United States Patent

[11] **3,567,987**

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[54] **SPARK PLUG CONSTRUCTION**
4 Claims, 3 Drawing Figs.

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[51] **Int. Cl.** **H01t 13/02,** H01t 13/46
[50] **Field of Search** 313/123, 130, 131, 140, 141; 315/32, 35, 36, 51, 52

[56] **References Cited**
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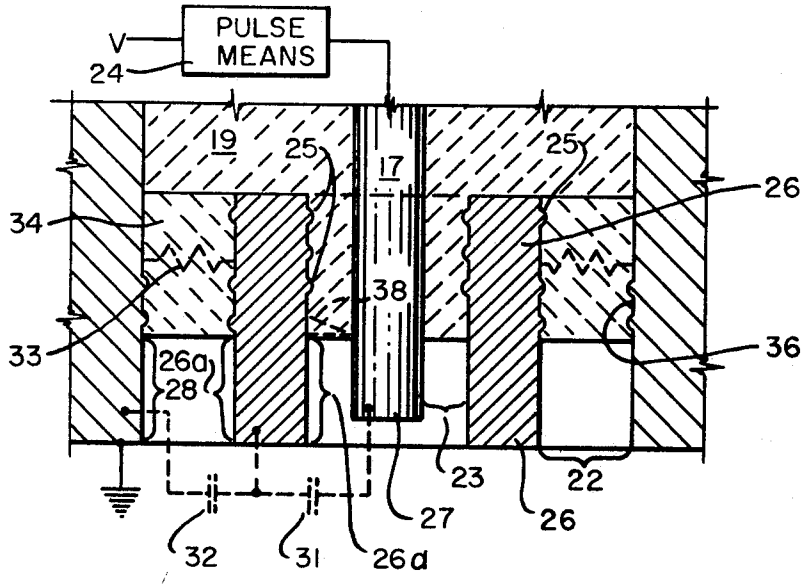
ABSTRACT: A spark plug construction of a type for use in a cylinder of an internal combustion engine includes a plurality of three concentric electrodes forming a pair of spark gaps. An annular resistance element encircles the intermediate electrode so as to discharge the capacitance defined between the intermediate and outer electrodes between successive firings of the gap therebetween.



