Nov. 17, 1959 R. J. POWELL ET AL 2,913,231

FUEL MANIFOLD

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FIG.1.

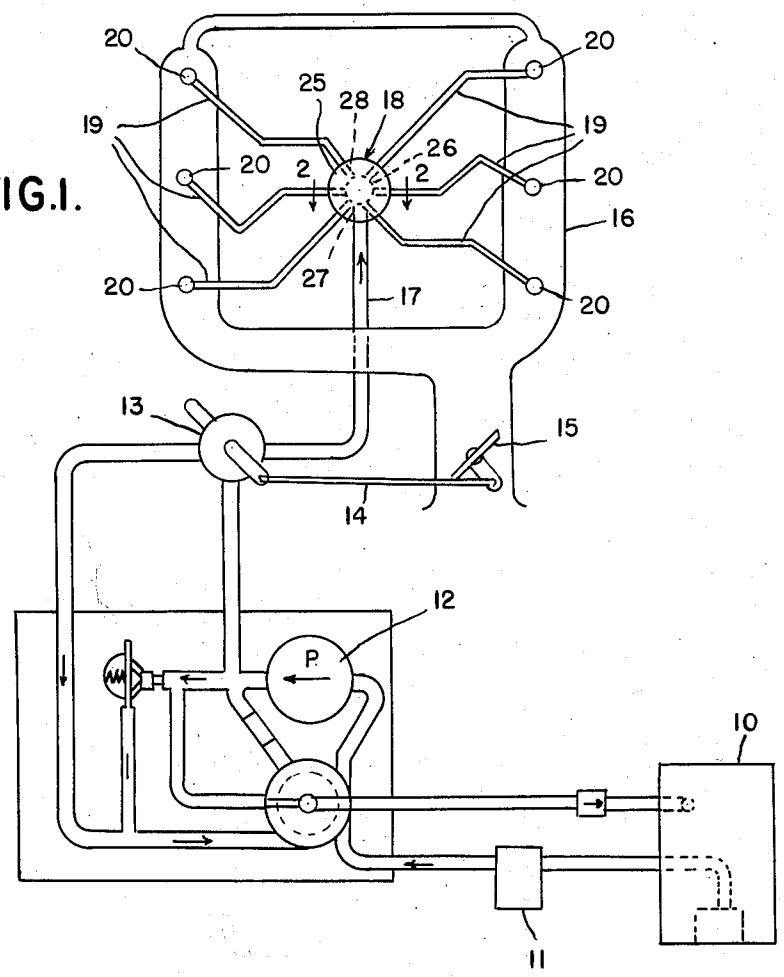

FIG.2.

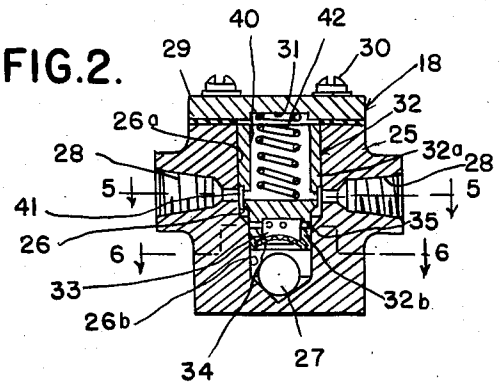

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FIG.3.

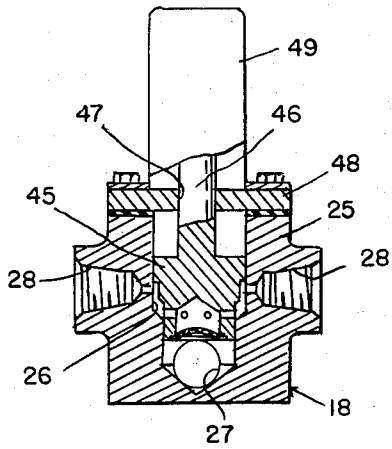


FIG.4.

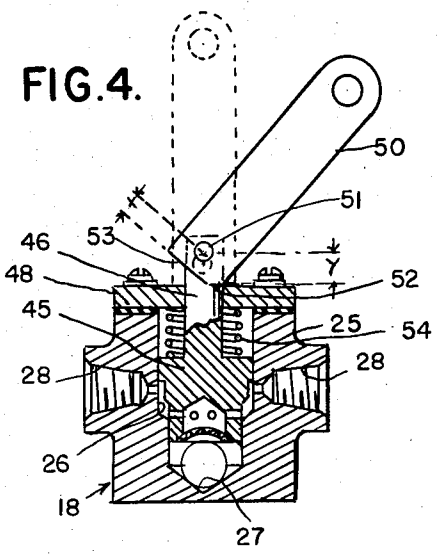


FIG.6.

