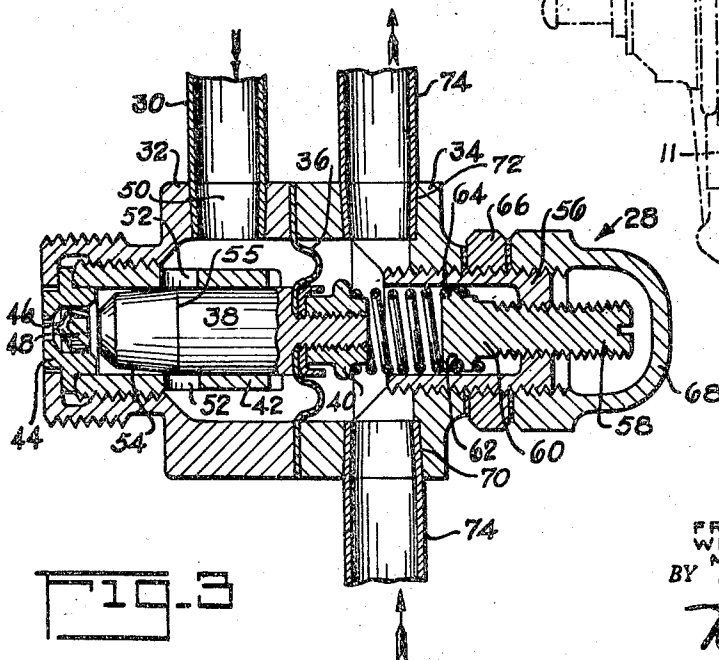
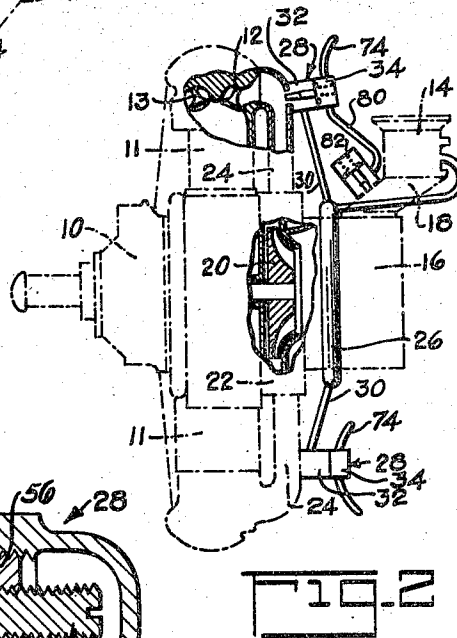
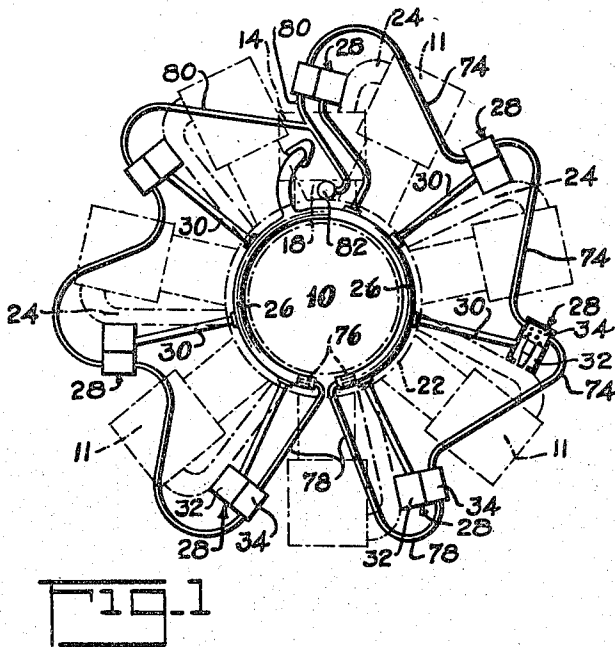


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CONTINUOUS FUEL INJECTION
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INVENTORS
FRANCIS J. WIEGAND.
WILLIAM T. STARK.
MARK R. ROWE.
BY *John E. Stark*
ATTORNEY

UNITED STATES PATENT OFFICE

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CONTINUOUS FUEL INJECTION

Francis J. Wiegand, Ridgewood, William T. Stark, Paterson, and Mark Robert Rowe, Teaneck, N. J., assignors to Wright Aeronautical Corporation, a corporation of New York

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This invention relates to fuel distributing systems and is particularly directed to a fuel distributing system for an engine.

