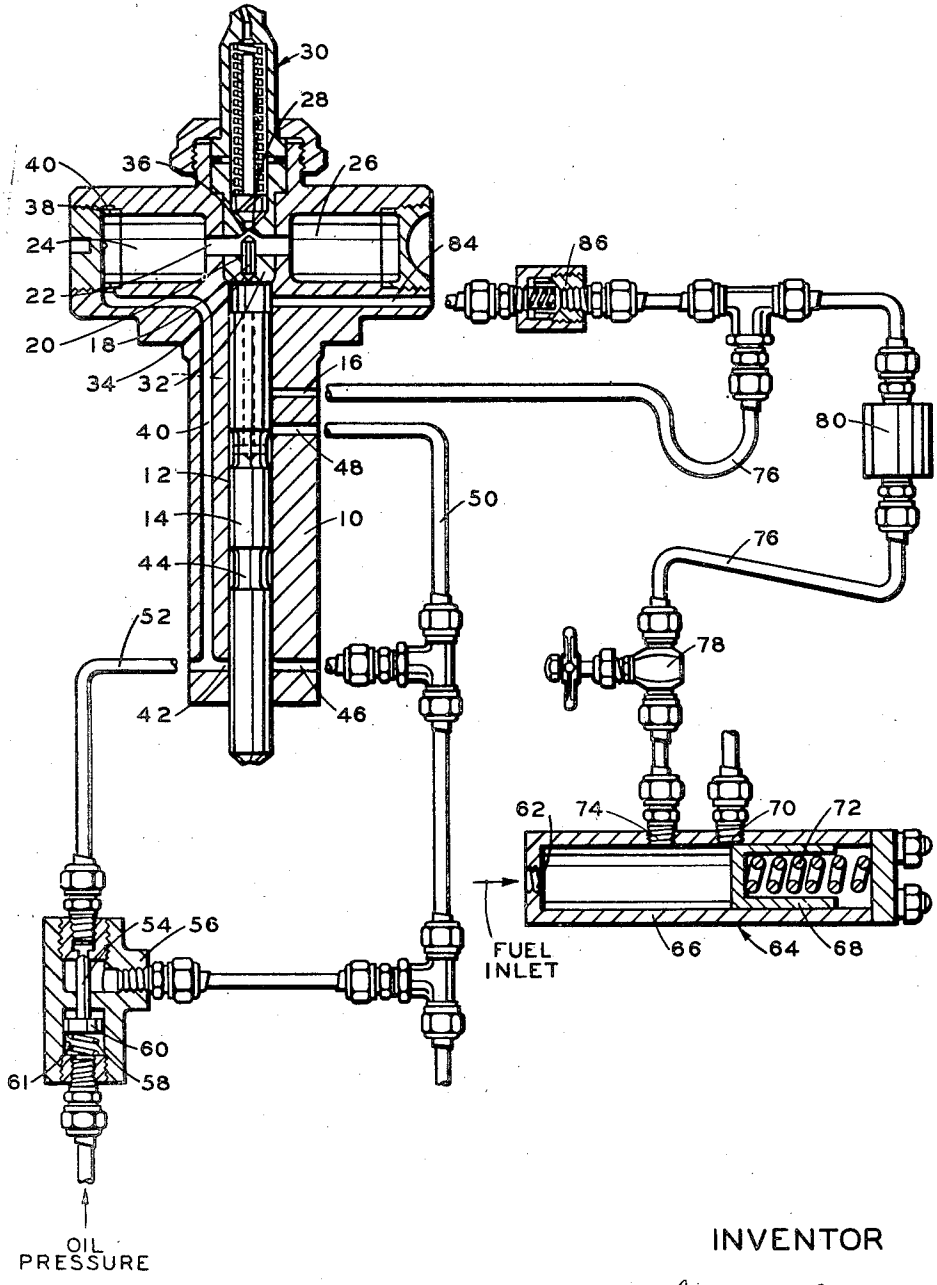
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FUEL INJECTION SYSTEM

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FUEL INJECTION SYSTEM

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This invention relates to fuel injection apparatus.

For satisfactory injection of fuel while starting the engine, the injection system must be free from air bubbles before the first injection stroke occurs. An object of this invention is a device for completely filling the apparatus with fuel while the apparatus is not operating.

