An engine fuel metering system including a plurality of valve means for controlling the engine fuel supply; and condition responsive means for actuating said valve means; said condition responsive means including: pressure and temperature responsive means for increasing said fuel supply upon increase of engine manifold air pressure, upon decrease of atmospheric pressure and upon decrease of manifold air temperature, and additional engine operating condition responsive means actuating one of said valve means independently of said pressure and temperature responsive means.

28. In an engine fuel metering system having a plurality of valve means for regulating the engine fuel flow: condition responsive means actuating said valve means; said condition responsive means including: means responsive to changes of engine induction air pressure, of surrounding atmospheric pressure and of induction air temperature, and additional engine temperature responsive means for actuating one of said valve means automatically.

29. Apparatus for automatically maintaining a predetermined ratio between the mass of fuel and the mass of air admitted to the cylinder of an internal combustion engine, comprising a temperature responsive device exposed to the air delivered to the cylinder, a pressure responsive device exposed to the boost pressure, a pressure responsive device exposed to the difference between the atmospheric pressure and the boost pressure, means for adjusting the fuel-to-air ratio, and an operative connection between the three said devices and the said adjusting means and a sealed casing pressure within which is maintained by the boost pressure of the engine, the said pressure responsive devices being enclosed within the said casing.

30. Apparatus for automatically maintaining a predetermined ratio between the mass of fuel and the mass of air admitted to the cylinder of a supercharged aero engine comprising a supercharging blower, a sealed casing, a conduit connecting said casing to the discharge side of the supercharging blower, a temperature capsule (with one end fixed in said casing) the temperature-responsive element of which is disposed in the discharge of the supercharging blower, an atmospheric capsule with one end fixed in said casing, a conduit connecting said capsule with the atmosphere, a boost pressure capsule disposed within said casing, a linkage operatively connected to the moving parts of each of the three capsules, adjusting means for controlling fuel delivery to the engine and an operative connection between the said linkage and said adjusting means.

31. A fuel injection device for aircraft engines which meters fuel in response to engine speed, intake manifold temperature, intake manifold pressure and atmospheric pressure; said device including a plurality of slide valve means for controlling the engine fuel supply; rotating governor weights to actuate one of said valve means; a housing; means for venting said housing to the manifold pressure of the engine; two unequal bellows in said housing for controlling another of said valve means, the larger bellows being evacuated and the smaller bellows being vented to the atmospheric pressure; and temperature responsive means to be connected to the intake mani-

fold of the engine for actuating another of said valve means.

32. In an engine fuel supply device: a pressure responsive component for metering the fuel in accordance with engine manifold pressure and atmospheric pressure including a housing adapted to be vented to manifold pressure and two unequal bellows in said housing, the larger bellows being evacuated and the smaller bellows being internally vented to atmospheric pressure; a temperature responsive component for metering the fuel in accordance with engine manifold temperature including a temperature responsive element adapted to be so connected to the engine as to be subject to changes of intake manifold temperature thereof; and a speed responsive component for metering the fuel in accordance with engine speed including centrifugal means adapted to be driven from the engine.

33. An engine fuel metering system including a fuel pump; a plurality of slidable elements for regulating the quantity of fuel metered by said system; a closed housing; means for connecting the space within said housing with the engine air induction system; two unequal bellows in said housing for actuating one of said elements, the larger bellows being evacuated and the smaller bellows being vented to surrounding air pressure; temperature responsive means for actuating another of said elements; and centrifugal flyweights for actuating still another of said elements.

34. A fuel metering system including a fuel pump; a plurality of slidable elements for regulating the quantity of fuel metered by said system; a housing; means for admitting variable pressure fluid into said housing; two unequal bellows in said housing for actuating one of said elements, the larger bellows being evacuated and the smaller bellows being vented to a pressure which varies with the altitude; temperature responsive means for actuating another of said elements; speed responsive centrifugal means for actuating still another of said elements; and additional means for further regulating the quantity of fuel metered by said system.

35. Engine fuel metering device including an engine driven fuel pump; and means for controlling the quantity of fuel supplied by the pump to the engine, including engine induction air pressure and engine induction air temperature responsive means, atmospheric pressure responsive means, and engine driven speed responsive means, whereby the engine fuel supply is metered in accordance with engine speed, engine air induction density and exhaust back-pressure.

36. In an engine fuel metering device: a fuel pump adapted to be driven by the engine; and means for controlling the quantity of fuel supplied by the pump to the engine, including a pressure responsive bellows assembly for metering the engine fuel supply in accordance with engine induction air pressure; temperature responsive means for metering the engine fuel supply in accordance with engine induction air temperature; and speed responsive centrifugal flyweight means adapted to be driven by the engine for metering the engine fuel supply in accordance with engine speed.