In a multi-cylinder internal combustion engine it is necessary to properly control the fuel supply and its ratio to the air supply and to distribute the fuel and air equally between the various engine cylinders. In a carburetion type internal combustion engine the total flow of fuel is regulated in proportion to the airflow and is continuously discharged into the air intake duct of the engine induction system from whence the fuel-air mixture is distributed to the various engine cylinders through their respective intake pipes. In such a system the drop in temperature produced by the vaporization of the fuel upon discharge into the induction system may produce icing conditions therein, and in addition, if the fuel and air is not uniformly mixed, the fuel will not be uniformly distributed to the various engine cylinders. In lieu of such carburetion systems, internal combustion engines are also equipped with so-called fuel injection systems in which the fuel is individually and intermittently injected into each cylinder, thereby positively proportioning the fuel between the various engine cylinders. However, such intermittent fuel injection systems are complicated by the necessity of providing pump means in combination with selective valve mechanism for feeding and distributing the fuel to the various cylinders.

It is an object of this invention to provide a continuous fuel injection system which provides means for proportioning the fuel between the individual engine cylinders. It is a further object of this invention to provide means for controlling the total fuel flow in combination with means for continuously discharging the fuel through individual discharge nozzles associated with the engine cylinders. It is a further object of the invention to deliver the total regulated fuel supply to a reservoir connected to individual fuel discharge valves, each adapted to continuously discharge fuel into the intake pipe for an engine cylinder.

In an aircraft engine the relative elevation of the various engine cylinders will vary with changes in the attitude of the aircraft, and therefore, it is a further object of this invention to provide means to make the rate of fuel delivery of each discharge valve independent of changes in the relative elevation of the various engine cylinders and their associated fuel discharge valves.

Other objects of the invention will become apparent upon reading the annexed detailed de-

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scription in connection with the drawing in which:

Figs. 1 and 2 are schematic rear end and side views, respectively, illustrating the invention applied to a radial cylinder internal combustion engine, and

Fig. 3 is a detailed section view of one of the discharge nozzles.

Referring to the drawing, a conventional radial cylinder aircraft engine 10 is provided with radially disposed cylinders 11 having intake and exhaust valves 12 and 13, respectively. A carburetor or other fuel metering device 14, to which fuel is supplied under pressure, is supported on the engine or section 16. A carburetor adapter or conduit section 18 establishes communication between the carburetor and the intake of a conventional engine driven supercharger 20, which in turn discharges the combustion air into an annular manifold 22 from whence it is distributed to the various engine cylinders through their intake pipes 24. The structure so far described is quite conventional.

The fuel metering device 14 may comprise any suitable mechanism to which fuel is supplied under pressure and in which the fuel is metered and delivered under pressure, for example, in accordance with the total air flow as in the fuel metering device disclosed in Patent No. 2,165,447 to K. Browne. The metered fuel is delivered to a fuel reservoir or fuel distributing manifold 26 which, as illustrated, comprises two semi-circular branches disposed about the bases of the radially disposed cylinders 11. Each of the intake pipes 24 is provided with a fuel discharge valve or nozzle 28 having its inlet side connected to the fuel distributing manifold through a conduit 30. The fuel pressure communicated from the manifold 26 through conduits 30 to each discharge valve, urges each valve in an opening direction against a suitable spring or other balancing force. If the engine were always to remain in a substantially constant attitude, the spring biasing force for urging each of the valves in a closing direction could be adjusted to compensate for the difference in fuel pressure at each valve resulting from their difference in elevation. That is, with the engine remaining in a substantially constant attitude each valve 28 may be adjusted such that fuel is always discharged at the same rate into each of the intake pipes 24. Upon an increase or a decrease in the amount of fuel supplied to the manifold 26, each valve 28 will open or close to discharge fuel at a corresponding larger or smaller rate into its associated intake pipe.

With such an arrangement and with the engine maintained in a constant attitude, fuel is continuously discharged into each of the intake pipes at equal rates, the fuel being picked up by the air supply to each intake pipe and taken into the associated cylinders on their intake strokes. However, in operation, particularly in an aircraft engine installation, the relative elevation of the various fuel discharge valves will be continuously changing, and therefore, it is essential that such changes in relative elevation of the various valves have no effect or have the same effect on each valve in order to maintain the proper division of fuel flow through the valves.

To this end each fuel valve and the entire fuel system is designed so that fuel is admitted to both sides of the valve operating means in such a manner that the differential fuel pressure acting on each valve operating means is the same regardless of the relative elevation of these valves. With such a system the fuel discharge valves may be adjusted to properly divide the fuel flow regardless of the attitude of the engine.

