May 21, 1957 C. M. BOVARD 2,793,077

FUEL INJECTION DEVICES FOR INTERNAL COMBUSTION ENGINES

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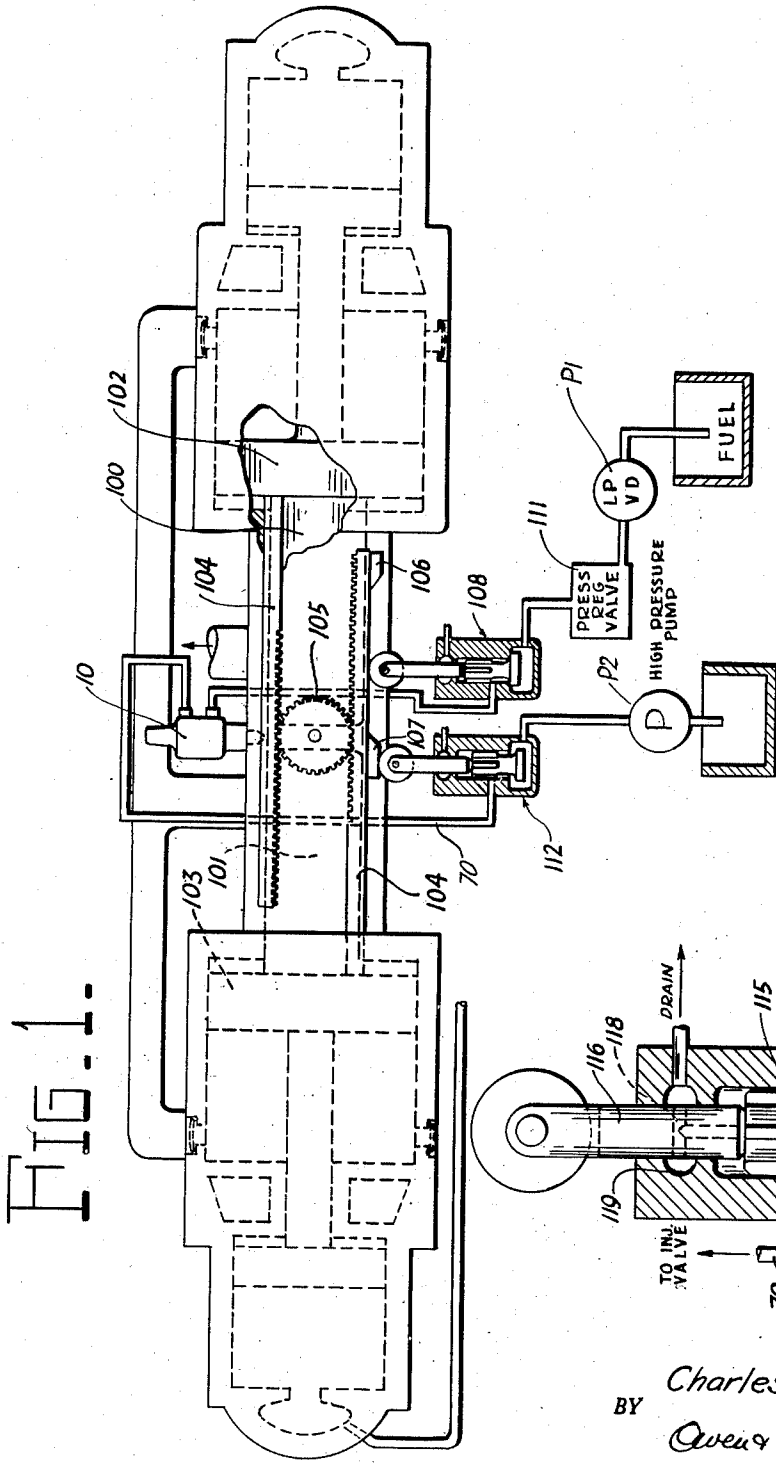

FIG. 1.

FIG. 2.

