United States Patent

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[54] **ELECTROMAGNETIC INJECTORS**

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[52] **U.S. Cl.** **239/96,** 239/533, 239/585

[51] **Int. Cl.**...**F02m 41/16**

[58] **Field of Search**.........................239/96, 533, 585

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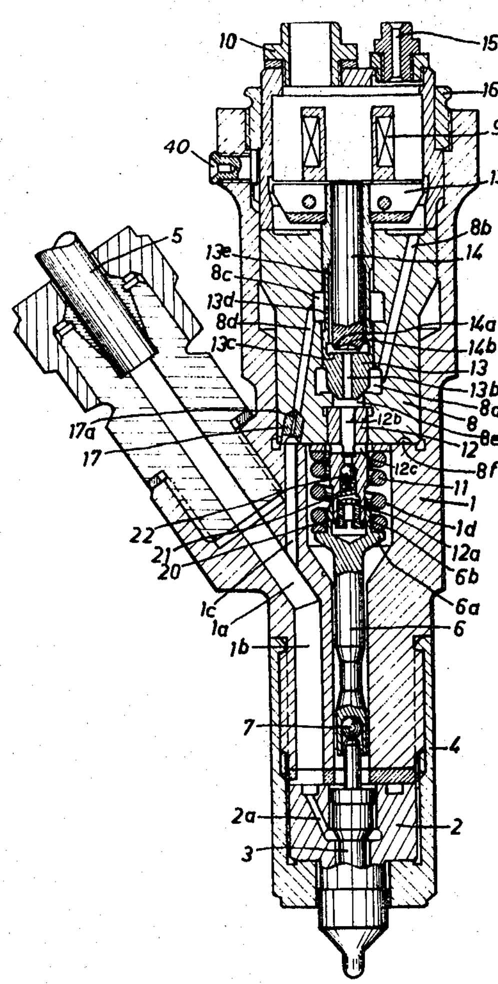
[57] **ABSTRACT**

An electromagnetically controlled fuel injector for internal combustion engines wherein the injector needle is normally held on its seat by the pressure of the fuel in a counter-pressure chamber, the release of said pressure which sets the needle in its operative position being ensured by causing the controlling electromagnet to connect the counter pressure chamber no longer with the supply of fuel but with an exhaust channel returning the fuel to the supply; to this end, the electromagnet acts on a plunger incorporating a slide valve, ball valve or needle valve controlling channels provided in a nozzle surrounding the rod operating the injector needle which channels lead to the counter-pressure chamber, with the supply and with the exhaust.

