Sept. 1, 1931. L. BERNER ET AL 1,821,173

FUEL INJECTION APPARATUS FOR INTERNAL COMBUSTION ENGINES

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Fig. 1

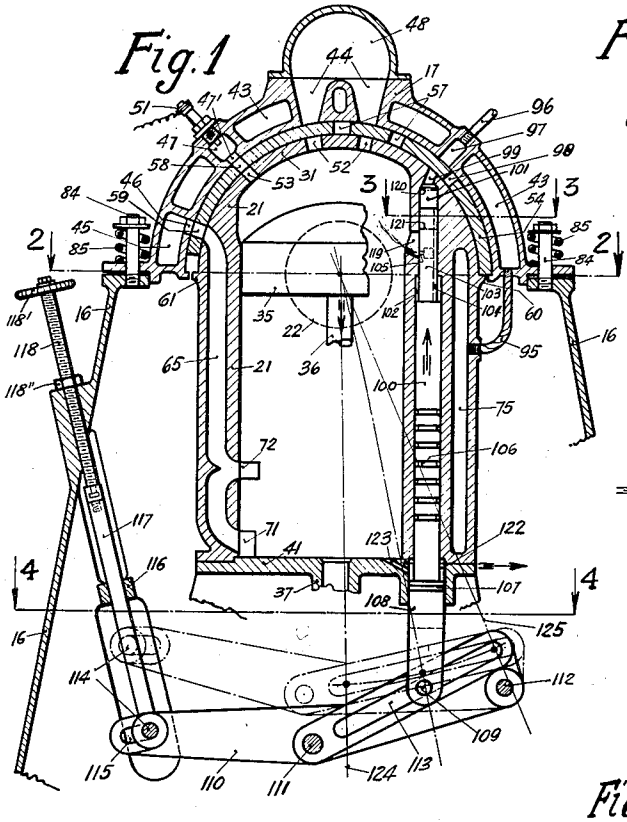
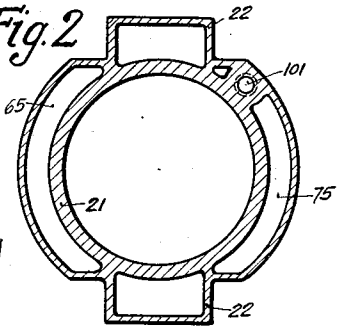


