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United States Patent [19]

[11] E **Patent Number: Re. 34,591**

Yoshida et al.

[45] **Reissued Date of Patent: Apr. 26, 1994**

[54] **HIGH PRESSURE FUEL INJECTION UNIT**

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[21] Appl. No.: **885,343**

[22] Filed: **May 19, 1992**

Related U.S. Patent Documents

Reissue of:

[64] Patent No.: **5,090,620**
Issued: **Feb. 25, 1992**
Appl. No.: **610,540**
Filed: **Nov. 8, 1990**

[30] **Foreign Application Priority Data**

Nov. 9, 1989 [JP] Japan 1-293366

[51] **Int. Cl.**^{5} **F02M 47/00**

[52] **U.S. Cl.** **239/96**; 239/533.4; 239/533.8; 239/533.12; 239/585.1

[58] **Field of Search** 239/88-92, 239/96, 533.2-533.12, 585.1-585.5

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,822,668	9/1931	Protzeller .	
2,637,407	5/1953	Burk et al. .	
2,769,943	11/1956	Matthews .	
3,079,947	3/1963	Hunt et al. .	
3,942,485	3/1976	Suda et al. .	
4,007,880	2/1977	Hans et al. .	
4,342,443	8/1982	Wakeman	239/585.5
4,513,719	4/1985	Edo	239/96
4,566,416	1/1986	Berchtold	239/585.1
4,637,553	1/1987	Kushida et al.	239/533.4
4,899,935	2/1990	Yoshida et al.	239/91
4,972,996	11/1990	Cerny	239/585.4
5,004,154	4/1991	Yoshida et al.	239/533.4

FOREIGN PATENT DOCUMENTS

64-36971 2/1989 Japan .

Primary Examiner—Karen B. Merritt
Attorney, Agent, or Firm—Knobbe, Martens, Olson & Bear

[57] **ABSTRACT**

An accumulator type of fuel injection nozzle having an injection valve, a first electromagnet for initiating fuel injection, and a second electromagnet for controlling the lift amount of the injection valve is provided with an energizing arrangement which enables effective fuel injection control but which greatly reduces the risk of burning damage to the electromagnets. The amp-turn characteristics of the first electromagnet coil provide for a rapid start-up time wherein the peak magnetic flux is reached relatively quickly. In contrast, the amp-turn characteristics of the second electromagnet coil provide for a more gradual start-up time so that peak magnetic flux is reached more gradually. The second electromagnet coil is also adapted to achieve a relatively large magnetic flux without the need for large current supply. In operation, when the second electromagnet is energized, such energization is started before energization of the first electromagnet for a particular fuel injection cycle.

