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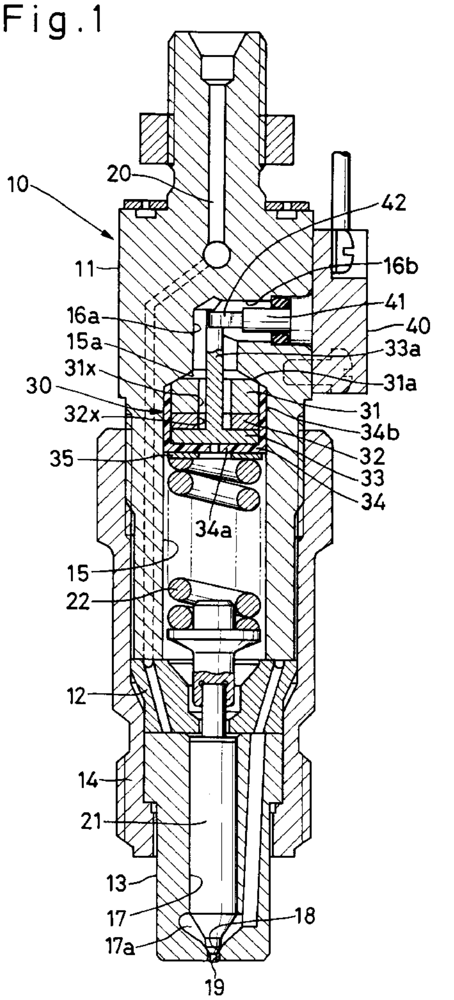
(54) Fuel injection device

(57) A fuel injection device comprises a body (10), a needle valve (21) axially slidably received in the body, a nozzle spring (22) for biasing the needle valve (21) toward a valve seat (18), and a detection assembly for detecting a time point for lifting the needle valve, that is, a fuel injection time. The detection assembly and the nozzle spring are received in a spring receiving hole (15). The detection assembly has an earth plate (31), a piezoelectric device (32) and an electrode plate (33) arranged in order toward the valve seat. A conical receiving surface (15a) is formed on an upper end of the spring receiving hole (15). The earth plate has an abutment surface (31a) which can be brought into surface contact with the receiving surface.

Fig.1



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Description

BACKGROUND OF THE INVENTION

This invention relates to a fuel injection device capable of detecting a fuel injection time (time point for injecting a fuel) using a piezoelectric device.

The fuel injection device includes a body, a needle valve axially slidably received in the body, and a nozzle spring for biasing the needle valve toward a valve seat formed on a lower end portion of the body. A nozzle port is closed during the time the needle valve sits on the valve seat and opened to allow a fuel to be injected therethrough when the needle valve lifts from the valve seat.

Among fuel injection devices, there is a device of the type in which a fuel injection time is detected and such a detected signal is fed back to a control unit in order to more precisely control the injection of fuel. This means for detecting a fuel injection time includes a piezoelectric device, and an electrode plate and an earth plate which plates are in contact with opposite end faces of the piezoelectric device, respectively. The piezoelectric device and the plates are disposed in an axial direction of the body.

When the needle valve lifts from the valve seat, the nozzle spring is compressed to increase its force for pressing the piezoelectric device. Consequently, an output voltage of the piezoelectric device is increased. The output voltage thus increased is served as a signal for detecting a fuel injection time.

As disclosed in Japanese Patent Publication No. Sho 63-14188, the detection means is received in an upper end portion (an end portion away from the valve seat and nozzle port) of a spring receiving hole formed in a body. A nozzle spring is received in the spring receiving hole and interposed between the detection means and the needle valve. In the detection means, an electrode plate, a piezoelectric device, and an earth plate are arranged in order toward the valve seat.

The body has a receiving surface disposed at an upper end of the spring receiving hole. An insulating member is interposed between the receiving surface and the electrode plate. Owing to this arrangement, an electrically-insulated state is maintained between the electrode plate and the body. On the other hand, it is required for the earth plate to maintain its electrically-connected state with the body. To this end, the earth plate is provided with a plurality of tongue pieces radially outwardly projecting from a peripheral edge area thereof. With the tongue pieces slantwise bent, the earth plate is press fitted into the spring receiving hole. The tongue pieces are resiliently contacted with an inner peripheral surface of the spring receiving hole to thereby achieve an electrical connection between the earth plate and the body.

