Sept. 14, 1954 H. H. OSTROFF 2,688,845

TWO-STAGE FUEL REGULATOR FOR PULSE JET ENGINES

Filed July 13, 1948

3 Sheets-Sheet 1

FIG. 2.

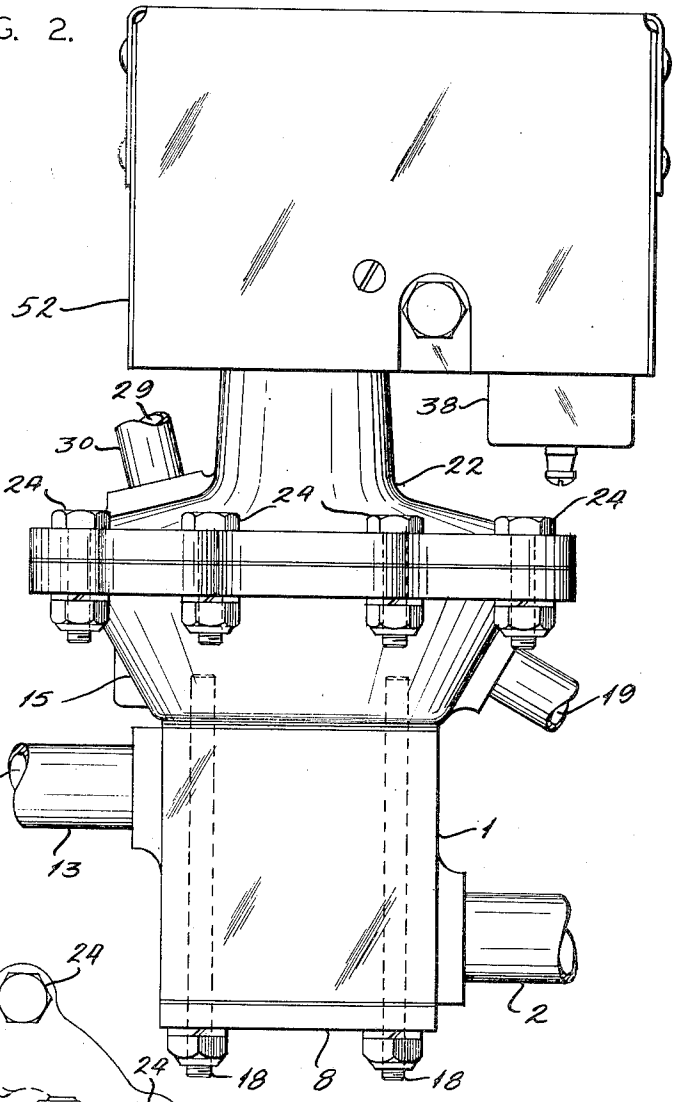
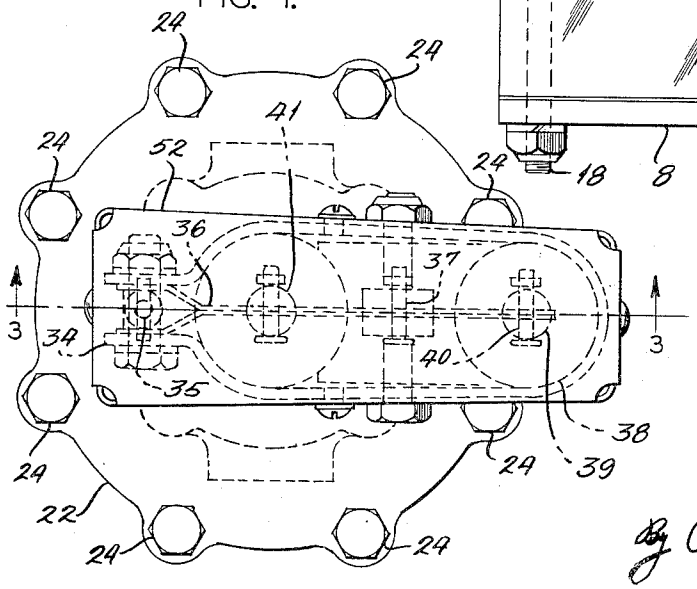


FIG. 1.



