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FUEL SYSTEMS FOR INTERNAL COMBUSTION ENGINES AND GAS TURBINES

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2 Sheets-Sheet 1

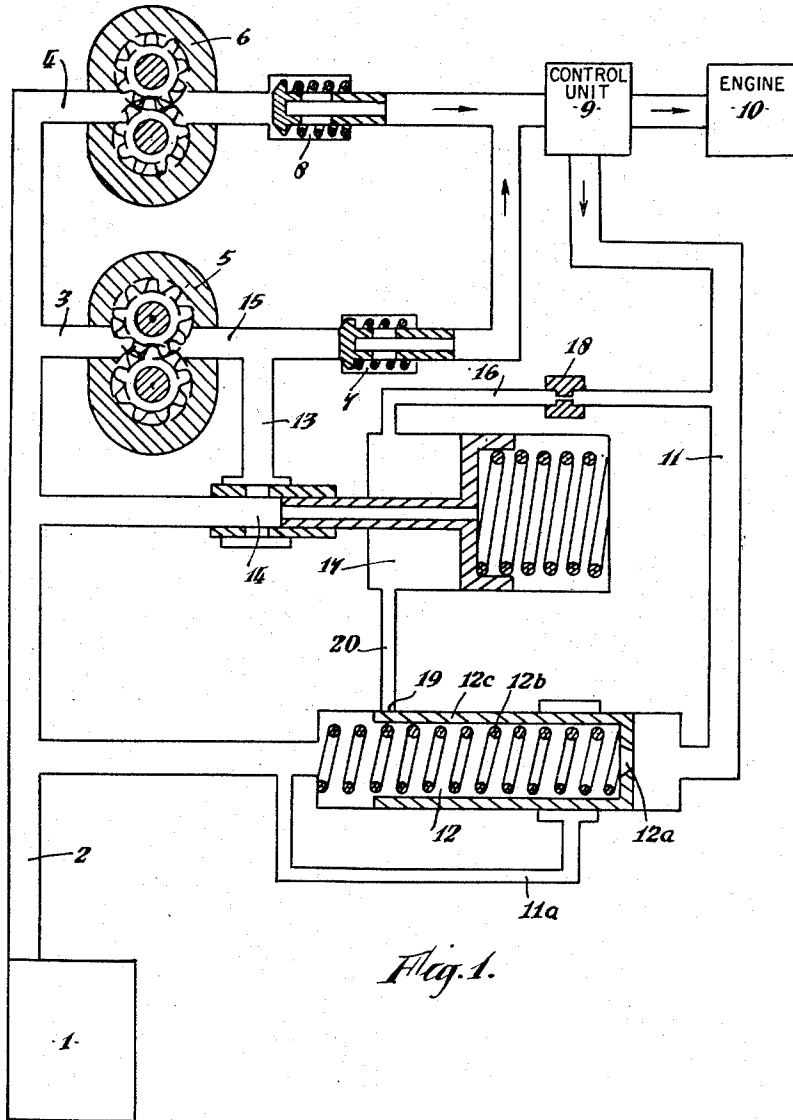


Fig. 1.

