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PILOT BURNER FUEL CONTROL

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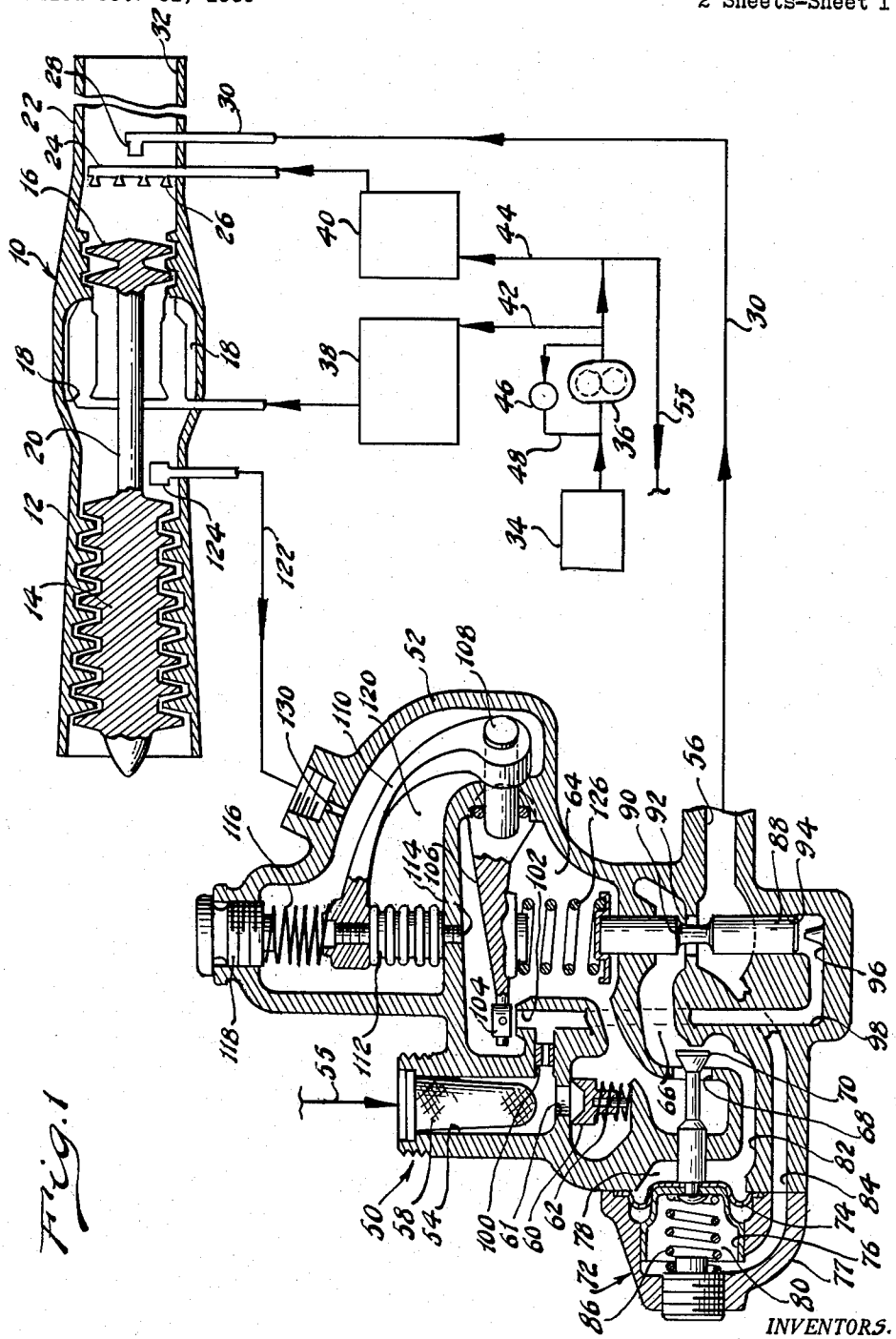