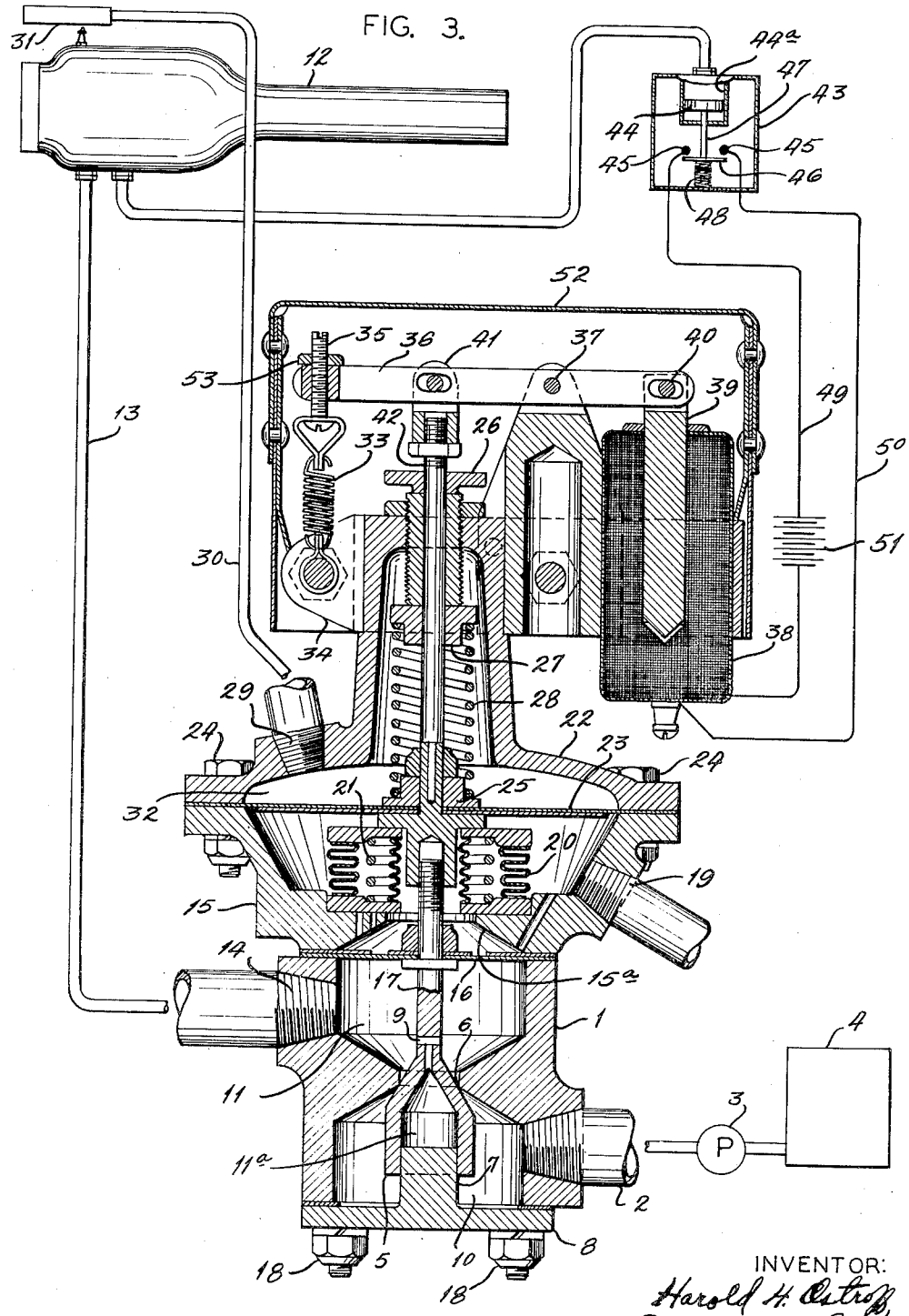
INVENTOR:
Harold H. Ostroff.
By Carr & Carr & Gravely
HIS ATTORNEYS.

Sept. 14, 1954 H. H. OSTROFF 2,688,845

TWO-STAGE FUEL REGULATOR FOR PULSE JET ENGINES

Filed July 13, 1948 3 Sheets-Sheet 2

FIG. 3.