However, since it is necessary for the above-mentioned construction to press fit the earth plate into the spring receiving hole, a troublesome work is required for assembling the detection means to the body. Further, since the pressing force of the nozzle spring acting on the piezoelectric device is reduced by friction between the tongue pieces of the earth plate and the inner peripheral surface of the spring receiving hole, accuracy of detection of a fuel injection time is low.

In another type of detection means disclosed in Japanese Laid-Open Utility Model Application No. Hei 4-47163, an electrode plate, a piezoelectric device and an earth plate are likewise arranged in order toward a valve seat as in the case with the detection means of the above-mentioned patent publication. An insulating member is interposed between the electrode plate and a receiving surface disposed at an upper end of a spring receiving hole. A sleeve portion is formed on a peripheral edge of the earth plate. This sleeve portion contacts an inner peripheral surface of the receiving hole to thereby achieve an electrical connection between the earth plate and the body. With this construction, an outer diameter of the sleeve portion must be in agreement with an inner diameter of the receiving hole with a high degree of precision. This inevitably results in increased manufacturing cost.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a fuel injection device which is easy to manufacture and easy to assemble and which is capable of detecting a fuel injection time with a high degree of precision.

According to the present invention, there is provided a fuel injection device comprising:

(a) an elongated body (10) having a spring receiving hole (15) and a valve receiving hole (17) arranged in order toward a distal end thereof and extending axially of the body, the body further having a nozzle port (19) disposed at the distal end portion and a valve seat (18) communicating with the nozzle port, the body further having a receiving surface (15a) disposed at a basal end of the spring receiving hole (15);

(b) a needle valve (21) axially slidably received in the valve receiving hole of the body, the nozzle port being in a closed state when the needle valve sits on the valve seat, the nozzle port being opened to allow a fuel to be injected therethrough when the needle valve is lifted from the valve seat;

(c) a nozzle spring (22) received in the spring receiving hole of the body and adapted to bias the needle valve toward the valve seat; and

(d) detection means (30) received in the basal portion of the spring receiving hole and adapted to detect a fuel injection time by detecting an increased force of the nozzle spring, the force being increased in accordance with lifting of the needle valve, the detection means having a piezoelectric device (32), an electrode plate (33) and an earth plate (31), the electrode plate and the earth plate being in contact with axially opposite end faces of the piezoelectric device, respectively;

CHARACTERIZED IN THAT the electrode plate (33) is disposed between the piezoelectric device (32) and the nozzle spring (22), and the earth plate (31) is disposed between the piezoelectric device (32) and the receiving surface (15a) of the body (10), the earth plate being brought into abutment with the receiving surface (15a) of the body (10), thereby achieving an electrical contact with the body.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a vertical sectional view of a fuel injection device according to one embodiment of the present invention;

Fig. 2 is an enlarged sectional view of an important portion of the above device; and

Fig. 3 is an enlarged plan view showing a state of connection between a rod portion of an electrode plate and a connector in the above device.

DETAILED DESCRIPTION OF THE EMBODIMENT

The present invention will now be described with reference to the accompanying drawings.

As is shown in Fig. 1, a fuel injection device comprises an elongated body 10 which is to be attached to a cylinder head of an engine (not shown). The body 10 includes a nozzle holder 11, a spacer 12, and a nozzle 13, all arranged in order downwardly along an axis of the body. The body 10 further includes a nozzle nut 14 for securing the spacer 12 and nozzle 13 to the nozzle holder 11.

The nozzle holder 11 has a spring receiving hole 15 extending axially of the body 10, a vertical hole 16a communicating with an upper end of the spring receiving hole 15 and extending axially of the body 10, and a horizontal hole 16b extending from an upper end of the vertical hole 16a in a perpendicular direction to the axis of the body 10 and opening at an outer peripheral surface of the nozzle holder 11. The spring receiving hole 15 is opened at a lower end face of the nozzle holder 11. The vertical hole 16a is smaller in diameter than the spring receiving hole 15. A conical receiving surface 15a is formed at a boundary area between the vertical hole 16a and the spring receiving hole 15 (i.e., at an upper end of the spring receiving hole 15).

The nozzle 13 is provided with a valve receiving hole 17 extending axially of the body 10. A lower end portion of the valve receiving hole 17 is defined by a pressure receiving chamber 17a. A valve seat 18 and a nozzle port 19 are formed in order downwardly at a lower end portion of the nozzle 13. The valve receiving hole 17, the valve seat 18 and the nozzle port 19 are arranged on the axis of the body 10.