7 Claims, 5 Drawing Sheets

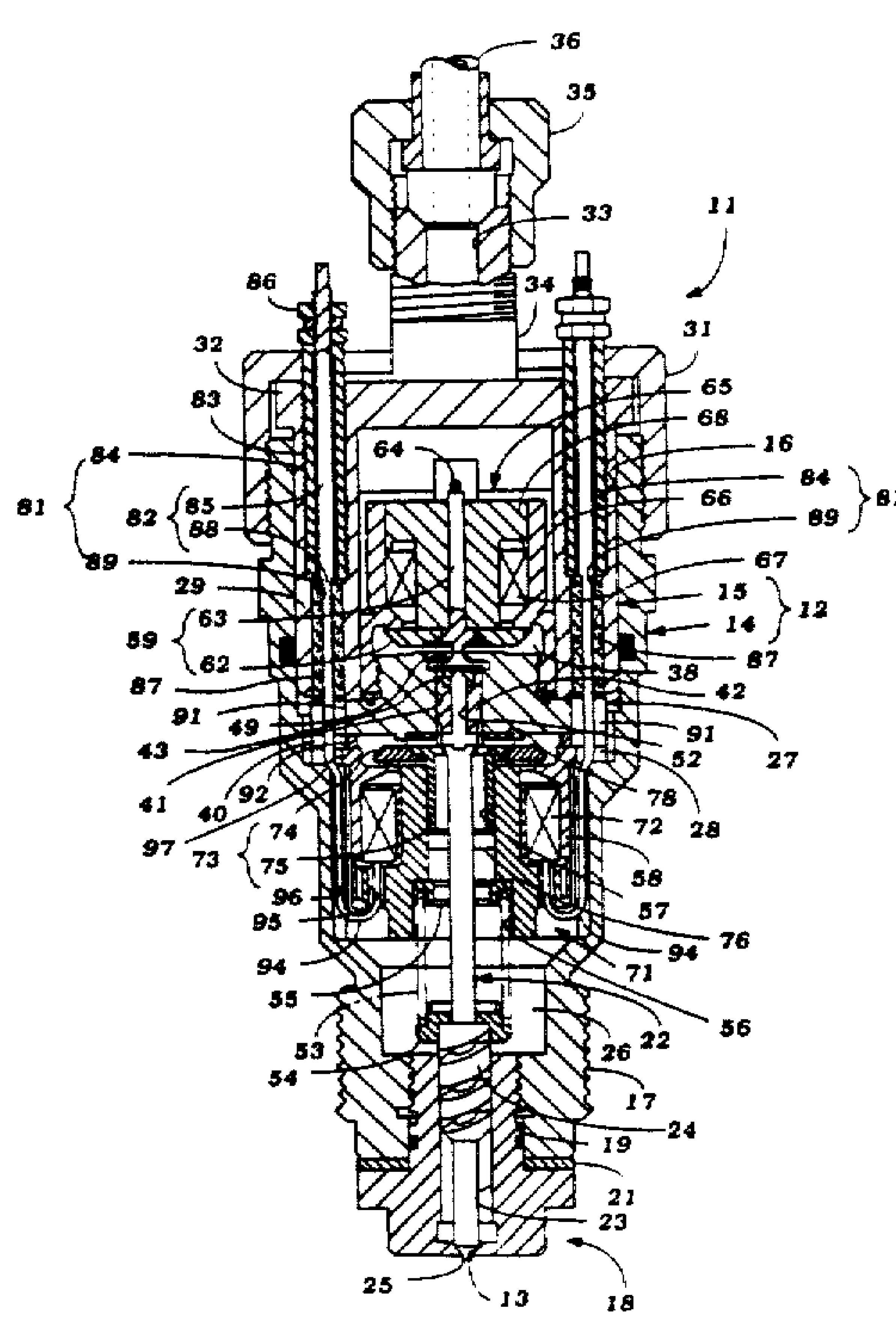

Figure 1

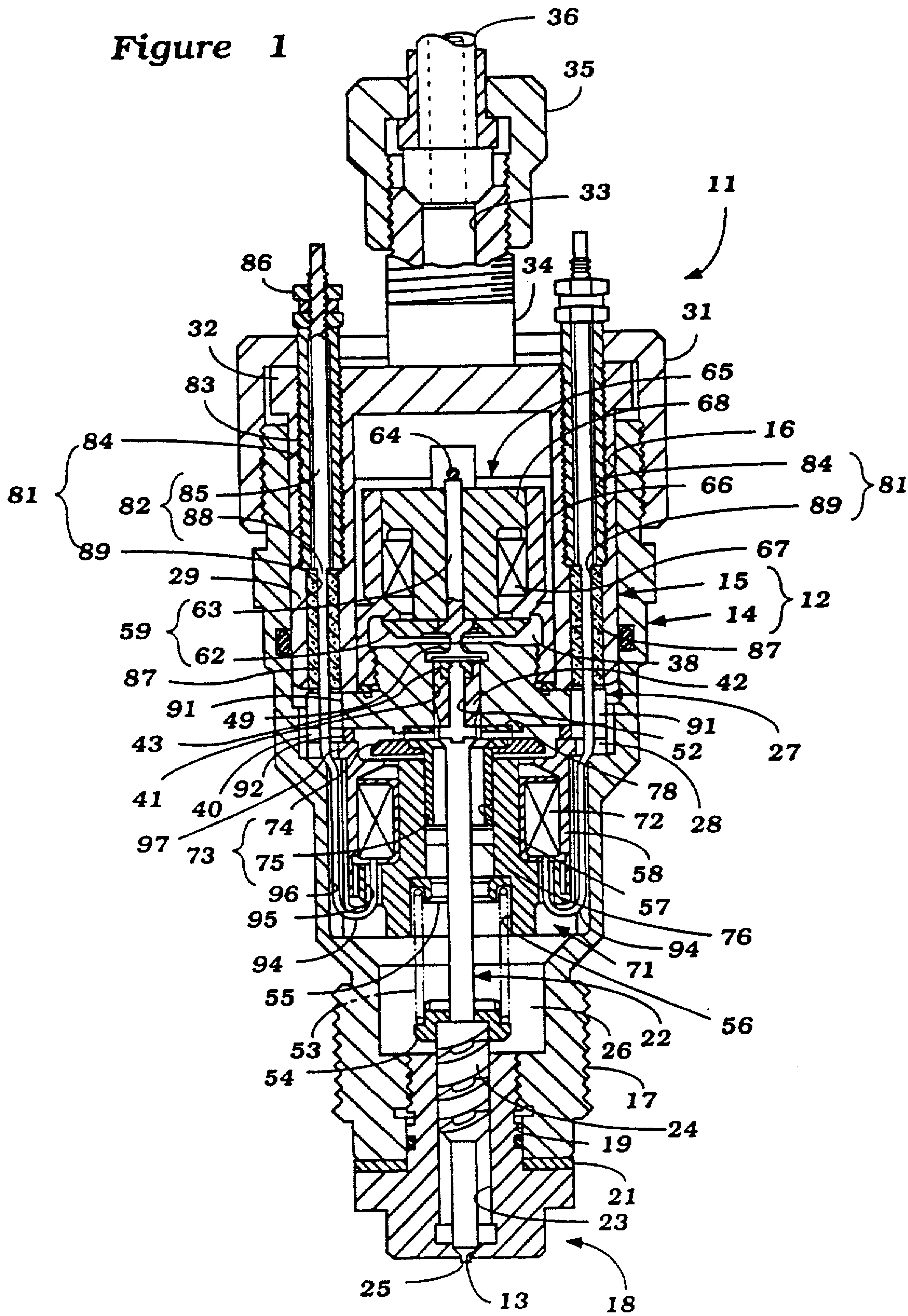
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Figure 2

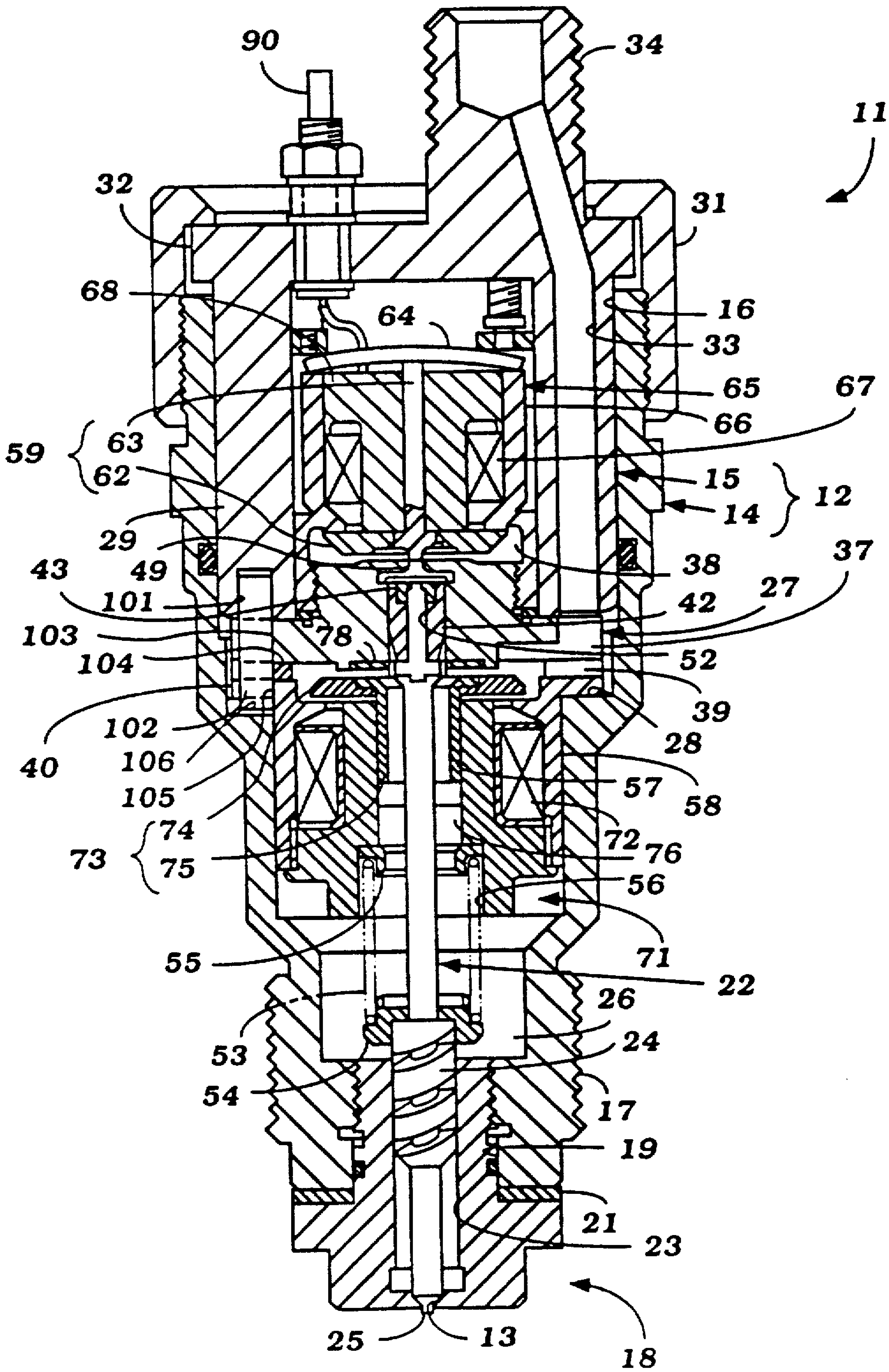
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Figure 3

