

May 3, 1966

J. G. CADIOU

3,249,308

FUEL INJECTOR FOR INTERNAL COMBUSTION ENGINES

Filed July 31, 1963

2 Sheets-Sheet 1

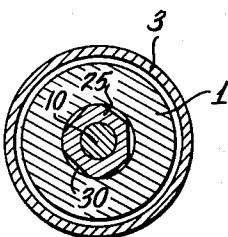
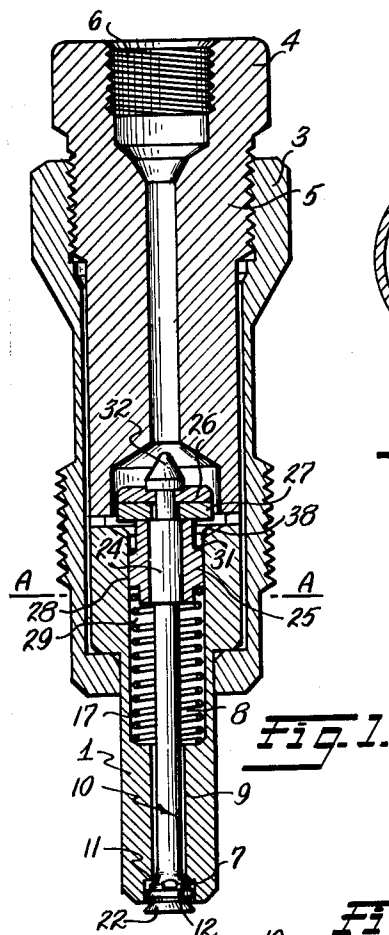


Fig. 2.

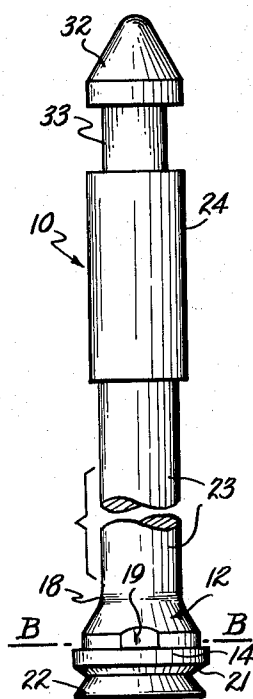


Fig. 3.

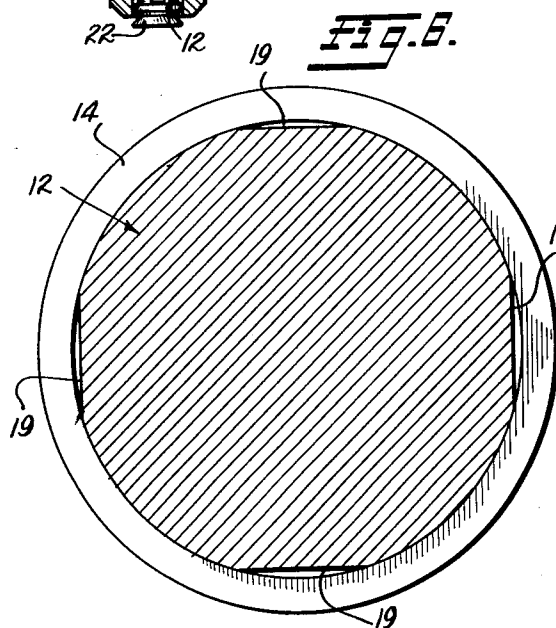


Fig. 4.

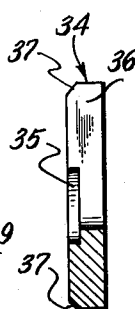


Fig. 5.

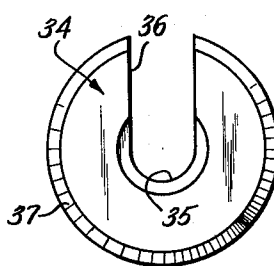


Fig. 6.

