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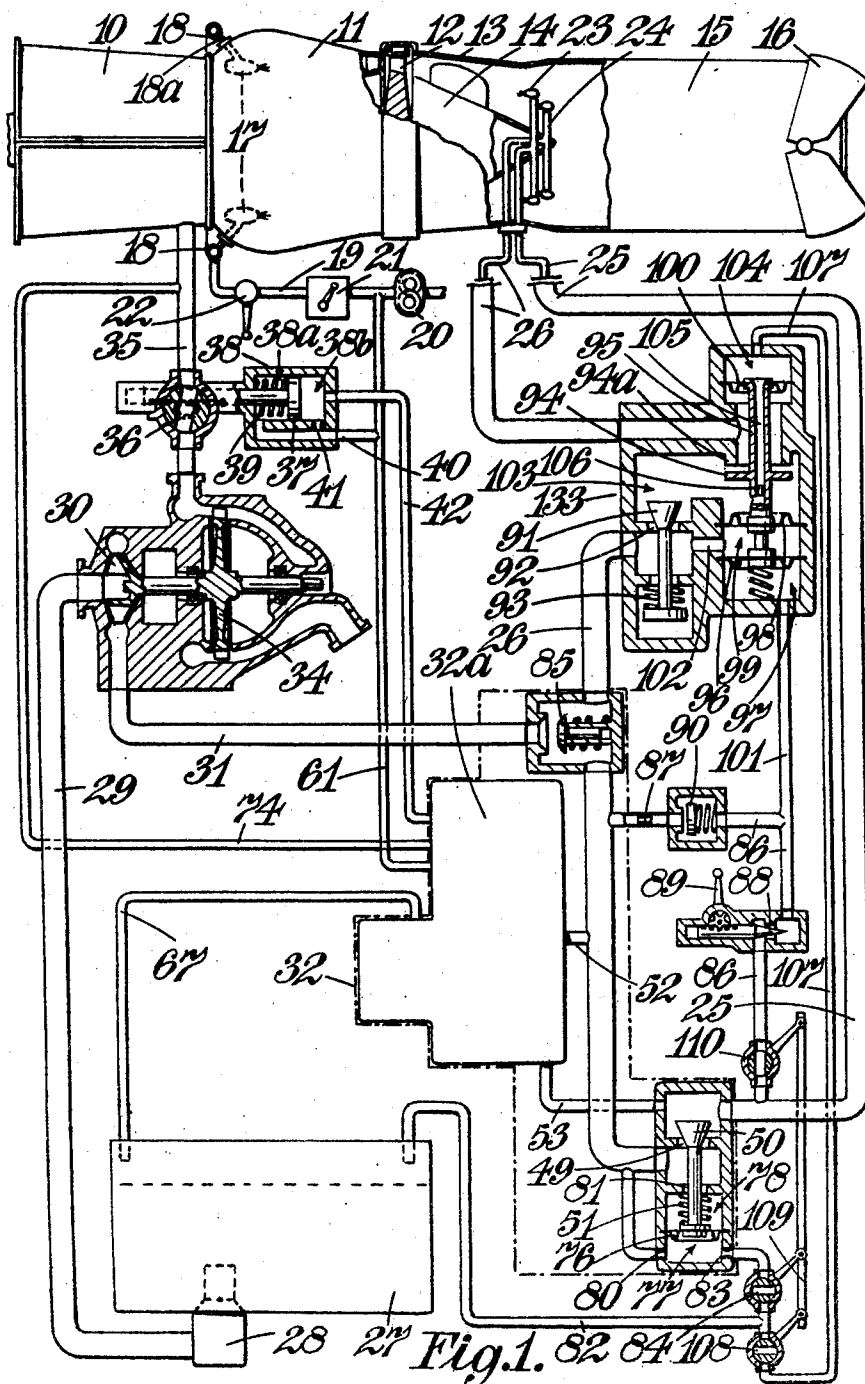
R. H. COLLEY ET AL

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REHEAT FUEL-SYSTEM FOR GAS-TURBINE ENGINE

