April 10, 1951

R. H. MOTH

SPARK PLUG

2,548,170

Filed Dec. 30, 1948

2 Sheets-Sheet 1

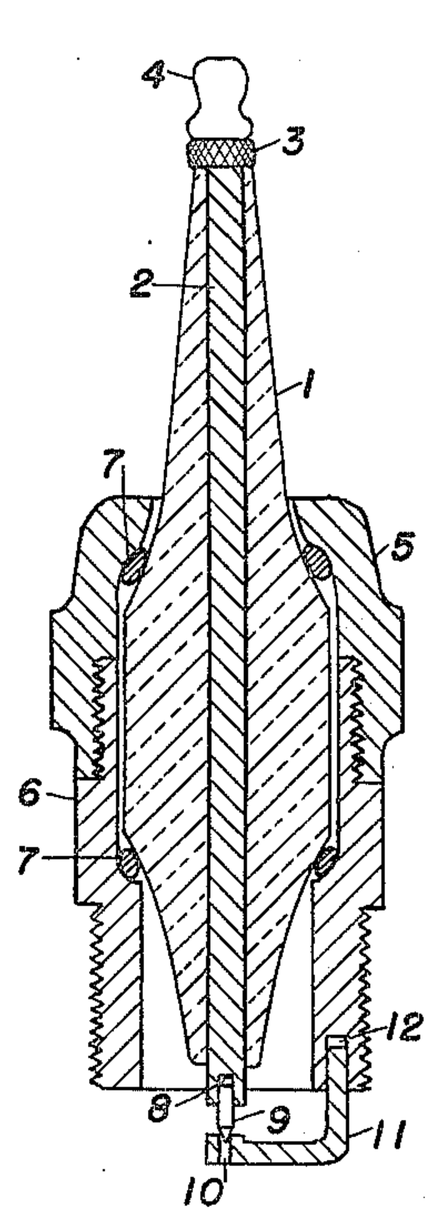

FIG. 1

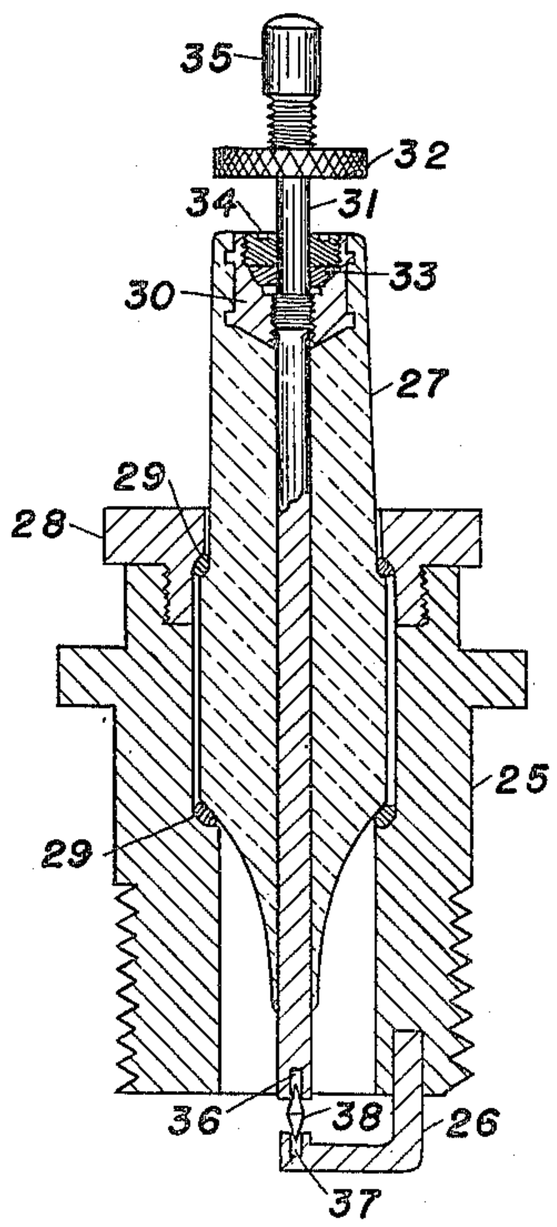

FIG. 4

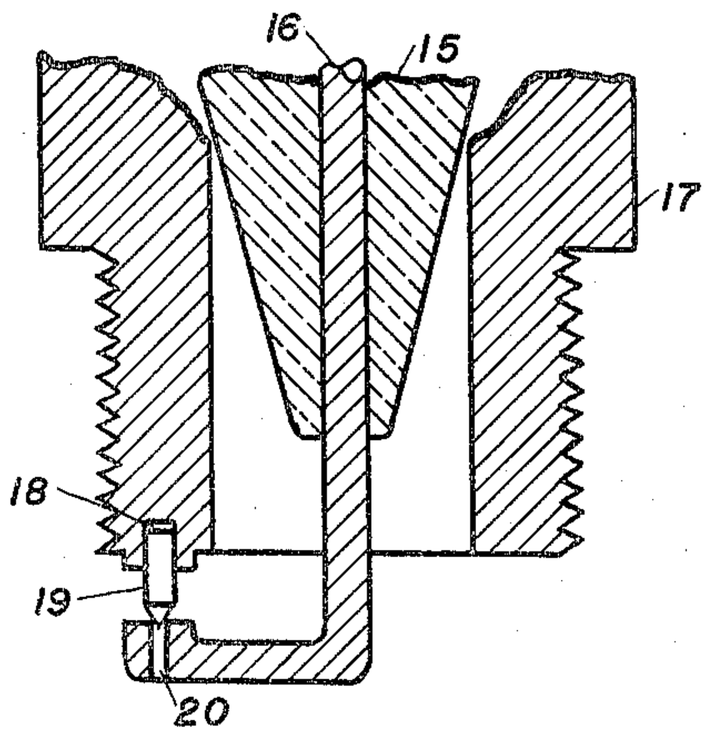

FIG. 2

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2 Sheets-Sheet 2

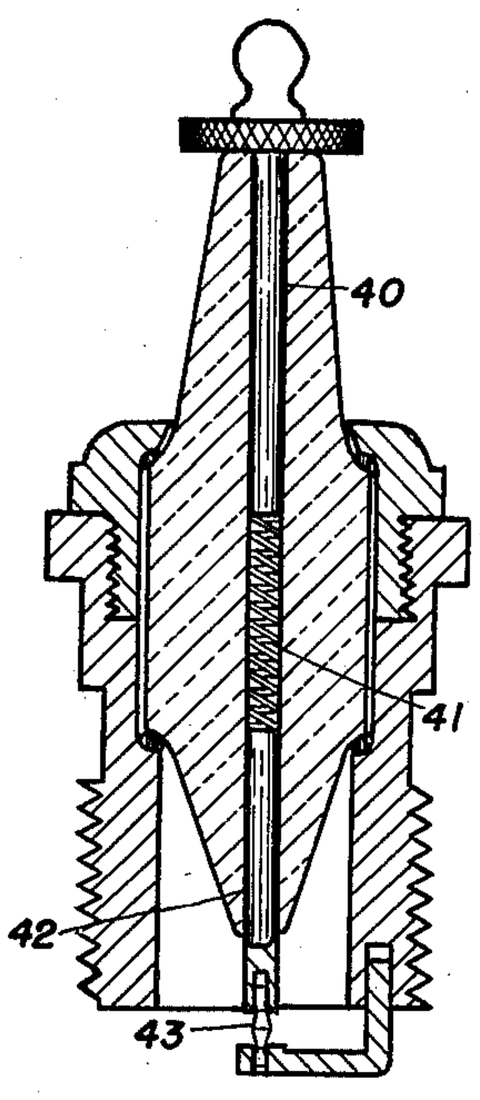

FIG. 5

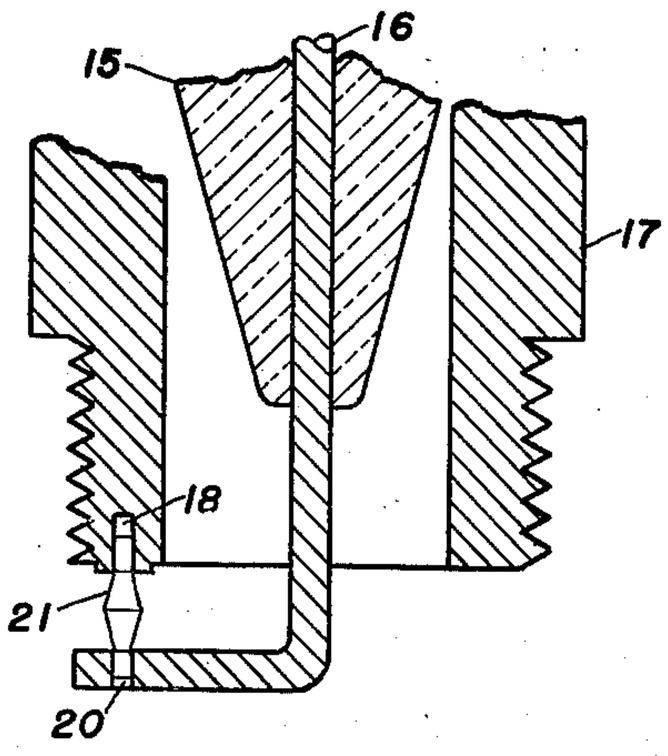

FIG. 3

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Patented Apr. 10, 1951

2,548,170

UNITED STATES PATENT OFFICE

2,548,170

SPARK PLUG

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Application December 30, 1948, Serial No. 68,295

7 Claims. (Cl. 123—169)

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This invention relates to ignition systems for internal combustion engines and more particularly, relates to a spark plug having a constant gap between electrodes during extended periods of constant service.

During the operation of an internal combustion engine, particularly large stationary engines used in industrial plants, the constant passage of current between the spark plug electrodes results in their disintegration to such an extent that their function may be seriously impaired. Consequently, it is necessary to periodically check the spark plugs as to gap adjustment and general sparking characteristics. In the installation of new spark plugs some allowances can be made for this electrode disintegration by adjustment