June 8, 1937. M. J. MURPHY 2,082,808

FUEL INJECTION APPARATUS

Filed Sept. 10, 1934 2 Sheets-Sheet 1

Fig. 1

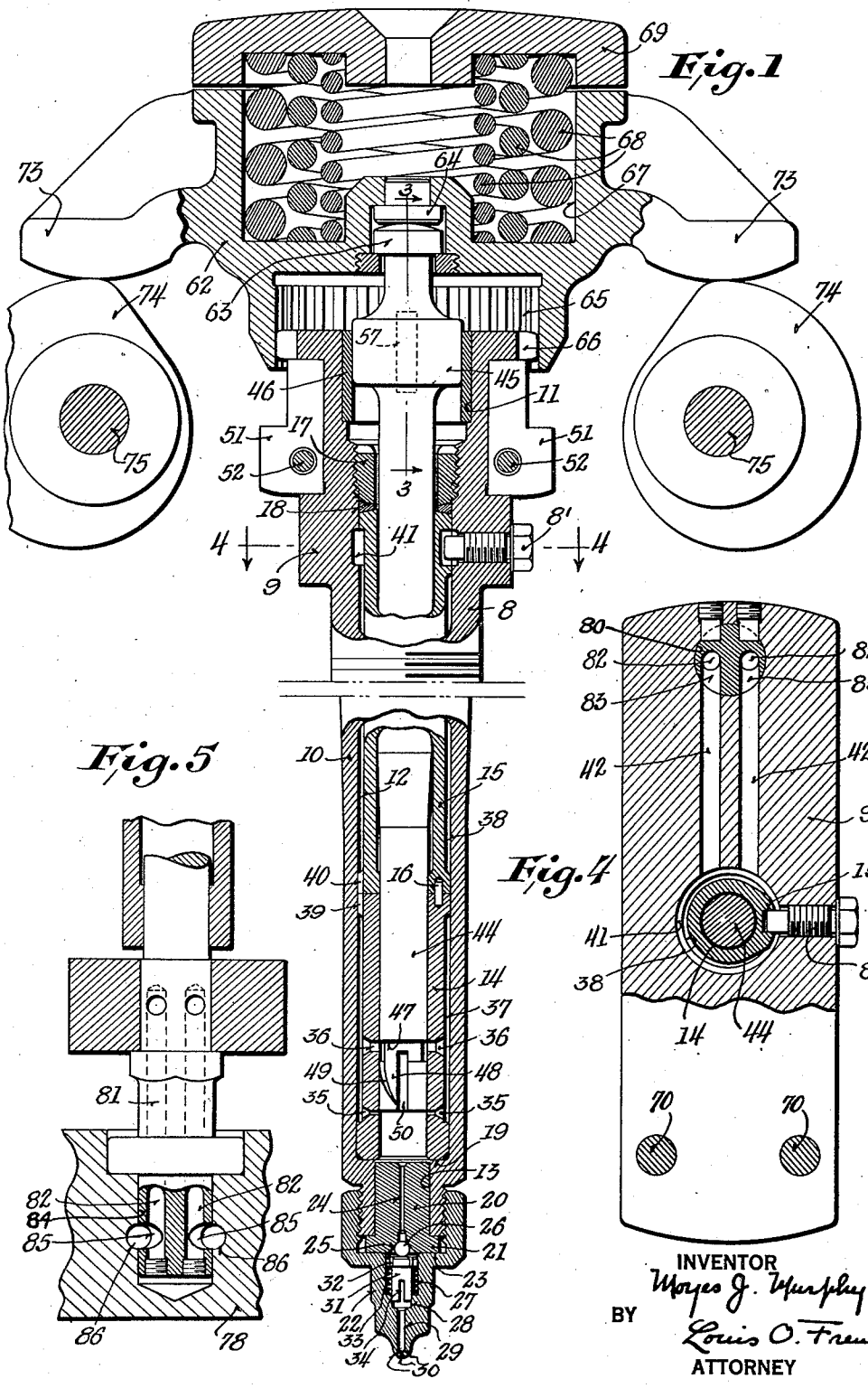


Fig. 5

Fig. 4

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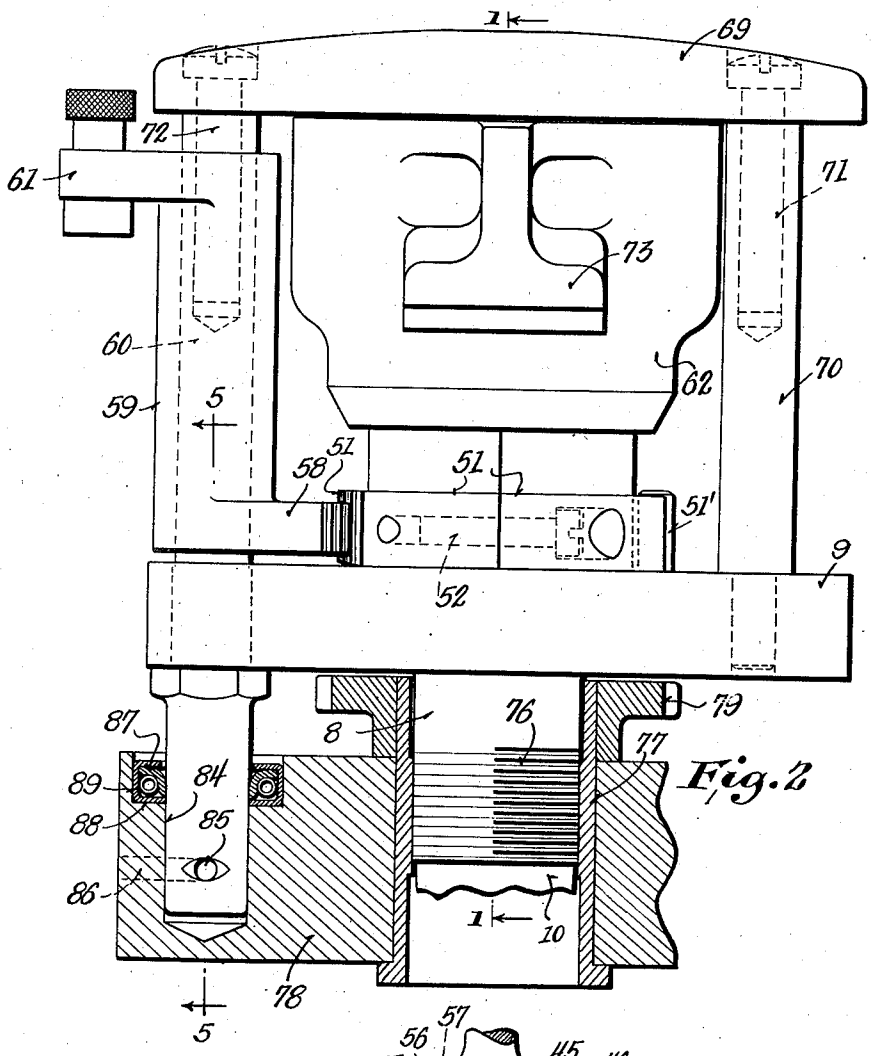


Fig. 2

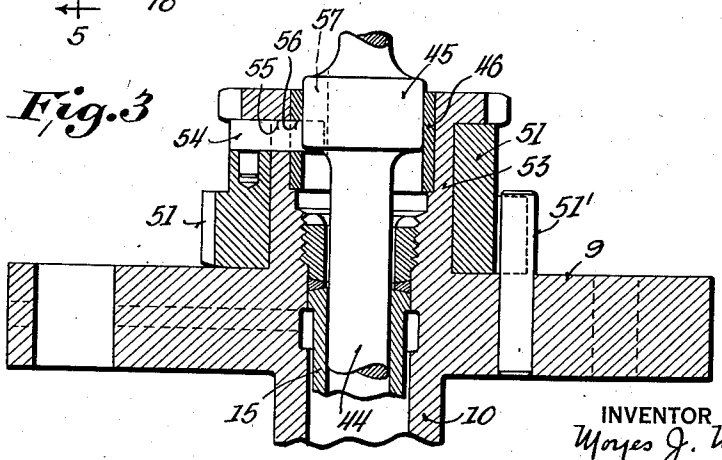


Fig. 3

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FUEL INJECTION APPARATUS

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Application September 10, 1934, Serial No. 743,339

16 Claims. (Cl. 299—107.2)

The invention relates to fuel injection apparatus or devices for solid fuel injection type internal combustion engines.

One of the objects of the invention is to provide an injector in which the pressure producing member is spring driven and directly associated with the nozzle, so that the condition of the engine may be observed by looking at the working of the valve since an erratic action of the valve will indicate either a dirty or plugged up nozzle or a sticking of the pressure producing member in its casing. Since the pressure producing member is spring driven, if the nozzle becomes plugged, damage to the engine will be prevented since the spring will not operate the pressure producing member above a predetermined pressure.