Fig. 1

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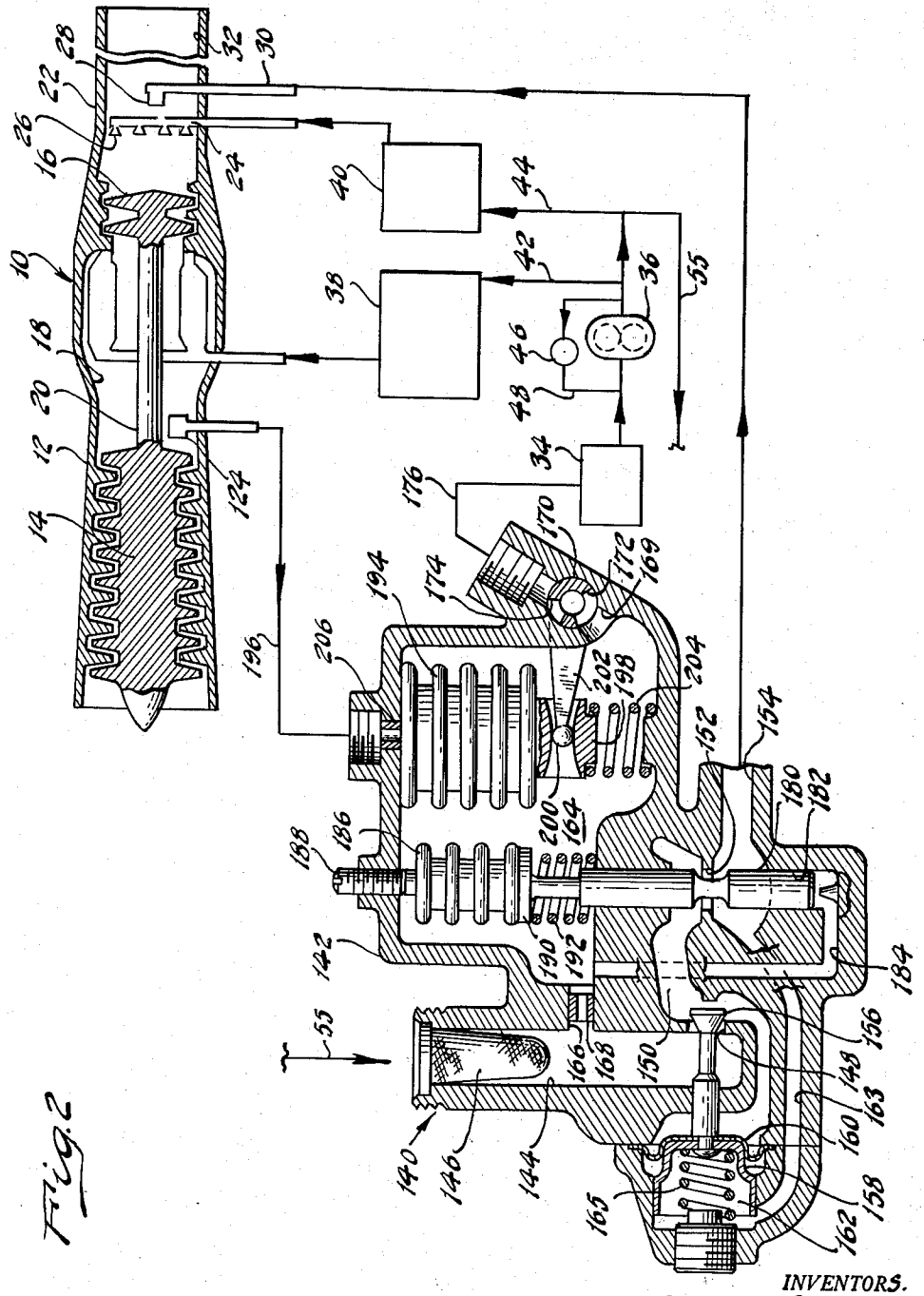


Fig. 2

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PILOT BURNER FUEL CONTROL

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This invention relates generally to fuel controls for turbine engines and more specifically to fuel controls for engines having afterburners associated therewith and still more specifically to those engines wherein the afterburners contain an afterburner fuel burner and a pilot burner to initiate combustion of the afterburner fuel burner.