The body 10 has a high pressure passage 20 extending through the nozzle hole 11, the spacer 12 and the nozzle 13. An upper end of the high pressure passage 20 is opened at an upper end face of the nozzle holder 11, and a high pressure fuel is supplied to this opening. A lower end of the high pressure passage 20 is in communication with the pressure receiving chamber 17a.

A needle valve 21 is axially slidably received in the valve receiving hole 17 of the nozzle 13. A compressed nozzle spring 22 is received in the spring receiving hole 15. The nozzle spring 22 biases the needle valve 21 toward the valve seat 18.

Since the above construction is known, operation thereof will be briefly described. During the time the needle valve 21 is caused to sit on the valve seat 18 under the effect of the nozzle spring 22, the nozzle port 19 is in a closed state. When a high pressure fuel is supplied from a fuel injection pump (not shown) to the high pressure passage 20, the needle valve 21 receives the fuel pressure in the pressure receiving chamber 17a and is lifted from the valve seat 18. As a consequence, the nozzle port 19 is opened to allow the high pressure fuel to be injected to a combustion chamber of the engine therethrough. When the supply of high pressure fuel is stopped, the needle valve 21 is caused to sit on the valve seat 18 under the effect of the nozzle spring 22 and thus the fuel injection is finished.

A detection assembly 30 (detection means) for detecting a fuel injection time is received in the upper end portion of the spring receiving hole 15. The detection assembly 30 is particularly clearly shown in Fig. 2. The nozzle spring 22 presses the detection assembly 30 upwardly through a shim 35. The detection assembly 30 includes an earth plate 31, a piezoelectric device 32, and an electrode plate 33, all arranged in order downwardly. This sequential order of arrangement is reverse to that of the previously described conventional device.

A surface of the piezoelectric device 32 on the positive electrode side faces downwardly. The electrode plate 33 is secured to this surface by electrically-conductive adhesive agent (not shown). A surface of the piezoelectric device 32 on the negative electrode side faces upwardly. The earth plate 31 is secured to this surface by electrically-conductive adhesive agent. An acceptable adhesive agent includes those of silver powder compounded epoxy resins, for example.

The earth plate 31 has a through-hole 31x formed in the center thereof. The earth plate 31 has a thick circular ring shape. A conical abutment surface 31a having an angle equal to that of the receiving surface 15a of the upper end of the spring receiving hole 15 is formed on an upper surface of the earth plate 31. The receiving surface 15a and the abutment surface 31a are in surface contact with each other under the effect of the nozzle spring 22.

The piezoelectric device 32 also has a through-hole 32x formed in the center thereof. The piezoelectric device 32 has a circular ring shape. The electrode plate 33 has a disk-like shape. A rod portion 33a extending upwardly and axially of the body 10 is formed on the center of the electrode plate 33. The rod portion 33a is inserted into the through-hole 32x of the piezoelectric device 32, the through-hole 31x of the earth plate 31 and the vertical hole 16a of the nozzle holder 11. An upper end of the rod portion 33a is disposed at a crossing portion between the vertical hole 16a and the horizontal hole 16b. Since an outer peripheral surface of the rod portion 33a is separated from inner peripheral surfaces of the earth plate 31 and piezoelectric device 32 through an annular gap, an electrically-insulated state is ensured between the electrode plate 33 and both of the earth plate 31 and the piezoelectric device 32.

The detection assembly 30 is formed as a unitary part by enclosing the earth plate 31, the piezoelectric device 32 and the electrode plate 33 with an insulating member 34. The insulating member 34 is constituted of a glass fiber reinforced PA (polyamide) 66, a glass fiber reinforced PPS (polyphenylene sulphide), or the like. The insulating member 34 is favorable in strength and thermal resistance.

For molding the detection assembly 30, the earth plate 31, the piezoelectric device 32 and the electrode plate 33, which were preliminarily fixed by electrically-conductive adhesive agent, are set in a metal mold and then the insulating resin is injected into the metal mold.

The insulating member 34 includes a disk portion 34a covering a lower surface of the electrode plate 33, and a sleeve portion 34b covering outer peripheral surfaces of the earth plate 31, piezoelectric device 32 and electrode plate 33. The disk portion 34a of the insulating member 34 insulates the electrode plate 33 from the shim 35 and the nozzle spring 22, whereas the sleeve portion 34b insulates the piezoelectric device 32 and the electrode plate 33 from the inner peripheral surface of the spring receiving hole 15.