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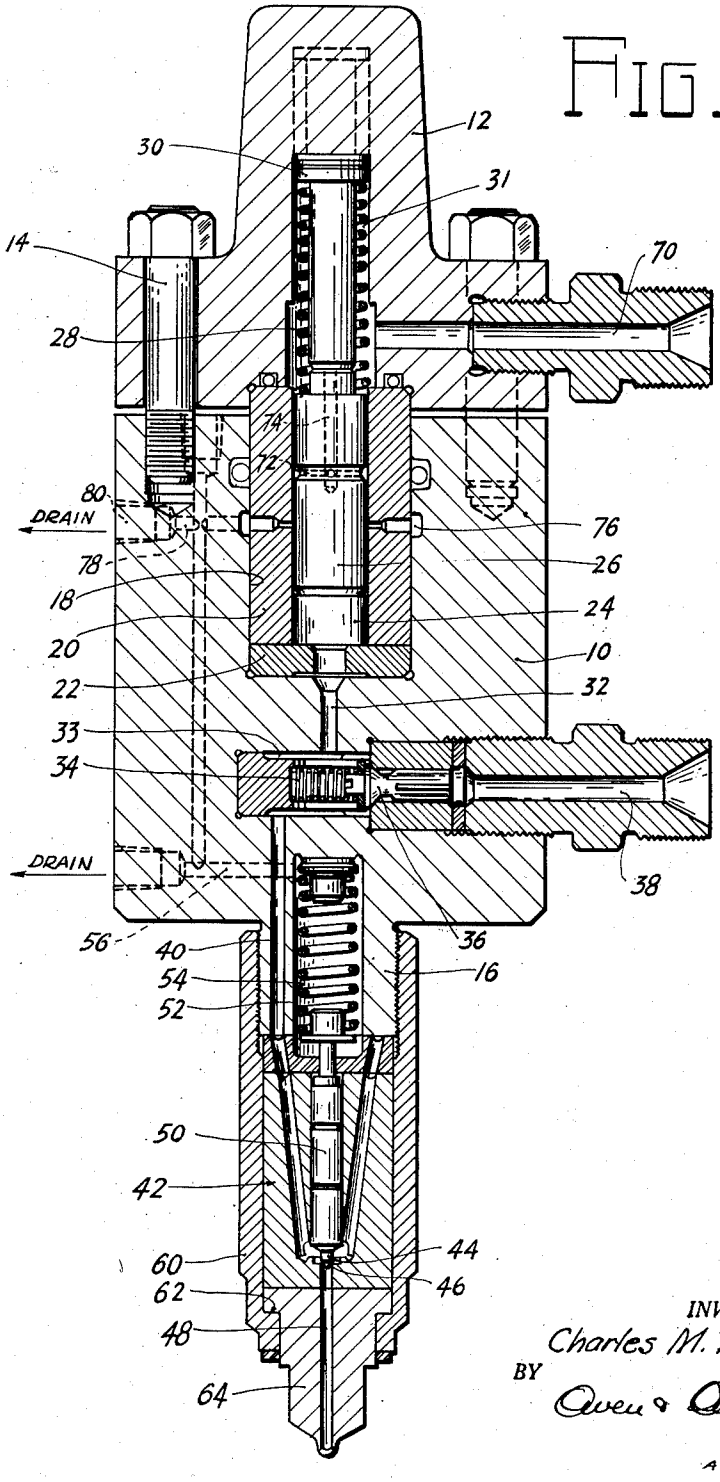
FIG. 3.



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FUEL INJECTION DEVICES FOR INTERNAL COMBUSTION ENGINES

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1 Claim. (Cl. 299—107.2)

This invention relates to fuel injection devices for internal combustion engines and is particularly directed to an improved means to accumulate a measured fuel charge and to inject the charge into an engine cylinder under a pressure greatly in excess of the pressure at which the charge was accumulated.

It has heretofore been proposed to provide accumulator fuel injectors in which fuel is accumulated under very high pressure on both sides of a movable wall and subsequently injected under the pressure at which it was accumulated by opening a discharge valve which has the effect of suddenly releasing the pressure on one side of the movable wall which then acts as a piston to force the fuel charge into and through a discharge line to an injection nozzle. Such devices have the disadvantage that the high pressure on the fuel charge must exist for an unnecessarily long period so that the liability of leakage is greatly increased, and also are disadvantageous in view of the necessity of opening a discharge valve against a very high pressure.

The primary object of the present invention is to provide an injector in which fuel is accumulated at relatively low pressure by means of a variable pressure pump, stored in the accumulator chamber and subsequently injected at high pressure by an actuating fluid from a separate, high pressure pump.

The invention is particularly applicable to the injection of fuel in free piston machines for the reason that the accumulation of a fuel charge can be made during either the outward stroke of the pistons or the early portion of the inward stroke and injection of the fuel may be caused at the extreme end of the inward stroke. Because injection takes place under a fluid pressure that can be developed entirely apart from any device that is moved in timed relation to the engine piston such as a constantly driven pump, the fact that piston motion has virtually stopped at the time fuel is injected into the engine cylinder has no effect on the injection characteristics.

Another object of the present invention is to provide an accumulator type fuel injector in which the quantity of fuel metered into the accumulator cylinder is variable in accordance with a simple input pressure and is independent, in quantity, of any mechanical movement that may be derived from the engine. In free piston engines wherein the length of the piston stroke varies with the load on the machine it is highly desirable to divorce the function of fuel metering from devices that depend for their functioning on the extent of the stroke of the pistons of the machine.

