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FUEL SUPPLY SYSTEM FOR GAS TURBINE ENGINES

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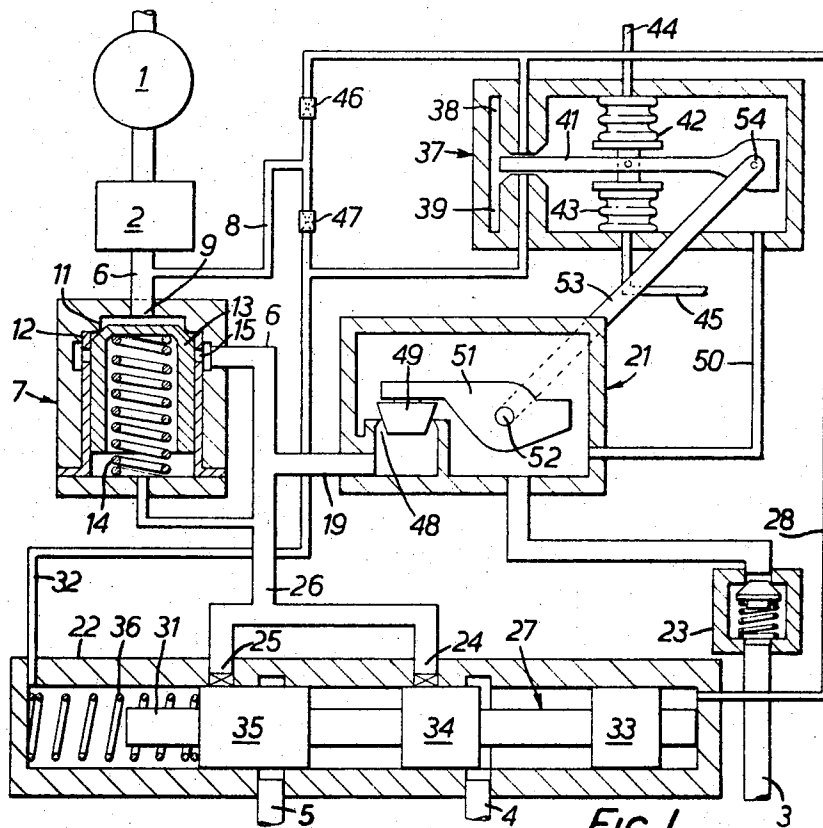


FIG. 1.

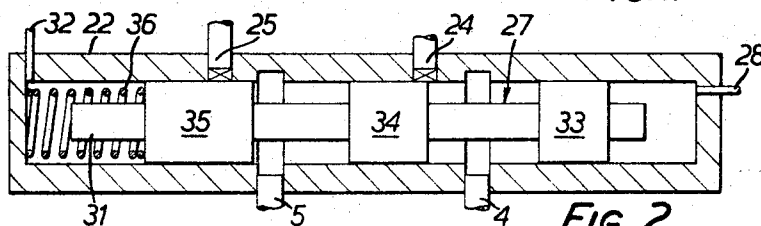


FIG. 2.

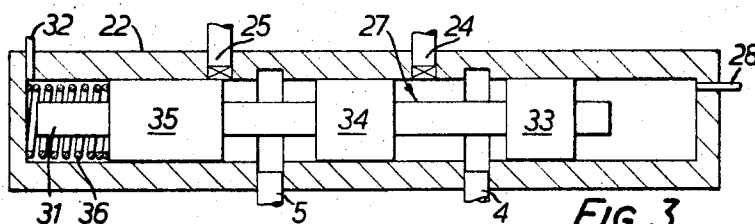


FIG. 3.