As is shown in Fig. 1, a support 40 is secured to the outer peripheral surface of the nozzle holder 11 where the horizontal hole 16b is opened. The support 40 is provided with a connector 41 received in the horizontal hole 16b. A terminal 42 disposed on a distal end of the connector 41 is electrically connected to the upper end portion of the rod portion 33a of the electrode portion 33. As is shown in Fig. 3, the terminal 42 is constituted of a U-shaped metal plate. The rod portion 33a of the electrode plate 33 is held by the U-shaped terminal 42 so as to be connected to the terminal 42.

An interface for a micro computer (not shown) for controlling a fuel injection pump is connected to the electrode plate 33 through the connector 41 and also connected to an earth terminal, not shown, secured to the nozzle holder 11.

In the detection assembly 30 thus constructed, when the needle valve 21 is lifted, the pressing force of the nozzle spring 22 applied to the piezoelectric device 32 is increased because the nozzle spring 22 is compressed. As a consequence, voltage generated in the piezoelectric device 32 is increased. This voltage signal is processed by the interface and input into the micro computer. The micro computer controls the fuel injection pump in accordance with a signal indicative of a fuel injection time.

In the detection assembly 30, since the earth plate 31 is caused to contact the receiving surface 15a of the nozzle holder 11 by the nozzle spring 22, the earth plate 31 can be positively electrically connected to the nozzle holder 11.

Since it is not required for this embodiment, unlike the above-mentioned conventional device, to resiliently contact the earth plate 31 to the inner peripheral surface of the spring receiving hole 15, the pressing force of the nozzle spring 22 acts directly on the piezoelectric device 32. Consequently, accuracy of detection of the piezoelectric device 32 can be increased. It should be noted that since the Young module of the insulating member 34 is considerably larger than that of the piezoelectric device 32, the force of the nozzle spring 22 is hardly applied to the sleeve portion 34b of the insulating member 34 but it is substantially applied to the piezoelectric device 32 alone.

Since it is no more required, unlike the above-mentioned conventional device, to insert, under pressure, the earth plate 31 into the spring receiving hole 15 and since the detection assembly 30 is molded of resin and handled as a unitary component element, the detection assembly 30 can be assembled to the nozzle holder 11 with ease.

Further, the receiving surface 15a of the nozzle holder 11 and the abutment surface 31a of the earth plate 31 are conical surfaces, and surface contact therebetween prevents the nozzle holder 11 from moving radially. As a consequence, the detection assembly 30 can be positively held in a predetermined position. Since it is no more required for the insulating member 34 to have the role for prohibiting the detection assembly 30 from moving radially, it becomes possible to provide a clearance A (see Fig. 2) between the outer peripheral surface of the sleeve portion 34b and the inner peripheral surface of the spring receiving hole 15. Owing to this arrangement, the insulating member 34, when rotated by the force of the nozzle spring 22, does not rub the inner peripheral surface of the spring receiving hole 15 and therefore, wear of the insulating member 34 can be prevented.

Even if the two surfaces of the piezoelectric device 32 and the surfaces of the electrode plate 33 and earth plate 31 placed opposite respectively to those of the piezoelectric device 32 are not planar microscopically, the force of the nozzle spring can be dispersed over the entire area of the two surfaces of the piezoelectric device 32 because an electrically-conductive adhesive agent is interposed between the opposing surfaces as previously mentioned. For this reason, the piezoelectric device 32 can be prevented from cracking by great force locally applied thereto.

It should be noted that an insulating material such as resin may be filled in the annular gap formed between the rod portion 33a of the electrode plate 33 and the inner peripheral surfaces of the earth plate 31 and piezoelectric device 32. Owing to this arrangement, there can be prevented a possible deterioration of insulating ability caused by dusts, etc. entered into the annular gap.

Claims

1. A fuel injection device comprising:

(a) an elongated body (10) having a spring receiving hole (15) and a valve receiving hole (17) arranged in order toward a distal end thereof and extending axially of said body, said body further having a nozzle port (19) disposed at the distal end portion and a valve seat (18) communicating with said nozzle port, said body further having a receiving surface (15a) disposed at a basal end of said spring receiving hole (15);

(b) a needle valve (21) axially slidably received in said valve receiving hole of said body, said nozzle port being in a closed state when said needle valve sits on said valve seat, said nozzle port being opened to allow a fuel to be injected therethrough when said needle valve is lifted from said valve seat;

(c) a nozzle spring (22) received in said spring receiving hole of said body and adapted to bias said needle valve toward said valve seat; and