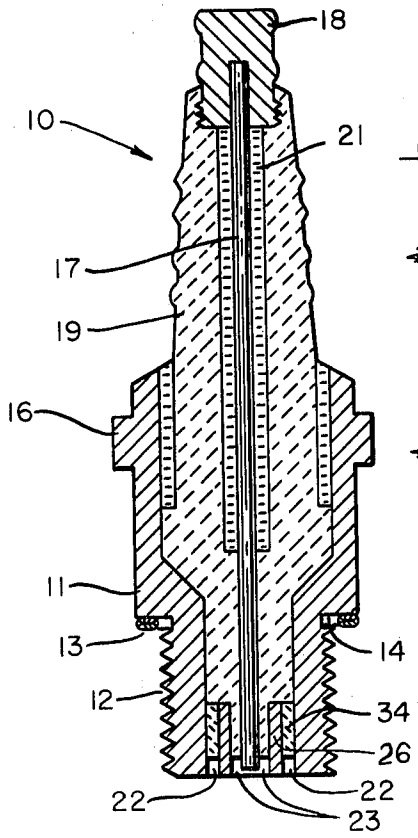


FIG. 1

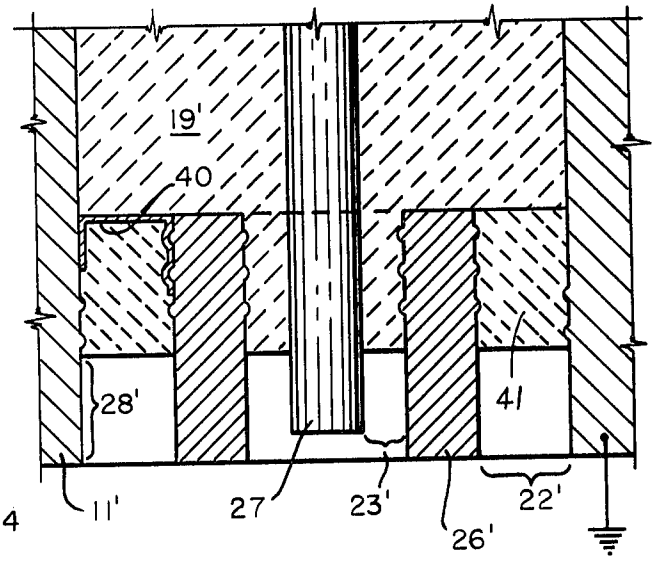


FIG. 3

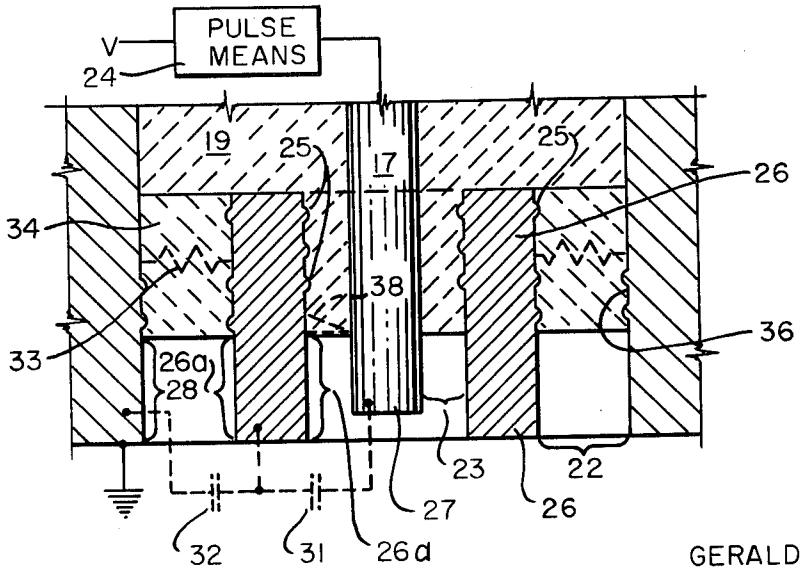


FIG. 2

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SPARK PLUG CONSTRUCTION

BACKGROUND OF THE INVENTION

This invention pertains to a spark plug construction, and more particularly to that type of spark plug customarily employed in the cylinder of an internal combustion engine.

As is known, spark plug constructions of the foregoing type generally include means for forming a gap between a pair of electrodes whereby whenever a predetermined potential is applied across the gap, a spark will be discharged from one of the electrodes to the other. Customarily, the outer electrode is grounded to the engine while the inner electrode is connected to a voltage supply derived from the electrical system of the installation. Thus, the two electrodes form a portion of the spark generating circuit defined between first and second voltage levels, wherein the second level is usually ground.

SUMMARY OF THE INVENTION AND OBJECTS

It is a general object of the present invention to provide an improved spark plug construction of the foregoing general type.

It is another object of the invention to provide an improved spark plug construction incorporating a plurality of spark gaps therein.

A further object of the invention is to provide a spark plug construction including a plurality of spark gaps wherein the series capacitance of the gaps has been decreased by means of a resistance element encircling the intermediate electrode.

These and other objects of the invention will be more readily apparent from the following detailed description of a preferred embodiment, according to the invention.

In general, there has been provided a spark plug construction of the above type employing a plurality of three electrodes forming a pair of spark gaps wherein a resistance element is disposed in parallel with the capacitance defined between two adjacent ones of the electrodes and wherein the resistance element is of sufficiently high value to cause a spark to occur in the second gap whenever the gap is pulsed and, it further serves to quickly discharge the capacitance between successive pulses applied to the plug. In this manner the voltage level required to be applied between the inner and outer electrodes for forming sparks in the gaps may be lowered.

BRIEF DESCRIPTION OF THE OF THE DRAWINGS

FIG. 1 is an elevation view, in centerline section, showing a spark plug construction according to the invention.

FIG. 2 is an enlarged schematic detailed view of the spark-forming region of the spark plug construction shown in FIG. 1.

FIG. 3 is an enlarged schematic detailed view of the spark-forming region of another embodiment of the construction shown in FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to the drawing, a spark plug construction is shown composed of a conventional shell **11** which is usually of steel or other conductive material. Shell **11**, of course, includes threads **12** adapted to be screwed into the cylinder block of an internal combustion engine sufficiently so as to dispose the lower end of shell **11** within a portion of the combustion chamber or cylinder of the engine (not shown). Typically, a sealing gasket **13** forms a gastight seal between the shoulder **14** of shell **11** and the seating portion (not shown) of the cylinder block.

Wrench flats **16** are disposed around shell **11** whereby the shell and plug construction can be removed from the cylinder block.

A central electrode **17** composed of an elongated cylindrically shaped rod element extends longitudinally of the plug construction **10** and is adapted to be connected to a source of high voltage, schematically indicated in FIG. **2**, as the initial V.

Thus, at the upper end of electrode **17**, there is provided the usual terminal stud **18** of conductive material having the usual shape adapted to receive a connector (not shown) leading to the supply voltage V.

