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FUEL INJECTOR FOR INTERNAL-COMBUSTION ENGINES

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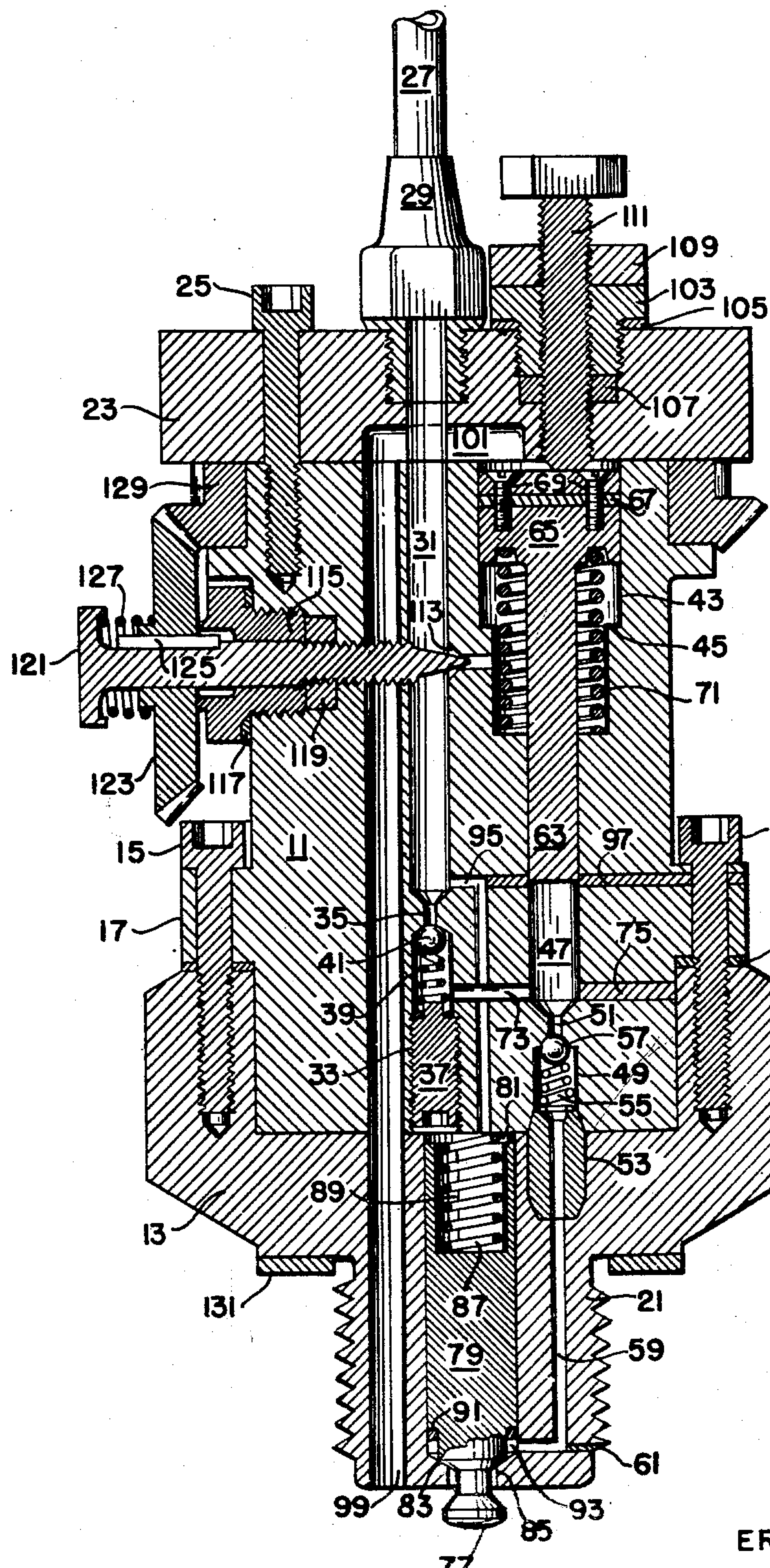

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FUEL INJECTOR FOR INTERNAL-COMBUSTION ENGINES

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This invention relates to improvements in fuel-injectors, and more particularly pertains to fuel-injectors for internal-combustion engines.