11 Claims, 6 Drawing Figures



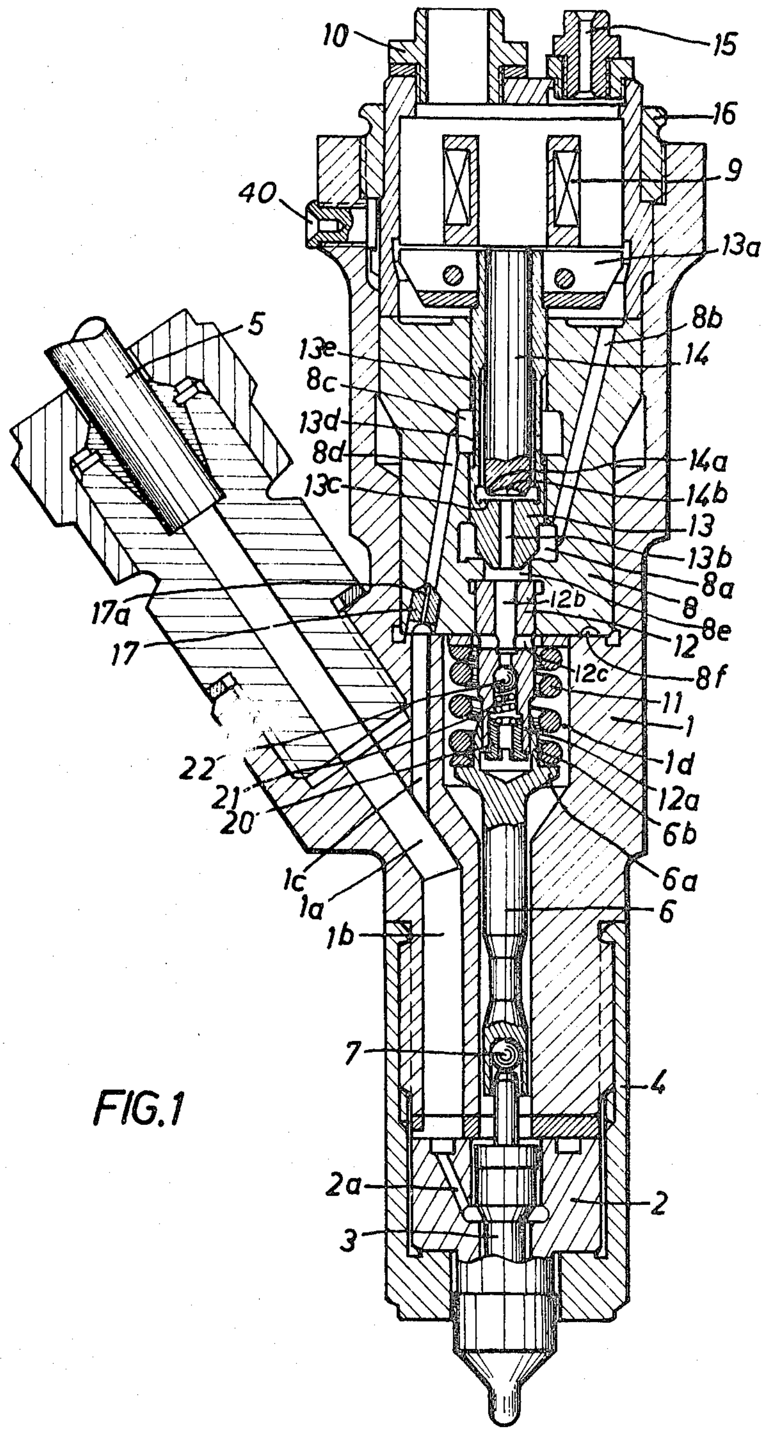


FIG. 1

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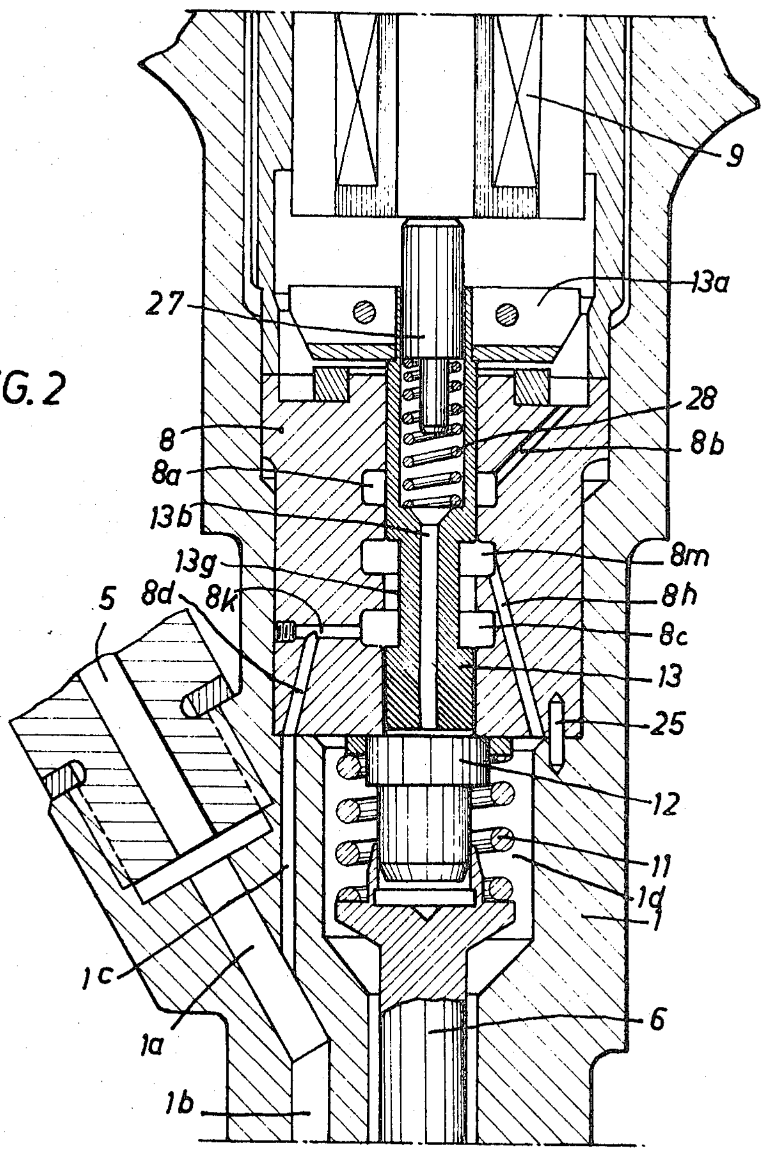
FIG. 2



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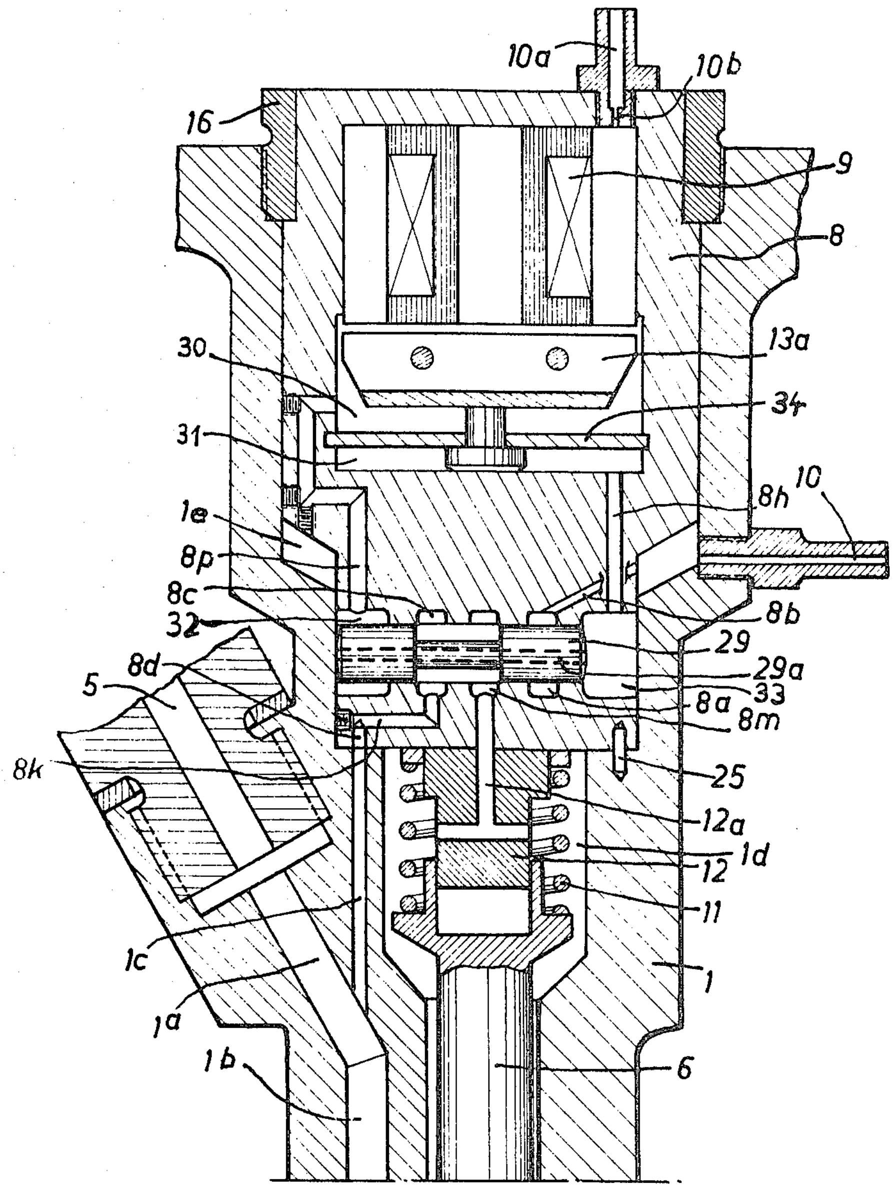