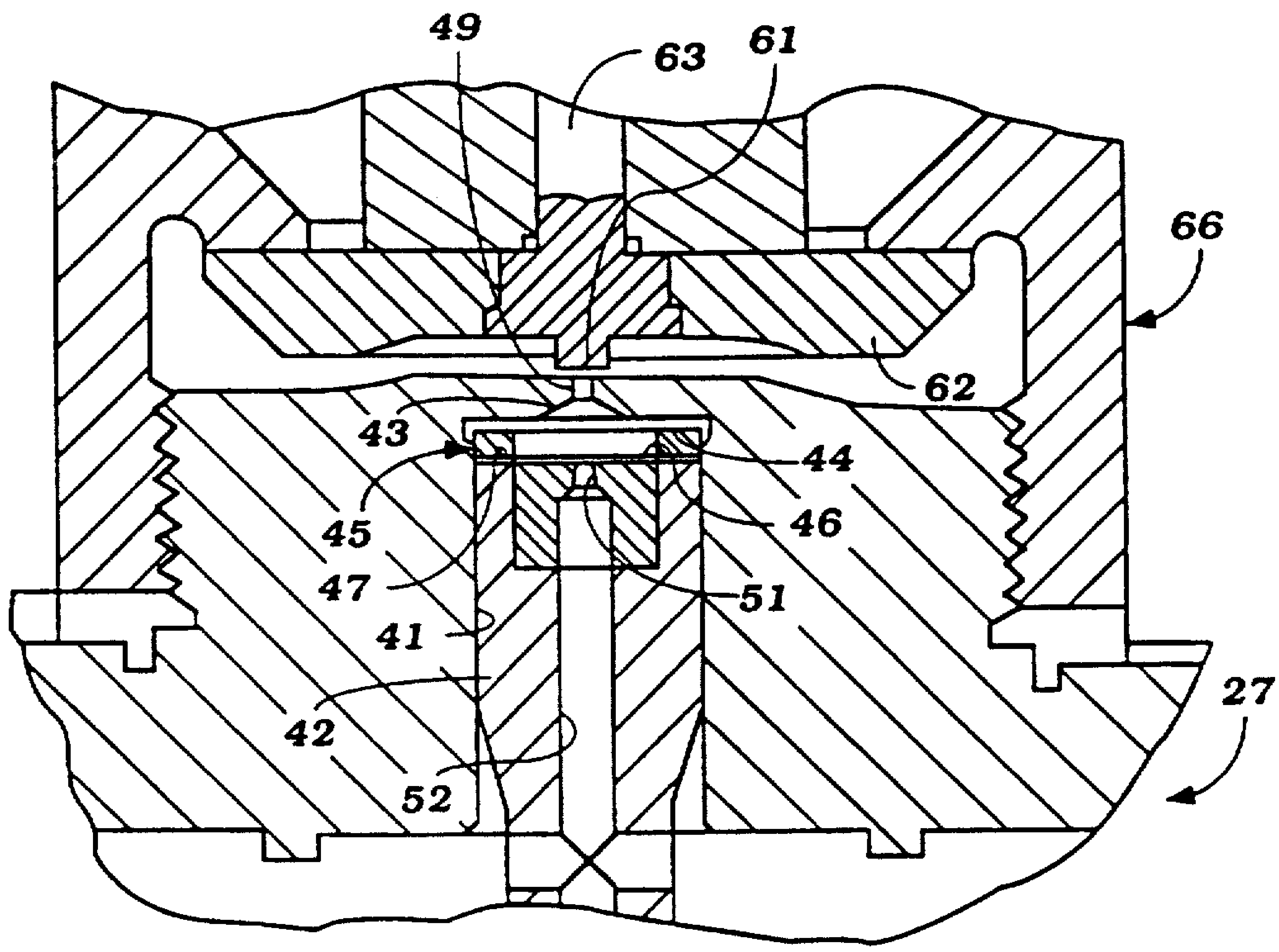


Figure 4
(a)

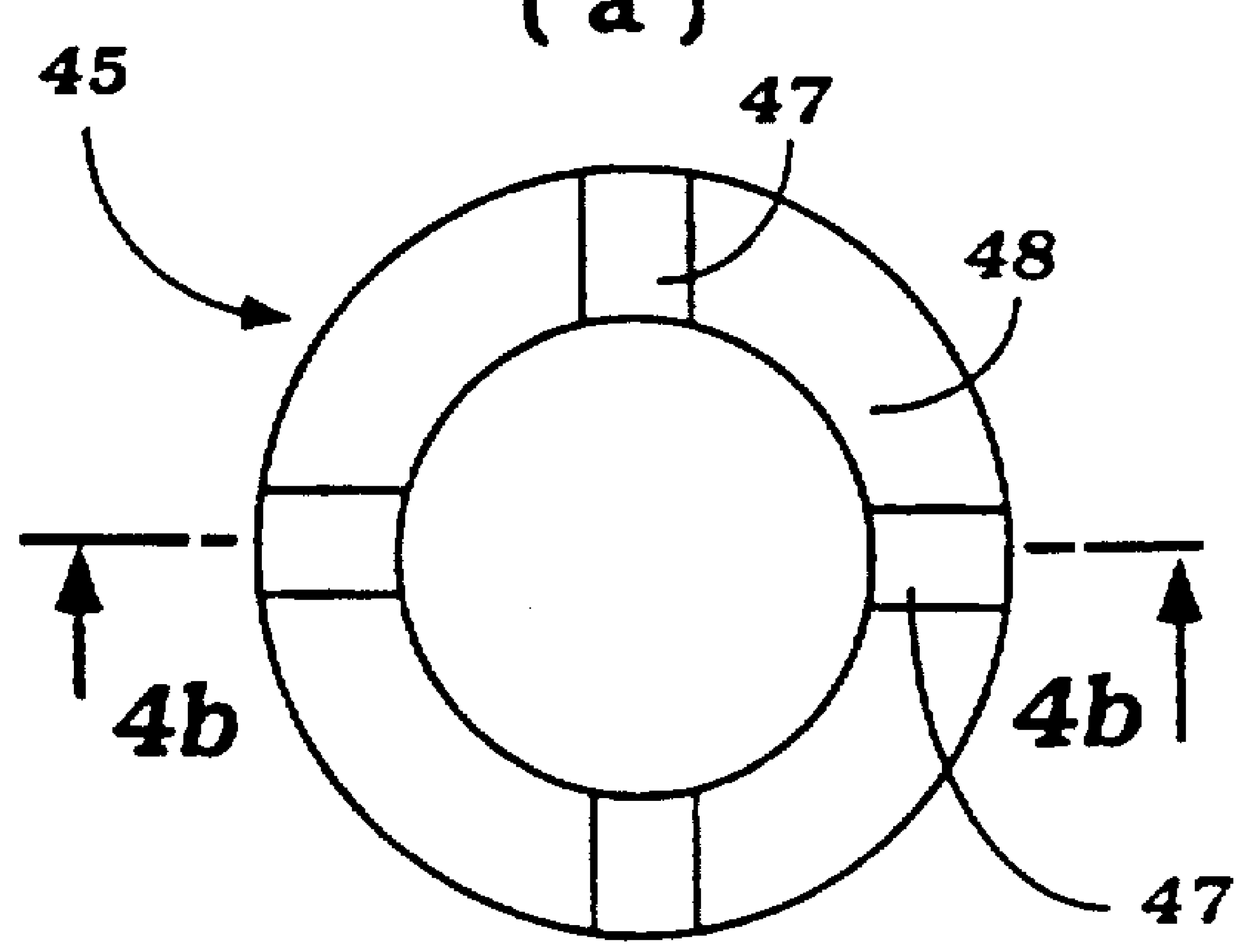


Figure 4
(b)