Electrode **17** is coaxially disposed within an insulative body **19** of rigid insulating material, such as the usual ceramic material employed in conventional spark plugs.

Sealing material, such as Sillment seal material **21**, fills the annular void defined between the interior of body **19** and the exterior of electrode **17**.

At the lower end of plug construction **10**, as shown, means have been provided for forming a pair of concentrically disposed annular spark gap regions **22, 23** whereby a plurality of sparks may be generated for each pulsing of the plug construction. Thus, as schematically shown in FIG. **2**, the usual pulsing means **24** is indicated as being disposed between the voltage supply source V and electrode **17**. A high voltage pulse may be applied to the center electrode **17** from the usual ignition coil of conventional design, or other suitable high voltage source having an output on the order of 10 to 50 kilovolts, depending upon the type of system in which the plug construction is to be employed.

Gaps **22, 23** have been formed by means of a cylindrically shaped electrode element **26** coaxially disposed about the lower end of electrode **17** by attachment to a portion of body **19**, as by means of ribs **25** formed with element **26** and embedded into body **19**. The exposed lower end of electrode element **26** includes a right cylindrical portion **26*a*** which forms a uniformly spaced gap **23** around tip **27**. Portion **26*a*** also confronts the annular firing rim portion **28** so as to define the uniformly spaced gap **22** extending continuously therearound. Rim portion **28** is, of course, part of shell **11** and, accordingly, is usually coupled to ground potential.

With the construction as thus far described, if it is to be assumed that a relatively high voltage level is applied to electrode **17** and a relatively low voltage level, such as ground potential, is applied to the firing rim portion **28**, it is readily apparent that electrode **26** forms a conductive portion of the spark discharge path as would be otherwise defined between electrode **17** and rim **28**. In the event that electrode **26** were not otherwise connected to one or the other of the two voltage levels, it could be stated that electrode **26** is disposed in a truly electrically "floating" condition. Thus, by applying sufficient voltage between electrodes **17** and **28**, a spark can be formed between the two electrodes **17** and **26** and subsequently discharged again between electrode **26** and rim **28**.

A certain amount of capacitive reactance is to be found between the closely spaced wall surfaces of the coaxially disposed annular components noted above. Accordingly, as shown in FIG. **2**, capacitors **31, 32** representative of this reactance are indicated in invisible lines between the electrodes. It has been observed that where capacitance **32** is sufficiently large, a time delay can occur between the formation of a spark in gap **23** and its subsequent formation in gap **22**. Thus, it will be evident that after a spark has been formed across gap **23**, the charging time for capacitor **32** can cause undue delay in the generation of an additional spark across gap **22**.

Means have, however, been provided herein for forming a leakage resistance **33** serving to rapidly discharge the capacitor **32** between successive pulses applied between electrode **17** and the electrode formed by shell **11** at the rim portion **28**. In this manner the required differential between the voltage level of source V and ground, as connected to shell **11**, is also reduced.

The value of resistance for resistor **33** is sufficiently low to accomplish the desired discharging of capacitor **32** between rapidly occurring pulses on the one hand while being sufficiently high to cause a spark to occur in gap **22** rather than to be merely shunted through resistance **33**.

Thus, a right cylindrically shaped annular resistor element **34** has been coaxially disposed between electrodes **26** and the cylindrical inner surface **36** of shell **11**. Resistance element **34**

can be made by suitable known procedures, as for example, from a high temperature ceramic material suitably doped or treated with a conductor or resistive substance so as to give the element the required electrical resistance desired as means measured through its wall thickness. Further, it is to be appreciated that the radial thickness of the wall of resistance element 34 is uniform so as to maintain resistance between the two electrodes substantially uniform for all radii of element 34.

As now to be explained, a spark plug construction 10 as disclosed above provides not only a plurality of sparks, but also has the advantage that the sparks discharged in each of the two gaps 22, 23 rarely occur for any sustained period at the same location, but occur randomly distributed about gaps 22, 23 so as to prolong the life of the spark plug.

Resistance element 34 enables the spark plug to be operated at a lower threshold voltage than if it were not present, inasmuch as it serves to decrease the series capacitance of the two concentric gaps 22, 23. Thus, its presence facilitates the breakdown, or discharge, of a spark by discharging the series capacitance of capacitor 32 or otherwise defined between the middle and ground electrodes 26, 28 respectively, but does not inhibit in any way the formation of the two sparks for each pulsation of voltage between electrodes 17 and rim 28.

