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FUEL-AIR CONTROL MECHANISM FOR METERING FLOW OF FUEL TO AFTERBURNERS IN JET OR TURBINE ENGINES

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FIG. 1.

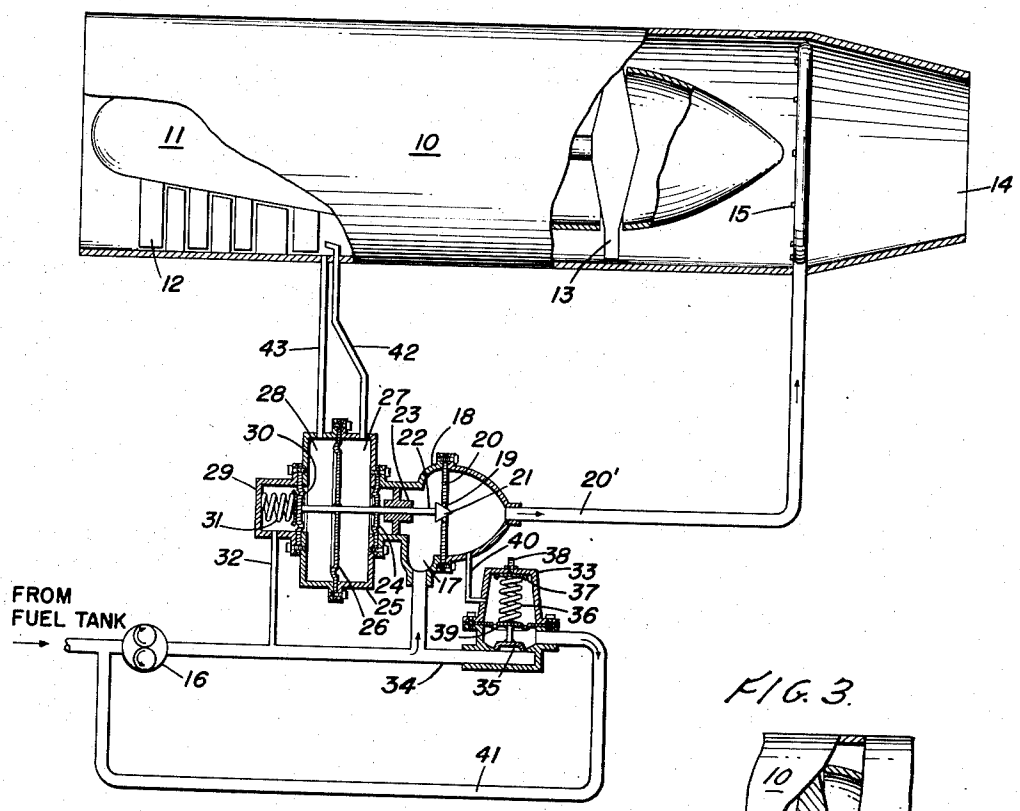
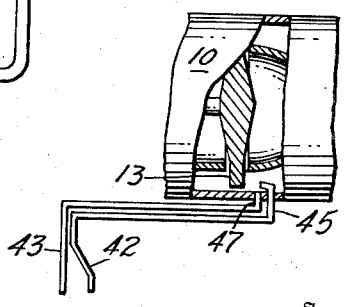


FIG. 3.



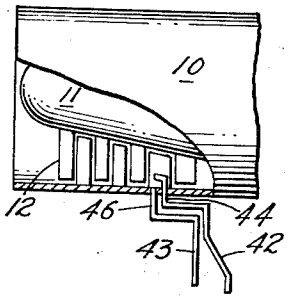


FIG. 2.

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FUEL-AIR CONTROL MECHANISM FOR METERING FLOW OF FUEL TO AFTERBURNERS IN JET OR TURBINE ENGINES

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4 Claims. (Cl. 60—35.6)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The present invention relates to fuel metering devices generally and to a fuel metering means for a turbine or jet engine afterburner specifically.

Control mechanisms for metering the flow of fuel to afterburners in jet or turbine engines now in use are of two types, those having manual control and those with thermostatic control. In the former, as is obvious, the rate of fuel flow to an afterburner is regulated by the pilot or engineer to provide for the amount of augmented thrust desired and attainable with the afterburner. In the latter type of control, the temperature of the gases in the turbine outlet is generally used to vary the rate of flow of fuel to the afterburner in order that the temperature at the turbine outlet be kept constant. In such a type of control variations in pressure due to altitude are usually compensated for by measuring the temperature of the compressor discharge and controlling air flow through an air-driven fuel pump to regulate the fuel flow to the afterburner.