A further object of the invention is to provide a fuel injection device in which the pressure producing member is spring driven with the release of the energy of the spring drive synchronized with the operation of the engine for regular operation and preferably for carrying out the mixed cycle of combustion, i. e. combustion partly at constant volume and partly at constant pressure. When, with such an arrangement, the spring drive does not synchronize itself with the engine, the injection of fuel becomes erratic and thus the present injector device may act as an overspeed governor since its action becomes erratic above a predetermined maximum speed and therefore tends to slow the engine down above this speed.

A further object of the invention is to provide a fuel injection device in which air is prevented from being trapped in the pressure producing chamber not only while establishing fuel flow through the supply lines but also in case the discharge valve from the chamber leaks and allows gas to get into said chamber.

A further object of the invention is to provide a fuel injection device having a double row of vertically disposed ports to provide for forcing any air or gas from the pump chamber out through the upper set of ports and thus prevent the trapping of air or gas in the pump chamber.

A further object of the invention is to provide simple and efficient means for supplying fuel to the pressure chamber of the injection device.

A further object of the invention is to provide a simple and compact arrangement of parts to form a fuel injector device that may be readily serviced and is of relatively rugged construction and does not depend upon maintaining careful fits of the discharge valve as is necessary with the usual needle type injector valve.

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 vertical sectional view through a device embodying the invention and taken along the line 1—1 of Fig. 2;

Fig. 2 is a side elevation view of device, parts being broken away and parts of the mounting being shown in section;

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

Fig. 4 is a view taken generally in section along the line 4—4 of Fig. 1;

Fig. 5 is a detail sectional view taken along the line 5—5 of Fig. 2.

Referring to the drawings, the numeral 8 designates the housing or casing having a top plate portion 9 and a tubular portion 10 with alined bores 11, 12, and 13.

A plunger barrel fits within the bore 12 and is formed of a lower portion 14 and an upper portion 15 alined therewith and connected thereto by the pins 16. This barrel is clamped in position by a clamping nut 17 in threaded engagement with the threaded upper end of the bore 12 and bearing on a washer or gasket 18 disposed on the top of said barrel, the lower portion of said barrel seating on the shoulder 19. The barrel assembly is prevented from rotating by a stop screw 8' having an end seating in a recess 15' in the upper barrel part 15.

A valve seat member 20 is mounted in the bore 13 and has a flanged end 21 seating and clamped in a fluid tight manner against the end of the tubular casing 10 by a nozzle member 22 having threaded engagement with the lower end of said casing, said member 22 having a clamping surface 23 in fluid tight engagement with the flanged end 21 of said member. The member 20 has a small passage 24 extending therethrough and slightly enlarged at its lower end and then conically flared at 25 to form a seat for a ball check valve 26.

The nozzle member 22 has alined bores 27, 28, and 29 formed therein and one or more small spray openings 30 at the lower end of the bore 29. The valve 26 is normally held to its seat and preferably to resist relatively high opening pressure by a spring 31 mounted in the bore 27 and interposed between the end of said bore and the grooved flanged head 32 of a pressure transmitting member or pin 33 whose tubular lower end is guided in the bore 28 and has a conduit slot 34 formed therein.

The barrel part 14 has two sets of ports, the

diametrically disposed lower ports 35 forming the lower set and a series of radially spaced upper ports 36 forming the upper set, said last named ports being preferably spaced ninety degrees apart. These ports connect the interior of said barrel with an annular space 37 formed by recessing the outer portion of said barrel part and connected with a similar space 38 formed in the barrel part 15 by alined sets of grooves 39, 40, the upper part of the space 38 being alined with an annular space 41 in the casing 8 which connects with spaced fuel supply ducts 42 formed in the part 9 of said casing and supplied with fuel as hereinafter described.

A plunger 44 has a working fit at its lower end in the barrel part 14 and extends loosely through the barrel part 15 and also an enlarged cylindrical portion 45 slidably mounted and guided in a bronze sleeve 46 mounted in the bore 11.

The plunger 44 is formed at its lower end to cooperate with the ports 35 and 36 to supply variable quantities of fuel to the spray nozzle under varying positions of said plunger relative to said ports. For this purpose the plunger has an annular space 47 formed therein in spaced relation to its end, a recessed portion 48 opening into said space 47 and having an inclined front face 49, and a slot 50 extending from said space 47 to the front end of the plunger and forming in effect a continuation of one side of the recessed portion 48. There is also preferably a slot identical with the slot 50 at the opposite side of the plunger and a recessed portion similar to the portion 48 on said other side and oppositely disposed with reference thereto.