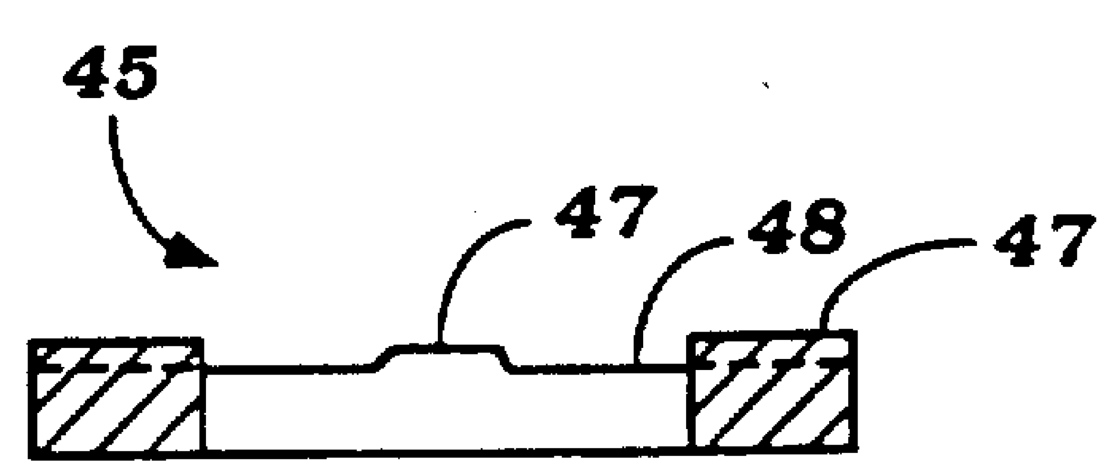


Figure 5

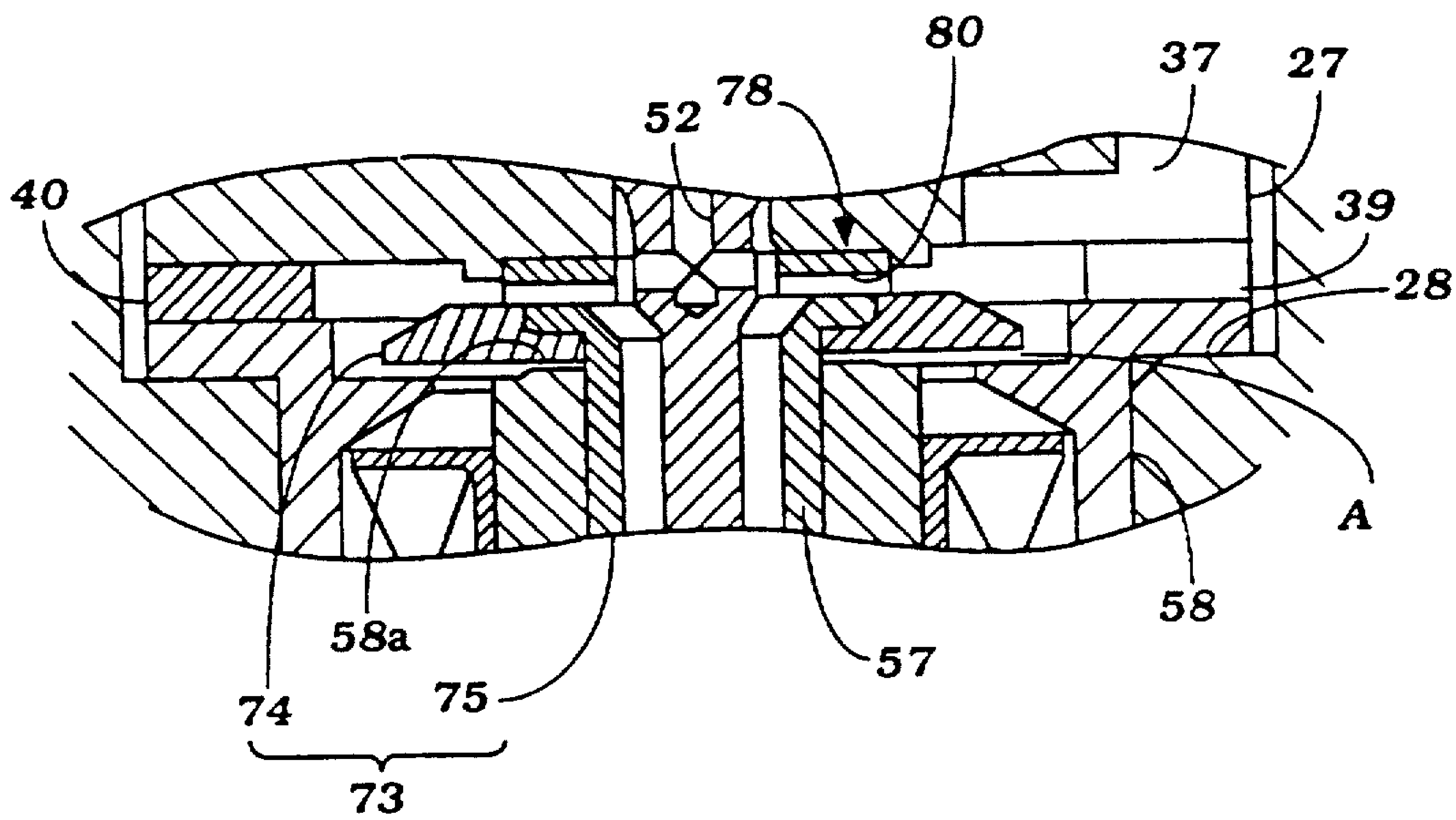


Figure 6
(a)

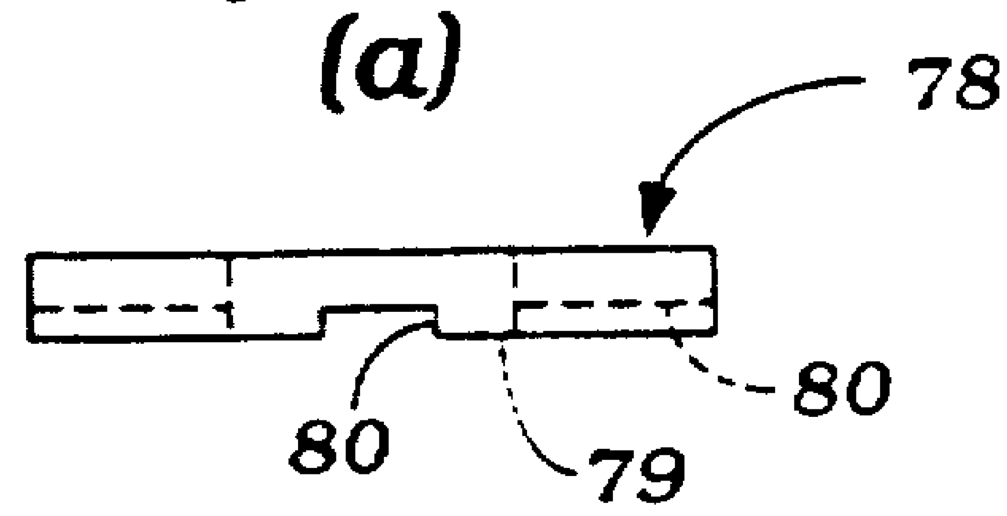


Figure 6
(b)