Filed May 31, 1955

2 Sheets-Sheet 1



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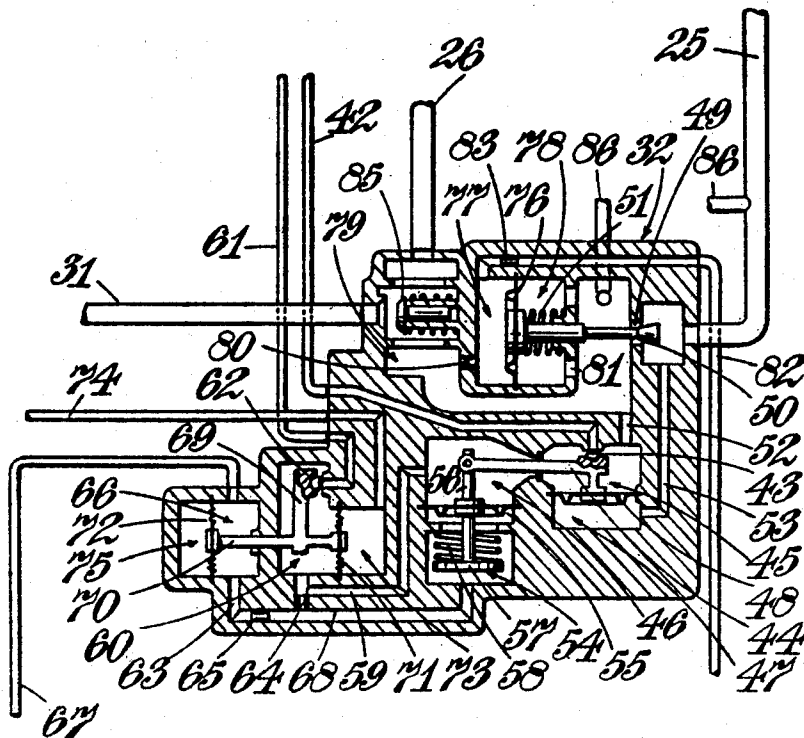
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REHEAT FUEL-SYSTEM FOR GAS-TURBINE ENGINE

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2 Sheets-Sheet 2

Fig. 2.



1

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REHEAT FUEL-SYSTEM FOR GAS-TURBINE ENGINE

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Claims priority, application Great Britain June 28, 1954

8 Claims. (Cl. 60—39.28)

This invention relates to fuel systems for gas-turbine engines.

In some gas-turbine engines provision is made for burning fuel in the working fluid after it has passed through one or more of the turbine stages in order to increase the power of the engine, and additional combustion equipment supplied by a fuel system (hereinafter referred to as a "reheat fuel system"), is provided for this purpose. Such additional combustion equipment is sometimes employed in jet-propulsion engines for aircraft, the working fluid exhaust from a gas-turbine engine being reheated in the jet pipe before being discharged through the jet nozzle. It is not usual to employ the reheat fuel system all the time that the power plant is operating, but only when an abnormally large power requirement is to be met. It has been proposed in reheat fuel systems to provide a pilot burner or burners through which a comparatively small proportion of the reheat fuel flow is passed. The fuel supplied through the pilot burner or burners maintains a flame which stabilises the combustion of the fuel delivered by main burners of the system, a suitable arrangement, being, for example, as described in U.S. Patent No. 2,708,339, granted May 17, 1955, to Rolls-Royce Limited, assignee of F. M. Johnson and E. Miller.

It is usual for the pilot flame to be ignited before fuel is supplied through the main burners so as to ensure that when this main fuel supply is injected, it is readily ignited and continues to burn.

The pilot fuel burner or burners may either convey to the jet pipe a small proportion of the reheat fuel or may convey to it a substantial proportion of the reheat fuel, but in any case when the additional combustion equipment is in operation fuel is fed into the jet pipe continuously through the pilot burner or burners. Where the pilot fuel burner or burners supply only a small proportion of the fuel then fuel will be fed through the main fuel injectors throughout operation of the reheat system, but, where the pilot burner or burners supply a large proportion of the reheat fuel (the burners being in this case usually known as primary injectors) the burner or burners may be operated on their own and the main burners (known as secondary injectors) may be brought into operation only when an extra large power is required.

It will be appreciated that the flame of the pilot burner or burners should be maintained stable despite variations of the conditions in the jet pipe which in the case of an aircraft jet-propulsion engine may vary due, for example, to changes in the altitude and forward speed of aircraft.

In U.S. Patent No. 2,742,755, granted April 24, 1956, to Rolls-Royce Limited, assignee of D. O. Davies, C. G. Morley and W. R. C. Ivens, there is described and claimed a reheat fuel system for supplying a pilot burner in a manner which results in a stable pilot flame being maintained despite such variations in conditions in the jet pipe, and the reheat fuel system comprises essentially

2

means to supply fuel to the pilot burner in a manner to maintain substantially constant the fuel/air ratio at the pilot burner. For instance, the means may be adapted to maintain the fuel flow to the pilot burner proportional to the absolute delivery pressure of the compressor, and this effects the desired control because in present engine designs the air mass flow, as more fully explained in U.S. Patent No. 2,742,755, granted April 24, 1956, to Rolls-Royce Limited, assignee of D. O. Davies, C. G. Morley and W. R. C. Ivens, is directly proportional to the absolute compressor delivery pressure under all conditions when the reheat combustion system is in operation.

