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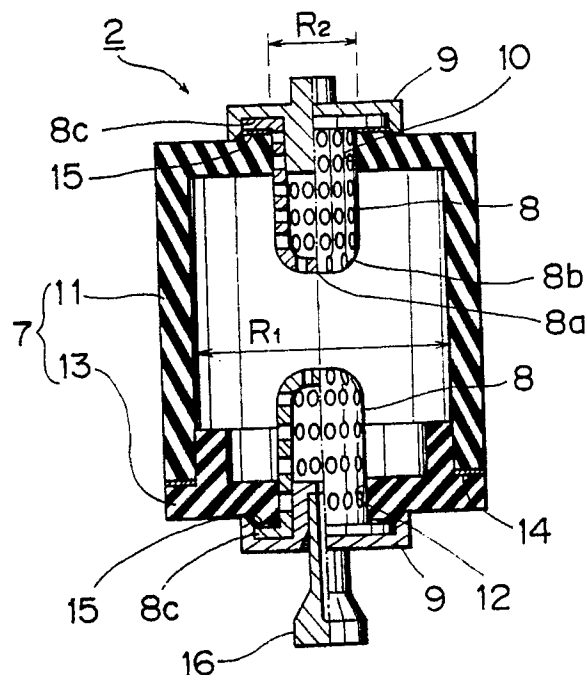
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D-8000 München 22(DE)(54) **Gas-filled discharge tube.**

(57) A gas-filled discharge tube of a compact construction for use as a series gap in the ignition system of an automotive spark-ignition engine and the like. The gas-filled discharge tube comprises an insulating tube unit having a tube provided with openings of a diameter smaller than the inside diameter thereof in the opposite ends thereof, a pair of electrode bases closely attached to the opposite ends of the tube so as to seal the openings, a pair of perforated discharge electrodes attached respectively to the opposite inner surfaces of the electrode bases to form a series gap, and an inert gas filling the tube. Since the diameter of the electrode bases sealing the comparatively small openings is comparatively small, the electrode bases of a comparatively small diameter may be used. Thus, the capacitance between the electrode bases, hence the capacitance of the gas-filled discharge tube, is comparatively small, which enables the firing potential of the gas-filled discharge tube to be increased without increasing the capacitance of the same.

FIG. 1**EP 0 407 837 A2**

GAS-FILLED DISCHARGE TUBE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a gas-filled discharge tube suitable for use in the ignition system with a series gap of an automotive engine and the like.

Description of the Prior Art

The ignition system with a series gap has a discharge tube having a predetermined capacitance and connected in series to a spark plug to prevent the sooting of the spark plug with carbon. Such an ignition system with a series gap disclosed in Japanese Utility Model Laid-open (Kokai) No. 63-101486 has a circuit configuration as shown in Fig. 3. This known ignition system comprises an ignition coil 1, a discharge tube 2, and a spark plug 3. Indicated at C_1 and C_2 are the respective feed capacitances of the discharge tube 2 and the spark plug 3. As shown in Fig. 4, the electric potential V_1 of the center electrode of the spark plug, i.e., the electric potential of a point B in Fig. 3, increases in proportion to the ratio between the respective capacitances C_1 and C_2 of the discharge tube 2 and the spark plug 3 when the voltage V applied across the discharge tube 2, i.e., the electric potential of a point A in Fig. 3, is increased. Discharge occurs in the discharge tube 2 when the electric potential of the point A reaches a sufficiently high level, and then the electric potential of the point A drops sharply and the electric potential of the point B increases sharply.

Fig. 5 shows a portion of the spark plug 3. If the circumference of the center electrode 4 of the spark plug 3 is sooted with a carbon layer 5 as shown in Fig. 5, it is possible that a leakage current flows through the carbon layer 5 to a portion 6 of the center electrode 4 deep from the extremity. When the center electrode 4 of the spark plug 3 is in such a sooted condition, the potential V_2 of the deep portion 6 of the center electrode 4, i.e., the potential of a point C in Fig. 3, increases with the potential V_1 of the center electrode 4 with a delay as the potential V_1 of the center electrode 4 is increased sharply by the discharge of the discharge tube 2. Suppose that the firing potential of the center electrode 4 (point B) is 8 kV. Then, the firing potential of the deep portion 6 (point C) is about 6 kV, because the gap between the deep

portion 6 and the casing is smaller than that between the center electrode 4 and the opposite electrode. Consequently, as shown in Fig. 4, a normal spark discharge S_1 is passed between the center electrode 4 and the opposite electrode at the point of intersection of a line corresponding to 8 kV and a curve representing the variation of the potential V_1 , and an abnormal spark discharge S_2 is passed between the deep portion 6 and the casing at the point of intersection of a line corresponding to 6 kV and the curve representing the variation of the potential V_2 . However, as is obvious from Fig. 4, the normal spark discharge S_1 occurs earlier by a time t_1 between the center electrode 4 and the opposite electrode than the abnormal spark discharge S_2 , and hence the spark plug may not be sooted due to the abnormal spark discharge S_2 .