With the above arrangement when the plunger 44 is in its upper position, the suction ports 35 are uncovered by the front end of the piston and the space 47 is alined with the ports 36 and in communication with the pumping space by way of the slot or slots 50. Thus if any air or gas has collected or found its way into the pump barrel, this gas will rise up into the space 47 and when the plunger 44 is forced downwardly, there is a tendency to force the fuel out through the ports 36 until the same are lapped by the piston and consequently carry any entrapped air or gas out through said ports 36 and into the suction line. This tendency for reverse flow through the ports 36 is increased by making these ports larger or wider than the ports 35 so that said ports 35 are lapped or closed by the piston or plunger 44 before the ports 36 so that the pressure being developed in the pumping chamber will force excess fuel, and air or gas if present, through said ports 36.

As shown, the plunger is in a position for full load or full charge delivery and as the plunger is rotated to different adjusted positions, the inclined face 49 will pass the adjacent lower port 35 sooner or later dependent on whether said plunger is turned anti-clockwise or clockwise as viewed in Fig. 1. When, on the delivery stroke of the plunger, said face 49 passes the port 35, the fuel in the pump chamber is free to be bypassed back to suction since under these conditions the fuel may then return via the slot 50, recess 48 and port 35. Also in all pumping positions of the plunger the pumping chamber is connected with suction during the later part of the stroke of said plunger by the space 47 alining with the ports 35 and connected to the pumping space through the slot or slots 50. When the plunger is turned to bring the slot 50 into alinement with its cooperative port 35, no fuel will be delivered as the fuel will then simply be forced out of the pumping chamber and through the slot 50, or slot 50 and space 47 to said port 35.

For axially rotating the plunger 44 to different positions of angular adjustment a two part segmental gear member 51, whose parts are clamped together by screws 52, is journalled to turn about the cylindrical extension 53 of the casing 8, said gear having a key 54 secured thereto which works through clearance slots 55 and 56 in the extension 53 and guide 46 respectively and engages in a vertically extending slot 57 in the plunger 44. The gear 51 is oscillated by a governor or manually operated segmental gear 58 meshing therewith and having its hub 59 journalled on a pin extension 60, said hub having a lever arm 61 integral therewith. The extent of swinging movement of the gear 51 is limited by a pin 51' cooperating with a notched portion of said gear.

The plunger 44 is spring driven and forced downwardly at a predetermined pressure and in cyclic synchronism with the engine and positively returned. This drive mechanism includes a head member 62 which is centrally connected to the plunger and free to swing to some extent relative thereto, the plunger having a spherically curved button end 63 engaging the hardened button end 64 inset in said head member. This head member is guided in a substantially straight movement parallel with the plunger by a splined connection with the casing comprising the teeth 65 formed on the upper flanged end of the casing 8 meshing with annular gear teeth 66 formed in the lower end of said head. The head also has a centrally disposed cavity 67 in which a plurality of coil springs 68 of varying capacities are mounted, said springs reacting between said head and a fixed plate 69 secured to the housing 8 by the spaced studs 70 and fastening screws 71 and the screw 72 in threaded engagement with the pin extension 60.

The head member 62 is provided with diametrically disposed cam follower portions 73 cooperating with the control cams 74 mounted on shafts 75 driven by or in cyclic synchronism with the engine, said cams acting to elevate said head 62 and the parts connected therewith resisted by the compression of the springs 68 and thus store up energy in said springs which is then released under the control of the cams and drives the plunger 44 downwardly putting the fuel in the barrel 14 under pressure and on the release of the valve 26 expelling it through the passages in the nozzle member 22 and through the spray orifices 30 into the combustion chamber of the engine. Thus the cams 74 act to control the time of the introduction of fuel into the engine and the rate at which said fuel is introduced. The energy stored up in the springs is such a quantity that for all regular operating speeds of the engine the head 62 will be held against the cams so that the plunger 44 will operate in cyclic synchronism with the engine. When the rated speed is exceeded the head parts 73 are no longer able to follow the cams and on a release of the energized springs the timing of the fuel injection becomes erratic and the engine slows down. Thus the spring drive herein provided acts as an automatic overspeed governor It also insures that the fuel will only be subjected to a predetermined delivery pressure which cannot be exceeded in case the nozzle becomes plugged and thus damage to the engine is prevented. Since the downward movement is determined by the predetermined pressure the visible action of the valve will per-

mit the operator to judge whether it is dirty, plugged up, or the plunger is stuck in the barrel.