As turbine engines are called upon to deliver greater or lesser amounts of power, the combustion air delivered to the engine is correspondingly increased or decreased in density because of variation in speeds of the compressor. Accordingly, as the density of the air varies, compensation must be made in the rate of fuel flow to the pilot burner in order to maintain a particular constant fuel-air ratio at the pilot burner in order to insure ignition of the afterburner fuel and also to prevent flame-out of the pilot burner. In accordance with the present invention, fuel is supplied to the pilot burner through a fuel metering device in such a way as to vary the fuel flow in accordance with the compressor discharge pressure.

It is an object of the present invention to provide a turbine engine having a compressor, an afterburner section including an afterburner fuel burner and a pilot burner, and means to control the flow of fuel to the pilot burner in accordance with air density as delivered by said compressor.

It is a further object of the present invention to provide in a turbine engine an afterburner including a pilot burner and means for controlling the flow of fuel to the pilot burner in accordance with the density of air delivered to said afterburner.

More specifically, it is an object of the present invention to provide a fuel control system including an inlet chamber for receiving fuel under substantially constant pressure, a metering valve for controlling the flow of fuel from said inlet chamber to a point of use, a pressure chamber having a restricted connection to said inlet chamber and including a bleed valve in such connection, means for actuating said bleed valve to control the pressure of fuel in said pressure chamber, and pressure responsive means connected to said metering valve and responsive to the pressure of fuel in said pressure chamber.

It is a further object of the present invention to provide a fuel control system including a chamber for receiving fuel under substantially constant pressure, a variable pressure chamber connected to said inlet chamber by a restricted passage, a bleed valve for controlling the pressure of fuel in said pressure chamber, a metering valve connected to control the flow of fuel from said inlet chamber to a point of use, and pressure responsive means connected to said metering valve and subjected to pressure within said variable pressure chamber.

Other objects and features of the invention will become apparent as the description proceeds, especially when taken in conjunction with the accompanying drawings illustrating a preferred embodiment of the invention, wherein:

FIGURE 1 is a schematic view of the invention as employed in conjunction with a typical solid turbine engine, with parts in section.

FIGURE 2 is a view similar to FIGURE 1 showing a second embodiment of the invention.

Referring more particularly to the drawings, FIGURE 1 illustrates a turbine engine 10 having an outer body 12

which contains an air compressor 14 and power turbines 16 between which is located a main burner section 18. A shaft 20 connects the turbine 16 to the compressor 14 for the purpose of supplying power to the compressor. An afterburner stage 22 contains an afterburner fuel ring 24 with nozzles 26 associated therewith and a pilot burner 28 with its individual fuel supply conduit 30 leading thereto. The discharge orifice 32 may of course be a variable orifice as is well known in the art.

A fuel reservoir 34 is illustrated as supplying fuel to a pump 36 which may be driven from the turbine 16 in any suitable manner so as to deliver fuel to the primary fuel control 38 and the afterburner fuel control 40 as by means of suitable conduits 42 and 44. In addition, as will subsequently appear, the pump 36 supplies fuel to the afterburner pilot burner through a control system which will be described in detail.

The pump 36 has a constant pressure bypass valve 46 connected around the pump by conduit 48. The arrangement is such as to maintain a substantially constant fuel pressure at the discharge side of the pump 36.

The pilot burner fuel control device designated generally at 50 is comprised of a housing 52 formed to provide an inlet chamber 54 connected by an external conduit 55 to the discharge side of the fuel pump 36. The housing 52 is also shaped to provide a metered fuel discharge passage 56 which is connected by the conduit 30 to the afterburner pilot burner 28. Chamber 54 is preferably provided with a filter 58 to eliminate the possibility of foreign matter being carried into the control device 50.