Fig. 6 shows the discharge tube 2 having the predetermined capacitance C_1 . The discharge tube 2 comprises a tube 7 formed of an electrically insulating material, such as a ceramic, and having opposite open ends, a pair of electrode bases 9 closely fitted respectively in the opposite ends of the tube 7, and a pair of discharge electrodes 8 held on the electrode bases 9 within the tube 7. The tube 2 is filled with an inert gas. The sum of the capacitance C_3 between the pair of discharge electrodes 8 and the capacitance C_4 between the pair of electrode bases 9 is the capacitance C_1 of the discharge tube 2.

In such an ignition system, it is desired to employ a compact discharge tube to enable the plug cap attached to the extremity of the high-tension cable to be formed in a compact construction. When the length of the discharge tube 2 of a construction shown in Fig. 6 is reduced to increase the capacitance C_1 of the discharge tube 2 and such a discharge tube having a comparatively large capacitance is employed in the ignition system and the same spark plug 3 having the same capacitance C_2 is used, the potential V_1 of the center electrode 4 (point B) and the potential V_2 of the deep portion 6 (point C) of the spark plug 3 increase according to the increase in the capacitance of the discharge tube 2 as indicated by broken lines in Fig. 4. Consequently, a time interval t_2 between the point of occurrence of the normal spark discharge S_1 (the point of intersection of the line corresponding to 8 kV and the curve representing the variation of the potential V_1 of the center electrode) between the center electrode 4 and the opposite electrode, and the point of occurrence of the abnormal spark discharge S_2 (the point of intersection of the line corresponding to 6 kV and a curve representing the variation of the potential V_2

of the deep portion 6) becomes very short and hence it is a matter of probability that which of the normal spark discharge S_2 and the abnormal spark discharge 5, will occur first. Therefore, increase in the capacitance C_1 of the discharge tube 2 entails increase in the possibility of the abnormal spark discharge S_2 sooting the spark plug 3.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a gas-filled discharge tube of a compact construction, having an appropriate capacitance which will not cause sooting the spark plug.

In one aspect of the present invention, a gas-filled discharge tube comprises a tube formed of an electrically insulating material and having openings in the opposite ends, a pair of electrode bases closely attached to the opposite ends of the tube so as to close the openings, a pair of discharge electrodes attached respectively to the opposite surfaces of the electrode bases to form a series gap, and an inert gas filling the tube. The diameter of portions of the opposite ends of the tube provided with the openings closed by the electrode bases is smaller than that of other portions of the tube.

Since the diameter of the portions of the opposite ends of the tube provided with the openings closed by the electrode bases is smaller than that of other portions, the diameter, hence the area, of the electrode bases may be comparatively small, so that the capacitance between the electrode bases, hence the capacitance of the gas-filled discharge tube, is comparatively small and hence the gas-filled discharge tube can be formed in a compact construction without excessively increasing the capacitance.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a longitudinal sectional view of a gas-filled discharge tube in a first embodiment according to the present invention;

Figure 2 is a longitudinal sectional view of a gas-filled discharge tube in a second embodiment according to the present invention;

Figure 3 is a circuit diagram of an ignition sys-

tem with a series gap;

Figure 4 is a graph showing potential variations at different points in the ignition system of Fig. 3;

Figure 5 is an enlarged fragmentary sectional view of the extremity of a spark plug; and

Figure 6 is a longitudinal sectional view of a conventional discharge tube.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Gas-filled discharge tubes embodying the present invention will be described hereinafter with reference to Figs. 1 and 2, in which parts like or corresponding to those of the conventional discharge tube previously described with reference to Figs. 3 to 6 will be denoted by the same reference characters.

