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AUTOMATIC TORCH IGNITION SYSTEM FOR INTERNAL-COMBUSTION TURBINE ENGINES

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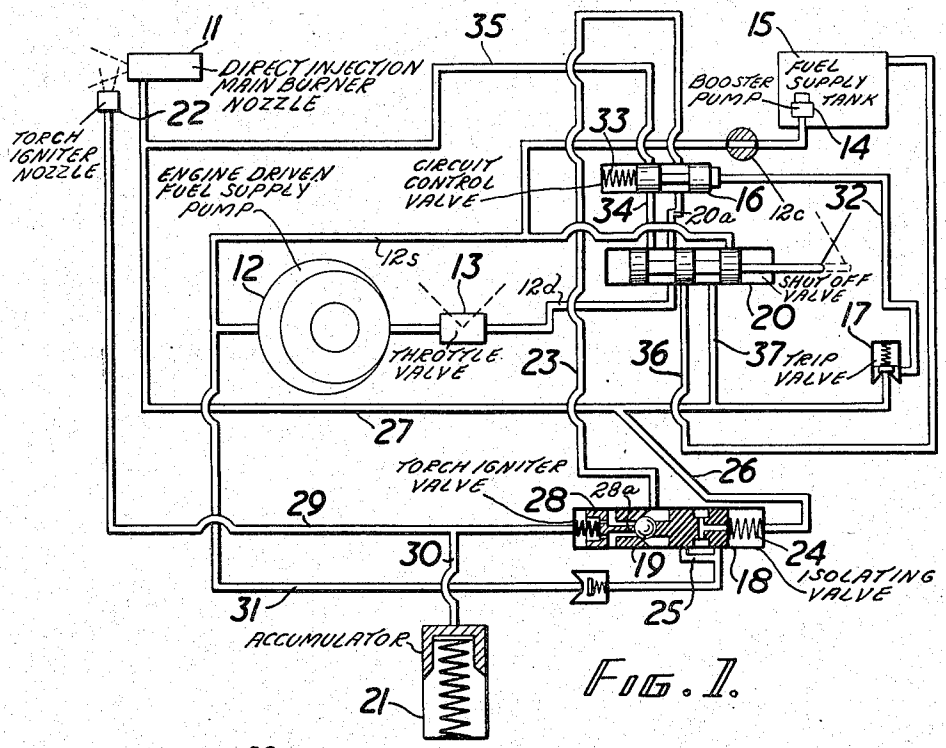


FIG. 1.

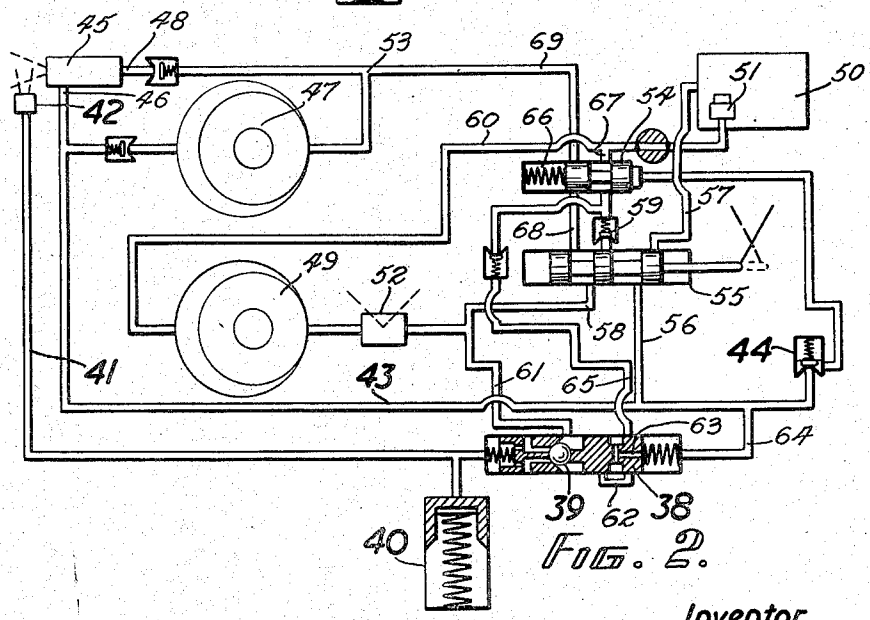


FIG. 2.

