

Nov. 11, 1952

J. ISREELI

2,617,477

STAND-BY FUEL FEED CONTROL WITH HYDRAULIC SWITCHING

Filed Aug. 5, 1948

FIG. 1

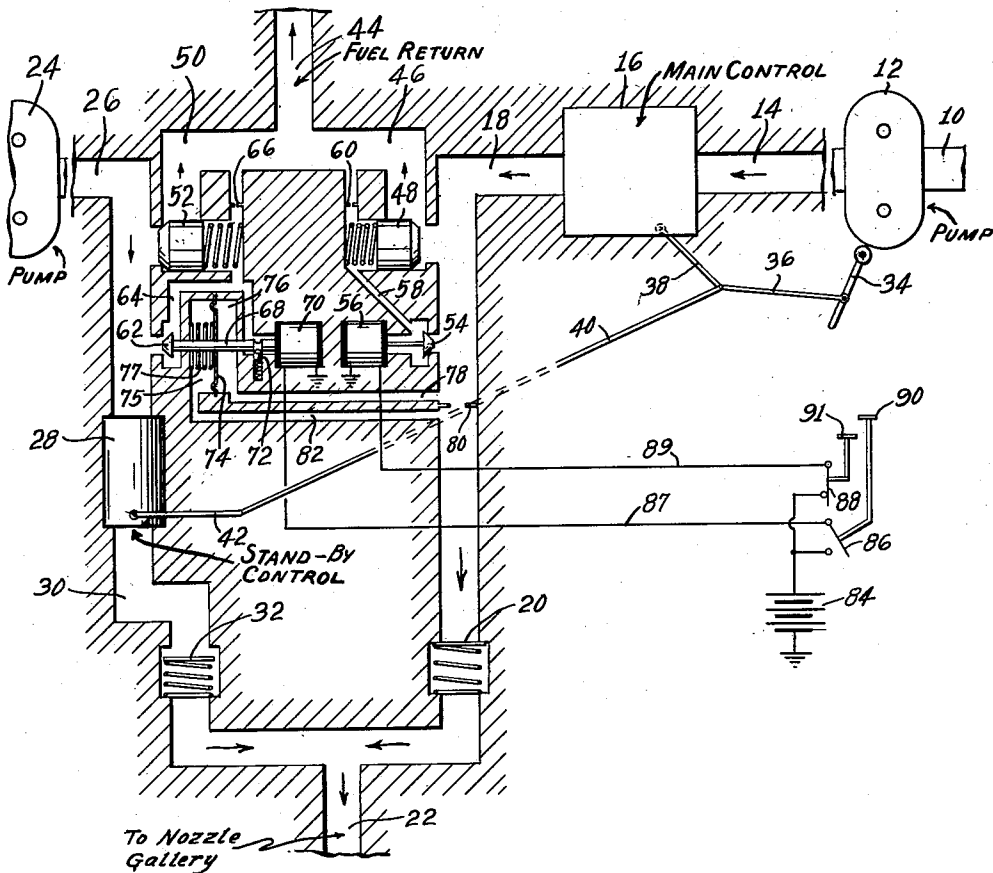
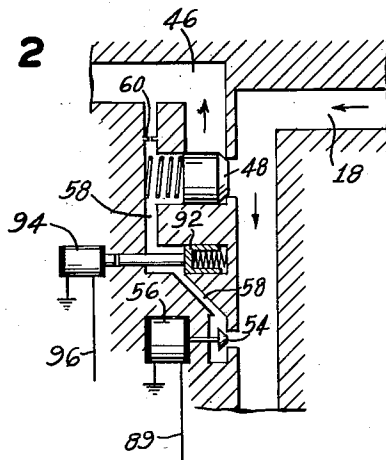


FIG. 2



INVENTOR
Jack Isreeli
 BY
Bonnie Edmonds, Milton and Barrows
 ATTORNEYS

UNITED STATES PATENT OFFICE

2,617,477

STAND-BY FUEL FEED CONTROL WITH
HYDRAULIC SWITCHING

Jack Isreeli, New York, N. Y., assignor to Simmonds Aeroaccessories Inc., Tarrytown, N. Y., a corporation of New York

Application August 5, 1948, Serial No. 42,645

13 Claims. (Cl. 158—36)

1

My invention relates to improvements in jet engine stand-by control systems for the supply of fuel to the engine in the event of the failure of the main control or fuel supply system. In a more particular sense my invention relates to improved automatic means for shifting the fuel supply to an engine from the main control to the stand-by control and the reverse.