First Embodiment

Referring to Fig. 1, a gas-filled discharge tube 2 comprises an insulating tube unit 7 formed of an electrically insulating material, such as alumina ceramic, steatite or crystallized glass, and provided with openings 10 and 12 of the same diameter R_2 at its opposite ends, a pair of metallic electrode bases 9 attached to the opposite ends of the insulating tube unit 7 so as to close the openings, respectively, a pair of discharge electrodes 8 projecting from the opposite inner surfaces of the electrode bases 9 so as to form a series gap, and an inert gas, such as argon gas or an argon-nitrogen mixed gas, filling the insulating tube unit 7.

The insulating tube unit 7 consists of a tube 11 and an end cap 13 fitted in one end of the tube 11 and provided with an opening 12. The other end of the insulating tube 7 is reduced to form the opening 10 having a diameter R_2 smaller than the diameter R_1 of the open end of the tube 11 closed by the end cap 13. The tube 11 and the end cap 13 are joined together with glass frit 14 or the like to form the insulating tube unit 7 provided with the openings 10 and 12 of the same diameter R_2 smaller than the diameter R_1 of the open end of the tube 11, i.e., the inside diameter of the tube 11.

The pair of discharge electrodes 8 are inserted through the openings 10 and 12 in the insulating tube unit 7 so as to form a discharge gap between the opposite top surfaces thereof. Each of the discharge electrodes 8 is of a so-called Rogowskii type having a flat top surface 8a having a curved periphery 8b, and provided with a number of small holes. Flanges 8c formed around the base ends of

the discharge electrodes 8 are seated on the peripheries of the openings 10 and 12, respectively. The electrode bases 9 have the shape of a cap and are jointed to the peripheries of the openings 10 and 12 so as to hold the flanges 8c of the discharge electrodes 8 on the peripheries of the openings 10 and 12 and to close the openings 10 and 12, respectively. The openings 10 and 12 may be sealed by soldering the flanges 8c of the discharge electrodes 8 held by the electrode bases 9 to the metallized surfaces 15 of the peripheries of the openings 10 and 12, respectively. A gas-charging pipe 16 connected to the electrode base 9 is sealed with a sealant after charging the insulating tube unit 7 with the inert gas.

Since the diameters R_2 of the openings 10 and 12 formed at the opposite ends of the insulating tube unit 7 are smaller than the diameter R_1 of the other portion of the tube 11, the electrode bases 9 having a comparatively small diameter, hence a comparatively small area, can be used for sealing the openings 10 and 12 after inserting the perforated discharge electrodes 8 of a Rogowskii type through the openings 10 and 12 in the insulating tube unit 7, so that the gas-filled discharge tube 2 can be formed in a comparatively small length without entailing increase in the capacitance, because the capacitance between the electrode bases, hence the capacitance of the gas-filled discharge tube 2, is comparatively small.

The insulating tube unit 7 thus constructed has a comparatively large surface area so that electric discharge passed along the surface of the insulating tube unit, i.e., so-called creeping discharge, can be prevented. An electric discharge can stably be passed between the discharge electrodes 8 of a Rogowskii type at a comparatively high firing potential even if the discharge electrodes 8 are disposed with a small discharge gap.

Second Embodiment

Referring to Fig. 2, a gas-filled discharge tube 2 in a second embodiment according to the present invention is substantially the same in construction as the gas-filled discharge tube 2 in the first embodiment, except that the gas-filled discharge tube 2 in the second embodiment employs an insulating tube unit 7 consists of two short tubes 19. One end of each of the short tubes 19 is reduced to form an opening 17 of a diameter R_2 smaller than the inside diameter R_1 of the short tube 19. The edge of the fully open end of one of the short tubes 19 is cut to form an external taper surface 18, and the edge of the fully open end of the other short tube 19 is cut to form an internal taper surface 18; the taper surfaces 18 are joined

closely when the short tubes 19 are joined together with glass frit or the like to construct the insulating tube unit 7.

The effects and advantages of the gas-filled discharge tube 2 in the second embodiments are the same as those of the gas-filled discharge tube 2 in the first embodiment.

Although the invention has been described in its preferred forms with a certain degree of particularity, obviously many changes and variations are possible therein. It is therefore to be understood that the present invention may be practiced otherwise than as specifically described herein without departing from the scope and spirit thereof.

