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71 Applicant: **Siemens Aktiengesellschaft**
Wittelsbacherplatz 2
D-8000 München 2(DE)

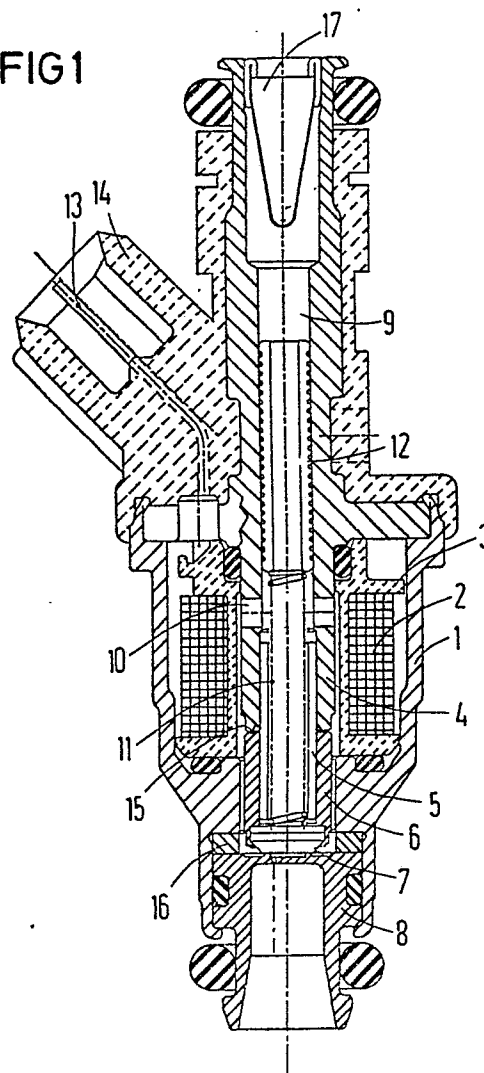
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72 Inventor: **Forapianti, Mauro**
Via Della Leccia, 35
Livorno(IT)

54 **Electromagnetically operated injector.**

57 An injector has a valve seat created by two planar surfaces (18, 19). Downstream the valve seat a first chamber (20) is located with a reduced depth and the position of one or more orifices (21) on the periphery of such chamber are such that the fuel flow must deviate with a sharp turn in order to be addressed to the one or more orifices (21) which have a direction basically parallel to the injector's axis. The sudden change of the direction of the fuel flow together with the fact that the orifices (21) are not centered against the feeding annular section, create a turbulent motion in the fluid which causes an atomization and a consequent conical pattern of the fuel coming out of the one or more orifices (21).

FIG1



Electromagnetically operated injector

This invention relates to an electromagnetically operated injector for use in electronically controlled fuel injection systems, of the single or multiple injector type, for internal combustion engines.

This type of injector characteristically comprises a casing, a fuel inlet in said casing, fuel discharge elements complete with at least partly magnetic valve means for controlling the fuel flow through said discharge elements, and a solenoid contained in said casing and which, when energized, causes said valve means to open in opposition to elastic means, and thus allowing the fuel to flow through said discharge elements.

One of the main characteristics to be considered in designing this type of electromagnetic injector is the shape of the jet coming out of the injection nozzle.

In certain applications, for instance, in order to reduce the emissions level in the engine exhaust gas, an atomized conical spray can be desirable to facilitate the mixing of the gasoline with the air drawn in by the engine.

One way to achieve a proper atomization is disclosed in European patent application 0 201 190. Therein, an orifice director plate with several orifice passages is provided downstream of the valve seat for controlling the pattern of the fuel spray. Each of said orifice passages directs a stream of fuel towards a central axis, so that they at least partly impinge upon each other so as to produce the desired atomized spray pattern.

In this case, the broken-down of the jet results from the reciprocal mechanical action among the streams and the final shape will be largely dependent by what amount of each stream takes part in the collision.

From this, it derives a demanding precision in the direction of each stream, not easily achievable in series production. The object of the present invention is therefore to obtain, in a simple manner and under low production costs, an electromagnetic injector which creates an atomized conical jet and which obviates the drawbacks of the known art.