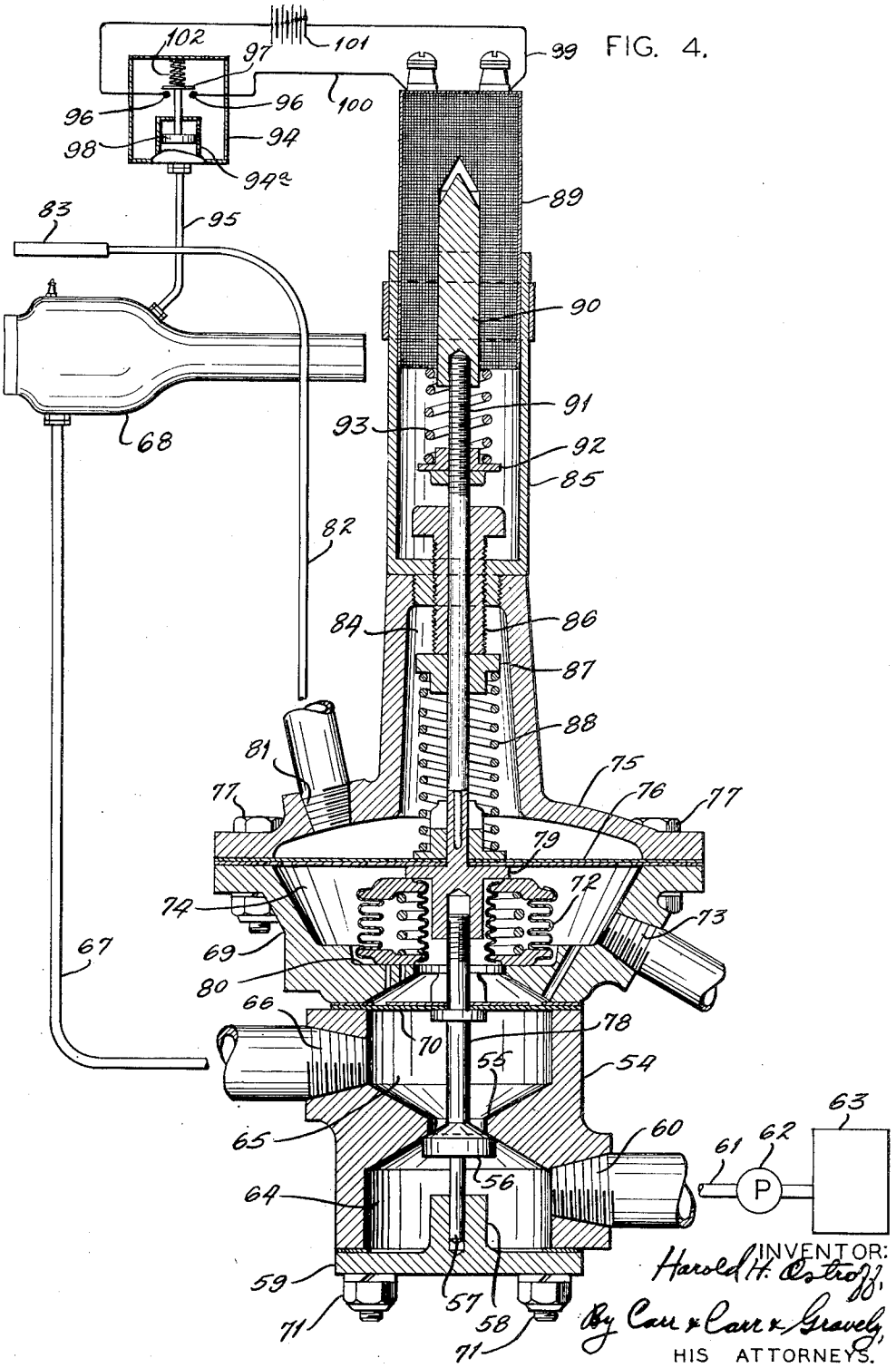
INVENTOR:
Harold H. Ostroff,
By Cane & Cane or Gravely,
HIS ATTORNEYS.

Sept. 14, 1954 H. H. OSTROFF 2,688,845

TWO-STAGE FUEL REGULATOR FOR PULSE JET ENGINES

Filed July 13, 1948 3 Sheets-Sheet 3

FIG. 4.



INVENTOR:
Harold H. Ostroff,
By Carr & Carr & Gravely,
HIS ATTORNEYS.

Patented Sept. 14, 1954

2,688,845

UNITED STATES PATENT OFFICE

2,688,845

TWO-STAGE FUEL REGULATOR FOR PULSE JET ENGINES

Harold H. Ostroff, Ferguson, Mo., assignor to McDonnell Aircraft Corporation, St. Louis, Mo., a corporation of Maryland

Application July 13, 1948, Serial No. 38,527

12 Claims. (Cl. 60—39.28)

1

This invention relates to fuel regulating systems for pulse jet engines of the type shown in application Serial No. 2,466, filed January 15, 1948, for Fuel Regulator Responsive to Speed and Atmospheric Pressure, and is more particularly directed to an improvement in the system disclosed in said application by providing for two different rates of fuel flow to the pulse jet engine under specified operating conditions.

