April 8, 1952 B. BISCHOF 2,592,111

INJECTOR FOR INTERNAL-COMBUSTION ENGINES

Filed Nov. 9, 1949 4 Sheets-Sheet 1

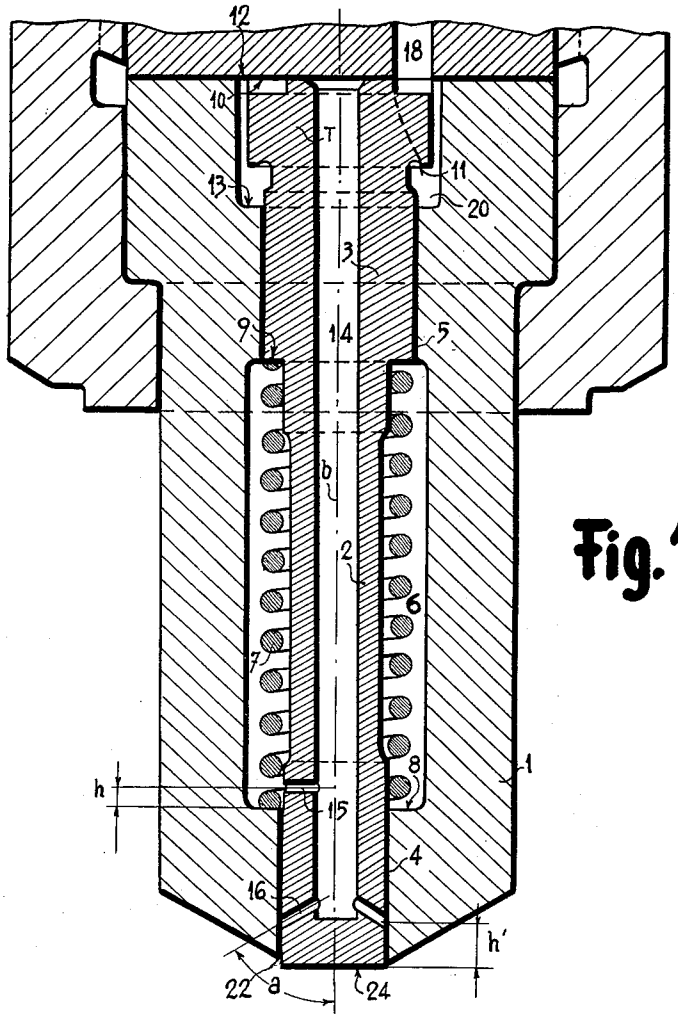


Fig. 1

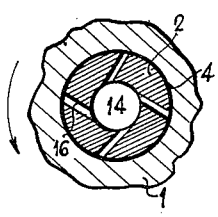


Fig. 2

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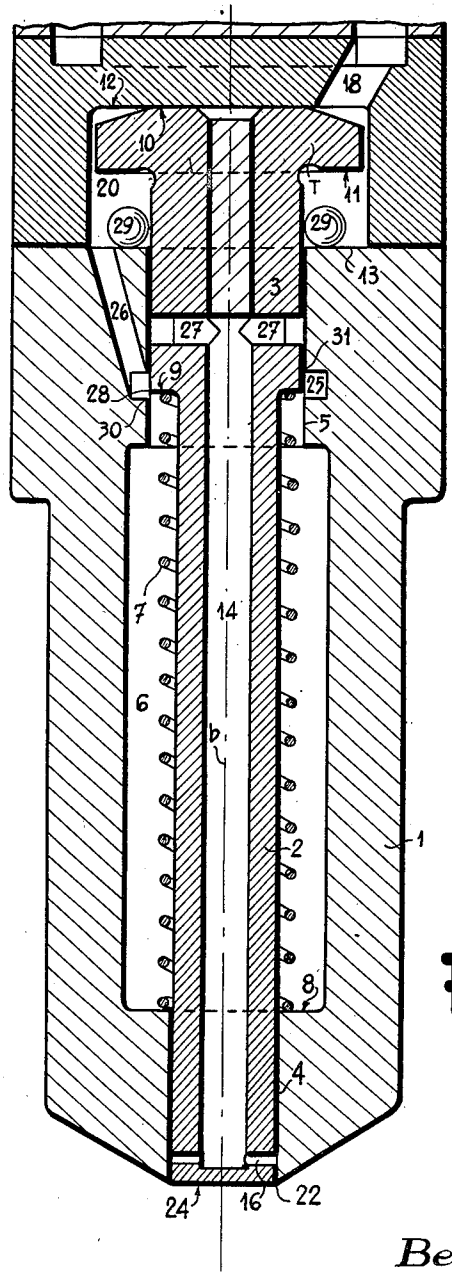