The disadvantages of these present control systems are numerous. The response to a temperature change in the turbine outlet is slow; electrical systems necessary to sense the temperature are complicated and expensive; and the performance of an altitude compensator is frequently poor when subject to the changes in ambient temperature as well as changes in pressure.

It is an object, therefore, of this invention to provide a fuel flow metering device for an afterburner which is simple in construction and reliable in operation.

Another object of the invention is to provide a fuel metering device for an afterburner which is not subject nor responsive to the high temperatures of the exhaust gases.

A further object is to provide a fuel flow control which may be adjusted without affecting the efficiency of the engine cycle.

A still further object is to provide a fuel flow control which is fast and responsive to the rapid changes in altitude or ambient air pressures encountered by rapidly ascending aircraft, guided missiles or jet propelled supersonic weapons.

The exact nature of this invention as well as other objects and advantages thereof will be readily apparent from consideration of the following specification relating to the annexed drawing in which:

Fig. 1 is a schematic diagram of the components of the invention;

Fig. 2 is a detail view showing the pressure sensory pipes placed at the intermediate compressor stage of the engine; and,

Fig. 3 is a detail view showing the pressure sensory pipes placed in the turbine stage of the engine.

Referring to the drawing, which is more or less schematic in form, the jet engine body **10** is shown as having a rotor **11** with compressor blades **12** and turbine blades **13**. In the jet nozzle **14** is shown the afterburner nozzle ring with nozzles **15**. Fuel is supplied from a fuel tank

(not shown) to the fuel pump **16** and under pressure to the chamber **17** in the housing **18** which has metering orifice **19** in wall **20** opening into pipe **20'** leading to the afterburner nozzles **15**. Metering orifice **19** has a needle valve **21** on stem **22** slidably supported in the housing **18** by sleeve **23**. A diaphragm **24** separates chamber **17** from a second chamber **27** in the adjacent housing **25**; and a second diaphragm **26** divides the latter housing into two chambers **27** and **28**. An auxiliary chamber **29** has another diaphragm **30** to which the stem **22** of valve **21** is fixed. The valve **21** is biased into seating position by spring **31**. Chamber **29** is connected by the pipe **32** to the fuel pump pressure line to provide the same pressure as in chamber **17**. Diaphragms **24** and **26** are sealed to stem **22** and move it, in a conventional manner, to open or close metering orifice **19**. A fuel pump output pressure regulating device **33** is connected to pressure line **34** and has a valve **35** held normally closed by spring **36**, the tension of which is made adjustable by the movable spring seat **37** and adjustable screw **38**.

Still another diaphragm **39** compartments the spring **36** with the relief passage **40** allowing movement of diaphragm **39**. Fuel flow through valve **35** is led back to the fuel pump **16** through by-pass **41**.

Chambers **27** and **28** are connected by pipes **42** and **43**, respectively, to the vicinity of the compressor discharge region, pipe **42**, as shown in Fig. 1, having an inlet opening directed upstream in the immediate discharge region of the last compressor stage and pipe **43** having an inlet opening in the same region directed transversely to the airstream. Thus, it is seen that chamber **27** is fed with the total impact air pressure of the region and chamber **28** with the static air pressure, the difference between the impact air pressure and the static air pressure being the differential pressure $(\Delta P)_m$ in the equation

$$Wa = K\frac{(\Delta P)m}{N}$$

where Wa=the mass flow of air through the turbo-jet engine, K= a constant dependent upon the dimensions of the particular turbo-jet engine, and N= the rotational speed of the turbo-jet engine compressor or impeller. This basic relation as set forth in the above equation has been previously disclosed by D. G. Russ in U. S. Patent #2,441,977 issued May 25, 1948. For a particular engine, assuming N to be at constant R. P. M., or optimum speed, then the mass flow of air through the engine is proportional to the pressure differential, and with the present invention in use, the rate of flow of fuel to the afterburner is therefore proportional to or a function of the mass air flow.

In operation, the impact air pressure in pipe **42** tends to move the diaphragm **26** toward the left lifting the needle valve **21** from its seat and permitting fuel flow to the afterburner nozzle **15**. Pressure drop in the fuel through orifice **19** is maintained substantially constant for any degree of opening due to the control exerted by the fuel pump's output regulating device **33**. The force tending to move the needle valve **21** to the left is the product of the difference between the pressures on opposite sides of the diaphragm **26** and the effective area of the diaphragm **26**. The spring **31** exerts a force upon the valve stem **22** to the right which is the product of the spring constant and the displacement to the left of the valve stem, therefore needle valve **21** is contoured so that the area of opening through the orifice **19** is proportional to or a predetermined function of the movement to the left of the needle valve **21**. As will be readily seen, the areas of the diaphragms **24** and **30** are substantially equal and as each of chambers **17** and **29** are under the same fuel pressure in the fuel pressure line **34**, the movement of the valve stem **22** in either direction is not impeded

by the forces on the diaphragms 24 and 30, and is still the result of the difference between the pressure in chambers 27 and 28. The adjustment of the fuel pressure at the jet nozzles 15 is made by varying the resistance of spring 36 by adjustment of screw 38 thus varying the fuel-air ratio to obtain optimum performance of the afterburner.

