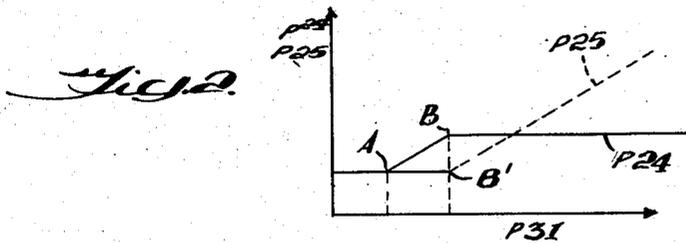
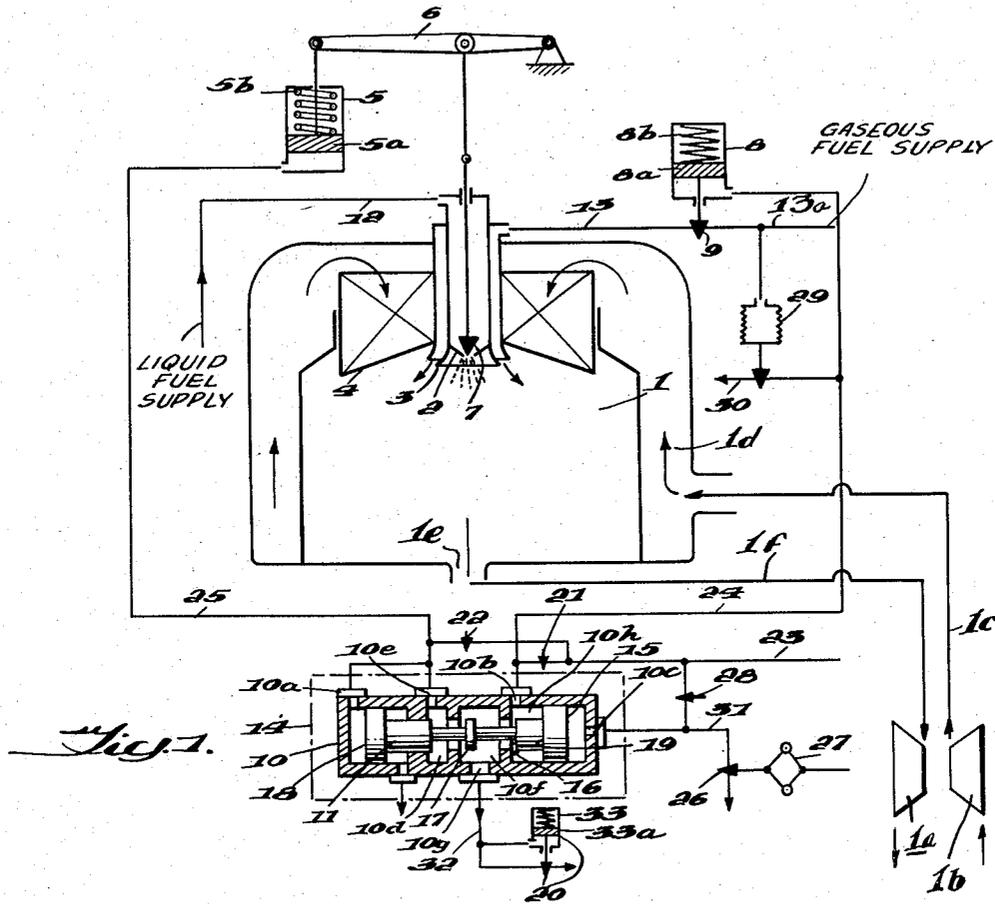


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 REGULATING DEVICE FOR BURNER OPERATING
 WITH SIMULTANEOUS COMBUSTION OF
 GASEOUS AND LIQUID FUEL
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REGULATING DEVICE FOR BURNER OPERATING WITH SIMULTANEOUS COMBUSTION OF GASEOUS AND LIQUID FUEL

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2 Claims. (Cl. 60—39.46)

This invention relates to fuel burners for the combustion chambers of gas turbines and in particular to fuel burners which burn gaseous and liquid fuels simultaneously.