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AUTOMATIC TORCH IGNITION SYSTEM FOR INTERNAL-COMBUSTION TURBINE ENGINES

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8 Claims. (Cl. 158—36.4)

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When an internal combustion turbine engine is started up from rest, combustion of the mixture of air and atomized fuel delivered into the combustion chambers from the main burners is usually propagated from torch igniters which each comprise a spray nozzle directing a jet across the discharge orifice of one of the main burners, and an igniter, for example a sparking plug, which ignites the jet from the nozzle of the torch igniter which in turn ignites the jet from the main burner. Usually two torch igniters are employed in an engine. Hitherto the duration of supply of fuel to the nozzles of the torch igniters has been determined by the setting of an electric time switch. Thus the period during which the torch igniters function has been independent of the condition of operation of the engine.

The present invention seeks to provide an improved system in which the torch igniters will remain operative for a period dictated by the condition of the engine whereby the torch igniters will not be extinguished until a certain engine condition has been established. By way of illustration, fuel may be supplied to the torch igniter upon commencement of operation of the fuel supply system, and will continue to be supplied to the torch igniter until the system comes into full operation, whatever time period, long or short, may be required to produce this result, but almost immediately upon the system's coming into full operation, and as an automatic consequence thereof, the supply of fuel to the torch igniter is cut off, and remains off all during normal operation.

According to the present invention there is provided in the supply duct from an engine driven pump to the nozzles of the torch igniters a control valve which is sensitive to pressure from the supply pump so as to open and permit fuel from the pump to reach said nozzles, and which is arranged to close when a predetermined pressure has been created in the supply line to the main burners of the engine. Such valve, hereinafter referred to as the "torch igniter valve," may conveniently be associated with a trip valve and a circuit control valve. The trip valve will open when a predetermined pressure has been developed in the main burner system to permit fuel from the supply pump to reach the circuit control valve and so shift the latter to a position at which it cuts off the supply from the pump to the torch igniter valve and diverts such supply to the main burner system. Although not essential, it is considered desirable to provide between the torch igniter valve and the nozzles of

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the torch igniters a small accumulator which is charged with fuel during such time as the torch igniter valve is open and which, after the torch igniter valve closes, serves to provide for continued supply to the torch igniters for a brief period. The invention is applicable to systems in which the main burners are of the direct injection type, i. e. of the type in which all the fuel supplied to the burner passes out through its discharge orifice, or to systems in which the main burners are of the spill type, i. e. of the type in which, except during certain operating conditions, only a proportion of the fuel which is supplied to the burner passes out through its discharge orifice and the remainder flows back along a return line.

In order that the invention may be clearly understood and readily carried into effect two systems in accordance therewith will now be described by way of example with reference to the diagrammatic drawings forming part of the specification.

Figure 1 is a diagram of a fuel system arranged to supply fuel to direct injection burners, wherein the present invention is incorporated, and

Figure 2 is a similar diagram, wherein the system supplies fuel to spill type burners.

Referring to Figure 1 of said drawings, main burners of the direct injection type, of which one is indicated at 11, are supplied with fuel from an engine driven pump 12 via a throttle 13. The system comprises a booster pump 14 in a supply tank 15, a circuit control valve 16, a trip diaphragm-mounted valve 17, an isolating valve 18 and torch igniter valve 19, a high-pressure shut-off valve 20, an accumulator 21, and torch igniters one of which is indicated at 22.

The various parts are shown in the positions they occupy when the engine is at rest, the fuel supply pump 12 in consequence is not functioning, and flow in the several conduits has ceased.