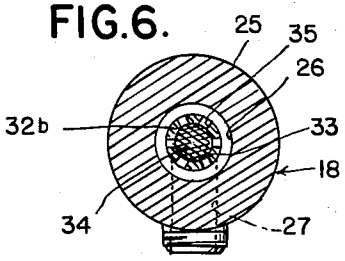
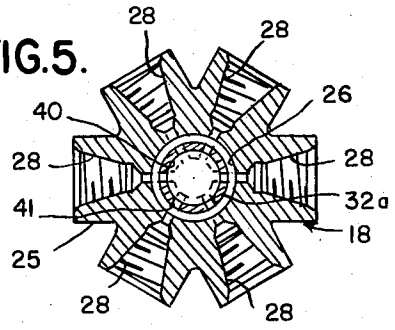


FIG.5.



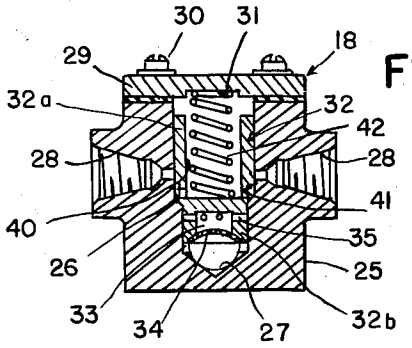


FIG.7.

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FUEL MANIFOLD

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Application January 16, 1957, Serial No. 634,539

11 Claims. (Cl. 261—23)

This invention relates to fuel injection systems for internal combustion engines and more particularly to continuous flow fuel injection systems preferably adapted for utilization in multi-cylinder engines for aircraft.

In the development of internal combustion engines employing continuous flow fuel injection, it is important to emphasize efficient starting and stopping characteristics. A vital factor in this respect is effective control of fuel in the fuel lines leading from the metering valve to the fuel injector nozzles. In starting the engine, it is necessary, to achieve prompt engine response, to provide immediate flow of fuel under pressure to the cylinders. This means that there should be no previous drainage of fuel from the fuel lines. Also, to provide for immediate fuel cutoff when stopping the engine, the system must insure that one or more cylinders will not be subject to any surge of injected fuel. Heretofore experience has shown that fuel cutoff at the metering valve is not enough, since fuel may be drawn from one cylinder fuel line back through another line to another cylinder, resulting in rough and ragged engine stopping operation. Moreover, in the case of aircraft engines particularly, when an engine is inoperative in a tilted position, fuel may drain from the higher lines into the lower, and when the engine is started, fuel is not immediately evenly supplied to every cylinder.

An object of the present invention is to improve engine starting and stopping characteristics by providing a fuel manifold valve operable to prevent fuel line drainage.

Another object of the present invention is to retain fuel in the cylinder fuel lines of a multi-cylinder engine embodying continuous flow fuel injection by providing a fuel manifold valve operable to disconnect or "shut-off" all fuel lines from each other.

A further object of the invention is to improve engine operation by providing a controllable fuel manifold valve of simplified construction.

For a more complete understanding of this invention, reference may be had to the accompanying drawings illustrating preferred embodiments of the invention in which like characters refer to like parts throughout the several views, and in which

Fig. 1 is a diagrammatic view of a preferred continuous flow fuel injection system embodying the present invention.

Fig. 2 is a cross-sectional view of one preferred construction of fuel manifold valve taken substantially on the line 2—2 of Fig. 1.

Fig. 3 is a cross-sectional view of another preferred construction of fuel manifold valve.

Fig. 4 is a cross-sectional view of another preferred construction of fuel manifold valve.

Fig. 5 is a cross-sectional view taken substantially on the line 5—5 of Fig. 2.

Fig. 6 is a cross-sectional view taken substantially on the line 6—6 of Fig. 2, and

Fig. 7 is a view similar to Fig. 2 but illustrating the valve in its closed position.

A preferred fuel injection system incorporating the present invention comprises a fuel tank **10**, a fuel cleaner **11**, a fuel pump **12**, a fuel metering valve **13** operatively connected by linkage **14** to a throttle valve **15** disposed in the air inlet of an air intake manifold structure **16** and operable to supply metered fuel under pressure through a conduit **17** to a fuel manifold valve **18**. A plurality of fuel delivery lines or conduits **19** connect the valve **18** with fuel injector nozzles **20** preferably mounted on the air intake manifold structure **16** at the engine cylinder air intakes.