In providing fuel-injectors responsive to variations in load and speed of an engine, various types of external cams, rocker arms and like adjusting means have been employed. However, such devices have many shortcomings: Many employ relatively long high-pressure fuel lines, thereby introducing undesirable "water-hammer" effects, use cumbersome and complex cam systems to effect cutoff at various load and speed conditions, and function inefficiently, in that they lack sufficient flexibility to furnish a speedy response to load changes and to eliminate knocking at idling speeds.

The primary object of this invention is to provide a self-regulating fuel-injector for internal-combustion engines.

Another object is to provide a fuel-injector that derives its actuating power directly from the pressure within the engine cylinder.

Still another object is to provide a self-regulating unit fuel-injector containing an automatic cutoff that is self-adjusting responsive to various loads and speed conditions.

A further object is to provide a fuel-injector of high flexibility characterized by virtually instantaneous response to changes in load and speed conditions.

Another object is to provide a fuel-injector characterized by acceleration of the rate of fuel injection during the injection stroke, whereby uniform burning and a smooth power response is attained and undesirable "knocking" at relatively low speeds is eliminated.

A further object is to provide a fuel-injector adapted to atomize fuel at a high injection pressure.

Still another object is to provide a fuel-injector wherein cutoff of fuel at various speeds and loads is effected without the employment of cumbersome and complicated external cams, rocker arms and the like.

A further object is to provide a fuel-injector that is not subject to undesirable "water-hammer" effects.

Further objects and advantages of this invention, as well as its construction, arrangement and operation, will be apparent from the following description and claims in connection with the accompanying drawing, in which the figure is a sectional elevation of a fuel-injector, showing a preferred embodiment of the invention.

The jacket or casing of the fuel injector comprises a body 11 ground-jointed to a hexagonal base 13, said body being mounted on said base by means of a plurality of mounting screws 15, which extend through an annular flange 17 in said body and into said base. A suitable body gasket 19, such as a soft neoprene rubber ring, forms a seal between said flange and said base, and the neck 21 of said base is threaded so that said base can be seated in the head of the motor. Said casing further includes a head 23 ground-jointed to body 11 and mounted upon the end of said body distal said base by means of a plurality of mounting screws 25 that extend through said head and into said body. Gasket 131 mounted on base 13 is employed in seating the fuel injector in the head of the motor.

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Low-pressure fuel line 27 is secured to head 23 by means of a suitable mounting collar 29, which is threaded into said head. Said fuel line feeds into fuel inlet chamber 31, which is a bore extending a substantial distance through body 11. In axial alignment with chamber 31 is threaded bore 33, extending into said body from the end thereof distal head 23, and to communication with chamber 31 through leader 35. Setscrew 37 mounted in threaded bore 33 carries helical spring 39, which in turn carries ball-bearing 41 against leader 35, said assembly of setscrew 37, spring 39 and ball-bearing 41 functioning as a suction ball-check, in the manner hereinafter described.

Compression-cylinder chamber 43 extends into body 11 from the end thereof abutting head 23. Said chamber 43 is of reduced cross-section at its nether portion, thus forming a shoulder 45, generally medial the length of said chamber, which shoulder operates as a cutoff ledge in the manner hereinafter described. Plunger-cylinder chamber 47 is disposed in axial alignment with compression-cylinder chamber 43, extending from the base of chamber 43 a substantial distance into body 11. A bore 49, in axial alignment with chamber 47, which preferably is super-finished, extends into body 11 from the end thereof abutting base 13, said bore 49 communicating with chamber 47 through leader 51. Coupling 53 is seated in bore 49 and a mating bore in base 13, said coupling 53 providing a high-pressure seal for the junction of body 11 and base 13 around bore 49. Said coupling 53 carries a helical spring 55, which in turn carries ball-bearing 57 against leader 51, said assembly of coupling 53, spring 55 and ball-bearing 57 functioning as an injection ball-check, in the manner hereinafter described.

Pressure leader 59 extends from bore 49

through coupling 53, thence through base 13 and into an orifice chamber hereinafter described, plug 61 sealing the opening in neck 21 cut during the machining of pressure leader 59.

Injection-plunger piston 63, mounted slidably in chamber 47 and preferably superfinished, is formed integral with compression-cylinder 65, which is mounted slidably in the upper portion of chamber 43. Said cylinder 65 is provided with a gas-seal disc 67, preferably a fibroid material, secured thereon by a plurality of countersunk screws 69, and helical spring 71 is positioned compressibly between the nether face of cylinder 65 and the floor of chamber 43. Suction leader 73 communicates between plunger-cylinder chamber 47 and bore 33, plug 75 sealing the opening in body 11 cut during the machining of said suction leader.