Referring particularly to Fig. 3, each valve 28 comprises a housing of two halves 32 and 34 between which a diaphragm 36 is supported. A movable valve member 38 is secured to the diaphragm 36 by a nut 40 and is slidably received within an annular valve guide 42. The valve guide 42 is threaded within the housing part 32 and clamps a nozzle member 44 thereto. A conventional spiral type nozzle plug 46 is secured within the nozzle 44 and is provided with a plurality of helically disposed grooves 48 about its periphery. The housing part 32 has an inlet opening 50 for the conduit 30, whereby fuel is admitted therefrom to the interior of the housing and against the valve side of the diaphragm 36. The annular valve guide 42 is provided with one or more circumferentially spaced openings 52 and the valve member has a tapered end 54 cooperating therewith. For clarity this taper has been greatly magnified in the drawing. With this construction upon axial movement of the valve member 38, the junction 55 of its tapered end 54 with the remainder of the valve member moves across the openings 52 to control the extent to which the valve is open.

The valve housing part 34 is provided with an adjusting sleeve 56 threaded therein and an axially disposed adjusted screw 58 is threaded through one end of said sleeve. The screw 58 is provided with a head end 60 having a helical groove 62 about its periphery for receiving one end of a helically coiled spring 64. The other end of the spring 64 engages the nut 40 to urge the valve member 38 in a closing direction against the fuel pressure acting on the valve side of the diaphragm 36. Upon an increase in the fuel supplied to the fuel manifold 26, there will be an increase in the fuel pressure therein and at the inlet side of each of the valves, whereby this increased fuel pressure acts against the valve side of each valve operating diaphragm 36 to effect a further opening at each of the valves to maintain a proper division of the fuel flow. Any adjustment of the screw 58 relative to the sleeve 56 threads the helical groove 62 of the head 60 along the spring, thereby controlling the length and stiffness of the spring. Also, adjustment of the sleeve 56 determines the fuel pressure at which the valve member 38 begins to open. In order that the sleeve 56 may be adjusted without disturbing the adjustment of the spring 64, the threads on the exterior of the ad-

justing sleeve 56 may be right handed and its internal threads cooperating with the screw 58 may be left handed, but of the same pitch. A lock nut 66 and a cap 68 are threaded about the sleeve 56 as illustrated.

In addition to the action of the springs 64, each of the valves 38 is also urged in a closing direction by a fuel pressure admitted to the housing portion 34 and against the rear side of the diaphragm 36 through an inlet opening 70. The housing portion of each valve 34 is also provided with an outlet opening 72, and conduits 74 interconnect the exit opening 72 of one valve housing with the inlet opening of another valve housing to serially connect the chambers at the rear sides of the diaphragms 36. As illustrated in Fig. 1, the housing parts 34 of the fuel discharge valves for cylinders on the one side of the engine are serially connected together, and similarly, the valve housing parts 34 associated with the cylinders on the other side of the engine are serially connected together. Also, the lower ends of the fuel manifold 26 are connected to the inlet openings of the valve housing portions 34 for the lower end cylinders of each series through restricted orifices 76 and conduits 78. The outlet openings 72 of the valve housing portions 34 for the upper end cylinders of each series are connected through conduits 80 to a valve 82 discharging into the carburetor adapter. The valve 82 is a common type valve which is spring biased toward closed position and is urged toward open position in response to the fuel pressure supplied thereto. The valve 82 is designed to maintain a small back pressure in order to insure that the conduits 74, 78 and 80 and housings 34 remain full of fuel. Because of the small size of the restricted orifices 76, the magnitude and the range of the back pressure maintained by the valve 82 is much smaller than the magnitude and the range of the fuel pressure within the manifold 26. For example, the fuel discharge pressure at each discharge valve may vary from nine to eleven pounds per square inch between their closed and full open positions, while the back pressure maintained by the valve 82 varies from one to two pounds per square inch. The orifices 76 are designed such that the flow through the valve 82 is quite small; for example, a fuel flow through the valve 82 amounting to but one percent of the total fuel flow has been found to be satisfactory.

With this system each valve assumes a position in which the fuel pressure on the valve side of the diaphragm 36 balances the force of the spring 64 and the fuel pressure on the other side of the diaphragm. Upon an increase or a decrease in the amount of fuel supplied to the fuel distributing manifold 26 there will be a similar opening or closing adjustment of each fuel discharge valve to maintain a proper division of fuel flow. Also, the fuel pressure on the valve side of any two diaphragms 36 differs only by an amount dependent on the difference in the fuel head at each diaphragm, which depends only on the difference in elevation of the two diaphragms. Similarly, the difference in the fuel pressure on the rear side of any two diaphragms differs only by an amount dependent on the difference in the fuel head at each diaphragm, which difference also depends only on the difference in elevation of the two diaphragms. That is, if any one diaphragm 36 is at a higher elevation than a second diaphragm, the fuel pressure on both sides of the one diaphragm will be greater than the corresponding fuel pressures on the two sides of the

second diaphragm by an amount equal to the pressure resulting from a fuel head corresponding to their difference in elevation.