(d) detection means (30) received in the basal portion of said spring receiving hole and adapted to detect a fuel injection time by detecting an increased force of said nozzle spring, the force being increased in accordance with lifting of said needle valve, said detection means having a piezoelectric device (32), an electrode plate (33) and an earth plate (31), said electrode plate and said earth plate being in contact with axially opposite end faces of said piezoelectric device, respectively;

CHARACTERIZED IN THAT said electrode plate (33) is disposed between said piezoelectric device (32) and said nozzle spring (22), and said earth plate (31) is disposed between said piezoelectric device (32) and said receiving surface (15a) of said body (10), said earth plate being brought into abutment with said receiving surface (15a) of said body (10), thereby achieving an electrical contact with said body.

2. A fuel injection device according to claim 1, in which said piezoelectric device (32) and said earth plate (31) have ring-shaped configurations, respectively, and said electrode plate (33) has a disk-like configuration, a rod portion (33a) being formed at a center of said electrode plate, said rod portion extending axially of said body (10) through said piezoelectric device and said earth plate so as to be in contact with a connector (41) supported by said body, an annular gap being formed between said rod portion and both of said earth plate and said piezoelectric device.

3. A fuel injection device according to claim 2, in which an insulating material is filled in said annular gap.

4. A fuel injection device according to any one of claims 1 to 3, in which said receiving surface (15a) of said body (10) is a conical surface, and said earth plate (31) has a conical abutment surface (31a) which can be brought into surface contact with said receiving surface.

5. A fuel injection device according to any one of claims 1 to 4, in which said earth plate (31), piezoelectric device (32) and electrode plate (33) are attached to one another by electrically-conductive adhesive agent.

6. A fuel injection device according to any one of claims 1 to 5, in which said earth plate (31), piezoelectric device (32) and electrode plate (33) are enclosed by an insulating member (34), said insulating member covering a surface of said electrode plate on the side of said nozzle spring (22) and also covering peripheral surfaces of said electrode plate and piezoelectric device.

7. A fuel injection device according to claim 6, in which said insulating member (34) is a molded resin, thereby integrating said earth plate (31), piezoelectric device (32) and electrode plate (33).

Fig.1

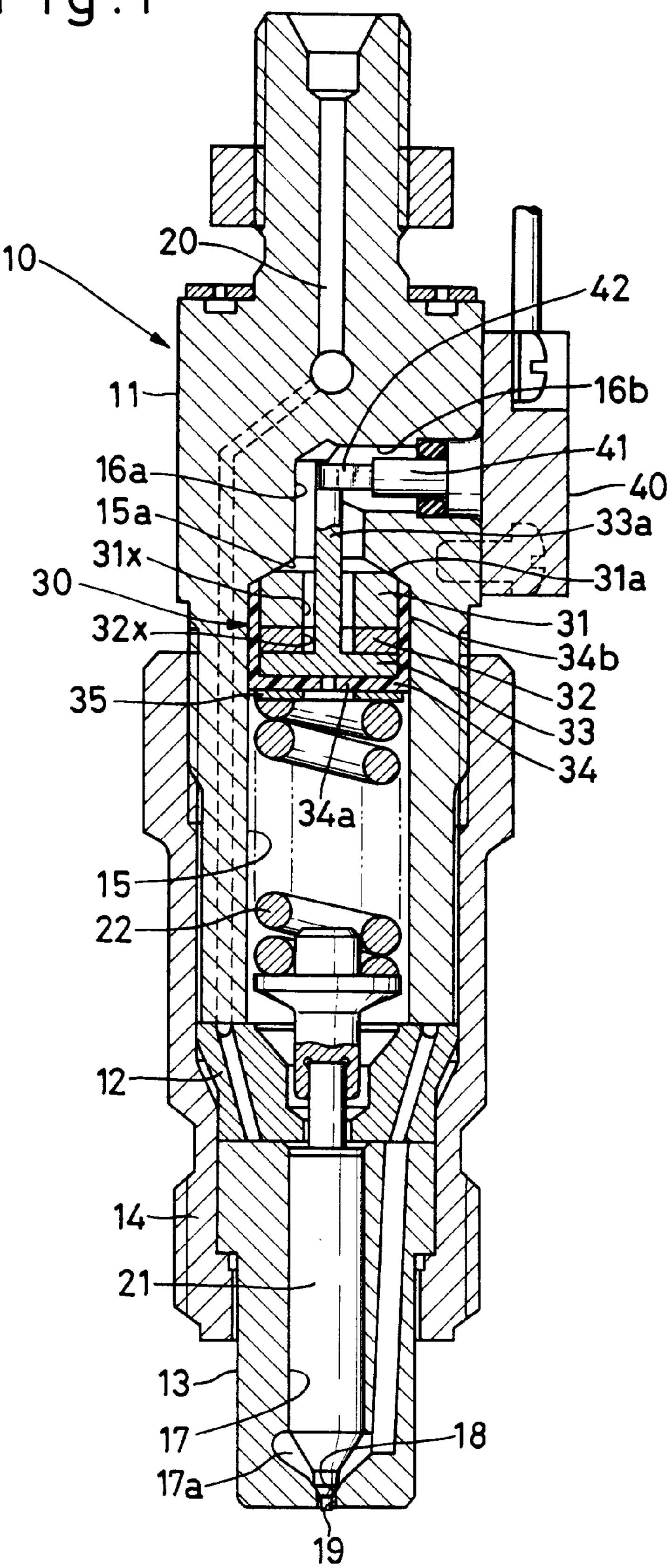
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Fig. 2

