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FUEL SYSTEM OF GAS TURBINE ENGINES

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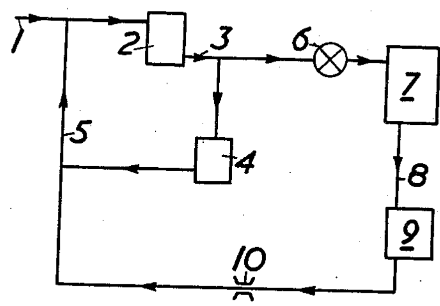

FIG. 1.

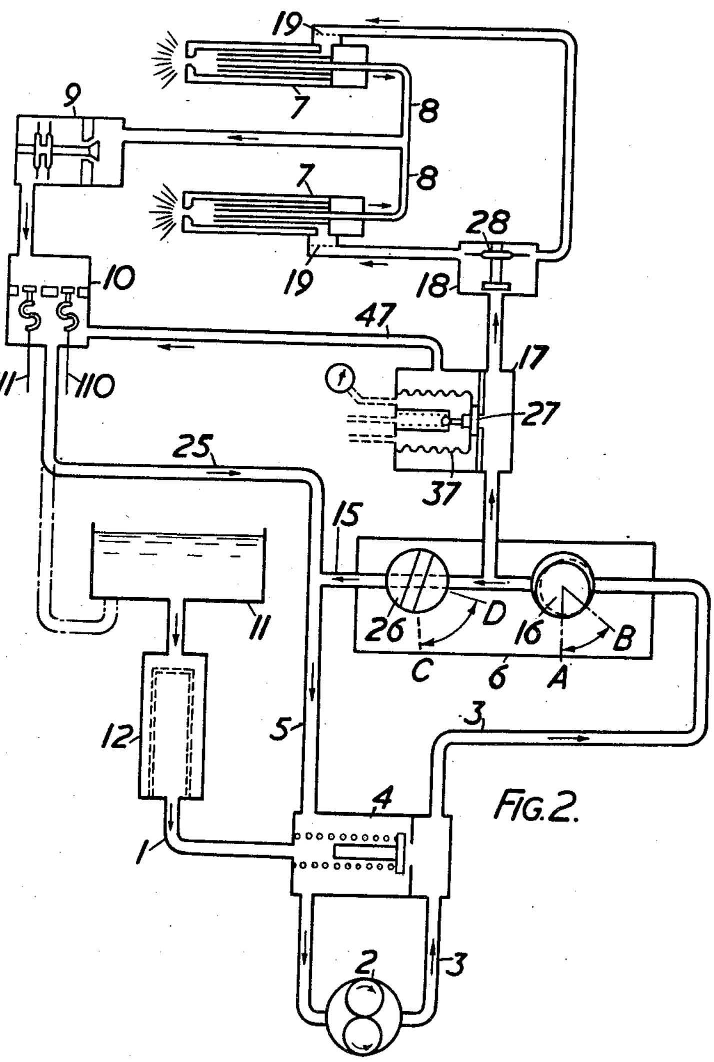

FIG. 2.

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1

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FUEL SYSTEM OF GAS TURBINE ENGINES

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1 Claim. (Cl. 60—39.28)

This invention relates to the control of the fuel supply to gas turbines having fuel burners of the so-called "spill control" type in which a supply of fuel enters the side of the burner and is led tangentially into a chamber in which it circulates with relatively high angular velocity prior to discharging through two alternative orifices of which one is the actual burner nozzle and the other leads back to the fuel pump inlet through a control valve.

For example, the invention refers to gas turbines of this type in which the fuel pump is of a positive displacement type and is mechanically driven from the turbine-compressor shaft of the gas turbine. A mechanically-driven pump of this type is convenient in many ways but it suffers from the disadvantage that if the gas turbine-compressor shaft has to operate at variable speeds the pump delivery varies in a manner which differs from the requirements of the engine.