In particular, an electromagnetic conical jet injector is required which:

- 1) has no additional mechanical element with respect to an injector in which the jet is of the cylindrical rod type;
- 2) enables the conical jet to be formed by hydraulic action;
- 3) leads to no increase in the fuel volume contained down stream of the valve means;
- 4) has its cone formation means disposed at the terminal section of the injection nozzle;
- 5) allows easy control of the effective fuel

discharge cross-section of the injection nozzle;

6) has the terminal bore of its injection nozzle completely free of reverberation pins, grooves or helical inserts;

7) has considerable jet direction uniformity;

8) allows the fuel to also undergo uniform distribution within the conical spray without presence of any preferential stream.

This object is attained by an electromagnetic injector according to claim 1.

Compared with the known art, an injector according to the present invention has the following advantages:

- a) No cost increase over an injector with a cylindrical rod jet;
- b) no delivery change in "hot" conditions;
- c) absence of harmful non-atomized pre-spray;

d) no variations in the discharge coefficient at the fuel passage area through the valve means;

e) ease of controlling the instantaneous throughput delivered by the injector for a mass-production run;

f) no delivery reduction with time due to carbon sediments of fuel lead residues depositing on jet reverberations elements;

g) no need for increase of the fuel passage area through the valve means, with relatively lesser possibility of rebound of the mobile assembly

The structural and operational characteristics of the invention and its advantages over the known art will be more apparent from an examination of the description given hereinafter by way of example, with reference to the accompanying drawings in which:

Figure 1 is a longitudinal section through an electromagnetic injector constructed in accordance with the principles of the present invention.

Figure 2 is a view, to an enlarged scale, of the valving part of the injector seen in Figure 1.

Figures 3 and 4 show some modifications of the outlet orifices which can be applied to the injector of Figure 1.

With reference to Figure 1, an electromagnetic fuel injector, in accordance with this invention, includes an external body 1 formed from magnetizable material which houses an electric coil 2, wound on a spool 3, which surrounds a cylindrical magnetic core 4, also formed from magnetizable material.

In the magnetic core 4, a bushing 5 is mounted, made of non-magnetizable material, which acts as the longitudinal guide to a cup-shaped mobile armature 6 which, together with the body 1 and the core 4, forms the magnetic circuit.

The mobile armature 6 carries a plastic-made seating insert 7 which cooperates with the upper surface of the nozzle body 8 so to create the shut-off system for the fuel flowing through an axial bore 9 and cross-holes 10 in the central core 4. In shut-off conditions, the valving system is kept closed by the force on the armature of a spring 11 housed in the central core 4 and reacting on a dowel 12.

When the coil 2 is electrically energized through conductors 13, partially embedded in a plastic connector 14, the armature 6 is magnetically attracted towards the core 4 and, overwhelming the force of the spring 11, moves from the nozzle 8, so allowing the fuel to flow through the nozzle orifice.

When the coil is deenergized a residual magnetic force tends to limit the fast return of the armature 6 in the shut-off condition against the nozzle 8; as a solution to this, a thin non-magnetic layer is present on an upper surface 15 of the armature 6, which avoids the direct contact between the armature 6 and the core 4.

The injector includes furthermore a series of O-rings, a spacer 16, which adjusts the lift to the armature 6, and an inlet filter 17.

Figure 2 describes in more details the area of the injector which is subject to this invention.

In the lower part of the cup-shaped armature 6 the plastic insert 7 is firmly assembled through the roll-over of the armature's rim; on the external face of such plastic insert 7 an external flat surface 18 is present which works together with an opposed planar annular ring 19, concentrically created on the upper surface of the injection nozzle 8 which has the shape of a bottom-up cup. The two surfaces 18 and 19 create the valving system which allows or closes the fuel flow towards the orifice of the nozzle.

The inside rim of the sealing annular ring 19, located on the upper surface of the nozzle body 8, extends in a chamber 20, also located in said nozzle. On the bottom of said chamber one or more injection orifices 21 are located in a out-of-center position, near to the side wall of the chamber (according to the spirit of the invention).

The total area of said one or more injection orifices 21 defines, together with their flow coefficient, the quantity of fuel delivered by the injector.

