

[54] **IGNITION PLUG WITH AUXILIARY ELECTRODE**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **313/131 R**, 313/140, 313/141, 313/143

[51] **Int. Cl.** **H01t 13/02**

[58] **Field of Search** 313/118, 123, 124, 130 R, 313/141, 143, 140; 123/169 EL, 169 R

[57] **ABSTRACT**

An ignition plug having a center electrode, an insulator surrounding the center electrode, and a metal plug surrounding the insulator and having a ground electrode and opposing the center electrode; further, the plug comprises an auxiliary ground electrode provided with an anti-fouling gap against the insulator surrounding the center electrode at the tip end of the metal plug.

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8 Claims, 7 Drawing Figures

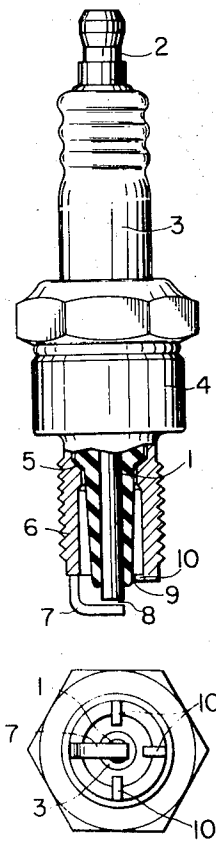


FIG. 1

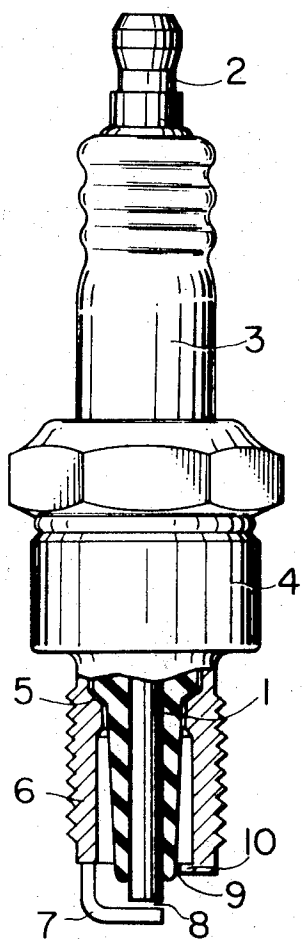


FIG. 2

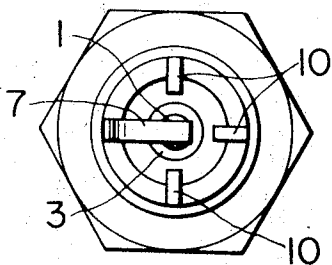


FIG. 3

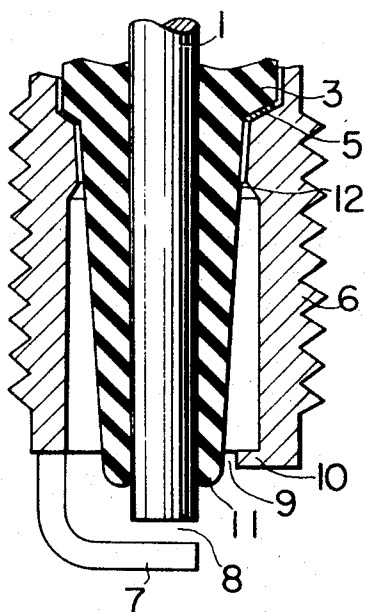


FIG. 4

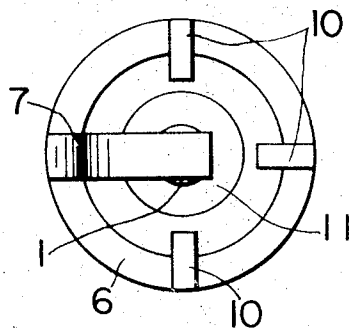


FIG. 5

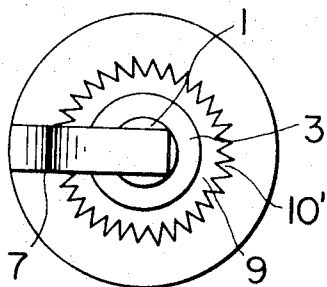


FIG. 6