In addition, it has been observed that the reliable breakdown threshold voltage necessary to produce a spark discharge in the above construction is considerably lower than for a conventional construction. The excess voltage present is, therefore, higher and results in a hotter spark being generated with cm commensurate efficiencies in combustion. Further, the resistance to element 34 serves the additional function of allowing the plug to be fired at a more rapid repetition rate without failure than would otherwise be present and is particularly important at high engine r.p.m.

In operation, the spark plug construction 10 is assumed to be disposed within a cylinder head of an internal combustion engine. The pulsing means 24 serves to apply to the center electrode 17 a high voltage pulse. The applied high voltage pulse causes a flow of electrons from electrode 17 due to corona discharge and field emission and this initiates breakdown between the two electrodes 17, 26. The source of electrons may be optimized by giving the tip 27 any one of several selected shapes of a type serving to cause the tip to present a sharp edge.

A radial spark is then formed in gap 23 following the application of high voltage pulse to electrode 17. In the corona process preceding breakdown of gap 23, photoelectrons are produced which facilitate the immediate breakdown of the second gap 22 when it is subjected to the excess voltage as caused by the breakdown of gap 23. For example, as schematically shown in FIG. 2 in dotted lines, after the discharge of a spark in gap 23, the electrode 17 is coupled as though an imaginary switch 38 had been moved to form a short circuit between the electrode 17 and electrode 26. Such a connection would, of course, cause the entire voltage drop between source V and ground to be placed across the gap 22 and this overvoltage immediately results in a radial spark formed in the gap 22.

As noted above, the spark discharges in gaps 22, 23 are not confined to any specific portion of the two concentric gaps but may take place at any and all radii successively. Thus, since successive spark discharges rarely occupy the same position, physical wear on the gap surfaces is evenly distributed over the entire annular surface thereof. In the event that one particular location should become worn more rapidly than other portions, the gap spacing at that particular location would immediately increase thereby forcing the next spark to seek a breakdown point on the annular surface where the gap spacing is at a minimum.

Since two sparks occur, separated very shortly in time, combustion is more efficient resulting in less fouling of the spark plug due to buildup on the gap surfaces of the products of incomplete combustion. Further, it is to be observed that in the event an electrical short circuit should develop between the electrodes 17 and 26, a spark discharge will still be available between electrode 26 and rim 28. Further, if a highly conducting path should develop between rim 28 and electrode 26, it is apparent that a spark will still occur between electrodes 26 and 17.

According to another embodiment as shown in FIG. 3, element 34 has been replaced by a resistance element comprising a semiconductive path of film formed as a radial band 40 secured to an insulative ceramic filler element 41. Band 40 may be prepared by deposit of a conductive film upon filler element 41 in known manner or can consist of a separate component. Band 40 is then connected across gap 22' defined between electrode 26' and shell 11'. The space previously occupied by element 34 may be filled with insulating ceramic material of body 19' or, as shown, the separate ceramic filler element 41 can be employed. In either event, resistor 40 is essentially embedded in the insulating body of the plug.

The foregoing embodiment, in certain circumstances, may entail advantages in manufacturing procedures associated with the production of spark plugs, according to the invention herein.

I claim:

1. In a spark plug construction of a type for use in a cylinder of an internal combustion engine and adapted to form and a portion of a spark generating circuit defined between first and second voltage levels, first, second and third substantially coaxially disposed spaced electrodes forming first and second gaps, respectively, between said first and second and said second and third electrodes, said first electrode being adapted to be connected to the first voltage level and said third electrode being adapted to be connected to the second voltage level to form a predetermined potential between said first and third electrodes adapted to apply pulses thereof between said first and third electrodes for forming sparks in the gaps between said first and second and between said second and third electrodes, said electrodes and gaps defining capacitance of measurable time charging value disposed in series between said fit first and third electrodes, and a resistance element in parallel with the capacitance defined between two adjacent ones and said electrodes, said resistance element having a sufficiently high value to cause a spark to occur in the second gap when said potential is coupled between said first and third electrodes, and further serving to discharge the last named capacitance between successive pulses applied between said first and third electrodes so as to lower the required differential between said levels for forming a spark in said gaps.

2. A spark plug construction according to claim 1 wherein said adjacent electrodes include said second and third electrodes and said resistance element comprises an annular element of electrical resistance material encircling said second electrode, said material and the thickness and configuration of said element serving to provide between said second and third electrodes substantially uniform electrical resistance values distributed evenly about said electrode.

3. A spark plug construction according to claim 1 further including an insulating body portion of the spark plug between said second and third electrodes, and wherein said resistance element comprises a semiconductive path formed by a resistor embedded in said body portion.

4. A spark plug construction according to claim 1 wherein said second and third substantially coaxially disposed spaced electrodes are arranged concentrically of each other to form said first and second gaps as first and second annular gaps.