Feb. 17, 1959 W. A. BYCHINSKY 2,874,322

LOW TENSION SPARK PLUG

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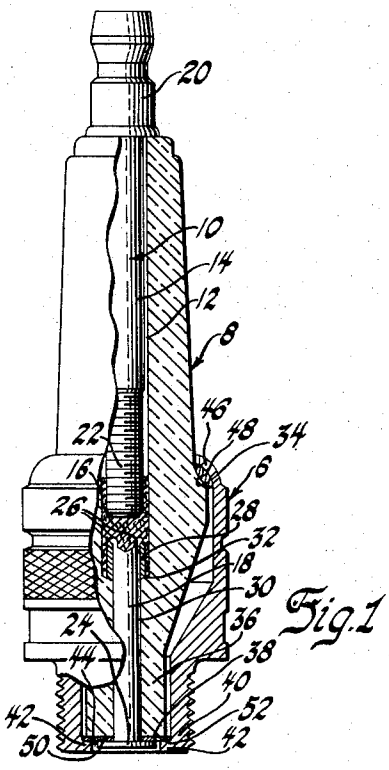


Fig. 1

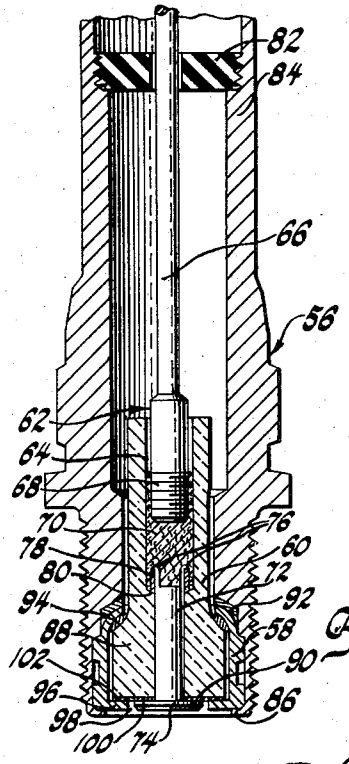


Fig. 2

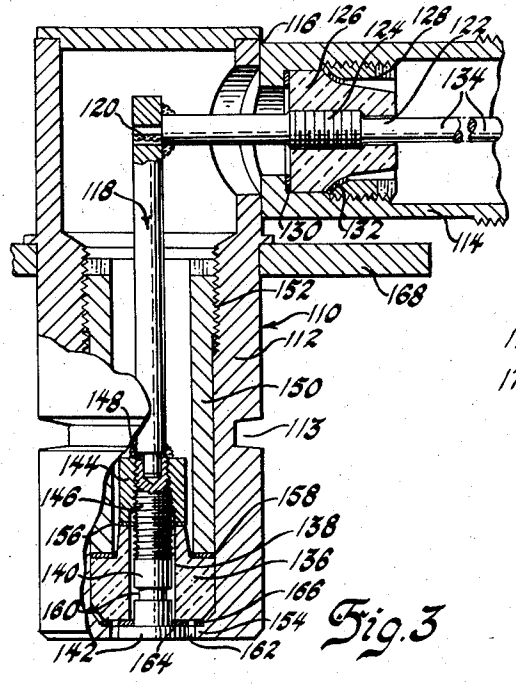


Fig. 3

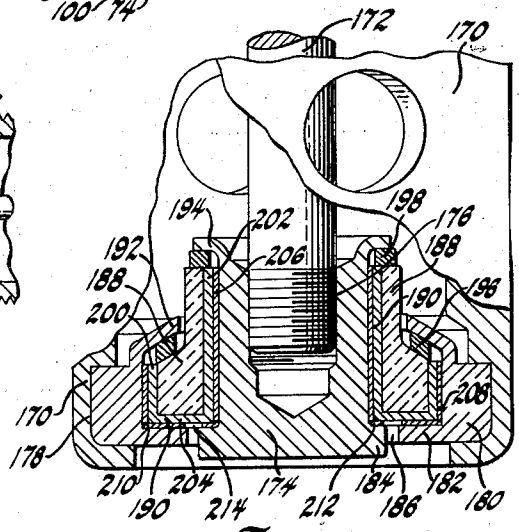


Fig. 4

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LOW TENSION SPARK PLUG

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This invention relates to spark plugs and more particularly to low tension spark plugs in which the electrodes are electrically separated by an insulator having a surface portion positioned adjacent the spark gap and conditioned or treated to provide a low tension spark path.

