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(56) Documents cited
GB A 2125894 GB 1582317 EP 0020888
GB A 2097859 EP 0045530 US 4111178
GB A 2075068

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F1B

# (54) Solenoid valve constituting an on-off switch

(57) In a solenoid valve (1) having a valve member (3) of conductive material and a conductive casing (2), (9) having a guide hole (13a) for guiding the valve member (3), an insulation layer (18) is provided between the valve member (3) and the guide hole (13a) so as to constitute a switch which is ON when the valve (3) is seated on a valve seat (5) and OFF when the valve is separated from the valve seat. The insulation layer (18) may be a resin, a ceramic or one of $Ta_2O_3$, $Si_3N_4$, AlN, $ZrO_2$, $SiO_2$ and $Al_2O_3$.

FIG. 1

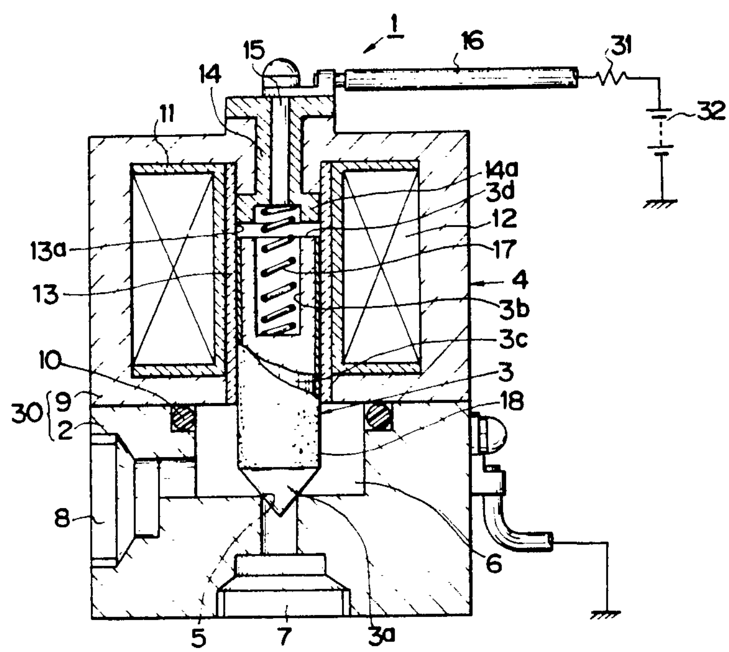


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FIG. 1

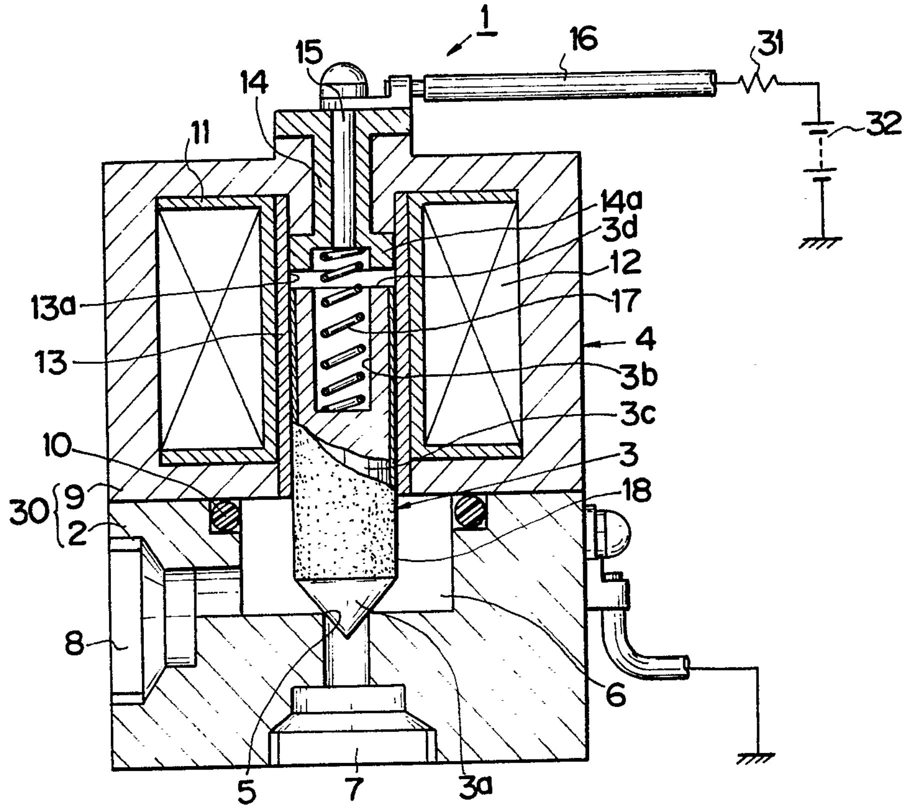



FIG. 2

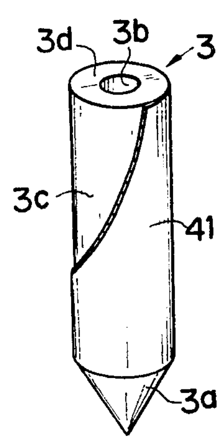
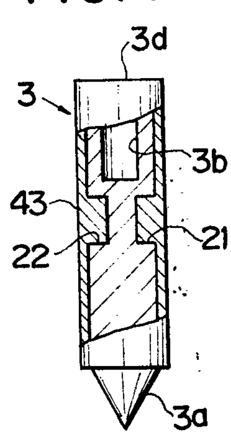



FIG. 3



SPECIFICATION

**Solenoid valve**

The present invention relates to a solenoid valve, and more particularly to a solenoid valve having an ON-OFF switch constituted by a valve and an associated valve seat.

*Description of the Prior Art*

In the prior art, to obtain an electric signal indicating the opening/closing state of a valve device, solenoid valves in which an ON-OFF switch is constituted by a valve and the associated valve seat are widely used. Such a solenoid valve is needed, for example, for constituting a solenoid valve driving circuit in which the driving pulse applied to the solenoid valve is corrected in response to the timing of opening/closing of the solenoid valve in order to make the open/close timing of the solenoid valve coincide with a target timing.

As such a valve device, there is disclosed for example in USP No. 4111178 (corresponding to ED OS 2748447) a fuel injection valve in which a mechanical switch is constituted by a needle valve and a nozzle body in order to obtain an electric signal indicating the timing of the beginning of fuel injection and the timing of the end of fuel injection in response to the movement of the needle valve. In the disclosed fuel injection valve, a nozzle body and a needle valve smoothly moving in the guide hole of the nozzle body are formed of an electrically conductive material and the outer surface of the needle valve is covered with a ceramic insulation film of a thickness between approximately 0.2 $\mu$ and 0.3 $\mu$, or an insulation film formed by the sputtering of aluminum oxide.

However, when the ceramic thin film is used as the insulation film the durability is insufficient and when the insulation layer formed by the sputtering of aluminum oxide is used the insulation film is liable to peel off from the outer surface of the needle valve. In either case, consequently, stable use over long periods is impossible.