A spring biased valve 60 is positioned so as to tend to close a port 61 which is in communication with the inlet chamber 54. A spring 62 biases the valve 60 in the closing direction and is calibrated to insure a particular pressure drop between the inlet chamber 54 and a pressure chamber 64. Chamber 64 is in communication with a chamber 66 through a port 68 which is controlled by a valve member 70. The valve member 70 is positioned in accordance with the pressure drop between chamber 66 and the discharge passage 56.

The constant pressure differential valve assembly indicated generally at 72 for controlling the position of the pressure regulating valve 70 comprises a flexible diaphragm 74 and a rigid cup-like member 76 slidable in a closure member 77. The valve member 70 is connected to the member 76. The diaphragm 74 serves to create two distinct pressure chambers 78 and 80 which communicate with the chamber 66 and passage 56 by means of passages 82 and 84 respectively. A spring 86 is contained within the chamber 80 so as to bias the valve element 70 in an opening direction.

The fuel metering valve includes a valve element 88 having a metering edge 90 which is adapted to cooperate with a metering edge 92 formed in the body 52 so as to control the rate of fuel flow from the chamber 66 to the discharge passage 56. As the metering valve 88 moves downwardly, fuel flow through the orifice defined generally between the metering edges 90 and 92 is reduced. It will be apparent that the valve 70 is operated to maintain a substantially constant pressure drop across the metering valve so that the rate of flow of fuel to the pilot burner 28 is a direct function of the amount of opening of the metering valve.

The regulation of the flow of fuel from the chamber 66 to the passage 56 is by vertical movement of the metering valve element 88. The lower portion of this valve is in the form of a piston movable in a cylinder 94, the lower end of the piston being exposed to fuel pressure within a pressure chamber 96. The chamber 96 is connected by a passage 98 to the inlet chamber 54. The passage is provided with a restriction 100. The passage 98 is connected by a short passage 102 to the chamber

64. The outlet to the short passage 102 is controlled by a bleed valve 104 carried by a lever arm 106 keyed or otherwise secured to a pivot shaft 108, to the other end of which is connected an arm 110. At its free end, the arm 110 carries a bellows 112, one end of which is connected as shown at 114 to a wall of the chamber 64. An adjustable spring 116 is interposed between the free end of the lever 110 and an adjustable spring seat 118.

The arm 110 is movable in a chamber 120 formed within the body 52 and is connected by a conduit 122 to a pressure probe 124 which measures the air density as delivered by the air compressor 14. Accordingly, the air pressure within the chamber 120 is variable in accordance with the density of air supplied to the several burners of the engine including the afterburner pilot burner.

It will be noted that within the pressure chamber 64 there is provided a spring 126 which extends between a spring seat carried by the upper end of the valve element 88 and a spring seat provided at the underside of lever arm 106. Accordingly, the movable metering valve element is controlled by the pressure of fuel within the chamber 64 which is substantially constant, the variable pressure of fuel within the chamber 96 and the force of the spring 126. It will be observed that upon counterclockwise rocking movement of the lever 106, the valve element 104 is moved toward its seat and accordingly pressure within the pressure chamber 96 increases toward a limiting value determined by the pressure of fuel within the inlet chamber 54. Downward movement of the arm 106 also provides a slight increase in the force exerted on the valve element by the spring 126. These forces, it will be observed, are in opposition and increase or decrease at the same time.

Operation

While the operation of the system is probably apparent from the foregoing description, it is believed desirable to describe the operation completely at this point.

