Nov. 3, 1970 KUNIO TERAO 3,538,372

WIDE GAP DISCHARGE SPARK PLUG

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Fig. 1.

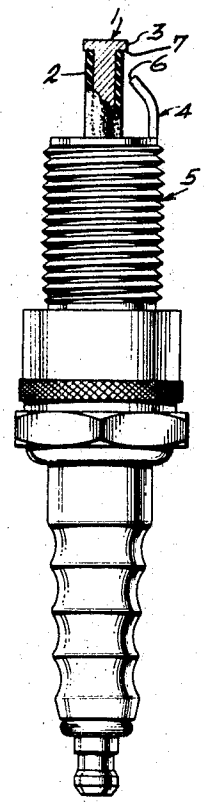


Fig. 2.

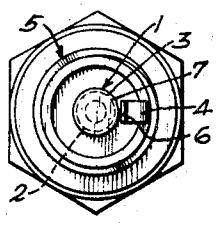


Fig. 3.

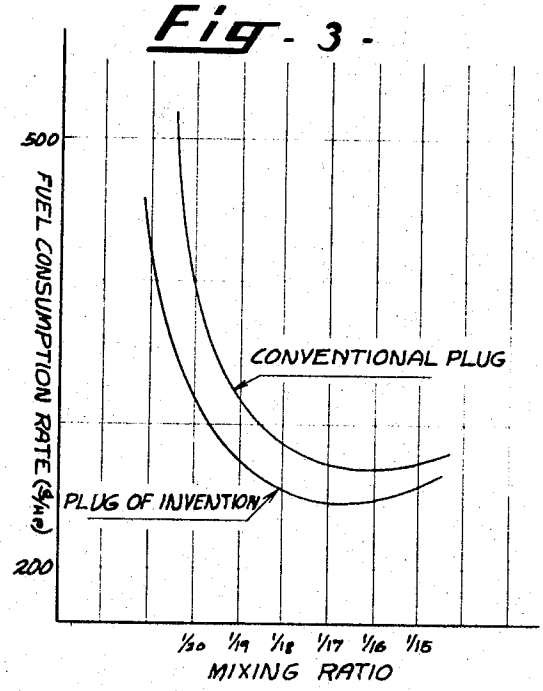
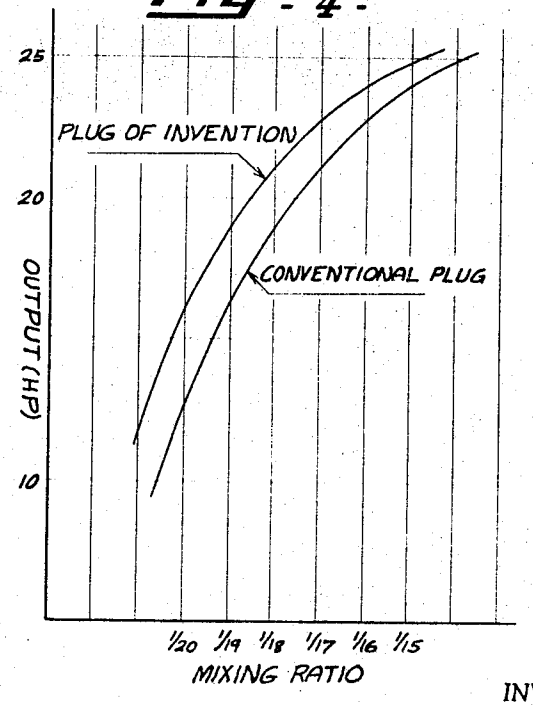


Fig. 4.