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FUEL SUPPLY SYSTEM FOR GAS TURBINE ENGINES

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5 Claims. (Cl. 60—39.28)

ABSTRACT OF THE DISCLOSURE

In a gas turbine engine having at least three burners which are brought into use, or closed down, one after the other, the first of said burners is supplied with fuel from a controlled source by way of a flow-sensing device, while the supply of fuel to the remaining burners is regulated by a distribution valve under the control of a pilot valve. This pilot valve is controlled by one or more signals of engine-operating parameters and by a flow signal from the sensing device so as to determine a maximum fuel flow to the first burner, any excess in the total fuel flow being passed by the distribution valve to one or more of the remaining burners.

BACKGROUND OF THE INVENTION

Field of the invention

Fuel supply systems for afterburners or like burners of internal combustion turbine engines.

Description of the prior art

An afterburner fuel control system is known having a main flow control which is regulated as a combined function of air supply rate and operator control input, a primary burner to which fuel is supplied through a first valve means, and a secondary burner to which fuel is supplied through a second valve means, said second valve means being responsive to the pressure drop across the first valve means and operative to hold constant said pressure drop by control of fuel flow to the secondary burner.

SUMMARY

According to the invention a fuel supply system comprises a fuel supply conduit arranged to receive fuel from a variably controllable source, a branch from said conduit connected through a flow-sensing device to a first burner, another branch connected through a distribution valve to a second burner and a third burner at least, the distribution valve having a second burner port and a third burner port which are opened one after the other to the supply of fuel from said other branch by movement of a fluid-actuated valve member in one direction, and which are closed one after the other from the supply of fuel by movement of said valve member in the opposite direction, and a fluid servo device operable to control the fluid-actuated valve member in response to an input signal of at least one engine-operating parameter and to a flow signal from the flow-sensing device, the fluid servo device determining a maximum fuel flow to the first burner which is a function of the one or more engine-operating parameters, and the fluid servo device controlling the

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fluid-actuated valve member to maintain said maximum flow to the first burner, when the total fuel flow in the supply conduit exceeds said maximum, by regulating the excess flow to the second burner at least.

DESCRIPTION OF THE PREFERRED EMBODIMENT

One embodiment of the invention is illustrated in the accompanying drawings, of which:

FIGURE 1 is a sectional diagram of a fuel distribution system for supplementary burners, for example reheat burners, of an internal combustion gas turbine engine, and

FIGURES 2 and 3 show the distribution valve at different stages of operation.

The diagram shows the distribution system arranged between a fuel pump 1 and a flow control device 2, neither of which are shown in detail, and a number of fuel outlet pipes 3, 4, 5 each of which is connected to a burner, or burner manifold, in the reheat stage of the gas turbine engine. A fuel supply conduit 6 leading from the flow control device 2 has a spring-loaded relief valve 7 therein for maintaining pressure in a servo pressure supply pipe 8 which is connected to the conduit 6 upstream of the relief valve 7. This valve is formed with an inlet 9 within a circular valve seat 11 and a ported cylinder 12 in which a hollow plunger 13 is slidable under the load of a spring 14 to engage the valve seat, an outlet 15 being formed by a port in the cylinder 12.

A branch 19 from the conduit 6 is connected through a flow-sensing device 21 and through a low pressure relief valve 23 to the outlet pipe 3. This valve 23 prevents escape of fuel into the outlet pipe 3 until there is pressure in the supply conduit 6. Another branch 26 is connected to axially spaced inlets 24 and 25 in a distribution valve cylinder 22, both of which inlets are formed as metering slots. Each of the outlet pipes 4 and 5 leads from an annular recess in the bore of the cylinder 22, which has a small axial spacing from the corresponding inlet. A fluid-actuated valve member 27 is formed as a spool which is movable in the bore of the cylinder 22. The spool has lands 34, 35 which are spaced to co-operate with the inlets 24, 25 respectively, so that these are opened and closed successively with respect to the corresponding outlets when the spool moves first in one direction and then in the opposite direction.

