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CENTRIFUGAL BALANCE FUEL VALVE FOR ROTATING COMBUSTION PRODUCTS GENERATORS

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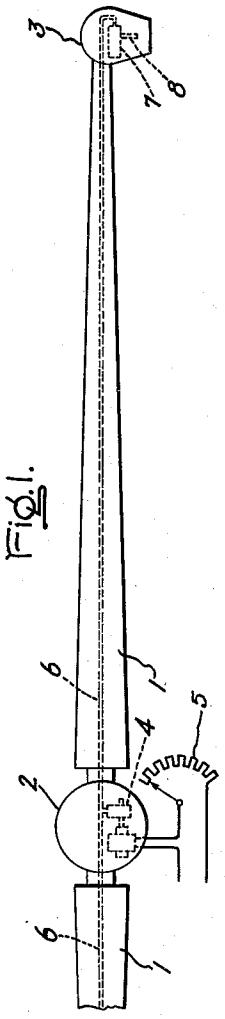


Fig. 1.

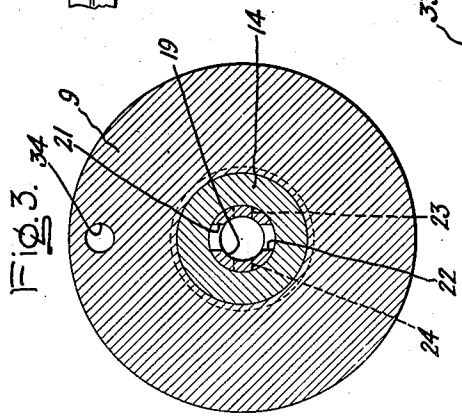


Fig. 3.

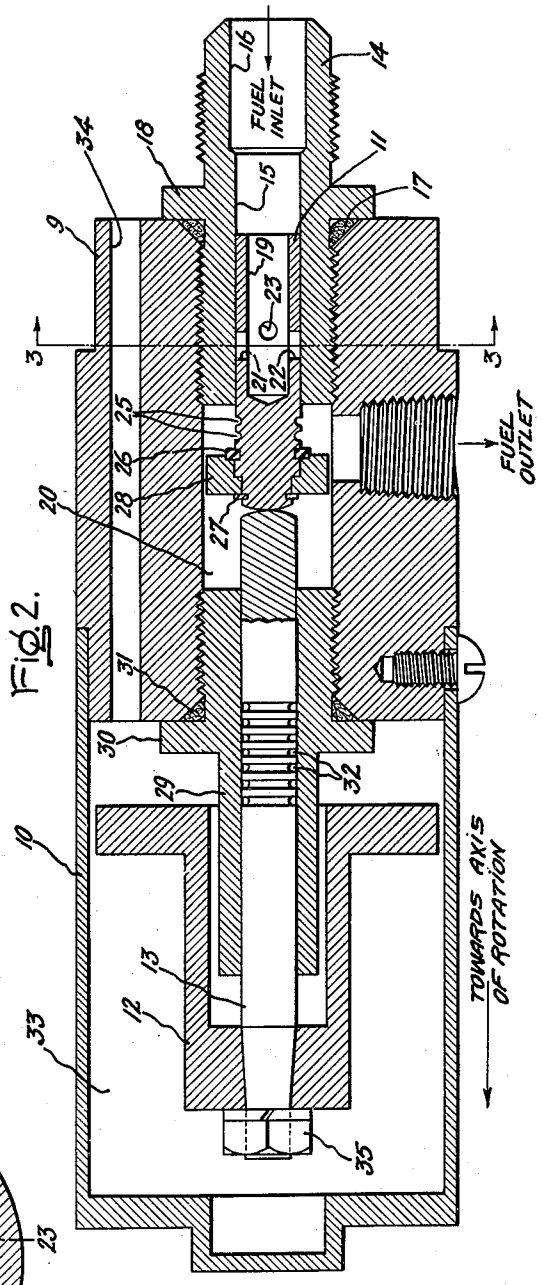


Fig. 2.

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CENTRIFUGAL BALANCE FUEL VALVE FOR ROTATING COMBUSTION PRODUCTS GENERATORS

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1 Claim. (Cl. 60—39.35)

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Our invention relates to a fuel supply system and more particularly to a fuel supply system utilized to supply fuel under variable pressure to a reaction motor carried on the tip of a helicopter rotor blade.