37. In combination with an engine having an air supply passage, a throttle therein, an engine driven fuel pump, and means for supplying fuel from the pump into the passage between throttle and engine, means responsive to pressure and temperature variations in the passage between throttle and engine for controlling the engine fuel

supply as a function of the pressure and temperature in said passage, and engine driven centrifugal means for controlling the engine fuel supply as a function of engine speed.

38. An engine fuel metering device having a fuel pump adapted to be driven by the engine; control means for variably regulating the quantity of fuel supplied by the pump to the engine; and automatic means for actuating said control means, including: pressure responsive means for metering the engine fuel supply in accordance with two operating pressures both of which pressures affect the engine air supply; temperature responsive means for metering the engine fuel supply in accordance with an engine operating temperature; and speed responsive centrifugal means adapted to be driven from the engine for metering the engine fuel supply in accordance with engine speed.

39. A fuel supply system having control means for variably regulating the engine fuel supply; and means for actuating said control means, including: pressure responsive means subject to surrounding atmospheric pressure and to induction air pressure, temperature responsive means subject to induction air temperature, and additional temperature responsive means subject to another engine operating temperature.

40. Engine fuel supply system including: pressure and temperature responsive means for modifying the engine fuel supply operative in a direction tending to increase the fuel to air ratio with increase of the engine manifold air pressure and with decrease of the engine manifold air temperature; pressure responsive means subject to atmospheric pressure for altering the engine fuel supply operative in a direction tending to increase the fuel to air ratio with decrease of atmospheric pressure; and additional engine operative condition responsive means for varying said fuel supply independently of said first and second mentioned means.

41. Engine fuel supply system comprising operatively interconnected manually operable control means and automatic means for controlling the engine fuel supply; said automatic means including: pressure and temperature responsive means for varying the engine fuel supply with changes of engine induction air pressure, atmospheric pressure and engine induction air temperature, and a speed responsive device having centrifugal means for controlling the engine fuel supply in accordance with engine speed.

42. Engine fuel supply system including a fuel pump; means for driving said pump from the engine; and manually operated and automatic means for controlling the engine fuel supply; said automatic means including: speed responsive means for regulating the engine fuel supply as a function of engine speed, pressure responsive means for altering the engine fuel supply with variations of engine induction air pressure and of a pressure against which the engine exhausts, and temperature responsive means for modifying the engine fuel supply with changes of an engine operative temperature.

43. A fluid supply and control device including a volumetric pump; means for driving said pump from an engine or other fluid consuming means; and means for controlling the fluid supply of said device, including a speed sensitive device driven at a speed which is equal or proportional to the pump speed, pressure responsive means for altering said fluid supply with changes of two pressures which both affect the operation of said en-

gine or other fluid consuming means, and temperature responsive means for varying the supply of said fluid with changes of a preselected temperature.

44. For use with an engine having at least one combustion chamber and unidirectional fluid flow conduit means for conducting atmospheric air to the combustion chamber and exhausting the combustion products from said chamber into the atmosphere, whereby the engine air flow is dependent upon the pressure both upstream and downstream with respect to said chamber: a fuel supply system including a fuel pump; means for driving said pump from the engine; and manual and automatic means for controlling the engine fuel supply; said automatic means including pressure responsive bellows for varying the engine fuel supply with pressure changes both upstream and downstream with respect to the combustion chamber, and a speed sensitive centrifugal device for controlling the engine fuel supply as a function of engine speed.

45. Engine fuel supply device including a fuel pump; means for driving the pump from the engine; and operatively interconnected manual and automatic means for controlling the engine fuel supply; said automatic means including speed responsive governor means for regulating the engine fuel supply with changes of engine speed, and barometric pressure responsive means for altering the engine fuel supply with changes of altitude.

46. Engine fuel supply device including a fuel pump; means for driving the pump from the engine; and means for controlling the engine fuel supply, including manually operable control means, speed responsive centrifugal means for controlling the engine fuel supply as a preselected function of engine speed, and atmospheric pressure responsive means for altering the engine fuel supply with variations of altitude.

47. Engine fuel supply device including a fuel pump; means for driving the pump from the engine; and means for controlling the engine fuel supply, including manually operable control means, speed responsive centrifugal governor means adapted to be driven from the engine and to render the manually operable means ineffective at high engine speed to control the engine fuel supply automatically as a preselected function of engine speed, and temperature responsive means for altering the engine fuel supply with variations of an engine operating temperature.