It is an object of the present invention to provide an improved solenoid valve having an ON-OFF switch.

It is another object of the present invention to provide a solenoid valve having an ON-OFF switch constituted by a valve and an associated valve seat, wherein the insulated state between the valve and the guide surface of the member for guiding the valve can be maintained in stable condition over a long period.

According to the present invention, in a solenoid valve having a valve made of a conductive material and a conductive casing having a guide means for guiding the valve and a valve seat associated with the valve, the solenoid valve comprises an insulation layer provided between the valve and the guide means so as to constitute a switch which assumes the ON state when the valve is seated on the valve seat and assumes the OFF state when the valve is separated from the valve seat and the insulation layer is made of a highly durable insulation material.

The insulation layer may be formed by subjecting the outer surface of the valve to an insulating process employing the ion-plating method.

When an insulation layer of $SiO_2$ or the like is formed on the outer surface of the valve by the ion-plating method, since the ionized insulation material is bonded to the valve with high kinetic energy due to the applied voltage, the insulation layer is formed at a high density and is strongly bonded to the base metal, namely, the valve. Therefore, the insulation layer has high durability and maintains its insulating effect for a long time. Furthermore, by the ion-plating method, the control of the thickness of the insulating film can be relatively easily carried out by adjusting the level of the applied voltage and the period over which the voltage is applied so that the quality of the insulating film can be easily and reliably controlled. As a result, it is possible to manufacture the valve with high dimensional accuracy.

The insulation layer may also be formed as a ceramic sleeve fitted on the surface of the valve or be formed on the surface of the valve by the use of an insulating resin having high durability. For example, polyphenylene sulfide (PPS) may be used as such a resin.

According to the present invention, since an insulation layer made of an insulating material having high durability is provided on the outer surface of the valve, a solenoid valve having a high reliability switch with long service life can be obtained.

The invention will be better understood and the other objects and advantages thereof will be more apparent from the following detailed description of a preferred embodiment with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross-sectional view of a solenoid valve in accordance with the present invention.