In supplying a fuel to a reaction motor located at the tip of a rotating blade, a problem arises in that the fuel which is carried in the fuel lines running from the hub of the rotors to the tip of the rotor blades has a centrifugal pressure head developed from the rotation of the rotor blades. As a result of this pressure head, the fuel delivered to the reaction motor is at a pressure which is equal in magnitude to the fuel pump pressure and the centrifugal pressure head. Since the centrifugal pressure head is dependent on the angular velocity of the rotating blades, the pressure of the fuel delivered to the reaction motor varies with the speed of the rotating blade. The reaction motor requires fuel under controlled pressure, and, therefore, it is necessary to provide a means to compensate automatically for the centrifugal pressure head.

It is, therefore, an object of our invention to provide a fuel supply system which is solely responsive to the fuel pump pressure regardless of the magnitude of the centrifugal pressure head even though it be much greater than the fuel pump pressure.

The novel features which we believe to be characteristic of our invention are set forth with particularity in the appended claim. The invention, itself, however, together with further objects and advantages thereof, may be best understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 shows a reaction motor powered helicopter rotor having a fuel supply system embodying our invention. Fig. 2 is a cross-sectional view showing constructional details of the fuel supply valve shown diagrammatically in Fig. 1 and Fig. 3 is a section taken along the line 3—3 of Fig. 2.

Referring to Fig. 1 of the drawing, we have shown diagrammatically a jet powered helicopter rotor comprising a lifting blade 1 extending from the hub 2 and carrying adjacent to its outer tip reaction motor 3. Mounted substantially concentrically with the center of rotation of the rotor assembly is a fuel pump 4 whose discharge is controlled by a suitable control 5 which is operated by the pilot. The fuel pump 4 is manifolded to supply line 6 and delivers fuel at varying pressures. The fuel supply line 6 is carried within the lifting blade 1 and runs the length of

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the blade towards the tip to fuel valve 7 which is mounted at the same radius from the hub as the reaction motor 3 substantially in the same position indicated. Connected to the outlet of the fuel valve 7 is a fuel conduit 8 leading to the combustion chamber of reaction motor 3.

Referring to Fig. 2 of the drawing, which is a cross-sectional view of the valve shown conventionally in Fig. 1, we have shown the valve as comprising a valve barrel 9 and a valve barrel extension 10. Lying within the valve barrel 9 and its extension 10 are the valving pieces consisting of a fuel flow governing piece 11 which cooperates in action with a weighted valving piece 12 through rod 13. The fuel flow governing piece 11 is supported by an end member 14 which is threaded to the inner peripheral surface of one end of the valve barrel 9 and terminates in a threaded open end portion adapted to receive an axially extending fuel line. Tightly encircling the end member 14 is a resilient ring 17 which cooperates with shoulder 18 to form a fluid tight seal between the valve barrel 9 and end member 14. According to the preferred form of the invention, the interior of end member 14 is provided with an axially extending uniform cylindrical bore 15 which abruptly tapers into a larger uniform cylindrical bore 16. Slidably mounted within the smaller internal bore 15 is a fuel flow governing piece 11 having an internal cavity 19 which is connected with outlet pressure chamber 20 by the vertical apertures 21, 22 and the horizontal apertures 23, 24 when the fuel flow governing piece 11 is in an open position. With an axial spaced arrangement of apertures 21, 22, 23, 24 as shown in Fig. 2, the amount of fuel transferred from the fuel line increases with movement of the fuel flow governing piece 11 toward the outlet pressure chamber 20 and while we have shown a plurality of circular apertures, it will, of course, be evident that the same result may be obtained by a single elongated aperture.