48. Engine fuel supply device including a fuel pump; means for driving the pump from the engine; and means for controlling the engine fuel supply, including manually operable means, speed responsive means for regulating the engine fuel supply as a function of engine speed, temperature responsive means for varying the engine fuel supply with changes of an engine operative temperature, and surrounding atmospheric pressure responsive means for altering the engine fuel supply with altitude variations.

49. Engine fuel supply device including an engine driven fuel pump; and means for controlling the engine fuel supply, including a manually controllable element, engine speed responsive means, engine induction air temperature responsive means, means responsive to a pressure which varies with the altitude, and means responsive to an additional engine operating temperature.

50. Engine fuel supply device including a fuel pump; and means for controlling the engine fuel supply, including manually operable control

means, engine speed responsive means, engine induction air temperature and pressure responsive means, means responsive to a pressure which tends to vary with changes of altitude, and means responsive to a further engine operating temperature.

51. A fuel system for aircraft engines, including a fuel pump; means for driving the pump from the engine; and means for controlling the engine fuel supply, including manually operable control means, atmospheric pressure responsive means operating in a direction to decrease the engine fuel supply as the altitude increases, a speed responsive centrifugal device, and means for driving the centrifugal device from the engine to regulate the engine fuel supply as a function of engine speed.

52. A fuel injection system for aircraft combustion engines, including a multi-plunger variable-delivery fuel injection pump; means for driving the pump from the engine; a pump control member to vary the fuel delivery of the pump; hydraulically operated piston means for actuating said pump control member; first and second valve means for controlling said piston means; a pressure responsive device sensitive to changes of surrounding atmospheric pressure for actuating the first valve means in a direction to decrease the fuel delivery of the pump with decrease of said atmospheric pressure; and a centrifugal device also drivable from the engine for actuating the second valve means to vary the fuel delivery of the pump in predetermined relation to engine speed.

53. A fuel injection system for aircraft engines, including a multicylinder plunger pump; means for driving the pump from the engine; pump control means for varying the fuel delivery of the pump; hydraulically operated piston means for operating said pump control means; first and second valve means for controlling the piston means; a pressure responsive device sensitive to changes of atmospheric pressure for actuating the first valve means in a direction to decrease the fuel delivery of the pump with increase of altitude; a centrifugal device also adapted to be driven from the engine for actuating the second valve means to vary the fuel delivery of the pump in dependence upon the engine speed; and additional means manually operable by the pilot for altering the flow of fuel delivered by the pump to the engine.

54. An aircraft engine fuel and control system including: a fuel pump; means for driving the pump from the engine; a manually operable control member for varying the flow of fuel supplied by the pump to the engine; a governor device including centrifugal flyballs, means for driving the flyballs from the engine, and a valve actuated by the flyballs for altering the flow of fuel supplied to the engine as a preselected function of engine speed; and a barometric device including a bellows responsive to changes of surrounding air pressure, and a valve actuated by the bellows for decreasing the engine fuel flow as the altitude increases.

55. A fuel and control system for aircraft engine, including: a fuel pump; a first shaft for driving the pump from the engine; a control member manually operable for varying the flow of fuel supplied by the pump to the engine; a first valve for altering the flow of fuel delivered by the pump to the engine; centrifugal flyballs for actuating said valve; a second shaft for driving the flyballs from the engine whereby the flyballs

operate the valve automatically to vary the flow of fuel delivered by the pump to the engine as a preselected function of engine speed; a second valve for altering the flow of fuel delivered by the pump to the engine; and a pressure responsive bellows subject to variations of surrounding air pressure for actuating said second valve in a direction to decrease the flow of fuel delivered by the pump to the engine as the altitude increases.

56. In combination with an aircraft engine having at least one combustion chamber and a fuel nozzle for spraying liquid fuel into said chamber: a fuel and control system including an engine driven fuel pump; conduit means for leading fuel discharged by the pump to nozzle; first control means for varying the engine fuel flow and a control lever manually operable to actuate said control means; a barometric fuel control including a pressure responsive device sensitive to changes of atmospheric pressure and a valve actuated by said device for decreasing the engine fuel flow as the altitude increases; and a governor device including engine driven centrifugal flyballs and a valve actuated by the flyballs for altering the engine fuel flow as a function of engine speed, said governor device being adapted to override said first control means under predetermined engine operating conditions.