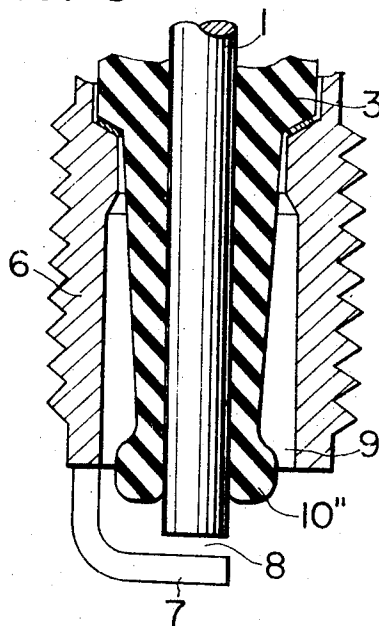
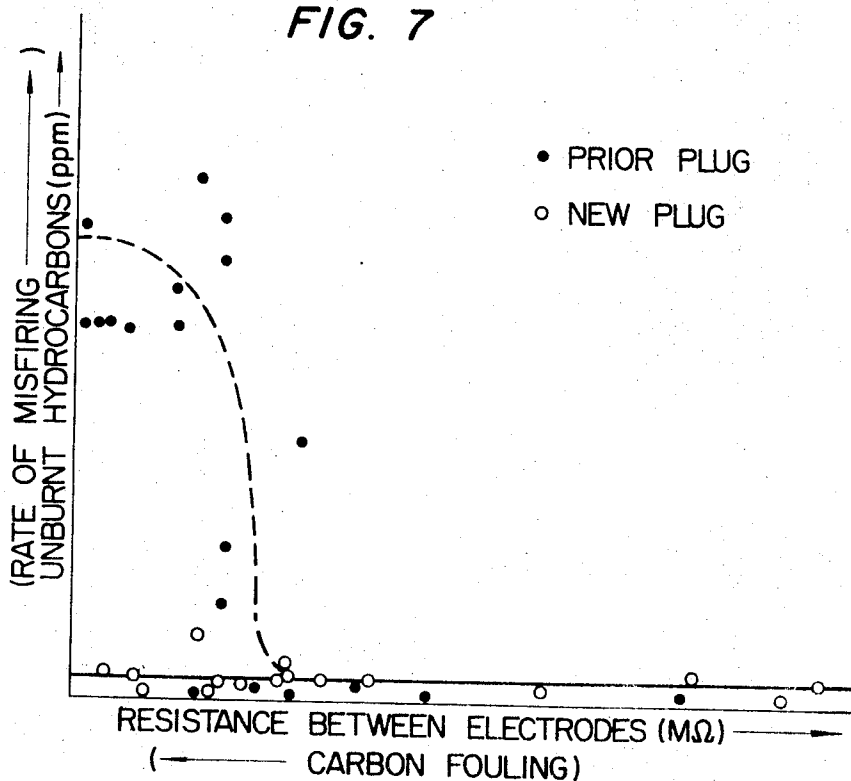


FIG. 7



IGNITION PLUG WITH AUXILIARY ELECTRODE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an improved spark plug for use in internal combustion engines.

2. Description of the Prior Art

Generally, when a spark-ignition engine is operated at low speed operation or when the engine is in a cold condition, the temperature of the ignition plug is also low. Combustion then becomes imperfect, so that carbon is deposited around the electrode, causing the insulation resistance between the electrodes to be reduced. This makes it difficult to generate a spark between the spark gap, so that the gas mixture may not be ignited. This phenomenon is called "carbon fouling." When a type ignition plug is used to avoid this carbon fouling, the electrode temperature of the spark plug becomes high during high speed operation and sometimes the gas mixture may be ignited spontaneously before the spark ignition. Accordingly, the carbon fouling of the ignition plug could not be avoided.