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Fig - 5 -

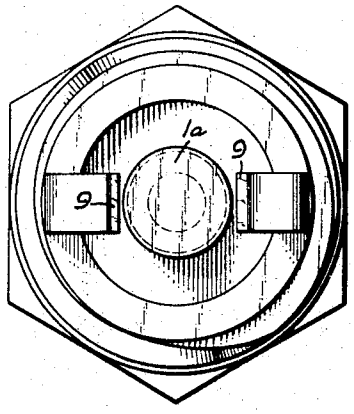


Fig - 7 -

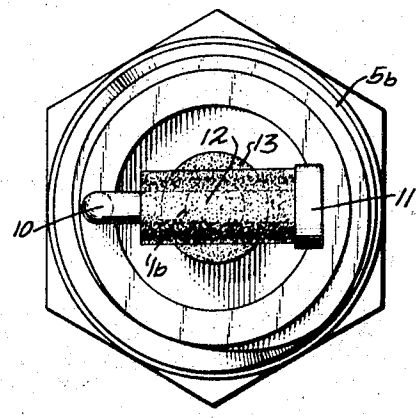


Fig - 6 -

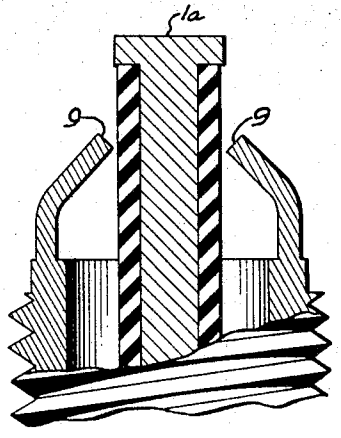
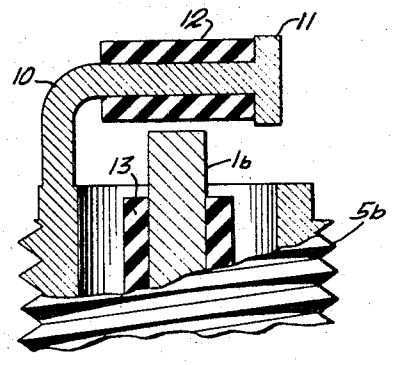


Fig - 8 -



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United States Patent Office 3,538,372 Patented Nov. 3, 1970

3,538,372

WIDE GAP DISCHARGE SPARK PLUG

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Filed Jan. 8, 1968, Ser. No. 696,385
Int. Cl. H01t 13/32, 13/52
U.S. Cl. 313—131 5 Claims

ABSTRACT OF THE DISCLOSURE

A wide gap spark plug for generating a strong spark across a gap of two or three times the width of the gap on a conventional type of spark plug without loss of electrostatic energy for generating the sparks. A strong spark across a wide gap as provided by the spark plug of this invention has the ignition energy sufficient to ignite a mixture of fuel and air in a most efficient proportion to provide improved combustion for greater economy and to decrease air pollution.

This invention relates to an improved spark plug for internal combustion engines and, particularly, to a spark plug for discharging across a relatively wide gap in relation to prior art spark plugs.

The spark gap or the distance between the electrodes of a spark plug for internal combustion engine depends primarily upon the potential difference or voltage which has been established between the electrodes of the spark plug, the gap being ordinarily approximately 0.6 mm. to 0.9 mm. However, a gap of such short distance is not adequate to generate sparks of maximum ignition energy for igniting a mixture of fuel and air in the most efficient proportions. Therefore, most internal combustion engines are operated by much thicker mixed gases than that which is theoretically required.

When the volume ratio of fuel to air exceeds a predetermined proporation, imperfact or incomplete combustion will occur with an accompanying exhaust of noxious combustion gases thereby adding pollution to the atmosphere and causing a loss of efficiency and waste of combustible materials.

If a long spark of strong ignition energy is generated across a wider inter-electrode gap, the actual volume of the mixed gas exposed to the spark and activated thereby is increased substantially and the fuel gases will burn more evenly and perfectly in a short time and, therefore, the above mentioned disadvantages would be removed. On the other hand, if only the distance between the electrodes is increased and a larger gap thus achieved, there is an accompanying loss of energy resulting in incomplete ionization of air between the electrodes which in turn reduces the spark generating power. If conventional spark plugs are utilized with increased gaps, the enlarged gap will accelerate the diffusion of activated mixed gases; thus, the amount of mixed gases as the source of ignition will be reduced and the ignition capacity will be lowered.

A principal object of this invention is to provide an improved plug for generating a strong spark across an enlarged gap preferably in the order of 2 or 3 times the width of the gap of a conventional plug to increase the utilization of the energy of the mixture on ignition by the electrostatic energy of the generated spark.

A further object of the invention is to provide an improved spark plug of the type which includes a first or central electrode and a second or ground electrode, the first electrode having an outer terminal end free of insulation and an intermediate portion coated with insulating material and the second electrode having a tip end adjacent the outer surface of the intermediate insulated portion and spaced from the outer surface of the jacketed first electrode a distance which is less than the distance from the terminal end of the ground electrode and the uninsulated terminal end of the first or central electrode. The shapes and sizes of both electrodes as well as the insulating coating jacketing the intermediate portion of the central electrode and the relationship of the distances between the electrodes, it will be seen, are so designed that there exists no insulation on the line of the shortest distance between the terminal or tip ends of both electrodes, notwithstanding the fact that the distance from the central elecrode through the insulating coating or jacket to the tip end of the ground electrode is shorter or less than the distance between the uninsulated tip ends of the electrodes.