Jet engines for aircraft are normally provided with a main automatic control and metering system for the supply of fuel to the engine in accordance with a given speed selection or schedule. An auxiliary stand-by control for the supply of fuel is highly desirable in engines of this type, particularly when they are used for military purposes, since either the electrical system or the main automatic control may be put out of order, damaged or shot away entirely.

In general, my invention constitutes an improvement upon a combined main automatic control and a stand-by control for jet engines of the type including a pipe-line for supplying fuel from a fuel supply and for delivering the fuel to the nozzle gallery and the jet engine, said pipe-line leading through and being under control of the main automatic fuel control and metering system thereof, a separate fuel supply line for supplying fuel from a source to the stand-by control system and connected into the line from and beyond the main automatic control leading to the engine nozzle gallery, a fuel return line connected into each of said fuel supply lines, a valve in each of the connections to the return line for controlling the flow of fuel from the supply line to the return line, a check valve in each fuel supply line between said valves and the engine nozzle gallery, pilot valve means for normally maintaining the valve between the main fuel supply line and the return line in closed position and an electrically controlled pilot valve means responsive to a predetermined pressure drop in the main fuel supply line between the main automatic control and the check valve in the line for closing the control valve between the stand-by fuel supply line and the fuel return line.

A system of this type which includes a metering mechanism in the stand-by control line is disclosed in pending application Serial No. 42,464, filed August 4, 1948, of which I am one of the inventors. The present application and application Ser. No. 42,464 are assigned to the same assignee.

The primary object of my present invention is to provide an improved automatic change-over

2

system for jet engines to automatically supply fuel to the engine through a stand-by fuel supply system in the event of a failure of the main control and the fuel supply associated therewith.

I have discovered that by providing a certain simplified arrangement in the system the fuel supply and the control thereof may be automatically changed over from the main automatic control to the stand-by control system in the event of the failure of the main automatic control or of the electrical system advantageously associated with the fuel supply systems. An important feature of my invention therefore is the provision of a hydraulic change-over system including an orifice in the main fuel supply line between the valve of the return fuel line and the check valve to provide a pressure differential in the line, and a pilot valve for the control valve between the stand-by fuel line and the return line having a diaphragm responsive to the pressure differential created in the main fuel supply line.

My improved change-over system also includes the feature of providing a needle type pilot valve operable by the diaphragm and having associated therewith a solenoid for operating the pilot valve, which in turn controls a supply of fuel for operating the control valve between the stand-by fuel line and the fuel return line.

An advantageous construction also includes a needle type pilot valve for controlling a supply of fuel for in turn controlling the positioning of the control valve between the main fuel supply line and the fuel return line, and a cut-off valve in the fuel line between these valves normally maintained in open position by a solenoid and by fuel pressure and which closes in the event of failure of the electrical system and a predetermined drop in pressure in the main fuel line.

In this application I illustrate and describe in detail one structural form embodying the features of my invention in connection with the accompanying drawings, it being understood that other structural forms may be made.

In the drawings:

Fig. 1 is a broken diagrammatic sectional view of an apparatus in connection with which the features of the invention are illustrated and described.

Fig. 2 is a broken diagrammatic sectional view of a portion of the apparatus shown in Fig. 1, illustrating a modified form of control for the pilot operated valve between the main fuel supply line and the fuel return line.

Referring to Fig. 1 of the drawings, the jet

engine fuel supply is normally drawn from a supply tank, not shown, through a supply line 10, and forced by an engine driven pump 12 through a line 14 into a main fuel metering and control system of known design and construction and shown diagrammatically at 16. The fuel metered through the control system 16 under normally operating conditions, is delivered through a line 18 having a check valve 20, into a main fuel line 22 leading to the nozzle gallery of the jet engine or engines.