Fig. 2



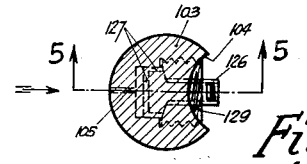


Fig. 3

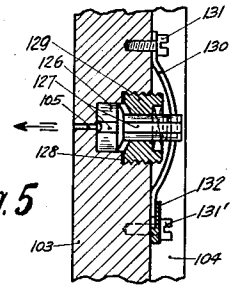


Fig. 5

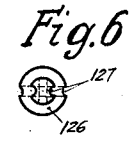


Fig. 6

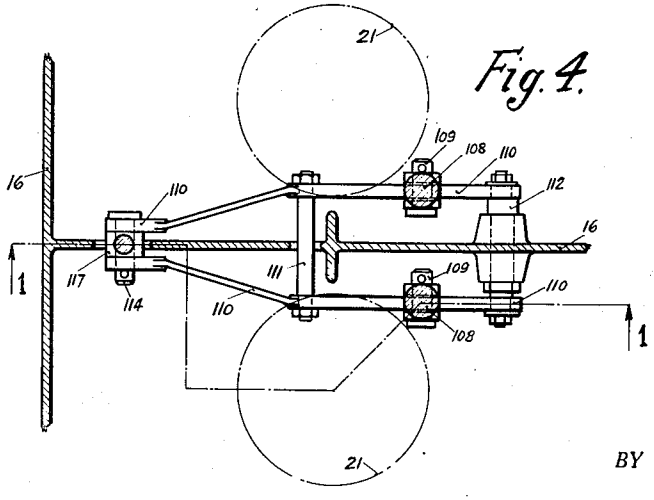


Fig. 4

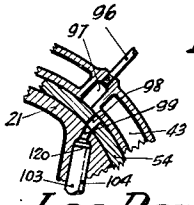


Fig. 7

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FUEL INJECTION APPARATUS FOR INTERNAL COMBUSTION ENGINES

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Fig. 9

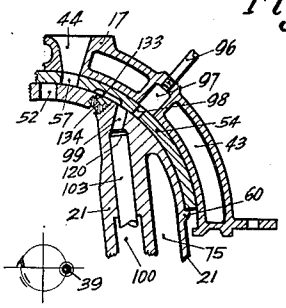


Fig. 8

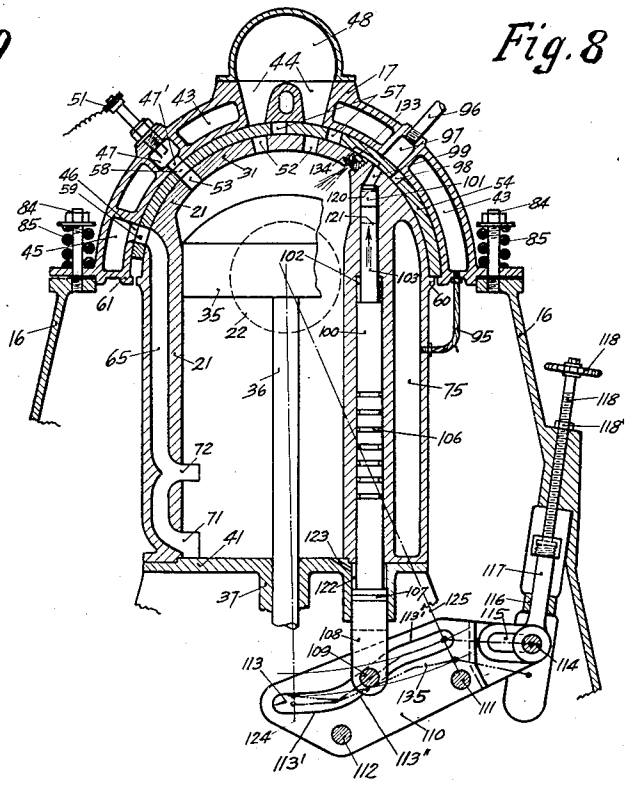


Fig. 10

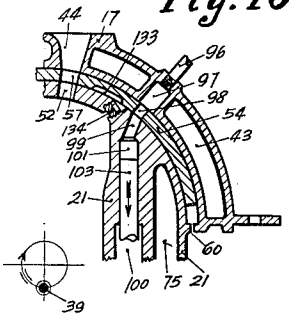


Fig. 11

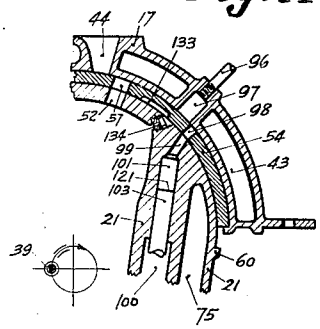
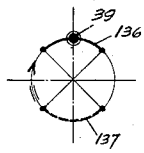


Fig. 12



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Patented Sept. 1, 1931

1,821,173

UNITED STATES PATENT OFFICE

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FUEL INJECTION APPARATUS FOR INTERNAL COMBUSTION ENGINES

Application filed June 13, 1929. Serial No. 370,583.

The invention relates to internal combustion engines and more particularly to fuel injection apparatus for spraying metered quantities of fuel, under pressure, to the combustion chamber of the engine at the desired time in the engine's cycle.

The object of the invention is to provide means for delivering metered quantities of fuel to an internal combustion engine of the oscillatory cylinder type, said means including a pump plunger which receives its motion from the engine cylinder and whose stroke is altered to vary the amount of fuel delivered to the engine.

The invention further consists in the several features hereinafter set forth and more particularly defined by claims at the conclusion hereof.