A second chamber 22 can be found on the bottom side of the nozzle body 8, concentric to the injector's axis, opposed to chamber 20 but having largely bigger dimensions, the one or more injection orifices 21 terminating in such chamber.

The axis of said injection orifices are coplanar with the injector's axis and they can be parallel with it or such to create with it an angle which can range between 0.5 and 15 degrees. Anyway, the

direction of the one or more orifices axis will be such to avoid any collision among themselves or with an inner wall 23 of the second chamber 22.

Figure 3 shows, as an example, a different embodiment of the injector subject to this invention, where two injection orifices are coplanar and parallel with the injector's axis.

Figure 4 shows, an embodiment where only one orifice is present and its axis converges with the coplanar injector's axis.

As regards the functional idea on which the invention is based, it is sufficient to mention that when the magnetic armature 6 is lifted towards the magnetic core 4, the fuel, when passing through the planar surfaces 18 of the plastic insert and 19 of the seating surface on the nozzle body 8, acquires an important inertial component on a plane which is perpendicular to the injector's axis.

The reduced depth of chamber 20 and the position of the one or more orifices on the periphery of such chamber are such that the fuel flow must deviate with a sharp turn in order to be addressed to the above one or more orifices 21 which have a direction basically parallel to the injector's axis.

The sudden change of the direction of the fuel flow together with the fact that the orifices are not centered against the feeding annular section, create a turbulent motion in the fluid which causes the atomization and the consequent conical pattern of the fuel coming out of the one or more orifices 21.

The spray pattern which is obtained in this invention shows quite an even distribution in the inside of the cone thanks to the lack of any mechanical element near the injection orifices.

Of course, the best results will be obtained, when the proper dimensional characteristics, which cooperate in establishing a turbulent flow, have been optimized.

From the results of many practical tests it was possible to define the following dimensional relationships:

1) The amount of the lift (S) of the magnetic armature 6 is correlated with the diameter (d) of the one or more orifices 21 and with the diameter (D) of the first inner chamber 20 by the following relationship:

$$0.1D \geq S \geq 0.5d$$

2) The depth (h) of the first inner chamber 20 is correlated with the number (n) of the one or more orifices 21 and with their diameter (d) by the following relationship:

$$0.75 \leq n \cdot d/h \leq 5$$

3) In order to avoid changes of calibration in hot engine conditions, the volume (V) of the first chamber 20 must be limited as follows:

$0.50 \leq V \leq 1.50$ cu. mm.

Finally it is proper to describe the positive action of the wall 23 of the second external chamber 22, such wall acting as a shield to the orifices 21, against the oil fumes and the recirculated gases flowing in the inlet manifold. In this way, no deposit is created in the nozzle orifice which can reduce the fuel flow area and, therefore, the delivered amount of fuel.

It must be noted, furthermore, that the reduced dimensions of the inner chamber 20 are such that, even when only one injection orifice 21 is used, positioned against the cylindrical wall of said chamber, its actual distance from the injector axis is negligible as far as the exact position of the jet in the intake manifold is concerned.

The injector can, therefore, be considered "a central discharge type".

This allows not to define a relative position of the nozzle 8 against the electrical connectors during the assembly phase and of the injector against the manifold of the engine.

Claims

1) Electromagnetically operated injector for feeding fuel to an internal combustion engine

- having a nozzle body (8) which has on the inner side of the injector an annular sealing ring (19) concentric to the injector's axis,
- said annular sealing ring (19) surrounding a first inner chamber (20) downstream the annular sealing ring (19) with at least one injection orifice (21) on its bottom,
- having a second cylindrical chamber (22) located downstream said first chamber (20) and said injection orifices (21) terminating in such second chamber (22),
- comprising a magnetic armature (6) with a sealing surface (18), movable along the injector's axis, which is pressed against the annular sealing ring (19) by the force of an elastic means and which can be lifted from the annular sealing ring (19) by electromagnetic force so to shut off or to allow the fuel flow,

characterised in that

- the one or more injection orifices (21) being located near to the side walls of said chamber (20),
- the axis of such one or more injection orifices (21) being coplanar with the injector's one and having directions such to avoid any collision of the fuel flows among themselves and/or with the cylindrical surface of the second chamber (22) and
- the maximum working distance between the annular sealing ring (19) of the nozzle body (8) and the sealing surface (18) of the magnetic armature (6) being lower than 50 % of the diameter of the

one or more injection orifices (21) and lower than 10 % of the diameter of the first inner chamber (20).