The injector casing 10 has a threaded portion 76 adapted to engage in a tubular nut 77 mounted in a part 78 of the cylinder head, said nut having a gear 79 secured thereto which is adapted to be turned by a manually rotatable gear (not shown). Thus turning of the nut 77 moves the casing 8 up or down relative to the cylinder so as to position or remove the injector from operative position in the engine.

The top plate portion 9 has the spaced fuel supply ducts 42 connecting the annular space 41 with a bore 80 in said plate, said bore having the extension 60 extending through it. The extension 60 and the main part of the pin 81 have spaced longitudinally extending passages 82 formed therein which communicate by transverse passages 83 with said ducts 42. The main part of the pin 81 fits into a bore 84 formed in the head part 78 and has transverse ducts 85 connecting the lower ends of the passages 82 with passages 86 in said head adapted to communicate with any suitable oil supply and circulating pump, so that fuel is at all times supplied through these passages to the injector at about a pressure of ten pounds per square inch. It is to be noted that the connection with the supply line is made by merely inserting the pin 81 in the bore 84, said pin also acting as a key to prevent rotation of the injector as the nut 77 revolves. It will also be noted that with such a circulating pump the fuel is in a continuous state of circulation from one passage 86, 82, and 42 to the chamber 41 and returns therefrom through the other set of communicating passages 42, 82, and 86 back to the supply. For preventing any leakage from the bore 84, a packing ring 87 is mounted in a recess 88 adjacent said bore and urged by a coiled spring 89 against said pin and also urged against said pin by the pressure of any fuel that may find its way along said pin.

I desire it to be understood that this invention is not to be limited to any particular form or arrangement of parts except in so far as such limitations are included in the claims.

What I claim as my invention is:

1. In a fuel injection apparatus, the combination with a valve controlled spray nozzle, of means for forcing fuel through said nozzle including a movable pressure producing member, spring means for driving said member, and means operating in cyclic synchronism with the engine for controlling the driving action of said spring means during the entire pressure stroke of said member.

2. In a fuel injection apparatus, the combination with a valve controlled spray nozzle, of means for forcing fuel through said nozzle including a reciprocatory pressure producing member, spring means for driving said member, and engine driven cam means for controlling the driving action of said spring means during the entire pressure stroke of said member.

3. In a fuel injection apparatus, the combination with a casing having a valve controlled spray outlet, a pump plunger reciprocating in said casing, spring means for moving said plunger on its working stroke, means for storing up energy in said spring means comprising an engine driven cam, and a cam follower operatively connected to said plunger and said spring means said cam controlling said spring means during the pressure stroke of said plunger

4. In a fuel injection apparatus, the combination with a casing having a valve controlled spray outlet, a pump plunger reciprocating in said casing, a head connected to said plunger, oppositely disposed engine driven cams, followers on said head engaging said cams for moving said plunger, and spring means engaging said head for holding said followers against said cams during the working stroke of the plunger at all rated loads.

5. In a fuel injection apparatus, the combination with a casing having a discharge nozzle at one end, of a constant stroke plunger for forcing fuel through said nozzle, spring means for imparting a driving force to said plunger, means for energizing said spring means and controlling said plunger during its working stroke, and adjustable relief means between said plunger and casing to vary the amount of fuel delivered by said nozzle.

6. In a fuel injection apparatus, the combination with a casing having a discharge nozzle at one end, of a pump barrel mounted in said casing, a plunger working in said barrel, said plunger and barrel provided with passages controlling inlet to and release of fuel from said barrel, a valve seat member between said barrel and nozzle, a spring pressed check valve cooperating with said seat member to control the flow of fuel to said nozzle, a head member connected to said plunger for limited tilting movement, spring means acting on said head member for moving said plunger on its delivery stroke, and oppositely disposed engine driven means for energizing said spring means and controlling their action during the working stroke of said plunger and moving said plunger on its non-working stroke.

7. In a fuel injection apparatus, the combination with a pump chamber, of a plunger working in said chamber, and vertically spaced sets of constantly open suction ports controlled by said plunger, the upper set of ports being of greater area than said lower ports and acting as fuel inlet ports through which the fuel passes at a lower velocity than through said lower ports and also adapted to conduct air or gas from said pump chamber.