In the specific embodiments of each of these reheat fuel systems, the main fuel burners are supplied by a fuel pump of which the delivery is controlled to maintain the required flow to the pilot burner. Thus in such arrangements, whilst the fuel delivery to the main fuel burners varies with the pilot fuel supply, there is no provision for ensuring that the main fuel supply is maintained in a given relation to the pilot fuel supply under all conditions of operation.

According to the present invention, a reheat fuel system for a gas-turbine engine comprises a plurality of main burners, a pilot burner to which fuel is supplied continuously while fuel is supplied to the main burners, means to supply fuel to the pilot burner in a manner to maintain substantially constant the fuel/air ratio at the pilot burner, and means responsive to the fuel flows to the pilot and main burners and adapted to maintain said fuel flows in a predetermined relation.

According to a feature of the invention, the fuel-flow-responsive means may comprise first restrictor means located in a pilot fuel supply conduit and adapted to produce a pressure drop which is a function of the pilot fuel flow, second restrictor means located in a main fuel supply conduit and arranged to pass a fuel flow to the main burners which is a function of the pressure drop across said second restrictor means, a valve in said main fuel supply conduit adapted to vary the pressure drop across said second restrictor means, and control means connected to control the valve and subjected to a first load which is dependent on the pressure drop across the first restrictor means and tends to open the valve when the pressure drop increases and to a second load which is dependent on the pressure drop across said second restrictor means and tends to close the valve when the latter pressure drop increases, whereby the pressure drop across said second restrictor means is maintained in predetermined relation to the pressure drop across said first restrictor means.

Preferably, in arrangements according to this feature of the invention, the pressure drop across the first restrictor means is directly proportional to the pilot fuel flow, and the fuel flow passed by the second restrictor means is directly proportional to the pressure drop across it. Preferably, also, the valve control means comprises pressure-responsive elements, one element loaded by a load which is a fraction of the pressure drop across the first restrictor means and a second element being loaded directly by the pressure drop across the second restrictor means.

In one arrangement according to the above feature of this invention, the fuel-flow-responsive means comprises a further conduit connected to said pilot fuel supply conduit in parallel with said first restrictor means and containing a pair of restricted orifices in series, and the control means for the valve in the main fuel supply conduit is subjected to a load due to the pressure difference across one of the restricted orifices in said further conduit so as to maintain the pressure difference across the second restrictor means proportional to that across said one of

the restricted orifices. Preferably one of the restricted orifices is of selectively variable area, whereby the pressure difference across said second restrictor means may be maintained in a selected ratio to the pressure drop across the first restrictor means.

One re-heat fuel supply system of the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 illustrate the re-heat fuel supply system, and Figure 2 illustrates one form of part of Figure 1.

Referring first to Figure 1, the gas-turbine engine comprises a compressor 10 which draws in air from the atmosphere and compresses it and delivers the compressed air into combustion equipment 11 where fuel is burnt with the air. The products of combustion are delivered from the combustion equipment 11 into a turbine 12 which is employed to drive the compressor 10 and the exhaust gases from the turbine pass into an exhaust structure. The exhaust structure comprises an outer wall 13, an inner conical wall 14 which is coaxial with the outer wall 13 and forms with it an annular exhaust duct passage, a jet pipe 15 which is connected to the downstream end of the outer wall 13 and receives the exhaust gases from said annular exhaust duct passage and a jet-propulsion nozzle 16 at the outlet end of the jet pipe 15. The jet-propulsion nozzle 16 is shown as a variable-area jet nozzle.

Fuel is delivered into the main combustion equipment 11 of the engine through injectors 17 which are supplied from a fuel manifold 18 through branch pipes 18a. Fuel is supplied to the manifold 18 through a fuel pipe 19 by a fuel pump 20 and the fuel pipe 19 has connected in it a control unit 21 by which the rate of flow to the injectors 17 is controlled, and a shut-off cock 22.

The engine also comprises reheat combustion equipment including two sets of fuel injectors, viz: primary injectors (or pilot burners) 23 and secondary injectors (or main burners) 24. The primary fuel injectors 23 are fed with fuel through a supply pipe 25 and the secondary fuel injectors 24 are fed through a supply pipe 26.

The reheat fuel system associated with the reheat combustion equipment is constructed as follows:

There is provided a fuel tank 27 fitted with a fuel tank booster pump 28 delivering into a pipeline 29 leading to the inlet of a centrifugal fuel pump 30, the outlet of which is connected to main delivery pipeline 31 leading to a control unit 32. The control unit 32 is adapted to maintain the fuel flow to the primary injectors 23 directly proportional to the absolute delivery pressure of the compressor 10 of the engine, and the part 32a of this control unit may be constructed and arranged to operate as described in U.S. Patent No. 2,742,755, granted April 24, 1956, to Rolls-Royce Limited, assignee of D. O. Davies, C. G. Morley and W. R. C. Ivens, or as shown in Figure 2 of the drawings.

