SPARK PLUG ELECTRODE AND PROCESS FOR MAKING SAME

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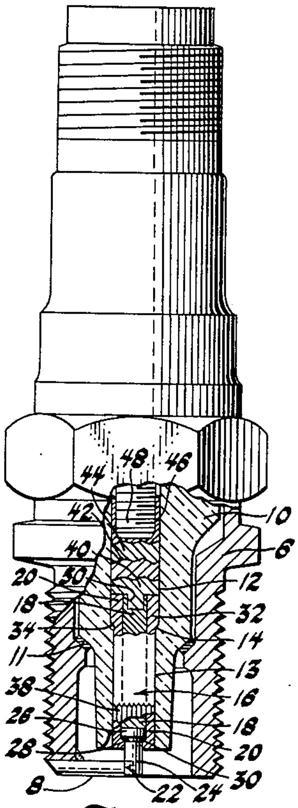

Fig. 1

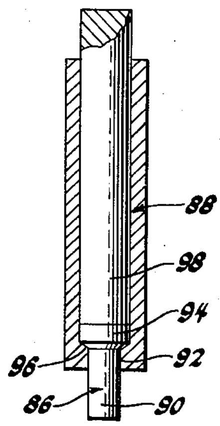

Fig. 2

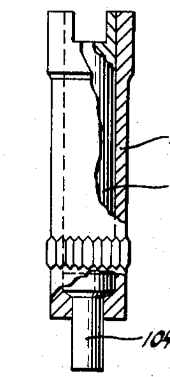

Fig. 3

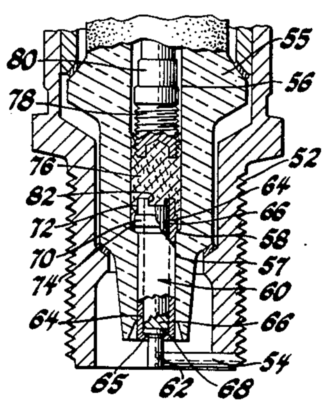

Fig. 4

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SPARK PLUG ELECTRODE AND PROCESS FOR MAKING SAME

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This invention relates to spark plugs for internal combustion engines of the type consisting of a central electrode provided with a surrounding insulator of some suitable ceramic and a metal shell which carries a ground electrode positioned in spaced relationship to the end of the central electrode to form a spark gap. More particularly, this invention relates to an improved spark plug central electrode and to a process for making same.

As is well known, spark plug electrodes are subject to wear and general deterioration due to both erosion and corrosion. Erosion is the mechanical wearing away and burning of the electrodes caused by the action of the spark. Electrode corrosion is produced by the action of various carbon, lead, and sulfur compounds, oxygen, water, etc., which are present in the combustion gases and which, under the conditions of spark plug operation, react with the electrode material. The problem of electrode wear with resulting spark plug failure is greatly increased by the development of modern high compression internal combustion engines which operate at higher temperatures than the older and more conventional types. Therefore, the development of these high operating temperature high compression engines, particularly for use in aircraft but also for use in automobiles and the like, has required a corresponding development in spark plug design and, in particular, in the choice of materials and design for the spark plug electrodes.

Because of its very high resistance to both erosion and corrosion under the most extreme temperatures, platinum is particularly suitable as an electrode material. Platinum, however, is a scarce metal and is therefore quite costly. Because of this high cost it has been the practice to utilize a composite centerwire electrode consisting of a silver or silver alloy positioned in the centerbore of the spark plug insulator and provided with a platinum firing tip. In this manner, the high heat conductivity of the silver and the high wear resistance of platinum are utilized in combination. For such a structure, however, a considerable amount of platinum has to be used since the platinum firing tip must extend a good distance into the silver wire in order to be firmly anchored. At the same time the silver alloy itself is quite expensive and thus the overall cost of the electrode is quite high. Even aside from the question of cost, however, such an electrode becomes quite impractical during times of scarcity of platinum and silver.

It is an object of this invention to provide a spark plug which is highly resistant to wear by corrosion and erosion and is also resistant to the high temperatures at which modern internal combustion engines operate. Another object of the invention is the provision of a spark plug electrode having a very long life and having a relatively low cost. Still another object of the invention is the provision of a simple and economical method for making composite spark plug electrodes which have high wear resistance and excellent heat conductivity.

These objects are carried out in accordance with the

present invention by the provision of a spark plug electrode having a noble metal firing tip firmly secured to and in intimate contact with a metal core of high heat conductivity surrounded by a sheath of metal having high heat and wear resistance.