Fuel-orifice valve 77 is carried on cylinder 79, which in turn is mounted slidably in chamber 81. Said chamber 81 extends a substantial distance through base 13 from the end thereof abutting body 11, terminating in valve seat 83 and fuel orifice 85. Helical spring 87, seated compressibly between the floor of cushioning chamber 89 and the end of body 11, is adapted to resist travel of cylinder 79 in chamber 81, and pressure-seal ring 91 is seated on the nether shoulder that is formed in cylinder 79 to provide annular chamber 93. Fuel-orifice valve-relief passage 95 communicates between chamber 81 and fuel-inlet chamber 31, plug 97 sealing the opening in body 11 cut during the machining of said passage 95.

Air tube 99 extends through base 13 and body 11 in axial parallelism with chamber 31, and thence forms connecting passage 101 in head 23, connecting to the upper end of compression cylinder chamber 43.

Packing nut 103, threaded into head 23 and provided with a suitable washer 105, such as a soft neoprene rubber washer, and further provided with suitable packing 107, in association with lock-nut 109, carries adjusting screw 111, said adjusting screw extending into chamber 43 above compression cylinder 65 and being adapted to limit the travel of said cylinder. While said adjusting screw is illustrated as being operable manually, it is apparent that the setting of said screw can be made responsive automatically to changes in speed of the engine, as by replacing the head of said screw with a rack-driven gear.

A control orifice 113 communicates between fuel inlet chamber 31 and compression cylinder chamber 43, opening into the latter at a point below shoulder 45. Packing nut 115, which is threaded into body 11 and is provided with a suitable washer 117, such as a soft neoprene rubber washer, and with suitable packing 119, carries needle-valve 121, said needle-valve being mounted slidably in said nut 115, threaded in body 11 and being adapted to vary the freedom of flow of fuel through orifice 113. Gear 123 is mounted slidably on needle-valve 121 and keyed thereto by key 125, so that gear 123 is effective to rotate needle-valve 121 while said needle-valve is free to be threaded into or away from orifice 113. Helical spring 127 extends compressibly between gear 123 and the nether face of the head of needle-valve 121, being adapted to retain said gear in abutment with packing nut 115.

Bevel gear 129 is mounted on body 11 in mesh with gear 123, said bevel gear being linked to and driven by the throttle rack of the engine by suitable means (not shown).

In the operation of the fuel injector, liquid fuel,

such as gasoline or kerosene, is fed through fuel line 27 and mounting collar 29, and fills fuel inlet chamber 31, compression cylinder chamber 43, suction leader 73, plunger cylinder chamber 47, pressure leader 59 and annular chamber 93. As the motor piston approaches top dead center and compresses the air in the motor cylinder, the air pressure is transmitted through the air tube 99, which is open to the motor cylinder and connects to the face of compression cylinder 65 through connecting passage 101 in head 23. As the air pressure increases, the injection plunger piston 63 is forced downward counter the force of helical spring 71. Gas-seal disc 67 prevents the compressed air from entering the compression-cylinder chamber 43 and from mixing with the fuel therein. The adjusting screw 111, in regulating the original postion of compression-cylinder 65 and piston 63 effected by the force of spring 71, determines at what air pressure the injection-plunger piston 63 will begin its downward stroke. As this stroke begins, the fuel in compression-cylinder chamber 43 is forced out through control orifice 113, and it is apparent that the rate of fuel passing through said orifice is governed by the setting of needle-valve 121: If the injection piston 63 is to move down slowly, needle-valve 121 closes orifice 113 almost completely, while if said piston is to move down rapidly, said orifice is wide open, thus permitting a faster rate of fluid flow from compression-cylinder chamber 43. As the injection plunger piston 63 moves downward, it forces the fuel in the plunger-cylinder chamber 47 past the injection ball check, ball-bearing 57, and down through coupling 53 and pressure leader 59 to the annular chamber 93. The pressure of the fuel also holds the suction-ball check, ball-bearing 41, closed against the relatively slight pressure of the fuel in the fuel-inlet chamber 31. The pressure of the fuel in the annular chamber 93 then forces the fuel-orifice valve 77 to be unseated, forcing said valve up contra the force of spring 87 and thereby opens the fuel orifice 85 and injects the fuel into the cylinder of the motor.

