

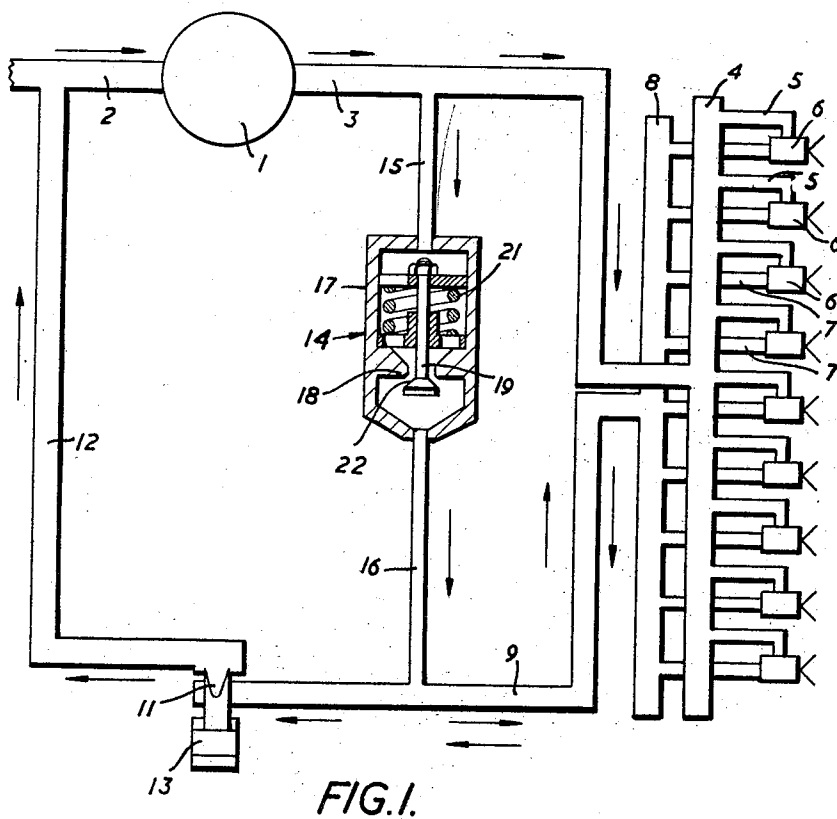
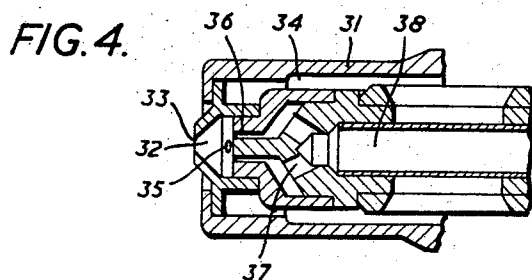
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S. R. TYLER
LIQUID SUPPLY SYSTEMS