The fuel flowing through the main delivery pipeline 31 into the unit 32 is divided into two flows within the control unit downstream of a non-return valve 85, part of the fuel flowing into the pipeline 25 and the remainder of the fuel flowing into the pipeline 26. The pipeline 26 has connected in it a valve mechanism 133 by means of which the supply of fuel to the secondary injectors 24 is controlled.

The centrifugal fuel pump 30 is driven by an air turbine 34 which is shown as being supplied with pressure air through a conduit 35 from the delivery end of the compressor 10 and the rate of flow of air to the turbine is controlled by an air throttle 36. It will be clear that the rate of delivery of fuel into the main delivery pipe 31 will depend upon the rotational speed of the centrifugal pump 30 and of the air turbine and thus upon the setting of the throttle 36.

The air throttle 36 is actuated by the piston 37 of a pressure-liquid-operated servo device. The piston is of different area on its two sides and works in a cylinder 38

against the action of a spring 39, the end 38a of the cylinder on the smaller-area side of the piston being connected through a pipe 40 directly to a source of liquid under pressure (in this case to the fuel delivery pipe 19 of the main combustion equipment fuel system) and the other end 38b of the cylinder being connected to the same pressure liquid source but through a restrictor 41. The end 38b of the cylinder 38 has a vent pipe 42 the outflow from which is controlled by a half-ball valve 43 contained in the part 32a of the unit 32 (Figure 2). When the valve opens and the flow through the vent pipe 42 is increased the pressure at the end 38b of the cylinder 38 will fall and so the piston will move to the right (as viewed in the drawing), and when the valve closes and the flow in the vent pipe decreases the piston 37 will move to the left. In this way appropriate control movements are applied to the air throttle 36 to decrease or increase the speed of rotation of the pump 30.

Referring now to Figure 2, the half-ball valve 43 is shown as carried on a pivoted lever 44 which is also arranged to be subjected to opposing loads which depend respectively upon the rate of fuel delivery to the primary fuel injectors 23 and to the absolute compressor delivery pressure.

One end of the lever 44 projects into a chamber 45, and the opposite end of the lever projects into a chamber 46. The chamber 45 is separated from a further chamber 47 by a flexible diaphragm 48 which is arranged to be subjected to the pressure drop across a linear flow valve through which passes the fuel flowing to the primary injectors 23. The linear flow valve comprises an orifice 49, a valve element having a shaped head 50 co-operating with the orifice 49 to vary its effective area and arranged to be moved in the sense of increasing the effective area by the fuel flow through the orifice 49, and a spring 51 which is arranged to load the valve in a sense to tend to reduce the effective area of the orifice 49. The shape of the head 50 and the rate of spring 51 are selected so that the pressure drop across the orifice 49 is directly proportional to the fuel flow through the orifice. The pressure drop across this orifice is applied to the diaphragm 48 by a duct 52 connecting the chamber 45 to the upstream side of the orifice 49 and by a duct 53 connecting the chamber 47 with the downstream side of the orifice 49. The diaphragm 48 is directly connected to the lever 44 and it is arranged that the load due to the pressure drop across the orifice 49 tends to lift the half-ball valve 43 off its seat.

The chamber 46 is separated from a chamber 54 by a further flexible diaphragm 55 which is connected by a rod 56 to the lever 44 and which has connected to it an abutment 57 for a spring 58 which has a second abutment on a shoulder within the chamber 54. The spring acts in a sense to tend to close the half-ball valve 43.

The chambers 46, 54 on each side of the diaphragm 55 contain liquid under pressure and it is arranged that the difference in the pressures acting in these chambers is directly proportional to the compressor delivery pressure. For this purpose the chamber 46 is connected by a duct 59 to a further chamber 60 having a pressure liquid inlet pipe 61 connected to it, the inflow being controlled by a half-ball valve element 62. The pressure liquid inlet pipe is connected to the pressure liquid supply pipe 40 of the servo mechanism for the air throttle 36, and thus to the fuel delivery pipe 19.

The chamber 60 also has an outlet duct 63 containing two fixed-area restrictors 64, 65 in series which lead to a chamber 66, and the latter has an outflow pipe 67 leading back to the fuel tank 27. A pressure tapping 68 connects the duct 63 between the two restrictors 64, 65 to the chamber 54 on one side of diaphragm 55.

It will thus be seen that the difference between the pressure in chamber 46 and the pressure in chamber 54 is equal to the pressure drop across the fixed restrictor 64.