The spool 27 is moved in the direction to open the inlets by fluid pressure in a pipe 28 which is connected to one end of the cylinder 22, the fluid pressure acting over a third land 33 on the spool which fits the bore of the cylinder. The spool 27 has a central stop 31 at its opposite end which engages the adjacent end of the cylinder 22 when the inlet 25 is fully open. The spool 27 is moved in the opposite direction by fluid pressure in a pipe 32 which is connected to the other end of the cylinder. The spool is also moved in the same direction to close all the inlets by a lightly loaded spring 36.

The controlling pressures in the pipes 28 and 32 are regulated in opposed nozzles 38 and 39 of a fluid servo device 37 by a pivoted pilot valve member 41 which is movable between the nozzles. Fluid pressure is fed to the nozzles 38 and 39 from the servo pressure supply pipe 8 through fixed restrictors 46 and 47 respectively.

The member 41 is controlled in part by two opposed capsules 42, 43 to which fluid pressure signals of

engine-operating parameters are admitted by way of pipes 44, 45 respectively. The pressure signal in the pipe 44 and capsule 42 may be that of compressor delivery pressure, and the pressure signal in the pipe 45 and capsule 43 may be that of jet pipe pressure. The member 41 is in addition controlled by a flow signal from the device 21.

The device 21 comprises an orifice 48 in the branch 19 and a generally conical plug 49 carried by an arm 51 which is pivoted at 52. A resilient torsion rod 53 couples the arm 51 to the member 41 at the pivotal point 54 of the latter. Flow through the orifice 48 to the first inlet 23 turns the plug 49 and arm 51 in a clockwise direction about the pivot 52 against the torsional resilience of the rod 53, while the reaction of the latter applies a clockwise moment to the member 41.

The interior of the servo device 37 into which the nozzles 38, 39 discharge is vented by a pipe 50 to the interior of the flow-sensing device 21 so that servo fuel is discharged through the valve 23 to the outlet pipe 3.

When the control device is set to stop reheat fuel flow, there is no pressure in the fuel supply conduit 6 and the pressure maintaining relief valve 7 is closed. The plug 49 also closes the orifice 48 in the flow-measuring device 21, and there is substantially no torsional load in the rod 53. With the engine running on main burners only, compressor delivery pressured in the capsule 42 exceeds jet pipe pressure in the capsule 43 whereby the pilot valve member 41 is loaded against the nozzle 39.

When, therefore, reheat flow is begun and servo-pressure is available in the supply pipe 8 to the fixed restrictors 46 and 47, the pressure at the closed nozzle 39 will exceed the pressure at the open nozzle 38. The pressure acting through the pipe 32 to hold the distributor valve spool 27 in the fully closed position will exceed the pressure acting through the pipe 28 to open the valve. Initially, all the reheat fuel flows through the flow-measuring device 21 and the low pressure relief valve 23 to the fuel outlet pipe 3. As the flow increases, the plug 49 lifts from the orifice 48 and applies a torsional load through the rod 53 to the pilot valve member 41 which tends to lift the free end of said member from the nozzle 39 towards the nozzle 38. The pressure difference acting on opposite ends of the spool 27 therefore reduces progressively until the member 41 is balanced at a mid position between the nozzles 38 and 39.

The pressure in the capsules 42 and 43 determine the maximum fuel flow to the first burner, and the device 21 signals when this flow has been attained. Upon continued increase in reheat fuel flow, the flow feedback signal urges the free end of the member 41 towards the nozzle 38 so that increased pressure in the pipe 28 moves the valve spool 27 to begin opening the inlet port 24, FIGURE 2. A part of the total fuel flow in the supply conduit 6 now flows through the branch 26 and the inlet port 24 to the outlet pipe 4. At a given total flow rate, the spool 27 attains a stationary position in which the land 34 regulates the excess flow through the inlet port 24 such that the maximum flow through the branch 19 to the outlet pipe 3 is maintained. Upon a continued increase in reheat fuel flow, the port 24 is fully opened by the land 34, and any further flow increase is momentarily shared by the outlet pipes 3 and 4. The flow in the outlet pipe 3 therefore tends to exceed the maximum, thereby causing the device 37 to produce a control pressure in the pipe 28 which exceeds that in the pipe 32. The spool 27 then moves so that the land 35 begins to open the inlet port 25, FIGURE 3. Again, the spool 27 attains a stationary position in which the land 35 regulates the excess flow through the inlet port 25, such that maximum flow to the outlet pipe 3 is maintained, while there is a maximum flow to the outlet pipe 4 which bears a pre-determined ratio to the flow in the outlet pipe 3. Upon reduction of reheat fuel flow, the spool 27 moves to close first the inlet 25 and then the inlet 24.

