The present invention relates to pneumatically operated fuel pumps for internal combustion engines and more particularly to such a pump having means permitting manual priming to insure reliable engine starting under extreme climatic conditions.

The high pressure engine driven fuel pumps now being used on small high performance gas turbine engines represent the major cost in the fuel systems for such engines. The greatest portion of this cost is attributable to the close manufacturing tolerances which are necessary for the efficient operation of such a pump. Further, to insure long life such pumps are necessarily limited to operating speeds below engine speed. The low speed required for the unit necessitates the use of accessory reduction gears adding to the cost of the engine and increasing the likelihood of malfunction.

It is an object then of the present invention to reduce the costs of manufacturing fuel systems for internal combustion engines by providing a rugged economically constructed pneumatically driven fuel pump which can be manufactured without adhering to close tolerances.

It is another object of the present invention to reduce the manufacturing costs of internal combustion engines by providing a pneumatically driven fuel pump and thus eliminating the need for accessory reduction gears to drive the pump.

It is another object of the present invention to facilitate the assembly of internal combustion engines by providing a fuel pump for such an engine which may be positioned in any convenient or remote location.

It is yet another object of the present invention to insure the reliable starting of internal combustion engines even in extreme climatic conditions by providing a fuel pump having means for manually priming the pump.

It is yet another object of the present invention to simplify fuel system controls for internal combustion engines by providing means for controlling fuel pressure by controlling the pressure of an air supply.

Still further objects and advantages of the present invention will readily occur to one skilled in the art to which the invention pertains upon reference to the following drawings in which like characters refer to like parts throughout the several views and in which.

FIG. 1 is an elevational view of a fuel pump of the present invention with portions in section for purposes of clarity.

FIG. 2 is a cross sectional view taken substantially on line 2--2 of FIG. 1 with portions shown in elevation for purposes of clarity.

FIG. 3 is a cross sectional view taken substantially on line 3--3 of FIG. 1.

FIG. 4 is a view as seen from the left of FIG. 3 with portions in section for purposes of clarity.

FIG. 5 is a fragmentary elevational view of the latch mechanism of the present invention enlarged for purposes of clarity.

FIG. 6 is a view taken substantially on line 6--6 of FIG. 5.

Now referring to the drawings for a more detailed description of the present invention a preferred fuel pump is illustrated as comprising a substantially cylindrical housing structure 10 closed at each end by cap members 11 and 12. As can best be seen in FIG. 2 the housing structure 10 and the cap members 11--12 define a substantially cylindrical pressure chamber 13. Longitudinal bore portions 14--15 are provided in the cap members 11--12 respectively which provide the means for carrying plug members 18. The plug members 18 are each provided with an O-ring seal 19. A piston 20 is axially slidably carried in the pressure chamber 13 and is provided with a piston ring 24 which engages with the interior surface of the housing structure 10. The piston 20 carries fuel pistons 21--22 so that axial movement of the piston 20 produces a corresponding axial movement of the fuel pistons 21--22 in the bores 14--15 respectively. The bores 14--15, the fuel pistons 21--22 and the plugs 18 define fuel chambers 23. O-ring seals 25--26 prevent communication between the chambers 23 and the pressure chamber 13.

As can best be seen in FIGS. 1 and 3 the cap members 11--12 each carry a fuel inlet 27 and a fuel outlet 28. The fuel inlet 27 is connected to an inlet passage 29 which in turn communicates with the fuel chamber 23. The inlet passage 29 is provided with an angled shoulder 30 which provides the seat for a ball 31. The ball 31 is urged to seat on the shoulder 30 by a spring 32. A ball guide 33 is preferably provided intermediate the spring 32 and the ball 31.

The fuel outlet 28 communicates with an outlet passage 34 which in turn communicates with the fuel chamber 23. The outlet passage 34 is provided with an angled shoulder 35 which forms the seat for ball 36. The ball 36 is urged to seat against the shoulder 35 by a spring 37. A ball guide 38 is carried intermediate the spring 37 and the ball 36.

As can best be seen in FIG. 2 the cap members 11--12 are each provided with a pressure inlet 39 and a pressure outlet 40. Bore portions 41--42 are provided in the cap members 11--12 respectively preferably in axial alignment with each other and having axes substantially parallel with the longitudinal axis of the bores 14--15. Longitudinally spaced annular recesses 43--44 are provided in the cap member 11 in communication with and concentric to the bore portion 41 and similar recesses 45--46 are provided in the cap member 12 in communication with and concentric to the bore portion 42. The pressure inlet 39 provided in the cap member 11 communicates with the annular recess 43 and the pressure outlet 40 communicates with the recess 44. Similarly the pressure inlet 39 of the cap member 12 communicates with the recess 45 and the pressure outlet 40 communicates with the recess 46.