It has been found that during certain periods of pulse jet engine operation, as, for example, in starting, it is desirable that for a predetermined length of time a fuel flow somewhat lesser in rate be supplied to the engine than when it is operating under normal conditions. It is also desirable that during other periods of operation a greater rate of fuel flow be supplied to the pulse jet engine for a predetermined length of time than when it is operating under normal conditions. The two-stage fuel flow system about to be described is intended to comprehend the latter condition of operation as well as the former. Under either condition, after the specified time or period of operation has elapsed, the normal flow of fuel to the pulse jet engine is resumed.

One of the objects of this invention is to provide a fuel regulating system for a pulse jet or other type of jet engine in which two distinctly different rates of fuel flow may be supplied thereto, and that these rates of fuel flow be proportioned to both air speed and altitude pressures.

Another object of the invention is to provide a fuel regulating system for a pulse jet engine in which the fuel supplied therefor is responsive to pressure conditions in the pulse jet engine.

A further object of the invention is to provide a fuel regulating system for a pulse jet engine in which two rates of fuel flow may be supplied thereto and in which means are provided for the selective operation of either rate of fuel flow.

Still another object of the invention is to provide a fuel regulator containing operating mechanism that may be responsive to remotely stationed mechanism for controlling the rate of fuel flow under specified operating conditions of the pulse jet engine.

In the drawings:

Fig. 1 is a plan view of a fuel regulator incorporating the invention,

Fig. 2 is an elevational view thereof,

Fig. 3 shows a section view taken substantially along the line 3—3 of Fig. 1 and in addition shows the complete regulator system; and

Fig. 4 is a section view of a modified fuel regulator and a pulse jet fuel supply system.

2

The fuel regulator comprises a valve housing 1 to which one end of a conduit 2 is connected and whose opposite end is connected to a pump 3 which pumps fuel from a reservoir 4 through a suitable conduit and into a cavity 10 in the valve casing 1. The valve member 5 is movable in the casing 1 and is engageable with the valve seat 6 that is formed in casing 1. A projection 7 is formed on a cover plate 8 for the lower end of the casing 1 and it is received in a socket or cavity formed in the valve 5. The slope of the valve member 5 and the seat 6 is such that there is a line contact between the two. In order to equalize the forces acting on valve 5 arising from the difference in fuel pressures existing in chambers 10 and 11, the stem is provided with bores 9 that communicate with the cavity in valve 5. Since there is a close sliding fit between projection 7 and the valve cavity, the pressure in chamber 11a and in chamber 11 will be substantially equal. The diameter of the valve cavity is substantially equal to that of the valve seat and there will be no resultant force imposed on the valve system. After being admitted into chamber 11, fuel is conducted to the combustion chamber of pulse jet engine 12 by means of conduit 13, one end of which is connected to the outlet port 14 in valve casing 1 and its opposite end is suitably connected to the fuel injection nozzles (not shown) in the pulse jet engine 12.

A casing 15 is disposed above and mounted on the casing 1 and a suitable diaphragm and mask assembly 16 is interposed therebetween, to which diaphragm the stem 17 of valve 5 is secured in the manner illustrated. The diaphragm mask assembly comprises a flexible membrance and a washer that is interposed between the casings 1 and 15. The washer has a diameter somewhat less than the diameter of chamber 11, thereby reducing the effective area of the diaphragm. The substitution of one washer for another controls the effective area of the diaphragm. The two housings are properly secured together by means of screws 18 that also secure the cover plate 8 to the casing 1, the screws extending up into the casing 15. The casing 15 is provided with a port 19 that communicates with the atmosphere and suitably disposed within the cavity in casing 15 and supported on a shoulder 15a therein is a sealed bellows member 20 containing a spring 21, the bellows member being preferably evacuated so that it will not be responsive to temperature changes but only to the particular altitude pressure at which the engine is operating.

A casing 22 is mounted on casing 15 between

which a suitable diaphragm and mask assembly 23 is interposed with the two casings being secured together by a plurality of bolts 24. Connected to the diaphragm assembly and in contact with the bellows 20 is a fitting 25 in which the valve stem 17 is threaded and threaded into the upper end of the casing 22 is an adjusting screw 26 that engages a washer 27. A spring 28 is interposed between the fitting 25 and the washer 27 which normally urges the diaphragm and valve assembly downward with a force that is directly proportional to the gage of the spring 28.

The casing 22 is provided with a port 29 that has one end of a conduit 30 connected thereto and whose opposite end is connected to a Pitot tube 31.