In a simple spill-control system such a mechanically-driven pump might have its outlet connected to the inlet of the burner and arranged so that the output of the pump at idling speed is sufficient to supply the fuel required by the engine and the spill flow required for good atomisation, but at all higher speeds the pump delivery would then exceed the requirements of the engine by a varying amount and the spill would be adjusted to pass these amounts. The smallest size of pump would be that pump which matched the requirements of the engine at full load but such an arrangement would result in instability at some intermediate point where the amount by which the delivery of the pump exceeds the engine requirements is a maximum since at such a point a reduction in spill flow might correspond to either an increase or decrease in engine speed. This instability may be avoided by fitting a pump of such a size that this point where the spill is a maximum occurs at full load but this necessitates a large pump which would absorb much power at full load in supplying the spill flow, and furthermore to obtain this large spill flow the pump would have to work at high pressure.

Alternatively a relief valve might be fitted in the spill line so as to keep the pressure in the spill line at some predetermined value but this value would then control the speed of the engine, and in order to raise this speed, the pressure in the spill line would have to be raised. However, the pump delivery pressure, being dependent upon the engine speed, would increase more slowly which would result in a drop in spill flow and an increase in burner delivery which might easily exceed that required to cause the desired acceleration, and might lead to serious overheating.

Yet an other alternative would be to supply fuel to the burner at constant pressure, but this would entail a very large pump since the spill flow at idling would exceed the delivery flow to the engine at full load.

It is an object of the present invention to avoid these disadvantages, and to allow a mechanically-coupled pump to be used, the delivery of which only slightly exceeds the demand of the engine.

2

According to the invention we provide a fuel system of a gas turbine operating at varying rotational speed, comprising in combination: a spill control burner, a spill line leading from the said burner to drain, a fuel pump mechanically coupled to the said gas turbine, a fuel supply line connecting the inlet of the said burner to the outlet of the said pump, an automatic pressure reducing valve and a restrictor device responsive to gas turbine inlet temperature arranged in series in the said spill line, the said reducing valve and restrictor device keeping the spill flow through the said line substantially contant, and a control means in the said fuel supply line controlling the pressure at which the fuel is supplied to the said burner.

In order that the invention may be clearly understood and readily carried into effect an embodiment thereof will now be described by way of example with reference to the accompanying drawing in which:

Fig. 1 is a simplified diagram of the fuel system of a gas turbine engine according to the invention.

Fig. 2 is a more detailed diagram of this fuel system.

Referring first to Fig. 1, fuel is supplied through a supply pipe **1** to an engine driven pump **2**, the discharge pipe **3** of which is connected back to the supply side thereof through a relief valve **4**. The discharge pipe **3** is also connected through a manual control valve **6** to the inlet side of the spill burner **7**, the spill line **8** of which is connected through an automatic reducing valve **9**, a restriction **10** and pipe **5** to said supply pipe **1**.

For example, a gas turbine engine in which the maximum rotational speed is three times the idling speed may have a mechanically coupled fuel pump with a maximum capacity of 5 gallons per minute at full speed. Then the capacity of this pump at idling will be approximately 1.67 gallons per minute. Further, if this engine has a fuel requirement of 3.1 gallons per minute at full load and 0.3 gallon per minute at idling, then the spill control might be set to give a constant spill flow of 1.1 gallons per minute. This would result in a flow to the burner of 4.2 gallons per minute at full speed and 1.4 gallons per minute at idling speed both of which are within the capacities of the mechanically coupled pump. The relief valve **4** may be set to open at a pressure of 600 pounds per square inch.

Referring now to Fig. 2, a fuel tank **11** is arranged below the level of the burners **7** and connected through a filter **12** to the supply side of the pump **2** which is mechanically coupled to the engine. A spring loaded relief valve **4** is arranged between the discharge pipe **3** of the pump **2** and the supply pipe **1**, and may be set to open at, for example, 600 lb./sq. in.