3,078,046

Filed Dec. 28, 1960

2 Sheets-Sheet 1



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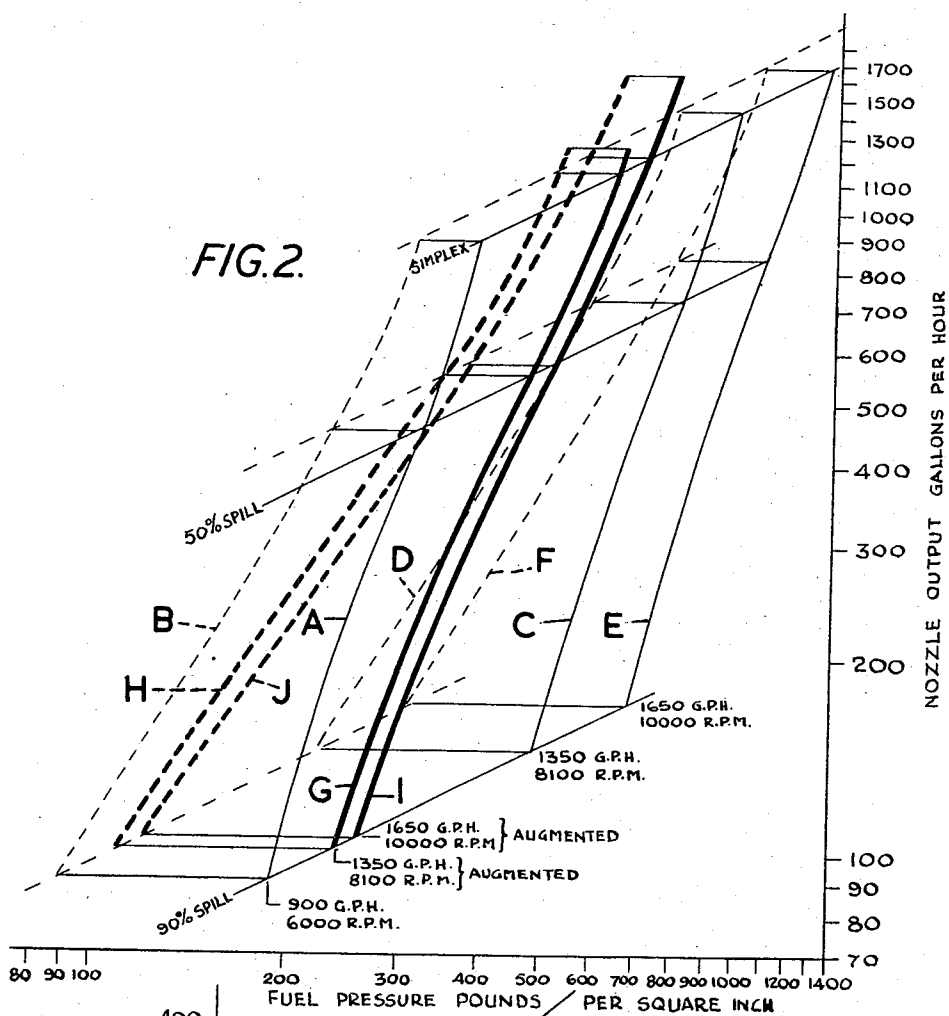
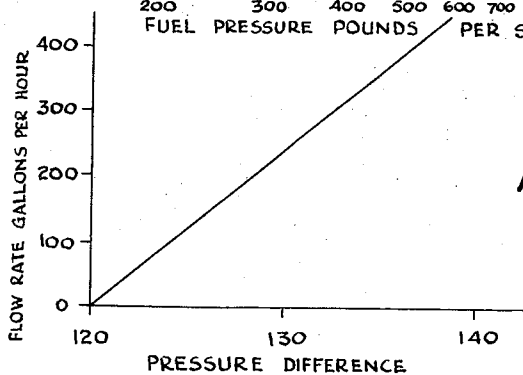
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LIQUID SUPPLY SYSTEMS

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4 Claims. (Cl. 239-126)

This invention relates to liquid supply systems in which liquid is fed or sprayed by means of one or more spill nozzles at a flow rate variable as desired. More particularly, the invention is concerned with the supply of liquid fuel for combustion. The term "spill nozzle" refers to a liquid flow control device comprising a swirl chamber into which liquid is fed tangentially to induce it to swirl within the chamber and from which liquid may leave by a main orifice disposed axially at the chamber at one end thereof, or through a spill aperture axially disposed at the opposite end of the chamber. By controlling the pressure in the zone into which liquid flows from the spill aperture the liquid flowing from the main orifice may be accurately controlled. Spill nozzles are of particular use where the output flow is required in the form of a finely divided spray, in which case the swirl motion of liquid leaving the main orifice may be arranged to cause atomization of the output flow. The present invention is concerned with the kind of liquid flow control for one or more spill nozzles comprising a positive displacement pump connected to supply fuel under pressure to one or more nozzle inlet connections, and a throttle valve to control spill flow from the nozzle or nozzles to a low pressure zone whereby to control output from the nozzle. This kind of liquid flow control will hereinafter be referred to as "a liquid flow control of the kind referred to."

The range of controlled flows from spill nozzles having a liquid flow control of the kind referred to is limited to a maximum value by the pump capacity and the maximum pressure when the throttle valve is entirely shut so that all the fuel entering the nozzle swirl chambers leaves through the main orifices. The object of the present invention is to reduce the range of pressure necessarily supplied by the pump to obtain a given range of liquid flow rates from spill nozzles used with a liquid flow control of the kind referred to.