It is a general object of this invention to provide an improved spark plug which is simple in construction, inexpensive to manufacture, provides for improved fuel consumption, and is adapted for use in increasing spark plug performance and of power plants on which it is installed.

It is another object of this invention to provide an improved spark plug which is characterized by a first central electrode, the intermediate portion of the length of which is jacketed by insulating material and a second or ground electrode having a tip end at about the medial portion of the length of the insulating material and spaced from the outer surface of the first electrode a distance which, as measured from the tip of the second electrode through the insulating material, is less than the distance from the terminal ends of the electrodes, and to provide various preferred configurations for achieving the results described herein which derive from the improved spark plug construction.

Other objects and advantages of this invention will become apparent from the following detailed description thereof when read in conjunction with the attached drawings in which:

FIG. 1 is a side elevation partly in section of the wide gap discharge spark plug of the present invention;

FIG. 2 is a plan view of FIG. 1;

FIG. 3 and FIG. 4 are diagrams showing the fuel consumption rate and output, comparing the test of the improved spark plug of the instant invention to a conventional plug;

FIG. 5 is a plan view illustrating a modified type of a wide gap discharge spark plug according to this invention;

FIG. 6 is a fragmentary side elevation, partly in section, of the plug of FIG. 5;

FIG. 7 is a plan view illustrating a further modification of a wide gap discharge spark plug; and

FIG. 8 is a fragmentary elevation, partly in section, of the plug of FIG. 7.

Referring first to the embodiment shown in FIGS. 1 and 2, the central eelctrode **1** extends through an insulator sleeve or jacket **2**, which is made of mica, hard porcelain, alumina porcelain or the like. The upper end of the central or first electrode **1** is provided with an enlarged head **3** which is not coated with insulation, that is, which is electrically conductive. The peripheral edge of the head **3** is preferably sized so as to extend radially beyond the neck portion of the first electrode and the outer surface of the insulation sleeve or packet **2**. A ground electrode **4** extends from the housing **5**, a distance substantially one-half the distance of projection or the height of the central electrode **1** from the end of the housing **5**. The terminal end **6** of the ground electrode **4** is turned inwardly, i.e., radially toward the longitudinal center line of the central electrode **1**, so that a slight gap is provided between the terminal end or upper end **6** and the outer surface of the insulation jacket **2**. It should be noted that, while the insulation jacket is provided on the intermediate length of the central electrode, the straight line distance be-

tween the tip ends of the ground electrode 4 and the uninsulated peripheral edge 7 of the head 3 is free and clear of obstruction by insulation in contrast to the insulation barrier caused by the intermediate jacket of insulation between the tip end 6 of the terminal 4 and the nearest portion of the electrically conductive central electrode 1.

In a preferred embodiment, a spark plug for general use and in accordance with the instant invention includes thread of approximately 14 mm. in diameter; and it is preferred that the height of the central electrode 1 is in the order of about 8 to 10 mm., the thickness of the head 3 about 1 to 1.5 mm., the diameter of the head 3 to 5 mm., the shortest distance between the head 3 and the upper end 6 of the ground electrode 4, 2 to 3 mm., the gap between the upper end 6 of the ground electrode 4 and the outer surface of the insulator sleeve or jacket 2, about 0.2 to 0.5 mm. Finally, the shortest distance between the upper end 6 of the electrode 4 and the central electrode 1 is fixed slightly shorter or less than that of the distance between the end 6 and the head 3.

In operation of the wide gap discharge spark plug of this invention, a considerable voltage is established between the upper end 6 of the ground electrode 4 and the central electrode 1; and an intense electric field is generated in the shortest distance between both electrodes 1 and 4 or between the upper end 6 of ground electrode 4 and the center electrode 1 at the plane through the insulating sleeve or jacket 2 which includes the upper end 6 of the electrode 4. The central electrode 1, however, being coated with the insulation material 2 and the gap being provided between the end 6 of the ground electrode 4 and the insulator 2, the voltage will not suddenly jump the gap but will ionize the air within the gap. This ionization of air progresses toward the weaker portion of the electric field. When the air between the upper end 6 of the ground electrode 4 and the head 3 of the central electrode 1 is ionized, the spark discharge will be taking place between the tip ends of the electrodes across the gap of approximately three times the width of a conventional plug. The mixed gases which are to be the source of iginition are thus ionized more extensively and substantially increased ignition energy is obtained to improve the capacity of ignition. This is in contrast to the conventional type of spark plug in which the ignition capacity of the mixed gases is lowered by rapid diffusion of activated mixed gases since there is no obstacle between both electrodes. According to this form of the invention, the insulator 2 is disposed between the electrodes at a side thereof for reducing the diffusion of activated gas resulting in improving the capacity of ignition.