Claims

1. A gas-filled discharge tube comprising:
 - an insulating tube unit having a tube formed of an electrically insulating material and having openings in opposite ends thereof;
 - a pair of electrode bases closely attached to the opposite ends of the tube unit so as to seal the openings, respectively;
 - a pair of discharge electrodes attached respectively to opposite inner surfaces of the electrode bases to form a series gap; and
 - an inert gas filling the insulating tube unit;
- characterized in that the diameter of peripheries of the openings covered with the electrode bases is smaller than the inside diameter of the tube.
2. A gas-filled discharge tube according to Claim 1, wherein the tube of the insulating tube unit consists of two shorter tubes, one end of each of the shorter tubes is reduced to form the opening.
3. A gas-filled discharge tube according to Claim 1 or 2, wherein the discharge electrodes are perforated discharge electrodes of a Rogowskii type.

FIG. 1

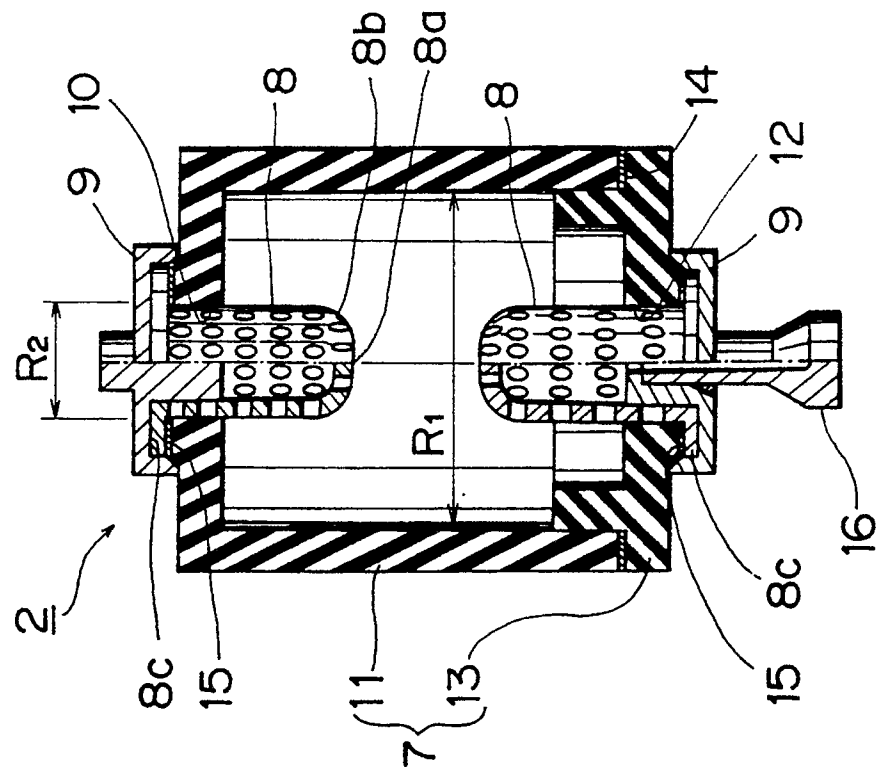


FIG. 2

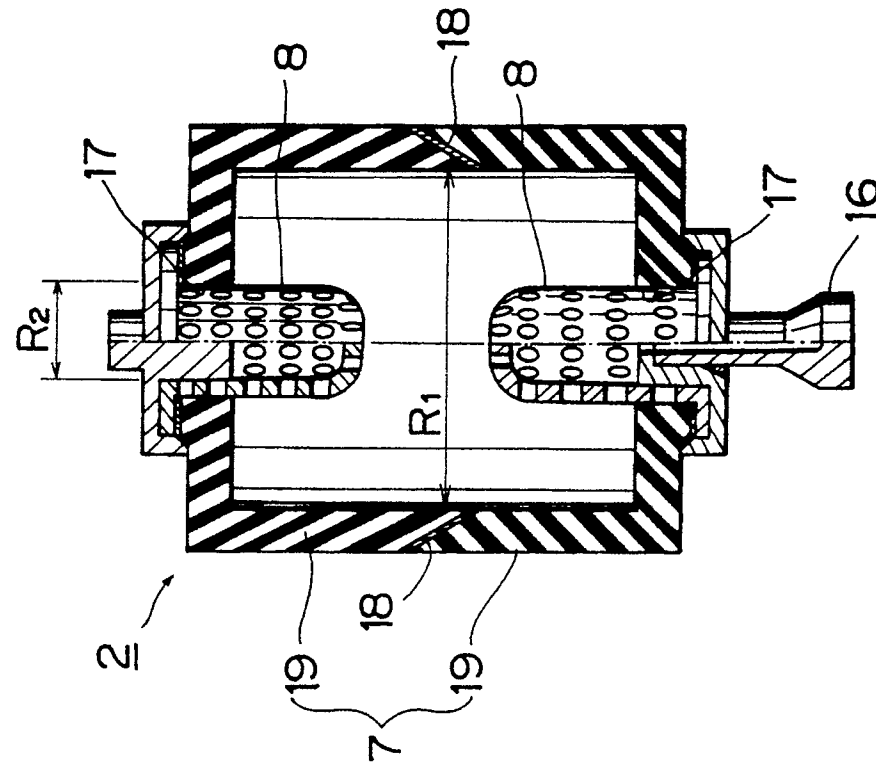


FIG. 3

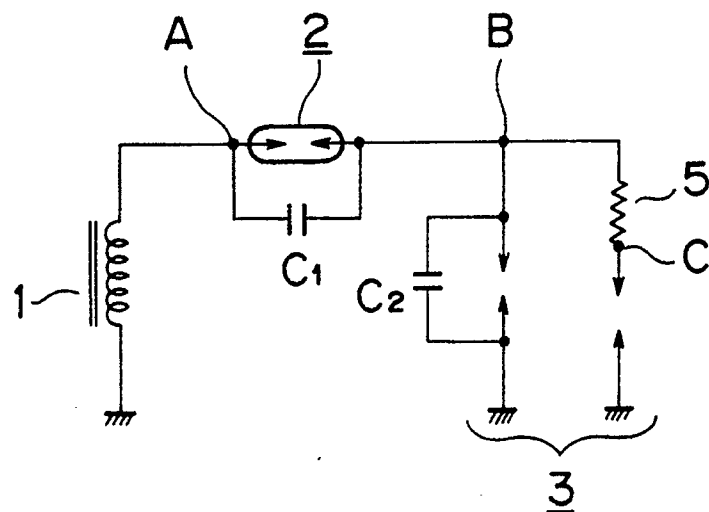


FIG. 4

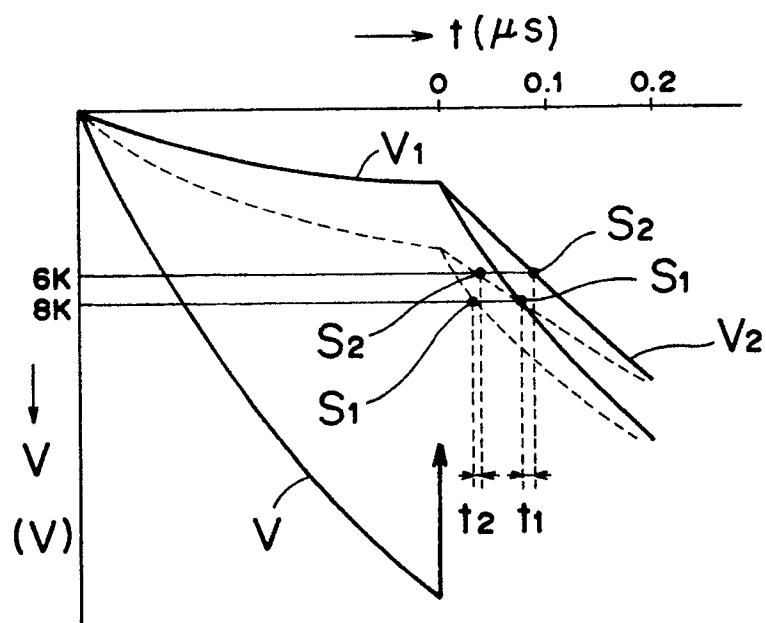


FIG. 5

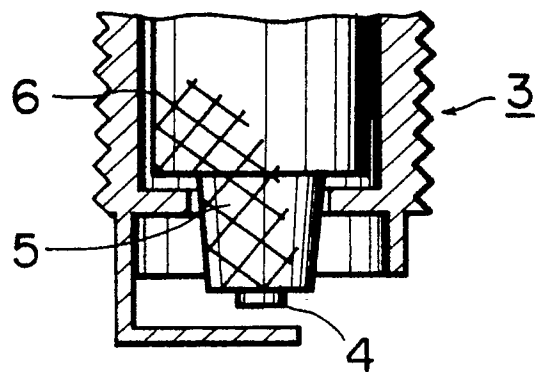


FIG. 6