The force exerted by spring 28 acts upon the diaphragm assembly 23 and consequently on the diaphragm assembly 16. This force is opposed by the force exerted by the pressure of the fuel in chamber 11 as well as by the spring 21 in the bellows 20. The spring 28 also acts in the same direction as the ram pressure in the chamber 32 derived from the Pitot tube 31. These several pressures and spring forces are balanced against each other so that the resultant determines the amount of fuel that passes between the valve 5 and its seat 6. It has been previously pointed out that, under certain conditions of operation the normal flow of fuel from the casing 1 to the engine 12 is too rich as, for example, in starting operations and, therefore, for a predetermined length of time a lesser fuel flow is desirable. This lesser fuel flow is brought about by varying the downward pressure acting on the diaphragm assembly 23 produced by the spring 28 and the ram pressure by means of an auxiliary spring 33, one end of which is anchored to a fixture 34 secured to the casing 22 and whose other end is anchored to a screw 35 mounted at the other end of a lever 36. The lever 36 is fulcrumed to the fixture 34 at 37 and also secured to the fixture 34 is a solenoid 38 whose plunger 39 is pivoted to the lever 36 by means of a pin 40. The spring 33 acts in conjunction with the spring 28 by means of a fitting 41 that is pivoted to the lever 36 at a point between the screw 35 and the fulcrum pin 37. A rod 42 is threaded into the fitting 41 and extends through the adjusting screw 26 and engages the fitting 25 secured to the diaphragm assembly 23. When solenoid 38 is energized, it lifts rod 42, disengaging it from the fitting 25 and thereby relieving the downward pressure on the diaphragm assemblies 23 and 16 in an amount that is proportional to the gage of spring 33 so that the fuel pressure in chamber 11 will force the diaphragm assembly 16 upwardly and thereby restrict the flow of fuel by an amount that is equal to the upward adjustment of the valve 5 as viewed in Fig. 3. As soon as the solenoid 38 is de-energized, the spring 33 will pivot the lever 36 downwardly and will reestablish the normal pressure balancing conditions that exist between the combined forces of springs 33 and 28 plus the ram pressure acting downwardly on the diaphragm assembly 23 which combined force is opposed by the upward forces exerted by the bellows assembly 20 and the fuel pressure acting on diaphragm 16, thereby enabling the pulse jet engine to operate normally.

One method of controlling the energization of the solenoid 38 is by means of a pressure responsive device associated with the jet engine which consists of a pressure operated switch 43 which contains a plunger 44 reciprocably disposed in a cylinder 44a. The plunger is responsive to the pressure in the combustion chamber of the jet engine, the chamber being connected to the cylinder 44a by means of a suitable conduit. A pair of switch contacts 45 are arranged in the switch 43 and are adapted to be bridged by a bridging member 46 that is connected to the plunger 44 by means of a suitable connecting member 47. A spring 48 is interposed between the bridging member 46 and the casing of switch 43 and normally maintains the switch closed. Conductors 49 and 50 are connected between the terminals of the solenoid 38 and the contacts 45 for the switch 43 and a suitable source of energy, such as the battery 51, is interposed in one of the conductors to provide a suitable source of power. Before starting the pulse jet engine there is a pressure in the combustion chamber thereof which is of such magnitude as to enable the spring 48 to maintain the switch in closed position and it is in this position that the switch stands while the engine is being started. As soon as the engine is in operation, the pressure therein increases, which forces the plunger 44 downwardly and opens the switch, thereby causing the solenoid 38 to become de-energized whereupon the normal flow of fuel to the pulse jet engine commences.

The tension of spring 33 is adjusted by means of an adjusting nut 53 threaded to the screw 35. The entire structure supported on the fitting 34 is enclosed in a casing 52 in order to provide protection for the several elements thereunder.

The aforementioned structure is shown as operated by mechanism responsive to the pressure conditions existing within the combustion chamber of the pulse jet engine and is intended to take care of the starting conditions thereof. It is also possible to control the energization of the solenoid 38 by a radio control means (not shown) which devices are well known in the art. It was also pointed out above that under certain conditions of operation it is desirable at times to supply a greater fuel flow to the pulse jet engine and in doing so, the operation of the adjusting system would be reversed from that illustrated in Fig. 3. The necessary re-organization of the device is believed apparent from the structure disclosed so that a detailed illustration and description thereof is not believed necessary.