One of the goals of internal combustion engine ignition research is a spark plug which will give an extremely hot spark but which at the same time is durable and reliable. One of the traditional problems of efficient spark plug operations is the fouling which results from the fuel additives, carbon, oil, etc., to which the plug is subjected. Conventional type spark plugs in common use today utilize a relatively large spark gap in combination with a high tension ignition system. In recent years, however, it has been proposed to use a spark plug having a relatively small spark gap in combination with a low tension high energy ignition system. By the use of extremely high energies a spark can be obtained despite the fouling which might occur; also, because the spark is hotter than usual, low tension plugs tend to prevent fouling.

These low tension spark plugs comprise a pair of electrodes electrically separated by an insulator body which has a surface portion interposed between the ends of the electrodes to form a path along the surface of the insulator for the formation of the discharge. The insulator may be formed of a semi-conductive material, or its surface adjacent the spark gap may be coated with a semi-conductive material. Alternatively, the insulator surface may be provided with a series of auxiliary electrodes embedded in the ceramic in order to form a low tension spark path.

Because, however, of the rapid electrode erosion which occurs, such spark plugs have been found to have a relatively short life. This is particularly true when the plugs are used in a high energy ignition system whereby an extremely hot spark is obtained. It has been found that the sparks have a tendency to erode that part of the electrode which directly abuts the insulator surface. This results in an enlarged spark gap and culminates in plug failure.

This invention has as its object the provision of a low tension spark plug operable at high energies to give an extremely hot spark and having increased durability and reliability.

Another object of the invention is the provision of a low tension spark plug which is operable at high energies and which avoids rapid electrode erosion.

It is impossible, by any commercially feasible spark plug manufacturing technique, to attain absolutely flat surfaces on the insulator face and on the insulator abutting faces of the electrodes. There will always be at least some very small surface voids, especially where the surface of the insulator consists of a semi-conductive coating. Also, after assembly, it is quite likely that the insulator face will not be in continuous and complete electrical contact with the abutting electrode surfaces. Thus,

during the manufacture and assembly of the spark plug parts, there are bound to occur small gaps, perhaps undetectably small, between the insulator and the electrodes.

I have found that excessive electrode erosion is caused by the sparks which form in these normally occurring small gaps between the insulator surface and the surfaces of the electrodes. Even where there is but one such small gap, and there usually will be a plurality, there is spark occurrence which tends to enlarge the gap. Gradually the electrodes are undermined and are eroded to the extent that they are out of contact with the insulator surface. In this way the low tension spark path is eventually destroyed and spark plug failure results.

The objects of this invention are attained by the provision of gaskets interposed between the normally insulator abutting portions of the electrode and the insulator in order to attain complete and continuous electrical and mechanical contact therebetween and thus prevent the formation of the sparks between the insulator and either of the respective electrodes. The resulting structure precludes electrode undermining and rapid erosion, thus greatly increasing the life of the spark plugs.

Other objects and advantages of the invention will appear more clearly from the following description of preferred embodiments and from the accompanying drawing in which Figure 1 shows a side view with parts broken away of one embodiment of the invention; Figures 2 and 3 show cross-sectional views of other embodiments of the invention; and Figure 4 shows a side view with parts broken away of still a fourth embodiment of the invention.