In accordance with the present invention a liquid flow control of the kind referred to for feeding one or more spill nozzles includes a spring-loaded non-return valve connected between the supply and spill flow connections to the nozzle or nozzles to permit flow from the supply connection to the spill connection when the pressure difference between these exceeds a predetermined value, whereby to permit entry of liquid into the spill nozzles through the spill connections at high flow rates from the nozzles. The advantage gained by this construction is that when the throttle valve is closed, or almost closed, a proportion of the liquid supplied can enter the swirl chamber or chambers from the otherwise closed spill apertures, thus making the inlet pressure lower than would be the case if all the liquid entered the swirl chamber or chambers through the tangential inlets. Where the spill nozzles are used to produce a main output as spray the flow entering the swirl chambers at the spill orifices is swirled by the swirling liquid within the swirl chambers and will also leave the main orifices as spray.

The spring-loaded valve may comprise a mushroom shaped valve member held on to a seat by a compression spring surrounding the stem of the valve. Preferably the seating surface of the valve member should be so shaped in conjunction with the rate of the spring that there is

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a linear relation between fuel flow through the valve and increase in fuel pressure difference between supply and spill connections above that necessary to open the valve. One example of the invention for use in the supply of fuel to an aircraft gas turbine engine will now be described with reference to the accompanying drawings, in which,

FIGURE 1 is a circuit diagram of the fuel supplied to the system,

FIGURE 2 is a graph illustrating the performance of the system as compared with a conventional system,

FIGURE 3 is a graph illustrating the characteristics of the spring loaded valve, and

FIGURE 4 is a cross section of a typical spill nozzle.

Reference is made initially to FIGURE 1. In this drawing a fixed displacement supply pump 1 driven by the gas turbine engine is supplied with fuel through pipe 2 from a low pressure supply pump not shown. The output from the pump 1 passes to a pipe 3 to a supply gallery 4 to which are connected the supply pipes 5 of a plurality of spill spray nozzles 6. Each of these spill spray nozzles 6 is arranged substantially as described with reference to FIGURE 4. The return flow or spill pipes 7 leading from the nozzles 6 are connected to a spill gallery 8 which in turn is connected to a spill flow pipe 9. The spill flow pipe extends to a variable throttle valve 11 from which a pipe 12 extends to the pump inlet 2. The throttle valve 11 is adjusted by means of a servo piston and cylinder 13 under the control of a fuel scheduling apparatus which computes fuel flow to the gas turbine engine to obtain the desired performance.

In between the two pipes 3 and 9 an augmenting valve 14 is connected by means of the pipes 15 and 16. The augmenting valve comprises a case 17 having a valve seating 18 in cooperation with which a mushroom valve 19 is movably mounted, the mushroom valve being spring loaded by a spring 21 to engage the seat 18. The valve is so arranged that the higher pressure in the pipe 3 tends to open the valve 19 against the load of the spring 21. The mushroom valve member 19 includes a shaped mushroom head 22 co-operating with the seat to obtain a particular relationship between the pressure difference and fuel flow through the valve, as shown particularly in the graph forming FIGURE 3. It will be seen from this graph that there is no flow until the pressure difference between the pipes 3 and 9 exceeds 120 lbs. per square inch, and that the flow rate through the valve is directly proportional to the excess pressure over 120 lbs. per square inch.

In order to explain the operation of the augmenting valve 14 reference is made to the graph forming FIGURE 2. This graph is plotted on a logarithmic scale to give the total fuel flow for all the nozzles 6 against the pressure applied in the supply and spill galleries. The graphs take the form of five pairs of curves each pair comprising one full line and one dotted line. In each pair of curves the full line represents the nozzle output flow plotted against the supply pressure for a particular engine speed. Since the pump is engine driven and is of fixed displacement it will be clear that the fuel delivered by the pump 1 at a particular speed is constant. The dotted line of each pair represents the spill pressure plotted against the nozzle output for a particular engine speed. It should be explained here that with an aircraft gas turbine at a particular speed the fuel flow will depend entirely on the altitude of the aircraft, and at high altitudes the fuel flow to the engine to maintain a particular speed is considerably less than the fuel flow required at sea level. Curves A and B represent the supply flow and spill flow conditions in pipes 3 and 9 for a medium engine speed of 6,000 r.p.m., and these curves are applicable whether