A modified construction of the aforementioned device is illustrated in Fig. 4 in which the valve casing 54 is shown containing valve seat 55 with which valve 56 cooperates. The vertical motion of the valve, as viewed in Fig. 4, is accomplished by a stem 57 that is slidably received in an aperture provided in the projection 58 integrally associated with the cover plate 59 and suitably secured to the casing 54. The casing is provided with an inlet port 60 to which a conduit 61 is connected in which a fuel pump 62 is inserted that supplies fuel under pressure from the reservoir 63 into the chamber 64 in the valve casing 54. Fuel passes valve 56 and enters the chamber 65 and is exhausted from the outlet port 66 into a conduit 67, one end of which is connected to the outlet port and whose opposite end is connected to the fuel nozzles in the pulse jet engine 68.

A casing 69 is mounted on the casing 54 between which a diaphragm and mask assembly 70 is interposed, the two casings being connected

together by means of a plurality of screws 71. Disposed within the chamber of the casing 69 is an evacuated bellows 72 and a port 73 in the casing 69 connects the chamber 74 therein to the atmospheric pressure at which the plane carrying the regulator is operated. Superimposed on the casing 69 is another casing 75 and a combination diaphragm and mask assembly 76 is disposed therebetween, the two casings being secured together by a plurality of screws 77. The mask and diaphragm assemblies 70 and 76 serve the same purpose as the assembly 16 described above. The stem 78 of valve 56 is secured to the diaphragm 70 and it is also secured to a fitting 79 that is secured to the diaphragm assembly 76. The evacuated bellows 72 in the chamber in casing 69 acts upwardly on the fitting 79 and rests on an appropriate shoulder 80 formed in the casing 69. The casing 75 is provided with a port 81 to which one end of a conduit 82 is connected and whose opposite end is connected to a Pitot tube 83 so that the chamber 84 in the casing 75 will be subjected to the ram pressure.

Superimposed on the casing 75 and connected thereto, such as by threading, is a casing 85 that contains an adjusting screw 86 against which a washer 87 abuts. A spring 88 is interposed between the washer 87 and the fitting 79 that urges the diaphragm assemblies 76 and 70 downwardly, aided and assisted by the ram pressure derived from the Pitot tube 83. The downward force of the spring and the ram pressure is counterbalanced by the upward force derived from the pressure of the fuel in chamber 65 and of the bellows 72 so that the resultant pressure determines the extent that the valve 56 has been opened for the passage of fuel. The pressure of the tension of spring 88 is adjusted by means of adjusting nut 86.

The two-stage fuel supply is brought about by means of a solenoid 89 secured to the upper end of the casing 85, the solenoid being provided with a plunger 90 to which a rod 91 is threadably connected and the other end of the rod engages a socket in the fitting 79. A nut 92 is threaded onto the threaded end of rod 91 and a spring 93 is interposed between the solenoid 89 and the nut 92 so that the tension of spring 93 may be varied. The spring 93 supplements the force of spring 88 in the same manner that spring 33 does in the Fig. 3 disclosure, the tension of spring 93 being adjusted by means of nut 92. The energization of solenoid 89 is controlled by a switch 94 that is responsive to pressure conditions existing within the combustion chamber of the pulse jet engine 68, the chamber being connected to the cylinder 94*a* in the pressure switch 94 by means of a conduit 95. Suitable switch contacts 96 are provided in the switch which are adapted to be bridged by bridging member 97 that is connected to the plunger 98 provided in the cylinder 94*a* in the pressure responsive switch 94. The switch contacts 96 are connected to the terminals of the solenoid 89 by means of conductors 99 and 100 in one of which a suitable source of energy, such as a battery 101, is provided. A spring 102 normally causes the bridging member to engage contacts 96. The operation of this device is identical with that described in connection with Fig. 3.

What I claim is:

1. A fuel regulator for jet engines comprising an engine; a pressured fuel supply therefor; means for establishing communication between said engine and said fuel supply; a valve interposed in said means; means responsive to fuel pressure and to altitude pressure connected to the valve for regulating said valve; spring means connected to the valve for regulating said valve; means responsive to air speed pressure connected to the valve for regulating said valve, said springs and said air speed pressure responsive means balanced against said fuel and altitude pressure responsive means, thereby balancing the respective pressures and spring means; and means responsive to pressures in the engine for additionally regulating said valve operative on said spring means to thereby adjust the rate of fuel flow through said valve to an amount different from that determined by said spring means during predetermined periods of engine operation.

2. A fuel regulator for jet engines comprising an engine; a pressured fuel supply therefor; means for establishing communication between said engine and said fuel supply; a valve interposed in said means; means responsive to fuel pressure and to altitude pressure connected to the valve for regulating said valve; adjustable spring means connected to the valve for regulating said valve; means responsive to air speed pressure connected to the valve for regulating said valve, said springs and said air speed pressure responsive means balanced against fuel and altitude pressure responsive means, thereby balancing the respective pressures and spring means; a solenoid for regulating said spring means; and means responsive to pressures in the engine for controlling the operation of said solenoid for additionally regulating said valve operative on said spring to thereby adjust the rate of fuel flow through said valve to an amount different from that determined by said spring means during predetermined periods of engine operation.