In gas turbine installations which are operated with gaseous as well as with liquid fuel, it is desirable to be able to burn the two fuels simultaneously in one combustion chamber under certain circumstances, whereby it is usually intended to burn the gas, which is obtained in variable quantities, completely, and to add only an amount of liquid fuel needed to produce the desired amount of heat representative of the then existing power requirement of the gas turbine. In order to effect the desired result, it is thus necessary to provide a regulating arrangement which adjusts the amount of gas supplied automatically in accordance with the gas yield and, at the same time regulates the sum of the gaseous and liquid fuel quantities in accordance with the then existing power demand from the turbine.

The object of the present invention is to provide an improved regulating arrangement for the two fuels which are combusted simultaneously in the combustion chamber wherein the amounts of gaseous and liquid fuel are regulated by a fluid pressure system of the modulated type, the fluid pressure in the system being varied in accordance with the speed of the turbine, and including means actuated by that fluid pressure for controlling the amounts of gas and liquid fuels.

More particularly, the improved combined fuel regulating arrangement includes a compound pressure modulating valve which includes a plurality of pressure chambers and pistons and inlet and outlet ports which are controlled by the pistons. A fluid pressure system is provided for regulating the amount of gaseous fuel, a second fluid pressure system is provided for regulating the amount of liquid fuel, both systems being of the pressure modulated type and the amount of fluid flow which determines the pressure being controlled by the compound modulating valve in such manner that with a decrease in turbine speed, which is a signal for more heat, first the fluid pressure in the system which regulates the amount of gaseous fluid is increased thus resulting in an increase in the supply of gaseous fuel, and thereafter the fluid pressure in the system which regulates the amount of liquid fuel is increased thus resulting in an increase in the supply of liquid fuel. With an increase in turbine speed the amounts of liquid and gaseous fuels are decreased.

The foregoing and other object and advantages of the invention will be clear from the following detailed description of one practical embodiment of the invention

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and the accompanying drawings which in Fig. 1 shows such embodiment in diagrammatic form. Fig. 2 is a plot or chart illustrating the operation of the device by means of pressure vectors.

5 With reference now to Fig. 1, the combustion chamber of a gas turbine installation is illustrated in part at 1. The gas turbine 1a and compressor 1b are arranged as illustrated. Air compressed by the compressor 1b is delivered via conduit 1c to the air inlet 1d surrounding the combustion chamber 1, and the combustion products from the chamber 1 are taken out through outlet 1e and delivered via line 1f to the inlet of gas turbine 1a. The burner unit comprises a fuel nozzle 2 located in chamber 1 for supplying liquid fuel such as oil for combustion in the chamber. Nozzle 2 is surrounded by an annular inlet 3 which acts as a burner for gaseous fuel, and inlet 3 is surrounded by a plurality of vanes 4 through which the combustion air for the gas and oil enters the chamber in a turbulent condition.

20 The liquid fuel such as oil, flows to the nozzle 2 under constant pressure through a line 12 and is regulated by a needle 7 cooperative with the nozzle 2, needle 7 being actuated in and out of the nozzle by means of a pivoted lever 6 which is articulated to the piston 5a of a single-acting fluid motor 5, the fluid pressure being applied to one side of the piston and being opposed at the other side by a counter loading spring 5b.

30 The gaseous fuel flows to the annular inlet 3 through a line 13 and is regulated by means of a single-acting fluid motor 8, the fluid pressure being applied to one side of the piston 8a and being opposed at the other side by a counter loading spring 8b. Piston 8a is connected to and actuates a valve 9 in the gaseous fuel supply line 13.

35 The single-acting motor 5 which controls the amount of liquid fuel is controlled by a fluid pressure system of the pressure modulated type, the fluid pressure being applied to the piston 5a via line 25, and the line 25 being supplied with pressure fluid such as oil from a main supply line 23 through a throttling valve 22.

40 The single-acting motor 8 which controls the amount of gaseous fuel is controlled by a second fluid pressure system of the pressure modulated type, the fluid pressure being applied to the piston 8a via line 24, and the line 24 being supplied with pressure fluid from the main supply line 23 through another throttling valve 21.