A preferred construction of fuel metering valve is illustrated in Figs. 2, 5, 6, and 7 as comprising a valve housing **25** having a stepped, substantially cylindrical distributing chamber **26** including a larger diameter portion **26*a*** and a smaller diameter portion **26*b***, a fuel inlet passage **27** open into the smaller diameter chamber portion **26*b*** and adapted for connection with the conduit **17** leading from the metering valve **13**, and a plurality of fuel delivery outlet passages **28** separately and individually open into the larger diameter chamber portion **26*a*** and respectively adapted for connection with the fuel delivery conduits **19**.

The outlet passages **28** are preferably substantially disposed in a common plane normal to the axis of the distributing chamber **26**.

A cover plate **29** is preferably secured to the top of the housing **25** by any means such as screws **30**, and in the modification as shown in Figs. 2, 5, 6 and 7 is provided with a shallow spring recess **31** and closes the upper end of the chamber **26**. A stepped, substantially cylindrical piston-like valve member **32** is slidably disposed in the chamber **26** and comprises a larger diameter portion **32*a*** adapted to closely fit on the diameter in the larger chamber portion **26*a***, and a smaller diameter portion **32*b*** adapted to closely fit on the diameter in the smaller chamber portion **26*b***.

A recess or passage **33** in the smaller valve portion **32*b*** and having a fuel screen element **34** at its open end is continuously open to the fuel inlet passage **27**. A plurality of radially disposed ports **35** extend through the side of the valve portion **32*b*** so that when the valve is in the open position of Fig. 1, fuel may flow into the larger chamber portion **26*a***, but when the valve is in the closed position of Fig. 7, fuel flow is cut off by the close fit in the smaller chamber porton **26*b***.

A spring recess **40** is provided in the larger valve portion **32*a***, and is open to the larger chamber portion **26*a*** by means of ports **41** so that the movement of the valve **32** won't be restricted by suction or pressure in the recess **40**. A spring **42** is disposed in the recess **40** and bears against the bottom of recess **31** of the cover **29**, tending to hold the valve **32** in the closed position of Fig. 7, in which position, the passages **28** are closed off from the chamber portion **26*a*** by the valve portion **32*a***. In this position fuel flow from the inlet is cut off as previously described, and fuel flow or drainage among the separate fuel conduits **19** is also prevented. The ports **35** and the passages **28** are preferably substantially simultaneously opened and closed by the valve action.

Fuel pressure from the inlet **27** is sufficient to move the valve **32** upwards against the resistance of the spring **42**, opening the ports **35** and the passages **41**. However, in Figs. 3 and 4, two other preferred actuating means are illustrated. In both of these other cases, all elements of the fuel manifold valve **18** are the same as that hereinbefore described, with the exception of the valve member.

In both Figs. 3 and 4, a valve member **45** is provided with an extension **46** which extends through a hole **47** in a cover plate **48**, being connected as shown in Fig. 3 to a solenoid **49** or as shown in Fig. 4 to an actuating

lever 50. The solenoid 49 may be operated through any suitable circuit to selectively open and close the valve 45 in the same manner as pressure actuation does in the valve of Figs. 1 and 7. The manually operated lever 50 is preferably pivotally secured to the extension 46 as at 51 and has two cam surfaces 52 and 53 respectively located at distances "Y" and "X" from the pivot 51. The cam surfaces 52 or 53 may be selectively disposed by moving the lever 50 to bear on the upper surface of the cover plate 48, providing for the necessary axial movement of the valve member 45 to open and close same. A spring 54 is preferably provided as shown, bearing on the valve member 45 and the inside of the cover plate 48 to hold the lever 50 in either position.

Although we have described but a few preferred embodiments of this invention, it will be apparent to one skilled in the art to which the invention pertains that various changes and modifications may be made therein without departing from the spirit of the invention or the scope of the appended claims.

We claim:

1. In a continuous flow fuel injection system for a multi-cylinder internal combustion engine having an air induction system including branches communicating with the cylinders, said fuel injection system comprising a fuel distributing valve instrumentality having a fuel inlet, means supplying metered fuel to said inlet, and fuel delivery outlets openly connected with said inlet and respectively communicating with said induction branches, said distributing valve instrumentality comprising a valve housing having a distributing chamber openly connected with said inlet and with said delivery outlets, and a valve means in said chamber and selectively operable to disconnect said delivery outlets and said inlet from said chamber, and means actuating said valve means.