In order to increase the safety of the aircraft and insure operation of the jet engine in case of emergency, the fuel for the stand-by control is not taken from the pump 12 or the supply line 10, but is drawn from a fuel tank, not shown, by a pump 24 which is advantageously independently driven by an electric motor, not shown. The fuel supplied by the pump 24 is forced under pressure through a line 26 into and through an emergency metering control system 28, shown only diagrammatically, and then delivered through a line 30, having a check valve 32, into the main line 22 leading to the nozzle gallery of the jet engine. The fuel sent through the main automatic control 16 is metered under control of a pilot's lever 34 connected to the control 16 by a link 36 attached to a fuel control lever 38. The link 36 is also connected by a link 40 and a lever 42 with the metering device of the stand-by automatic control 28.

In the normal operation of the apparatus, fuel is supplied continuously by pumps 12 and 24, and even when the main control is malfunctioning there may be some fuel supplied into the line 18. Provision is made for bypassing fuel either from the line 18 or the line 26 to a fuel return line 44. This means includes a branch line 46 between the line 18 and the return line 44, immediately down stream from the control 16, the line 46 being provided with a spring biased valve 48. In a similar manner, the line 26, in advance of the stand-by control 28, is connected by a fuel line 50 with the fuel return line 44, the line 50 being provided with a spring biased valve 52. The valves or valve members 48 and 52 are constructed alike and operated in substantially the same manner, that is, by the pressure of fuel in front and in back of these members.

The apparatus shown in Fig. 1 is illustrated with the valves and associated means in a position to supply fuel through the stand-by control, as may be the case in the engine starting position, the valve 48 being open and the valve 52 being closed, so that fuel is bypassed from the line 18 to the line 44, while the engine is supplied with fuel from the line 26 through the stand-by metering control 28 and the check valve 32. The check valves 20 and 32 are provided with light springs so as to provide minimum flow restriction. As shown, the check valve 20 is held closed by the pressure of fuel supplied through the stand-by control system.

The valve 48 controls a relatively large opening, and it is therefore advantageously operated by a needle type pilot valve 54 which is arranged to be closed by a solenoid 56. The valve 48 is shown as being held open against a spring by the pressure of fuel in the line 18. This valve is closed when the solenoid 56 is de-energized and the needle valve 54 permitted to open, so that fuel will flow through the valve 54 and a passageway 58 into the space in back of the valve 48, this space being vented to the return line 46 by a pas-

sageway provided with an orifice 60. The arrangement is such that the pressure of liquid flowing through the valve 54 and passageway 58 in back of the valve 48 holds it against its seat while a small amount of fuel continuously flows through the orifice 60. Since the pressure of fuel on each side of the valve 48 is equalized, the valve will be held to its seat because its back area is greater than the area of the front of the valve projecting through its seat and facing into the line 18. When the solenoid 56 is energized, as shown in Fig. 1, the valve 54 is closed, and therefore the pressure in back of the valve 48 falls off because of leakage through the orifice 60, so that the pressure in the line 18 moves the valve to open position.

The valve 52 is actuated in the same manner as the valve 48 but a needle valve 62 associated therewith has other functions. When the needle valve 62 is opened as shown, fuel from the line 26 flows through a passageway 64 in back of the valve 52 and is bled slowly through an orifice 66. The fuel pressure in back of the valve 52, keeps it seated because of the different valve areas referred to above in connection with the valve 48. The stem 68 of the needle valve 62 is actuated by a solenoid 70 when it is desired to close the valve by the electrical system. Means is provided for causing the valve 62 to snap from open to closed position comprising a recess in the stem of the valve 62 engaging the spring catch 72 when the valve 62 is open. The snap action is obtained because of the initial resistance provided by the catch 72 when pressure is applied to close the valve 62. A diaphragm 74 is attached to the stem 68 and arranged to provide a pair of annular chambers 75 and 76 around the stem for receiving fuel from the line 18. The diaphragm 74 is acted upon by a light spring 77 which tends to keep the valve 62 open. The chamber 76 to the right of the diaphragm 74 is connected by a passageway 78 into the fuel line 18 up-stream from a flow-restricting orifice 80, while the chamber 75 on the opposite side of the diaphragm 74 is connected by a passageway 82 with the fuel line 18 downstream from the orifice 80.