2) Electromagnetically operated injector according to claim 1, characterized in that a depth (h) of said first inner chamber (20), a diameter (d) of said injection orifices and a number (n) of same have the following relationship:

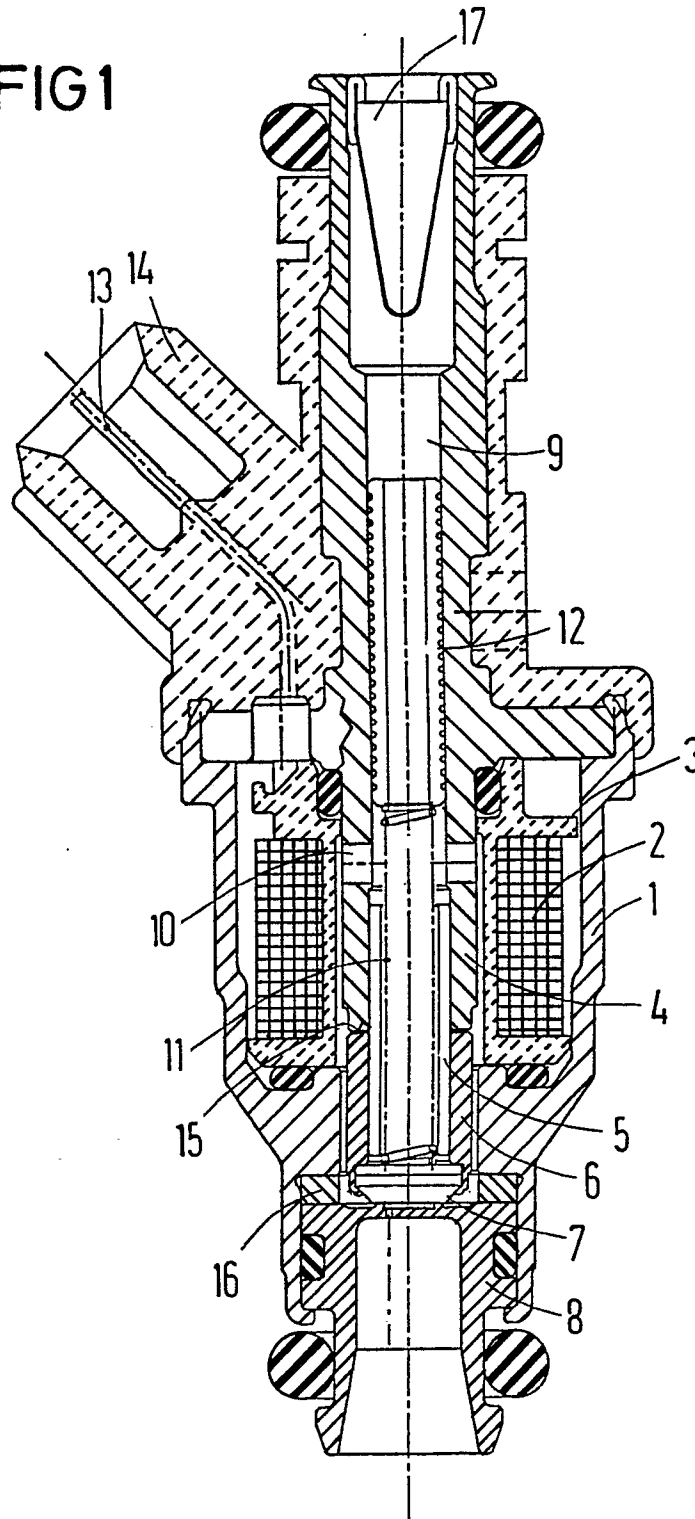
$$0.75 \leq n \cdot d/h \leq 5.$$

3) Electromagnetically operated injector according to claim 1, characterized in that said one or more injection orifices (21), coplanar with the injector axis are also parallel with such axis.

