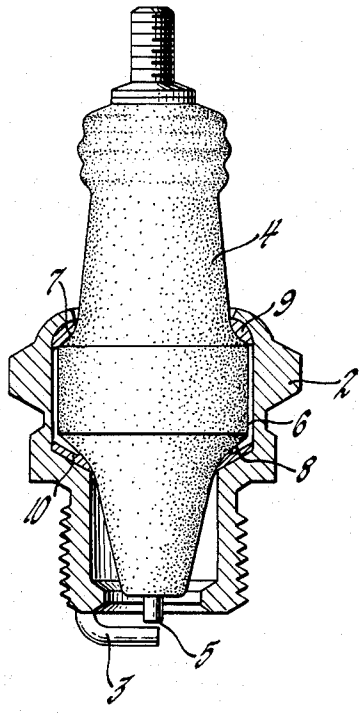
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CERAMIC-TO-METAL SEAL FOR SPARK PLUGS

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CERAMIC-TO-METAL SEAL FOR SPARK PLUGS

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This invention relates to spark plugs and more particularly to an improved ceramic-to-metal seal for spark plugs.

One of the more difficult problems in the manufacture of spark plugs is that of attaining a good hermetic seal between the spark plug outer metal shell and the ceramic insulator. To be one hundred percent effective the seal must prevent gas leakage throughout the wide temperature range in which the spark plug is required to operate, i.e., from below zero up to as high as about 700° F. The problem is complicated by the fact that the steel shell and the ceramic insulator inherently have considerably different coefficients of expansion. Also, because the ceramic insulator is susceptible to cracking, there is a serious limitation on the amount of pressure which can be exerted during manufacture on any packing between the shell and insulator.

At present two types of spark plug shall-to-insulator seals are in common use. One of these consists of an annular powder pack of talc or the like between the insulator and the shell. Such a seal does a reasonably good job of allowing for differences in coefficients of expansion; however, it is relatively expensive to manufacture and the seals of this type which are commercially practical are not uniformly one hundred percent effective in preventing gas leakage. The second type of seal consists of a copper or malleable nickel gasket crimped between the shell and the insulator. Such a seal has the advantage of simplicity and it is quite effective through a temperature range of from below zero to about 550° F. However, from 550° F. upwards the effectiveness of such a seal in preventing gas leakage from the combustion chamber diminishes greatly. For many types of spark plugs this lack of high temperature sealing characteristics is no great problem, so long as the engine and plug are operating normally, because the temperature at the location of the seal does not exceed 550° F. However, for a spark plug designed to run particularly hot such a seal creates a serious gas leakage problem since the temperature at the seal location can reach temperatures on the order of 650° to 675° F. Also, even for spark plugs with a low heat rating, such a seal lacks perfection in that if there should be preignition or some other condition which causes excessive heat, the seal will fail as the critical temperature in the seal location is exceeded. There is a need, therefore, for a simple and inexpensive spark plug seal which is completely effective in preventing gas leakage throughout a temperature range of from below zero to as high as about 675° F. The present invention provides such a seal.

Briefly, I have discovered that if an aluminum base alloy gasket having a hardness of the Rockwell H scale of 65 or higher and tensile strength of at least 16,000 p.s.i. is tightly pressed between the metal shell and the ceramic insulator, an hermetic seal is accomplished which is completely effective throughout a temperature range of from below zero to as high as 690° F.

In the drawing to which the following detailed description is referenced, there is shown a side view in partial section of a spark plug embodying the invention.

Referring now to the drawing the spark plug shown is of the ordinary automotive type and comprises a generally tubular shaped steel shell **2** having a ground electrode **3** welded to he lower end thereof, a ceramic insulator **4** secured concentrically in the shell and a center electrode **5** extending through the insulator with its lower end in spaced spark-gap relationship to the ground electrode. The ceramic insulator should preferably be of a sintered alumina base composition containing upwards of 85% by weight aluminum oxide such, for example, as is covered by United States Patent 2,760,875 Schwartzwalder et al. The external configuration of the shell and the structural details of the electrodes are unimportant to the present invention and can be conventional or of such structure as desired.

To secure the insulator in the shell in hermetically sealed relationship therewith, the insulator is provided with an axial center portion **6** of enlarged diameter which mates with an internal annular recessed portion in the shell **2**. Hence, the insulator has upper and lower external annular shoulders **7** and **8** which cooperate with mating annular shoulders on the interior of the shell.