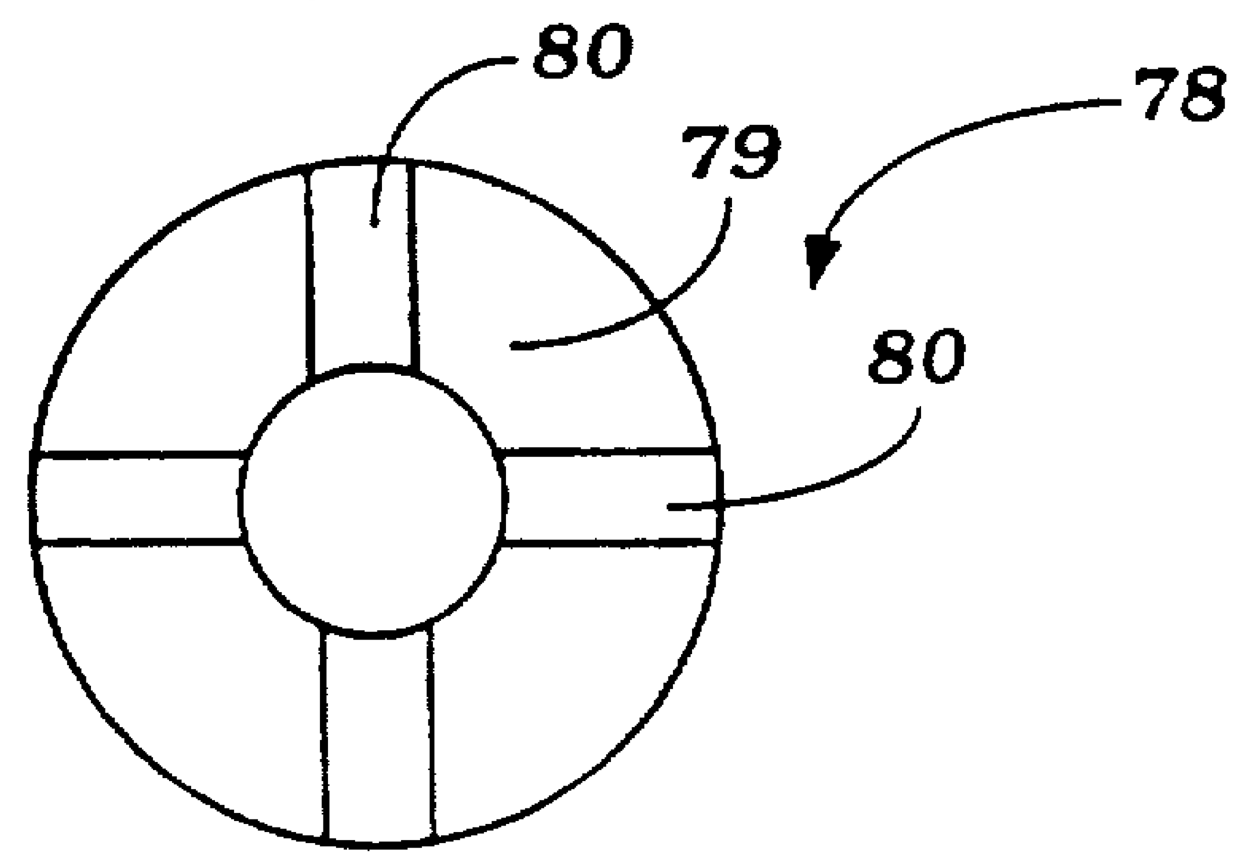
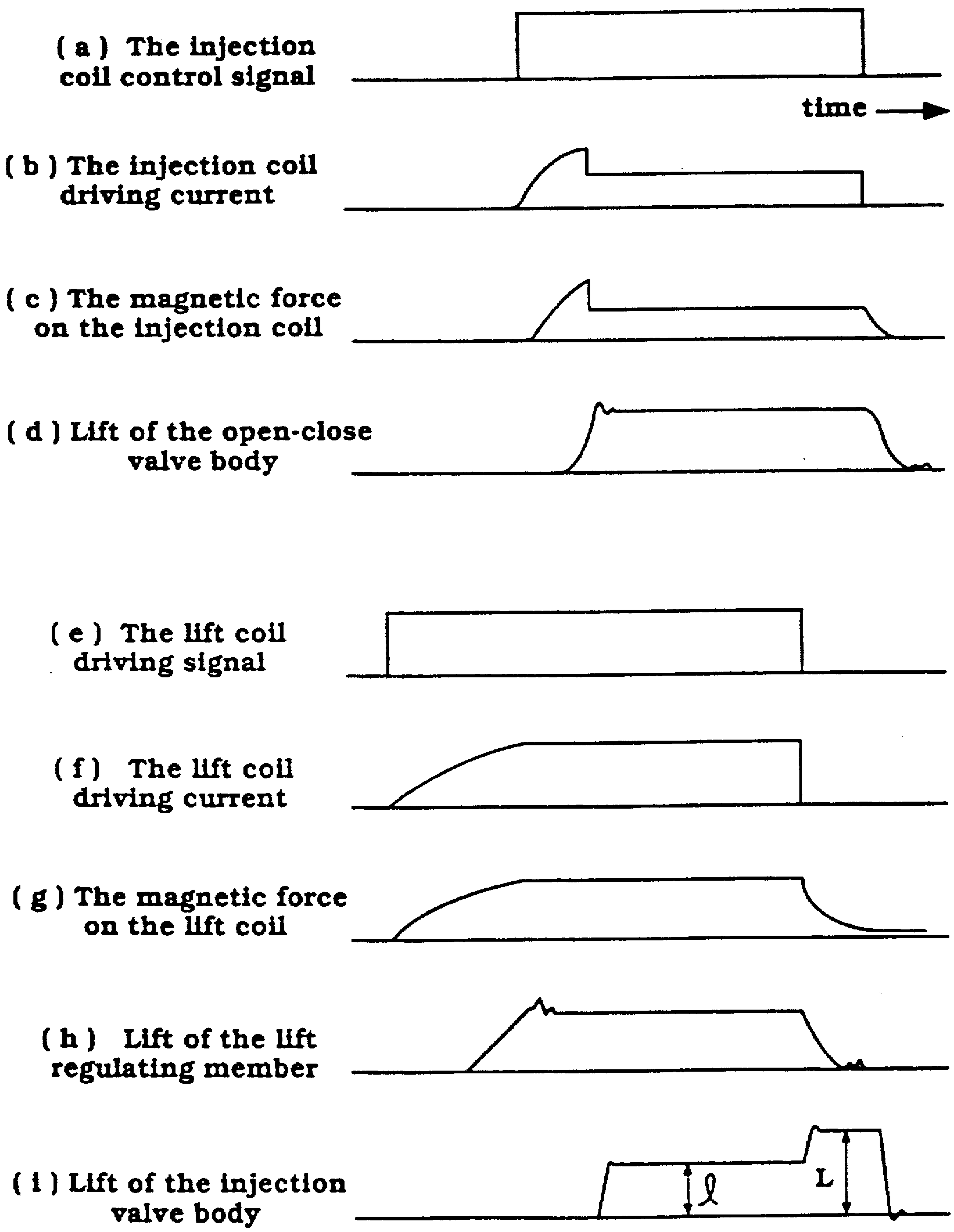


Figure 7


(a) The injection coil control signal
time
(b) The injection coil driving current
(c) The magnetic force on the injection coil
(d) Lift of the open-close valve body
(e) The lift coil driving signal
(f) The lift coil driving current
(g) The magnetic force on the lift coil
(h) Lift of the lift regulating member
(i) Lift of the injection valve body
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L

HIGH PRESSURE FUEL INJECTION UNIT

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

This invention relates to a high pressure fuel injection unit for an engine, and more particularly to an improved arrangement for energizing the electromagnetic assemblies of the injection unit which control fuel injection timing and the lift of the injection valve respectively so as to reduce the risk of burning damage to the electromagnetic assemblies and to improve the durability of the injection unit.

One popular form of fuel injection unit for engines is the so-called "accumulator type." This type of injection nozzle includes an accumulator chamber that is charged with fuel under pressure and which communicates with a nozzle port. An injection valve is supported within the accumulator chamber and controls the discharge through the nozzle port. An actuating device is associated with the injection valve and is moveable within a control chamber that is also pressurized with fuel. A valve is associated with the control chamber and is opened so as to reduce the pressure and cause the pressure in the accumulator chamber to unseat the injection valve and initiate fuel injection. Typically, the valve is operated by a main electromagnetic assembly that is contained within the housing of the fuel injection nozzle.

To control the amount of fuel injected, the inventors have proposed to provide an additional and separate subelectromagnetic assembly within the accumulator chamber to control the lift movement of the injection valve. This assembly is provided with a coil which, when energized, attracts a lift regulating member downward against a holder member which supports the coil to permit only a relatively small upward lift movement of the injection valve to allow injection of a smaller amount of fuel when injection is initiated. On the other hand, when the coil is not energized, the regulating member moves freely within a bore of the holder member so the injection valve is able to move upward a greater distance to permit injection of a larger amount of fuel.