Under normal operating conditions, the valve 54 is open, the valve 48 closed, the valve 62 closed, and the valve 52 open. The pressure drop across the orifice 80 is normally sufficient to carry the needle valve 62 and the solenoid plunger or stem 68 to the left, so that the valve 62 is closed and maintained closed. Now, if for some reason, the main control 16, or fuel supplied thereto, should fail, the pressure drop across the orifice 80 would be reduced to such an extent as to be insufficient to overcome the spring 77. The valve 62 would therefore open, permitting fuel to flow through the passageway 64 and close the valve 52, thereby causing fuel to flow through the line 26, the stand-by metering control 28 and the line 30 into the main fuel supply line 22. It will be noted that this automatic change-over arrangement is entirely independent of any electrical operation of the solenoid 70.

If at any time while fuel is supplied by the pump 24, the main automatic control 16 should be repaired or go back into normal operation, fuel would flow through the valve 54 and passageway 58 to close the valve 48, thereby creating the normal pressure drop across the orifice 80, which would act upon the diaphragm 74 to close the valve 62 and therefore open the valve 52. At the same time, the fuel pressure in the line 18 would

5

open the check valve 20 and close the check valve 32.

The electrical system for the solenoids 56 and 70 includes any suitable source of electricity, such as a battery 84, one terminal of which is grounded, a switch 86 and a wire 87, for energizing the solenoid 70, one side of which is grounded. The electrical system also includes a switch 88 connected by a wire 89 to the solenoid 56, one side of which is grounded. The pilot may operate the switches 86 and 88 from buttons 90 and 91.

When the electrical system is in operation, as illustrated in Fig. 1, it is apparent that the pilot may select the stand-by control or the main control at will. If both switches 86 and 88 are left open, the main control will function, and if anything should happen to the metering system 16, the pump 12 or the fuel supply, the stand-by control system would automatically cut in, in the manner explained above. However, if the operator wishes to select the stand-by control, for example, in starting the engine, since the pump 24 is electrically driven and the pump 12 is driven by the engine, he actuates the switch button 91 to close the valve 54 and thereby bypass the fuel from the line 18 through line 46. Since the valve 62 is open, the valve 52 will be closed and fuel will be supplied through the stand-by control. After the engine is in operation the pilot may switch over to the main control by opening the switch 88 and closing the switch 86. When the electrical system is in operation, the valve 62 may be held closed by solenoid 70. If the electrical control system should fail, and the main fuel supply system is still in operation, the valve 62 will be held closed by the pressure of fuel on the diaphragm 74. The switch buttons 90 and 91 may be used as a "cut-off" for the engine since when both switches are closed the solenoids 56 and 70 will be energized to close the valves 54 and 62, so that valves 48 and 52 will open and the check valves 20 and 32 will close to stop the supply of fuel to the engine.

The stand-by control system is scheduled to meter a quantity of fuel slightly less than that supplied by the main control, the latter being regulated by the lever 38 while the stand-by metering control is regulated by the lever 42. Under these conditions, it is possible that after the main control has failed that it could produce short-lived pressures of a higher value than that of the rated pressure of the stand-by control, and therefore cause a change from the main system to the stand-by system and back again, under conditions which might give unsatisfactory engine operation. A change-over from the main supply to the reserve supply and back again can occur when the operator desires to check the reserve supply system for proper operation prior to take-off, or the change-over sequence can occur in flight if the main supply fails momentarily due possibly to temporary icing or dirt clogging. As long as the electrical control system is in operation this changing back and forth can be avoided by closing the switch 88 to keep the valve 54 closed and the valve 48 open.

However, the apparatus as shown in Fig. 1, may advantageously include a cut-off valve 92 such as shown in Fig. 2 which comes into operation in case of the failure of the main control or of the electrical control system. It will be noted that the valve 92 is arranged to close the passageway 58, and that it is held open against the biasing spring by energizing a solenoid 94.

6

If the electrical control system should fail and the main control is operating to supply fuel through the line 18 at normal pressure, the valve 92 is kept open against the valve spring by the fuel pressure in the passageway 58. As soon as the main fuel supply system fails so that the pressure therein falls below the established minimum, the spring for the valve 92 moves the valve to close off the flow of fuel through the passageway 58, thereby permitting the opening of the valve 48. At the same time the valve 62 would be opened and the valve 52 closed to send fuel through the stand-by system. The solenoid 94 is supplied with current through a line 96 which may be connected up through a switch in the pilot's cockpit and arranged to take current from the battery 84 or other suitable source.