It will be observed that the fuel-orifice valve 77 travels upward a relatively short distance, and that such travel is stopped by the bottom surface of the body 11. Pressure-seal ring 91 prevents the high pressure fuel from passing too freely in the clearance space between the valve 77 and the base 13. The fuel that does pass reaches the fuel inlet chamber 31 through the fuel-orifice valve-relief passage 95. Fuel also fills the cushioning chamber 89, and it is apparent that the limited flow of fuel through relief passage 95 tends to eliminate valve chatter and damps operation of the fuel-orifice valve 77, which would otherwise tend to hammer the valve-seat 83 and cause "water hammer" effects in the injection passages.

As soon as the injection plunger piston 63 ceases its downward motion, the fuel orifice valve 77 and the injection ball check, ball-bearing 57, close. As the pressure in the motor piston commences to drop, the pressure on the face surface of compression cylinder 65 also drops and helical spring 71, which preferably is calibrated, forces the plunger piston 63 upward. As this motion occurs, the suction ball-check, ball-bearing 41, opens and admits fuel through the suction leader 73 to the plunger-cylinder chamber 47, thereto await the next injection stroke. It is to be noted that, while the speed of the return stroke of the injection plunger piston 63 is also limited by the setting of needle-valve 121 in orifice 113, since the injection period is only a small fraction of the total cycle time, a much longer period is available for the return of said injection-plunger piston to its initial position.

Recapitulating the foregoing description with reference to various load and speed conditions, operation occurs as follows: When the motor is idling at low speed with no load, the needle-valve 121 is adjusted so that it almost closes the control orifice 113, and therefore permits only a very slow injection stroke of the injection-plunger piston 63, and thus allows only a very small quantity of fuel into the cylinder. Injection time is very short. When the motor is operating at low speed with a load, the needle-valve adjustment allows a more rapid flow of fuel through the control orifice 113 and thus permits more rapid injection. Since the speed of the motor is the same as in the first condition above described, the injection plunger piston 63 moves down a greater distance and more fuel is injected into the cylinder than under the first described condition. Injection time is comparatively long.

In normal operation, at medium speed and medium load, the setting of needle-valve 121 is virtually the same as its setting at low speed and heavy load. However, since the load is lighter and the speed of the motor is therefore greater, the injection piston 63 travels a shorter stroke than under the condition of low speed and heavy load, and a smaller quantity of fuel is injected.

At medium speed and heavy load, the needle-valve 121 is set wide open, thus allowing rapid travel of injection-plunger piston 63. This condition permits the full stroke of said piston down to the shoulder 45, which functions as a cutoff ledge in compression-cylinder chamber 43. This shoulder, therefore, is the limiting factor in determining the maximum power output of the motor under heavy load. Parenthetically, it is to be noted that this condition, and possibly a low speed and heavy load condition, are the only cases where the cutoff point is determined by shoulder 45, in all other conditions of operation the cutoff point being determined by the pressure drop in the motor cylinder.

Where operation is at high speed with little or no load, the needle-valve setting is wide open, but since the speed of the motor is high, the injection plunger piston 63 travels only a very short distance. Even though such motion is rapid, the rapidity of the pressure rise and fall of the air compressed in the motor cylinder limits the stroke of said piston 63 to a very short distance, so that only a small amount of fuel is injected.

Thus it can be seen that, in general, assuming that there is a constant load, the speed of travel of the injection-plunger piston 63 is a function of the setting of needle-valve 121, and that the travel of said piston is governed by the needle-valve setting. For constant speed, the engine load is proportional to the piston travel, which is governed by the needle-valve setting.

In passing, further comment on the significance of the structure and arrangement of certain elements will serve to amplify the disclosure: It is to be noted that the adjusting screw 111 may prove unnecessary for injection units on slow speed engines, but, in the case of engines that must operate over a wide range of speeds, it may be necessary to have the adjusting screw setting governed by the speed of the engine, if proper injection timing is to be effected. That is to say, the injection stroke should start sooner for high speeds than for low speeds and, particularly when starting, the injection must not begin before top dead-center position of the motor piston is reached.

The length of air tube 99 prevents combustion gases from entering the top of compression-cylinder chamber 43 and thus depositing carbon in the top of compression cylinder chamber 43. The relatively long tube allows the combustion gases to pass only a short distance up the tube, and formation of carbon deposits on the walls of said tube is deterred by the scouring action of the expanding air as it passes out into the cylinder of the engine at the end of the power stroke.