Other objects and advantages of the invention will be apparent from the following specification which describes a preferred embodiment thereof, reference being had to the accompanying drawings, in which—

Fig. 1 is a diagrammatic view, with parts broken away, of a free piston engine equipped with a fuel injection system incorporating the present invention;

Fig. 2 is a somewhat diagrammatic, vertical sectional view of a control valve used with the injector of the present invention; and

Fig. 3 is a somewhat diagrammatic vertical sectional view of a fuel injector incorporating the present invention.

Referring to Fig. 3, a fuel injector is shown somewhat diagrammatically as comprising a body **10** having an upper cap extension **12** fastened thereto by bolts **14** and a lower nozzle carrying extension **16**. The body **10** is formed with a central accumulator cylinder **18** which may be of any suitable construction but preferably comprises a lapped liner **20** seated against a hardened and ground end member **22**. The bore of the liner **20** which constitutes the actual accumulator chamber is designated **24** and receives an accumulator and injector piston **26**.

The piston **26** is urged into the accumulator cylinder by a spring **28** which bears at its outer end against a stop member **30** the shank of which extends within the coils of the spring in the path of the upper end of the piston. The spring and stop member are disposed within a bore **31** in the cap extension **12**, the bore being sealed off so that it can contain high pressure actuating fluid. The parts are shown in the drawing in the position that would be occupied by the accumulator piston **26** at the end of the accumulating portion of its cycle of operation with the maximum quantity of fuel metered into the accumulator chamber **24**. At part load the ultimate upper position of the piston **26** is such that no contact will occur between its end and the stop member **30**, because, as will be hereinafter described, the quantity of fuel accumulated is made to depend on the pressure at which the accumulation is made, this pressure being balanced by spring **28**. For different engines the characteristics of the spring **28** will be varied by making it longer or shorter, stiffer or less stiff so that the range of accumulating pressures is changed. For this reason the axial extent of bore **31** is indefinite as indicated in dotted lines.

The lower end of the accumulator chamber **24** communicates by a passage **32** with a bore **33** in which is disposed a spring **34** pressing against an inlet check valve **36**. The valve **36** controls an inlet passage **38** which extends outwardly of the injector and is coupled to the discharge of a suitable variable pressure fuel pump P_1 (Fig. 1). Pump P_1 is a low pressure device, the output pressure of which is variable between 200 p. s. i. to 400 p. s. i.

The bore **33** also communicates with a discharge passage **40**. The passage **40** runs out of the body **10** to enter an injection nozzle generally designated **42**. Nozzle **42** may be of any suitable construction, and many satisfactory devices are known in the art. The device shown in the drawings includes a needle valve **44** which cooperates with a seat **46** to close off a passage **48** leading to the end of the nozzle and thus to the interior of an engine cylinder in which the entire unit is mounted. The needle valve is carried at the end of a plunger **50** and the plunger and valve are urged to closed position by a spring **52** disposed in a chamber **54** which is maintained at atmospheric pressure by connection to a drain line through a small lateral passage **56**. The entire nozzle is held in place with respect to the injector body by a sleeve **60** threaded to the body extension **16** and having a lower internal flange **62** that bears against a shoulder of the conventional nozzle tip **64**.

Above the piston **26** the bore of the accumulator cylinder communicates with an operating fluid inlet passage **70**. This passage extends outwardly from the injector body and communicates with the discharge of a high pressure pump P_2. The piston **26** is preferably provided with a relief groove **72** on its periphery which communicates with a central relief passage **74** opening at the top of the piston into the chamber or bore **31**.

The relief groove is spaced from the lower or inner end of the piston **26** a distance such that, when the piston is at the end of its movement and is standing against the end member **22**, the groove registers with a series of peripherally spaced communicating relief ports **76** in the wall of the accumulator cylinder liner **20**. The relief ports, in turn connect with a drain passage **78** and outlet **80**.

Figure 1 of the drawings shows diagrammatically a free piston engine and its fuel system including the present invention. The engine includes the usual opposed piston sets **100** and **101** including the usual large compressor pistons **102** and **103**. The compressor pistons are each provided with a rack **104** extending outwardly along the central part of the engine and meshing with a synchronizing pinion **105**. The fuel injector body is indicated by its numeral **10** and is disposed between the piston sets **100** and **101** to inject fuel into the combustion chamber formed thereby.

As diagrammatically shown in Fig. 1, one of the racks **104** may be provided with cams **106** and **107** at positions corresponding to the inner and outer positions of the piston sets. Cam **106** operates a valve **108** whenever the pistons are at the outer end of the stroke, and valve **108** admits fuel from the low pressure (200 p. s. i. to 400 p. s. i.) pump P_1 through a manual or automatically controlled regulator valve **111** into the fuel accumulator or inlet line or passage **38**.