Figure 2 is a perspective view, partially cut away, of a valve and associated insulation layer for use in the solenoid valve of Figure 1.

Figure 3 is a side view, partially in section, of another valve and associated insulation layer for use in the solenoid valve of Figure 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows a cross-sectional view of an embodiment of a solenoid valve according to the present invention. A solenoid valve 1 has a lower casing 2, a valve 3 made of a conductive material such as steel and a driving section 4 which is fixed to the lower casing 2 and electromagnetically drives the valve 3. In the lower casing 2, which is made of a conductive material, there are formed a valve seat 5 on which the valve 3 seats, an outlet port 7 communicated through the valve seat 5 with a chamber 6, and an inlet port 8 communicated with the chamber 6.

An upper casing 9 of the driving section 4 is fixed to the lower casing 2 by an appropriate fixing means (not shown) and liquid tight condition is maintained between the lower casing 2 and the upper casing 9 by an O ring 10 provided therebetween, whereby a casing 30 of the solenoid valve 1 is formed. A solenoid coil 12 wound on a bobbin 11 is mounted in the upper casing 9, and the valve 3 is slidably supported and guided by a cylindrical guide member 13 which is made of a non-magnetic metal material, such as brass, and disposed in the center portion of the bobbin 11.

An electrode 15 is fitted through an insulating sleeve 14 into the top end portion of the upper casing 9. One end of the electrode 15 is connected with a lead wire 16 and the other end of the electrode 15 is in contact with an expansion coil spring 17 received in a concave portion 3b of the valve 3. The valve 3 is urged downward by the coil spring 17 and the tip portion 3a of the valve 3 is pressed onto the valve seat 5 when no driving current flows through the solenoid coil 12 to close the solenoid valve 1. On the other hand, when the driving current flows through and energizes the solenoid coil 12, an electromagnetic force acts on the valve 3 causing it to move upward against the force of the coil spring 17. As a result, the tip portion 3a of the valve 3 separates from the valve seat 5 to open the solenoid valve 1.

Since both the valve 3 and the coil spring 17 are made of electrically conductive materials, the electrical contact state between the valve 3 and the electrode 15 can be maintained by the coil spring 17.

To constitute a switch by the valve 3 and the valve seat 5 utilizing the fact that when the solenoid valve 1 closes the valve 3 comes in contact with the valve seat 5 and when it opens the valve 3 separates from the valve seat 5, an insulation layer 18 is formed on the cylindrical outer surface 3c of the valve 3 for establishing a non-conductive state between the valve 3 and the guide surface 13a of the guide member 13 which is electrically connected with the upper casing 9.

Thus, when the insulation layer 18 is formed on the outer surface 3c of the valve 3 to establish the electrically non-conductive state between the guide member 13 and the valve 3, the non-conductive state between the valve 3 and the upper casing 9 can be also established when the solenoid valve 1 is opened so that the valve 3 is separated from the valve seat 5. Therefore, the lower casing 2 is electrically disconnected from the lead wire 16 when the solenoid valve 1 is open. On the other hand, the lower casing 2 is electrically connected with the lead wire 16 when the solenoid valve 1 is closed. That is, a switch is constituted by the valve 3 and the associated valve seat 5 which is turned ON or OFF in response to the open or closed state of the solenoid valve 1.

In this embodiment, a flange portion 14a is formed at the lower end portion of the insulation sleeve 14 to prevent the top end surface of the valve 3 from coming in contact with the upper casing 9 when the valve 3 is lifted at the time of energization of the solenoid coil 12. Alternatively, of course, an insulation layer may be provided on the top end surface 3d of the valve 3.

The insulation layer 18 may be formed by, for example, applying a coating of $SiO_2$ on the outer surface 3c using the ion-plating method, one type of physical evaporating method. When the ion-plating method is employed for coating the outer surface 3c of the valve 3 with an insulation material such as $SiO_2$, $Al_2O_3$ or the like, the insulation layer 18 is formed at a high density and is strongly bonded to the valve 3. Therefore, the insulation layer 18 has high durability and maintains its insulating effect for a long time.

As the material for the insulation layer 18, insulating materials such as $Ta_2O_3$, $Si_3N_4$, AlN, $ZrO_2$ are also usable in place of $SiO_2$ or $Al_2O_3$.