2. In a continuous flow fuel injection system for a multi-cylinder internal combustion engine having an air induction system including branches communicating with the cylinders, said fuel injection system comprising a fuel distributing valve instrumentality having a fuel inlet, means supplying metered fuel to said inlet, and fuel delivery outlets openly connected with said inlet and respectively communicating with said induction branches, said distributing valve instrumentality comprising a valve housing having a distributing chamber openly connected with said inlet and with said delivery outlets, and a valve means in said chamber and selectively operable to substantially simultaneously disconnect said delivery outlets and said inlet from said chamber, and means actuating said valve means.

3. In a continuous flow fuel injection system for a multi-cylinder internal combustion engine having an air induction system including branches communicating with the cylinders, said fuel injection system comprising a fuel distributing valve instrumentality having a fuel inlet, means supplying metered fuel to said inlet, and a plurality of fuel delivery outlets openly connected with said inlet and respectively communicating with said induction branches, said distributing valve instrumentality comprising a valve housing having a distributing chamber openly connected with said inlet and with each of said delivery outlets, and a valve means in said chamber and selectively operable to substantially individually simultaneously disconnect each of said delivery outlets and said inlet from said chamber, and means actuating said valve means.

4. In a continuous flow fuel injection system for a multi-cylinder internal combustion engine having an air induction system including branches communicating with the cylinders, said fuel injection system comprising a fuel distributing valve instrumentality having a fuel inlet, means supplying metered fuel to said inlet and a plurality of fuel delivery outlets openly connected with said inlet and respectively communicating with said induction branches, said distributing valve instrumentality comprising a valve housing having a distributing chamber, separate ports openly connecting each of said outlets and said inlet with said chamber, and a valve means in said chamber and selectively operable to substantially individually simultaneously close and open all of said ports, and means actuating said valve means.

5. In a continuous flow fuel injection system for a multi-cylinder internal combustion engine having an air induction system including branches communicating with the cylinders, said fuel injection system comprising a fuel distributing valve instrumentality having a fuel inlet, means supplying metered fuel to said inlet and a plurality of fuel delivery outlets openly connected with said inlet and respectively communicating with said induction branches, said distributing valve instrumentality comprising a valve housing having a substantially cylindrical distributing chamber, an inlet port opening into said chamber and connected with said fuel inlet, a plurality of annularly spaced outlet ports radially opening into said chamber and respectively individually connected with said fuel delivery outlets, and a substantially cylindrical valve member closely fitted on the diameter in said chamber and selectively longitudinally slidable therein to close and open said inlet port and said outlet ports, and means actuating said valve member.

6. In a continuous flow fuel injection system for a multi-cylinder internal combustion engine having an air induction system including branches communicating with the cylinders, said fuel injection system comprising a fuel distributing valve instrumentality having a fuel inlet, means supplying metered fuel to said inlet and a plurality of fuel delivery outlets openly connected with said inlet and respectively communicating with said induction branches, said distributing valve instrumentality comprising a valve housing having a substantially cylindrical distributing chamber, an inlet port opening into said chamber and connected with said fuel inlet, a plurality of annularly spaced outlet ports radially opening into said chamber and respectively connected with said fuel delivery outlets, and a substantially cylindrical valve member closely fitted on the diameter in said chamber and selectively longitudinally slidable therein to close and open said inlet port and said outlet ports, and means actuating said valve member, said outlet ports being disposed in a common plane normal to the axis of said distributing chamber, said valve member being constructed and arranged to simultaneously open and substantially simultaneously close said inlet port and said outlet ports.

7. In a continuous flow fuel injection system for a multi-cylinder internal combustion engine having an air induction system including branches communicating with the cylnders, said fuel injection system comprising a fuel distributing valve instrumentality having a fuel inlet, means supplying metered fuel to said inlet, and fuel delivery outlets openly connected with said inlet and respectively communicating with said induction branches, said distributing valve instrumentality comprising a valve housing having a stepped substantially cylindrical distributing chamber including a larger diameter portion and a smaller diameter portion, an inlet port opening into said smaller diameter portion and connected with said fuel inlet, annularly spaced outlet ports radially opening into said larger diameter portion and respectively connected with said fuel delivery outlets, and a stepped substantially cylindrical valve member having a larger diameter portion and a smaller diameter portion respectively closely fitted on the diameter with said chamber larger and smaller diameter portions, said valve member being selectively longitudinally slidable therein, a passage in said valve member continuously openly connected with said inlet port via the smaller diameter portion of said chamber, at least one port in said smaller diameter portion communicating with said passage and constructed and arranged to be open to the chamber

larger diameter portion when said valve member is in one position and to be closed by the chamber smaller diameter portion when said valve member is in a second position whereby to selectively permit fuel flow into said chamber larger diameter portion, and means selectively actuating said valve member from the first to the second position.