It is to noted at this point that, if the upper end 6 of the ground electrode 4 were connected to the insulator 2, the insulator would be charged by low voltage and come into creeping discharge. However, the gap according to this invention which is provided between the upper end 6 of the ground electrode 4 and the insulator 2, requires high voltage for the ionization. The effect is that the discharge voltage is elevated with a consequent increase of ignition energy being obtained. A discharge voltage in the order of about 7,000 v. to 8,000 v. may be achieved in a plug of the preferred embodiment of the invention. Further, since the discharging path in the plug of the invention is spaced slightly apart from the periphery of the insulator 2, the flame nucleus is enlarged which improves ignition of the mixed gases.

The above mentioned features of the invention have been of proven effectiveness in the case of a decreased mixture of fuel to air. The comparative results of (a) the fuel consumption rate and the output of the plug of the invention and (b) a corresponding conventional plug are illustrated in FIGS 3 and 4. The data for use in constructing these graphs was taken from a test wherein the plugs were mounted in a water-cooled, four-cylinder engine with overhead valves and having a displacement of 1,200 cc.; and the engine was rotated at a rate of 3,000 r.p.m. As compared with a conventional plug this test demonstrates that, on the one hand, the ignition according to this invention was increased by approximately 5 percent in its output and a reduction of approximately 10 percent in its fuel consumption rate, when the fuel mixture ratio is of approximately 1:15; on the other hand, it has an increase of approximately 30 percent in its output and a reduction of approximately 30 percent in its fuel consumption rate, when the mixture ratio of fuel is of approximately 1:20.

In the wide gap discharge plug of FIGS. 5 and 6, two ground electrodes 9 are provided which are positioned on diametrically opposed sides of the electrode 1(a), each in the same manner as described in the plug referred to in FIGS. 1 and 2, that is, with the distance from the terminal ends, which is uninterrupted by insulation being greater than the direct distance between the tip end of the ground electrode and the central electrode through the insulating jacket. In the wide gap discharge plug of FIGS. 7 and 8, the same structure obtains generally; however, the upper portion of a ground electrode 10 is provided which extends upwardly from the housing 5(b) and is bent horizontally over the upper tip end of the central electrode 1(b). The electrode 10 has a flanged portion 11 at the tip end thereof. A porcelain insulator 12 is coated or jacketed around the horizontal portion of the ground electrode 10 over the upper end of central electrode 1(b). The central electrode 1(b) is coated with a porcelain insulator 13 except for the upper end portion thereof. In this construction, the spark is produced between the nearest portions of the upper end of the central electrode 1(b) and the flanged portion 11 of the ground electrode 10.

While the instant invention has been shown and described herein in what is conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of the invention, which is therefore not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent apparatus and articles.

What is claimed is:

1. A spark plug for producing a wide-gap discharge spark in a combustion chamber of internal combustion engines or the like comprising:

an elongated tubular housing having a terminal edge in a single plane;

a central electrode projecting axially from said tubular housing a substantial distance above said terminal edge;

at least one ground electrode projecting axially from the terminal edge of the housing and in radially spaced relation from said central electrode; one of said electrodes including a tubular insulating sleeve of uniform cross-section circumposed about said one electrode,

said one electrode projecting beyond said sleeve and terminating in a portion extending radially beyond the outer surface of said insulating sleeve, the other electrode terminating intermediately of said insulating sleeve and in relatively close proximity to said insulating sleeve,

the length of the gap between said radial edge portion of said one electrode and said other electrode being substantially greater than the distance from the center of said one electrode and the immediate end of said other electrode measured through said insulation sleeve.

2. The structure as claimed in claim 1 in which said tubular insulation is disposed about said central electrode.

3. The structure as claimed in claim 1 in which a second ground electrode projects axially from said terminal edge of the housing in diametrically opposed relation to the first-mentioned ground electrode.

4. The structure as claimed in claim 1 in which said portion projecting radially beyond the outer surface of said insulating sleeve comprises a terminal, enlarged head on the one electrode.

5. The structure as claimed in claim 1 in which said ground electrode extends vertically from the terminal edge of said sleeve and includes a laterial portion extending transversely above the terminal end of said other electrode.

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U.S. Cl. X.R.

313—141, 142; 315—59