To obtain an electric signal indicating the time at which the solenoid valve 1 is opened or closed, the lower casing 2 is grounded and the lead wire 16 is connected to a voltage source 32 through a resistor 31. With this circuit arrangement, a voltage signal is developed across the resistor 31 only when the valve 3 is seated on the valve seat 5. That is, since the valve 3 and the valve seat 5 constitute an ON-OFF switch which is closed when the solenoid valve 1 is closed, the current from the voltage source 32 flows through the resistor 31 and a voltage drop of a predetermined level develops across the resistor 31. On the other hand, the electrical connection between the valve 3 and the valve seat 5, that is, between the valve 3 and the lower casing 2, is broken when the solenoid valve 1 is opened by the energization of the solenoid coil 12 and the current flow through the resistor 31 becomes zero so that the voltage developed across the resistor 31 becomes zero.

Thus, both the open and closed states of the solenoid valve 1 can be detected from the voltage developed across the resistor 31.

The insulation layer 18 can instead be formed by the high frequency excitation ion-plating method, the cluster ion-beam method, the election beam smelting method, the hollow cathode method or the like.

In the embodiment described above, although the insulation layer 18 is formed by the ion-plating method, the insulation layer 18 can instead be provided by fitting a ceramic sleeve on the valve 3.

Fig. 2 shows a modification of the insulation layer for the valve 3. In this case, the insulation layer for establishing the electrical isolation between the valve 3 and the guide member 13 is formed by a cylindrical ceramic sleeve 41, which is fitted on the outer surface 3c of the large diameter portion of the valve 3 and fixed such as by an appropriate adhesive. When the ceramic sleeve 41 is used as an insulation layer in place of the insulation layer 18 of Fig. 1, the formation of the insulation layer on the valve 3 is made easier, wear of the insulation layer is reduced, and adequate smoothness can be attained between the guide member 13 and the ceramic sleeve 41.

Since the ceramic sleeve 41 is considerably thicker than a mere ceramic film, it has excellent durability so that the reliability of the insulation portion is remarkably improved and the service life thereof becomes extremely long.

Fig. 3 shows another modification of the insulation layer for the valve 3 of Fig. 1. An insulating layer 43 made of highly durable insulating resin is integrally formed on the outer surface 3c of the valve 3 as shown in Fig. 3, so as to insulate the outer surface 3c of the large diameter portion of the valve 3 from the guide surface 13a of the guide member 13. Concaves 21 and 22 are defined at the middle portion of the large diameter portion of the valve 3. Consequently, when the insulation layer 43 is integrally formed on the valve 3, it is not only formed on the outer surface 3c of the valve 3 but also enters into the concaves 21 and 22. As a result, the insulation layer 43 is physically integrated with the valve 3 in such a way that it cannot move around the valve 3. As the insulating resin of the insulating member 43 there can be used, for example, a resin having high durability such as polyphenylene sulfide (PPS).

When the insulating layer is made of an insulating resin such as a polyphenylene sulfide, it suffers little wear and provides sufficient smoothness in motion between the valve 3 and the guide member 13.

CLAIMS

1. A solenoid valve, comprising:

a valve made of a conductive material; a conductive casing having a guide means for guiding the valve and a valve seat associated with the valve;

and an insulation layer provided between the valve and the guide means so as to constitute a switch which is in 0× state when the valve is seated on the valve seat and is in OFF state when the valve is separated from the valve seat, said insulation layer being made of a highly durable insulation material.

2. A solenoid valve as claimed in Claim 1, wherein said insulation layer is formed on the outer surface of the valve by a physical evaporation method.

3. A solenoid valve as claimed in Claim 2, wherein the physical evaporation method is an ion-plating method.

4. A solenoid valve as claimed in Claim 3, therein the valve is made of steel and a $SiO_2$ layer is formed on the outer surface of the valve by an ion-plating method.

5. A solenoid valve as claimed in Claim 1, wherein said insulation layer is a ceramic sleeve fitted on the outer surface of the valve.

6. A solenoid valve as claimed in Claim 1, wherein said insulation layer is made of a highly durable insulating resin.

7. A solenoid valve as claimed in Claim 6, wherein said insulation resin is formed integrally with the valve on the outer surface thereof.

8. A solenoid valve as claimed in Claim 7, wherein at least one concave portion for receiving a part of the insulation resin when the insulation resin is coated on the outer surface of the valve is provided on the outer surface of the valve, whereby the insulation layer is prevented from moving on the outer surface of the valve.

9. A solenoid valve as claimed in Claims 6, 7 or 8, wherein the insulation resin is polyphenylene sulfide.

10. A solenoid valve as claimed in claim 1 and substantially as hereinbefore described with reference to, and as shown in the accompanying drawing.

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