It should be understood, of course, that the foregoing disclosure relates to only a preferred embodiment of the invention and that numerous modifications or alterations may be made therein without departing from the spirit and the scope of the invention as set forth in the appended claims. For example, although the end portions of pipes 43 and 42 are located in the immediate discharge region of the last stage of the axial compressor in the figure they may be located at the immediate discharge of any stage of the compressor or at the discharge of the turbine, as shown in Figs. 2 and 3, respectively. In these figures pipes 44 and 45 correspond to the total pressure pipe 42 of Fig. 1 and pipes 46 and 47 to the static pressure pipes of Fig. 1. Also, the compressor may be of the centrifugal or of the mixed flow type, or may be any other type of rotor which handles all of the flow of any single fluid through the engine as for example an air turbine in a ram jet engine which drives engine accessories.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. In combination with a jet engine having an air compressor in an inlet leading to a combustor and an exhaust nozzle with an afterburner therein, a fuel-air ratio control for the afterburner comprising a body defining four aligned chambers, a flexible diaphragm in said body separating each of said chambers from the chamber adjacent, a first conduit connecting the end two chambers of said four aligned chambers to a source of fuel under pressure, a metering port in said body connecting one of said two end chambers with a second conduit leading to said afterburner, a third and a fourth conduit connected one to each of the inner two of said four aligned chambers and opening into the air inlet of the jet engine immediately aft of said compressor to receive static pressure and total fluid pressure respectively, a valve coacting with said metering port and having its stem secured to each of said diaphragms and operable to open by movement of said diaphragms upon an increase of total fluid pressure over static fluid pressure, fuel pressure regulating means in said first conduit, and spring biased valve closing means in the other of said two end chambers.

2. In combination with a jet engine having a zone of air under pressure immediately aft of the engine compressor, an exhaust nozzle, an afterburner positioned to discharge into said exhaust nozzle, a fuel regulator for the afterburner comprising a body defining two chambers, a diaphragm separating said chambers, a first conduit connecting one of said chambers to said jet engine and opening into said zone of air under pressure to sense static fluid pressure, a second conduit connecting the other of said chambers to said jet engine and opening in said zone to sense total fluid pressure, a fuel conduit connecting said afterburner with a source of fuel under pressure, a metering valve in said fuel conduit, a stem connecting

said diaphragm with said valve operable to open said valve in accordance with the air mass flow through said zone upon an increase of total fluid pressure over static fluid pressure as sensed in said first and second conduits, spring means external to said chambers and operatively related to said stem for holding said valve normally in closed position, fuel pressure regulating means connected to said fuel conduit, and means for adjusting the fuel-air ratio in said afterburner, the outer wall of said chambers adjoining the fuel conduit being flexible and said stem passing through and being sealed to said wall.

3. In combination with a jet engine having a compressor and burner, a fuel metering device for said jet engine comprising a housing, a first flexible diaphragm dividing said housing into two chambers, a total fluid pressure sensing means in the immediate discharge region of the engine compressor, a static fluid pressure sensing means located adjacent said total pressure sensing means, means connecting each sensing means to a separate one of said chambers, a conduit for conveying fuel under pressure to the jet engine burner, a valve in said conduit, a second flexible diaphragm separating said fuel conduit and the chamber receiving total fluid pressure from said compressor, a stem passing through said second diaphragm and sealed thereto with one end connected to the chamber diaphragm and the other end connected to the fuel conduit valve, and means for balancing the fuel pressure on said second diaphragm.

4. In combination with a jet engine having an air compressor and burner, a fuel metering device for said jet engine comprising a housing, a flexible diaphragm dividing said housing into two chambers, a total fluid pressure sensing means in the discharge region of the engine compressor, a static fluid pressure sensing means located transversely to the air stream in the discharge region of the engine compressor, means connecting each sensing means one to each of said chambers, a conduit for conveying fuel under pressure to the jet engine burner, a valve in said conduit, a stem connecting said valve to said diaphragm operable to open said valve by movement of said diaphragm in accordance with the pressure difference between said chambers, spring means exterior to said chambers and operatively related to said stem for holding said valve normally in closed position, and a second flexible diaphragm separating said fuel conduit and the adjoining one of said two chambers, said stem being sealed to said diaphragm.

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