8. In a continuous flow fuel injection system for a multi-cylinder internal combustion engine having an air induction system including branches communicating with the cylinders, said fuel injection system comprising a fuel distributing valve instrumentality having a fuel inlet, means supplying metered fuel to said inlet, and fuel delivery outlets openly connected with said inlet and respectively communicating with said induction branches, said distributing valve instrumentality comprising a valve housing having a stepped substantially cylindrical distributing chamber including a larger diameter portion and a smaller diameter portion, an inlet port opening into said smaller diameter portion and connected with said fuel inlet, annularly spaced outlet ports radially opening into said larger diameter portion and respectively connected with said fuel delivery outlets, and a stepped substantially cylindrical valve member having a larger diameter portion and a smaller diameter portion respectively closely fitted on the diameter with said chamber larger and smaller diameter portions, said valve member being selectively longitudinally slidable therein, a passage in said valve member continuously openly connected with said inlet port via the smaller diameter portion of said chamber, at least one port in said diameter portion communicating with the passage and constructed and arranged to be open to the chamber larger diameter portion when said valve member is one position and to be closed by the chamber smaller diameter portion when said valve member is in a second position whereby to selectively permit fuel flow into said chamber larger diameter portion, and means selectively actuating said valve member from the first to the second position, said valve member larger diameter portion constructed and arranged to selectively open and close said outlet ports substantially respectively simultaneously with the aforesaid opening and closing of said valve member port.

9. In a continuous flow fuel injection system for a multi-cylinder internal combustion engine having an air induction system including branches communicating with the cylinders, said fuel injection system comprising a fuel distributing valve instrumentality having a fuel inlet, means supplying a metered fuel to said inlet, and fuel delivery outlets openly connected with said inlet and respectively communicating with said induction branches said distributing valve instrumentality comprising a valve housing having a stepped substantially cylindrical distributing chamber including a larger diameter portion and a smaller diameter portion, an inlet port opening into said smaller diameter portion and connected with said fuel inlet, annularly spaced outlet ports radially opening into said larger diameter portion and respectively connected with said fuel delivery outlets, and a stepped substantially cylindrical valve member having a larger diameter portion and a smaller diameter portion respectively closely fitted on the diameter with said chamber larger and smaller diameter portions, said valve member being selectively longitudinally slidable therein, a passage in said valve member continuously openly connected with said inlet port via the smaller diameter portion of said chamber, at least one port in said diameter portion communicating with the passage and constructed and arranged to be open to the chamber larger diameter portion when said valve member is in one position and to be closed by the chamber smaller diameter portion when said valve member is in a second position whereby to selectively permit fuel flow into said chamber larger diameter portion, and means selectively actuating said valve member from the first to the second position, said valve member larger diameter portion constructed and arranged to selectively open and close said outlet ports substantially respectively simultaneously with the aforesaid opening and closing of said valve member port, said outlet ports being disposed in a common plane normal to the axis of said distributing chamber.

10. In a continuous flow fuel injection system for a multi-cylinder internal combustion engine having an air induction system including branches communicating with the cylinders, said fuel injection system comprising a fuel distributing valve instrumentality having a fuel inlet, means supplying metered fuel to said inlet, and fuel delivery outlets openly connected with said inlet and respectively communicating with said induction branches, said distributing valve instrumentality comprising valve means selectively operable to disconnect said delivery outlets from said inlet, and means actuating said valve means and comprising an electrically operated solenoid actuating means connected with said valve.

11. In a continuous flow fuel injection system for a multi-cylinder internal combustion engine having an air induction system including branches communicating with the cylinders, said fuel injection system comprising a fuel distributing valve instrumentality having a fuel inlet, means supplying metered fuel to said inlet, and fuel delivery outlets openly connected with said inlet and respectively communicating with said induction branches, said distributing valve instrumentality comprising valve means selectively operable to disconnect said delivery outlets from said inlet, and means actuating said valve means and comprising a manually actuated cam actuator connected with said valve.

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