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**May 3, 1966**

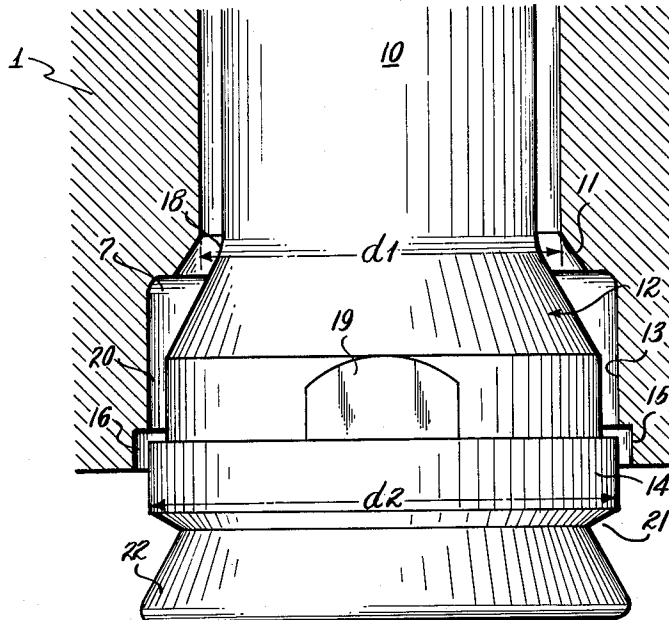
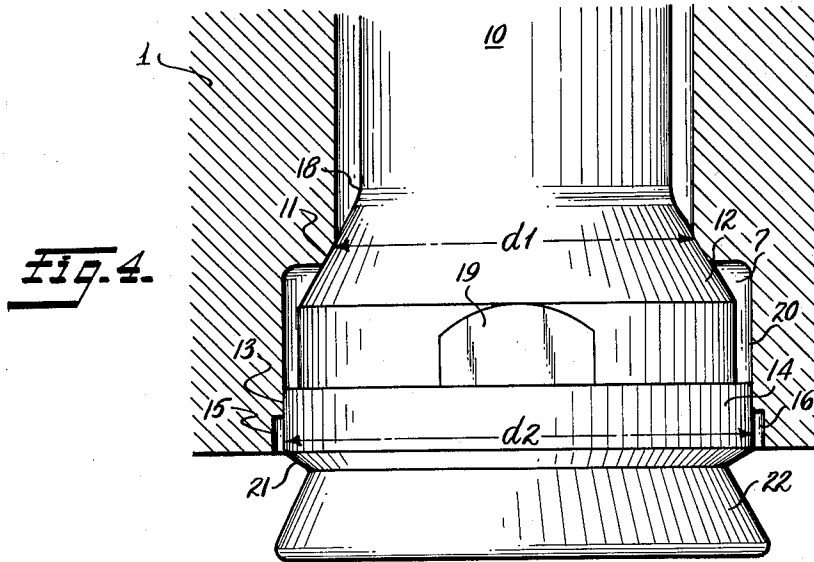
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FUEL INJECTOR FOR INTERNAL COMBUSTION ENGINES

2 Sheets-Sheet 2

Filed July 31, 1963



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3,249,308

## FUEL INJECTOR FOR INTERNAL COMBUSTION ENGINES

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Filed July 31, 1963, Ser. No. 298,995

Claims priority, application France, Aug. 2, 1962,

905,881, Patent 1,344,917

4 Claims. (Cl. 239-453)

The present invention relates to fuel injectors for internal combustion engines, and has for an object, improvements therein.

As is known, in order to obtain good combustion in an injection-fed internal combustion engine, it is necessary for the injection system to effect the following operations simultaneously:

(a) A fine and uniform atomization of the fuel in the mass of combusive air;

(b) An accurate release of the right quantity of fuel injected for each stroke;

(c) A highly accurate determination of the pressure corresponding to the opening of the valve in order to facilitate the adjustment of the injectors and to ensure reliability in operation.

Apart from pneumatic systems in which the fuel is injected by a current of air, and which are little used, there exist mechanical systems in which the fuel is injected without using compressed air, under the action of the pressure of the liquid alone.

Such mechanical injectors are closed under the action of a return spring which returns the valve head onto its seat and whose tension is so adjusted that the needle begins to move only at a predetermined pressure called the calibration pressure.

Some injection devices in which the valve head opens in the direction of flow of the fuel, make use of a phenomenon known as the needle differential effect, which consists of an increase in the surface area over which the pressure is exerted during operation. After the valve has opened, the pressure acts over a section of the needle with a surface area which is effectively greater than that of the valve and thus causes the valve to open rapidly.

Under very light working conditions, such as may arise in car engines which are idling or operating under a very low load, there occurs a vibration of the needle (popping action) favorable to good atomization.