At starting up, the separately driven booster pump 14 is first started up. Directly the pump 12 starts to turn with the engine, the pump is primed by fuel from the booster pump by way of conduit 12s (assuming that cock 12c is open), and delivers by way of conduit 12d through a section of the shut-off valve 20, and conduit 20a through the circuit control valve 16, and along a conduit 23 to one end of the isolating valve 18. The pressure of the fuel so delivered shifts the isolating valve 18 to the right against a spring 24 until the valve 18 partially uncovers a bleed port 25 at which position the valve is maintained by the action of the spring 24 and by the escape

of some of the fluid through the port 25. The fluid passing through the port 25 is able to flow through internal passages in the isolating valve 18 and along a branch conduit 26 leading to the line 27 extending from the burners 11 to the trip valve 17. Such movement to the right of the isolating valve 18 permits the torch igniter valve 19 to unseat, said latter valve being moved by the projection 28*a* on the spring loaded piston member 28. The piston member is apertured so that fuel from the conduit 23 can flow along the conduit 29 to the nozzles of the torch igniters 22. At the same time the accumulator 21 is charged through a branch line 30. While this is happening the tank booster pump 14, which is driven independently of the engine and which was previously set in motion, has, in accordance with our co-pending application Serial No. 36,011, filed June 30, 1948, now Patent No. 2,640,318 issued June 2, 1953, been serving to prime the supply pump 12 and has also been feeding into the main burner supply line 27 through conduits 12*s* and 31 and through the internal passages of the isolating valve 18 and the branch conduit 26. As soon as a predetermined pressure has been built up thus in the line 27 leading to the burners 11 the trip valve 17 will open and thereafter during continued operation will remain open, since the entire area of its diaphragm is now subject to system pressure, to permit fuel to flow along a conduit 32 to the circuit control valve 16 in order to shift said valve to the left against a spring 33. The valve 16 when so shifted will close the conduits 20*a* and 23 leading to the isolating valve 18 and to the torch igniter valve 19 both of which latter thereupon close. At the same time such shifting of the circuit control valve 16 places the supply pump 12 and its delivery conduit 12*d* in communciation with the burners 11 through conduits 34 and 35. Return movement of the isolating valve 18 to its closed position, as shown in Figure 1, and resulting from closure of conduit 23, prevents flow from the tank booster pump reaching the branch conduit 26 from the conduit 31 so that said booster pump now serves solely for priming the supply pump 12. Closure of the torch igniter valve 19 to its illustrated closed position, also resulting from closure of conduit 23, is followed for a short period by discharge from the accumulator 21 to the nozzles of the torch igniters 22. After this discharge has been expended the torch igniters extinguish and the system continues to function for normal running of the engine as dictated by the usual control including the throttle 13. When the shut-off valve 20 is moved to the stopping position, i. e. is moved to the right from the position illustrated, the outlet 12*d* of the supply pump 12 communicates with the tank 15 through a conduit 36 and the inlet of the pump 12 is placed in communication with the burners 11 through the branch conduit 37, as described in my co-pending application Serial No. 2,341, filed January 14, 1948, now Patent No. 2,530,649, issued November 21, 1950. The pressure in the lines 32 and 27 extending from the burners 11 to the circuit control valve 16 drops to permit the circuit control valve to return under the influence of its spring 33 to its original position, as illustrated. The conduit 32 which leads from the right-hand end of the circuit control valve 16 opens beneath the diaphragm carrying the valve element of the trip valve 17, hence the pressure in the conduit 32 brought about by the spring loading 33 is sufficient to lift or hold the valve 17 off its seat to permit escape of liquid from conduit 32 across the valve 17, into the now low-pressure conduit 27, and thus to permit the circuit control valve 16 to return to its original position. Closing of the trip valve 17 under the influence of its biasing spring follows return of the circuit control valve 16 to its original position. The system is now ready to be started again when desired after opening the shut-off valve 20. It should be noted that although return to its original position of the circuit control valve places the supply pump in communication with the previously closed conduit 23, the torch igniter valve will not unseat owing to the supply pump now being in unrestricted communication, by way of conduits 12*d*, 36, with the tank.