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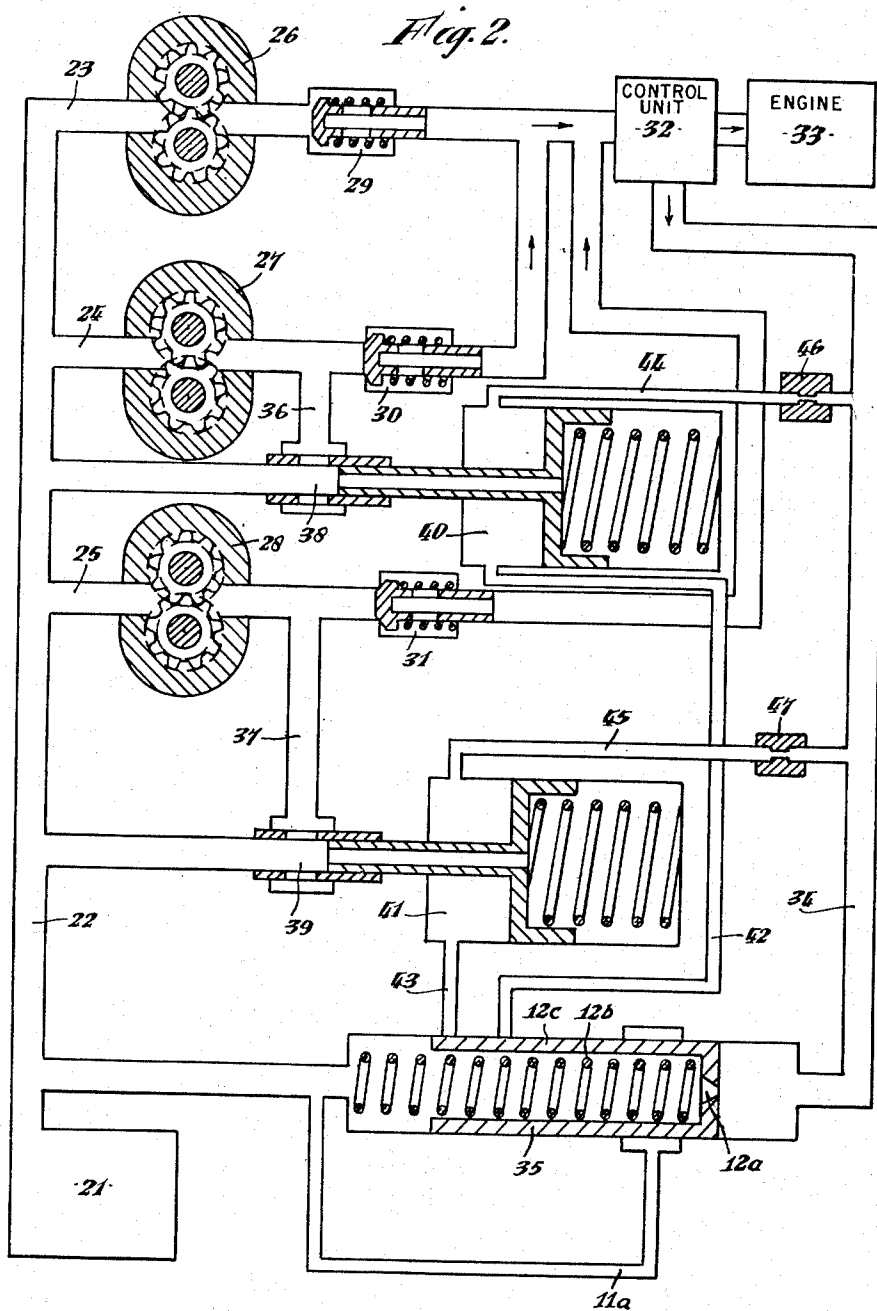
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FUEL SYSTEMS FOR INTERNAL COMBUSTION ENGINES AND GAS TURBINES

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2 Claims. (Cl. 158—36.3)

This invention relates to a fuel system for internal combustion engines and gas turbines, more particularly aircraft engines.

In an aircraft engine fuel system, it is sometimes desirable to save space, weight and to effect an economy, to use simple fixed displacement pumps to supply the engine with fuel. These pumps operate satisfactorily at low altitudes but at high altitudes, where the engine fuel requirements become low and it is necessary to by-pass a large proportion of the pump delivery back to the inlet, a considerable amount of energy is put into the small amount of fuel required by the engine. This causes a rise in temperature of the fuel which in extreme cases can cause failure of the pump or control system.

An object of this invention is to reduce this rise in temperature by using two or more fixed displacement pumps.

According to this invention, a fuel system has two or more pumps for supplying liquid fuel to an engine in excess of maximum requirements, the excess fuel being by-passed back to the low pressure side of the system, and a servo-valve means operatively connected with the delivery side of one or more of the pumps and the low pressure side, enabling the delivery from said pump or pumps to be separately by-passed at low pressure when the flow in the by-pass exceeds a pre-determined value, whereby one or more pumps is unloaded.