8. In a fuel injection apparatus, the combination with a pump chamber, of a plunger working in said chamber, vertically spaced sets of cylindrical constantly open suction ports controlled by said plunger, the upper set of ports being of larger diameter than the lower set of ports and acting as inlet ports through which the fuel may pass at a lower velocity than through said lower ports and also adapted to conduct air or gas from said pump chamber and closing after the lower set of ports.

9. In a fuel injection apparatus, the combination of a casing having a tubular portion, means for delivering fuel to said tubular portion including a pin member provided with a passage, a member having a bore to slidably receive said pin member, means to supply said bore with fuel under pressure, and sealing means for preventing fuel leaking out along said pin member.

10. In a fuel injection apparatus, the combination with a casing having a tubular part provided with a threaded portion, an engine part having a nut member to receive said threaded portion, means for rotating said nut member to move said casing lengthwise to mount said casing in operating position, a pin forming a key and having a passage communicating with said casing, said engine part having a bore to slidably receive said pin member, means to supply said

bore with fuel under pressure, and sealing means for said pin member.

11. In a fuel injection apparatus, the combination of a casing having a fuel receiving space, means for circulating fuel through said space including a pin member provided with spaced passages, a member having a bore to slidably receive said pin member and provided with spaced passages communicating with the spaced passages in said pin member, and sealing means for preventing fuel from leaking out along said pin member.

12. In a fuel injector, the combination of a casing having a pump chamber at its lower end, a fuel receiving space at its upper end, and a passage connecting said space with said chamber and allowing air or gas to pass from said chamber to said space, said pump chamber having ports, a plunger reciprocating in said chamber and cooperating with said ports to control the entrance thereto and the discharge of fuel therefrom, and means for circulating fuel through said fuel receiving space.

13. In a fuel injector, the combination of a casing having a pump chamber at its lower end, a fuel receiving space at its upper end, and a vertically disposed passage connecting said space with said pump chamber, a plunger reciprocating in said chamber, said chamber having vertically spaced sets of open suction ports controlled by said plunger, the upper set of ports adapted to conduct air or gas from said pump chamber and closing after the lower set of ports, and means for circulating fuel through said fuel receiving space.

14. In a fuel injection device, the combination with a casing having a discharge nozzle at one end, of a pump barrel mounted in said casing, a plunger working in said barrel, said plunger and barrel provided with passages controlling inlet to and release of fuel from said barrel during the working stroke of said plunger, a valve seat member between said barrel and nozzle, a spring pressed ball check valve cooperating with said seat member to control the flow of fuel to said nozzle, spring means for driving said plunger, and engine driven cam means for controlling the driving action of said spring means during the entire pressure stroke of said plunger.

15. In a fuel injection apparatus, the combination of a casing having a lengthwise extending bore reduced in diameter near its lower end to provide a shoulder and a reduced bore portion, a pump barrel removably mounted in said bore and abutting said shoulder at its lower end, means at the upper end of said casing for clamping said pump barrel in position, a plunger working in said barrel, a head member connected to said plunger and having a splined connection with the upper end of said casing, oppositely disposed engine driven cams, followers on said head engaging said cams for moving said plunger, an abutment supported by said casing, spring means disposed between said abutment and head for holding said followers against said cams during the working stroke of the plunger at all rated loads, said plunger and barrel provided with passages controlling inlet to and release of fuel from said barrel during the working stroke of said plunger, a valve seat member mounted in the reduced bore portion of said casing and abutting the end thereof, a nozzle member in threaded engagement with the lower end of said casing and clamping said seat member thereto, an outwardly opening check valve seated at the lower end of said seat member, and a spring mounted in said nozzle member for normally closing said valve.

16. In a fuel injection apparatus, the combination with a casing having a valve controlled spray outlet, a pump plunger reciprocating in said casing, a head rotatably connected to said plunger, adapted to move lengthwise therewith, and having slidably splined connection with the upper end of said casing, oppositely disposed engine driven cams, followers on said head engaging said cams for moving said plunger, an abutment supported by said casing, spring means interposed between said head and abutment for holding said followers against said cams during the working stroke of the plunger at all rated loads, adjustable release means between said plunger and casing to vary the amount of fuel delivered by said spray outlet and controlled by the angular position of said plunger, a control member journalled on the exterior of said casing, and a key connection between said control member and said plunger for varying the angular position of said plunger.

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