In the drawings Fig. 1 is a detail vertical sectional view through an internal combustion engine equipped with fuel injection apparatus embodying the invention;

Fig. 2 is a detail sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a detail sectional view taken on the line 3—3 of Fig. 1;

Fig. 4 is a detail sectional view taken on the line 4—4 of Fig. 1;

Fig. 5 is a detail sectional view taken on the line 5—5 of Fig. 3;

Fig. 6 is a front end view of the discharge valve;

Fig. 7 is a detail sectional view of parts shown in Fig. 1, showing them in a different position;

Fig. 8 is a detail vertical, sectional view through an internal combustion engine equipped with a modified form of fuel injection apparatus embodying the invention;

Fig. 9 is a detail sectional view of parts shown in Fig. 8 showing the position of the plunger and ports at the end of the stroke of the plunger.

Fig. 10 is a detail sectional view similar to Fig. 9, showing the position of the ports and the plunger as the plunger starts on its suction stroke;

Fig. 11 is a detail sectional view similar to Fig. 9, showing the position of the plunger and ports during the intermediate part of the cycle;

Fig. 12 is a diagrammatic view showing the timing of the plunger movements.

The fuel injection apparatus embodying the invention has been designed for association with internal combustion engines of the oscillatory cylinder type and more particularly to engines of the form shown in our copending application, Serial No. 277,582, filed May 14, 1928.

The engine herein shown embodies features shown in the aforementioned application and includes a fixed frame or entablature 16 associated with the engine crankcase (not shown) and forming a support for trunnions 22 projecting from opposite sides of an oscillatory cylinder 21, the upper half of said trunnions being journalled in bearing caps (not shown) secured to the fixed frame. Thus, each cylinder is mounted for oscillation and its lower end closed off by a cover plate 41 provided with a tubular extension 37.

A piston 35 is mounted to reciprocate in each cylinder and is provided with a piston rod 36 slidably mounted in said extension and operatively connected to the crank shaft in any suitable manner, though the arrangement shown in our application Serial No. 277,582 is preferred. Thus, the cylinder is caused to oscillate as the rod 36 is oscillated by the crank shaft, while at the same time said rod and piston are reciprocated relative to the engine cylinder.

A head 17 is yieldingly mounted relative to the fixed frame 16 by springs 85 interposed between said head and the heads of bolts 84 upon which the flanged edges of said head are also slidably mounted.

This head is provided with a cooling jacket space 43, exhaust ports 44, an air inlet space 45 having a port 46 for each cylinder and may have an ignition chamber 47 having a port 47′ for each cylinder of a pair. The exhaust ports 44 communicate with an exhaust conduit 48 secured to the head and a sparking ignition device 51 or other suitable igniter may extend into the chamber 47.

The head 31 of each cylinder 21, which is of semi-cylindrical formation, is provided

with spaced exhaust ports 52 adapted to register with the exhaust ports 44 and with a port 53 movable into register with the port 47′ at the proper time in the cycle of the engine. The inner side of the head 17 above each cylinder is of a curvature conforming to that of the cylinder head.

A semi-cylindrical oscillatory valve 54, whose axis coincides with the axis of oscillation of the cylinder, is interposed between the head 31 of each cylinder and the fixed head 17, said heads being curved to accurately conform to the curvature of the valve. Each valve 54 has spaced exhaust ports 57 adapted to register with the exhaust ports 44 and 52, a port 58 adapted to register with the ports 53 and 47′, and a port 59 adapted to register with the port 46 and with a transfer passage 65 at the proper time in the cycle of the engine.

Each valve 54 is intermittently oscillated by the movement of the cylinder associated therewith and for this purpose we provide projections 60 and 61 alternately engageable with the adjacent side edges of said valve.