Fig. 3

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Fig.4

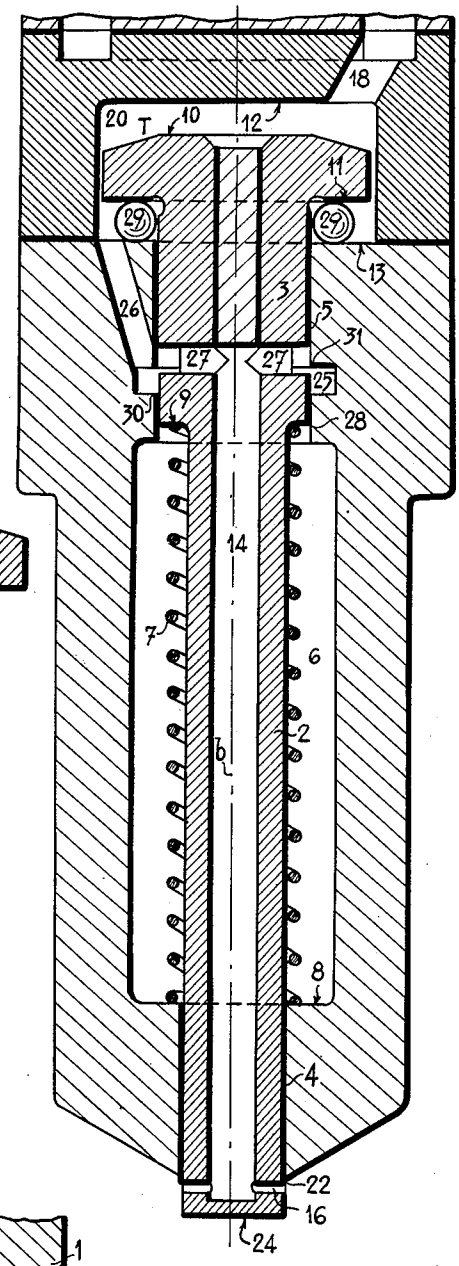
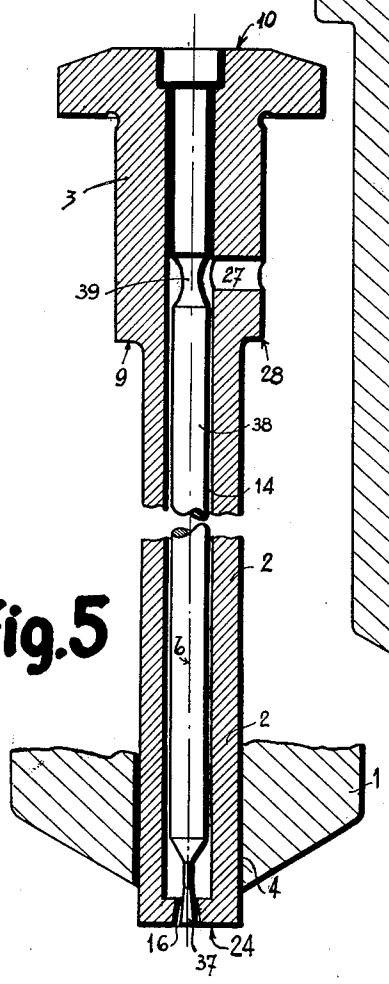