Assume that the engine is operating under a steady state condition. At this time, the fuel delivered by the pump 36 and conduit 55 entering the inlet chamber 54 is at some relatively high pressure P_1. The fuel then flows through the port 61 as permitted by the valve 60 until the pressure of fuel designated P_2 within the chamber 64 is sufficient in conjunction with the spring 62 to maintain the valve 60 in closed position. In other words, the valve 60 will maintain the pressure P_2 at a constant value less than the pressure P_1 existing in the inlet chamber 54. It will of course be recalled that fuel is delivered to the inlet chamber 54 at a substantially constant pressure. The flow of fuel from the pressure chamber 64 to the metering valve is through the pressure regulating valve 68, 70 whose position is determined by the pressure of fuel at opposite sides of the metering valve. Accordingly, the fuel is permitted to flow to the chamber 66 at a rate sufficient to maintain a substantially constant pressure drop across the metering valve 88. The result is that the quantity of fuel delivered to the pilot burner is a direct function of the cross sectional area of the valve opening of the metering valve. The pressure of fuel within the chamber 96 which is primarily determinative of the position of the metering valve element 88 is determined by the position of the bleed valve 104 which in turn is determined completely by the density of air delievred by the air compressor.

Suppose that the turbine engine now is called upon to operate with greater power. It can be seen that this increases the compressor discharge pressure P_{t3} as communicated to the chamber 120 by means of the conduit 122 and probe 124. This causes the bellows 112 to be somewhat compressed permitting counterclockwise rotation of the arm 110 and hence, of the arm 106. This results in movement of the valve element 104 toward its seat, thus restricting the flow of fuel from the passage 102 into the chamber 64, thereby causing the pressure P_5 within the chamber 96 to increase toward a value approaching the inlet pressure P_1 as an ultimate limit. As the pressure P_5 increases, the valve 88 is urged upwardly against the combined resisting forces of the spring 126 and the pressure P_2 existing within the chamber 64, thus opening the metering valve orifice as determined by the metering edges 90 and 92. Consequently, it can be seen that as the compressor discharge pressure increases, the valve 88 will be moved in the opening direction allowing greater fuel flow therethrough to the pilot burner 28. The amount which the valve 88 moves in either direction is of course determined by the pressures P_2 and P_5 and the force of the spring 126.

It may be mentioned at this time that a restriction 130 is preferably provided between the passage 122 and the chamber 120. This has the effect of dampening out any minor fluctuations occurring in the compressor discharge pressure.

Embodiment of FIGURE 2

Referring now to FIGURE 2, there is shown a second embodiment of the present invention. In this figure, the turbine and the means for supplying fuel to the primary burner and the afterburner nozzles is the same as in the embodiment illustrated in FIGURE 1 and like reference numerals have been applied thereto. However, the fuel control device for controlling flow of fuel to the afterburner pilot burner is different and will be described in detail.

In this embodiment of the invention, the pilot burner fuel control device indicated generally at 140 comprises a casing 142 having a fuel inlet chamber 144 for connection to the conduit 55 which delivers fuel at substantially constant pressure from the fuel pump 36. The inlet chamber 144 preferably includes the filter 146 as illustrated.

Fuel from the inlet chamber 144 flows through a port 148 to a chamber 150 which is in communication with the metering valve port 152 through which the fuel flows to the outlet passage 154.

The flow of fuel through the port 148 is controlled by a pressure regulating valve 156 connected to a slidable cup 158 sealed by means of a diaphragm 160 to define a pressure chamber 162 communicating by a passage 163 with the outlet passage 154. A spring 165 is provided in the chamber 162 urging the cup 158 in a direction tending to open the valve element 156.

The cup 158 and diaphragm 160 are subjected at opposite sides to a pressure within the chamber 162 equal to the pressure at the downstream side of the metering valve and at the opposite side to a pressure existing at the upstream side of the metering valve. Accordingly, the pressure regulating valve 156 is controlled to maintain a substantially constant pressure drop across the metering valve.

Located within the casing 142 is a variable pressure chamber 164 communicating by a passage 166 having a restriction 168 therein with the inlet chamber 144. The variable pressure chamber 164 has an outlet passage 169 controlled by a rotatable valve element 170 having ports 172 and 174 therein. Passage 169 is connected by a low pressure return conduit 176 to the fuel tank 34. Accordingly, the pressure of fuel existing within the chamber 164 is determined by the amount of opening of the exhaust or bleed valve 170.