The air inlet or transfer passage 65 in each cylinder leads by way of ports 71 to the space between the head or plate 41 and the back of the piston 35 and the scavenge ports 72 lead from said passage 65 into the cylinder and are uncovered by the piston at the end of its inward stroke, at which time the clearance between the piston and the bottom head 41 is preferably a minimum so as to just prevent mechanical contact and thus all the compressed fuel charge is confined within the transfer passage 65 just before its entrance into the cylinder.

The cooling space 43 of the head may be connected with the cooling space 75 of the cylinder by a flexible pipe 95.

The operation of the valve structure is similar to that of our application Serial No. 277,582, to which reference may be made for a full and complete explanation thereof, it being noted here that the oscillation of the cylinder 21 serves at the proper time to move the valve 54 to bring about the usual events of two cycle operation, the ports 52, 57 and 44 being in register during exhaust and until the port 72 is uncovered by the piston, the ports 53, 58 and 47′ being in register near and at the end of the compression stroke where an ignition device, such as the spark plug 51, is used to fire the charge.

The fuel injection apparatus includes a differential pump plunger 100 and 103 working in differential bores 102 and 101, respectively, in each cylinder, said plunger having the usual annular grooves 106 formed therein, resisting leakage and having a cross-head portion 108 working in a bore 122 in the cover plate 41.

A fuel supply pipe 96 connects with a passage 97 in the fixed head 17 which, through the port 98 in the valve 54, connects with a passage 99 leading into the upper bore of the pump, the port 98 moving into register with the passages 97 and 99 during the downward stroke of the plunger, which occurs as the lower end of the cylinder 21 is oscillated toward the left in opposite direction from that indicated by the arrow in Fig. 1.

For reciprocating the pump plunger as the cylinder is oscillated, a lever 110, pivoted on a fixed shaft 112, has a slot 113 in which a suitable pin or block 109 on the portion 108 works, said lever 110 being held relatively stationary by means hereinafter described, whereby the oscillatory movement of the cylinder in conjunction with the limiting of the movement of the pump plunger by said lever will cause a relative reciprocatory movement between the cylinder and plunger, whereby fuel drawn into the pump casing during the lower half of the downward and upward movement of the piston 35 and the oscillation of the cylinder toward the left, as previously noted, will, at the desired time in the upper half of the up-stroke and downward stroke of the piston, and preferably at half stroke, be expelled from the pump casing by the plunger and into the cylinder, as hereinafter described.

The cylinders 21, as shown in Fig. 4, are preferably arranged in pairs and the pumps for said cylinders are likewise arranged in pairs with the levers 110 connected together by a tie-pin 111.

The means for varying the stroke of the pump plunger or plungers includes means for adjusting the angular position of the lever or levers 110 from the full to the dotted line position shown in Fig. 1, that is, from a position of full to no delivery. For this purpose a pin 114, mounted in slots 115 of the levers 110, connects said levers with the lower eyed end of a rod 117 mounted in a guide bore 116 and suitably connected to a threaded shaft 118 so as to be reciprocated thereby as said shaft is turned in a threaded boss in the frame by means of a handwheel 118′, said shaft being held in adjusted position by a locknut 118″.

The plunger has a groove 104 formed in the section 103 whereby the bores 101 and 102 are kept in communication with each other and the discharge from these bores into the cylinder is through a spray opening 105 in the plunger as said plunger moves past the port 119 formed in the cylinder wall.

Passage to the opening 105 may be controlled by a discharge valve and as shown in Figs. 3, 5 and 6, a check valve 126 is slidably mounted in and seats against a plug 129 mounted in the plunger against a packing 128, said valve having grooves 127 formed in the front and sides of its head and in its stem,

whereby fuel from the passage 104 is free to flow past said valve when the same is open to the spray nozzle 105. The valve 126 is normally held closed by a spring and as here shown a flat bowed spring 130, disposed in the groove 104 and anchored at one end to the plunger by a screw 131 and at its other end having limited sliding movement in a clip 132 secured to the plunger by a screw 131', passes through a slot in the stem of the valve.