The distribution valve may be extended to include more than two inlet ports through which fuel flow to a corresponding number of outlet pipes is regulated such that the inlet ports are opened and closed successively as the valve spool is moved in opposite directions respectively.

The invention is applicable to any form of engine having sets of burners which are brought into operation, or closed down, successively. For example, the supplementary burners may be reheat burners arranged in the main engine duct. In a by-pass type of engine the supplementary burners may be arranged in the by-pass duct to raise the temperature of the gas stream to approximately that in the main duct, with or without additional burners in the duct beyond the confluence of the two gas streams.

I claim as my invention:

1. A fuel supply system for gas turbine engines comprising,

(A) a fuel supply conduit (6) arranged to receive fuel from a variably controllable source (1, 2),

(B) a branch (19) from said conduit connected through a flow-sensing device (21) to a first burner supply pipe (3),

(C) another branch (26) connected through a distribution valve (22, 27) to a second burner supply pipe (4) and a third burner supply pipe (5) at least, the distribution valve having

(1) second and third burner ports to which the supply pipes (4) and (5) respectively are connected, and

(2) a fluid-actuated valve member (27) which is movable in one direction to open said ports one after the other to the supply of fuel in the conduit (6), and which is movable in the opposite direction to close said ports one after the other from the conduit (6), and

(D) a fluid servo device (37) operable to control the fluid-actuated valve member (27) and including

(1) means (42, 43) responsive to an input signal of at least one engine-operating parameter and

(2) another means (53) responsive to a flow signal from the flow-sensing device,

the fluid servo device (37) determining a maximum fuel flow to the first burner supply pipe (3) which is a function of the one or more engine-operating parameters, and controlling the fluid-actuated valve member (27) to maintain said maximum flow to the first burner supply pipe (3), when the total fuel flow in the supply conduit (6) exceeds said maximum, by regulating the excess flow to the second burner supply pipe (4) at least.

2. A fuel supply system according to claim 1, wherein the distribution valve comprises

(A) a cylinder (22) having an inlet port (24) associated with the second burner supply pipe (4) and another inlet port (25), axially spaced from said one inlet port (24) and associated with the third burner supply pipe (5), and

(B) a spool (27), forming the fluid-actuated valve member, having axially spaced lands (34 and 35) which co-operate with the inlet ports 24 and 25 respectively.

3. A fuel supply system according to claim 1, wherein the fluid servo device comprises a pilot valve having

(A) opposed nozzles (38, 39) which are fed with fluid pressure and which communicate with opposite ends of the fluid-actuated valve member (27), and

(B) a pilot valve member (41) which is movable between the nozzles under the influence of the one means (42, 43) and said other means (53) to vary the restriction of the nozzles and thus to vary the fluid pressures acting on the movable member (27) of the distributing valve.

4. A fuel supply system according to claim 3, wherein the flow sensing device comprises

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(A) an orifice (48) through which fuel flows in the branch (19) and
(B) a pivotally mounted arm (51) carrying a plug (49) which is movable with respect to the orifice (48) in response to a change of fuel flow, and a resilient torsion rod (53) forming the means which applies a flow signal to the pilot valve member (41).
5. A fuel supply system according to claim 3, wherein the fluid servo device (37) is fed with fuel through a branch (8) from the supply conduit (6) upstream of a

pressure-maintaining valve (7) which is formed as a spring-loaded relief valve.

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