3. A fuel regulator for jet engines comprising an engine; a pressured fuel supply therefor; means for establishing communication between said engine and said fuel supply; a valve interposed in said means; means responsive to fuel pressure and to altitude pressure connected to the valve for regulating said valve; an adjustable spring means connected to the valve for regulating said valve; a second spring means for regulating said valve; means responsive to air speed pressure connected to the valve for regulating said valve, said springs and said air speed pressure responsive means balanced against fuel and altitude pressure responsive means to thereby balance the respective pressures and spring means; and means responsive to pressures in the engine operative on said second mentioned spring means for additionally regulating said valve to a rate of fuel flow different from that normally determined by said second mentioned spring during predetermined periods of engine operation.

4. A fuel regulator for jet engines comprising an engine; a pressured fuel supply therefor; means for establishing communication between said engine and said fuel supply; a valve interposed in said means; means responsive to fuel pressure and to altitude pressure connected to the valve for regulating said valve; an adjustable spring means connected to the valve for regulating said valve; a second adjustable spring means for regulating said valve; means responsive to air speed pressure connected to the valve for regulating said valve, said springs and said air speed pressure responsive means balanced against fuel and altitude pressure responsive means, to there-

by balance the respective pressures and spring means; and means responsive to pressures in the engine operative on the said second mentioned spring means for additionally regulating said valve to a rate of fuel flow different from that normally determined by said second mentioned spring during predetermined periods of engine operation.

5. A fuel regulator for jet engines comprising an engine; a pressured fuel supply therefor; means for establishing communication between said engine and said fuel supply; a valve interposed in said means; means responsive to fuel pressure and to altitude pressure connected to the valve for regulating said valve; a spring means connected to the valve for regulating said valve; a second spring means for regulating said valve; means responsive to air speed pressure connected to the valve for regulating said valve, said springs and said air speed pressure responsive means balanced against fuel and altitude pressure responsive means, to thereby balance the respective pressures and spring means; a solenoid for regulating said second mentioned spring means; and means responsive to pressures in the engine for controlling the operation of said solenoid for additionally regulating said valve to a rate of fuel flow different from that normally determined by said second mentioned spring during predetermined periods of engine operation.

6. A fuel regulator for an engine comprising an engine; a valve for regulating the flow of fuel under pressure to the engine; means responsive to fuel pressure connected to the valve for regulating said valve toward closed position; an evacuated bellows assembly connected to the valve for regulating said valve in the same direction; means responsive to atmospheric and ram pressures connected to the valve for further regulating said valve, the atmospheric and ram pressures acting on opposite sides of said means so that the atmospheric pressure regulates said valve to closed position and the ram pressure regulates said valve to open position; a spring for regulating said valve to open position; and an electromagnet controlled by pressures in the engine for modifying the force of said spring to thereby enable said valve to be moved toward closed position.

7. A fuel regulator for an engine comprising an engine; a valve for regulating the flow of fuel under pressure to the engine; means responsive to fuel pressure connected to the valve for regulating said valve toward closed position; an evacuated bellows assembly connected to the valve for regulating said valve in the same direction; means responsive to atmospheric and ram pressures connected to the valve for further regulating said valve, the atmospheric and ram pressures acting on opposite sides of said means so that the atmospheric pressure regulates said valve to closed position and the ram pressure regulates said valve to open position; a spring connected to the valve for regulating said valve to open position; a second spring for modifying the force of said first mentioned spring; and an electromagnet controlled by pressures in the engine for removing the influence of said second spring for enabling said valve to be further regulated to closed position.

8. A fuel regulator for an engine comprising an engine; a housing having fuel under pressure and a valve seat formed therein; a valve engageable with said seat for regulating the fuel flow to the engine; a diaphragm responsive to fuel pressure in said housing and connected to said valve for urging the valve to closed position; a second housing mounted on said first mentioned housing; a diaphragm in said second housing responsive to atmospheric and ram pressures and connected to said valve means, ram pressure acting on one side of the diaphragm and atmospheric acting on the other side thereof; means for aiding fuel pressure in urging the valve to closed position; means for urging said valve to open position and assisting the ram pressure in acting on said second diaphragm; and means controlled by pressures in the engine for modifying the force exerted by said last mentioned means for adjusting the fuel flow past said valve so that the flow will be different from that determined by said last mentioned means.