Fig.5



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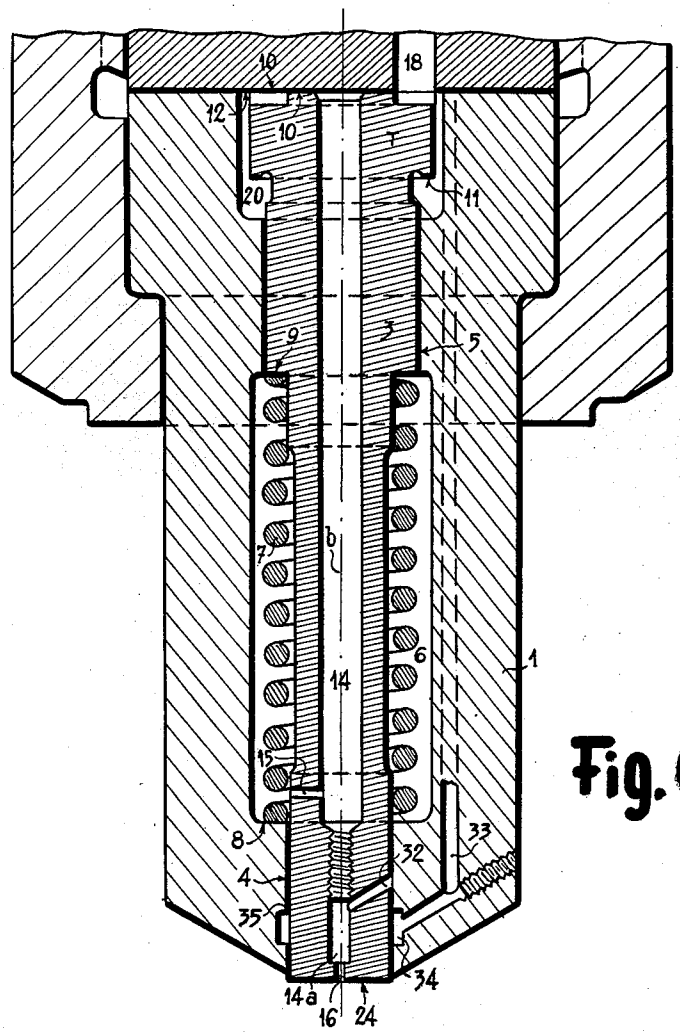


Fig. 6

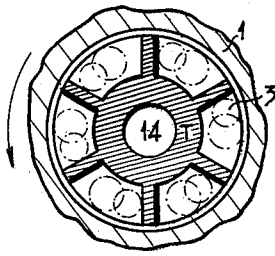


Fig. 7

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UNITED STATES PATENT OFFICE

2,592,111

INJECTOR FOR INTERNAL-COMBUSTION ENGINES

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12 Claims. (Cl. 299—107.4)

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Injectors actually used for the injection of fuel into the cylinders of internal combustion engines generally comprise a needle-shaped valve subjected to the action of a spring tending to maintain it in contact with a seat in order to cut off the communication between the injection duct and the outlet orifices of the injector. The opening of this valve is effected by a movement of the same in a direction opposed to the flow of the fuel supply caused by the pressure of the said fuel supply.

The very idea of these injectors results in that the extent of the thrust exerted on the valve during its closing is always considerably less than that of the thrust causing its opening.

There also exist injectors comprising a needle-shaped valve, the opening of which is effected by a movement of the same in the direction of flow of the fuel and in which said fuel first crosses the seat of the valve, then passes above a shoulder in the shape of a piston provided on the valve and enclosing the outlet orifices of the injector, and is finally injected into the combustion chamber of the engine through the said outlet orifices. These constructions offer the disadvantage that a relatively large quantity of fuel subjected to the closing pressure of the valve is retained in the space located between the seat of the valve and the outlet orifices. It follows that after the end of the injection, a flow of fuel results which chokes the injector.

The object of the present invention is a fuel injector for an internal combustion engine comprising a closing member slidable in a body the movements of which control the ejection of fuel through the outlet orifices fed by ducts connected to a supply orifice, the opening movements of the said member taking place in the direction of flow of the fuel and being caused by the pressure of the fuel supply. This injector tends to eliminate the drawbacks mentioned by the fact that the said closing member consists of a piston comprising two parts of different diameters and slidable in fluid tight guides placed on both sides of a compression chamber fed with fuel through the supply orifice, that part of said two parts of the piston having the larger diameter being so arranged that movement of the same in the direction of flow of the fuel causes a reduction in the volume of the compression chamber, and by the fact that the piston and the body are provided with parts which co-operate with each other in order to bring about, upon such a movement of the piston, on the one hand the closing of the said compression chamber and on the other hand the ejection of the fuel through the outlet orifices.

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The accompanying drawing shows diagrammatically and by way of example various embodiments of the injector.

Fig. 1 is an axial sectional view of an injector in accordance with a first embodiment comprising several outlet orifices.

Fig. 2 is a partial cross sectional view of a modified embodiment of Fig. 1.

Fig. 3 is an axial sectional view of an injector in accordance with a second embodiment, the piston being in the position of rest.