A feature of the invention is that a common flow responsive valve is provided irrespective of the number of displacement pumps and each said pump has a separated servo-operated valve and non-return valve, thus for example in the case of three or more pumps, the flow to low pressure from the second, third and so on pumps, operates in sequence. In the case where there are three pumps, if the demand is such that one pump is not required, it by-passes liquid fuel back to low pressure by the operation of its associated servo-valve means. If the demand for liquid fuel is still insufficient for two pumps, then the supply from the second pump is by-passed to low pressure through actuation of the second servo-operated means, thereby leaving one pump in operation.

The invention will now be described with reference to the accompanying drawings in which—

Fig. 1 is a block diagram of one embodiment using two pumps, and

Fig. 2 is a block diagram of a system using three pumps.

Referring to Fig. 1 of the drawings:

A tank 1 containing liquid fuel is connected by a conduit 2 to two parallel passages 3, 4. Each passage 3 and 4 contains gear pumps 5 and 6 for supplying pressurized liquid fuel through non-return valves 7, 8 to a control unit 9 of a known type.

The control unit 9 meters the correct amount of liquid fuel to an engine 10 and excess fuel is by-passed through conduit 11 containing a flow responsive valve 12 back

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to the low pressure side of conduit 2. The flow responsive valve 12 comprises a sleeve 12c in which is formed an orifice 12a and provided with a spring 12b. A passage 11a forms a continuation of conduit 11 when the flow responsive valve 12 is in the fully closed position.

A branch passage 13 leading from the passageway 3 of the pump 5 is connected to a servo-operated throttle valve 14 whereby pressurized fuel from the delivery side 15 of the pump 5 is passed to low pressure as hereinafter set forth.

A conduit 16 leading from the by-pass 11 to a servo-valve cylinder 17 contains a restrictor orifice 18.

A port 19 in the flow responsive valve 12 is connected by a passage 20 to the servo-valve cylinder 17 to adjust the throttle valve 14 in the passage 13.

The operation of the system will now be described as applied to an aircraft.

At low altitudes the fuel flow required by the engine 10 is high and the flow in the by-pass 11 will be below a pre-determined value. The flow responsive valve 12 will be in a position that will leave the port 19 open and the servo chamber 17 at low pressure. The servo valve 14 will be fully closed by the spring loading. Under these conditions both pumps 5 and 6 will be delivering their full capacity to the control unit 9.

As the aircraft climbs the amount of fuel supplied to the engine 10 will fall and the fuel flow in the by-pass conduit 11 will increase. This flow passing through the orifice 12a of the flow responsive valve 12 will give rise to a pressure drop across said orifice 12a and when this pressure drop reaches a predetermined value the sleeve 12c will move against the load of the spring 12b and start to close the port 19. This closing of the port 19 causes the pressure in the servo cylinder 17 to increase to approach the value of the pressure in the by-pass conduit 11 to which it is connected by the orifice 13.

This pressure in the cylinder 17 will overcome the spring load on the piston and start to open the valve 14.

As the fuel requirements of the engine continue to decrease the flow in the by-pass conduit will remain substantially constant while the excess fuel is by-passed through the servo operated valve 14 the pump 5 continuing to deliver a proportion of its output through the non-return valve 7 to the control unit 9. This action will continue until the entire delivery of the pump 5 is being by-passed through the servo operated valve 14. A slight increase in flow in the by-pass conduit 11 will now cause the flow sensitive valve 12 to close the servo bleed port 19 completely. This will cause the servo operated valve to move rapidly to its fully open position and the pump 5 will now be circulating fuel at virtually zero pressure and the non-return valve 7 will be closed. If the engine's fuel requirements continue to decrease the flow through the by-pass conduit 11 will again increase and will cause the sleeve 12c of the flow sensitive valve 12 to move back and allow the excess flow to pass through the low pressure connection 11a thus avoiding an increase of pressure through the orifice 12a.

Under these conditions the power input to the pumps 5 and 6 is reduced by one half with a consequent reduction in temperature rise compared with that which would occur if both pumps were operating at pressure. Under these conditions the power input to the pumps 5 and 6 is reduced by one half with a consequent reduction in temperature rise compared with that which would occur if both pumps were operating at pressure.