As in the embodiment of the invention previously described, the fuel metering valve 180 includes a lower piston portion slidable in a cylinder 182, the cylinder being connected by a passage 184 to the variable pressure chamber 164. The upper end of the metering valve 180 is connected to a collapsible bellows 186 adjustably mounted as by a threaded stud 188 at the inner wall of the chamber 164. The valve 180 includes a head 190 serving as a seat for a compression spring 192, the lower end of which is supported on an inner surface of the chamber 164. The spring 192 thus urges the metering valve 180 upwardly in valve opening direction. Any increase in pressure of fuel within the chamber 164 will cause a collapse of the

expansible bellows **186**, thus tending to permit further upward or opening movement of the metering valve. In addition, an increase in pressure of fuel within the chamber **164** is communicated directly to the lower end of the valve **180** so that the valve element is moved upwardly.

In order to render the fuel metering valve responsive to variations in density of air delivered by the compressor of the engine, there is provided another expansible sealed bellows **194** located within the variable pressure chamber **164**. This bellows is connected by an external conduit **196** to the pressure probe **124**. At its lower end, the expansible bellows is provided with a coupling **198** engaging the ball end **200** of an arm **202** connected to the valve **170**. A compression spring **204** interconnects the lower end of the bellows **194** to the opposite inner surface of the chamber **164** tending to urge upward movement of the bellows and hence, clockwise rotation of the arm **202**. Preferably, the communication between the interior of the bellows **194** is limited by a restriction **206**.

Operation of FIGURE 2

The overall operation of the fuel regulating device or system illustrated in FIGURE 2 is essentially similar to that of the embodiment of the invention illustrated in FIGURE 1. Fuel is delivered to the inlet chamber **144** under substantially constant pressure. This fuel flows to the chamber **150** through a pressure regulating valve **148**, **156** which is controlled in accordance with pressures at opposite sides of the fuel metering valve in such a way as to maintain a substantially constant pressure drop across the valve. The metering valve includes a piston-like actuator movable in the cylinder **182** where it is subjected to a variable pressure as existing in the variable pressure chamber **164**. The pressure in the chamber **164** in turn is controlled by the pressure drop across the restriction **168** and this in turn is controlled by the exhaust or bleed flow out of the pressure chamber as controlled by the valve **170**. The pressure or density of air delivered by the compressor determines the instantaneous position of the valve **170** and hence, determines the pressure of fuel within the chamber **130**. In this case, it will be observed that as the air density increases the increase in pressure existing within the bellows **194** will cause the arm **202** to move counterclockwise, thus partially closing the valve **170** and causing an increase in pressure in the chamber **164**. This increase in the pressure of fuel within the chamber **164** operates to compress the bellows **186**, thus permitting upward movement of the valve **180**. In addition, the increase in pressure within the chamber **164** is communicated through the passage **184** to the chamber in communication with the cylinder **182**, thus providing an increase in the force tending to move the valve element **180** upwardly or toward open position.

Accordingly, an increase in air density results in an increase of fuel delivered to the pilot burner **28**.

The drawings and the foregoing specification constitute a description of the improved fuel control system in such full, clear, concise and exact terms as to enable any person skilled in the art to practice the invention, the scope of which is indicated by the appended claims.

What we claim as our invention is:

1. A fuel control unit comprising a housing having parallel fuel flow passages therein, a metering valve in one of said passages, a pressure regulating valve in said one passage including means responsive to pressure drop across said metering valve, condition responsive valve means in said other flow passage, a restriction in said other flow passage upstream from said condition responsive valve means, pressure responsive actuating means connected to said metering valve, and a pressure connection between said actuating means and said other passage at a point intermediate said restriction and said pressure regulating valve.