Fuel is generally supplied to the injection apparatus by a separate pump which may be operated independently of the engine to which the injection apparatus is connected. A feature of this invention is an arrangement by which the injection apparatus may be filled with fuel by this pump independently of the position of the injection pump plunger.

The filling port in many fuel injection pumps is covered and uncovered by the injection plunger during its movement. When the engine is stopped, the plunger may completely cover the filling port. A feature of this invention is an arrangement for by-passing the filling port in filling the injection apparatus with fuel. Another feature is the bypassing of the venting system so that the entire apparatus may be filled with fuel before the engine is operated.

The quantity of fuel for each injection has been adjusted by changing the angular position of the plunger within the cylinder. In certain instances, it is inconvenient to have adjustment of the fuel quantity at this point. A feature of this invention is the control of the fuel quantity by means which may be located at a point in the supply line spaced from the injection pump.

Another feature is the filling of an injection device of the accumulator type before the device operates to assure satisfactory injection on the first reciprocation of the plunger.

When an injection device is used for injecting fuel into the engine cylinder of a free-piston unit, it is essential that injection occur on the first plunger stroke, since free-piston units generally have no means for motoring the engine until it starts. A feature of this invention is an injection device adapted for use in a free-piston unit and which may be filled before the unit is started.

Other objects and advantages will be apparent from the specification and claims and from the accompanying drawing which illustrates what is now considered to be a preferred embodiment of the invention.

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The single figure is a diagrammatic view of the fuel system with the injection apparatus in section.

The injection apparatus includes a casing 10 having a bore 12 in which a plunger 14 is movable. An inlet port 16 in the bore is uncovered by the plunger at the start of the injection stroke for filling the end of the cylinder with fuel. As the plunger moves upwardly on the pumping stroke, fuel is delivered through a groove 18 in a valve 20 to a cross passage 22 connecting with accumulator chambers 24 and 26. Fuel from these chambers discharges through a passage 28 to the injection nozzle 30. Valve 20 slides in a ring 32 and alternately engages a seat 34 at the end of bore 12 or a seat 36 at the end of passage 28 for controlling the flow of fuel into and out of the accumulator chambers.

The high point of accumulator chamber 24 has a port 38 connected by a passage 40 in casing 10 to a port 42 in bore 12. When the injection plunger is at the outer end of its stroke (at the beginning of the injection stroke) a groove 44 in the plunger connects port 42 to a relief port 46. Another relief port 48 in the casing adjacent to inlet port 16 is connected by a conduit 50 to a sump, port 46 also being connected to this conduit.

A conduit 52 intersects passage 40 and has a check valve 54 in a casing 56 held closed by a spring 58. The check valve includes a plunger 60 in a cylinder 61 and fluid under pressure from a pressure source independent of the fuel system acts on the plunger to hold it closed after the system is filled.

Fuel is supplied from a source, not shown, through a port 62 to a constant pressure reservoir 64 including a casing 66 having a bore in which a plunger 68 is slidable. The plunger is in a position to cover a vent port 70 and is urged to the left by a spring 72. This arrangement permits the pressure within the chamber to be maintained substantially constant.

An outlet port 74 in casing 66 is connected to inlet port 16 by a conduit 76. This conduit has a throttle valve 78 for adjusting the quantity of fuel supplied to the injection pump, and may have a filter 80. Port 16 is restricted, as shown, to maintain the desired pressure in conduit 76.

A branch conduit 82 extends from conduit 76 to a passage 84 in casing 10 and has a check valve

86 arranged to permit flow of fuel into passage 84. This passage connects with the end of bore 12 at the head of plunger 14 and permits filling of the bore and the accumulator chambers when the plunger covers inlet port 16. Fluid pressure from reservoir 64 will thus fill the entire fuel system, discharging through passage 40 and past check valve 54.

The injection system having been filled with fuel, and the pressure source for oil acting on plunger 60 having been set in operation, the engine with which the injection system is used may be started and proper fuel injection on the first stroke will be assured.

This system may be used with a free-piston unit which may be started by a device which causes the piston or pistons to be moved rapidly from starting position on a compression stroke by delivery of air under pressure to the air springs. If the injection system does not operate satisfactorily on this stroke, the unit does not run and the starting device must operate again. To avoid repeated starting attempts, the injection system must operate properly on the first compression stroke. By the arrangement above described the injection system will be full of oil before starting of the unit is attempted and injection of fuel will occur on the first stroke. In this arrangement, the pressure fluid acting on the plunger 60 may be, for example, the lubricant for the unit, or the gas under pressure used in the air spring.