FIG.3

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FIG. 4

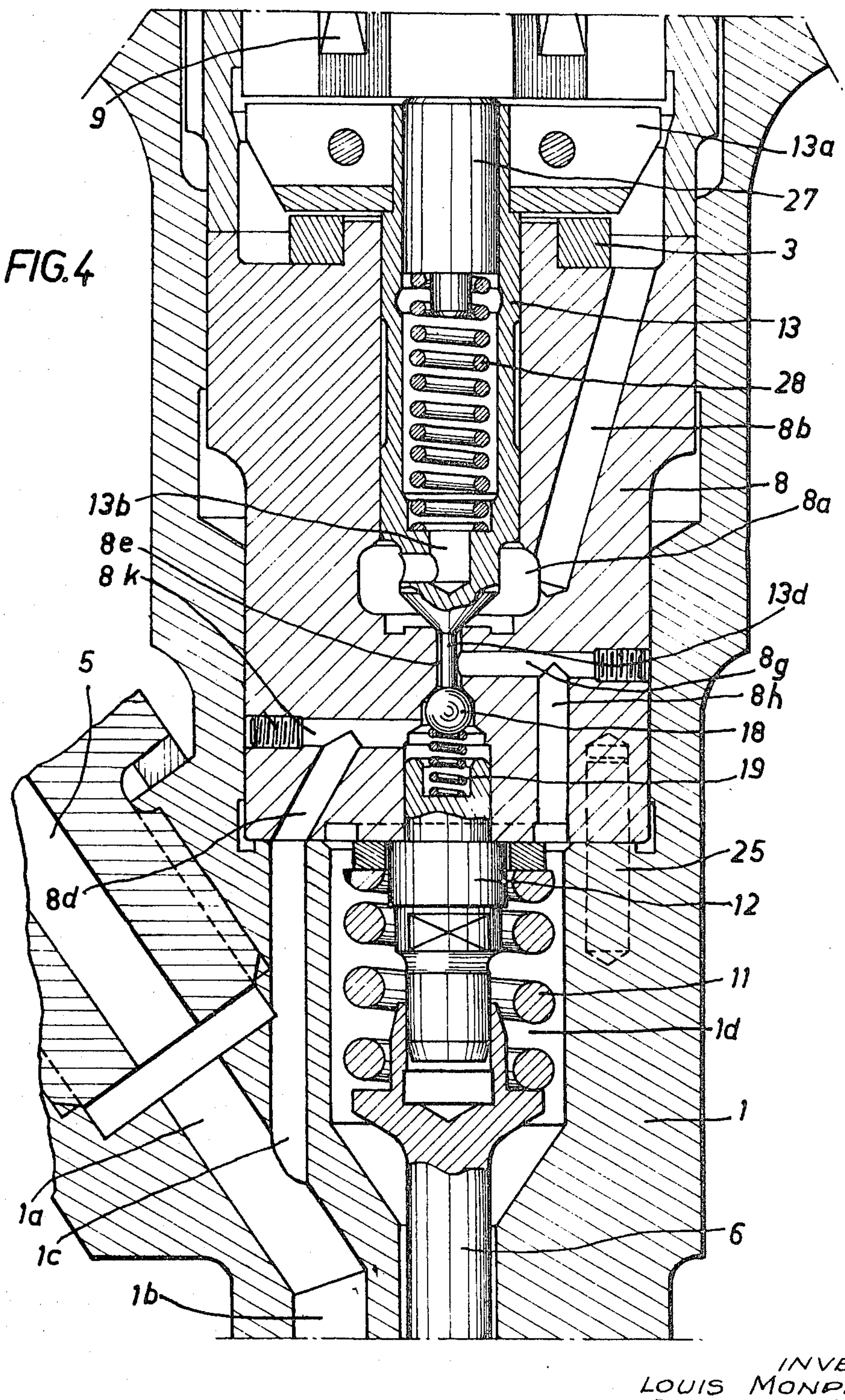

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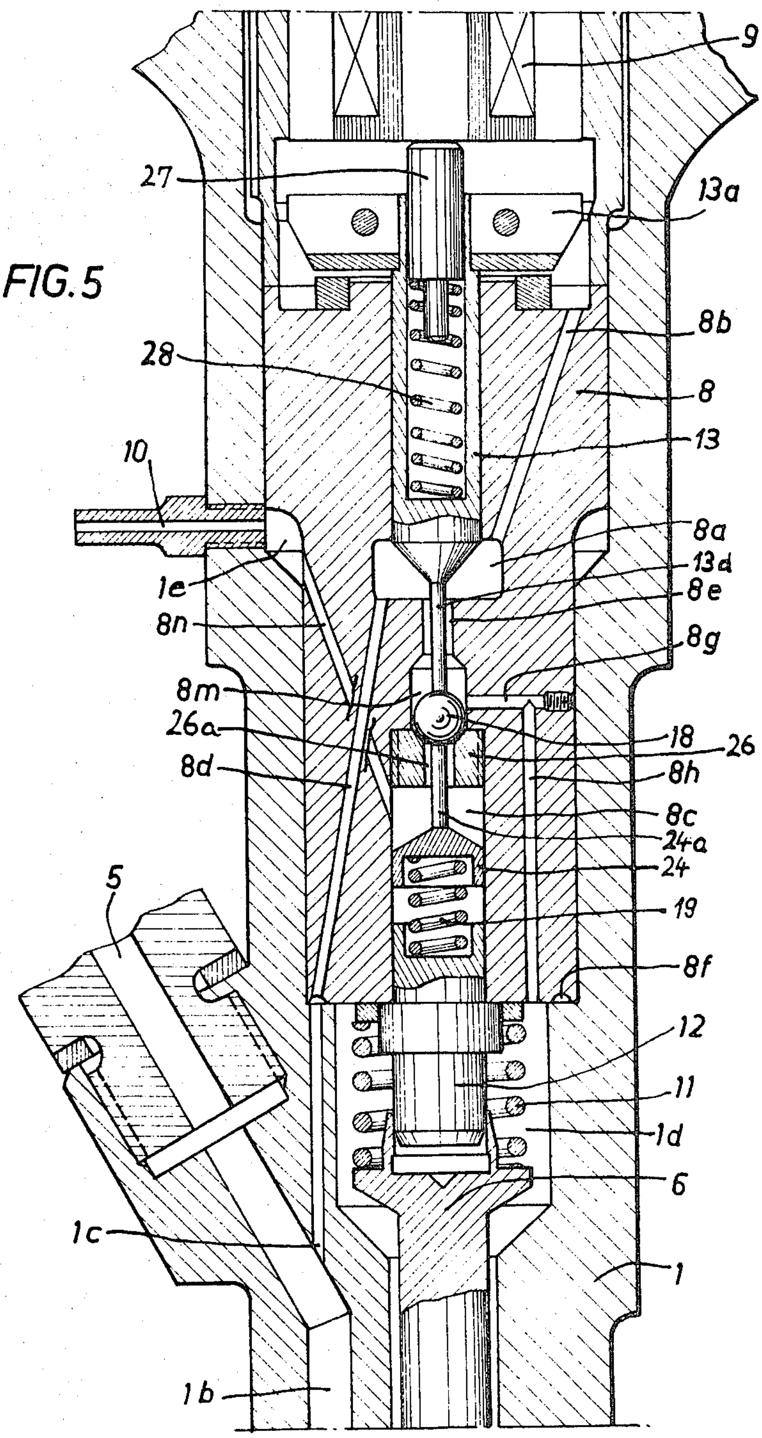
FIG. 5



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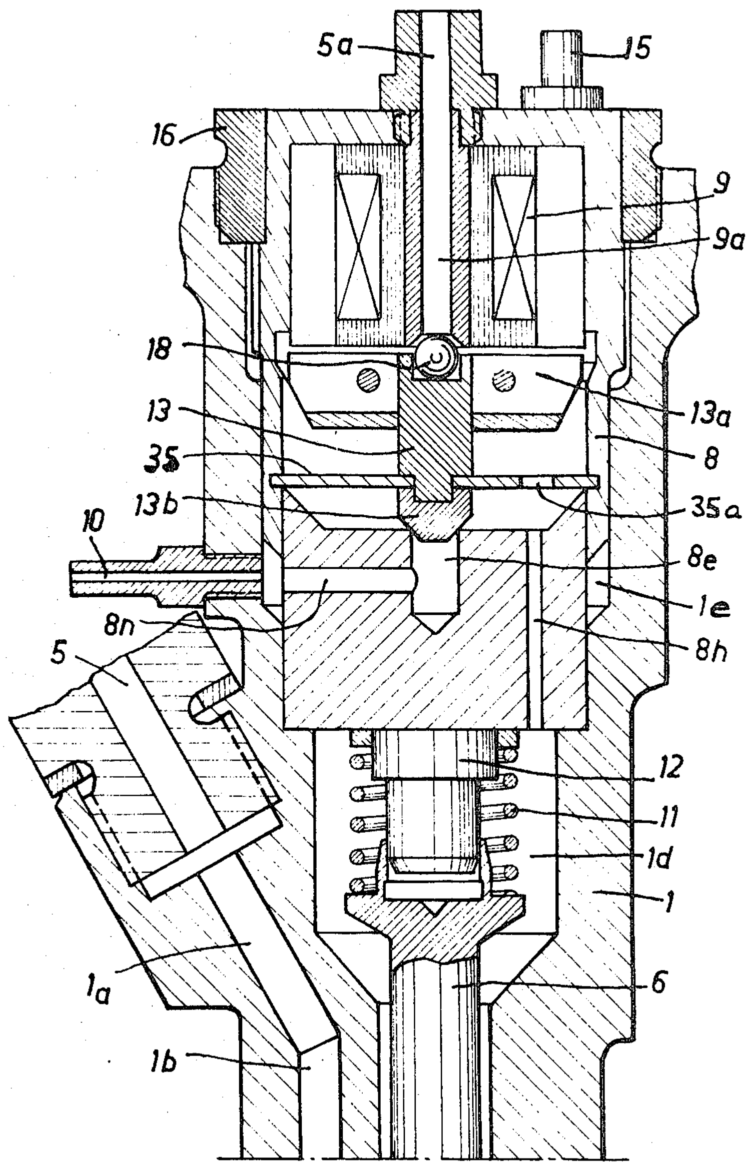

FIG. 6

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ELECTROMAGNETIC INJECTORS

Our invention covers an improvement in electromagnetically controlled assisted injectors.

Fuel injectors for internal combustion engines of an electromagnetically controlled type are already known, which include a needle valve connected with the movable armature of the controlling electromagnet, said needle valve cooperating with the gauged injection port so as to produce its opening. The injectors of such a type are entirely satisfactory as far as the time required for response and their atomizing properties are concerned, but they are subjected to a limitation of the maximum amount of fuel they are capable of injecting per unit of time.

It has already been proposed to cut out said difficulty by resorting to an assisted injector comprising an injector needle held in a closed condition with reference to the injector port by a return spring and by the pressure of a liquid introduced under pressure inside a counter-pressure chamber surrounding the rear surface of said injector needle. The injection is released in such a case by the opening of an electromagnetic valve connecting said counter-pressure chamber with a discharge channel returning the liquid into the feed tank. By providing a throttled port between the admission of liquid under pressure and the counter-pressure chamber, the loss of head is such that the pressure drops within the counter-pressure chamber, at the moment of the opening of the electromagnetically controlled valve, to a sufficient extent for the pressure of the liquid to raise the injector needle and to initiate the injection operation. When the electromagnetically controlled valve closes, the liquid under pressure fills again the counter-pressure chamber through the throttled port so that the injector needle urged by said pressure is returned into its closed position.