Figure 2 illustrates an arrangement in which the invention is applied to a fuel supply system incorporating the features of my copending application Serial No. 36,011 first referred to, and of my copending application Serial No. 2343 filed January 14, 1948, now Patent No. 2,608,247, issued August 26, 1952, in which latter application burners known as spill burners are supplied with fuel by circulating and supply pumps. As shown, a number of spill burners, one of which is indicated at 45, each has an inlet 46 connected with the delivery side of a circulating pump 47 and a return or spill orifice 48 connected with the inlet side of said pump. The pump 47 thus serves to circulate fuel round a circuit including the swirl chambers of all the burners. During normal operation of the system a supply pump 49 withdraws fuel from a tank 50 with the assistance of a booster pump 51 and, the circuit control valve 54 having been shifted to the left from the inactive position illustrated, to which it is biased by spring 66, delivers fuel through a throttle 52 by way of ducts 68, 69 to the point 53 of the circulating pump 47 at the inlet side of said circulating pump, and thence to intake 46 of the main burners. As in the Figure 1 arrangement, the system includes a circuit control valve 54, a trip valve 44, an isolating valve 38, a torch ignition valve 39 and a manually shiftable shut-off valve 55. This valve is shown occupying its left-hand position into which it is moved after the booster pump 51 has been set in operation and before the supply pump 49 has caused fuel to reach the burners 45 or the torch igniter nozzle 42. Before the shut-off valve had been moved to the left it served to connect the delivery side of the circulating pump 47 with the tank 50 by way of the conduit 43 and branch conduits 56 and 57. During such time as the circulating pump 47 is connected with the tank, the supply pump 49 delivers along the conduit 58 and across the non-return valve 59 into the conduit 60 connected on the one hand with the tank 50 and on the other hand with the inlet of the supply pump. When the shut-off valve 55 has been moved into the left-hand position shown in the figure, the whole of the output of the supply pump 49 is directed along the conduit 61 to between the isolating valve 38 and the torch ignition valve 39. Delivery from this pump 49 shifts the isolating valve 38 to the right to permit fuel from the conduit 61 to flow along the by-pass 62 and along the passage 63 to the conduit 64 which leads into the conduit 43 extending in the one direction to the burners 45 and in the other direction to the trip valve 44. The movement of

the isolating valve also permits delivery from the booster pump 51 to pass from the conduit 65 into the conduit 64 by way of the passage 63. The booster pump 51 and the supply pump 49 therefore both deliver to the inlets of the burners 45. The movement to the right of the isolating valve 38 also permits fuel from the conduit 61 to flow through the torch ignition valve 39 along the conduit 41 to the torch igniter nozzle 42 and into the accumulator 40. When pressure in the delivery line 43 reaches a predetermined pressure the trip valve 44 opens to allow fuel from the line 43 to reach the right-hand end of the circuit control valve 54 which latter thereby moves to the left against its spring loading 66. It will be seen that movement of the circuit control valve 54 to the left cuts off the branch line 67 from the booster pump 51 which now serves solely to prime the supply pump 49. Also the circuit control valve 54 now permits fuel to pass from the conduits 58 and 60 into the conduit 69 leading at 53 into the closed circuit of the pump 47. The build-up of pressure in the conduit 43 and in the conduit 64 then returns the isolating valve to the position shown and also closes the torch ignition valve. The torch igniter nozzle 42 continues to receive fuel only so long as the accumulator 40 is capable of supplying it whereafter the torch igniter is extinguished through lack of fuel supply. The system is now in its normal running condition in which the circulating pump 47 circulates fuel around the swirl chambers of the burners and the supply pump 49 delivers into the circulating flow at the inlet side of the circulating pump. The main burners discharge fuel to the extent that fuel is supplied into the circuit by the supply pump and this is controlled by the setting of the throttle 52. When the system is to be shut down the shut-off valve 55 is moved to its right-hand position in which the delivery side of the circulating pump 47 is in communication with the tank and the outlet of the supply pump 49 also communicates with the tank by way of the non-return valve 59. Communication between the conduits 58 and 60 is now interrupted. The main burners 45 will then become extinguished through lack of fuel supply.