It will also be seen that, even though the fuel injector is operated by the air pressure in the engine cylinder, little or no provision need be made in engine design for the slight pressure drop due to the movement of the injection-plunger piston when the engine piston is on the compression phase of its stroke, because the volume displaced is negligible when compared with the clearance volume. The compression pressure of the engine cylinder multiplied by the area of the face surface of the compression cylinder 65 equals the injection pressure multiplied by the area of the nether face of piston 63, and therefore the proportioning of the two said areas determines the injection pressure.

Various modifications and changes can be made in the subject device without departing from the scope of the invention.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalty thereon or therefor.

I claim:

1. A fuel-injector comprising a body carrying a base adapted to be mounted on the cylinder of an engine and a head distal said base, a fuel line in communication with a fuel-inlet chamber in said body, a suction ball-check adapted to seal a leader that communicates with said fuel-inlet chamber, a compression-cylinder chamber in said body having a compression cylinder carried slidably therein, means to retract said compression cylinder, a plunger-cylinder formed integral said compression-cylinder and carried slidably in a plunger-cylinder chamber, a suction leader communicating between said ball check and said plunger-cylinder chamber, a bore extending into said body and carrying an injection ball check adapted to seal a leader that communicates with said plunger-cylinder chamber, a pressure-leader communicating between said second bore and an orifice chamber in said base, said orifice chamber being provided with valve means adapted to control the flow of fuel therefrom, a valve-relief passage communicating between said fuel-orifice chamber and said fuel-inlet chamber, an air tube extending through said base and said body and through said head into communication with said compression-cylinder chamber, a control orifice communicating between said fuel-inlet chamber and said compression-cylinder chamber, and means to vary the rate of flow of fuel through said control orifice.

2. A fuel-injector comprising a body carrying a base adapted to be mounted on the cylinder of an engine and a head distal said base, a fuel line extending through said head and into communication with a fuel-inlet chamber in said body, a first bore extending into said body and carrying a suction ball-check, said ball-check being adapt-

ed to seal a leader that communicates with the nether end of said fuel-inlet chamber, a compression-cylinder chamber in said body provided with a shoulder forming a cutoff ledge for a compression-cylinder carried slidably therein, said compression cylinder being provided with spring expanding means disposed compressibly between its nether face and the floor of said compression-cylinder chamber, a plunger-cylinder chamber having a plunger cylinder formed integral said compression-cylinder and carried slidably in said plunger-cylinder chamber, a suction leader communicating between said first bore and said plunger cylinder chamber, a second bore extending into said body and carrying an injection ball-check, said injection ball-check being adapted to seal a leader that communicates with the nether end of said plunger-cylinder chamber, a pressure leader communicating between said second bore and an orifice chamber in said base, said orifice chamber, being provided with valve means adapted to control the flow of fuel therefrom, a valve-relief passage communicating between the top of said fuel-orifice chamber and the nether end of said fuel-inlet chamber, an air tube extending through said base and said body and through said head into communication with said compression-cylinder chamber, a control orifice communicating between said fuel-inlet chamber and said compression-cylinder chamber at a point below said shoulder and means to vary the rate of flow of fuel through said control orifice.

3. A fuel-injector comprising a body carrying a base adapted to be mounted on the cylinder of an engine and a head distal said base, a fuel line extending through said head and into communication with a fuel-inlet chamber in said body, a first bore extending into said body from the end thereof distal said head and having a ball-check mounted on a spring, said ball check being adapted to seal a leader that communicates with the nether end of said fuel-inlet chamber, a compression-cylinder chamber in said body having a compression-cylinder carried slidably therein, means to retract said compression-cylinder, a plunger-cylinder chamber having a plunger-cylinder formed integral said compression-cylinder and carried slidably in said plunger-cylinder chamber, a suction leader communicating between said first bore and said plunger-cylinder chamber, a second bore extending into said body and carrying an injection ball-check, said injection ball-check being adapted to seal a leader that communicates with the nether end of said plunger-cylinder chamber, a pressure leader communicating between said second bore and an orifice chamber in said base, said orifice chamber being provided with valve means adapted to control the flow of fuel therefrom, a valve-relief passage communicating between the top of said fuel-orifice chamber and the nether end of said fuel-inlet chamber, an air tube extending through said base and said body and through said head into communication with said compression-cylinder chamber, a control orifice communicating between said fuel-inlet chamber and said compression-cylinder chamber, and means to vary the rate of flow of fuel through said control orifice.