Although injectors of last-mentioned type are satisfactory in many cases, it should be remarked that they also show certain drawbacks. As a matter of fact, the cross-section afforded by the electromagnetically controlled valve for the passage of fuel is comparatively small for structural reasons and it should in fact be larger than the cross-section of the throttled port in order to provide for the discharge of the counter-pressure chamber. Consequently, with injectors of such a type, it has been found that the drop in pressure inside the counter-pressure chamber upon opening of the electrically controlled valve is comparatively slow and the same is the case for the rise in pressure at the moment of its closing; in fact, the pressure can drop down only to a still comparatively high value when the opening lasts at a maximum 2 milliseconds, which is actually the maximum allowable duration in the case of Diesel engines. Consequently the law governing the injection does not register with the desired law and there is no possibility for adjusting it. Furthermore, the conditions of atomization are detrimentally influenced by the slow rising of the injector needle and still more by its slow closing.

It should be remarked furthermore that a leak of fuel passes through the throttled port throughout the duration of the opening of the valve, the leak volume of fuel conveyed in a fully useless manner by the pump leading to an objectionable heating of said fuel.

Now, our invention has for its object to cut out these drawbacks and it covers an assisted fuel injector for internal combustion engines of the type including an electro-magnetically controlled measuring valve inserted in the body of the injector while an injector nozzle carried by the end of said injector carries an injection needle opening under the action of the injecting pressure which raises said needle off its seat as soon as the counter-pressure acting normally on one side of said needle drops suddenly as a consequence of the opening of the measuring valve. According to our invention, the measuring valve may assume two positions and cooperates with a fuel channel feeding the fuel and with a channel connected with the counter-pressure chamber associated with the corresponding end of the injector needle, said channels being designed with reference to the valve in a manner such that for one position of the latter a connection is established between the channel feeding the fuel under pressure and the channel connected with the counter-pressure chamber whereas for the other position of the valve a connection is established between the channel connected with the counter-pressure chamber and a discharge channel.

Further features and advantages of our invention will appear in the reading of the following description of a preferred embodiment thereof, reference being made to the accompanying drawings wherein:

FIG. 1 is an elevational sectional view of an injector according to a first embodiment of our invention.

FIG. 2 is a sectional view of an injector according to a second embodiment.

FIG. 3 is a cross-sectional view of an injector according to a third embodiment.

FIG. 4 is a cross-sectional view of an injector according to a fourth embodiment.

FIG. 5 is a cross-sectional view of an injector according to a fifth embodiment.

FIG. 6 is a cross-sectional view of an injector according to a sixth embodiment.

Turning to FIG. 1, the injector as a whole includes an elongated body such as hollow body 1 to which the actual injector carrying the injector needle 3 is secured by the clamping nut 4. The connection 5 feeding fuel under pressure, the nozzle 8 and the stationary section of an electromagnet 9 are secured on the other hand to the body 1 by the threaded member 16. The injector needle 3 is urged against its seat by the spring 11 acting through the control member such as the rod 6 and of the ball 7 together with the pressure of the liquid in the counter-pressure chamber 1*d*, which pressure acts on the end of the injector needle 3 facing said counter-pressure chamber. The rod 6 is provided with an expansion 6*a* forming a seat for the spring 11 and with a cylindrical extension 6*b* slidably carried by a guiding member such as the guiding stud 12. Inside a bore in said guiding stud 12 there is provided a check valve or one-way valve such as a ball 22 urged against its seat by a spring 21 held in position in its turn by an axially perforated screw 20. This ensures a damping of the rising movement of the injector needle 3, the sinking of the needle being in contradistinction not subjected to any braking. Such a damping of the rising movement is of interest in certain cases with a view to gradually starting the injecting procedure.

The needle valve 13 is rigid with the movable armature 13*a* of the electromagnet and slides as fluidtightly as possible inside the nozzle **8**. Said nozzle **8** is provided with a first channel such as oblique channel **8***d* feeding liquid under pressure into an annular chamber **8***c* and with a second channel such as discharge channel **8***b* provided for the return of the liquid out of an additional chamber such as annular chamber **8***a* into a connection returning the liquid to the supply tank **10**, a third channel such as connecting channel **8***e* being lastly provided for the counter pressure chamber **1***d*.

The channel **8***d* is fed with liquid under pressure through the throttled port **17***a*, formed in the axial bore of the screw **17** engaging the said channel, and the channel **1***c* in the body **1**. Said channel **1***c* communicates on the other hand with the connection **5** feeding liquid under pressure through the channel **1***a*, the extensions **1***b* and **2***a* of which lead to the seat of the injector needle.

The needle valve **13** is provided with transverse bores **13***d* connecting the annular chamber **8***c* with the inner chamber **13***e* formed within the needle valve **13**. The controlling slide valve **14** is urged by the pressure of the liquid against the stationary armature of the electromagnet **9** and it is fitted with a very reduced clearance inside the hollow needle valve **13**. The ridge formed at **14***a* on the slide valve round a recess **14***b* engages the flat surface **13***c* of the needle valve in its raised position so as to close thus the axial bore **13***b* in the needle valve.

The electromagnet **9** is held angularly in position by a stud **40** and it is grounded through one terminal while its other terminal is connected with a jack **15**. In contradistinction, the nozzle **8** is freely revolvable and the liquid passes through the annular groove **8***f* when the channel **1***c* and the port **17***a* are not in accurate registry.