Other objects and advantages of the invention will appear more clearly from the following description of specific embodiments of the invention and from the accompanying drawings in which Figure 1 is a side view with parts broken away of an embodiment of the invention; Figure 2 is a side view with parts broken away of the electrode parts as they appear in an early stage in the process for producing the electrodes; Figure 3 is a side view with parts broken away of the completed electrode as it appears after the final step in the process; and Figure 4 is a side view with parts broken away of another embodiment of the invention.

Referring now to the drawing, Figure 1 shows a spark plug having a metal outer shell **6** carrying a ground electrode **8** of platinum or other suitable metal and enclosing and supporting an insulator **10** which is provided with a centerbore **12**. The lower end of the centerbore **12** is of reduced diameter as shown at **13**, thereby providing an annular shoulder **14** within the bore. A metal gasket **11** is positioned between the insulator shoulder and the outer shell flange to firmly secure the insulator in the shell and to seal the assembly. Located within the centerbore **12** is the centerwire including the central electrode structure **16** to which this invention chiefly relates.

The composite central electrode **16** consists of a core **18** of a metal having a high heat conductivity enclosed by a tubular sheath **20** of a metal having a high resistance to the heat, corrosion and erosion, and a noble metal firing tip **22** secured to the base of the sheath **20** and in heat and electrical conducting contact with the core **18**. In the preferred embodiment of the invention, the tip **22** consists of the noble metal, platinum. It is to be understood that by the term "platinum" I mean to include the various platinum rich alloys and by the term "noble metal" I mean to include the various noble metal rich alloys which may be used as electrode materials.

The firing tip **22** has a shank portion **24** which extends to the exterior of the sheath **20**, and the head portion **26** within the sheath **20**. A circumferential portion **28** of the bottom of the head **26** engages an inwardly extending annular flange **30** on the base of the sheath **20**, thus retaining the firing tip in place. The top of the tubular sheath is formed into a head portion **32**, thereby providing an outwardly extending annular shoulder **34** which engages the shoulder **14** on the interior of the centerbore of the insulator **18**. In the modification shown in Figure 1, a knurled surface **38** is provided on the exterior of the sheath for purposes set forth in United States Patent 2,350,396 granted June 6, 1944, to Gretzinger et al. By means of a heat treatment hereinafter described, the metal core is preferably alloyed to the sheath, thereby providing the optimum of heat and electrical conductivity.

I wish to call particular attention to the manner in which the firing tip **22** is secured to the sheath **20**. By the cooperation of the firing tip head **26** and the sheath flange **30** there is complete assurance that the tip will remain securely in position. At the same time a very small amount of platinum or other noble metal is required.

The remainder of the centerwise construction follows conventional practices with **40** indicating an electrically conducting seal consisting of glass and a conducting powder; **42**, a glass bonded resistance material; **44**, a second electrically conducting seal; and **46**, a third electrically conducting seal surrounding and gripping the lower threaded or grooved end of a centerwire screw **48**, the top of which (not shown) makes electrical contact with the electrical lead from the ignition wiring system. The top of the electrode head 32 is bifurcated to provide a slot 50 which serves to better secure the central electrode in position. In addition, the slot 50 exposes a greater surface to the glass seal 40 thereby aiding the dissipation of heat. The glass seal 40 and resistor 42 are fused or softened in the bore by the application of heat, whereupon the centerwire screw 48 is pressed into place and the seal allowed to harden. The various seal and resistance constructions are described and claimed in the following United States patents: Schwartzwalder and Kirk, Patent 2,106,578 granted January 25, 1938; Schwartzwalder and Rulka, Patent 2,248,415 granted July 8, 1941; and McDougal, Schwartzwalder and Rulka, Patent 2,459,282 granted January 18, 1949.

Because of its particularly high heat and electrical conductivity and its relatively low cost, we prefer to use copper as the material for the electrode core 18. By the term copper, I means to include also the various alloys which are predominantly copper and which are soft and have about the same functional characteristics of heat and electrical conductivity as copper.

The sheath 20 may be either pure nickel or a nickel alloy. I have found that either pure nickel or an alloy containing from about 78 to 100% nickel, about 0 to 20% chromium, and about 0 to 2% manganese, is particularly suitable as a sheath material. The following will serve as examples of specific alloys within this range: 98% nickel, 2% chromium, 98.5% nickel, 1% chromium, .5% manganese; and 96% nickel, 2% chromium, 2% manganese. The use of small amounts of manganese is advantageous in that it facilitates the working of the metal. In general, the use of nickel with or without a small percentage of manganese results in a sheath having a relatively high heat conductivity which of course is a desirable characteristic. On the other hand, the corrosion-resistance of the sheath is enhanced by the use of small amounts of chromium. This is particularly true as regards the corrosion-resistance toward fuels containing sulfur impurities. Thus, in the preferred embodiment, the sheath consists of the alloy containing about 96% nickel, about 2% chromium and about 2% manganese.