The chief disadvantage of such injectors is their high cost of manufacture, chiefly due to the necessity for grinding-in operations and particularly elaborate truing. It is a question of machining a needle of a more or less complex geometrical structure, free to slide in a bore in the body of the injector, while ensuring a perfect hermetic seal when at rest. These two parts are in contact with one another at the level of conical and cylindrical bearing surfaces providing both a seal and an axial guide. It is therefore necessary to produce absolutely coaxial parts.

In one known injector, two cylindrical bearing surfaces on either side of a conical bearing surface simultaneously provide the seal and the guide and also apply the head or moving part of the valve against its seat. The manufacture of this injector is complicated by technological difficulties due to the need to machine three absolutely coaxial adjacent bearing surfaces.

Another known injector, which is more simple to manufacture, has only two distinctly differentiated bearing surfaces. One of these, which is conical, provides the seal, and the other, cylindrical, the axial guide for the needle. But since the needle bears only on one surface, the guiding is not perfect as in the aforementioned type.

It is an object of the present invention to provide an accurately operating injector opening in the direction of flow of the fuel, in which the spindle or needle moves freely along the axis defined by the end bearing surfaces. This is made possible by a simple construction which does not call for perfect alignment of the said bearing surfaces, but avoids the appearance of stress during the movement of the needle.

Accordingly, the invention consists in a fuel injector for an internal combustion engine, having a spindle or needle carrying a valve head or body for application against a seating, wherein the spindle or needle has three bearing surfaces, of which two are cylindrical and are at the two ends of the spindle or needle, and one is conical and in the neighborhood of the injection valve head, the spindle or needle being guided by said two cylindrical bearing surfaces and the valve seal being provided by the conical bearing surfaces and the cylindrical bearing surface nearer the valve head.

Preferably, the cylindrical portion of the spindle or needle, which is located immediately after the conical valve head, is provided with plane surfaces defining channels opening into an annular discharge orifice. This orifice is limited on the one hand by a bore of larger diameter in the body of the injector and on the other hand by the corresponding cylindrical part of the valve head constituting the bearing surface. The valve head is also provided, at the level of the stage providing both the seal and the guides for the spindle or needle, with chamfers, the number and dimensions of which will be given later on in the description, which ensure the passage of the fuel and also enable the lower end of the spindle or needle to be permanently guided.

Advantageously, the spindle or needle is provided at the end opposite the valve head with a washer of appropriate shape, through which the tension of the return spring is applied to said valve head.

The manufacture of such an injector has the advantage that it lies within the scope of present-day precision mechanics. It is trouble-free, since the tolerances required are such that in spite of the small size of the part they may be machined with no particular difficulty.

The present invention also relates, by way of new industrial products, to apparatus in which the present device is used, and to fixed or mobile assemblies, and in particular, motors provided with such apparatus.

In order that the invention shall be more clearly understood, reference will now be made to the accompanying drawings, which show one embodiment thereof purely by way of example, and in which:

FIGURE 1 shows an injector in accordance with the present invention, in the closed position, in diagrammatic axial section;

FIGURE 2 shows a section made along the line A—A through the injector shown in FIGURE 1;

FIGURE 3 shows a more detailed view of the needle separated from the injector shown in FIGURE 1;

FIGURE 4 is a side view, on a larger scale, of the injection poppet valve in the closed position;

FIGURE 5 is a side view, on a larger scale, of the injection valve in the open position;

FIGURE 6 shows the injection valve in cross-section along the line B—B of FIGURE 3;

FIGURE 7 shows a section of the washer mounted at the upper end of the spindle or needle, and

FIGURE 8 shows the same washer, seen from above.

Referring to the drawings, in an injector according to the invention, a body 1, which has a multi-stage bore axially therein, acts as a feed for fuel under pressure. The said body 1 is housed in an injector-holder 3 and is held in position by an end-plug 4 screwed into a threaded

female portion 5 in the said injector-holder 3, the said end-plug 4 carrying a conventional connection 6 for connecting the injector to the injection pump.

The body 1 of the injector has two coaxial cylindrical chambers 7 and 8 which intercommunicate via a narrow co-axial channel 9, and through which the stem of the injector spindle or needle 10 may be passed.

The chamber 7 located at the lower end of the injector comprises a conical seat 11 against which the head or moving portion 12 of the valve, which is located at the lower end of the injector spindle 10, is applied, and, also a cylindrical bearing surface 13 guiding the piston or slide portion 14 of the valve head, the lower end 15 of this cylindrical bearing surface being turned to a slightly larger diameter so as to define, together with the corresponding portion of the spindle, an annular outlet orifice 16.