From the foregoing description, it will be apparent that the improved apparatus of the present invention provides a system which is automatic and effective for the changing over of an engine fuel supply from a main control and supply system to a stand-by fuel supply and control system. The particular elements of the apparatus, and to some extent their arrangement, may be changed without departing from the spirit and scope of the invention as defined by the appended claims.

What I claim is:

1. In an apparatus for controlling the supply of fuel to an engine, means including a main fuel line for conducting fuel from a fuel supply to the engine, a main automatic fuel supply control in said line, a stand-by fuel supply line separate from the main fuel line for conducting fuel from a fuel supply to the engine, a stand-by fuel supply control in the stand-by fuel line, a fuel return line connected into the main fuel line down-stream of the control therefor and having a control valve therein, a fuel return line connected into the stand-by fuel line up-stream of the control therefor and having a control valve therein, means for normally maintaining the control valve in the fuel return line from the main fuel line in closed position, a check valve in the main fuel line down-stream of the fuel return line therefor, a flow-restricting means in the main fuel line between the check valve and the fuel return line therefor for creating a normal pressure drop in the main fuel line at the position of said flow-restricting means, and means responsive to the maintenance of a normal pressure difference in the main fuel line on opposite sides of said flow-restricting means for keeping the control valve open in the fuel return line from the stand-by fuel line.

2. An apparatus as defined by claim 1 in which the control valve in the fuel return line from the stand-by fuel line includes a piston-like valve member mounted in a cylindrical chamber, a passageway for fuel from the stand-by fuel supply line to the back portion of the chamber in which the piston-like member moves, a passageway having an orifice therein leading from said chamber to the return line from the stand-by fuel line, and a needle-valve means in said passageway for fuel from the stand-by fuel supply line, said needle valve means being responsive to fuel pressure changes in the main fuel line for controlling the flow of fuel through said passageway from the stand-by fuel supply line.

3. An apparatus for controlling the supply of fuel to an engine as defined by claim 1 in which the control valve in the fuel return line from the stand-by fuel supply line includes a piston-like

valve member mounted for reciprocation in a chamber, a passageway leading from the stand-by fuel supply line to the chamber in back of the piston-like member, a passageway having a leakage orifice leading from said chamber into the fuel return line from the stand-by fuel line, a small valve in the passageway leading from the stand-by fuel supply line, a solenoid operatively associated with said small valve for effecting its operation, and means responsive to pressure changes in the main fuel line for operating said small valve.

4. An apparatus for controlling the supply of fuel to an engine as defined in claim 1, characterized by including a valve member for each control valve, and a relatively small pilot valve for controlling the actuation of each valve member, thereby controlling the flow of fuel to the return line, the pilot valve for the control valve in the stand-by return line being connected to said responsive means and operable thereby.

5. An apparatus as defined by claim 1 in which the control valve for controlling the flow of fuel from the stand-by fuel line into its return line includes a piston-like valve member mounted in a cylindrical chamber, a passageway for fuel from the stand-by fuel supply line to one end-portion of the chamber in which the piston-like member moves, a needle-type valve member in said passageway for controlling the flow of fuel therein, said needle-type valve having a stem extending through a chamber and attached to a diaphragm dividing the chamber in two, and passageways respectively connecting the chambers on the opposite sides of said diaphragm with the main fuel supply line, one above and one below said flow-restricting means.

6. An apparatus as defined by claim 5 in which the chamber on the side of said diaphragm opposite the needle-type valve is connected into the main fuel supply line upstream from said flow-restricting means, whereby the pressure drop created in the main fuel supply line is effective for maintaining said needle-type valve in closed position.

7. An apparatus as defined by claim 6 in which the stem of the needle-type valve comprises the plunger of a solenoid for actuating the needle-type valve to closed position.

8. An apparatus as defined by claim 1 in which the control valve in the fuel return line from the main fuel supply line comprises a hydraulically operated piston-like valve member movable endwise in a chamber, a passageway between the main fuel line and a chamber in back of said piston-like member, a valve in said passageway including a piston-like member normally retainable in open position by the pressure of fuel in the passageway, and a solenoid adapted to hold said last-mentioned valve member in open position when energized.