For this reason, to improve the ignition performance when the ignition plug became carbon-fouled, various systems have been adopted, such as the use of a capacitor discharge ignition system, or burning off the carbon deposit on the surface of the insulator using a surface discharge plug, or a combination of these systems. In the capacitor discharge ignition system, however, the ignition performance becomes inferior to the conventional system when the ignition plug is in a normal condition; in the surface discharge plug system, the ignition performance is likewise poor, and when fuel in liquid form adheres on the surface between electrode of the surface discharge plug, the ignition performance becomes even more deteriorated. On the other hand, improvements on the ignition plug itself have been made. For example, it has been known to use a colder type of ignition plug for engines operated at higher temperature, and a hotter type of plug for engines operated at lower temperatures; the rate of this burning is expressed as a "heat range." At present, research has been carried out to obtain ignition plugs having a wide heat range, but it cannot be said to be sufficient as yet.

SUMMARY OF THE INVENTION

In view of such problems, the object of the present invention is to provide an ignition plug which has a sufficient ignition performance even in the case where the plug is in a carbon fouled condition, and which will not fail to ignite the gas mixture.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevation, partly in section, showing an ignition plug according to the present invention;

FIG. 2 is a plan view of the electrode portion;

FIG. 3 is a partly enlarged section of a carbon fouled condition of the ignition plug according to the present invention;

FIG. 4 is a plan view of the electrode portion of FIG. 3;

FIG. 5 is a plan view showing another embodiment of the electrode portion according to the present invention;

FIG. 6 is an enlarged section showing the essential part of a further embodiment; and

FIG. 7 is a graph showing differences in the degree of carbon fouling as well as the rate of ignition performance due to misfire for the conventional and the present ignition plugs.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The ignition plug according to the present invention will now be described in detail referring to the drawings. The ignition plug comprises a center electrode 1, having a terminal 2. An insulator 3 surrounds the center electrode 1, and a metal plug 4 surrounds the insulator 3 through a packing 5, plug 4 being formed with a threaded portion 6 to be screwed into a cylinder head (not shown). A ground electrode 7, which is opposite the center electrode 1, is connected to the metal plug 4. A primary spark gap 8 is provided between the center electrode 1 and the ground electrode 7.

An auxiliary ground electrode 10 forming a secondary spark gap 9 for anti-fouling, according to the present invention, is provided between the tip end of the threaded portion of plug 4 and the insulator 3 surrounding the center electrode 1. A number of auxiliary ground electrodes 10 are provided, in the embodiment shown in FIGS. 1 and 2, on the periphery of the end surface at the threaded portion 6 on the metal plug 4. The tip end of each auxiliary electrode 10 is pointed or rounded, as occasion demands. The spark gap 9 for anti-fouling amounts to about 0.5 mm, which is selected to be smaller than spark gap 8.

The function of the spark plug according to the present invention will now be described. When the spark plug is not in a carbon fouled condition, and a voltage is applied across the center electrode 1 and the ground electrode 7, a spark is produced at the spark gap 8 and the gas mixture is ignited. However, when an imperfect combustion occurs in the combustion chamber, carbon deposit 11 is formed on the surface of the insulator, as shown in FIGS. 3 and 4. As the insulation between the center electrode 1 and the threaded portion 6 deteriorates, a spark will fail to occur at the spark gap 8 when a voltage is applied across electrodes 1 and 7. The electric current supplied from the terminal 2 flows from the center electrode 1 to the threaded portion 6 of the plug 4 through the carbon deposit 11. For this reason, in the conventional ignition plug, the spark will fail to occur, and therefore the gas mixture will not be ignited.

In the ignition plug according to the present invention, however, auxiliary ground electrodes 10 are provided. The electric field at the anti-fouling spark gap 9, between the insulator 3, on which carbon deposit 11 is formed, and the auxiliary electrode 10, is intensified, a spark is produced at the auxiliary gap, and the gas mixture is ignited. In this case, although a current flows at the portion 12 on the side of the packing 5 through carbon deposit 11 on the surface of the insulator to the metal plug 4, since the voltage drop from the center electrode to the neighborhood of the anti-fouling spark gap 9 is very small as compared with the voltage drop from the center electrode 1 to said portion 12, a sufficient spark discharge is provided at this anti-fouling spark gap 9. By this electric discharge, the gas mixture is ignited, the carbon deposit 11 is burned with the combustion gas, and a self-cleaning of the ignition plug is obtained.