45 A pressure responsive regulator 29 is connected to the gas supply line 13 and the actuating member of regulator 29 is coupled to a pressure modulating valve 30 in the pressure line 24 so that when the gas pressure in line 13a falls, valve 30 moves to a more open position thus decreasing the opening of the gas regulating valve 9 in line 13.

50 The pressure modulation in the two pressure systems 24 and 25 is controlled by a valve generally indicated at 14 comprising an elongated cylinder 10 and a piston 11 slidable therein to control leakage ports associated with the two systems 24 and 25. Piston 11 includes one piston surface portion 18 subjected to the fluid pressure existing in system 25 and which enters cylinder 10 through port 10a. A second piston surface portion 19 is subjected to the fluid pressure existing in system 24 and which enters cylinder 10 through port 10b. A third piston surface portion 15 is subjected to the fluid pressure of still another pressure system which enters the

cylinder 10 through port 10c from the fluid pressure line 31 which is also supplied with pressure fluid from supply line 23 through throttling valve 28. The amount of leakage from line 31 and hence the modulation in pressure applied against the piston surface portion 15 is controlled by a regulating device 27 which is responsive to speed of the turbine 1a, the device 27 actuating a pressure modulating valve 26 in the line 31 and controlling the amount of fluid passing to the leakage outlet from this line. As the turbine speed increases, valve 26 is opened wider and the pressure in line 31 decreases. Conversely, as the turbine speed decreases, valve 26 is moved to a more closed position and the pressure in line 31 increases. The fluid pressure in line 31 is a measure of the required turbine output.

The pressures exerted against the piston surfaces 18 and 19 oppose the pressure exerted against the piston surface 15.

The modulation for the pressure system 25 and also for the pressure system 24 is through the valve 14. It will be seen from Fig. 1 that line 25 enters the cylinder chamber 10d through a port 10e, passes longitudinally from this chamber into an adjacent chamber 10f through an axial aperture controlled by another surface portion 17 of piston 11, and from chamber 10f passes out through port 10g into the outlet, or return line 32.

In a similar manner, line 24 enters cylinder chamber 10h through port 10b, passes longitudinally from this chamber into the adjacent chamber 10f through another axial aperture controlled by another surface portion 16 of piston 11, and from chamber 10f passes through port 10g to the return line 32.

A pressure holding valve 20 actuated by the piston 33a of a fluid motor 33 responsive to the pressure in line 32 is inserted in the leakage return line 32 which, in the working range of the control valve 14, maintains the pressure p25, and which is referred to later, constant at an adjustable minimum value.

The pressure in the system 31 regulated in accordance with the turbine speed, the pressure in system 24 which regulates the amount of gaseous fuel supplied for combustion in chamber 1 and the pressure in system 25 which regulates the amount of liquid fuel supplied for combustion in chamber 1 are jointly effective as regards the valve 14 and particularly its piston element 11 such that the latter constantly maintains a relation:

$$ap_{24} + bp_{25} = p_{31}$$

In the above equation, p24, p25 and p31 designate respectively the fluid pressures in each of the pressure systems 24, 25 and 31: a and b are proportionality factors which are so selected that a pressure change in the system 31 always yields the same change in the heat supply to combustion chamber 1 regardless of whether such change in the heat quantity is brought about by a change in the quantity of the gaseous fuel or of the liquid fuel.

Fig. 2 illustrates the mode of operation of the improved fuel flow regulating system. When the pressure p31 in line 31 rises due to a decrease in turbine speed signifying an increase in load, it attains at point A a value at which forces acting upon piston 11 establish a condition of equilibrium. The forces exerted by the pressure p24 and p25 in lines 24 and 25, respectively, and by the piston faces 19 and 18, respectively, are directed to the right and their sum is equal to the force exerted to the left by pressure p31 on the piston face 15. If pressure p31 further increases, piston 11 is displaced to the left and the control edge 16 begins to throttle the discharge from line 24, i.e. at point A. Pressure p23 increases so far until the equilibrium is established again; it thus does not increase linearly with pressure p31. If enough gas is available in the line 13a to balance an increase in load, the gas regulating valve 9 opens so far with increasing pressure p24 until normal turbine speed is again attained. In such case the pressure in the line