Although previous injection units of this type have been generally satisfactory, effective operation of such units has typically required that regulating member be held down against the holding member with a magnetic flux which is greater than the magnetic flux generated by the main electromagnet during the entire time of small lift operation. Generation of such a large magnetic flux in the sub-electromagnetic coil has typically required that the coil be supplied with a relatively large current during the entire small lift operation. This may cause burning damage to the coil and may also decrease the durability of the coil.

It is, therefore, a principal object of this invention to provide an improved energizing arrangement for an electromagnetic assembly which controls the lift amount of an injection valve so as to eliminate or greatly decrease the likelihood of causing burning damage to the electromagnetic assembly.

It is another object of this invention to provide an improved energizing arrangement for an electromagnetic assembly which controls fuel injection, wherein this electromagnetic assembly does not require a large current for a long period of time during injection process so as to eliminate or greatly decrease the likelihood of causing burning damage to the electromagnetic assembly.

SUMMARY OF THE INVENTION

This invention is adapted to be embodied in an accumulator type of injection nozzle that is comprised of an outer housing assembly defining a cavity partitioned into an accumulator chamber which is adapted to be supplied with high pressure fuel and a coil chamber. A nozzle port leads from the accumulator chamber and an injection valve is moveable between a closed position and an open position for controlling the discharge of fuel from the accumulator chamber through the nozzle port. A control chamber is also incorporated that receives pressurized fuel. An actuating member is supported for movement within this control chamber and is associated with the injection valve for retaining the injection valve in its closed position when the control chamber is pressurized and for movement of the injection valve to its open position when pressure is relieved in the control chamber. A valve means is moveable between a closed position for maintaining pressure in the control chamber and an open position for relieving pressure in the control chamber for effecting fuel discharge through the nozzle port.

In accordance with the invention, a first electromagnet is positioned within the outer housing assembly for moving the valve means to one of the positions when the first electromagnet is energized. A second electromagnet is also positioned within the outer housing assembly for controlling the lift amount of the injection valve when the second electromagnet is selectively energized or de-energized. In accordance with the invention, when the second electromagnet is energized, energization thereof is started before energization of the first electromagnet for a given fuel injection cycle.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional front view of a fuel injection nozzle constructed in accordance with an embodiment of the invention.

FIG. 2 is a cross-sectional side view of the fuel injection nozzle.

FIG. 3 is an enlarged cross-sectional view of the control chamber portion of the fuel injection nozzle.

FIG. 4 (a) is a bottom view of the shim plate of the fuel injection nozzle.

FIG. 4(b) is a cross-sectional view taken alnog line IV(b)—IV(b) of FIG. 4(a).

FIG. 5 is an enlarged cross-sectional view showing the armature portion of the regulating member.

FIG. 6(a) is a side view of the stopper plate for the regulating member.

FIG. 6(b) is a bottom view of the stopper plate.

FIGS. 7(a) through (i) are wave form diagrams illustrating the operation of the fuel injection nozzle.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

Referring to the drawings, and in particular to FIGS. 1 and 2, a fuel injection nozzle constructed in accordance with an embodiment of the invention is identified generally by the reference numeral **11**. The injection nozzle **11** is comprised of an outer housing assembly, indicated generally by the reference numeral **12**, that is adapted to be mounted, in a manner to be described, in the cylinder head of an internal combustion engine with a nozzle port **13** communicating with the combustion chamber for delivering fuel to it in a manner to be described. The invention may be used for direct cylinder injection, or instead may be utilized in conjunction with manifold injection systems. The invention, however, has particular utility with direct fuel injection, for example, as used with high speed diesel engines.

Fuel is supplied to the injection nozzle **11** from a remotely positioned fuel tank (not shown) by means of a high pressure pump (not shown). Excess fuel is returned back to the fuel tank or reservoir through a return line.

The outer housing assembly **12** is comprised of a casing body **14** and a cover member **15** which is removably seated within an opening **16** at the top of the casing body **14**. The casing body **14** has a threaded lower end **17** which is adapted to be threaded into a suitable aperture in the cylinder head of the associated engine (not shown) in a known manner. The nozzle port **13** is defined by a tip **18** that has a threaded portion which is received in a threaded bore **19** formed at the lower end of the casing body **14**. An adjusting shim **21** is interposed between the nozzle piece **18** and the lower end of the casing body **14** for length adjustment of the fuel injection nozzle **11**.

An injection valve **22** is slidably supported within a bore **23** of the nozzle piece **18** and has a guide portion **24** formed with a helical groove at its lower portion, and a flow controlling tip **25** which, when in the closed position, closes the injection nozzle port **13**.

An accumulator chamber **26** is formed at the upper end of and above the bore **23** in the lower portion of the casing piece **14**. The accumulator chamber **26** is closed at its upper end by means of a partitioning plate **27** that is held against a shoulder **28** in the casing body **14** by a bottomed cylindrical pipe portion **29** of the cover member **15**. A cap **31** having a threaded bore engages a threaded portion of the upper portion of the casing body **14** and presses against a top plate **32** of the cover member **15** to hold it in position.

The cover member **15** is formed with an inlet conduit **33** that has a threaded external portion **34** so as to receive a fitting **35** for connecting a supply line **36** extending from the pressure pump to the inlet conduit **33**. The inlet conduit **33**, which is generally a drilled opening, extends axially along the cover member **15** at its periphery at one side thereof and communicates at its lower end with the accumulator chamber **26** through a corresponding fuel groove **37** formed in the partitioning plate **27** and groove **39** in spacer **40** for delivering fuel to the accumulator chamber **26**.

The partitioning plate **27** is generally disc-shaped, and serves to separate the accumulator chamber **26** from a coil chamber **38** in the upper portion of the casing body **14**. The partitioning plate **27** has a centrally positioned aperture **41** into which an actuator portion **42** of the injector valve **22** is slidably supported and which closes a control chamber **43** formed within the partitioning plate **27** in a space defined by the upper portion of this aperture **41** and an inner face **44** of the partitioning plate **27**, as shown in FIG. **3**. A shim plate **45** is positioned between a top face **46** of the actuator portion **42** and the partitioning plate face **44** as shown in FIG. **3** for adjusting the lift of the injection valve **22**.

The shim plate **45** is an annular plate, as shown in FIGS. **4**(a) and **4**(b), and has raised portions **47** projected every **90** degrees which abut against the partitioning plate face **44**. Grooved portions **48** are interposed in between for receiving pressurized fluid. This shim plate **45** may be installed upside down.

A restricted orifice **49** communicates the control chamber **43** with the coil chamber **38**. As shown in FIG. **3**, a throttle hole **51** fixed in the end of the actuator portion **42** and an axial passage **52** formed through the upper portion of the injection valve **22** communicate the control chamber **43** with the accumulator chamber **26**. The control chamber **43** communicates with the throttle hole **51** to receive the pressurized fluid and normally urge the injection valve **22** toward its downward or closed position.

A coil compression spring **53** encircles the injection valve **22**, and at its lower end engages a cup-shaped retainer **54** that is held axially in position against the helical groove of the guide portion **24**. The upper end of the spring **53** bears against an upper spring seat **55** which is positioned against a shoulder formed by an enlarged portion **56** at the lower end of a bore **57** formed in a holder member **58**. The coil compression spring **53** acts to further assist in maintaining the injection valve **22** in the closed position, as shown in FIGS. **1** and **2**.

A valve **59** is supported at the upper end of the partitioning plate **27** and controls the opening of the restricted orifice **49**. The valve **59** comprises a headed portion **61** that is received within a corresponding recess formed in an enlarged disc-like armature plate **62**, and a stem portion **63** which is in engagement with a spring **64** so as to bias the valve **59** toward its closed position to maintain the orifice **49** in its closed position.