4. A fuel-injector comprising a body carrying a base adapted to be mounted on the cylinder of an engine and a head distal said base, a fuel line extending through said head and into communication with a fuel-inlet chamber in said body, a first bore extending into said body from the end

thereof distal said head and having an adjustable ball-check mounted on a spring, said ball-check being adapted to seal a leader that communicates with the nether end of said fuel-inlet chamber, a compression-cylinder chamber in said body provided with a shoulder forming a cutoff ledge for a compression-cylinder carried slidably therein, said compression-cylinder being provided with spring expanding means disposed compressibly between its nether face and the floor of said compression-cylinder chamber, a plunger-cylinder chamber having a plunger-cylinder formed integral said compression-cylinder and carried slidably in said plunger-cylinder chamber, a suction leader communicating between said first bore and said plunger-cylinder chamber, a second bore extending into said body and carrying an injection ball-check, said injection ball-check being adapted to seal a leader that communicates with the nether end of said plunger-cylinder chamber, a pressure leader communicating between said second bore and an orifice chamber in said base, said orifice chamber being provided with valve means adapted to control the flow of fuel therefrom, a valve-relief passage communicating between the top of said fuel-orifice chamber and the nether end of said fuel-inlet chamber, an air tube extending through said base and said body and through said head into communication with said compression-cylinder chamber, a control orifice communicating between said fuel inlet chamber and said compression cylinder chamber at a point below said shoulder, and means to vary the rate of flow of fuel through said control orifice.

5. A fuel-injector comprising a body carrying a base adapted to be mounted on the cylinder of an engine and a head distal said base, a fuel line extending through said head and into communication with a fuel-inlet chamber in said body, a first bore extending into said body from the end thereof distal said head and having an adjustable ball-check mounted on a spring, said ball-check being adapted to seal a leader that communicates with the nether end of said fuel-inlet chamber, a compression-cylinder chamber in said body having a compression-cylinder carried slidably therein, means to retract said compression-cylinder, a plunger-cylinder chamber having a plunger-cylinder formed integral said compression-cylinder and carried slidably in said plunger-cylinder chamber, a suction leader communicating between said first bore and said plunger-cylinder chamber, a second bore extending into said body from the end thereof distal said head and having a ball-check mounted on a spring and adapted to seal a leader that communicates with the nether end of said plunger-cylinder chamber, a pressure leader communicating between said second bore and an orifice chamber in said base, said orifice chamber being provided with a cylinder carried slidably therein, said cylinder having a fuel orifice valve adapted to engage a valve-seat in said orifice chamber and thereby seal the fuel orifice of said chamber, and a spring mounted compressibly between said cylinder and the nether end of said chamber, a valve-relief passage communicating between the top of said fuel-orifice chamber and the nether end of said fuel-inlet chamber, an air-tube extending through said base and said body and through said head into communication with said compression-cylinder chamber, a control orifice communicating between said fuel-inlet chamber and said compression cylinder chamber, a needle-

valve threaded in said body and adapted to vary the freedom of flow of fuel through said control orifice, and a gear mounted slidably on said needle-valve and adapted to rotate said needle-valve, said gear being driven by a bevel gear linked to the throttle-rack of the engine.

6. A fuel-injector comprising a body carrying a base adapted to be mounted on the cylinder of an engine and a head distal said base, a fuel line extending through said head and into communication with a fuel-inlet chamber in said body, a first bore extending into said body and carrying a suction ball-check, said ball-check being adapted to seal a leader that communicates with the nether end of said fuel-inlet chamber, a compression-cylinder chamber in said body provided with a shoulder forming a cutoff ledge for a compression-cylinder carried slidably therein, said compression-cylinder being provided with spring expanding means disposed compressibly between its nether face and the floor of said compression-cylinder chamber, a plunger-cylinder chamber having a plunger-cylinder formed integral said compression-cylinder and carried slidably in said plunger-cylinder chamber, a suction leader communicating between said first bore and said plunger-cylinder chamber, a second bore extending into said body from the end thereof distal said head and having a ball-check mounted on a spring and adapted to seal a leader that communicates with the nether end of said plunger-cylinder chamber, a pressure leader communicating between said second bore and an orifice chamber in said base, said orifice chamber being provided with a cylinder carried slidably therein, said cylinder having a fuel-orifice valve adapted to engage a valve seat in said orifice chamber and thereby seal the fuel orifice of said chamber, and a spring mounted compressibly between said cylinder and the nether end of the chamber, a valve-relief passage communicating between the top of said fuel-orifice chamber and the nether end of said fuel inlet chamber, an air tube extending through said base and said body and through said head into communication with said compression-cylinder chamber, a control orifice communicating between said fuel-inlet chamber and said compression-cylinder chamber at a point below said shoulder, a needle-valve threaded in said body and adapted to vary the freedom of flow of fuel through said control orifice, and a gear mounted slidably on said needle-valve and adapted to rotate said needle-valve, said gear being driven by a bevel gear linked to the throttle rack of the engine.