The chamber 8 provides a seat for a spring 17 bearing on the base thereof and enabling the injector spindle 10 to be guided by means of a guide sleeve 25 sliding in the upper portion of the said chamber.

With the exception of the valve head, the largest diameter of the stem of the injection spindle 10 must be less than that of the narrow channel 9, so that it can be inserted into the body of the injector. This spindle is acted on both by the pressure of the liquid to be injected and by the pressure of the return spring 17.

Referring to FIGURES 4 and 5, which show a side view, to a larger scale, of the head of the injector, it will be seen that the valve head 12 has a conical shoulder portion 18 applied against the seat 11 and a cylindrical piston or slide portion 14 of which the diameter is very slightly less than that of the chamber 7, so as to achieve a satisfactory hermetic seal.

These conical and cylindrical bearing surfaces must be machined with sufficient accuracy to obtain a satisfactory seal.

The said piston or slide portion 14, which is guided by the bearing surface 13, is provided with lateral chamfers such as 19, evenly distributed around its periphery, which define free spaces 20 between the spindle and the body of the injector which enable the fuel to pass through. These chamfers are cut only into the upper portion of the piston or sliding portion (referring to the position shown), so that so long as the injector is closed they cannot open into the discharge orifice 16. Their number, and the depth to which they are machined, are determined by the area of the cross-section of the passage it is sought to provide. This area is in the neighborhood of the area of the cross-section of the discharge orifice and depends both on the minimum volume of liquid to be injected, so as to allow for sufficient velocity of the jet, and on the maximum volume, so as not to exceed maximum permissible pressure values. Moreover, it has the advantage of remaining constant throughout the entire injection stroke.

The cylindrical piston or sliding portion 14 leads to a throat 21 and then to a divergent conical extension 22 which deflects the jet emerging from the discharge hole and atomizes it. The said conical extension 22 remains permanently outside the body of the injection 1.

When the needle is closed, the pressure of the fuel is exerted on the circular section of the needle at the level of the output opening of the channel 9 (diameter  $d_1$ ). When the force resulting from the pressure exceeds the thrust of the spring, the spindle leaves the seating 11 and the pressure of the liquid is then exerted over the section of the cylindrical piston or sliding portion 14 which has a diameter  $d_2$ .

As  $d_2$  is considerably greater than  $d_1$ , the force acting on the spindle is increased and the movement of the spindle is considerably accelerated until it reaches the stop position which will be defined hereinafter. At this point the flow spaces 20 defined by the chamfers 19 and the body of the injector are uncovered and the fuel is forced into the discharge orifice 16, after which it is atomized. The pressure of the fluid then decreases until it becomes

equal to the closure pressure. Injection then ceases. The spring 17 forces the spindle 10 against its seat 11, while the flow spaces 20 are once again blocked. The injector is then ready for a new injection stroke.

The spindle 10 is constituted over the greater part of its length by a stem 23, the diameter of which has been reduced in order to reduce its weight and to allow for the necessary passage of fuel. This stem has an enlarged portion encircled by a bearing surface 24, on which a sleeve is mounted with very slight play. This guide sleeve 25 guides the injection spindle 10 and bears, under the action of the spring, on a washer 26 engaged in a throat 33 on the spindle. The said guide sleeve 25 is provided with a flange 27 which comes into contact at the end of its travel with the upper surface of the injector and limits the movement of the valve portion 18, preventing the piston or sliding portion 14 from completely leaving the annular discharge orifice 16.

The cylindrical portion 28 which carries the bearing surface 24, slides freely in the bore 29 in the chamber 8, and is provided with chamfers 30 which can be seen in FIGURE 2 and which enable the fuel to flow directly into the said chamber 8.

In this geometrical arrangement, in which the bearing surfaces are short and localized at the two ends of the spindle 10, it is possible to tolerate a certain eccentricity of the said bearing surfaces, within the limits of play permissible. Thus no supplementary stress is introduced during the movement of the needle, although the conical poppet valve head is allowed to apply itself firmly against its seating, and although a perfect seal is ensured.

The chamfers 30 communicate at their upper ends with a throat 31 machined in the sleeve under the flange 27, which collects the fuel brought thereto by grooves 38 provided in the upper surface of the body of the injector 1, and allowing for the free passage of the fuel when the flange 27 is applied against the body 1.