The valve **59** is opened and closed so as to control the discharge of fuel from the nozzle port **13** by means of an electromagnetic assembly, indicated generally by the reference numeral **65**. This electromagnetic assembly **65** includes a generally cylindrical yoke **66** that has a threaded opening at an enlarged diameter lower end portion which is received on a threaded portion of the partitioning plate **27** so as to secure the electromagnetic assembly **65** in position. The electromagnetic assembly **65** is further comprised of a solenoid coil or winding **67** that is disposed within the housing or yoke **66** and which encircles an armature **68**. The armature **68** is formed with a bore that slidably supports the valve stem **63** of the valve **59**.

A circuit (not shown) is used for energizing the coil **67** of the electromagnetic assembly **65** for opening and closing the valve **59**.

The condition shown in FIGS. **1** and **2** is that which occurs when the winding **67** is de-energized. When the winding **67** is deenergized, the valve **59** will be held in its closed position by the spring **64** so that the accumulator chamber **26** and control chamber **43** may be pressurized.

At the appropriate instant for fuel injection to begin, which may be controlled by any suitable strategy, the winding **67** is energized. When this happens, the valve armature **62** will be attracted upwardly by the flux in the armature **68** so as to urge the stem portion **63** upwardly and open the valve **59** against the action of the spring **64**. This will open the orifice **49** to rapidly deplete the pressure in the control chamber **43**. The higher pressure of the fuel acting in the accumulator chamber **26** will then urge the injection valve **22** upwardly to its open position and permit fuel to issue from the nozzle port **13**. When the fuel pressure in the accumulator **26** has been depleted, the spring **64** will move the injection valve **22** to its closed position and the fuel pressure can then build up in the accumulator chamber **26**. This action is initiated by discontinuing the energization of the winding **67** so as to close the valve **59** and permit pressure in the control chamber **43** to again build up.

The amount of fuel injected can be varied by varying the lift distance of the injection valve **22** by energizing or deenergizing a coil **72** of a sub-electromagnetic assembly, indicated generally by the reference numeral **71**, and which is positioned within the accumulator chamber **26** for adjusting the lift and/or for detecting the lift of the injection valve **22**. The coil **72** is supported within the holder member **58**. A regulating member **73** comprised of an armature **74** fixed on the upper end of a cylindrical guide portion **75** which is slidably supported within the bore **57** of the holder member **58** regulates the lift amount of the injection valve **22**. The lower end of the cylindrical guide portion **75** is positioned above a stopper portion **76** of the injection valve **22** to define a smaller lift distance of the injection valve **22**. A stopper plate **78** made of non-magnetic material is positioned above the armature **74** and has a contacting face **79** in contact with the lower end of the partitioning plate **27** so as to provide a stop surface for the regulating member **73** and to prevent transmission of stray magnetic flux paths through the partitioning plate **27**. The contacting face **79** has radially extending grooves **80** for receiving pressurized fluid. A stopper plate **78** having a different thickness may be substituted to adjust the maximum lift of the regulating member **73** and thus the lift of the injection valve **22**.

If injection of a larger amount of fuel is desired, the coil **72** is maintained in a de-energized state so as to allow the regulating member **73** to move freely between the top surface of the holder member **58** and the stopper plate **78**. In this condition, the injection valve **22** will be urged upward the distance defined by the space between the top face of the shim plate **45** and the partitioning plate face **44**. On the other hand, if injection of a smaller amount of fuel is desired, the coil **72** is energized. When this occurs, the armature **74** is attracted downwardly by the flux in holder member **58** so as to lower the cylindrical guide portion **75**. In this state, the injection valve **22** will be moved upward the distance defined by the space between the lower end face of the guide portion **75** and the upper face of the injection valve stopper portion **76** so as to permit a smaller amount of fuel to issue from the nozzle port **13**.

With this type of arrangement, the amount of fuel delivered to the combustion chamber during each cycle of operation can be controlled as well as the injection pattern so as to provide optimum fuel delivery and control.

In accordance with the invention, the wire of coil **67** has a larger diameter than the wire of coil **72** of the subelectromagnetic assembly **71**, and coil **67** is also wound by a lesser number of turns. The coil **67** is also designed and operated so that, for a given voltage and resistance and inductance characteristics, the current in amperes (A) supplied to it is greater than its number of turns (T); that is, the amp-turn characteristics of coil **67** are given by the relationship: A is greater than T. With these characteristics, the peak magnetic flux produced

by the coil **67** is reached very quickly when a relatively large current is supplied to the coil **67**, thus giving the coil **67** relatively quick start-up characteristics.

On the other hand, the wire of coil **72** has a smaller diameter and coil **72** is wound by a greater number of turns. The design and operational characteristics of this coil **72** are such that, for a given voltage and resistance and inductance characteristics, the current in amperes (A) supplied to it is less than its number of turns (T); that is, the amp-turn characteristics of coil **72** is such that A is less than T. Hence, the resulting peak magnetic flux generated by coil **72** is reached more gradually, giving the coil **72** slower start-up characteristics.

In addition, the holder member **58** has a stepped portion **58**a projected up around its axis which serves to form a gap, designated by A in FIG. **5**, which functions as a magnetic circuit interrupting portion for abruptly reducing the magnetic flux applied to the armature **74** when the electric current being supplied to coil **72** is interrupted.

With this type of arrangement, the amount of fuel injected can be varied by changing the lift distance of the injection valve **22** between a smaller lift indicated by (**1**) in FIG. 7(i) and a larger lift indicated by (L) in FIG. 7(i) while substantially reducing the risk of either of the coils **67** or **72** suffering burn damage.

When injection of a smaller amount of fuel and hence the smaller lift distance (**1**) for the injection valve **22** is desired, a control signal is first transmitted to the electromagnetic assembly **71**, as shown in FIG. 7(e), which causes a driving current to be supplied to coil **72** causing a magnetic flux to be generated by coil **72**, as illustrated in FIGS. 7(f) and 7(g) respectively. When the magnetic flux in coil **72** reaches a predetermined magnitude, the armature **74** is attracted onto the holder member **58**, as graphically shown in FIG. 7(h). Because the amp-turn characteristics of coil **72** are given by the relationship: $A<T$, the start-up characteristics of coil **72** is more gradual, as illustrated in FIGS. 7(g). Once peak magnetic flux is reached in coil **72** and movement of the regulating member **73** is completed, the coil **67** is energized to initiate fuel injection. This timing may vary depending on the characteristics of the coils **67** and **72**; however, coil **67** should not be energized until movement of member **73** is completed.

After peak magnetic flux is applied to the regulating member **73** by coil **72** so as to complete movement of the regulating member **73**, a control signal is transmitted to the electromagnetic assembly **65**, as shown in FIG. 7(a), which initially causes a relatively large driving current to be supplied to coil **67** whereby peak magnetic flux in the coil **67** is generated very rapidly, as shown in FIGS. 7(b) and 7(c) respectively. This causes a rapid upward movement of valve armature **62** and stem **63** which, in turn, causes upward movement of the injection valve **22** until the stopper portion **76** engages the lower end face of the guide portion **75**. Once the valve **59** is completely lifted and fuel injection occurs, the driving current for coil **67** is immediately decreased, as shown in FIG. 7(b), which results in a corresponding decrease in the peak magnetic flux generated by the coil **67**.

When a larger amount of fuel and therefore a large lift distance (L) for the injection valve **22** is desired following a smaller injection, the control signal to the sub-electromagnetic assembly **71** is greatly reduced, as shown in FIG. 7(e), so as to abruptly interrupt the driving current being supplied to coil **72** (FIG. **7**(f)), causing gradual reduction of its peak magnetic flux (FIG. 7(g)). This reduces the attracting force applied to the regulating member **73** so that the injection valve **22** may be lifted up the distance L, pushing up the regulating member **73** in the process, as illustrated in FIG. 7(i).