With this construction, as the piston 35 moves through the lower half of the up and downward stroke and the lower end of the cylinder 21 oscillates toward the left, the lower end of the pump plunger travels over toward the left in the slot 113 from the position shown in the drawings and the plunger moves down relative to the cylinder 21 during the firing or expansion stroke and at that time a new charge of fuel is being taken into the pump body through the registering ports 99, 98 and 97 and when the piston nears the end of its stroke the exhaust ports come into registry. Thereafter, as the cylinder oscillates toward the left the valve 54 is shifted to close the exhaust ports. At the half upward stroke the port 98 is moved out of registry with the port 97 and as the piston 35 continues to move upwardly ports 99, 98 and 97 are in the position shown in Fig. 7. During this oscillatory movement the relative movement between the pump plunger and the cylinder causes the pump plunger to move upward on its expressing stroke and puts pressure on the fuel in the bores 101 and 102, thereby opening the valve 126 and spraying the fuel through the opening 105 and port 119 into the cylinder, this action taking place in the present design as the piston 35 is moving through the latter half of its compression stroke and the first half of the expansion stroke. The maximum range of movement of the plunger is indicated by the lines having the designating numerals 120 and 121 applied thereto, but, as previously pointed out, this stroke may be lessened by moving the lever 110 upwardly until said lever reaches its dotted line position, at which time there is practically no relative movement between the pump plunger and the cylinder so that no fuel is delivered to the engine cylinder. Should any of the fuel leak by the grooves 106 it will find its way into the bore 122, from which it is expelled through the passage 123 into the space behind the piston.

A modified form of this device is shown in Figs. 8 to 12 of the drawings. In Figs. 9 to 11, inclusive, the fuel supply pipe 96 connects with the passage 97 in the fixed head 17, which, through the port 98 in the valve 54, connects with the passage 99 in the cylinder leading into the upper bore 101 of the pump, the port 98 moving into register with the passage 97 during the downward stroke of the plunger, which occurs when the valve 54 is oscillated to the left, as shown in Figs. 9 and 10 of the drawings, and the passage 99 coming into alinement with the passage 97 and port 98 as the cylinder turns to a dead center position, as shown in Fig. 10.

For reciprocating the pump plunger as the cylinder is oscillated a lever 110 pivoted on a fixed shaft 112 has a cam slot 113 formed therein in which a suitable pin or plug 109 on the portion 108 works, said lever being held relatively stationary by means hereinafter described whereby the oscillatory movement of the cylinder in conjunction with the limiting of the movement of the pump plunger by said lever will cause a relative reciprocatory movement between the cylinder and plunger whereby fuel drawn into the pump casing during the movement of the piston 35 from about 45 degrees before lower dead center to 45 degrees after lower dead center, as indicated by the numeral 137 in Fig. 12, and the oscillation of the cylinder toward the left, as previously noted, will, at the period between 45 degrees before upper dead center and 45 degrees after upper dead center, as indicated by the numeral 136 in Fig. 12, be expelled from the pump casing by the plunger and into the cylinder, as hereinafter described.

The means for varying the stroke of the pump plunger includes means for adjusting the angular position of the lever 110 from the full line position shown to a position in which the cam slot 113 assumes the position indicated by the numeral 135 in Fig. 8 of the drawings, that is, from the position of full to no delivery. For this purpose the same construction as previously described is used, including a pin 114 mounted in slot 115 of the lever 110 connecting said lever with the lower eyed end of a rod 117 mounted in a guide bore 116 on the frame 16 and suitably connected by a threaded coupling to a threaded shaft 118 so as to be reciprocated thereby as said shaft is turned in a threaded boss in said frame by means of a handwheel 118', said shaft being held in adjusted position by a locknut 118''.

For controlling the discharge to the cylinder the valve 54 has a port 133 formed therein, adapted to connect the passage 99 of the pump casing with a spray nozzle 134 mounted in the cylinder head adjacent the passage 99 whereby, as noted in Fig. 8, showing the mid position of the pump plunger, the fuel in the pump casing will be discharged through passage 99 and port 133 and spray nozzle 134 into the engine cylinder during the time that the piston is moved through the angle of 45 degrees before dead center to 45 degrees after dead center for a maximum delivery, which may be lessened by the adjustment of the lever 110, as previously de-

scribed, cutting down the stroke of the pump and hence the amount of fuel delivered.