at closer tolerance to overcome the tendency of the spark gap space to increase, but such adjustment is not a satisfactory solution to the problem because it changes the general spark density and intensity. Commercial engines operating continuously for extended periods of time are subject to serious shutdown delays due to spark plug failure or maladjustment thereof. Since many such industrial engines cannot be started again with one man, it may be necessary to call in a crew of men for that operation.

To meet these problems, I have devised a spark plug system of novel construction which gives automatic adjustment or correction of the spark gap between the electrodes, thereby prolonging the inspection periods and eliminating frequent adjustments of the spark plug. As a consequence thereof, the general combustion conditions within the engine cylinder are more uniform and engine performance is substantially constant. Also, longer life is imparted to the high tension coil because of the more substantially uniform spark gap conditions and resistance in the ignition system. Accordingly, it is the primary object of my invention to provide a spark plug having automatic self-adjusting electrodes.

A secondary object of my invention is to provide a spark plug which will give longer service without the necessity of adjustment.

A third object of my invention is to provide a spark plug with electrodes which are held at a constant distance from each other by the positioning of a suitable non-conductor material therebetween.

A fourth object of my invention is to provide a spark plug, the electrodes of which are separated by a sapphire crystal.

Other objects and advantages of my invention will become apparent from the detailed disclosure which follows and the accompanying drawings of which

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Figure 1 is a longitudinal cross-sectional view through the center of one form of my spark plug showing the permanent attachment of a non-conductive separator to the negative central electrode and impinging against a recess within the positive electrode.

Figure 2 is a fragmentary vertical cross-section showing another embodiment of my invention with the non-conductive separator firmly affixed within the positive electrode body and impinging upon a recess within the negative electrode.

Figure 3 is a fragmentary vertical cross-sectional view showing another modification of the non-conductive separator which may be incorporated in my invention.

Figure 4 is a vertical cross-section illustrating another embodiment of the invention in which a manually adjustable negative electrode maintains the electrodes in contact with the non-conductive separator.

Figure 5 illustrates a longitudinal cross-sectional view of still another embodiment of my invention in which the negative electrode is spring loaded to maintain contact upon the non-conductive separator.