It is to be understood that the invention is not limited to the specific embodiment herein illustrated and described, but may be used in other ways without departure from its spirit as defined by the following claims.

I claim:

1. Fuel injection apparatus including a casing having a bore, a plunger in said bore, an accumulator chamber to which fuel is delivered by said plunger, an outlet passage for the chamber through which fuel is discharged, means for venting said chamber in one position of the plunger, said means including a groove in the plunger and ports in the cylinder connected by said groove in one position of the plunger, one of said ports being connected to the chamber and the other port being a relief port, and means for filling said cylinder and chamber with fuel independently of the position of the plunger in the cylinder.

2. Fuel injection apparatus including a cylinder, a plunger in said cylinder, an accumulator chamber to which fuel is delivered by said plunger, an outlet passage for the chamber through which fuel is discharged, said cylinder having a filling port adapted to be covered and uncovered by the plunger during its movement in the cylinder, and means for filling said cylinder and chamber with fuel independently of the position of the plunger, said means including a supply of fuel under pressure and a connection from the supply to the cylinder.

3. Fuel injection apparatus including a casing having a bore, a plunger movable in said bore, an accumulator chamber to which fuel is delivered by said plunger, an outlet passage for the chamber through which fuel is discharged, said bore having an inlet port, a bypass around said port to the end of the bore, and means for supplying fuel to said bore and chamber when the plunger is not moving.

4. Fuel injection apparatus including a casing having a bore, a plunger movable in said bore, an accumulator chamber to which fuel is delivered by said plunger, an outlet passage for the chamber through which fuel is discharged, said bore having an inlet port, a bypass around said port to the end of the bore, and means for supplying fuel to said apparatus for filling the bore and chamber when the plunger is not moving.

5. Fuel injection apparatus including a casing, a plunger movable in said casing, an accumulator chamber in which fuel is accumulated under pressure by said plunger, and an outlet passage for the chamber through which fuel is discharged, and a vent for said chamber, said plunger having means for connecting said vent to relief in one position of said plunger, a bypass around said connecting means, a check valve in said bypass, and means for delivering fuel to said apparatus for filling the casing and chamber when the plunger is not moving.

6. Fuel injection apparatus including a casing, a plunger movable in said casing, a filling port, an accumulator chamber in which fuel is accumulated under pressure by said plunger, and an outlet passage for the chamber through which fuel is discharged, and a vent for said chamber, said plunger having means for connecting said vent to a relief port in one position of said plunger, a bypass around said connecting means, a check valve in said bypass, a second bypass around said filling port and means for delivering fuel to said apparatus for filling the cylinder and chamber when the plunger is not moving.

7. Fuel injection apparatus including a casing, a plunger movable in said casing, an accumulator chamber to which fuel is delivered by said plunger, an outlet passage for the chamber through which fuel is discharged, a vent for said chamber, said plunger having means for connecting said vent to a relief port in one position of said plunger, said casing having an inlet port adapted to be covered and uncovered by said plunger, a bypass around said port to the end of the casing, and a bypass around the connecting means on said plunger, a valve in each bypass, and means for supplying fuel to said apparatus when the plunger is not moving for filling the chamber and casing, said bypass permitting the entry of fuel into the casing and chamber independently of the position of the plunger.

8. Fuel injection apparatus including a casing, a plunger movable in said casing, an accumulator chamber to which fuel is delivered by said plunger, an outlet passage for the chamber through which fuel is discharged, a vent for said chamber, said plunger having means for connecting said vent to a relief in one position of said plunger, said casing having an inlet port adapted to be covered and uncovered by said plunger, a bypass around said port to the end of the casing, and a bypass around the connecting means on said plunger, a valve in each bypass, means for delivering fuel to said chamber and casing when the plunger is not reciprocating, said bypass permitting the entry of fluid into the cylinder and chamber when the inlet port is covered by the plunger and fluid pressure actuated means for closing the valve in the second bypass when the apparatus is operating.

9. Fuel injection apparatus including a casing, a plunger movable in said casing, a filling port for said casing, and means for controlling the quantity of fuel admitted to said casing, said means including an adjustable throttle between the fuel supply and the inlet port, and a restriction in the connection from the throttle to the inlet port, and means for maintaining sub-

stantially a constant pressure on the fuel delivered from the supply to the adjustable throttle.

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