In other words, the fuel pressure differential on each diaphragm 36 is the same regardless of their relative elevation and therefore the extent to which each valve opening 52 is uncovered is always the same and the fuel flow through each valve is substantially the same. Actually, although each valve opening 52 is uncovered to the same extent, the pressure differential across these openings will be slightly larger for the lower valves because of the larger static fuel head on their inlet sides. However, this latter variation in pressure differential has substantially no effect on the relative magnitude of the fuel flow through each valve, particularly as compared to the effect on fuel flow which a corresponding variation in pressure differential across the diaphragms 36 would have because of the resulting variation in the extent to which each valve opening 52 would be uncovered. In fact, each valve 28 obviously may be so designed that the fuel pressure differential between its inlet and outlet sides is such at each valve opening that the flow through the valve depends primarily only on the extent to which the valve opening 52 is uncovered.

While we have described our invention in detail in its present preferred embodiment, it will be obvious to those skilled in the art, after understanding our invention, that various changes and modifications may be made therein without departing from the spirit or scope thereof. We aim in the appended claims to cover all such modifications and changes.

We claim as our invention:

1. In an internal combustion engine comprising a plurality of cylinders each with an intake passage and an intake valve therefor, a fuel system comprising a plurality of fuel discharge valves each respectively associated with one of the engine cylinders, means to regulate the total fuel flow and to feed said fuel to said valves, each of said valves being adapted to continuously discharge fuel into the intake passage of its associated cylinder anterior of the intake valve of said cylinder, and means to automatically adjust said valves to properly divide the fuel between the engine cylinders independently of changes in their relative elevation.

2. In an internal combustion engine having a plurality of cylinders each with an intake pipe; a fuel system comprising means to regulate the total fuel flow, and to feed said fuel under pressure to a fuel distributing manifold, a plurality of fuel discharge valves each respectively associated with one of said intake pipes, each of said valves having its inlet side connected to said manifold and being adapted to continuously discharge fuel therefrom into its associated intake pipe, means to adjust each of said valves automatically in response to changes in the fuel pressure supplied thereto, and means to render each of said valve adjusting means independent of the relative elevation of said valves.

3. In an internal combustion engine having a plurality of cylinders each with an air intake pipe, a fuel system comprising a fuel distributing manifold means for regulating the total fuel flow and feeding said fuel under pressure to said fuel manifold, a fuel discharge valve for each intake pipe, each of said valves having its inlet side connected to said fuel manifold and being adapted to continuously discharge fuel therefrom into its associated intake pipe, valve operating means for

each of said valves, each of said valve operating means having one side responsive to the pressure of the fuel supplied to the inlet side of its associated valve for urging said valve in an opening direction, liquid passage means interconnecting the opposed sides of said valve operating means, and means for maintaining said liquid passage means full of fuel.

4. In an internal combustion engine having a plurality of cylinders, an air intake duct, and an air intake pipe for each of said cylinders connected to said intake duct; a fuel system comprising a fuel distributing manifold, means for regulating the total fuel flow and feeding said fuel under pressure to said manifold, a fuel discharge valve for each cylinder intake pipe, each of said valves having its inlet side connected to said fuel manifold and being adapted to continuously discharge fuel therefrom into its associated intake pipes, a fuel chamber associated with each of said valves, said chambers being connected in series with one end of said series of chambers connected to said fuel manifold through a restricted orifice, the other end of said serially connected chambers being arranged to discharge fuel flowing therethrough into said intake duct, and valve operating means for said valves, each of said valve operating means being responsive to the fuel pressure supplied to the inlet side of its associated valve for urging said valve in an opening direction and to the fuel pressure within the chamber associated with said valve for urging said valve in a closing direction.

5. A fuel system for an engine comprising a fuel manifold, means to feed fuel under pressure to said manifold, a plurality of spaced fuel discharge valves each having their inlet sides in communication with said manifold, means for adjusting each of said valves, each said adjusting means having one side in communication with the fuel supplied to its associated valve for urging said valve in an opening direction, fuel passage means interconnecting the opposed sides of each of said valve adjusting means, and means for maintaining fuel under pressure within said passage means for urging each of said valves in a closing direction.