Referring now to the drawing, Figure 1 shows a spark plug having an outer metal shell **6**, an insulator **8**, and a center electrode or centerwire **10** positioned in the longitudinally extending centerbore **12** of the insulator **8**.

The center electrode **10** comprises a centerwire screw **14**, an electrical conducting seal **16**, and a center electrode spindle **18**. The centerwire screw **14** is provided with an electrical contact head **20** for connection with the ignition wiring system and a threaded or serrated portion **22** which is embedded in the electrical conducting seal **16** to retain the centerwire screw within the bore **12**. The conductive seal **16**, which may consist of a mixture of glass and some conductive material such as copper or nickel powder, is bonded to the walls of the insulator centerbore **12**, thus providing a gas-tight seal and is also bonded to the top of the center electrode **18** and to the centerwire screw to secure these parts in position.

The bottom of the center electrode spindle **18** extends to the exterior of the centerbore and is provided with a head **24** while the top is bifurcated to provide a pair of prongs **26** which are bent outwardly and over the top of a metal electrode retainer ring **28** to secure the center electrode in the lower end **30** of the insulator centerbore **12**. It will be noted that the lower end **30** of the centerbore is of reduced diameter, thus providing a centerbore shoulder **32** to support the retainer ring **28**.

In the embodiment shown in Figure 1 the insulator **8** is of one-piece construction and is provided with an outwardly extending annular shoulder **34** and a cylindrical base portion **36** which terminates in a flat surface **38**. This flat surface **38** may be provided with a semi-conductive coating or be otherwise adapted to furnish a low tension spark path.

The outer metal shell **6** has a threaded portion **40** of reduced diameter for engagement with a threaded hole provided in the cylinder head of an internal combustion engine.

The outer or ground electrode consists of an inwardly extending annular flange **42** which is secured to the metal shell **6** and which, in the embodiment shown, is integral with the ground shell. The edge of the ground electrode is in continuous spaced relation to the edge of the center electrode head, thus providing a circular spark gap **44**.

Besides serving as the ground electrode, the flange **42** also cooperates with a circumferential inwardly turned lip **46** on the top of the shell **6** to retain the insulator in position. A metal washer **48** between the insulator shoulder **34** and the lip **46** serves to seal the structure and also to assure a secure fit.

Interposed between the head **24** of the center electrode spindle **18** and the flat base surface **38** of the insulator **8** is an annular gasket **50** of some suitable heat and wear-resistant deformable metal such as annealed nickel or nickel alloy. A second annular gasket **52** also of a heat and wear-resistant deformable metal such as annealed nickel or nickel alloy is interposed between the outer electrode **42** and the base surface **38** of the insulator. The gaskets **50** and **52** are concentric with each other, the edge portions being flush with the edges of the respective electrodes to form an aligned continuation of the spark gap **44**.

The gaskets **50** and **52** are pressed tightly into continuous mechanical and electrical contact with the abutting surfaces of the electrodes and of the insulator and thus serve not only to inhibit electrode erosion but also as a gas-tight seal for the assembly.

The precise nature of the creep gap or low tension type igniter is not fully understood. It is believed, however, that the electrical discharge which forms along the insulator surface and which may occur at low voltages ionizes the gas or in some other manner conditions the spark gap to allow sparking at low voltage. The precise mechanism, whereby the spark plug construction of this invention prevents excessive electrode erosion and undermining, is not fully and completely known; however, it has been found that, by the use of heat resistant metal gaskets interposed between the insulator and the electrode as heretofore described, a greatly improved low tension igniter having a much longer life than those of conventional design may be attained.

The embodiment shown in Figure 2 is particularly adapted for use in aircraft reciprocating engines and consists of a metal shell **56**, a metal insert sleeve **58** in electrical contact with the shell **56**, an insulator **60** secured within the sleeve **58**, and a center electrode or centerwire **62** within a centerbore **64** of the insulator **60**. The centerwire structure is quite similar to that shown in Figure 1 and consists of a centerwire screw **66** which has a threaded portion **68** embedded in a conducting seal **70** and a center electrode spindle **72** having a head **74** at its lower end and a bifurcated top portion embedded in the seal **70**. The prongs **76** resulting from the bifurcation are bent outwardly over a retainer ring **78** which rests against a shoulder **80** in the insulator centerbore **64**.