Fig. 4 is a sectional view similar to that of Fig. 3, the piston being however in an operating position.

Fig. 5 is a partial view, in axial cross section, of a modified embodiment of the injector shown in Figs. 3 and 4.

Fig. 6 is a sectional view of an injector in accordance with a third embodiment comprising a single central outlet orifice.

Fig. 7 is a partial cross sectional view of a modified embodiment of Fig. 6.

The members and equivalent parts of the various embodiments are indicated in all the figures by the same reference numerals.

According to the embodiment shown in Fig. 1, the injector comprises a body 1 provided with a piston comprising a head T and two parts 2, 3, part 2 having a smaller diameter than part 3, which is itself smaller in diameter than the head T. This piston is movable axially in fluid tight guides 4, 5, whose diameters correspond to the diameters of the parts 2 and 3 of the piston, and placed at both ends of a compression chamber 6. A return spring 7, located in the said chamber 6 and bearing on the one hand against the bottom 8 of the latter and on the other hand against a shoulder 9 formed at the point where the diameter of the piston changes, tends to maintain the latter in its position of rest defined by the engagement of the rear front face 10 of its head T with a supporting surface 12. The said head T is located within a chamber 20 limited on the one hand by the said supporting surface 12 and on the other hand by an arresting surface 13. The piston is provided with an axial bore 14 extending throughout the greater part of its length and into which emerge:

a. A gauged conduit 15 which connects it with the compression chamber 6;

b. Outlet conduits 16 situated in radial planes arranged symmetrically about the axis *b* of the

piston and the axes of which form angles *a* with the said axis *b*.

A supply orifice **18**, adapted to be connected by a passage to an injection pump (not shown), issues into the chamber **20**.

The operation of the injector described is as follows:

In the position of rest, that is to say between two injections of fuel, the members of the injector occupy the positions shown in Fig. 1 of the accompanying drawing. The spring **7** maintains the piston in its axial position defined by the front face **10** co-operating with the supporting face **12**. In this position of the piston, the outlet conduits **16** open out on a part of the cylindrical surface of the part **2** of the piston, situated within the guide **4**, so that these conduits are closed. On the other hand, the gauged conduit **15** establishes a communication between the compression chamber **6** and the bore **14**.

When the injection pump (not shown) forces fuel through the supply orifice **18**, the pressure of the fuel discharged into the chamber **20** tends to move the piston axially. This axial movement causes a reduction of volume of the compression chamber **6** and therefore:

a. Compression of the fuel enclosed in the said chamber **6**.

b. The discharge of part of the fuel through the gauged conduit **15** into the bore **14** which communicates with the chamber **20**.

Axial movement of the piston to an extent *h* brings the conduit **15** into the plane of the bottom **8** which controls its closure. When this conduit is completely closed, the fuel enclosed in the chamber **6** can no longer escape, so that the pressure in the latter increases rapidly in function of the axial movement of the piston.

When the piston has moved to an extent *h'*, the orifices of the conduits **16** are located in the plane of the front face of the injector, so that the ridge **22** controls their opening. Full opening of the conduits **16** is effected before the shoulder **11** of the head T engages the bottom **13** of the chamber **20**.

From the preceding and from an examination of the accompanying drawing, it will be seen that the extent of the compression of the fuel at the beginning of the injection is defined by the thrusts exerted on the piston and opposing its axial movement in the direction of the opening of the conduits **16** and which are:

a. The light thrust exerted by the return spring **7**.

b. The thrust exerted on the forward front face **24** of the piston by the compressed gases in the cylinder of the engine.

c. The thrust exerted on the shoulder **9** by the compressed fuel in the compression chamber **6**.

Now, it will be seen that the first thrust mentioned above is constant, whereas the second is determined by the construction of the engine. On the other hand, the extent of the last mentioned thrust varies according to the amount of fuel discharged through the gauged conduit **15** before its complete closure.

It is obvious that this amount grows up with the diameter of the conduit **15**, the smallness of the speed at which the piston moves and with the length of the path to be travelled by the piston until full closure of the conduit **15**.

Now, the greater the speed of the engine, the greater the speed at which the piston moves, and it therefore follows that the pressure prevailing in the compression chamber **6** and therefore the pressure of the fuel during the injection, and in particular that prevailing at the end of the injection, increases with the speed of the engine, which is very advantageous for the satisfactory operation of the latter.