Cam **107** is disposed on rack **104** (although it may be mounted on either rack) at a position corresponding to the inner end of the stroke of the pistons when injection is desired. Cam **107** operates a valve **112** in a line from the high pressure pump P_2 to the high pressure activating fluid line **70** so that fluid is admitted to line **70** whenever the cam **107** depresses the valve **112** and continues to exert its pressure so long as the valve is open.

The valve designated generally **112** in Fig. 1 is shown in greater detail in Fig. 2. The valve serves the purpose of admitting a pulse of high pressure oil to line **70** to drive the piston **26** downwardly and cause injection of the metered fuel charge. The valve comprises a head **113** normally closed against a seat **114** and carried at the end of a reciprocable body **115** having a plurality of guiding ribs **116** disposed in grooves in the body of the valve housing. The valve is thus guided and restricted to purely rectilinear movement. At its upper end the valve engages a plunger **117** and while engaged closes off a pressure relief passage **118** disposed centrally of the plunger and extending into a peripheral relief groove **119** which, in turn, communicates with a drain line.

When valve head **113** is forced off its seat by cam **107** acting through a suitable follower and through plunger **116**, high pressure oil is admitted to line **70** to cause injection as above described. This high pressure oil will continue to flow so long as the valve head **113** is off its seat **114** and after the piston **26** has reached the end of its stroke the flow will be through relief passage **74**, groove **72** and drain passage **80** in the injector body. When the cam **107** releases the plunger **116** so that valve head **113** can re-engage its seat, the plunger **116** becomes a pressure relief valve for the chamber above the accumulator piston **26**, since oil can move out of this chamber back through line **70**, around the valve body **115** and between this body and the lower face of the plunger **116** to enter the relief passage **118** and relief groove **119** to drain away. In this manner the piston **26** is free to move up under the influence of the next accumulated fuel charge without danger of being locked hydraulically by oil above it. Thus the only resistance to the accumulation of fuel is imposed by the calibrated spring **28** above the piston.

In operation, fuel under relatively low pressure (200–400 p. s. i.) is admitted to the injector from pump P_1 to the inlet line **38** past the inlet check valve **36** and into the accumulator chamber **24**. Fuel will continue to flow into the chamber until the spring **28** has been deformed to the point where its force exactly balances the pressure of the low pressure charging pump as determined by the setting of regulator valve **111**. A predetermined quantity of fuel has thus been accumulated irrespective of the duration of the opening of the valve which controls the passage between the charging pump discharge and the injector inlet. Thus, in a free piston machine in which the cam **106** which controls the valve is on or driven by the synchronizing rack **104**, the fact that the valve is opened during the outward stroke and again during the inlet stroke is immaterial since the quantity of fuel accumulated is a function of pressure and not of time.

Once the fuel charge has been accumulated in chamber **24** beneath piston **26** it remains there until actuating fluid is admitted through passage **70** above the piston **26**. This fluid is taken from the high pressure pump P_2 and communication is established by the cam controlled valve **112** which is opened at the inner end of the stroke of the free pistons. The pressure may be several thousand pounds per square inch, greatly in excess of the pressure at which the charge has been accumulated. The high pressure forces the piston **26** down and forces the fuel out of the accumulator chamber **24**, through discharge passage **40** to the space below the plunger **50** lifting the same against its spring **52** and thus raising the needle valve **44** from its seat. The charge is thus injected through passage **48** into the engine cylinder.

It will be seen that injection of fuel will continue only during the stroke of piston **26** regardless of the fact that high pressure may be maintained above it for some time thereafter, and that a positive stop to the injection occurs when the piston **26** strikes the hardened end member **22**. This is also a distinct advantage in free piston engines because the cam **107** which controls the opening of valve **112** in the high pressure line is at the position on the synchronizing rack corresponding to the inner end of the piston stroke and thus acts to hold the valve open not only during the last portion of the inward stroke when it is desired, but also for a corresponding period during the outward stroke before which injection should have been completed.

What I claim is:

In a fuel injector, the combination of means defining an accumulator chamber and including a piston defining one side of said chamber, said accumulator chamber having a peripheral pressure relief opening, and said piston having a pressure relief groove registering with said opening when said piston is at the limit of its movement into said accumulator chamber, spring means resisting movement of said piston in a direction tending to enlarge said accumulator chamber, means to introduce fuel into said accumulator chamber beneath said piston at a predetermined pressure against the force of said spring means until the pressure of accumulation balances the force of said spring means, an injection nozzle, and hydraulic means to force fuel out of said accumulator chamber through said injection nozzle under pressure much higher than the pressure at which it was accumulated, the pressure of said hydraulic means being relieved when said piston strikes the opposite wall of said accumulator chamber and is in the position of registry between its relief groove and the relief opening in said accumulator chamber.

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