Figure 4 shows a spark plug having an outer metal shell 52 carrying a ground electrode 54 and enclosing and supporting a ceramic insulator 55. The insulator has a centerbore 56, the end of which is of reduced diameter as shown at 57, thus providing a shoulder 58 in the bore. The composite electrode 60, which is positioned in the centerbore 56, consists of a headed platinum or other noble metal tip 62, a nickel or nickel alloy sheath 64 with an inwardly extending annular flange 65 to support the firing tip, and a core 66 preferably of copper. The surface of the core 66 is alloyed to the surface of the sheath 64. It will be noted that the firing tip head 68 is not as thick as that shown in Figure 1 and thus does not require the use of as much metal. Also, in this embodiment, the sheath head 70 has an upper portion of reduced diameter as shown at 72. The resulting annular shoulder 74 cooperates with the shoulder 58 in the insulator centerbore to retain the electrode in position. By the provision of this type of head, more surface contact is obtained between the electrode and the glass seal, thus facilitating the passage of heat away from the electrode.

The upper portion of the centerwise structure is conventional, 76 being a conductive glass seal, 78 a centerbore screw embedded in the glass seal 76, and 80 a cartridge-type resistor which is held against the centerbore screw by some means (not shown) and which is in electrical contact with the lead from the ignition wiring system. As in the embodiment shown in Figure 1, the top of the head 70 is provided with a slot 82 to give additional heat conducting surface contact between the core of the electrode and the conductive glass seal 76, and to better secure the central electrode in position.

To produce the composite electrode, the sheath is first formed by drilling a blind hole axially in a suitably dimensioned rod of the desired nickel or nickel alloy and then drilling a concentric second hole of smaller diameter in the end of the rod to receive the shank of the firing tip. Thus, the resulting tubular sheath will be provided with an inwardly extending annular flange at one end.

The sheath, firing tip, and core, are then assembled as shown in Figure 2. The firing tip 86 is inserted into the sheath 88 so that the firing tip shank 90 extends through the smaller hole 92 and the firing tip head 94 rests against the inwardly extending sheath flange 96. Then the core 98 is inserted into the sheath. At this stage of the process there should be enough clearance between the parts to facilitate assembly. Thus, there is a slight clearance between the core and the sheath and in this regard it should be noted that the core rod 98 is of sufficient length to provide enough metal to completely fill the sheath during the steps of the process which follow.

The thus assembled electrode is then swaged in order to pack the core material and bind the parts into a unit. This swaging operation may be performed by placing the assembly in a slightly tapered bore and applying blows to the end of the core rod. Some of the force from the blows is utilized in pushing the entire assembly into the bore, thus forcing the sheath inwardly against the core. Most of the force is utilized in packing the core metal to force it intimately against the sheath and firing tip head. When the swaging is complete, the thickness of the sheath walls will be reduced somewhat and the core will be firmly packed, no excess metal extending beyond the top of the sheath.

The unit is then heat treated in a reducing atmosphere, such as one consisting of hydrogen, at just below the melting point of the core metal. When, as in the preferred embodiment, copper is used as the core metal, a temperature of from about 1850° to 1900° F. is suitable. This heating step causes the adjacent surfaces of the core and the nickel or nickel alloy sheath to alloy by diffusion.

After the alloying step, a heading operation is used to form the top or head portion on the electrode. The electrode is placed in a hole or die cavity, the contour of which matches the contour of the desired electrode shape. The hole, therefore, will have a top portion of increased diameter the same size as that of the desired head. Pressure is applied to the top of the electrode by hammer blows or otherwise to force the metal against the walls of the cavity to form the sheath head.

If it is desired to form a head of the type shown in Figure 4, that is, a head with a circumferentially relieved upper portion such as is shown at 72 in Figure 4, the required machining may be accomplished at this stage of the process. This machining can be performed by any method known in the art. Likewise, if it is desired to provide a circumferential knurled portion on the electrode as shown at 38 in Figure 1, this may be accomplished after the heading operation by any suitable means known in the metal working art.

The last step of the process is that of cutting the transverse slot in the top of the head. This cutting operation may be performed in any suitable manner.