Referring to Figure 1, the numeral 1 represents an insulator composed of the usual insulating material now commonly used in spark plugs. Insulator 1 may be of any desired shape or design as long as it functions to efficiently insulate the electrodes (yet to be described) of the spark plug from each other. Vertically through the center of insulator 1 is fitted electrode 2 which is formed of any suitable electrical conductor material preferably metallic. Electrode 2 is tightly sealed within insulator 1 to form a gas-tight construction. It is common practice to mold the insulator material around the electrode to obtain the close fit required to withstand the cylinder pressures encountered. The upper end of electrode 2 is threaded, and fitted thereon are knurled nut 3 and cap nut 4 for the attachment of the distributor wire. The top body portion 5 and lower body portion 6, made of electrical conducting material such as steel or brass, are adapted to engage each other by screw threads and bind upon heat resistant packing rings 7 to form a gas-tight seal on the outer periphery of the central portion of the insulator. The lower terminus of electrode 2 contains recess 8 in order to accommodate a cylindrical non-conductive separator 9. Non-conductive separator 9 is

pointed at its lower terminus and fits into a cylindrical recess 10, of lesser diameter than the separator 9, positioned at the end of electrode 11. Electrode 11 may be an integral part of lower body portion 6 or may, as shown in the drawing, be a separate piece tightly fitted in recess 12 of lower body portion 6. Electrode 11 is fitted into body portion 6 in such a manner as to impart a spring tension thereto when the separator 9 is placed between the two electrodes, thereby causing the separator 9 to be tightly held between the electrodes. This can readily be accomplished by bending electrode 11 to a position such that the ends of the two electrodes must be forced apart in order to accommodate the separator between them.

It is known that a high tension spark when jumping across an air or vapor filled gap between electrodes takes the shortest metal to metal path and as the metal of the electrodes disintegrates over the metal area through which the spark passes, the gap will become increasingly larger. When gap space increases of approximately .020 inch or more are experienced, the spark intensity will decline or the spark will seek the next less resistive path offered by the system. The surfaces between which the spark jumps become eroded, thereby increasing the distance between the electrodes. Since the separator 9 rests on the outside periphery of recess 10, as this periphery corrodes or erodes the electrodes will by reason of the tension on electrode 11 move together a distance equal to the amount of erosion or corrosion of the recess periphery, thereby maintaining a substantially constant spark gap between the electrodes.

The fragmentary vertical cross-sectional view, Figure 2, is meant to show another embodiment of my invention in which the insulator is represented by number 15 with the electrode 16 tightly sealed therein. Lower body portion 17 contains recess 18 into which non-conductive separator 19 is tightly fitted. Separator 19 is substantially cylindrical in shape and is pointed at its lower end. Electrode 16 is curved or bent so that its terminus containing recess or hole 20 is adjacent to separator 19. A tension is placed on the terminal portion of electrode 16 which tends to thrust the sparking surface of the electrode toward lower body portion 17. The non-conductive separator 19 is of greater diameter than recess 20 so that the topmost edges of recess 20 impinge upon the beveled or sloping surfaces of the pointed end portion of separator 19, thus tending to hold the electrodes apart. In operation the electrodes and non-conductive separator as represented by this embodiment of my invention function the same as the electrodes and non-conductive separator in Figure 1.

Figure 3 is another fragmentary vertical cross-sectional view of another embodiment of my invention in which the insulator 15, electrode 16 and lower body portion 17 are the same as in Figure 2. The difference here is in the size of the recess 18 and recess or hole 20, and the shape of non-conductive separator 21. As shown iin the drawing, the separator 21 has substantially cylindrical portions which fit relatively loosely within recess 18 and recess or hole 20. The central portion of separator 21 is enlarged to present sloping surfaces above and below which impinge upon the right-angled periphery of recess 18 and against the similar outer periphery of recess 20, thus keeping the electrode 16 at a constant distance from lower body portion 17 as

the spring action in electrode 16 tends to press it against the separator 21. The outer diameter of separator 21 at its enlarged central portion must be greater than the inside diameter of recess 18 and recess 20 so that the separator will not become detached from its position between the electrodes, and so that its sloping surfaces will reach the periphery of the recesses. The central enlarged portion of separator 21 may take the form defined by rotating an isosceles triangle 360° about its base line.