After this larger amount of fuel is injected, the control signal to the electromagnetic assembly **65** drops as illustrated in FIG. 7(a). The magnetic flux of coil **67** is then reduced through interruption of its driving current (FIGS. 7(c) and 7(b)), thereby causing the valve **59** to close the orifice **49** by action of the spring **64** which, in turn, causes the pressure in the control chamber **43** to again build up.

By employing a lift coil **72** which has slower start-up characteristics but which is able to achieve a relatively large magnetic flux during the small injection process without the need for a large current, and by utilizing an arrangement wherein energization of coil **72** occurs before energization of coil **67** so as to complete movement of the regulating member **73** before injection is initiated, the chance that coil **72** will be damaged by burning is greatly reduced. This also improves the durability of the electromagnetic assembly **71**.

Moreover, the gap A created between the holder member **58** and the armature **74** permits the magnetic force applied to the regulating member **73** to be abruptly eliminated when the electric current supplied to the coil **72** is interrupted. As a result, the regulating member **73** is freed once the electric current is interrupted so that the lift distance of the injection valve **22** can be rapidly changed. This permits greater control accuracy of the injection process.

Referring again to FIGS. **1** and **2**, a feeder wire structure is provided for energizing the coil **72** of the sub-electromagnetic assembly **71** so as to vary the lift distance of the injection valve **22**, as desired. This structure includes a pair of bores **81** which extend axially through the cap **31** and cover member **15** in the periphery thereof to provide a wire passage for feeder wires to the coil **72**. The feeder wires are defined by a pair of terminal feeder rods **82**, preferably made of copper, which extend through the bores **81** with insulating sleeves **83** being interposed between holding portions **84** of the bores **81** and larger diameter portions **85** of the feeder rods **82**. The larger diameter portions **85** of the feeder rods **82** are fixed to the inner surface of the insulating sleeves **83** with a high strength adhesive to withstand the high fuel pressure within the injection nozzle **11**. A soft sealing adhesive **87** is interposed between a smaller diameter portion **88** of each feeder rod **82** and a sealing portion **89** of the bores **81**. This sealing adhesive **87** is longitudinally compressed by the fuel pressure within the accumulator chamber **26** which acts on the lower end of the adhesive **87** causing it to radially expand so as to provide a strong seal around the smaller diameter portion **88** of each feeder rod **82** within the coil chamber **38**. A nut **86** is affixed on the posts **90** of each rod **82** so as to afford attachment to an appropriate lead wire (not shown).

The lower ends of the smaller diameter portions **88** extend through circumferential grooves **91** in the partitioning plate **27** and are positioned in proximity to guide holes **92** in the spacer **40**. A pair of wire harnesses **94** are connected to the coil **72** and extend downwardly through guide holes **95**, and then upwardly through guide grooves **96** and **97**, where the wires **94** are soldered to the lower ends of the smaller diameter portions **88**.

With this type of feeder wire structure, the wire passages **81** can be sealed along their entire length to insure a sufficient seal against the high pressure which forms within the fuel injection nozzle **11**, without the need for increasing the outer diameter of the injection nozzle **11**. The seal is particularly effective when the wire passages **81** is formed in the cover member **15** or like structure which is originally formed thicker to accommodate the inlet conduit **33**. This construction also eliminates the need for increasing the outer diameter of the injection nozzle **11**. It should be noted that, although the wire passages **81** are formed through the cover member **15** in the preferred embodiment, these wire passages **81** may instead be formed through another structure in which the inlet conduit **33** is formed, for example, through the casing body **14** when the inlet conduit **33** is formed therein.

This type of feeder wire structure also provides for easy installation of the injection nozzle into the engine and permits the injection nozzle **11** to be oriented in any number of different positions within the engine without interference from the engine or other components.

Moreover, the cylindrical pipe portion **29** of the cover member **15** has a pair of knock pin holes **101** formed in the lower portion. Knock pins **102** are fitted into these pin holes **101** and extend downwardly through knock pin grooves **103**, **104** and **105** formed through the periphery of the partitioning plate **27**, the spacer **40** and the holder member **58** respectively, and are fitted into oppositely oriented knock pin holes **106** formed in the shoulder **28**. These knock pins **102** serve to prevent these components from rotating relative to each other, and thus to prevent the feeder wire structure from becoming displaced.

It should be readily apparent from the foregoing description that the described fuel injection nozzle is constructed and arranged so as to improve its durability. The injection nozzle described herein is particularly adapted for supplying varying amounts of fuel to the engine while reducing the probability of coil burn damage occurring. It is to be understood, however, that the foregoing description is only that of a preferred embodiment of the invention, and that various changes and modifications may be made without departing from the spirit and scope of the invention, as defined by the appended claims.

We claim:

1. An accumulator type of injection nozzle comprising an outer housing assembly defining a cavity partitioned into an accumulator chamber adapted to be supplied with high pressure fuel and a coil chamber, a nozzle port leading from said accumulator chamber, an injection valve moveable between a closed position and an open position for controlling the discharge of fuel from said accumulator chamber through said nozzle port, a control chamber for receiving pressurized fuel, an actuating member supported for movement within said control chamber and associated with said injection valve for retaining said injection valve in its closed position when said control chamber is pressurized and for movement of said injection valve to its open position when pressure is relieved in said control chamber, valve means moveable between a closed position for maintaining pressure in said control chamber and an open position for relieving pressure in said control chamber for effecting fuel discharge through said nozzle port, a first electromagnet within said outer housing assembly for moving said valve means to one of said positions when said first electromagnet is energized, and a second electromagnet within said outer housing assembly for controlling the lift amount of said injection valve by selectively energizing or de-energizing said second electromagnet, *wherein said first and second electromagnets have first and second coils respectively, said first coil being wound with a lesser number of turns than said second coil and the wire of said first coil having a larger diameter than the wire of said second coil and* wherein when said second electromagnet is energized, energization of said second electromagnet is started before energization of said first electromagnet for a given fuel injection cycle.

[2. An accumulator type of injection nozzle as recited in claim **1**, wherein said first and second electromagnets have first and second coils respectively, the wire of said first coil having a larger diameter than the wire of said second coil and said first coil is wound with a lesser number of turns than said second coil.]

3. An accumulator type of injection nozzle as recited in claim [2] *1*, wherein the amp-turn characteristics of said first coil is such that the current supplied to said first coil is greater than its number of turns so that, when energized, said first coil reaches peak magnetic flux more quickly than said second coil when said second coil is energized.

4. An accumulator type of injection nozzle as recited in claim **3**, wherein the amp-turn characteristics of said second coil is such that the current supplied to said second coil is less than its number of turns.

5. An accumulator type of injection nozzle as recited in [2] *1*, wherein the amp-turn characteristics of said second coil is such that the current supplied to said second coil is less than its number of turns so that, when energized, said second coil reaches peak magnetic flux less quickly than said first coil when said first coil is energized.

6. An accumulator type of injection nozzle as recited in claim **1**, further comprising a regulating member moveable by said second electromagnet when energized such that when said second electromagnet is energized, movement of said regulating member is completed before energization of said first electromagnet for a given fuel injection cycle.

7. An accumulator type of injection nozzle as recited in claim **1**, wherein said first electromagnet is within said coil chamber and said second electromagnet is within said accumulator chamber.

8. An accumulator type of injection nozzle as recited in claim 1, further comprising a holder member having an upper surface and a bore formed therein, and a regulating member movable by said second electromagnet and comprised of a guide portion having upper and lower ends and slidably supported within the bore and an armature having a lower surface facing the upper surface of said holder member and fixed on the upper end of the guide portion, wherein when electric current is supplied to said second coil, the upper surface of said holder member and the lower surface of said armature each have a portion in contact with each other and each have another portion apart from each other.

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