A center electrode supporting ring **82** of any suitable electrical insulating material threadedly engages the interior of the metal shell as shown at **84** and maintains the center electrode in a concentric position with the shell.

The sleeve **58** is secured within the shell by means of the inwardly extending annular flange **86** on the base of the shell.

The insulator has a lower portion **88** of enlarged diameter which is positioned in the sleeve and which terminates in a flat surface portion **90** which may be provided with a semi-conductive coating or otherwise adapted to furnish a low tension spark path. Washers **92** and **94**, which are positioned between the sleeve and the shell and between the sleeve and the insulator respectively, assure a secure fit and also provide a gas-tight structure.

The base of the sleeve has inwardly turned flange **96** which serves as the ground electrode and is in spaced relation to the head **74** of the center electrode to provide a circular spark gap **98**. Interposed between the flat bottom surface **90** of the insulator **60** and the head **74** of the electrode and between the surface **90** and the ground electrode **96** are gaskets **100** and **102** of nickel or some other heat-resistant metal. These gaskets are pressed tightly between their respective abutting surfaces to give a firm and continuous mechanical and electrical contact, thereby sealing the structure and preventing electrode erosion and undermining.

In the embodiment shown by Figure 3, the spark plug outer shell **110** is L-shaped and is constructed in two sections **112** and **114** secured together by a welding or brazing at the junction **116**. The centerwire **118** is likewise L-shaped and has a soldered or brazed junction shown at **120**. The upper centerwire section **122** has a threaded portion **124** which is cemented or otherwise substantially secured in an insulator **126**, the insulator **126** being held in the upper section **114** of the spark plug shell by means of a nut **128** which threadedly engages the shell. Metal washers **130** and **132** serve to assure a tight fit and seal the assembly. Electrical contact with the ignition lead conductor is of course made through the exposed end **134** of the centerwire.

The lower shell section **112** receives an insulator **136** having a centerbore **138** in which there is located the bottom of the centerwire herein referred to as the center electrode spindle **140**. A head **142** and a threaded member **144**, which engage a threaded portion **146** on the center electrode, serve to retain the electrode within the insulator bore. The top of the electrode is provided with a blind hole to receive the end of the centerwire which is brazed or soldered in place as shown at **148**. A metal sleeve **150**, having an externally threaded portion **152**, threadedly engages the lower shell section and presses the insulator-center electrode assembly toward an inwardly extending flange **154** at the base of the shell. Metal washers **156** and **158** are positioned between the threaded member and the insulator and between the sleeve and the insulator to provide a tight and secure structure. The insulator has a flat base portion which may be provided with a semi-conductive coating or other means for furnishing a low tension spark path. The flange **154**, besides serving as an insulator retaining means, also serves as the ground electrode, it being in spaced relation with the edge of the cylindrical center electrode head **142** to provide an annular spark gap **162**.

Positioned between the insulator and the respective electrodes are heat-resistant metal gaskets **164** and **166**. As described in conjunction with the embodiments shown by Figures 1 and 2, these gaskets are in continuous mechanical and electrical contact with the insulator and with the respective electrodes to form a gas-tight seal and to prevent electrode erosion and undermining. The shell section **112** has an annular groove **113** and the central electrode spindle an annular groove **160**. In the process of assembling the spark plug the shell is heated to the plastic stage by passing a heavy electrical current through the shell from top to bottom, at which time a pressure is applied to the two ends of the shell which pressure causes the grooved section **113** to collapse and so exert a pressure on the gaskets **158** and **166** thereby insuring a gas-tight assembly. Similarly, the spindle **140** is heated to collapse the grooved section **160** and thereby exert pressure on the gasket **164**, this being done prior to the installation of the insulator-electrode assembly into the shell **112**. This process is very useful in accomplishing an extremely tight fit between the gaskets and the gasket abutting parts. It will be noted that the shell **6** of the embodiment shown in Figure 1 and the sleeve **58** of the embodiment shown in Figure 2 have similar grooves which, in the process of assembly, are used for this same purpose.