The operation of the arrangement is as follows:

As long as the electromagnet **9** is not energized, the needle valve **13** rests on its seat and prevents the liquid under pressure from reaching the chamber **8***a* and the discharge channel **8***b*. As a matter of fact, the liquid under pressure fills the channels **1***a*, **1***b*, **1***c*, **2***a* and **8***d*, the annular chamber **8***c* and the counter-pressure chamber **1***d* since it passes through the chamber **13***e* inside the needle valve, the bore **13***b* the connecting channel **8***e*, the axial bore **12***b* and the transverse bore **12***c*. Thus, the injector needle **3** is held in a closed position by the pressure of the liquid and the needle valve **13** is held also in a closed position since the diameter of the seat of the needle valve at the input end of the channel **8***e* is smaller than the diameter of the controlling slide valve **14**, which is urged furthermore by said liquid pressure against the stationary section of the electromagnet **9**.

Upon energization of said electromagnet **9**, the armature **13***a* is drawn upwardly and raises the needle valve **13** off its seat; but at the end of the stroke of said armature, the flat surface **13***c* on the armature engages the ridge on the said slide valve **14**. Consequently, the liquid under pressure can no longer enter the counter-pressure chamber **1***d*, which latter is now connected with the discharge channel **8***b*. The counter pressure is thus cut off the the injector needle **3** is raised and allows the injection to be performed. The injection port is not opened instantaneously in the case illustrated by reason of the braking of the rising movement of the rod **6** by the non-return valve inserted in the guiding stud **12**. The electromagnet **9** is energized by an electric signal the duration of which is defined by electronic means of a type known per se and depends on the operative parameters of the engine. At the end of said signal, the electromagnet **9** is deenergized and the needle valve **13** returns onto its seat so as to close again the connection between the counter pressure chamber **1***d* and the discharge channel **8***b*. The return of the needle valve is produced by the pressure of the liquid inside the annular chamber **13***e* since the diameter of the fluidtight ridge formed on the controlling slide valve **14** is smaller than the diameter of the actual slide valve.

It should be remarked that, for intermediate positions between the extreme positions of the needle valve **13**, the channel **8***d* feeding the liquid under pressure, the channel **8***e* opening into the counter-pressure chamber **1***d* and the discharge channel **8***b* are simultaneously interconnected so that a leak output is obtained during said period. Said leak output should be reduced to a minimum so as to cut out the necessity of resorting to a very large and expensive fuel-delivering pump in the arrangement and to remove starting difficulties. This may be obtained by reducing the length of the travel of the needle valve **13** between its extreme positions down to a few hundredths of a mm. the losses of head between the fluidtight surfaces of the needle valve and its seat in the nozzle **8** and also between the surface **13***e* of the pressure chamber and the ridge of the controlling slide valve **14** becoming then sufficiently large for them to reduce substantially the leak output without detrimentally affecting the speed of loading and unloading the counter-pressure chamber **1***d*. It should however be remarked that with such an arrangement the advantages of our improved injector are lost to a great extent. As a matter of fact, the operation of the injector according to FIG. **1** is practically independent of the length of travel of the needle valve **13**, the travel of which may range between a few hundredths of a mm. and a few tenths of a mm. Consequently, the allowances in the assembly may be comparatively large. In order to retain in such a case this advantage of the injector, a screw **17** provided with a throttled port **17***a* is inserted in the channel **8***d* feeding the liquid under pressure. Thus, the leak output depends only on the loss of head in the port **17***a* and this may delay to a certain extent the rise in pressure inside the counter-pressure chamber **1***d* after deenergization of the electromagnet **9** and consequent closing of the injector needle **3**. This however does not form necessarily a drawback since it is possible thereby to act on the law governing the injection during the closing period.

An injector cutting out the leaks arising through the simultaneous opening of the channels is illustrated in FIGS. **2** and **3**. In both cases, the measuring valve is constituted by a slide valve controlled directly by the electromagnet **9** in the case of FIG. **2**, and indirectly in the case of FIG. **3**.

As illustrated in FIG. **2**, the nozzle **8** is provided with three spaced-apart chambers such as annular chambers **8***c*, **8***m*, **8***a*, which chambers are connected with the channels feeding fuel under pressure **8***d*, **8***k*, with the third channel such as channel **8***h* connected with the counter-pressure chamber **1***d* and with the discharge channel **8***b* respectively. The unitary distributing slide valve **13** is rigid with the movable armature **13***a* includes a part **13***g* of a reduced diameter turned from the bar and the length of which is such that it uncovers simultaneously either the chambers **8***c* and **8***m* in its inoperative position or else the chambers **8***m* and **8***a* when the electromagnet **9** is energized and attracts the slide valve. Thus, the distributing slide valve when urged downwardly into its first position by the opposing spring **28** bearing against the stud **27** causes the counter-pressure chamber **1***d* to communicate with the channel **8***k* admitting fuel under pressure whereas for the second position of the slide valve, the counter pressure chamber **1***d* communicates with the discharge channel **8***b*.

For a suitable selection of the length of the part **13***g* turned from the bar and also of the breadth and spacing of the annular chambers **8***c*, **8***m* and **8***a*the admission of liquid under pressure is stopped before the discharge channel is uncovered and reversely so that no leak can appear.

Since the slide valve executes substantially large movements there is provided in its center a bore **13***b* adapted to balance the pressure on the opposite ends of the slide valve. The nozzle **8** is held axially in its housing by a pin **25**.

In order to avoid any direct control of the controlling slide valve, which would require movements of the movable armature **13***a* by a few mm. and thereby increase the delay of response of the injector, there is provided in the embodiment illustrated in FIG. **3** a transverse floating distributing slide valve **29** of which the portion having a reduced diameter cooperates as in the case of FIG. **2** with the annular chambers **8***c*, **8***m* and **8***a* and therethrough with the fuel admitting pipes **8***k*, **8***d*, the channel **4***a* opening into the counter-pressure chamber **1***d* and the discharge channel **8***b* respectively.