Figure 3 shows a finished electrode of the type shown in Figure 1 after completion of the above described process, 100 being the tubular sheath, 102 the core and 104 the firing tip.

While, for purposes of illustration of the various electrode parts, I have indicated in the drawing a distinct dividing line between the core and the sheath, it is to be understood that in the preferred embodiments the surface of the core is alloyed to the surface of the sheath, thus resulting in a unitary integral structure.

By the improved electrode of this invention, excellent heat conducting properties are attained. The highly conductive core conducts heat away from the firing tip and dissipates it through the sheath and the glass seal. The sheath, consisting of the aforementioned nickel alloys, affords excellent protection against electrode wear. Utilization can be made of a platinum or other noble metal firing tip without the need for relatively large amounts of the metal. At the same time there is ample protection against loosening of the firing tip and resulting igniter failure. By means of the cooperation of the headed tip and flanged sheath, a secure and permanent positioning of the firing tip is assured.

Various changes and modifications of the embodiments of the invention described herein may be made by those skilled in the art without departing from the spirit and principles of the invention.

I claim:

1. A composite spark plug electrode comprising a tubular sheath of a material consisting of from 78 to 100% nickel, from 0 to 20% chromium, and from 0 to 2% manganese, said sheath having an inwardly extending annular flange at one end thereof, a platinum firing tip having a head portion within said sheath and abutting said flange and a shank portion extending to the exterior of said sheath, and a copper core packed into said sheath and contacting said firing tip, said copper core and said sheath being diffusion alloyed substantially throughout the interface therebetween.

2. A composite spark plug electrode comprising a tubular sheath of high heat and wear resistant metal, said sheath having an inwardly extending annular flange formed as an integral part and at one end thereof, a platinum firing tip having a head portion within said sheath and abutting said flange and a shank portion extending to the exterior of said sheath and a copper core packed into said sheath and contacting said firing tip, said copper core and said sheath being diffusion alloyed substantially throughout the interface therebetween.

3. A composite spark plug electrode comprising a tubular sheath of an alloy consisting of about 96% nickel, about 2% chromium, and about 2% manganese, the bottom of said sheath having an inwardly extending annular flange formed as an integral part thereof and the top of said sheath having an external annular shoulder, a platinum firing tip having a head portion within said sheath and abutting said flange and a shank portion extending to the exterior of said sheath, and a copper core packed into said sheath and contacting said firing tip, said copper core and said sheath being diffusion alloyed substantially throughout the interface therebetween and the top of said electrode being bifurcated to expose a greater surface area of said copper core.

4. A spark plug comprising a metal shell having a ground electrode secured to the base thereof, an insulator surrounded and supported by said shell, a centerbore in said insulator having a lower end of reduced diameter to define a shoulder therein, a composite electrode having a head portion abutting said shoulder to retain said electrode in said centerbore, said electrode comprising a tubular sheath consisting of about 96% nickel, 2% chromium, and 2% manganese, said sheath having an inwardly extending annular flange formed as an integral part therewith at one end thereof, a copper core packed into said sheath and a platinum firing tip having a head portion within said sheath and abutting said flange and a shank portion extending outside said sheath and in spaced relationship to said ground electrode to form a spark gap therebetween, said copper core and said sheath being diffusion alloyed substantially throughout the interface therebetween.

5. The method of making a spark plug electrode comprising the steps of: forming a tubular sheath from an alloy containing about 96% nickel, 2% chromium, and 2% manganese, to provide an inwardly extending annular flange at one end thereof, positioning in said sheath a platinum firing tip having a headed portion and a shank portion so that said headed portion engages said flange and said shank portion extends to the exterior of said sheath, inserting a copper core in said sheath, swaging said electrode to reduce the wall thickness of said sheath and pack said copper into said sheath, heat treating said electrode in a reducing atmosphere at from 1850° to 1900° F. to alloy the surface of said core to the surface of said sheath and forming a head on said electrode.

6. The method of making a spark plug electrode comprising the steps of: forming a tubular sheath from a high heat and wear resistant metal to provide an inwardly extending annular flange at one end thereof, positioning in said sheath a platinum firing tip having a headed portion and a shank portion so that said headed portion engages said flange and said shank portion extends to the exterior of said sheath, inserting a copper core in said sheath, swaging said electrode to reduce the wall thickness of said sheath and pack said copper into said sheath, heat treating said electrode in a reducing atmosphere at from 1850° to 1900° F. to alloy the surface of said core to the surface of said sheath, and forming a head on said electrode.

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