Pressed between each of these insulator shoulders and the shell is a metal gasket, the upper gasket being shown at **9** and the lower gasket at **10**. In accordance with the present invention, the upper gasket **9** is an aluminum base alloy having a Rockwell H hardness (⅛" steel ball, 60 kg. load) of at least 65 and a tensile strength of 16,000 p.s.i. or higher. I have found eminently suitable the alloys containing about 95% to 99% aluminum and the remainder magnesium, manganese or chromium either singly or in combination. Some examples of such alloys are as follows, proportions being indicated in terms of percentage by weight:

1.2% Mg, remainder aluminum, annealed at about 650° F.
.75% Mg, remainder aluminum, annealed at about 900° F.
.5% Mn, 2.75% Mg, .1% Cr, remainder aluminum
2.5% Mg, .25% Cr, remainder aluminum.

Because the upper gasket **9** provides so effective an hermetic seal the lower gasket is not critical insofar as preventing gas leakage is concerned. Hence, the lower gasket **10** can be of nickel, steel, iron or copper. In actual practice the metal selected for the lower gasket is generally required to have higher heat resistance than the upper gasket for the reason that it is located lower in the plug and hence is subjected to higher temperatures. Because of this, nickel or steel is preferred for the lower gasket.

In the manufacture of the spark plug, the shell is first formed with the top edge portion, which is subsequently to be crimped inwardly over the upper sealing gasket **9**, extending upwardly so as to allow assembly of the insulator within the shell. The lower sealing gasket **10** followed by the insulator and the upper sealing gasket **9** are placed in the shell and the upper edge of the shell is then crimped inwardly over the upper sealing gasket as shown. Next, an electric current is passed through the shell so as to cause the annular thin section located about midway thereof to soften, axial pressure being simultaneously applied to the ends of the shell to cause the thin section to slightly collapse and thereby tightly press the upper and lower gaskets between the insulator and the shell. The pressure is sufficient to cause the upper aluminum base gasket to slightly deform, the bottom surface thereof extruding to a small extent into the thin annular space between the enlarged insulator center portion **6** and the shell. This resistance heating operation whereby the shell is collapsed to press the gaskets into sealed relationship with the insulator is well known in the art and is commonly referred to as Cico-Welding. Instead of locating the thin section of the shell midway thereof as shown, the upper flange portion of the shell can, if desired, be made to serve as the thin section such

that the heat is generated in this flange during the passage of electric current through the shell.

The reasons why the seal described is so effective are not fully understood; what is known, however, is that both composition and hardness are important. That is, the gasket must be of an alloy predominantly of aluminum (i.e., more than about 95% aluminum), and it must have a Rockwell H hardness of at least 65 and a tensile strength of at least 16,000 p.s.i. in order to provide the excellent results. A gasket which is formed of commercially pure aluminum and which therefore has a Rockwell H hardness of less than 65 has, for example, been found unsatisfactory as regards preventing gas leakage at seal temperatures in excess of about 550° F. And a gasket of copper, annealed steel or ductile nickel or iron is not effective to prevent leakage above about 550° F. albeit the gasket might have a Rockwell H hardness and tensile strength substantially the same as or greater than those of an aluminum base gasket which is effective.

It will be understood that while the invention has been described with reference to specific embodiments thereof various changes may be made within the full and intended scope of the claims which follow.

I claim:

1. A spark plug including a generally tubular shaped metal shell having an internal annular shoulder therein, a ceramic insulator in said shell having an external annular shoulder positioned adjacent the internal annular shoulder of said shell and an annular gasket pressed tightly between said shoulders to form a seal between said insulator and said shell, said annular gasket being of an aluminum base alloy having a Rockwell H hardness of at least 65 and a tensile strength of at least 16,000 p.s.i.

2. A spark plug as defined in claim **1** wherein said gasket is of an alloy containing from about 95% to 99% by weight aluminum and the remainder substantially all

metals selected from the group consisting of magnesium, manganese and chromium.

3. A spark plug including a generally tubular shaped metal shell having a portion of enlarged internal diameter so as to define upper and lower internal annular shoulders in said shell, a ceramic insulator in said shell having upper and lower external annular shoulders positioned adjacent the upper and lower internal shoulders respectively of said shell, a high heat resistant metal gasket pressed between the lower shoulder of said insulator and the lower shoulder of said shell and a gasket between the upper shoulder of said insulator and the upper shoulder of said shell forming an hermetic seal between said insulator and said shell, said second-mentioned gasket being of an aluminum base alloy having a Rockwell H hardness of at least 65 and a tensile strength of at least 16,000 p.s.i.

4. A spark plug as defined in claim **3** wherein said aluminum base alloy gasket contains from about 95% to 99% by weight aluminum and the remainder substantially all metals selected from the group consisting of magnesium, manganese and chromium.

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