A series of parallel circumferential grooves 25 arranged in a space relationship along the fuel flow governing piece 11 form a seal which decreases leakage of fuel from the cavity 19 to the outlet pressure chamber 20 when apertures 19, 20, 21, 22 are not in communication therewith. Mounted on the end of the fuel flow governing piece 11 by means of a circular resilient washer 26 and a snap ring 27 is a stabilizing piece 28 which dampens the natural oscillation of the fuel flow governing piece 11. A second end member 29 is threaded to the inner peripheral surface of the remaining end of valve barrel 9 and is

adapted to support rod 13. Tightly encircling the end member 29 is a resilient ring 31 which cooperates with shoulder 30 to form a fluid tight seal between the valve barrel 9 and end member 29. Slidably mounted in end member 29 is rod 13 having a series of axially spaced circumferential grooves 32 in the outer blade. Thus, at any point in the fuel lines, the pressure is equal to the sum of the pressure caused by the centrifugal force plus that supplied by the fuel pump. It is desirable, however, that the fuel valve respond only to the fuel pump pressure. To accomplish this object, the valving pieces in the valve are built of such mass that their centrifugal force balances the centrifugal pressure of the body or mass of fuel in the fuel line. The length of the supporting portion of end member 29 depends on the number of circumferential grooves 32 in rod 13 which are required to form an effective seal between the atmospheric pressure of chamber 33 and the fuel pressure in chamber 20. In this connection it will be noted that chamber 33 is maintained at atmospheric pressure by passageway 34. The rod 13 is provided with a tapered section adapted to receive the weighted valving piece 12 which is secured thereto by a nut 35 which cooperates with the threaded end portion of rod 13.

In operation, the fuel pump 4 provides the amount of fuel required at a pressure which is impressed upon the fuel along the fuel lines to the valve 7 where the fuel pressure opens the valve to permit fuel flow. When the rotor is rotating, the fuel in the fuel line is also being rotated about the center of rotation and is consequently submitted to additional pressure caused by the centrifugal forces on the fuel itself. The pressure due to this force increases along the fuel lines and reaches a maximum at the tip of the valve where the centrifugal force of the valving pieces opposes the centrifugal pressure of the fuel in the fuel lines. The only unbalanced forces acting on the valving pieces are those exerted by the fuel pump pressure and the fuel outlet pressure. When the force exerted by the latter exceeds the force exerted by the fuel pump pressure, the resutlant force acting on the valving pieces partially closes the apertures 19, 20, thereby reducing the amount of fuel transferred to the outlet pressure chamber 20 and reduces the pressure therein. In operation, an equilibrium position is reached in which the amount of fuel transferred to the outlet pressure chamber is just sufficient to maintain the product of the fuel outlet pressure and the area on which it acts equal to the product of the fuel pump pressure and the area on which it acts. With an arrangement such as that described the automatic balancing of forces provides a means of varying the fuel outlet pressure by varying the area on which the fuel outlet pressure is exerted. Since the product of the fuel outlet pressure and the area on which it acts must be a constant for any given pump pressure, a decrease in the area on which the fuel outlet pressure acts decreases

the fuel outlet pressure, and similarly, a decrease in the area increases the pressure. It will, of course, be obvious to one skilled in the art that the operation of the valve requires that the fuel inlet pressure exceeds the fuel outlet pressure by an amount sufficient to cause a transfer of fuel between pressure chambers 20 and 33. Hence the operation of the valve requires a minimum rotational speed of the fuel line.

Thus, while we have illustrated and described a particular embodiment of invention, modifications thereof will occur to those skilled in the art. We desire it to be understood, therefore, that our invention is not to be limited to the particular arrangement disclosed, and we intend in the appended claim to cover all modifications which do not depart from the spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

A fuel supply system for a reaction motor mounted on a rotor powered by said motor and comprising a fuel pump having an adjustable output pressure, a fuel line interconnecting said motor and said pump, said fuel line extending radially outward along said rotor so that due to rotation of said rotor the fuel pressure therein is affected by both the fuel pump pressure and the centrifugal force acting on the fuel therein, a fuel pressure responsive valve interposed in said fuel line at substantially the same radius as said motor for regulating the pressure between said connections, said control valve comprising a valve barrel having inlet and outlet connections adapted to receive said fuel line, a fuel flow governing piece for regulating the flow between said connections, said fuel flow governing piece being slidably mounted in said inlet connection and having a fluid passageway adapted at its outer end to receive fuel from said fuel line and terminating in at least one aperture connecting said passageway to said outlet connection when said valve is open, said aperture being gradually closed by axial movement of said fuel flow governing piece, a member slidably mounted in said valve barrel substantially in alignment with said fuel flow governing piece and adapted to butt against said fuel flow governing piece, a weighted valving piece mounted on said member and having a predetermined mass of such magnitude that when the motor is in operation, the centrifugal force of said valving piece opposes the centrifugal force of the fuel in the fuel line.

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