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or not the valve 14 is used. Curves C and D, and E and F, respectively show the supply and spill pressures at 8100 r.p.m. and 10,000 r.p.m. in the case where the augmenting valve 14 is not used. Curves G and H, and I and J, show the supply and spill conditions respectively at 8,100 r.p.m. and 10,000 r.p.m. where the augmenting valve 14 is in use. Three sets of parallel lines having the references "90% spill," "50% spill" and "simplex" pass through the curves A, C, E, G and I to indicate the state of operation of the nozzles. The 90% spill line indicates that 90% of the fuel supplied to the nozzle through the gallery 4 is returned as spill flow through the gallery 8. The simplex line indicates that all flow through the gallery 4 issues a spray from the nozzles and there is no return flow through the gallery 8. The advantage gained by the invention is particularly shown by the comparison of the curves E and I. The curve E represents maximum speed and at its upper end, corresponding to sea level conditions, requires a total fuel flow of 1650 gallons per hour at a pressure of about 1300 lbs. per square inch. By applying the augmenting valve to the system the curve E becomes the curve I and here it will be seen that the maximum fuel flow of 1650 gallons per hour is obtained at a pressure of 800 lbs. per square inch. To obtain this condition fuel supplied through line 3 divides to pass partly through the pipe 15 and the valve 14 and partly through the gallery 4 to the nozzles 6. Fuel passing through the valve 14 and the gallery 8 enters into the nozzles 6 through the spill orifices, the total of supply and spill fuel through the galleries 4 and 8 issuing from the nozzles as spray. At this condition in fact the total fuel flow of 1650 gallons per hour is represented by a flow approximately of 1,050 gallons per hour through gallery 4 and 600 gallons per hour through gallery 8.

A characteristic of spill nozzle operation by an engine driven fixed displacement pump is that for any given engine speed the pressure difference at any instance between the supply and spill flows in the galleries 4 and 8 is constant for that speed irrespective of the actual fuel output from the nozzles. Thus, for the curves A and B the pressure difference remains constant at about 95 lbs. per square inch irrespective of the percentage spill flow. For the curves E and F the pressure difference is approximately 270 lbs. per square inch. In the curves I and J the constant pressure difference, which incidentally still applies during augmented conditions, is about 140 lbs. per square inch, which when referred to FIGURE 3 will correspond to a fuel flow through the augmenting valve 14 of about 500 gallons per hour. This flow rate through the valve 14 will remain substantially constant provided that the engine speed remains constant, and the only variation as the throttle valve 11 is adjusted is that the flow from pipe 16 into pipe 9 is directed towards the throttle valve 11 at low nozzle outputs and at high nozzle outputs is directed to the gallery 8 for augmented nozzle outputs. There are, of course, intermediate conditions where the flow from the pipe 16 divides at the pipe 9 and partially flows through the throttle 11 and partially to the gallery 8.

Curves G and H represent operating conditions with the valve 14 in use at an engine speed of 8,100 r.p.m. In the case of these curves there is a constant pressure difference of about 130 lbs. per square inch between supply and spill pipes and by referring to FIGURE 3 it will be seen that at this pressure difference the valve 14 will pass about 240 gallons per hour. At the higher flow rate of 1350 gallons per hour the entire flow from the valve 14 passing through pipe 16 will enter the gallery 8 and will combine with the supply flow from the gallery 4 to issue from the nozzles as spray. At lower flow rates from the nozzles the output from the pipe 16 may divide to flow partially to the throttle 11 and partially to the gallery 8, or it may flow entirely to the throttle 11.

It will be seen from curves G, H, I and J that lower

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fuel outputs from the nozzles at lower pressures are obtainable in the 90% spill condition, but this does not mean that such low flow rates are required in practice. It may, for example, at a speed of 10,000 r.p.m. be necessary to supply a minimum of 200 gallons per hour from the nozzles, this representing the highest obtainable altitude of the aircraft. When working in accordance with the curves E and F without the augmenting valve 14 the operating condition is with slightly smaller than 90% spill flow and with a supply pressure of approximately 700 lbs. per square inch. When operating in accordance with the curves I and J with the augmenting valve 14 the same fuel output will demand a pressure only of about 300 lbs. per square inch, but there will be considerably less than a 90% spill flow. Spill flow when considered as a percentage, is the percentage ratio between the flows in the galleries 4 and 8, and thus at 90% spill flow, 90% of the fuel entering the gallery 4 will be returned as spill flow through the gallery 8. In considering flow with the valve 14 in operation it has previously been stated that the curves I and J have a constant pressure difference of 140 lbs. which results in a constant fuel flow through the augmenting valve of 500 gallons per hour. This at the lower flow rates from the nozzles is subtracted from the pump delivery into the gallery 4 with the result that the actual delivery into the gallery 4 is 1150 gallons per hour. The percentage spill is then expressed as the percentage of this flow rate which returns through the gallery 8.