The pressure inlets 39 are preferably connected by a manifold tubing 47 as can best be seen in FIG. 1 which in turn is connected by a T-fitting, or a similar means (not shown) to a pressure supply source (not shown). The pressure outlets 40 are preferably open to the atmosphere.

A pilot valve 48 is axially slidably carried in each of the bore portions 41--42. The pilot valves 48 preferably comprise a rod 49a having a central recess 49 opening to the pressure chamber 13 and an orifice 50 communicating with the recess 49. A spring 51 is carried within the recess 49 and has an end portion 52 extending into the pressure chamber 13.

As can best be seen in FIG. 1, a rod 53 is axially slidably carried in a bore 53a provided in the cap member 11--12 in a position exteriorly of the pressure chamber 13 and the housing 10. A recess 54 is provided in the cap member 11 and has an axis substantially normal to the axis of the bore 53 and in communication therewith. A pair of spaced annular grooves 55--56 are provided in the rods 53 and a spring 57 carried in the recess 54 by a retaining member 54a urges a ball 58 to seat in one of the grooves 55--56 to delay axial movement of the rod 53 until the force of the spring 57 has been overcome. The ends of the rod 53 are each connected to the
exterior ends of the pilot valves 48a by links 59 so that axial movement of one of the rods 53 or 48a will produce a corresponding axial movement of the others.

The grooves 55–56 and the pressure inlets 39 and outlets 40 are spaced and the orifices 50 are positioned such that when the ball 58 axially positions the rod 53 in the position shown in FIG. 1 the pressure inlet 39 in cap 12 is opened to the pressure chamber 13 through orifice 50 and recess 49 and the pressure outlet 40 in cap member 11 is opened to pressure chamber 13 through orifice 58 and recess 49. When sufficient axial force is exerted on rod 53 to force the ball 58 upward on the angled sides of groove 55 the rod 53 will move axially and the ball 58 will be snapped by the spring 57 into the groove 56. With the rod 53 moved to this position the pilot valves 48 will also move such that the pressure inlet 39 in cap member 11 is open to the pressure chamber 13 and the pressure outlet 40 in cap member 12 is opened to the pressure chamber 13.

As can best be seen in FIG. 2, the cap members 11–12 are provided with axially aligned bores 65–66 which axially slidably carry push rods 67–68 respectively. The push rods 67–68 are positioned to engage opposite sides of the piston 20 when urged inwardly to the position illustrated in FIG. 2. As can best be seen in FIG. 4, the cap members 11–12 also are provided with axially aligned bores 69–70 respectively. Bearings 71–72 are preferably provided in the bores 69–70 respectively. A rod 73 is axially slidably carried in the bore 69 and a tubular member 74 is axially slidably carried in the bore 70.

The rod 73 is adapted to be inserted in the tubular member 74 and spring 75 is biased between the end of the rod 73 and seat 76 carried in the tubular member 74. The end of the tubular member 74 is connected with the push rod 68 by a link 77 so that axial movement of the tubular member 74 produces a corresponding axial movement of the push rod 68. The end of the rod 73 is similarly secured to the push rod 67 by a link 78.

As can best be seen in FIG. 4, a pin 79 is carried in the cap members 11–12 and carries a transverse pin 80 exteriorly of the housing 10. A lever 81 is pivotally carried on the pin 80 by a bolt 82 and washer 83. The lever 81 is provided with a cam opening 84 spaced from the pin 80 and a handle portion 85 at the end of the lever 81 opposite the pin 80. A guide 86 is preferably secured to the cap members 11–12 by bolts 87 and is provided with an elongated opening 88 which limits the movement of the lever 81.

As can best be seen in FIGS. 5–6 a latch mechanism 89 preferably comprises a body portion 90 having a bore 91 adapted to receive the rod 73. A set screw 92 secures a cylindrical cam follower 93 to the body portion 90 and the body portion 90 to the rod 73. The cam follower 93 extends axially into the cam opening 84 and is adapted to ride on the sides thereof. A pair of latch members 94 are pivotally mounted on the body portion 90 as at 95. A C-spring 96 is carried intermediate each portion 97 of the latch members 94. The tubular member 74 is provided with a frusto-conical end portion 98 having a shoulder 99. Finger portions 99a of the latch members 94 engage the shoulder 99 when the mechanism 90 is in the position illustrated.