The plug shown by Figure 3 is designed for use in turbine type engines, a flange **168** being secured to the shell for suitable mounting.

The embodiments shown by Figures 2 and 3 serve to illustrate the relatively small sized electrical insulators which may be used, much less insulation being required because of the low operating voltages required.

Figure 4 shows the lower end of another gas turbine engine type igniter, **170** being the outer metal shell and **172** being the lower end of the central electrode to which a cylindrically shaped electrode head **174** is threadedly secured as shown at **176**. The outer shell has a groove **178** which receives an annular metal ring **180** having an inwardly extending flange **182** which serves as the ground electrode. The base **184** of the center electrode head is of enlarged diameter and is in spaced relationship with the ground electrode **182** to provide the circular spark gap **186**. An electrical insulator **188** having a semi-conductive coating **190** is positioned between the center electrode and the metal insert ring **180** and is secured by the flanges **182**, **192** and **194**, metal washers **196** and **198**, assuring a tight fit. The coating **190** may be a mixture of ceramic and a conductive or semi-conductive material such as metal powder, metal oxides, carbon, etc., and may be integral with the insulator **188**, the entire ceramic unit being monolithic. It will be noted that the semi-conductive coating continues along the vertical sides **200** and **202** of the insulator as well as on the flat base **204**. In this embodiment of the invention a second coating of nickel or some other suitable metal is provided over the semi-conductive coating on the vertical sides of the insulator body as shown at **206** and **208** to prevent arcing along those surfaces with resulting undermining and erosion. Nickel or other heat-resistant metal gaskets **210** and **212** are interposed between the base of the insulator and the respective electrodes as described in conjunction with previously discussed embodiments of the invention. The metal coating **206** and **208** may be sprayed onto the insulator or may be applied by any other suitable means. By using such a metal coating, continuous intimate electrical contact between the surfaces of the insulator and of the ring **180** is assured. The coatings **206** and **208** may of course continue onto the base of the insulator and thus take the place of the gaskets **210** and **212**. One way of accomplishing this is to spray the vertical sides and bottom of the semi-conductor coated insulator with a continuous coating of metal and then machine or cut away the circular gap shown at **214**.

It is to be understood that such a nickel or other metal coating on the base of the insulator may be used in place of the gaskets shown by Figures 1, 2 and 3 and described heretofore in conjunction therewith. Thus, the term gaskets as used herein is meant to include not only the annular metal members as shown in Figures 1, 2 and 3, but also the metal castings as discussed in conjunction with Figure 4.

It is to be understood that, although the invention has been described with specific reference to particular embodiments thereof, it is not to be so limited since changes and alterations therein may be made which are within the full intended scope of this invention as defined by the appended claims.

I claim:

1. A spark plug for use at low voltages and at high energies comprising a generally tubular shaped metal shell, an insulator within said shell having a bore extending longitudinally therethrough and having a base with a mass of semi-conductive material thereon, a center electrode in said bore having a cylindrical head portion exterior of the semi-conductive material on said insulator base, an inwardly extending ground electrode connected to the base of said shell having an annular inner edge portion in spaced relationship to the head portion of said center electrode to form an annular spark gap therewith, a thin annular deformable metal gasket positioned between and pressed into continuous electrical contact with said head portion and said semi-conductive material, and a thin annular deformable metal gasket positioned between and pressed into continuous electrical contact with said ground electrode and said semi-conductive material, the distance between said annular gaskets being at least as great as the distance between said head portion and said ground electrode.