The half-ball valve 62 is carried on an arm 69 project-

ing laterally from a rod 70 which is secured at its ends to a pair of flexible diaphragms 71, 72. The diaphragm 71 separates the chamber 60 from a further chamber 73 which is connected by a conduit 74 to the air conduit 35 upstream of the air throttle 36, so that the pressure within the chamber 73 is the delivery pressure of the compressor 10.

The diaphragm 72 separates the chamber 66 from a further chamber 75 which is evacuated. It will be seen that the chamber 75 is on the side of the diaphragm 72 remote from the diaphragm 71, and that chamber 73 is on the side of diaphragm 71 remote from diaphragm 72, and the diaphragms 71 and 72 are made of equal area so that there is a load on the diaphragm system, due to the pressures in chambers 73, 75, proportional to the absolute delivery pressure of the compressor 10.

It will be seen that this arrangement maintains the difference in fuel pressures between the chamber 60 and the chamber 66 directly proportional to the absolute compressor delivery pressure. If the pressure difference tends to increase then the half-ball valve 62 closes down so reducing the pressure in the chamber 60 and reducing the pressure difference. Contrariwise, if the fuel pressure difference tends to decrease the half-ball valve 62 is opened up so allowing the pressure within the chamber 60 to increase. Since the pressure drop across the two restrictors 64, 65 is maintained directly proportional to the compressor delivery pressure, the pressure drop across the fixed restrictor 64 (and thus the pressure drop across the diaphragm 55) is also maintained directly proportional to the absolute compressor delivery pressure.

The operation of the mechanism as so far described is as follows. An increase in the delivery pressure of the compressor causes a corresponding increase in the pressure difference acting on the diaphragm 55, so closing down the half-ball valve 43 and reducing the flow through the vent pipe 42, which causes opening of the air throttle 36 and an increase in the fuel delivery by the fuel pump 30. The increase in the fuel delivery causes a corresponding increase in the pressure drop across the orifice 49 and thereby an increase in the liquid pressure load acting on the diaphragm 48 and tending to open the half-ball valve 43 to cause a decrease in the delivery of the fuel pump 30, thus tending to maintain the fuel delivery to the pilot injectors 23 directly proportional to the absolute compressor delivery pressure, the proportion being determined by the effective areas of the diaphragms 48 and 55, by the length of the lever arms by which its diaphragms act on the lever 44, and by the effective restrictions of the restrictors 64 and 65.

The reheat fuel system as illustrated in Figure 1 also includes control means according to this invention whereby the rate of delivery of fuel to the secondary injectors 24 is maintained in a preselected proportion to the rate of delivery of fuel to the primary injectors 23 and in the construction illustrated this is achieved by providing a flow control valve in the supply pipe 26 and controlling the valve by means of pressure drops which are respectively representative of the actual fuel flows to the primary injectors 23 and the secondary injectors 24 respectively.

The pressure drop which is proportional to the actual fuel flow to the primary injectors 23 is a selected proportion of the pressure drop across the above-described linear flow valve 49, 50, 51 forming part of the unit 32, and is derived in the following way. A conduit 86 is connected to pipe-line 25 at points respectively upstream and downstream of orifice 49 to be in parallel with the orifice, and there is provided in flow series in the conduit 86 a fixed-area flow restrictor 87 and a variable-area flow restrictor in the form of a needle valve 88, the effective area of which is selected as by a manually-adjustable lever 89. The pressure drop across the fixed restrictor 87 is thus a proportion of the pressure drop

across the orifice 49, the proportion depending upon the selected effective area of the restrictor 88. By increasing the effective area of the orifice 88 the proportion of the pressure drop across the fixed restrictor 87 increases and by decreasing the effective area of the restrictor 88 the proportion of the pressure drop across the fixed restrictor 87 decreases.

A non-return valve 90 is also provided in the conduit 86, conveniently between the two restrictors 87 and 88.

The pressure drop which is proportional to the actual fuel flow to the secondary injectors 24 is developed in the valve mechanism 133 by means of a linear flow valve through which flows the whole of the fuel flow to the secondary fuel injectors 24. The linear flow valve comprises a shaped head 91 for varying the area of an orifice 92 and adapted to be moved by the fuel flow through the orifice in a sense to increase the effective area, and a spring 93 which acts on the valve element in a sense to decrease the effective area of the orifice 92. As in the case of the linear valve above described, by suitable selection of the shape of the head 91 and of the rate of spring 93, the pressure drop across the orifice 92 and the fuel flow through it may be made to be directly proportional to one another.