It is to be noted that the plunger is provided with a differential bore so as to enable the lower end of the plunger to be made larger for the purpose of securing further sealing in the event that fuel should pass by the smaller bore 101 into the larger bore 102.

With this construction, as the piston 35 moves from the position shown in Fig. 8, through an angle of about 45 degrees, as shown in Fig. 12, the valve 54 is moved toward the left, as shown in Fig. 9, while the pump plunger continues to move through the remainder of its stroke which finishes at 45 degrees after dead center, the parts then assuming the position shown in Fig. 9, as the piston moves from the 45 degrees after upper dead center to 45 degrees before lower dead center.

As the piston moves through 45 degrees before lower dead center to 45 degrees after lower dead center the suction period of the pump occurs and the position of the parts at lower dead center is shown in Fig. 10, the cylinder having oscillated from the position shown in Fig. 9 to the position shown in Fig. 10, the valve 54 remaining stationary under these conditions but the discharge of the pump being cut off through the movement of the passage 99 out of register with the port 133.

As the piston moves from 45 degrees after lower dead center to 45 degrees before upper dead center the parts assume the position shown in Fig. 11, the pump plunger having completed its suction stroke, the source of fuel supply having been cut off by the movement of the port 98 out of register with the port 97 and the continued cut-off between the passage 99 and the port 133, the piston being shown in its 90 degree position in Fig. 11. Thus it will be noted that only during the upper and lower halves of the stroke of the piston is the pump plunger reciprocated to provide for the discharge and inlet of fuel to the pump casing, respectively, and that during the intermediate positions of the piston the pump plunger is relatively at rest. This action is accomplished by the dwells provided in the lever 110 through the portions 113′ of the slot 113, while the portion 113″ of this slot brings about the active reciprocation of the plunger through the relative movement between the plunger and the oscillating cylinder.

The events of inlet of air, exhaust and scavenging of the cylinder and ignition of the charge are carried out through the relative reciprocation between the cylinder and valve 54 in the same manner as previously described in connection with the first construction.

The lines indicated by the numerals 124 and 125 in the drawings show in each instance the extreme positions of movement of the pump plunger.

The compression may be high enough to produce auto-ignition or it may be lower and the spark plug 51 or other igniting device used to ignite the charge.

Furthermore, the clearance space may be varied by suitable adjustment of the piston 35 so that the engine may be used either as an injection type engine or as an explosive mixture engine.

We desire it to be understood that this invention is not to be limited to any specific form or arrangement of parts except insofar as such limitations are specified in the claims.

What we claim as our invention is:

1. In an internal combustion engine, the combination with an oscillatory cylinder provided with a pump casing, of a pump plunger working in said casing for delivering charges of liquid fuel into said cylinder, and means cooperating with said cylinder for producing relative reciprocatory motion between said cylinder and pump plunger.

2. In an internal combustion engine, the combination with an oscillatory cylinder, of a pump casing associated with the cylinder, a pump plunger working in said casing, and means for reciprocating said pump plunger relative to said cylinder including an adjustable lever operatively connected to said pump plunger and movable to different positions relative to the cylinder to vary the stroke of the pump plunger to deliver variable quantities of fuel to said cylinder.

3. In an internal combustion engine, the combination with an oscillatory cylinder, of a fuel pump including a pump casing moving with the cylinder and the pump plunger movable relative to the cylinder, means for varying the stroke of the pump plunger comprising a pivoted lever having a slotted portion connected with said pump plunger and an adjustable means connecting the free end of said lever with a relatively fixed support for varying the angular position of said lever relative to said cylinder.