2. A spark plug for use at low voltages and at high energies comprising a generally tubular shaped metal shell, an insulator within said shell having a bore extending longitudinally therethrough and having a base with a mass of semi-conductive material thereon, a center electrode in said bore having a cylindrical head portion exterior of the semi-conductive material on said insulator base, an inwardly extending ground electrode connected to the base of said shell having an annular inner edge portion in spaced relationship to the head portion of said center electrode to form an annular spark gap therewith, a thin annular deformable metal gasket positioned between said head portion and said semi-conductive material, a thin annular deformable metal gasket positioned between said ground electrode and said semi-conductive material, the distance between said first-mentioned and said second-mentioned annular gaskets being at least as great as the distance between said head portion and said ground electrode, means on said center electrode cooperative with said insulator to press said first-mentioned gasket tightly into continuous electrical contact with said head portion and said semi-conductive material, and means in said shell also cooperative with said insulator to press said second-mentioned gasket tightly into continuous electrical contact with said ground electrode and said semi-conductive material.

3. A spark plug for use at low voltages and at high energies comprising a generally tubular shaped metal shell, an insulator within said shell having a bore extending longitudinally therethrough and having a base with a mass of semi-conductive material thereon, a center electrode in said bore having a cylindrical head portion exterior of the semi-conductive material on said insulator base, an inwardly extending ground electrode connected to the base of said shell having an upper surface coplanar with the upper surface of the head portion of said center electrode and an annular inner edge portion in spaced relationship to said head portion to form an annular spark gap therewith, a thin annular deformable metal gasket positioned between said head portion and said semi-conductive material, a thin annular deformable metal gasket positioned between said ground electrode and said semi-conductive material, the distance between said first-mentioned and said second-mentioned annular gaskets being the same as the distance between said head portion and said ground electrode, means on said center electrode cooperative with said insulator to press said first-mentioned gasket tightly into continuous electrical contact with said head portion and said semi-conductive material, and a metal member within said shell pressing against an upper surface of said insulator to press said second-mentioned gasket tightly into continuous electrical contact with said ground electrode and said semi-conductive material.

4. A spark plug for use at low voltages and at high energies comprising a generally tubular shaped metal shell, an insulator within said shell having a bore extending longitudinally therethrough and having a base with a mass of semi-conductive material thereon, a center electrode in said bore having a cylindrical head portion exterior of the semi-conductive material on said insulator base, an inwardly extending ground electrode connected to the base of said shell having an upper surface coplanar with the upper surface of the head portion of said center electrode and an annular inner edge portion in spaced relationship to said head portion to form an annular spark gap therewith, a thin annular deformable metal gasket positioned between said head portion and said semi-conductive material, a thin annular deformable metal gasket positioned between said ground electrode and said semi-

conductive material, the distance between said first-mentioned and said second-mentioned annular gaskets being the same as the distance between said head portion and said ground electrode, means on said center electrode cooperative with said insulator to press said first-mentioned gasket tightly into continuous electrical contact with said head portion and said semi-conductive material, an annular deformable metal gasket positioned on an upper surface of said insulator, and a metal sleeve secured to the interior surface of said shell pressing against said third-mentioned gasket on said insulator to thereby press said second-mentioned gasket tightly into continuous electrical contact with said ground electrode and said semi-conductive material.

References Cited in the file of this patent

UNITED STATES PATENTS

1,100,650	Besson	June 16, 1914
1,940,325	Rabezzana	Dec. 19, 1933
2,168,206	Hastings	Aug. 1, 1939
2,248,415	Schwartzwalder et al.	July 8, 1941
2,507,278	Smits	May 9, 1950
2,527,489	Smits	Oct. 24, 1950
2,605,754	Smits	Aug. 5, 1952
2,684,665	Tognola	July 27, 1954
2,786,158	Tognola	Mar. 19, 1957

FOREIGN PATENTS

528,269	France	Nov. 9, 1921