The valve mechanism 133 also includes a main fuel control valve 94 for varying the flow through the supply pipe 26. The control valve 94 has a stem 95 by which it is connected with a diaphragm system comprising a flexible diaphragm 96 forming a wall of a chamber 97, a diaphragm 98 of the same area as diaphragm 96 and forming with it walls of a chamber 99 and a third diaphragm 100 the purpose of which will be described below.

The chamber 97 is connected by means of a pipe 101 to the conduit 86 at a point between the non-return valve 90 and the variable-area restrictor 88 and the chamber 99 is connected by a duct 102 to the supply pipe 26 just upstream of the orifice 92. Thus the diaphragm 96 is loaded by the pressure drop across the fixed-area restrictor 87 in a sense to tend to lift the control valve 94 off its seating 94a on increase of the pressure drop. The side of the diaphragm 98 remote from the chamber 99 forms a wall of a chamber 103 wherein the fluid pressure is that just downstream of the orifice 92, and so the diaphragm 98 is loaded in accordance with the pressure drop across the orifice 92 in the sense of tending to close the valve 94 on increase of this pressure drop. The load on the diaphragm 98 opposes that on the diaphragm 96 and so the valve 94 will tend to take up a position such that the pressure in the chamber 103 is adjusted so that the pressure drop across the orifice 92 is equal to that across the restrictor 87. In this way the fuel flow to the secondary injectors 24 will be in constant proportion to the fuel flow to the primary injectors 23, the last-mentioned flow being varied in accordance with the compressor delivery pressure of the engine. Furthermore, the flow to the secondary injectors 24 may be selected to be any desired multiple or fraction of the flow to the primary injectors 23 within limits, by adjustment of valve 88 through lever 89.

The arrangement illustrated also comprises a shut-off cock mechanism for both the primary and secondary fuel supplies.

It is also arranged that during the time that the auxiliary combustion equipment is non-operative, there is a flow of fuel through the control unit 32 for cooling purposes.

The shut-off cock mechanism for the fuel supply to the primary injectors 23 comprises a flexible diaphragm 76 separating a pair of chambers 77, 78 and carrying the valve element 50 of the linear flow valve leading to the primary fuel injectors 23. The chamber 77 is connected to the chamber 79 upstream of the linear flow valve through a flow restrictor 80 and the chamber 78 is connected to the chamber 79 through an orifice 81 so that the pressure within the chamber 78 is the pressure within

the chamber 79. The chamber 77 has an outflow duct 82 fitted with a flow restrictor 83 and with a two-position valve 84 (Figure 1), and the outflow duct 82 leads back to the fuel tank 27. The valve 84 in one position is fully open and in a second position is fully closed.

During operation of the additional combustion equipment the valve 84 is closed and so there is no outflow through the duct 82 and the liquid pressures on each side of the diaphragm 76 are equal, so that the liquid pressure loading on the diaphragm has no effect on the operation of the linear flow valve.

The shut-off cock mechanism for the fuel supply to the secondary injectors 24 is similar to that for the primary fuel supply and comprises the diaphragm 100 which separates a chamber 104 from the supply pipe 26 at a point downstream of the control valve 94, which preferably is of the same area as the flange of valve 94, and which is connected with the stem 95 of the valve 94. The stem has a longitudinal bore 105 leading from the chamber 104 past a restrictor 106 to open into the chamber 103, and the chamber 104 also has a vent pipe 107 containing a two-position valve 108, and the downstream end of the vent pipe 107 is connected through the vent pipe 82 of the pivot fuel shut-off cock mechanism to the tank 27. The two valves 84, 108 are connected by an operating rod 109 to open and close together and the operating rod 109 also connects these valves to a further two-position valve 110 in the conduit 86, the arrangement being such that the valve 110 is open when the valves 84 and 108 are shut, and vice versa.

When the valve 108 is shut there is no flow through the vent pipe 107 so the pressure within the chamber 104 is equal to the pressure in the chamber 103, and the position of the valve 94 is therefore controlled solely by the loads on the diaphragms 96, 98.

In order to close the shut-off cocks for the primary and secondary fuel supplies, the valves 84 and 108 are opened. The valve 110 is also simultaneously closed, by reason of the rod 109.

When the valve 84 is open, there is a bleed flow through the restrictors 80, 83, so causing the pressure in chamber 77 to fall relative to that in chamber 79, so that diaphragm 76 is loaded to hold valve element 50 onto its seating.

When the valve 108 is open there is a flow through the vent pipe 107, and, due to the restrictor 106, the pressure within the chamber 104 is lower than the pressure within the chamber 103 and the valve 94 is therefore forced against its seat 94a preventing a flow of fuel to the secondary injectors 24. When the valves 84, 108 are opened in order to cause the valve members 50, 94 to be held on their respective seatings, and thus to shut off the supply of fuel to the primary injectors 23 and secondary injectors 24, the valve member 110 is closed in order to prevent fuel flowing from the main delivery pipe 31 through the bypass pipe 86 and the supply pipe 25 to the primary fuel injectors 23.