4) Electromagnetically operated injector according to claim 1, characterized in that said one or more injection orifices (21), coplanar with the injector axis, create with this an angle ranging from 0.5 to 15 degrees.

5) Electromagnetically operated injector according to claim 1, characterized in that such first inner chamber (20) located on the nozzle body has a volume ranging from 0.5 to 1 cu.mm.

FIG 1



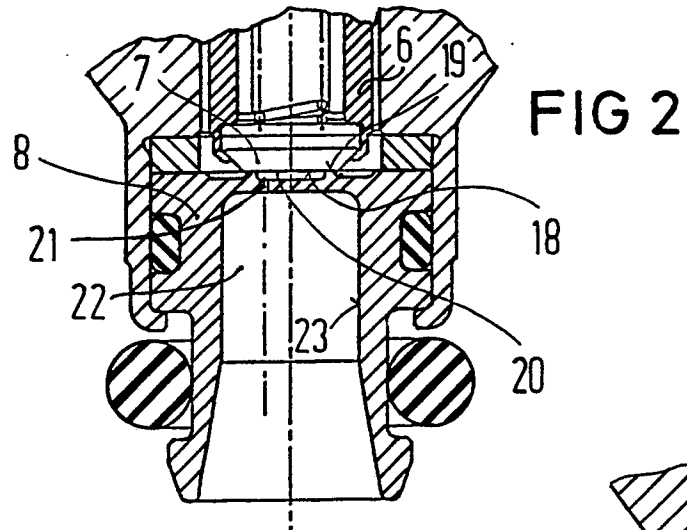


FIG 3

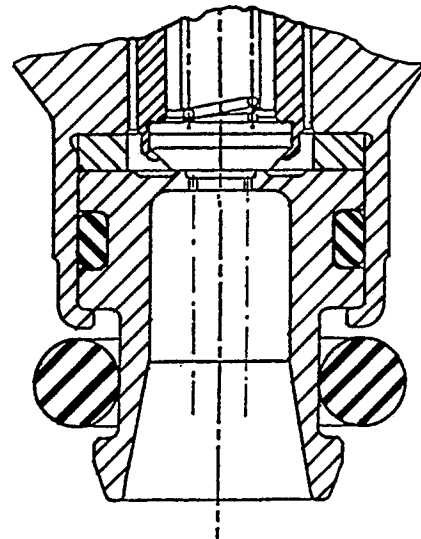
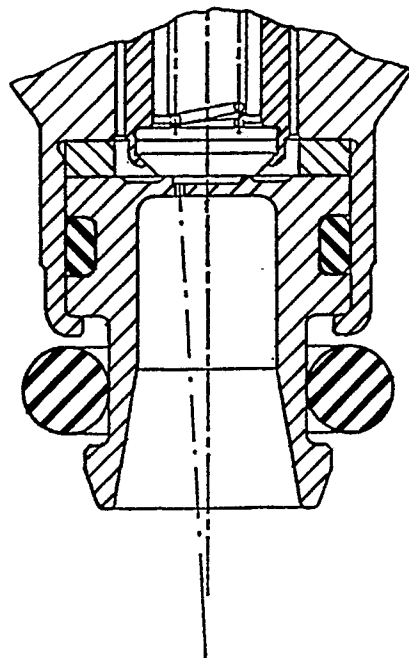


FIG 4





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.3)
Y	GB-A-2 190 428 (LUCAS) * Figure 1; page 1, lines 46-96 * ---	1,3	F 02 M 61/18 F 02 M 51/08
Y	GB-A-2 147 949 (LUCAS) * Front-page; page 2, lines 9-12 * ---	1,3	
A	---	4	
A	US-A-2 382 151 (W. HARPER Jr.) * The whole document * ---	1,3,4	
A	US-A-4 101 074 (A.M. KIWIOR) * Figures 3,4; column 10, line 41 - column 11, line 44 * ---	1,3,4	
A	US-A-4 699 323 (J. RUSH et al.) ---		
A	FR-A-2 399 551 (ALFA ROMEO) -----		
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.3)
			F 02 M
Place of search THE HAGUE		Date of completion of the search 06-06-1989	Examiner LEROY C.P.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			