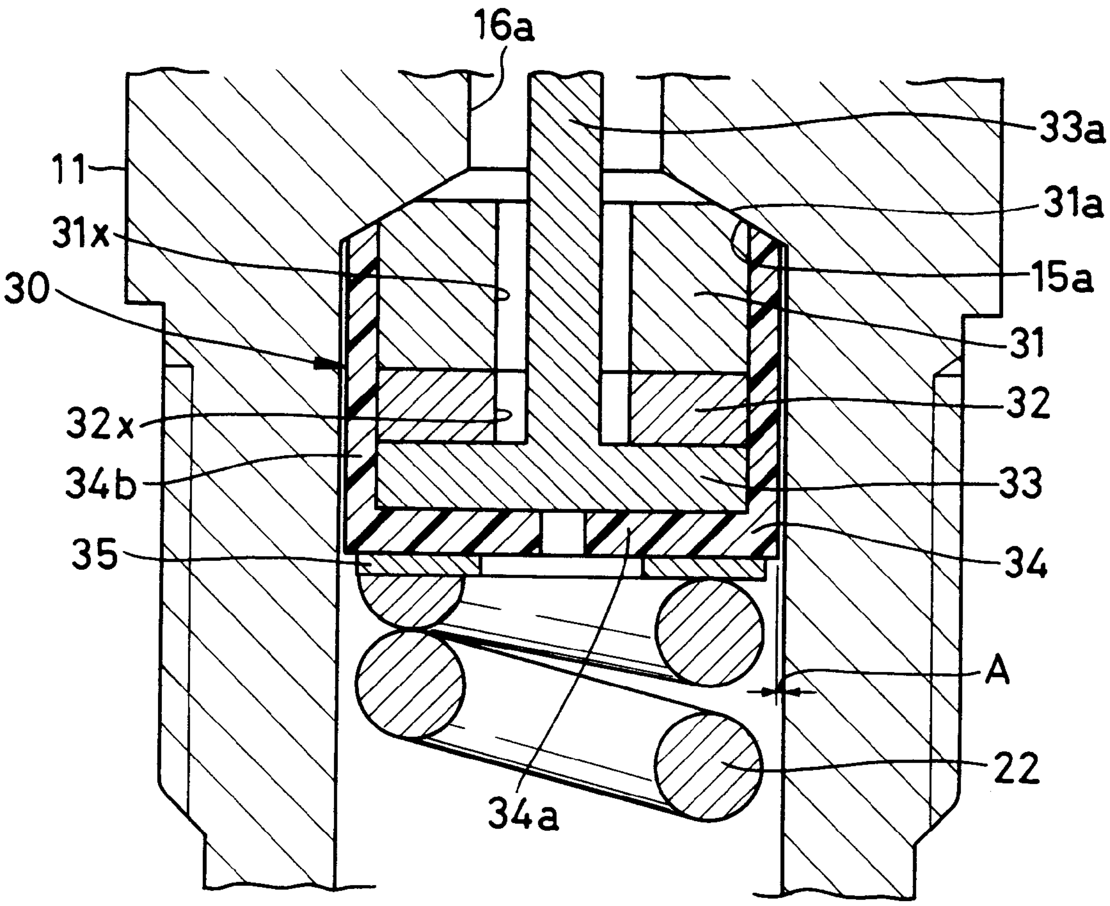

Fig. 3