The embodiment of my invention shown in Figure 3 has the distinct advantage of providing for automatic adjustment of the distance between the electrode surface regardless of wear or disintegration of either or both of the sparking surfaces of the electrodes.

Figure 4 is a longitudinal cross-sectional view through the center of another form which my spark plug may assume. In Figure 4 the lower body portion of the spark plug is represented by number 25 having rigid electrode portion 26 firmly fitted therein. Number 27 represents the insulator which is held within lower body portion 25 by the action of upper body portion 28 which is threaded to fit within lower body portion 25 and adapted to press upon heat resistant gasket seal rings 29 to form a gas-tight seal about the enlarged center portion of insulator 27. Within the top center portion of insulator 27 is sealed bushing 30 which has a central threaded portion having a common axis with electrode 31. Bushing 30 is formed within insulator 27 by any of the known molding processes to form a gas-tight seal therewith. Electrode 31, passing through the center of insulator 27 and bushing 30, has a threaded portion to match the threaded portion of bushing 30. Electrode 31 is, therefore, free to revolve within insulator 27 and by turning knurled thumb wheel 32 can be caused to be raised or lowered therein. Electrode 31 may be fitted with a locknut (not shown) to insure retention of the electrode in any desired position and prevent vertical displacement due to engine vibration. A gas-tight seal must be formed around electrode 31. This seal may take any form which serves the purpose efficiently. I show one such gas seal in Figure 4 wherein the upper portion of bushing 30 is formed with a recess in the form of an inverted frustrum to accommodate gasket material 33 which is held tightly in place by threaded insert 34. Gasket material 33 must be heat resistant and also form a seal against electrode 31. Nut 35 is provided at the upper end of electrode 31 for securing the distributor wire thereto.

Referring now to the spark gap area of my spark plug as shown in Figure 4, it can be seen that electrode 31 and electrode 26 both contain recesses, represented by numbers 36 and 37, respectively. These recesses are cylindrical in shape and uniform in diameter. The non-conductive separator 38 fits between the two electrodes in such a manner that its sloping surfaces bind upon the peripheral inner edges of the recesses. Thus as the sparking surface of the electrodes wears away, it is possible to keep a constant spark gap by merely turning knurled thumb wheel 32 to lower electrode 31 against the sloping surfaces of non-conductive separator 38. This adjustment can become one of the routine checks made by one man as he inspects the engine during operation.

Figure 5 is a cross-sectional view of my spark plug which is substantially the same as Figure 1

with the exception of the central electrode and the non-conductive separator. In Figure 5, I show the central electrode 40 with coil spring 41 as an integral part thereof. The upper part of electrode 40 is tightly sealed within the insulator while the spring 41 and the lower part of electrode 40 represented by number 42 are free to move longitudinally within the insulator. Non-conductive separator 43 is lodged in recesses in the ends of the two electrodes. The recesses in both electrodes are sufficiently deep to permit the separator to move inwardly as the electrode becomes eroded. The action of spring 41 eliminates manual adjustment of electrode 40 and maintains constant contact of the wearing surfaces of the electrodes with the sloping surfaces of non-conductive separator 43.

My invention is not to be limited to the relative size or shape or function of the various parts of the spark plug. The materials of construction may also be any suitable material for the purposes intended. Mention has been made of recesses within the electrodes which function both to hold the separators firmly or may function as retaining guides for the protruding portions of the separator. The size of these recesses may vary from .020 to .040 inch in diameter depending on the diameter of the electrodes, and from 0.02 to 0.25 inch in depth. The outer diameter of the non-conductive separators used may vary within a wide range; however, the portion outside the recess must be greater in diameter than the recesses with which they are used in order to provide a sloping surface to impinge upon the wearing surface of the electrode.