It will be seen that in contradistinction to the hitherto employed arrangements in which the duration of the function of the torch igniters is determined once and for all by the setting of the electrically operated time switch, the duration of operation of the torch igniters in accordance with the present invention may vary and is determined by the build-up of pressure in the supply system of the main burners. Thus the torch igniters will not be extinguished until the main burners have reached a stabilized condition at which the engine should be capable of self running.

I claim:

1. A fuel supply system for delivery of fuel to a turbine engine of the continuous combustion type, which system comprises a torch igniter nozzle, a supply pump adapted to be driven by such an engine, conduit means including said pump and said nozzle, and including a portion adapted to be connected to a fuel source for supply of fuel to said pump, and also adapted to be connected by a normal running path to a main burner nozzle of such an engine but not to said torch igniter nozzle; a manually shiftable shut-off valve and a pressure-shiftable circuit control valve connected in such normal running path successively from said pump to the burner connection, and each having passages for inclusion in such normal running path and each shiftable to open or to close the normal running path, and conversely to close or to open an alternate path, said conduit means including another portion constituting such alternate path, between said pump and each of the main burner nozzle connection and said torch igniter nozzle, the shut-off valve and the circuit control valve having also passages for inclusion, in accordance with their respective shifted positions, in the alternate path; a torch igniter valve means in the alternate path, between the circuit control valve and the torch igniter nozzle, said torch igniter valve means being biased to close normally, but operable under the influence of pressure in the alternate path while the normal path is closed, to be opened thereby; and said conduit means including a pressure connection to said circuit control valve, and subject to system pressure, as delivered to the main burner nozzle connection by either path, to shift said circuit control valve automatically under the influence of such system pressure into position to open the normal running path and to close the alternate path, and so to terminate automatically the fuel supply to the torch igniter nozzle upon attainment of supply under adequate pressure to the main burner nozzle connection.

2. A fuel supply system as defined in claim 1, including additionally an accumulator in the alternate path between the torch igniter valve and the torch igniter nozzle, for limited further supply to the latter following closure of the former.

3. A fuel supply system as defined in claim 1, including a self-closing trip valve arranged in the pressure connection to the circuit control valve to prevent access of subnormal system pressure to the circuit control valve, and thus to retain the latter in position to close off the normal path, when itself closed, but subject to system pressure and arranged to open, for access of system pressure to the circuit control valve to shift the latter into position to open the normal path, upon attainment of a predetermined system pressure consonant with normal burner nozzle operation.

4. A fuel supply system for the supply of fuel to a turbine engine of the continuous combustion type, which system includes a main burner nozzle, a torch igniter nozzle, a supply pump means adapted to be driven by such an engine, and conduit means interconnecting said main burner nozzle, said torch igniter nozzle, and said supply pump means, said conduit means including also an intake duct for connecting the intake of said pump means to a fuel supply source, and a delivery duct leading from the pump means; a shut-off valve included in said delivery duct and manually shiftable from a running position to a stopping position wherein said delivery duct is closed, and vice versa; a pressure-shiftable circuit control valve to which said delivery duct leads, biased to remain in a position to close said delivery duct; said conduit means including further a duct leading from said circuit control valve to the main burner nozzle and constituting a normal running path, and an alternate duct leading from the shut-off valve and through the circuit control valve by one path to the torch igniter nozzle, and also by a second path to the main burner nozzle; a torch igniter valve means in the alternate duct, biased to close normally,

but openable under the influence of pressure in the alternate duct while the normal path is closed, for delivery from the pump to the torch igniter nozzle and to the main burner nozzle; and said conduit means including a pressure connection to said circuit control valve, and subject at all times to system pressure, as delivered to the main burner nozzle by either path, to shift said circuit control valve from its biased position automatically under the influence of such system pressure into position to open the normal running path and to close the alternate duct, and so to terminate automatically the fuel supply to the torch igniter nozzle upon attainment of supply under adequate pressure to the main burner nozzle, and at the same time to transfer supply to the main burner nozzle from the alternate duct to the normal path.