Normally the fuel pump of the present invention is self-cycling operating from air pressure supplied by the turbine engine or any other convenient source of air or fluid pressure. Pressure enters one of the pressure inlets 39 and valve 48 and into the pressure chamber 13. The pilot valve 48 on the opposite side of the piston 20 simultaneously opens the pressure outlets 40 and the pressure differential across the piston 20 moves the piston 20 and the fuel pistons 21–25 axially. This produces a fuel pressure in one of the fuel chambers 70 directly proportional to the pressure in the pressure chamber 13 and opens the other fuel chamber 23 to the fuel inlet 27 past the ball 31. Fuel is pumped past the ball 33 and out the fuel outlet 38. As the piston 20 moves into engagement with the end portion 52 of the spring 51 an axial force is exerted against the pilot valve 48 which is transmitted through the link 59 to the rod 53. When a sufficient axial force has been stored by the spring 51 to cause the ball 58 up the inclined surface of the groove 55 the rod 53 and pilot valves 48 will move axially to a new position. The new position of the pilot valves 48 will allow pressure to be directed to the opposite side of the piston 20 to produce the return stroke. The grooves 55–56 and spring urged ball 58 insures that the pilot valves 48 will move to the new operative position.

If it is desired to manually operate the pump as when starting the engine under extreme climatic conditions the lever 81 is pivoted to the extreme right position as shown in dotted lines in FIG. 4. This moves the rod 73 axially inwardly into the tubular member 74 against the force of the spring 75 until the finger portions 99 snap over the shoulder 99 as shown in FIG. 5. In this position the rod 73 and tubular member 74 are secured together and pivoting the lever 81 will move these members axially. Axial movement of the tubular member 74 and rod 73 in this connected position will produce a corresponding axial movement of the push rods 67–68 through the links 77–78. The push rods 67–68 in this position bear against the surface of the piston 20 as shown in FIG. 2 and thus axial movement of the push rods 67–68 produces a corresponding axial movement of the piston 20 and fuel pistons 21–25. TA. Rod 80 may then be pushed back and forth to pump the fuel.

When the engine starts and normal operation of the fuel pump begins, pressure in the pressure chamber 13 will move the piston 20 to the extreme left as shown in FIG. 2. The ear portions 97 will engage the inner surface of the cap member 11 which will cause the latch members 94 to pivot upwardly against the force of the C-spring 96 and to disengage the finger portions 99a from the shoulder 99. The spring 75 will cause the rod 73 and tubular member 74 to move away from each other which will in turn return the push rods 67–68 to a position in which they do not interfere with the movement of the piston 20.

It is apparent that the fuel pump of the present invention since it is pneumatically operated requires no reduction gears. It is rugged and economical in construction since it does not require the close tolerances necessary in the manufacture of gear driven pumps. The pump may be located at a point remote from the engine since it is not engine driven.

The fuel pressure produced by the pneumatic pump of the present invention is directly proportional to the air pressure used to operate the pump. This fact provides a number of simple ways to provide the necessary control of fuel pressure. Fuel pressure can be regulated by controlling the pressure of the air supply or a pressure controller can be used to maintain a constant air pressure and fuel pressure varied by varying the area of a restriction placed between the pump and the fuel nozzle. Although I have described but one embodiment of the present invention, it is apparent that many other changes and modifications may be made without departing from the spirit of the invention or the scope of the appended claims.

I claim:
1. A fuel pump for an internal combustion engine and the like comprising
   (a) a housing structure having a pressure chamber and a fuel chamber,
   (b) a first piston axially slidably carried in said pressure chamber,
   (c) a second piston disposed in said fuel chamber,
   (d) said second piston being operably connected with said first piston and axially slideable therewith,
   (e) an inlet and an outlet provided in said housing and valve means disposed between said inlet and said pressure chamber and said fuel chamber and said outlet,
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(f) said inlet being adapted for connection to a source of fluid under pressure and said valve means being operable to alternately direct pressurized fluid to and from said pressure chamber whereby said piston is axially slidably moved in said pressure chamber.

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(g) a fuel inlet and a fuel outlet connected with said fuel chamber and valve means disposed in said fuel inlet and in said fuel outlet.

(h) means manually selectively operable to engage opposite sides of said first portion to axially slidably move same, and

(i) means operable to automatically release said first piston from engagement with said manually operable means upon said first piston being moved to a predetermined axial position.