2. In an internal combustion engine, an afterburner, an air compressor connected to deliver air to said afterburner, said afterburner including nozzles and a pilot burner for igniting fuel delivered to said afterburner nozzles, a source of fuel under elevated substantially constant pressure, a connection between said source and said pilot burner including a fuel control unit comprising a housing having an inlet chamber for receiving the fuel at elevated substantially constant pressure, a first pressure chamber, a check valve for metering fuel into said first pressure chamber from said inlet chamber at a substantially constant pressure below said elevated pressure, a passage extending between said inlet chamber and said first pressure chamber, a restriction in said passage, a bleed valve positioned over the passage and between the first pressure chamber and the restriction and means responsive to compressor air density for varying the opening of the bleed valve in accordance with compressor air density, a second and third pressure chamber having a fuel metering orifice therebetween, a metering valve responsive to the pressure in the passage between the restriction and the bleed valve movably mounted within the housing for controlling the area of the metering orifice, a valve opening providing communication between said first pressure chamber and said second pressure chamber, a constant pressure valve positioned in said opening responsive to the pressure in the second and third pressure chambers for maintaining the pressure in said second pressure chamber substantially constant and means connecting said third pressure chamber to said pilot burner.

3. An internal combustion engine, and an afterburner, an air compressor connected to deliver air to said afterburner, said afterburner including nozzles and a pilot burner for igniting fuel delivered to said afterburner nozzles, a source of fuel under elevated substantially constant pressure, a connection between said source and said pilot burner including a fuel control unit comprising a housing, having an inlet chamber for receiving the fuel at an elevated substantially constant pressure, a first pressure chamber, a passage between said inlet chamber and first pressure chamber, a restricting orifice within said passage, an exhaust valve within said first pressure chamber and means within said first pressure chamber for controlling the opening of the exhaust valve in accordance with compressor air density, second and third pressure chambers within said housing having a fuel metering orifice therebetween, a fuel metering valve responsive to the pressure in said first pressure chamber movably mounted within said housing for controlling the area of the metering orifice, means connecting said third chamber to said pilot burner, a valve opening providing communication between said inlet chamber and second pressure chamber and a constant pressure valve positioned within said opening responsive to the pressure in both said second and said third pressure chambers for maintaining a substantially constant pressure in said first pressure chamber.

4. A fuel control unit comprising a housing, having an inlet chamber for receiving fuel at a substantially constant pressure, a first pressure chamber, a valve for metering fuel to said first pressure chamber from said inlet chamber at a substantially constant pressure, a passage extending between said inlet chamber and said first pressure chamber, a restriction in said passage, a bleed valve positioned over the passage and between the first pressure chamber and the restriction and condition responsive means for varying the opening of the bleed valve in accordance with a predetermined condition, a second and third pressure chamber having a fuel metering orifice therebetween, a metering valve responsive to a condition in the passage between the restriction and the bleed valve movably mounted within the housing for controlling the area of the metering orifice, an opening in said housing providing communication between said first pressure chamber and said second pressure chamber, a constant pressure valve positioned in said opening responsive to the pressure in the second and third pressure chamber for maintaining the pressure in said second pressure chamber

substantially constant and fuel outlet means connected to said third pressure chamber.

5. A fuel control unit comprising a housing, having an inlet chamber for receiving fuel at a substantially constant pressure, a first pressure chamber, a passage between said inlet chamber and first pressure chamber, a restriction within said passage, an exhaust valve within said first pressure chamber and condition responsive means within said first pressure chamber for controlling the opening of the exhaust valve in accordance with a sensed condition, second and third pressure chambers within said housing having a fuel metering orifice therebetween, a fuel metering valve responsive to a condition in the first pressure chamber movably mounted within said housing for controlling the area of the metering orifice, fuel outlet means connected to said third chamber, a valve opening providing communication between said inlet chamber and second pressure chamber and a constant pressure valve positioned within said opening responsive to a condition in both said second and said third pressure chambers for maintaining a substantially constant pressure in said first pressure chamber.

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