9. A fuel regulator for an engine comprising an engine; a housing to which fuel for the engine is supplied under pressure; a valve seat in said housing; a valve engageable with said seat for regulating the flow of fuel through said housing; a second housing mounted on said first mentioned housing; a diaphragm and mask assembly interposed between said housings connected to said valve and responsive to fuel pressure for urging said valve to closed position; a second diaphragm and mask assembly responsive to atmospheric and ram pressures connected to said valve, ram pressure acting on one side of the second diaphragm and atmospheric acting on the other side thereof; an evacuated bellows and spring assembly in said housing acting on said second diaphragm and mask assembly connected to the valve for urging said valve to closed position; a spring acting on said second diaphragm and mask assembly connected to the valve for moving said valve to open position and aided by ram pressure thereon; and means controlled by pressures in the engine for modifying the force of said second mentioned spring to thereby alter the rate of fuel flow past said valve to an amount different from that determined by said second mentioned spring.

10. A fuel regulator for an engine comprising an engine; a housing to which fuel under pressure is supplied; a valve seat in said housing; a valve engageable in said seat for regulating the flow of fuel from said housing; a second housing mounted on said fuel housing; a diaphragm and mask assembly between said housings and connected to said valve and responsive to fuel pressure for regulating said valve to closed position; a second diaphragm and mask assembly in said second housing one side of which is responsive to ram pressure and the other side to atmospheric pressure and connected to said valve for regulating the valve; an evacuated spring supported bellows acting on the side of said second assembly responsive to atmospheric pressure connected to the valve for regulating said valve to closed position; a spring acting on the side of said second assembly responsive to ram pressure connected to the valve for regulating said valve; a second spring for modifying the force exerted by said first mentioned spring; and an electromagnet actuated by pressures in the engine for removing the modifying force of said second spring to thereby enable said bellows and the fuel pressure to regulate said valve to closed position.

11. A fuel regulator for an engine comprising an engine; a housing to which fluid under pressure is supplied; a valve seat in said housing; a valve engageable with said seat for regulating

the flow of fuel from said housing; a second housing mounted on said fuel housing; a diaphragm and mask assembly interposed between said housings and connected to said valve and responsive to fuel pressure for regulating said valve to closed position; a second diaphragm and mask assembly in said second housing one side of which is responsive to ram pressure and the other side responsive to atmospheric pressure and connected to said valve; an evacuated spring supported bellows acting on the side of said second assembly responsive to atmospheric pressure connected to the valve for regulating said valve to closed position; a spring acting on the other side of said second assembly responsive to ram pressure connected to the valve for regulating said valve to open position; a third spring for modifying the force exerted by said second spring; and an electromagnet actuated by pressures in the engine for removing the modifying force of said third spring to thereby enable said bellows and the fuel pressure to regulate said valve to closed position.

12. A fuel regulator for an engine comprising a housing; a valve seat in said housing forming two chambers therein to one of which fuel under pressure is supplied; a valve engageable with said seat for regulating the flow of fuel from one chamber to the other; means for substantially equalizing the pressure on both sides of said valve; a second housing mounted on said housing; a diaphragm and mask assembly interposed between said housings and connected to said valve and responsive to fuel pressure for regulating said valve to closed position; a second diaphragm and mask assembly in said second housing one

side of which is responsive to ram pressure and the other side responsive to atmospheric pressure and connected to said valve; an evacuated spring supported bellows acting on the side of said second assembly responsive to atmospheric pressure and connected to the valve for regulating said valve to closed position; and a spring acting on the side of said second assembly responsive to ram pressure and connected to the valve for regulating said valve to open position, means responsive to pressures in the engine for modifying the force of said second mentioned spring to thereby alter the rate of fuel flow past said valve to an amount different from that determined by said second mentioned spring.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,169,683	Dunham et al.	Aug. 15, 1939
2,213,663	Berard	Sept. 3, 1940
2,219,441	Carnes	Oct. 29, 1940
2,274,693	Heinrich et al.	Mar. 3, 1942
2,283,175	Berger	May 19, 1942
2,302,014	Fausek et al.	Nov. 17, 1942
2,313,149	Jacobsson	Mar. 9, 1943
2,454,511	Heymann et al.	Nov. 23, 1948
2,489,586	Ray	Nov. 29, 1949
2,511,213	Leslie	June 13, 1950
2,609,662	Vogt et al.	Sept. 9, 1952

FOREIGN PATENTS

Number	Country	Date
537,026	Great Britain	June 5, 1941
544,048	Great Britain	Mar. 25, 1942