The movable armature **13***a* is secured to an elastic diaphragm **34** fitted fluidtightly in the nozzle **8**. The two auxiliary channels such as chambers **30** and **31** formed to either side of the diaphragm **34** are connected with the liquid-filled recesses **32** and **33** respectively through corresponding auxiliary channels such as channels **8***p* and **8***h*. This arrangement is such that the liquid shifted by the movement of the elastic diaphragm **34** controls the movements of the distributing slide valve **29** engaging said recesses **32** and **33**. As a matter of fact and assuming that, when inoperative, the slide valve **29** is in the position illustrated, the energization of the electromagnet **9** causes the movable armature **13***a* to rise together with the diaphragm **34** so that a corresponding amount of liquid is driven out of the chamber **30** towards the recess **32** while an equal amount is urged from the chamber **31** into the recess **33**. Consequently, the distributing slide valve **29** is shifted towards the right hand side so as to cover the annular chamber **8***c* and to uncover the annular chamber **8***a*. Upon deenergization of the electromagnet **9**, the reverse movements are obtained. According to the position of the slide valve **29**, the channels feeding the liquid under pressure **8***d*, **8***k* communicate with the counter-pressure chamber **1***d* through the bore **12***a* or else said counter-pressure **1***d* communicates with the output **10** through the discharge channel **8***b* and the annular chamber **1***e* in the body **1**.

It is possible to suitably select the diameters of the diaphragm **34** and of the distributing slide valve **29** so as to obtain a shifting of said slide valve **29** by a few millimeters for a shifting of the diaphragm by only a few tenths of a mm.

Consequently, it is possible to produce a high magnetic attraction by reason of the reduced gap obtained, whereby the delay for response of the injector becomes very short. A passageway between the channels **8***h* and **8***p* such as the axial bore **29***a* in the slide valve **29** and the equilibrating return connection **10***a* having the throttled port **10***b* can be provided so as to make up for the thermal expansion and unequality between the volumes displaced by the diaphragm **34** and by the slide valve **29**.

Turning to FIG. **4**, a valve such as the needle valve **13** is rigid with the movable armature **13***a* and controls through its conical tip the passage of fuel between an inner chamber such as the annular chamber **8***a* and an additional channel such as the channel **8***e*, which channel **8***e* is connected with the counter-pressure chamber **1***d* through the bores **8***g* and **8***h*. When the needle bar **13** rests on its seat, it urges another valve such as the ball **18** offits seat through the agency of its extension **13***d* so as to provide a connection between the channel **8***k* feeding liquid under pressure and the counter pressure chamber **1***d* through the same bores **8***g* and **8***h*. The needle valve **13** and the ball **8** are urged on the corresponding seats by the opposing springs **28** and **19** respectively and therefore when the electromagnet **9** is energized, the needle valve **13** is raised off its seat and compresses the spring **28** while the ball rests on its seat onto which it is urged by its spring **19** and by the pressure of the liquid, said counter-pressure chamber **1***d* being thus connected with the discharge channel **8***b* through the bores **8***h* and **8***g*, the channel **8***e* and the chamber **8***a*.

The bore **13***b* in the needle valve **13** ensures the balance between the pressures in the needle valve **13** and in the chamber **8***a* during the movements of said needle valve **13**.

FIG. **5** illustrates an embodiment wherein a ball **18** carried in an additional channel such as a casing **8***m* ensures for a deenergized condition of the electromagnet **9**, a closing of the channel **26***a* extending through the screwed member **26** whereas, when the electromagnet **9** is energized, the ball closes the bore **8***e* in the nozzle. To this end, the needle valve **13** is provided with an extension constituted by a rod **13***b* bearing against the ball **18** while a thrust member **24**, provided with an extension constituted by the rod **24***a*, is urged by the spring **19** against the ball **18** in antagonism with the rod **13***d*. The housing **8***m* enclosing the ball **18** is connected with the counter-pressure chamber **1***d* through the bores **8***g* and **8***h* whereas the annular chambers **8***a* and **8***c*in the nozzle are connected with the channel **8***b* admitting liquid under pressure and with the connection **10**, returning the liquid to the supply **10** through the channel **8***a* and the annular collecting chamber **1***e*, respectively. The bore **8***b* in the nozzle is adapted to balance the pressure in the chamber **8***a* with that in the chamber enclosing the movable armature **13***a*.

It should be remarked that the stress exerted by the spring **19** on the ball **18** should be larger than the stress exerted on the ball **18***b* by the pressure of the liquid when the ball closes the channel **8***e* and the stress exerted by the spring **28** should again be larger than the stress exerted by the spring **19** so that it may return the ball **18** onto its seat over the bore **16***a* when the electromagnet **9** is deenergized.

FIG. **6** shows a still further embodiment wherein the injector is provided with two channels **5** and **5***a* feeding liquid under pressure, the channel **5** being connected through the channels **1***a* and **1***b* with the injector needle whereas the channel **5***a* supplies liquid under pressure to the counter pressure chamber **1***d* through the bore **9***a* in the stationary section of the electromagnet **9**, a port **35** *a* provided in the elastic diaphragm **35** and the channel **8***h* when the electromagnet **9** is deenergized. As a matter of fact, under such conditions the needle valve **13** closes through its conical fluidtight section **13***b* the channel **8***e* leading to the discharge connection **10** through the bore **8***n* and the annular chamber **1***e*, while the ball **18** drops away from its seat. When the electromagnet **9** is deenergized the movable armature **13***e* is attracted and urges said ball **18** against its seat on the end of the bore **9***a*. The admission of liquid under pressure from **5***a* is thus stopped while the communication between the counter-pressure chamber **1***d* and the discharge connection **10** is simultaneously opened.

It should be remarked that in the case of FIGS. **4**, **5** and **6**, a leak output may appear since the channels feeding the liquid under pressure and the discharge channel are open simultaneously during a short lapse of time, as already mentioned with reference to FIG. **1**. However, said leak throughput may be cut out in the same manner as in the case of FIG. **1** by shortening the travel of the movable armature or else by providing a throttled port in the channel feeding liquid under pressure.

In order to cut out the continuous injection of fuel as may occur in the case of a seized injector needle, it is possible to insert an output-limiting mechanism of a type known per se in the channel feeding liquid under pressure on the upstream side of the injector needle, but on the downstream side of the shunt leading to the measuring valve and to the counter-pressure chamber. Such an output limiting mechanism closes automatically the feed channel whenever the output rises above a predetermined limit value.