4. In an internal combustion engine, the combination with an oscillatory cylinder provided with differential bores and a discharge port leading from the smaller of said bores, a pump plunger having portions of differential diameter working in said bores, with a slot in the portion of smaller diameter establishing communication between said bores and with a discharge opening, means for introducing fuel into the smaller bore, and means for discharging fuel under pressure through said discharge opening and said port into the cylinder, and means cooperating with said cylinder to provide for relative reciprocatorial movement between said plunger and cylinder.

5. In an internal combustion engine, the combination of an oscillatory cylinder hav-

ing a pump casing associated therewith, of a plunger working in said casing, means for introducing fuel into said casing, said plunger having a spray opening and a discharge valve in said plunger controlling passage through said opening, and a port in said cylinder registering with said opening during the expressing stroke of the pump.

6. In an internal combustion engine, the combination with a cylinder having a closed lower end, a piston working in said cylinder provided with a rod slidably mounted in said lower end, a pump casing associated with said cylinder, a plunger working in said cylinder, inlet and discharge valves for the pump casing, and means for delivering any fuel leaking past said pump plunger into the lower end of said cylinder adjacent said closed end.

7. In an internal combustion engine, the combination with an oscillatory cylinder provided with a pump plunger bore, a plunger working in said bore, inlet valve mechanism controlled by the cylinder for controlling the supply of fuel to said bore, a discharge port in said cylinder, said plunger having a discharge opening communicating with said bore and registering with said port during the expressing stroke of the plunger for delivering liquid fuel into said cylinder, and means cooperating with said cylinder for producing relative reciprocatorial movement of said plunger relative to said cylinder, said means being adjustable to vary the stroke of the pump plunger.

8. In an internal combustion engine, the combination with an oscillatory cylinder provided with a pump plunger bore, a plunger working in said bore, of a valve mechanism controlled by the cylinder for controlling the supply of fuel to said bore, discharge valve mechanism controlled by the cylinder for controlling the discharge of fuel into the cylinder, said cylinder having a spray nozzle associated with said discharge valve mechanism, and means cooperating with said cylinder for producing reciprocatory movement of said plunger relative to said cylinder.

9. In an internal combustion engine, the combination with an oscillatory cylinder provided with a pump plunger bore, a plunger working in said bore, of a valve mechanism controlled by the cylinder for controlling the supply of fuel to said bore, discharge valve mechanism controlled by the cylinder for controlling the discharge of fuel into the cylinder, said cylinder having a spray nozzle associated with said discharge valve mechanism, and means cooperating with said cylinder for producing reciprocatory movement of said plunger relative to said cylinder, said means being adjustable to vary the stroke of the plunger.

10. In an internal combustion engine, the combination of an oscillatory cylinder having a pump casing associated therewith, of a plunger working in said casing, means for introducing fuel into said casing, means for discharging fuel from said casing into the engine cylinder, and a slotted member associated with the pump plunger and cooperating with the cylinder to provide relative reciprocatory movement between said cylinder and plunger, the slot in said member providing for dwells of the pump plunger while the piston is moving through its intermediate positions providing for the inlet of fuel to the pump casing as the piston is moving through its lower dead center position and the discharge of fuel from the pump casing as the piston is moving through its upper dead center position.

11. In an internal combustion engine, the combination of an oscillatory cylinder provided with a semi-cylindrical head and a pump casing having a passage extending through said head, a semi-cylindrical oscillatory valve having a fuel supply port to register with said passage during the suction stroke of the plunger and a fuel discharge port to register with said passage during the delivery stroke of the plunger, said cylinder head also having a discharge opening registerable with said fuel discharge port during the delivery stroke of the plunger, a fixed head having a port registerable with said fuel supply port and in communication with a source of fuel supply, said cylinder having parts intermittently engageable with said valve to oscillate the same by the cylinder, a pump plunger working in said pump casing, and means cooperating with said cylinder to produce relative reciprocatory motions between said cylinder and pump plunger in proper cyclic sequence with the movement of said valve.

In testimony whereof, we affix our signatures.

LEO BERNER.
PAUL LOHR.