2. A fuel pump for an internal combustion engine and the like comprising

(a) a housing structure having a pressure chamber and fuel chamber,

(b) a first piston axially slidably carried in said pressure chamber,

(c) a second piston carried by said first piston and axially slidably disposed in said fuel chamber,

(d) a pressure inlet adapted for connection to a fluid pressure source and a pressure outlet provided in said housing and communicating with each end of said pressure chamber,

(e) said first piston being disposed intermediate said pressure inlet and outlet at one end of said pressure chamber and said pressure inlet and outlet at the other end of said pressure chamber,

(f) valve means carried in said housing and being operable to substantially simultaneously open said pressure chamber to said pressure inlet at one end of said pressure chamber and to said pressure outlet at the other end of said pressure chamber whereby said first piston will axially slidably move in said pressure chamber,

(g) a fuel inlet and a fuel outlet being provided in said housing and being connected with said fuel chamber,

(h) valve means carried in said housing intermediate said fuel chamber and said fuel inlet and said fuel outlet,

(i) means manually selectively operable to engage opposite sides of said first piston to axially slidably move same, and

(j) means operable to automatically disengage said manually operable means from said first piston upon said first piston being moved to a predetermined axial position.

3. The fuel pump as defined in claim 2 and in which said first mentioned valve means comprises,

(a) a pilot valve axially slidably carried intermediate said pressure inlet and said pressure outlet at each end of said pressure chamber.

(b) means operably connecting each of said pilot valves with said first piston for axial movement therewith,

(c) said last mentioned means including means operable to accurately position said pilot valves with respect to said pressure inlets and said pressure outlets.

4. The fuel pump as defined in claim 1 and in which said manually operable means comprises

(a) a pair of axially aligned rods axially slidably carried in said housing,

(b) means selectively operable to move said rods into engagement with opposite sides of said first piston and to lock said rods in said engaging position,

(c) a handle pivotally carried exteriorly of said housing structure and operably connected to said rods to axially move same upon pivotal movement of said handle whereby said first piston is axially moved in said first chamber.

5. A fluid pump comprising

(a) a housing structure having a chamber,

(b) a piston axially slidably carried in said chamber,

(c) pressure means operable to reciprocate said piston in said chamber,

(d) fluid pumping means actuated by axial movement of said piston, and

(e) manually operable means selectively engaging said piston to axially move same, and

(f) means automatically releasing said manually operable means from engagement with said piston upon said piston being moved to a predetermined axial position.

6. The fluid pump as defined in claim 5 and in which

(a) said manually operable means comprises a pair of rods carried in said housing and selectively operable to engage opposite sides of said piston and means latching selectively operable to lock said rods in said piston engaging position,

(b) said automatic releasing means comprising an arm carried by said latching means and being disposed in a position to engage with a wall of said chamber upon movement of said piston toward said wall and to disengage said latching means upon engagement of said lever and said wall.

7. A fluid pump comprising

(a) a housing structure having a chamber,

(b) a piston axially slidably carried in said chamber,

(c) pressure means operable to reciprocally move said piston in said chamber,

(d) fluid pumping means operably connected to said piston,

(e) means selectively operable to engage said piston for manual movement of same, and

(f) means automatically disengaging said manual means from said piston upon said piston being moved to a predetermined axial position.

8. The fluid pump as defined in claim 7 and in which

(a) said manually operable means comprises a pair of substantially axially aligned rods carried by said housing, means selectively operable to move said rods into engagement with opposite sides of said piston, and means selectively operable to lock said rods in said engaged position,

(b) said disengaging means being operable to unlock said rods upon said piston being moved closely adjacent one of the walls of said chamber and including means urging said rods apart.

9. A fluid pump comprising

(a) a housing structure having a first chamber and a second chamber,

(b) said housing having an inlet and an outlet open to said first chamber and an inlet and an outlet open to said second chamber,

(c) said first mentioned inlet being adapted for connection to a source of fluid under pressure,

(d) a pressure responsive means carried in said first chamber to be actuated by said fluid under pressure,

(e) pressure producing means operably connected to said pressure responsive means and carried in said second chamber,

(f) said second mentioned inlet being adapted for connection to a fluid source and said second mentioned outlet being adapted for connection with a fluid user whereby actuation of said pressure responsive means pumps fluid from said second mentioned inlet to said second mentioned outlet,

(g) manually operable means selectively operably connected with said pressure producing means and including means automatically disconnecting said manually operable means and said pressure producing means upon actuation of said pressure responsive means.

10. The pump as defined in claim 9 and in which

(a) said pressure responsive means comprises a first
piston axially slidably carried in said first chamber, (b) said pressure producing means comprises a second piston axially slidably carried in said second chamber, (c) said second piston being axially slidably movable in response to axial movements of said first piston, and (d) said manually operable means comprises rods extending substantially parallel with the axis of said first piston and selectively engaging opposite sides thereof and a handle member disposed exteriorly of said housing operably connected to said rods to produce axial movement of said rods upon movement of said handle.

11. The pump as defined in claim 10 and in which said disconnecting means comprises means automatically disengaging said rods from said first piston upon said first piston being moved to a predetermined axial position.

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