The discharge is provided more easily when the tip end of this auxiliary electrode 10 is pointed, and cool-

ing effect on the flame kernel is small and it is advantageous to the ignition in this case. Also, since the auxiliary electrode discharges only under fouled conditions, less problem occurs as to the consumption of the auxiliary electrode even if the pointed tip is used. Furthermore, it is advantageous to arrange a number of auxiliary electrodes at the end of the threaded portion, because, in some cases, the carbon fouled condition on the insulator is not uniform. In this case, however, due consideration should be taken not to hinder the scavenging of burnt gas, and also not to increase the cooling of the flame kernel.

An embodiment in FIG. 5 shows an example where a teethhaped auxiliary ground electrode 10' is provided at the tip end of the threaded portion 6 of the plug 4, and FIG. 6 shows an example where a projection 10'' is formed on the side of the insulator 3, said projection serving as an auxiliary electrode.

FIG. 7 is a graph of the relationship between the insulation resistance between electrodes (or the degree of carbon fouling of a spark plug) and the concentration of the unburnt hydrocarbon in the exhaust gas (or the rate of misfiring); the larger the insulation resistance between the electrodes, the smaller the carbon fouling, and the larger the amount of unburnt hydrocarbon, the greater the rate of misfiring. According to the graph, it is seen that, in conventional ignition plugs, when the carbon fouling increases to a predetermined value, the unburnt hydrocarbon increases rapidly, causing the rate of misfiring to rise accordingly. On the other hand, with the ignition plug according to the present invention, the concentration of the unburnt hydrocarbon does not change greatly even when the carbon fouling increases considerably, and there is little, if any, possibility of misfiring.

Thus, with the ignition plug of the present invention, the ignition performance of the gas mixture will not be deteriorated; thus the amount of harmful exhaust gas, such as unburnt hydrocarbon, produced is considerably reduced. It is known that by providing an exhaust gas recirculation system or ignition time delaying device as the exhaust purifying means, the combustion temperature is lowered, and the carbon fouling condition is easily produced. In this case, however, even when carbon fouling may occur, the ignition of the gas mixture is always assured by the ignition plug of the present invention, so that overheating of the exhaust gas purifying catalyser is prevented, and the danger of vehicle fire or deterioration of the catalyser can be prevented. Moreover, the ignition performance to the gas mixture is excellent, and the carbon is burnt off by electric current flowing over the insulator, so that recovery from a carbon fouling condition of the ignition plug is improved

remarkably. Since the auxiliary ground electrode is short, cooling is excellent and no abnormal combustion will be produced.

What is claimed is:

1. An ignition plug, comprising:

a center electrode;

an insulating member surrounding at least a portion of said center electrode;

a mounting member surrounding at least a portion of said insulating member and adapted for mounting said ignition plug in an operating condition;

a ground electrode coupled to said mounting member and disposed adjacent to and spaced from an end portion of said center electrode to form a primary spark gap therewith; and an auxiliary electrode defining a secondary spark gap between the end portions of said insulating and mounting members adjacent said primary spark gap, wherein said secondary spark gap is selected to be smaller than said primary spark gap.

2. A ignition plug according to claim 1, wherein said auxiliary electrode comprises a radially inwardly extending end portion of said mounting member, said secondary spark gap being defined between the tip of said radially extending end portion and said insulating member.

3. An ignition plug according to claim 2, further comprising a plurality of auxiliary electrodes defining said secondary spark gap, each of said auxiliary electrodes comprising radially inwardly extending end portions of said mounting member.

4. An ignition plug according to claim 3, wherein adjacent ones of said plurality of auxiliary electrodes are displaced substantially orthogonally with respect to each other.

5. An ignition plug according to claim 2, wherein the tip end of said auxiliary electrode is pointed.

6. An ignition plug according to claim 2, wherein the tip end of said auxiliary electrode is rounded.

7. An ignition plug according to claim 1, wherein said auxiliary electrode comprises a tooth-shaped radially inwardly extending end portion of said mounting member surrounding said insulator member and forming therewith said secondary spark gap.

8. An ignition plug according to claim 1, wherein said auxiliary electrode comprises a radially inwardly extending end portion of said mounting member, said secondary spark gap being defined between the tip of said radially extending end portion and said insulating member such that a spark will occur in only one of said primary and secondary spark gaps at a given time.

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