The pipe **3** leads to the manual control valve **6** which contains a throttle valve **16** and a shut down valve **26**. The throttle valve **16** has a continuous range of throttling positions varying from an idling position A indicated in dotted lines to a full load position B indicated in full lines, while the shut down valve **26** is normally in a closed position C as indicated in full lines but when put into position D shown in dotted line provides a by-pass to the supply side of pump **2** through pipes **15** and **5**, and the casing of valve **4**.

Between the throttle valve **16** and the shut down valve **26**, the said manual control valve **6** is connected to a trip device **17** for lubricating oil failure and then through a loading valve **18** and filters **19** to the burners **7**.

The interior of bellows **37** of the trip device **17** is exposed to lubricating oil pressure so as to keep the valve **27** closed as long as the hydraulic force produced by the lubricating oil is greater than the hydraulic force produced by the fuel on the face of the valve **27**. In the event of a failure of lubricating oil pressure the valve **27** lifts and the fuel is by-passed through pipes **47** and **25** and **5** to the pump supply.

The loading valve **18** contains a capsule **28** partly filled with liquid which liquid safeguards the capsule **28** from damage when the pressure of the fuel oil is high, say of the order of 600 lb./sq. in. This loading valve **18** is arranged so as to require a pressure of approximately 60 lb./sq. in. on the valve face to lift the valve but, once it is lifted, the fuel pressure acts on the capsule **28** and keeps the valve open until the fuel pressure drops to a low value of, say 30 lb./sq. in. When the fuel falls below this minimum value, the valve **17** positively cuts off the fuel supply to the burners **7**.

The spill lines **8** of the burners **7** are connected to an automatic reducing valve **9** arranged to maintain the pressure before the restrictor **10** at some constant value and so to ensure a constant spill flow through the said restrictor **10** as long as the pressure in the spill lines **8** is above the said constant value. The valve **9** is adjustable so that the value at which the spill flow is kept constant may be chosen.

The restrictor **10** is preferably constructed as a modulating valve controlled by the temperature of the engine combustion chamber through lines **110** and **111**. This temperature-controlled modulating valve fully opens the spill line behind the reducing valve **9** when the temperature in the combustion chamber exceeds a predetermined value. When the spill line is thus opened, the spill flow is increased and the flow from the burner to the combustion chamber is correspondingly reduced, thus causing the temperature to fall until it reaches a predetermined value, when the valve **10** again restricts the orifice. In a gas turbine plant having more than one combustion chamber, there is a modulating valve **10** for each chamber arranged in parallel such that whichever chamber exceeds the predetermined value, causes the spill lines to be opened. Thus, in Fig. 2, line **110** would be connected to one combustion chamber and line **111** to the second chamber of an engine having two combustion chambers.

Instead of joining the spill lines **8** of the two burners and using a single automatic reducing valve **9** and two modulating valves **10** operating in parallel as shown in Fig. 2, there may be separate spill lines, separate reducing valves and separate modulating valves, one for each combustion chamber. The by-pass pipe **25** may, however, be common to both modulating valves.

It will be noted that the fuel control system according to the present invention dispenses with the usual tip shut-offs of spill burners, which shut-offs are necessarily exposed to high temperature and therefore liable to difficulties in maintenance. Furthermore, with constant spill flow the total amount of fuel entering the burner varies with the amount entering the combustion chamber, which simplifies the design of a burner to give good atomisation over a range of burner inlet pressures and fuel flows.

What we claim as our invention and desire to secure by Letters Patent is:

A fuel system of a gas turbine operating at varying rotational speed, comprising in combination: a spill control burner, a spill line leading from the said burner to drain, a fuel pump mechanically coupled to the said gas turbine, a fuel supply line connecting the inlet of the said burner to the outlet of the said pump, an automatic pressure reducing valve and a restrictor device responsive to gas turbine inlet temperature arranged in series in the said spill line, the said reducing valve and restrictor device keeping the spill flow through the said line substantially constant, and a control means in the said fuel supply line controlling the pressure at which the fuel is supplied to the said burner.

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