9. An apparatus as defined by claim 1 in which the control valve in the fuel return line from the main fuel supply line includes a piston-like member movable endwise in a chamber, a passageway for fuel between the main fuel line and the chamber in back of the piston-like member, a solenoid operated needle-type valve for said passageway, a second valve for said passageway including a piston-like member normally retainable in open position by the pressure of fuel in said passageway, and a solenoid associated with the piston-like valve member of said passageway and adapted to move said member to open position.

10. A change-over system for the supply of liquid including a common outlet line, a main supply line for conducting liquid to said outlet line, a stand-by supply line for conducting liquid to said outlet line, a return line connected into each of said supply lines, a control valve in each connection to the return line, the control valve in the connection between the stand-by line and the return line being a hydraulically operated valve comprising a piston-like closure member mounted for reciprocation in a chamber, a flow-restricting means in the main supply line downstream of its connection to the return line for creating a pressure drop in the main supply line, a hydraulically-operated means responsive to the maintenance of a pressure drop in the main supply line at the position of said flow-restricting means for keeping the piston-like valve member in open position for the flow of liquid from the stand-by supply line to the return line, said hydraulically-operated means including a passageway from the stand-by supply line to the chamber in back of the piston-like valve member, a needle-type valve member for said passageway, means forming a pair of chambers adjacent said needle-type valve member including a flexible diaphragm separating said chambers, said needle-type valve member having a stem extending through one of said chambers and attached to said diaphragm for operation thereby, a biasing spring around the stem and arranged to urge the diaphragm in a direction to move the needle-type valve to open position, and a passageway connecting the chamber on the side of said diaphragm opposite the needle-type valve member with the main liquid supply line on the high pressure side of said flow-restricting means.

11. An apparatus as defined by claim 10 characterized by including a passageway from the low pressure side of said flow-restricting means to the chamber on the side of said diaphragm adjacent the needle-like valve member.

12. A change-over system for the supply of liquid including a common outlet line, a main supply line for conducting liquid to said outlet line, a stand-by supply line for conducting liquid to said outlet line, a return line connected into each of said supply lines, a control valve in each connection to the return line, the control valve in the connection between the stand-by line and the return line being a hydraulically-operated valve comprising a piston-like closure member mounted for reciprocation in a chamber, a flow-restricting means in the main supply line downstream of its connection to the return line for creating a pressure drop in the main supply line, a hydraulically-operated means responsive to the maintenance of a pressure drop in the main supply line at the position of said flow-restricting means for keeping the piston-like valve member in open position for the flow of liquid from the stand-by supply line to the return line, said hydraulically-operated means including a passageway between the stand-by line and the chamber in back of the piston-like valve member, said passageway having a valve therein for controlling the flow of liquid therethrough, and a solenoid operatively associated with the valve in said passageway for moving it to closed position.

13. A change-over system for the supply of liquid including a common outlet line, a main supply line for conducting liquid to said outlet line, a stand-by supply line for conducting liquid to said outlet line, a return line connected into

each of said supply lines, a control valve in each connection to the return line, the control valve in the connection between the stand-by line and the return line being a hydraulically-operated valve comprising a piston-like closure member 5 mounted for reciprocation in a chamber, a flow-restricting means in the main supply line downstream of its connection to the return line for creating a pressure drop in the main supply line, a hydraulically-operated means responsive to the 10 maintenance of a pressure drop in the main supply line at the position of said flow-restricting means for keeping the piston-like valve member in open position for the flow of liquid from the stand-by supply line to the return line, said hydraulically-operated means including a passage- 15 way from the stand-by fuel supply line to the chamber in back of the piston-like valve member, an orifice bleed from said chamber, a snap-acting needle-type valve for controlling the flow of liquid in said passageway, and means for normally holding said needle-type valve in closed

position thereby permitting said piston-like valve member to be in open position for the flow of liquid from the stand-by supply line to the return line.

JACK ISREELI.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,229,132	Samiran	Jan. 21, 1941
2,394,506	Woods	Feb. 5, 1946
2,431,345	Samiran	Nov. 25, 1947
2,440,262	Groy et al.	Apr. 27, 1948
2,440,371	Holley	Apr. 27, 1948
2,464,802	Davin	Mar. 22, 1949

FOREIGN PATENTS

Number	Country	Date
918,123	France	Oct. 7, 1946