7. A fuel-injector comprising a body carrying a base adapted to be mounted on the cylinder of an engine and a head distal said base, a fuel line extending through said head and into communication with a fuel-inlet chamber in said body, a first bore extending into said body from the end thereof distal said head and having an adjustable ball-check mounted on a spring, said ball-check being adapted to seal a leader that communicates with the nether end of said fuel-inlet chamber, a compression-cylinder chamber in said body provided with a shoulder forming a cutoff ledge for a compression-cylinder carried slidably therein, said compression-cylinder being provided with spring expanding means disposed compressibly between its nether face and the floor of said compression-cylinder chamber, a plunger-cylinder chamber having a plunger-cylinder formed integral said compression-cylinder and carried slidably in said plunger-cylinder chamber, a suction leader communicating between said first bore and said plunger-cylinder chamber, a second bore extending into said body from the end thereof distal said head and having a ball-check mounted on a spring and adapted to seal a leader that communicates with the nether end of said plunger-cylinder chamber, a pressure leader communicating between said second bore and an orifice chamber in said base, said orifice chamber being provided with a cylinder carried slidably therein, said cylinder having a fuel orifice valve adapted to engage a valve-seat in said orifice chamber and thereby seal the fuel orifice of said chamber, and a spring mounted compressibly between said cylinder and the nether end of said chamber, a valve-relief passage communicating between the top of said fuel-orifice chamber and the nether end of said fuel-inlet chamber, an air tube extending through said base and said body and through said head into communication with said compression-cylinder chamber, a control orifice communicating between said fuel-inlet chamber and said compression-cylinder chamber at a point below said shoulder, and means to vary the rate of flow of fuel through said control orifice.

8. A fuel-injector comprising a body carrying a base adapted to be mounted on the cylinder of an engine and a head distal said base, a fuel line extending through said head and into communication with a fuel-inlet chamber in said body, a first bore extending into said body from the end thereof distal said head and having an adjustable ball-check mounted on a spring, said ball check being adapted to seal a leader that communicates with the nether end of said fuel-inlet chamber, a compression-cylinder chamber in said body provided with a shoulder forming a cutoff ledge for a compression-cylinder carried slidably therein, said compression-cylinder being provided with spring expanding means disposed compressibly between its nether face and the floor of said compression-cylinder chamber, a plunger-cylinder chamber having a plunger-cylinder formed integral said compression-cylinder and carried slidably in said plunger-cylinder chamber, a suction leader communicating between said first bore and said plunger-cylinder chamber, a second bore extending into said body from the end thereof distal said head and having a ball-check mounted on a spring and adapted to seal a leader that communicates with the nether end of said plunger-cylinder chamber, a pressure leader communicating between said second bore and an orifice chamber in said base, said orifice chamber being provided with valve means adapted to control the flow of fuel therefrom, a valve-relief passage communicating between the top of said fuel-orifice chamber and the nether end of said fuel-inlet chamber, an air tube extending through said base and said body and through said head into communication with said compression-cylinder chamber, a control orifice communicating between said fuel-inlet chamber and said compression-cylinder chamber at a point below said shoulder, a needle-valve threaded in said body and adapted to vary the freedom of flow of fuel through said control orifice, and a gear mounted slidably on said needle-valve and adapted to reciprocate said needle-valve, said gear being driven by a bevel gear linked to the throttle rack of the engine.