A typical spill nozzle to which the invention may be applied is illustrated in FIGURE 4. This nozzle comprises a hollow body member 31 within which functional components of the burner are clamped in an axial sense. A swirl chamber 32 is located at one end of the nozzle from which a spray orifice 33 extends. Fuel under pressure is supplied into the casing 31 then passes along the passage 34 into tangential holes 35, which give access into the swirl chamber causing entering fuel to swirl around the chamber. Within the rear wall of swirl chamber 32 an annular take-off connection 36 is located from which fuel may pass rearwardly from the swirl chamber 32. Fuel passing from the connection 36 passes backwardly through passages 37 into a central spill pipe 38 which extends centrally through the nozzle body. This fuel spray nozzle is the subject of United Kingdom Patent No. 649,970 (U.S. Patent 2,697,636).

Whilst the invention is apparently quite simple and might be said to comprise merely the addition of an augmenting valve to a spill nozzle supply system it will be appreciated that the great advantage is obtained of considerably lowering the maximum pressures required to obtain a predetermined flow rate from the nozzles. In the example illustrated in FIGURE 3 the pressure required to obtain the maximum flow rate has been reduced almost by one half without any substantial alteration to the system other than by the addition of the valve 14. This in turn will considerably reduce the load on the supply pump and increase its effective life. From the point of view of the aircraft there is the added advantage of greater reliability and safety because the supply pump is not subjected to extremely high pressures.

I claim as my invention:

1. A fluid supply assembly comprising means defining a nozzle chamber having an orifice at one end thereof, a fluid supply conduit communicating with the chamber through an inlet therein adapted to impart a swirling motion to the fluid in its passage to the orifice, and a spill conduit communicating with the chamber through an outlet in the other end thereof, means for pumping fluid through the supply conduit to the chamber, valve means in the spill conduit for throttling fluid flow therethrough, means for adjusting the throttling action of the valve means, said throttling action giving rise to a variable pressure differential between the supply and spill conduits whereby the fluid output through the nozzle orifice can be varied over a predetermined range, means de-

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fining a bypass conduit so interconnecting the supply conduit with the spill conduit at a point intermediate the chamber and the throttle valve means therein as to simultaneously communicate through the spill conduit with both the throttle valve means and the chamber spill outlet, an augmenting valve in the bypass conduit, and means for closing the augmenting valve, said augmenting valve closure means being responsive to a predetermined pressure differential between the supply and spill conduits to open the augmenting valve and permit fluid flow therethrough into the spill conduit, said predetermined pressure differential being selected so that in at least the upper portion of said output range fluid flow through the augmenting valve is greater than flow through the throttle valve means, whereby fluid will flow through the chamber spill outlet at a lower pressure than at said chamber inlet.

2. A fluid supply assembly according to claim 1 wherein said augmenting valve closure means includes a spring urging the augmenting valve to close but yieldable at said predetermined pressure differential to open the augmenting valve.

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3. A fluid supply assembly according to claim 2 wherein the augmenting valve has a movable head and a seat therefor which are so cooperatively shaped as to control fluid flow therebetween when opened against the spring bias in direct proportion to increase in the pressure differential between the supply and spill conduits above said predetermined pressure differential.

4. A fluid supply assembly according to claim 1 wherein the pumping means includes a positive displacement pump disposed in the supply conduit.

References Cited in the file of this patent

UNITED STATES PATENTS

1,296,614	Blakely	Mar. 11, 1919
2,436,815	Lum	Mar. 21, 1948
2,578,934	Janssen	Dec. 18, 1951
2,614,888	Nichols	Oct. 21, 1952
2,697,636	Hahn	Dec. 21, 1954
2,743,137	Wilson	Apr. 24, 1956