57. For an engine having at least one combustion chamber, an air compressor whose discharge side is connected to the combustion chamber for delivering compressed air thereto, and at least one fuel nozzle for discharging fuel under pressure into the combustion chamber: a fuel and a control system including a multicylinder piston type fuel pump having variable fuel delivery; conduit means for leading fuel discharged by the pump to the nozzle; a first shaft for driving the fuel pump from the engine; a pump control member for varying the fuel delivery of the pump independently of the speed of the latter; hydraulically operated piston means for actuating the pump control member; a plurality of valve means for controlling said piston means; a mechanical governor; a second shaft for driving the governor from the engine; said mechanical governor actuating one of said valve means for altering the fuel delivery of the pump in preselected relation to engine speed; pressure responsive means; conduit means for subjecting the pressure responsive means to compressor discharge air pressure; said pressure responsive means actuating another of said valve means for altering the fuel delivery of the pump as a function of compressor discharge pressure; temperature responsive means subject to variations of engine exhaust temperature for actuating still another of said valve means for varying the fuel delivery of the pump as a function of engine exhaust temperature to protect the engine from excessive temperatures; and additional control means manually operable by the pilot for varying the fuel delivery of the pump.

58. Engine fuel supply and control system including a multicylinder piston type fuel pump having variable fuel delivery for supplying controllable fuel flow to the engine; a first shaft for driving the fuel pump from the engine; a pump control member for varying the fuel delivery of the pump independently of engine speed; hydraulically operated piston means for actuating the pump control member; first and second valve means for controlling said piston means; a mechanical governor; a second shaft for driving the governor from the engine; said governor actu-

ing the first valve means to alter the fuel delivery of the pump as a function of engine speed; temperature responsive means actuating the second valve means upon changes of an engine temperature dependent upon the engine fuel supply for altering the fuel delivery of the pump to protect the engine from excessive temperatures; and control means manually operable by the pilot for varying the fuel delivery of the pump.

59. For use with a combustion engine having at least one combustion chamber and an air compressor for supplying compressed air to the combustion chamber; a fuel supply and control system including a fuel pump; and manual and automatic means for controlling the engine fuel supply; said automatic means including pressure responsive bellows, walls defining passage means for subjecting said bellows to the pressure of the air before it enters the compressor and to the compressor discharge pressure; and a speed sensitive centrifugal device for controlling the engine fuel supply as a function of engine speed.

60. An engine fuel supply device including a fuel pump; first and second control means for varying the flow of fuel supplied by the pump to the engine; a closed housing; first and second bellows in the housing; the first bellows being evacuated and responsive to the pressure in the housing; the space within the second bellows being vented to pressure outside the housing which varies with the altitude; walls defining a passage whereby the pressure within the housing may be maintained substantially at engine intake manifold pressure; said two bellows being adapted to actuate said first control means in a direction to increase the flow of fuel supplied to the engine with increase of engine intake manifold pressure and with increase of altitude; and speed responsive means for actuating said second control means automatically in predetermined relation to engine speed.

61. An engine fuel control device including a fuel pump; means for driving the pump from the engine; control means whereby the flow of fuel supplied by the pump to the engine may be variably regulated independently of the pump speed; and means operatively connected with said control means for actuating the latter automatically to vary the flow of fuel supplied to the engine as a preselected function of engine manifold air pressure, manifold air temperature, atmospheric pressure and engine speed.

62. An engine fuel control device including a fuel pump; means for driving the pump from the engine; first, second and third valve means for varying the flow of fuel supplied by the pump to the engine; pressure responsive means for actuating the first valve means to vary the engine fuel flow with changes of engine intake manifold pressure and atmospheric pressure; temperature responsive means for actuating the second valve means to vary the engine fuel flow with variations of engine intake manifold temperature; and speed responsive means for actuating the third valve means to vary the engine fuel flow in preselected relation to engine speed.

63. For an engine having at least one combustion chamber, a first passage leading air thereto and a second passage leading combustion products therefrom, a fuel and control system having a fuel pump; means for driving the pump from the engine; and means for controlling the flow of fuel supplied by the pump to the combustion chamber, including: pressure responsive means to vary the fuel flow to said combustion cham-

ber automatically with changes of pressure in the first passage, speed responsive means to alter said fuel flow automatically as a function of engine speed, manually actuated means to control the effect of one at least of said responsive means, and temperature responsive means adapted to be subjected to the temperature in the second passage to vary said fuel flow in a direction to decrease the temperature in the second passage upon attainment of predetermined values of said temperature.

64. Fuel and control device for a combustion engine including a fuel pump; means for driving the pump from the engine; and operatively interconnected manual and automatic means for controlling the engine fuel supply; said automatic means including speed responsive governor means for regulating the engine fuel supply with changes of engine speed, and temperature responsive means subjected to the temperature of the combustion products to alter the engine fuel supply as a preselected function of the temperature of said combustion products, said speed and temperature responsive means being adapted to render the manual means ineffective at high engine speed and temperature, respectively.