As soon as the supply of fuel to the chamber **20** is cut off, the pressure in the latter diminishes rapidly and the piston is thrown back to its position of rest (Fig. 1) by:

1. The thrust of the return spring **7**.
2. The thrust of the compressed fuel in the chamber **6**.
3. The thrust of the gases undergoing combustion in the cylinder.

Now, the pressure in the cylinder during the combustion of the gases is always much higher than the rate of compression of the engine, so that the resultant of the thrusts exerted on the piston and causing its withdrawal closing movement is always greater than the resultant of the thrusts exerted thereon in order to bring about the opening of the conduits **16**.

On withdrawal of the piston, the ridge **22** controls the closure of the conduits **16**, then the bottom **8** controls the opening of the conduit **15**. The pressures prevailing in the chambers **20** and **6** can then become equalized.

It is obvious that the number, diameter and slope *a* of the conduits **16** must be adapted to the shape and size of the combustion chamber of the engine.

According to a modified embodiment of the injector described above with reference to Fig. 1, the conduits **16** may be arranged approximatively tangentially to the conduit **14** (Fig. 2). In this case, fuel passing through these inclined conduits produces, during the injection, a rotation of the piston about its axis *b*. Thus, the fuel is distributed homogeneously throughout the whole combustion chamber of the engine.

According to the embodiment of Figs. 3 and 4, the injector comprises a compression chamber **6**, supplied with fuel by means of a guide **5**, an annular groove **25** formed in the body **1** and a conduit **26**. On the other hand, the outlet orifices **16** are supplied through the axial bore **14** whose upper end is closed, and radial conduits **27** which set up a communication between the conduit **14** and the groove **25**. The operating position (Fig. 4) of the piston varies and is defined by the thrust acting on the shoulder **9**. The ball thrust bearing **29** secures the maximum movement of the piston. This ball thrust bearing bears against the bottom **13** of the chamber **20**.

The operation of this embodiment is similar to that of the injector described with reference to Figs. 1 and 2. Indeed, when fuel is discharged through the supply conduit **18** by the injection pump (not shown), the piston is moved axially from the position of rest shown in Fig. 3 to its operating position. In the course of this movement, the ridge **28** of the shoulder **9** co-operating with the ridge **30** formed by the intersection of one of the walls of the groove **25** with the cylindrical surface of the guide **5**, interrupts the connection between the chamber **20** and the compression chamber **6**. Then, the piston continuing its axial movement, the ridge **22**, formed by the cylindrical surface of the guide **4** and the front face of the injector, controls the opening of the conduits **16**. Finally, before the shoulder **11** bears against the ball thrust bearing **29**, the ridge **31** formed by one of the walls of the groove **25** and the cylindrical surface of the guide **5** controls the opening of the conduits **27**. From then on, the

chamber **20** communicates with the outlet conduits **16** which are entirely disengaged so that fuel is ejected through the same. The pressure of the fuel during the ejection is therefore a function of the pressure in the chamber **6**.

The withdrawal of the piston at the end of the injection is brought about by the rapid drop in pressure within the chamber **20**.

According to the modified form shown in Fig. 5, the piston comprises only one central outlet orifice. The beginning and the end of the injection are controlled, as described above, by the ridge **31** formed by the cylindrical surface of the guide **5** and one of the walls of the groove **25**.

In accordance with this embodiment, a rod **38** is housed in the axial bore **14**, one of the ends of which is engaged in a bore of the frontal wall of the piston so as to obtain an annular outlet orifice. The other end of this rod is removably fixed in the part **3** of the piston. Close to its fixed end, this rod presents a part **39** having a reduced section which imparts to it, when the fuel injection takes place, a flexibility sufficient for its end **37** centering itself automatically in the bore of the frontal wall of the piston. In the embodiment shown, the annular slot **16** has the form of a circle and the end **37** the form of a cone, but it is clear that this slot and this end may have any other desired forms, these being chosen according to the wanted form for the fuel jet.

Practical tests have proved that in the case the end **37** being mechanically excentrally disposed in its bore, this is automatically repelled in the axis of said bore during the injection by the fuel passing through the outlet orifice **16**. One can also provide several parts having a reduced section, such as **39**, which may also be replaced by two parts flattened in accordance with planes perpendicular one to the other.