13a remains constant and pressure regulator 29 is not brought into operation. Let it be assumed that at point B a pressure is obtained at which the gas regulating valve 9 allows the entire amount of gas available at that moment to pass through to the combustion chamber. If the gas network feeding line 13a is then already loaded to the limit the pressure in the gas network must not be reduced at random but must be kept at a constant level. If, under such a condition, the load on turbine 1a increases, pressure p24 rises and the gas regulating valve 9 opens further. This further opening of the valve 9 results in a drop of the pressure in the gas line 13a. Consequently, the gas pressure regulator 29 then becomes operative and opens the discharge line 30 so that pressure p24 drops again and the gas regulating valve 9 closes so far that the pressure in line 13a again attains its nominal value. In this manner, pressure p24 is limited by the gas pressure regulator 29 in dependence upon the amount of gas available. The same condition applies if the pressure in the gas supply line 13a drops due to a reduced amount of gas available rather than from an increase in load. Starting from point B, the pressure p24 thus remains constant. If the pressure p31 now continues to rise, the equilibrium of the forces acting on piston 11 is disturbed once again. The piston is displaced further to the left until the control edge 17 begins to throttle, i.e. at point B' which is located under point B. Thus the pressure p25 increases so as to increase the rate of supply of liquid fuel until the equilibrium at the valve is again reestablished; pressure p25 thus increases in dependence upon pressure p31.

In conclusion it will be seen that the pressure changes in the systems 24, 25 effect changes in the two fuel quantities through which the desired result is obtained; the quantity of gaseous fuel supplied to the burner is automatically adapted to the gas yield and moreover the sum of the gaseous and liquid fuels is accordingly adjusted to the required power demand as reflected by departures in turbine speed from the particular speed desired to be maintained.

I claim:

1. In a regulating arrangement for the burner of a combustion chamber for a gas turbine installation for the simultaneous combustion of a gaseous fuel and a liquid fuel, the combination comprising a supply line for the gaseous fuel leading to said combustion chamber, a second supply line for the liquid fuel leading to said combustion chamber, a fluid pressure responsive valve in each of said supply lines for regulating the fuel supply, a first fluid pressure modulation system for controlling said fuel supply regulating valve in said gaseous fuel supply line, a second fluid pressure modulation system for controlling said fuel supply regulating valve in said liquid fuel supply line, a third fluid pressure modulation system including a pressure modulating valve actuated in accordance with the speed of said turbine for regulating the pressure therein, and a pressure modulating valve connected in said first and second fluid pressure modulation systems for controlling the pressures in said systems and thereby varying the pressures applied to said fuel supply regulating valves in said gaseous and liquid fuel supply lines, said pressure modulating valve including a cylinder and piston operable longitudinally therein, said piston including a first piston surface subjected to the pressure in said third pressure modulation system and second and third piston surfaces acting in opposition to said first piston surface, said second piston surface being subject to the pressure in said first pressure modulation system and said third piston surface being subject to the pressure in said second pressure modulation system, and said piston further including two other surfaces controlling respectively the modulation in pressure of said first and second pressure modulation systems and so positioned that upon an increase in pressure in said third pressure modulation system indicative of a decrease in turbine speed, first the pressure of said first pressure

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modulation system is increased thereby increasing the flow of gaseous fuel to said combustion chamber and which is then followed by an increase in pressure of said second pressure modulation system thereby increasing the flow of liquid fuel to said combustion chamber, the pressure increases in said first and second pressure systems being dependent upon the increase in pressure in said third pressure modulation system.

2. The invention as defined in claim 1 and which further includes means responsive to a decrease in pressure in said supply line for the gaseous fuel for effecting a

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decrease in the pressure in said first fluid pressure modulation system thus moving said fluid pressure responsive valve in said gaseous fuel supply line to a more closed position.

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