65. Engine fuel and control device including a fuel pump; means for driving the pump from the engine; first and second valves for regulating the engine fuel flow; speed responsive governor means to actuate the first valve automatically in response to the engine speed; barometric pressure responsive means for actuating the second valve to decrease the engine fuel flow upon increase of altitude; and manually actuated means for varying the fuel flow independently of the altitude and engine speed.

66. In a combustion engine fuel and control device, a fuel pump; and manually adjusted and automatically operated means for controlling the fuel flow delivered from the pump to the engine, including: first and second valve means, a speed responsive centrifugal governor driven from the engine to actuate the first valve means automatically in dependence upon engine speed, and temperature responsive means subjected to combustion product temperature and connected to the second valve means to actuate the latter automatically so as to protect the engine from excessive operating temperatures.

67. Aircraft engine fuel and control system including: a fuel pump; manually actuated means for variably adjusting engine operation; automatic altitude compensating means including pressure responsive means for decreasing the fuel flow supplied by the pump to the engine upon increase of altitude to maintain engine operation substantially as called for by the setting of the manually actuated means regardless of altitude variations; a speed responsive governor and means for driving the governor from the engine to regulate the engine fuel flow automatically in predetermined relation to engine speed; and temperature responsive means adapted to be subjected to the temperature of engine combustion products for regulating said fuel flow automatically in predetermined relation to said temperature.

68. For an engine having at least one combustion chamber, a first passage leading air thereto and a second passage leading combustion products therefrom, a control system including: a fuel pump to supply a controllable flow of fuel to the combustion chamber; absolute pressure responsive means unaffected by temperature varia-

tions and connected with the first passage to decrease the fuel flow supplied by the pump to the combustion chamber upon decrease of pressure in the first passage; engine driven speed responsive means to vary said fuel flow in predetermined relation to engine speed; manual control means to vary the effect of one at least of said two responsive means; and temperature responsive means subjected to the temperature in the second passage and adapted to render the manual control means ineffective and cause temperature-decreasing variation of said fuel flow when the temperature in the second passage reaches high values.

69. For an engine having at least one combustion chamber and an exhaust passage, a fuel supply and control system including a fuel pump; at least one spray nozzle to inject pressure fuel into the combustion chamber; fuel conduit means to lead pressure fuel from the pump to the spray nozzle; and means to variably regulate the flow of fuel supplied by the pump to the spray valve, including spring loaded speed responsive centrifugal flyballs and means for driving the flyballs from the engine to alter said flow of fuel automatically in dependence upon engine speed, and temperature responsive means adapted to be subjected to the temperature in said exhaust passage to so vary the flow of fuel supplied to the spray nozzle as to prevent the attainment of excessive engine operating temperatures.

70. For an engine having at least one combustion chamber and a passage for the discharge of combustion products from said chamber, a fuel and control system including a fuel pump; nozzle means connected with the pump to inject fuel under pressure into said combustion chamber; and means for varying the flow of fuel injected in said combustion chamber, including temperature responsive means adapted to be connected

with said passage to vary said flow of fuel in dependence upon the temperature in said passage whereby the temperature therein may be automatically maintained within safe limits, and speed responsive means having centrifugal means adapted to be driven from the engine and operatively connected with said temperature responsive means to vary the effect of said temperature responsive means in preselected relation to engine speed.

71. Engine fuel and control system including a fuel pump; fuel flow regulating means for varying the flow of fuel supplied by the pump to the engine; engine driven speed responsive means; temperature responsive means subjected to an engine operating temperature which is dependent upon the flow of fuel supplied to the engine; and motor means operatively connected to said speed and temperature responsive means to be actuated thereby for operating the fuel flow regulating means.

FERDINANDO CARLO REGGIO.

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Certificate of Correction

Patent No. 2,435,902.

February 10, 1948.

FERDINANDO CARLO REGGIO

It is hereby certified that errors appear in the above numbered patent requiring correction as follows: In the heading to the printed specification, line 4, for the word "Application" read *Original application February 3, 1939, Serial No. 254,355. Divided and this application*; column 8, line 48, after the word "various" insert *other ways, in connection with*; column 11, lines 25 and 26, after "supply" insert a comma; column 18, line 15, before "nozzle" insert *the*; line 35, before "control" strike out "a"; column 19, line 13, after "chamber" strike out the semicolon and insert instead a colon; column 20, line 47, for "product" read *products*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 25th day of May, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.