9. A fuel-injector comprising a body carrying a base adapted to be mounted on the cylinder of an engine and a head distal said base, a fuel

line extending through said head and into communication with a fuel-inlet chamber in said body, a first bore extending into said body from the end thereof distal said head and having an adjustable ball-check mounted on a spring, said ball-check being adapted to seal a leader that communicates with the nether end of said inlet chamber, a compression-cylinder chamber in said body provided with a shoulder forming a cutoff ledge for a compression-cylinder carried slidably therein, said compression-cylinder being provided with spring expanding means disposed compressibly between its nether face and the floor of said compression-cylinder chamber, an adjusting screw extending through said head into said compression-cylinder chamber and adapted to limit the travel of said compression-cylinder, a plunger-cylinder chamber having a plunger-cylinder formed integral said compression-cylinder and carried slidably in said plunger-cylinder chamber, a suction leader communicating between said first bore and said plunger-cylinder chamber, a second bore extending into said body from the end thereof distal said head and having a ball-check mounted on a spring and adapted to seal a leader that communicates with the nether end of said plunger-cylinder chamber, a pressure leader communicating between said second bore and an orifice chamber in said base, said orifice chamber being provided with a cylinder carried slidably therein, said cylinder having a fuel-orifice valve adapted to engage a valve seat in said orifice chamber and thereby seal the fuel orifice of said chamber and a spring mounted compressibly between said cylinder and the nether end of said chamber, a valve-relief passage communicating between the top of said fuel-orifice chamber and the nether end of said fuel-inlet chamber, an air tube extending through said base and said body and through said head into communication with said compression-cylinder chamber, a control orifice communicating between said fuel-inlet chamber and said compression-cylinder chamber at a point below said shoulder, a needle-valve threaded in said body and adapted to vary the freedom of flow of fuel through said control orifice, and a gear mounted slidably on said needle-valve and adapted to reciprocate said needle-valve, said gear being driven by a bevel gear linked to the throttle rack of the engine.

10. A fuel-injector comprising a body carrying a base adapted to be mounted on the cylinder of an engine and a head distal said base, a fuel line extending through said head and into communication with a fuel-inlet chamber in said body, a compression-cylinder chamber in said body provided with a shoulder forming a cutoff ledge for a compression-cylinder carried slidably therein, said compression-cylinder being provided with spring expanding means disposed compressibly between its nether face and the floor of said compression-cylinder chamber, a plunger-cylinder chamber having a plunger-cylinder formed integral said compression-cylinder and carried slidably in said plunger-cylinder chamber, a second bore extending into said body from the end thereof distal said head and having a ball-check mounted on a spring and adapted to seal a leader that communicates with the nether end of said plunger-cylinder chamber, a pressure leader communicating between said second bore and an orifice chamber in said base, said orifice chamber being provided with a cylinder carried slidably therein, said cylinder having a fuel-orifice valve adapted to engage a valve seat in said orifice chamber and thereby seal the fuel orifice of said chamber, and a spring mounted compressibly between said cylinder and the nether end of said chamber, a valve-relief passage communicating between the top of said fuel-orifice chamber and the nether end of said fuel-inlet chamber, an air tube extending through said base and said body and through said head into communication with said compression-cylinder chamber, a control orifice communicating between said fuel-inlet chamber and said compression-cylinder chamber at a point below said shoulder, a needle-valve threaded in said body and adapted to vary the freedom of flow of fuel through said control orifice, and a gear mounted slidably on said needle-valve and adapted to reciprocate said needle-valve, said gear being driven by a bevel gear linked to the throttle rack of the engine.

11. A fuel injector comprising a casing member adapted to be seated in the head of a motor, a fuel-inlet chamber in said casing member, first valve means adapted to seal the base of said chamber, a compression-cylinder chamber having a cutoff ledge and carrying a compression cylinder slidably, a plunger-cylinder chamber in axial alignment with said compression-cylinder chamber and carrying slidably a plunger cylinder linked to said compression cylinder, means to retract said compression cylinder, second valve means adapted to seal the base of said plunger-cylinder chamber, a fuel-orifice valve, means to close said valve, a control orifice communicating between said fuel-inlet chamber and the portion of said compression-cylinder chamber below said cutoff ledge, a first leader communicating between said first valve means and said plunger-cylinder chamber, a second leader communicating between said second valve means and said fuel-orifice valve, a valve-relief passage communicating between said fuel-orifice valve and said fuel-inlet chamber, an air tube extending from the fuel-orifice valve end of said injector to the distal face of said compression cylinder, means to limit retraction of said compression cylinder, and third valve means adapted to vary the flow of fuel through said control orifice.

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