When the valve 49, 50 in the fuel pipe 25 leading to the primary fuel injectors 23 and the control valve 94, 94a in the fuel pipe 26 leading to the main burners 24 are closed, the fluid pressure acting on the diaphragm 48 will cause the half-ball valve 43 to open fully and the air throttle 36 will move to the fully closed position so stopping the fuel pump 30.

However, there will still be a flow through the vent pipe 42 and half-ball valve 43, since pressure fuel will flow from the delivery pipe 19 of the main combustion equipment through the pipe 40, restrictor 41 into the end 38b of the cylinder 38 and thence through the vent pipe 42 and past the half-ball valve 43 into the chamber 45 and thence into the chamber 79. The fuel will flow from the chamber 79 through restrictor 80 into chamber 77, through restrictor 83 into the outflow pipe 82 and past the valve 84 back to the tank 27: this flow is for cooling purposes and is relatively small.

Also there will be a flow of fuel from chamber 79 into pipe-line 26, causing the non-return valve 85 to close under these conditions to prevent flow of fuel into the main delivery pipe 31, and in this case the flow of fuel will pass through the valve mechanism 133 for cooling purposes, by way of orifice 92, chamber 103, bore 105, chamber 104, vent pipe 107 and pipe 82 back to the tank 27. This flow is relatively small.

We claim:

1. A reheat fuel system for a gas-turbine engine comprising a plurality of main burners, a pilot burner, means supplying fuel to the main burners and supplying fuel continuously to the pilot burner while fuel is supplied to the main burners, said fuel supply means including a main fuel supply conduit and a pilot fuel supply conduit, means controlling the supply of fuel to the pilot burner in a manner to maintain substantially constant the fuel/air ratio at the pilot burner, and means responsive to the fuel flows to the pilot and main burners and adapted to maintain said fuel flows in a predetermined relation, said fuel-flow-responsive means comprising first restrictor means located in the pilot fuel supply conduit and adapted to produce a pressure drop which is a function of the pilot fuel flow, second restrictor means located in the main fuel supply conduit and arranged to pass a fuel flow to the main burners which is a function of the pressure drop across said second restrictor means, a valve in said main fuel supply conduit adapted to vary the pressure drop across said second restrictor means, and means for maintaining the flow of fuel to the main burner in a predetermined fixed relation to the fuel flow to the pilot burner comprising control means connected to control the valve and subjected to a first load which is dependent on the pressure drop across the first restrictor means and tends to open the valve when the pressure drop increases and to a second load which is dependent on the pressure drop across said second restrictor means and tends to close the valve when the latter pressure drop increases, whereby the pressure drop across said second restrictor means is maintained in predetermined fixed relation to the pressure drop across said first restrictor means.

2. A reheat fuel system as claimed in claim 1, wherein the pressure drop across the first restrictor means is directly proportional to the pilot fuel flow, and the fuel flow passed by the second restrictor means is directly proportional to the pressure drop across it.

3. A reheat fuel system as claimed in claim 1, wherein the valve control means comprises pressure-responsive elements, of which one is loaded by a load which is a function of the pressure drop across the first restrictor means, and of which a second is loaded directly by the pressure drop across the second restrictor means.

4. A reheat fuel system for a gas-turbine engine comprising a plurality of main burners, a pilot burner, means supplying fuel to the main burners and supplying fuel continuously to the pilot burner while fuel is supplied to the main burners, said fuel supply means comprising a pilot fuel supply conduit and a main fuel supply conduit connected together at their upstream ends, means controlling the supply of fuel to the pilot burner in a manner to maintain substantially constant the fuel/air ratio at the pilot burner, and means responsive to the fuel flows to the pilot and main burners and adapted to maintain said fuel flows in predetermined relation, the fuel-flow-responsive means comprising a linear flow valve in said pilot fuel supply conduit, whereby a pressure drop is produced in said pilot fuel supply conduit directly proportional to the pilot fuel flow, a by-pass conduit connected at one end to said pilot fuel supply conduit upstream of said linear flow valve and at its other end to said pilot fuel supply conduit downstream of said linear flow valve, a fixed restrictor in said by-pass conduit, a variable-area restrictor in said by-pass conduit in series with and downstream of said fixed restrictor, selectively adjustable means connected to vary the effective area of said variable-area