What we claim is:

1. A fuel injector for an internal combustion engine, the engine having a fuel supply adapted for providing fuel at a high-pressure at one side thereof and for receiving fuel at a lower pressure at another side thereof, said fuel injector comprising an electromagnet, an elongated body having an output port, a counter-pressure chamber, first channel adapted to be communicatively connected to said high-pressure side of said fuel supply, a second channel being adapted to be communicatively connected to said low-pressure side of said fuel supply, and a third channel being communicatively connected to said counter-pressure chamber, a control member mounted within said elongated body for movement to and from a closing position, said control member having an injector valve at one end thereof for closing said output port when the control member moves to the closing position, a fuel chamber being adapted to be connected to said high-pressure side of said fuel supply, said fuel chamber surrounding at least a portion of said control member and being in communication with said output port when said control member moves from said closing position, a valve means communicatively connected to said first channel, said second channel and said third channel and being adapted for movement between an inoperative position and an operative position in response to energization of said electromagnet, when said valve means is in said inoperative position said first channel being in communication with said third channel for providing high-pressure fuel to said counter-pressure chamber, when said valve means is in said operative position said communication between said first channel and said third channel being terminated and said third channel being in communication with said second channel for permitting at least a portion of the high-pressure fuel in said counter-pressure chamber to be returned to said low-pressure side of the fuel supply for reducing the pressure of the fuel in said counter-pressure chamber, the pressure of the fuel in said counter-pressure chamber enabling said control member to remain in said closing position when said valve means is in said inoperative position, said control member being adapted for movement from said closing position when said valve means is in said operative position and the pressure of the fuel in said counter-pressure chamber is less than the pressure of the fuel in said fuel chamber.

2. A fuel injector in accordance with claim **1** in which said valve means is a slide valve having a section of reduced diameter for forming a passage between the slide valve and the elongated body, the elongated body having three spaced-apart chambers co-axially surrounding the slide valve, the central chamber being connected with the third channel and each of the outside chambers being connected with a different one of the first and second channels, the passage formed by the portion of the slide valve having a reduced diameter being adapted for establishing communication between the first channel and the third channel when the slide valve is in the inoperative position and for establishing communication between the second channel and the third channel when the slide valve is in the operative position.

3. A fuel injector in accordance with claim **2** and further including two auxiliary chambers formed within the elongated body, each auxiliary chamber adapted to be filled with a liquid, an elastic diaphragm being mounted within the elongated body and separating the auxiliary chambers, two auxiliary channels being formed in the elongated body, each auxiliary channel communicatively connecting a different one of the auxiliary chambers and to a different one of the ends of the slide valve, the elastic diaphragm being adapted to deflect in response to energization of the electromagnet for moving the slide valve between the inoperative position and the operative position in response to the fluid pressure caused by the deflection of the diaphragm.

4. A fuel injector in accordance with claim **3** in which one of the auxiliary chambers is adapted to be connected to the low-pressure side of the fuel supply through a throttled section, a passageway extending axially through the slide valve being provided for communicatively connecting the auxiliary channels.

5. A fuel injector in accordance with claim **1** in which an additional channel is formed in the elongated

body, the additional channel being in communication with the third channel, the valve means including a valve adapted to move between a closed position and an open position in response to energization of the electromagnet, one end of the additional channel being in communication with the second channel when the valve is in the open position, the valve terminating the communication when it moves to the closed position, and another valve being adapted to move between an open position and a closed position in response to movement of the valve between the closed position and the open position, the other end of the additional channel being in communication with the first channel when the other valve is in the open position, the other valve terminating the communication when it moves to the closed position.

6. A fuel injector in accordance with claim 1 in which the valve means includes an additional channel formed in the elongated body of the injector, the additional channel being communicatively connected with the third channel and having a seat formed at each of its opposite ends, one of the seats being communicatively connected with the second channel and the other seat being communicatively connected with the first channel, a member being adapted to be shifted between an inoperative position and an operative position in response to energization of the electromagnet, the shiftable member being seated in the one seat when the shiftable member is in the inoperative position and terminating the communication between the second channel and the third channel, the shiftable member being seated in the other seat when the member shifts to the inoperative position and terminating communication between the first channel and the third channel.

7. A fuel injector in accordance with claim 5 in which a spring urges the shiftable member into engagement with the seat communicating with the second channel and a weaker spring urges the shiftable member towards engagement with the seat communicating with the first channel.

8. A fuel injector in accordance with claim 5 in which the end of the shiftable member adapted to be seated in the other seat communicating with the first channel is a ball, the other end of the shiftable member being adapted to seat in the one seat communicating with the second channel being a needle valve.

9. A fuel injector in accordance with claim 1 in which the valve means includes a needle valve adapted for movement between a closed position and an open position in response to energization of the electromagnet, an additional chamber being communicatively connected to the second channel and to the third channel, one end of the needle valve being adapted for seating in the opening between the additional chamber and the third channel and for terminating communication between the second channel and the third channel when it is in the closed position, the needle valve having an axial bore therethrough in communication with the third channel and in communication with the first channel when the needle valve is in the closed position, when the needle valve moves to the open position the other end of the needle valve being urged against a portion of the elongated body for sealing the open end of the axial bore adjacent the other end and for terminating communication between the first channel and the third channel.

10. A fuel injector in accordance with claim 1 in which a throttled port is provided in the first channel.

11. A fuel injector in accordance with claim 1 in which a guiding member is mounted within the elongated body adjacent the other end of the control member, the guiding member having a cavity therein, the cavity being in communication with the counter-pressure chamber, the other end of the control member being slidably mounted about one end of the guiding member, the cavity in the guiding member being in communication with the third channel, a check valve being mounted in the cavity in the guiding member and being adapted to only permit communication from the third channel towards the cavity, whereby when the control member moves from the closing position fuel flows from the cavity to only the counter-pressure chamber, and when the control member moves to the closing position fuel flows into the cavity from both the counter-pressure chamber and the third channel.

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