5. A fuel supply system as in claim 4, wherein the torch igniter valve means is itself biased to open, but wherein the system includes an isolating valve biased to close, and operatively connected to the torch igniter valve to hold the latter normally in closed position, said alternate duct branching at the torch igniter and isolating valves, one branch comprising said alternate duct which leads, as indicated in claim 4, past the torch igniter valve to the torch igniter nozzle, and the other branch leading past the isolating valve to said pressure connection and then to the main burner nozzle and to the circuit control valve to shift the latter, and a trip valve interposed in said other branch, intermediate the isolating valve and the circuit control valve, to open for pressure-shifting of the circuit control valve only upon the attainment of substantially full system pressure in said pressure connection.

6. A fuel supply system as in claim 4, wherein the pump means include a circulating pump and a supply pump, and wherein the conduit means include a closed circulating duct including the circulating pump and the main burners, the system's intake duct being connected to said supply pump, and the system's delivery duct including a connection from the supply pump and beyond the circuit control valve, to said closed circulating duct, and thence to the main burners.

7. A system for the supply of fuel to a turbine engine of the continuous combustion type, which system includes a main burner nozzle, a torch igniter nozzle, a fuel tank, a high pressure supply pump adapted to be driven by such an engine, a low pressure booster pump driven independently of such an engine to deliver fuel from such fuel tank to the intake of said supply pump; a suction conduit leading from the booster pump to the supply pump; a delivery conduit leading from said supply pump to the main burner nozzle; a shut off valve and a circuit control valve interposed successively in said delivery conduit between the supply pump and the main burner nozzle, said shut off valve being manually shiftable to open said delivery conduit for supply of

fuel to the main burner nozzle for normal running and starting the engine or to close said delivery conduit to cut off fuel supply to the main burner nozzle for stopping the engine, and the circuit control valve being biased to close said delivery conduit; a branch conduit subject to delivery conduit pressure at the burner; a trip valve in said branch conduit biased to close at pressures less than full pressure therein but openable at substantially full pressure; said branch conduit leading, past said trip valve, to the circuit control valve to shift the latter under the influence of full delivery pressure into position to open said delivery conduit; an alternative delivery conduit leading from the shut off valve and past the circuit control valve to said branch conduit at a point in advance of the trip valve, and arranged to be open to supply pump delivery pressure so long as the circuit control valve is in closed position; an isolating valve and a torch igniter valve operatively connected thereto and interposed in said alternative delivery conduit in advance of the trip valve and of the connection to said branch conduit, the isolating valve being biased to closed position and the torch igniter valve being biased to open position, but being held by the isolating valve in closed position; a torch igniter supply conduit leading from said torch igniter valve to the torch igniter nozzle, for supply of fuel to the latter by way of the alternative delivery conduit upon opening of the torch igniter valve; said isolating valve being sensitive to delivery pressure by way of said alternative delivery conduit to open at pressure in excess of the pressure of said booster pump, and thereby to permit opening of said torch igniter valve, and the trip valve being likewise sensitive to pressure past the isolating valve and the branch conduit, of a value in excess of the booster pump's pressure, to open.

8. A system as in claim 7, including a return conduit leading from the shut off valve to the fuel tank, and arranged relative to the shut off valve for connection to the supply pump's delivery conduit when the shut off valve is moved to closed position, and a connecting conduit leading from the shut off valve to the suction conduit, and arranged relative to the shut off valve for connection to the branch conduit, for return of fuel from the burner to the intake of the supply pump, and thence by way of said return conduit to the fuel tank, when the shut off valve is moved to closed position.

FREDERICK HENRY CAREY.

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