restrictor, and valve means connected in said main fuel supply conduit and comprising a first chamber, a second linear flow valve in said main fuel supply conduit upstream of said first chamber, an outlet from said first chamber to the main burners, a control valve member co-operating with said outlet, a first diaphragm connected to move said control valve member and forming a wall of said first chamber to be loaded on one surface in the sense of opening said control valve member by the pressure within said first chamber, a pressure connection from said main fuel supply conduit upstream of said second linear flow valve to load said first diaphragm on its other surface and in a sense to close said control valve, a second chamber, a second diaphragm of equal effective area to said first diaphragm and forming a wall of said second chamber, said second diaphragm being connected to move said control valve and being loaded on one surface in a sense to open said control valve through said pressure connection from the main fuel supply conduit upstream of the second linear flow valve, and a pressure connection opening at one end into said by-pass conduit between said fixed restrictor and said variable-area restrictor and opening at its opposite end into said second chamber whereby said second diaphragm is loaded on its other surface in a sense to close the control valve by the pressure in said by-pass conduit between said two restrictors, and whereby said control valve member varies the outlet flow from said first chamber in a manner to maintain the pressure drop across said second linear flow valve equal to the pressure drop across said fixed restrictor in the by-pass conduit.

5. A reheat fuel system for a gas-turbine engine comprising a plurality of main burners, a pilot burner, means supplying fuel to the main burners and supplying fuel continuously to the pilot burner while fuel is supplied to the main burners, said fuel supply means including a main fuel supply conduit and a pilot fuel supply conduit, means controlling the supply of fuel to the pilot burner in a manner to maintain substantially constant the fuel/air ratio at the pilot burner, and means responsive to the fuel flows to the pilot and main burners and adapted to maintain said fuel flows in a predetermined relation comprising first restrictor means located in the pilot fuel supply conduit and adapted to produce a pressure drop which is a function of the pilot fuel flow, second restrictor means located in the main fuel supply conduit and arranged to pass a fuel flow to the main burners which is a function of the pressure drop across said second restrictor means, a valve in said main fuel supply conduit adapted to vary the pressure drop across said second restrictor means, a further conduit connected to said pilot fuel supply conduit in parallel with said first restrictor means and a pair of restricted orifices in series in said further conduit, and control means connected to control the valve and subjected to a first load which is dependent on the pressure drop across the first restrictor means and tends to open the valve when the pressure drop increases and to a second load which is dependent on the pressure drop across said second restrictor means and tends to close the valve when the latter pressure drop increases, whereby the pressure drop across said second restrictor means is maintained in predetermined relation to the pressure drop across said first restrictor means, and the control means for the valve in the main fuel supply conduit being subjected to a load due to the pressure difference across one of the restricted orifices in said further

conduit so as to maintain the pressure difference across the second restrictor means proportional to that across said one of the restricted orifices.

6. A reheat fuel system as claimed in claim 5, wherein one of the restricted orifices is of selectively variable area whereby the ratio of the pressure drop across said second restrictor means to the pressure drop across said first restrictor means is selectively variable.

7. A reheat fuel system for a gas-turbine engine comprising a plurality of main burners, a pilot burner, means supplying fuel to the main burners and supplying fuel continuously to the pilot burner while fuel is supplied to the main burners, said fuel supply means including a main fuel supply conduit and a pilot fuel supply conduit, means controlling the supply of fuel to the pilot burner in a manner to maintain substantially constant the fuel/air ratio at the pilot burner, and means responsive to the fuel flows to the pilot and main burners and adapted to maintain said fuel flows in a predetermined relation comprising first restrictor means located in the pilot fuel supply conduit and adapted to produce a pressure drop which is a function of the pilot fuel flow, second restrictor means located in the main fuel supply conduit and arranged to pass a fuel flow to the main burners which is a function of the pressure drop across said second restrictor means, a valve in said main fuel supply conduit adapted to vary the pressure drop across said second restrictor means, a further conduit connected to said pilot fuel supply conduit in parallel with said first restrictor means and a pair of restricted orifices in series in said further conduit, and control means connected to control the valve and subjected to a first load which is dependent on the pressure drop across the first restrictor means and tends to open the valve when the pressure drop increases and to a second load which is dependent on the pressure drop across said second restrictor means and tends to close the valve when the latter pressure drop increases, whereby the pressure drop across said second restrictor means is maintained in predetermined relation to the pressure drop across said first restrictor means, and the control valve means for the valve in the main fuel supply conduit comprises a pair of pressure-responsive elements of which one element is subjected to a load due to the pressure difference across one of the restricted orifices in said further conduit, and of which the other element is loaded directly by the pressure drop across the second restrictor means, thereby to maintain the pressure difference across the second restrictor means proportional to that across said one of the restricted orifices.

8. A reheat fuel system as claimed in claim 7, wherein one of the restricted orifices is of selectively variable area whereby the ratio of the pressure drop across said second restrictor means to the pressure drop across said first restrictor means is selectively variable.

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