Thus far in the disclosure of my invention, I have referred to a non-conductive separator affixed between movable or spring activated electrodes. This non-conductive separator may be formed from any material which offers a high resistance to the passage of an electric current. One very suitable substance of which these separators may be formed is synthetic sapphire. Sapphire has a high electrical resistance and does not exhibit the tendency to accumulate carbon on its surface during use. Any non-conductive material which will offer a comparable resistance to the passage of an electric current, which will withstand the severe conditions within the internal combustion engine firing chamber and which has no substantial tendency to form encrustations on its surface may be used. Examples of such other materials are aluminum oxide, quartz, glass, diamond, emerald, mica, corundum, ruby, amethyst and picotite (black mica). My invention is not to be limited to the particular size or shape of the non-conductive separator inserted between the electrodes. In one form of my invention, I contemplate the use of a spherical separator between the electrodes. Various shapes of separators other than those I have described may be used within the scope of my invention as long as the separator functions to gradually allow the electrodes to move toward each other as their wearing surfaces disintegrate.

What is claimed:

1. A sparking device comprising at least two electrodes spaced in sparking relationship to each other, at least one of said electrodes having a recess in its wearing surface, a non-conductive separator held between said electrodes, said separator resting on the periphery of said recess, said separator having the surface of said separator tapering outwardly from a point located within said recess, said electrodes being under tension toward each other and said separator holding said electrodes at a substantially constant sparking distance from each other.

2. A sparking device in accordance with claim 1 in which the non-conductive separator is synthetic sapphire.

3. A spark plug comprising a ceramic body carrying two electrodes, one a circumferential electrode surrounding said ceramic body and the other a centrally mounted electrode within said ceramic body, said centrally mounted electrode having an active end juxtaposed in sparking relationship with an active portion of said circumferential electrode, a sapphire insulating means securely held to said circumferential electrode at said active portion thereof, said centrally located electrode having a recess in its active end, said sapphire insulating means having an inclined surface which impinges on the periphery of said recess and maintains said centrally located electrode in substantially constant sparking distance from said circumferential electrode.

4. A spark plug comprising a ceramic body carrying two electrodes, one a circumferential electrode surrounding said ceramic body and the other a centrally mounted electrode within said ceramic body, said centrally mounted electrode having an active end juxtaposed in sparking relationship with an active portion of said circumferential electrode, said centrally mounted electrode having a recess in its active portion, a sapphire insulating means having recess-engaging members at its ends and having inclined surfaces in a central portion larger in diameter than the diameter of said recesses, said sapphire insulating means inserted between said electrodes with said recess-engaging members within said recesses and said inclined surfaces impinging on the periphery of said recesses.

5. A spark plug comprising a ceramic body carrying a centrally mounted electrode, a body portion surrounding said ceramic body and carrying a second electrode with a recess at its active end, said centrally mounted electrode having three conductively connected sections, a section sealed within said ceramic body, a spring section free to move longitudinally within said ceramic body and a longitudinally movable section having an active end with a recess therein, the active ends of both of said electrodes being juxtaposed in sparking relationship with one another, a sapphire insulating means having inclined surfaces, said sapphire insulating means inserted between said active ends of said electrodes displacing said longitudinally movable section of said centrally mounted electrode against said spring section, said inclined surfaces impinging against the peripheries of said recesses.

6. A spark plug comprising a ceramic body carrying a centrally and slidably mounted electrode, said electrode having a recess in its active end, a thumb wheel at the opposite end and having a screw thread between its ends, said screw thread engaging a threaded bushing secured within said ceramic body, a body portion carrying a second electrode with a recess at its active end, said body portion surrounding said ceramic body, said centrally mounted electrode having its active end juxtaposed in sparking relationship with said active end of said second electrode, a sapphire insulating means inserted between said electrodes with its inclined surfaces engaging the peripheries of said recesses whereby to maintain a constant spark gap between the active ends of said electrodes as said active ends erode and

said centrally mounted electrode is turned down by means of said thumb wheel.

7. A spark plug comprising a ceramic body carrying a centrally mounted electrode, a body portion carrying a second electrode with a recess in its active end, said body portion surrounding said ceramic body, said centrally mounted electrode having an active end juxtaposed in sparking relationship with the active end of said second electrode, a sapphire insulating means fastened to said active end of said centrally mounted electrode, said sapphire insulating means having an

inclined surface which impinges on the periphery of said recess in the active end of said second electrode.

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The following references are of record in the file of this patent:

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Number	Name	Date
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