In the embodiment according to Fig. 6, the injector comprises only one central outlet orifice. The conduit **14** is closed below the gauged conduit **15** in order to eliminate any connection between this conduit **14** and the outlet orifice **16**. The latter issues into an axial conduit **14***a* supplied through conduits **32** formed in the part **2** of the piston. A conduit **33** connects the chamber **20** to a groove **34** formed inside the guide **4**.

The start and the end of the injection are controlled by the ridge **35** formed by one of the walls of the groove **34** and the cylindrical surface of the fluid-tight guide **4**.

In operating position, that is to say during the injection, the piston occupies an axial position in which the conduits **32** connect the groove **34** to the axial conduit **14***a*.

In the modified embodiment shown in Fig. 7, the head T of the piston is provided with conduits **36** connecting its front faces **10** and **11**. These conduits are inclined with respect to radial planes passing through the axis *b* of the piston so that the fuel discharged into the chamber **20** and passing through these conduits produces a rotation of the piston.

A certain number of embodiments of the injector, which is the object of the invention, have been described above with reference to the accompanying diagrammatical drawing, but it is obvious that many constructive details may be modified without departing from the scope of the annexed claims.

I claim:

1. A fuel injector for an internal combustion engine comprising a body having a fuel inlet adapted for connection to a fuel supply and enclosing a compression chamber, a piston urged to a certain position and movable by the fuel from that position through the compression chamber and including at least two sections of different diameter, the section of larger diameter upon movement varying the volume of the compression chamber, a fuel supply duct connecting the inlet and the compression chamber during movement of the piston from that position to a second position and closed during piston movement from that position, and outlet duct means in the piston and connected to the inlet and closed at the outlet during movement of the piston from the first position and prior to reaching a third position beyond the second position.

2. The injector according to claim 1 and wherein the compression chamber is closed by the larger section of the piston after movement thereof from the first position.

3. The injector according to claim 1 and wherein the piston section of smaller diameter has an opening constituting part of the fuel supply duct and closed upon piston movement to the second position.

4. The injector according to claim 1 and wherein the smaller piston section is hollow and a flexible valve rod is removably affixed to the piston within the hollow and the outer end of the piston has an outlet opening surrounding and spaced from the outer end of the rod.

5. The injector according to claim 1 and wherein the outlet of the last mentioned duct is on the piston section of smaller diameter.

6. The injector according to claim 1 and wherein the compression chamber is closed by the piston section of larger diameter upon movement thereof and the outlet duct is axial of the piston and establishes the connection between the inlet and outlet upon movement of the piston to a third position after closing the chamber.

7. The injector according to claim 1 and wherein the piston has an axial conduit and the outlet comprises orifices connected to the piston conduit and disposed tangentially thereto in the piston section of smaller diameter.

8. The injector according to claim 1 and wherein the connection between the inlet and the compression chamber is cut off prior to establishing the connection between the inlet and outlet duct.

9. A fuel injector for an internal combustion engine comprising a body having a fuel inlet and enclosing a compression chamber, a piston guided in the body and urged to a certain position and including at least two sections of different diameter the section of larger diameter varying the volume of the chamber, said piston having an axial conduit connected to the inlet by movement from said position, said piston having an orifice connecting the piston conduit to the chamber and covered by the body upon movement of the piston from the first to a second position, said piston also having other orifices normally covered by the body and communicating with the exterior of the body upon piston movement to a third position and exceeding the piston movement to the second position.

10. The injector according to claim 9 and wherein the other orifices are tangential to the piston conduit.

11. A fuel injector for an internal combustion engine comprising a body having a fuel inlet and enclosing a compression chamber, a piston guided in the body and urged to a certain posi-

tion and movable by the fuel from that position and including at least two sections of different diameters, the section of larger diameter varying the volume of the chamber, the piston having an axial conduit communicating with the inlet upon piston movement from the first to a second position closing the chamber by the piston section of larger diameter, the piston also having orifices in the section of smaller diameter normally covered by the body and open upon movement of the piston to a third position.

12. A fuel injector for an internal combustion engine and comprising a body having a fuel inlet and enclosing a compression chamber, a piston guided in the body and urged to a certain position and having an axial conduit communicating at one end with the inlet upon movement from that position and terminating short of the other

end, said piston also having an orifice normally connecting the piston conduit with the chamber and covered by the body upon piston movement to a second position, the piston having also an outlet orifice, and a conduit in the body communicating at one end with the inlet and communicating at the other end with the outlet orifice after movement of the piston to a third position.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,214,757	Alden	Sept. 17, 1940