At its upper end, the spindle is provided under its head 32, with a throat 33 in which the aforementioned washer 26 is engaged, transmitting the thrust of the spring 17 to the end of the spindle.

A particularly advantageous embodiment of this washer comprises, as can be seen from FIGURES 7 and 8, a metal disk 34 provided with a central bore 35 and a slit 36 running from the said bore to the edge of the disk.

The thickness of the said washer is made such that when the conical poppet valve head bears on its seat and the guide sleeve 25 rests on the injector body via the flange 27, it may just be slipped under the head 32 of the spindle. The depth of the chamfer 37 on the washer corresponds to the path of the spindle when the washer is in position, which enables this to be accurately defined.

The action of the spring 17 may be modified by the addition of washers placed at the bottom of the base of the chamber 8.

In particular, its compression must be sufficient to hold the valve head against its seat against the fuel pressure acting at the level of the orifice and tending to force back the spindle so long as the said pressure is less than a predetermined value sufficient for injection. It is only when the pressure of the fuel reaches and exceeds this value that the spindle is forced back and the injection begins.

What is claimed is:

1. In a fuel injector of the type comprising a hollow body defining a bore having inlet and outlet ends, a needle longitudinally slidable for a limited distance within said bore, and resilient means biasing said needle in one direction relative to said bore, the improvement which comprises three axially spaced bearing surfaces carried on said needle which engage three mating bearing surfaces on said body, one of the bearing surfaces on said needle being frusto-conical and the other two

5

cylindrical, each of the cylindrical bearing surfaces on said body being positioned to be in contact with at least a portion of the mating bearing surface on said needle and thereby guide said needle throughout its longitudinal movement within said bore, the frusto-conical bearing surface on said needle being biased toward its mating surface and positioned between the two cylindrical bearing surfaces on said needle, the diameter of said needle between said bearing surfaces being sufficiently less than that of the encircling portions of said bore to prevent contact therebetween, said resilient means being positioned between the frusto-conical bearing surface and the cylindrical bearing surface nearest the inlet end of said bore, said cylindrical bearing surfaces forming guides for said needle, and the frusto-conical bearing surface on said needle nearest said outlets end being interrupted by a plurality of inwardly depressed chamfers circumferentially spaced about a portion of its length remote from said outlet end and the bore in said body having at its outlet end a short section having a diameter greater than that of said last mentioned cylindrical bearing surface, so that a passage is formed between said needle and bore when, but only when, the bearing surface on said needle nearest the outlet end of the body projects so far beyond the mating bearing surface on said body that only the portion thereof interrupted by said chamfers overlaps and is guided by said body bore.

2. A fuel injector as claimed in claim 1, comprising a cylindrical sleeve carried by said needle, the cylindrical bearing surface carried on said needle nearest the inlet

6

end of said bore being formed on the outer surface of said sleeve.

3. A fuel injector as claimed in claim 1 in which said bore defines cylindrical inlet and outlet chambers in which the cylindrical bearing surfaces carried by said body are respectively positioned, and said needle comprises successively a cylindrical portion of larger diameter positioned in said inlet chamber, a neck and a terminal head portion, said injector also comprising a cylindrical sleeve carried by said cylindrical portion of larger diameter, said sleeve being provided with a bearing surface mating with one in said inlet chamber and serving to axially guide said needle, and resilient means positioned between said sleeve and said frusto-conical shoulder and biasing the frusto-conical surface on said needle toward its mating surface.

4. A fuel injector as claimed in claim 3 in which said needle is necked near its outlet end and its terminal portion flares conically outward beyond said neck to form an appendage which projects beyond said chamber at all positions of said needle.

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EVERETT W. KIRBY, Primary Examiner.

**UNITED STATES PATENT OFFICE**  
**CERTIFICATE OF CORRECTION**

Patent No. 3,249,308

May 3, 1966

Jean Georges Cadiou

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the drawings, Sheets 1 and 2, in Figs. 4 and 5 the horizontal line tangent to the arcuate line representing the top of the chamfer 19 should be eliminated and replaced by two horizontal lines, one leading from each of the intersections between said arcuate line and a vertical line defining the chamfer to the nearest vertical line defining the exterior of the piston. In each of Figs. 3, 4 and 5, the horizontal lines connecting the lower ends of the vertical lines defining the chamfer 19 to the nearest vertical line defining the exterior of the piston should be eliminated.

Signed and sealed this 11th day of March 1969.

(SEAL)

Attest:

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Commissioner of Patents