Referring to Fig. 2, the liquid fuel is supplied from a tank 21, by way of a conduit 22 communicating with three passages 23, 24, 25, arranged in parallel. Each passage 23, 24, 25 contains a gear pump 26, 27, 28 for supplying pressurized liquid fuel through non-return

valves 29, 30, 31 to a control unit 32 which in turn meters the correct amount of fuel to an engine 33 and excess liquid fuel is by-passed through a conduit 34 containing a flow responsive valve 35 in a similar manner to that described with reference to Fig. 1.

A passage 36 is connected from the delivery conduit 24 of the pump 27 and a similar conduit 37 is connected to the delivery conduit 25 of the pump 28, both conduits 24, 25 being provided with servo-operated throttle valves 38, 39 operated by hydraulic means consisting of a cylinder and piston arrangement 40, 41, passages 42 and 43 and conduits 44, 45 having an orifice 46, 47 located in each said conduit.

In operation, excess liquid fuel from the control unit 32 will move the flow responsive valve 35 to close the passage 42, thereby causing pressure to increase in servo-valve cylinder 40. This has the effect of opening servo-valve 38 and thereby causing fuel from the second pump 27 to be circulated back to the low pressure inlet 22 through the conduit 36, whereby the pump 27 is unloaded.

Should the flow in the by-pass 34 be sufficient to move the pressure responsive valve 35 further, thereby closing passage 43, it will cause a build up of pressure in the cylinder 41 which will open the valve 39 whereby the third pump 28 is unloaded, the system being maintained by the first pump 26.

The operation of the flow responsive valve 35 is similar to that herein described with reference to Fig. 1 with the exception that the pumps 27, 28 are operated in sequence and like reference numerals in Fig. 1 apply equally to those applied to the flow responsive valve 35.

A further advantage of this system is the additional safety factor, for if a pump should fail, the others will automatically take over. One pump is sufficient to maintain full power at altitude.

The system described for two and three pumps can be adapted to cover any number of stages.

I claim:

1. In a fluid control system, a fuel supply, first and second positive displacement pumps arranged in parallel and connected to said supply, a fuel system delivery connected to the outlet from said first and second pumps receiving fuel under pressure individually discharged by said pumps, a control unit metering the correct flow of fuel in said delivery and which is of the type that by-passes the excess fuel which is received by the same, a by-pass passage leading from said control unit to said supply returning such excess fuel from said control unit to the fuel supply, a branch passage leading from the outlet of the second pump and communicating with the fuel supply, a spring loaded servo-operated valve means arranged in said branch passage, a further passage in-

cluding metering means for applying fuel from the by-pass passage to operate the servo-operated valve in opposition to its return spring loading, a single flow responsive valve means arranged in said by-pass passage beyond said further passage and a separate passage-way controlled by said flow-responsive valve means connecting the servo-operated valve means with the fuel supply in a manner such that increased flow in said by-pass passage causes an opening movement of the servo-operated valve.

2. In a fluid control system, a fuel supply, a first positive displacement pump and at least two further positive displacement pumps each having an inlet and an outlet, the inlets of all said pumps being connected in parallel to said supply, a fuel delivery system connected to the outlets of all said pumps in parallel to receive fuel under pressure individually discharged by said pumps, a control unit metering the correct flow of fuel in said delivery, a by-pass passage leading from said control unit to the fuel supply, said unit being of the type that by-passes the excess fuel which is received by the same, a plurality of branch passages respectively leading from the outlet of each such further pump and communicating with the fuel supply, a plurality of individual spring-loaded servo-operated valve means respectively arranged in each such branch passage and respectively controlling the return flow of fuel to the supply through said branch passage, a plurality of further passages, each including metering means, for applying fuel from the by-pass passage to respectively operate each servo-operated valve means in opposition to the spring loading of such valve means, a single flow-responsive valve means arranged in said by-pass passage beyond said further passages, and a plurality of separate passageways controlled by the single flow-responsive valve means and respectively connecting each of said individual servo-operated valve means with the fuel supply in such manner that progressively increased flow in said by-pass passage causes sequential closing of said separate passageways resulting in sequential opening movements of said individual servo-operated valve means according to the increasing pressure of fluid in the by-pass passage.

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