6. In an engine having a fuel distributing manifold and a plurality of spaced fuel discharge valves in communication therewith; the method of controlling the fuel flow to said engine comprising the steps of supplying fuel under pressure to said manifold, continuously discharging fuel from said manifold through said valves during engine operation, adjusting each of said valves in response to changes in the fuel pressure of said manifold, and rendering the extent to which each valve opens or closes independent of changes in the relative elevation of said valves.

7. In an engine having a plurality of cylinders each with an individual intake passage, a fuel distributing manifold and a plurality of fuel discharge valves, each communicating with said manifold and respectively adapted to discharge fuel into one of said intake passages; the method of controlling the fuel flow comprising the steps of supplying fuel under pressure to said manifold, continuously discharging fuel from said manifold through said valves during engine operation, adjusting each of said valves in response to changes in the fuel pressure in said manifold, and rendering the extent to which each valve opens or closes independent of changes in the relative elevation of said valves.

8. In an internal combustion engine having a

plurality of cylinders, a plurality of fuel discharge valves, one for each cylinder, each of said valves being arranged to continuously discharge fuel during engine operation, a plurality of means each respectively connected to one of said valves and operative to adjust its associated valve with changes in the pressure of the fuel supplied thereto, and means for automatically rendering each said valve adjusting means ineffective to adjust its associated valve in response to changes in the pressure of the fuel supplied thereto as a result of changes in the relative elevation of said valves.

9. In an internal combustion engine having a plurality of cylinders each having an intake pipe, a fuel distributing manifold, means to supply fuel under pressure to said manifold, a plurality of fuel discharge valves each respectively adapted to continuously discharge fuel from said manifold into one of said intake pipes during engine operation, a plurality of means each respectively connected to one of said valves and operative to adjust its associated valve with changes in the pressure of the fuel supplied thereto, and means for automatically rendering each said valve adjusting means ineffective to adjust its associated valve in response to changes in the pressure of the fuel supplied thereto as a result of changes in the relative elevation of said valves.

10. A fuel system for an engine comprising a fuel distributing manifold, means to supply fuel under pressure to said manifold, a plurality of spaced fuel discharge valves having their inlet sides in communication with said manifold, each of said valves being arranged to continuously supply fuel to said engine during engine operation, and means to automatically adjust said valves to maintain a predetermined division of the fuel between said valves independently of changes in their relative elevation.

11. A fuel system for an engine comprising a plurality of spaced fuel discharge nozzles each adapted during engine operation to continuously supply fuel thereto, and means operative to control each of said nozzles such that the fuel flow through each nozzle is substantially independent of changes in the relative elevation of said nozzles.

12. A fuel system for an engine comprising a fuel distributing manifold, a plurality of spaced fuel discharge valves each adapted during engine operation to continuously supply fuel thereto from said manifold, and means operative to adjust each of said valves in response to changes in the fuel pressure at their inlet sides except as to fuel pressure changes at their inlet sides resulting from changes in the relative elevation of said valves.

13. A fuel system for an engine comprising a

fuel manifold, means to supply fuel under pressure to said manifold, a plurality of spaced fuel discharge valves, each of said valves having their inlet sides in communication with said manifold, a plurality of means each respectively connected to one of said valves and normally operative to automatically adjust its associated valve with changes in the pressure of the fuel supplied thereto, and means for automatically rendering each said valve adjusting means ineffective to adjust its associated valve in response to changes in fuel pressure supplied thereto as a result of changes in the relative elevation of said valves.

14. A fuel system for an engine comprising a fuel manifold, means to supply fuel under pressure to said manifold, a plurality of spaced fuel discharge valves each of said valves having their inlet sides in communication with said manifold, and means operative to control the position of each of said valves such that the fuel flow through each valve is continuous during engine operation and is substantially independent of changes in the relative elevation of said valves.

15. A fuel system for an engine, said system comprising a plurality of spaced fuel discharge valves each adapted to continuously supply fuel to said engine during engine operation, interconnected fuel passages for supplying fuel to said valves, a plurality of means each connected to one of said valves for automatically adjusting said valves such that the fuel flow therethrough is independent of changes in their relative elevation, each of said valve adjusting means being subjected on one side to the pressure of the fuel supplied to the inlet side of its valve for urging its valve in one direction, and fuel passage means interconnecting the opposite sides of said valve adjusting means such that the fuel pressure on said opposite sides of the valve adjusting means urges their respective valves in the opposite direction.

FRANCIS J. WIEGAND.
WILLIAM T. STARK.
MARK ROBERT ROWE.

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