Dec. 12, 1972 J. T. RAUSCH ET AL 3,705,951

SPARK PLUG SEALING GASKET

Filed Nov. 12, 1970

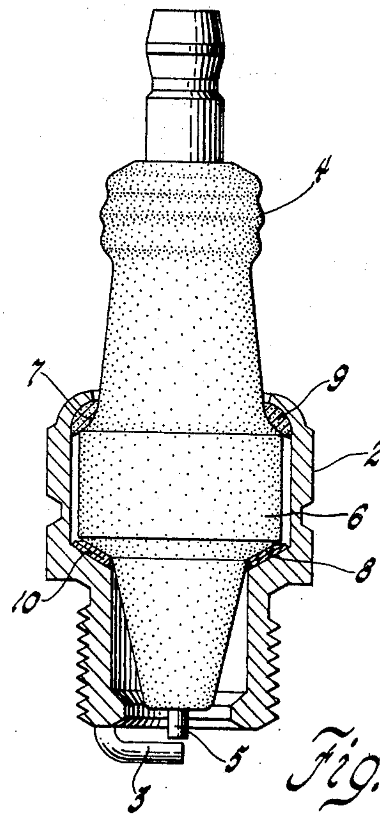


Fig.1

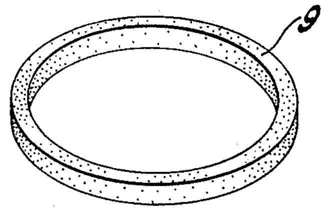


Fig.2

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SPARK PLUG SEALING GASKET
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## ABSTRACT OF THE DISCLOSURE

This invention relates to spark plugs and more particularly to an improved upper seal or gasket for spark plugs. The seal is initially made of 99.4% pure commercially available iron powder that upon heat treat becomes even higher in iron content to provide the necessary ductility for the gasket to seat properly.

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 through the wide temperature range in which the spark plug is required to operate; i.e., from below zero up to as high as 700° F. and higher. insulator. To be one hundred percent effective, the seal shell and the ceramic insulator inherently have considerable different coefficients of expansion. Further, 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. The ceramic could very likely have tiny burrs or other imperfections remaining at the seat area that will create a problem in seating the gasket or seal and therefore a ductile seal material is needed to absorb such imperfections. Also, dimensional variations of the angular seats on the insulator and steel shell require a uniformly ductile gasket material to insure conformability necessary to prevent leakage between all surfaces. The desirable ductility that is achieved by using the highest percentage of pure powdered iron also prevents high stress points that could occur due to dimensional variations.

At present, four types of spark plug shell-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 combustion gas leakage through the spark plug 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. and higher. 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

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in the seal location is exceeded. A third type of seal consists of an alloy containing about 95% to 99% aluminum and the remainder magnesium, manganese or chromium. The aluminum alloy gasket has basically the same limitations as those noted above relative to the copper or malleable nickel gasket. A fourth type of seal made of low carbon steel is presently being used because of its ability to provide a stabile seal at temperatures well in excess of those generated even in high-performance engines. To insure proper functioning of this sealing gasket, however, requires extremely close control metallurgically of the material to insure ductility. It is also subject to variations caused by variance in the stamping dies.

There is a need, therefore, for a simple and inexpensive spark plug seal which is completely effective in preventing combustion gas leakage between the steel shell and the ceramic insulator through a temperature range of from below zero to as high as 700° F. and higher. The present invention provides such a seal.

We have discovered that if a 99.4% pure powdered iron is used and properly heat treated, a hermetic seal is accomplished which is completely effective throughout a temperature range of from below zero to as high as 2795° F., the melting point of the pure iron. This type of sealing gasket embodies all the desirable features of seals in common usage today; these features being: uniform ductility, dimensional uniformity, uniform grain structure and good metallurgical control of hardness. Because it is iron, it has ability to withstand the required high temperatures.

In the drawing:

FIG. 1 is a side view in partial section of a spark plug embodying the invention; and

FIG. 2 is an isometric view of our improved seal.

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 the 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 eletcrode. 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 No. 2,760,875, Schwartzalder et al. The external configuration of the shell and the structural details of the electrodes are conventional.

The process of forming our gasket comprises the steps of blending an iron powder with a lubricant commonly used in the art, such as zinc stearate or wax, and in an amount of about 1% by weight. We have found that the iron powder need not be of any particular type or shape, such as spherical or spongy, but may be of any commercially available type where the material is substantially entirely iron, except for normally encountered impurities.

The size of the metal powder is less than 300 microns, with an average size of at least about 40 microns. When mixed with the lubricant, the powder should be of the type to have little or no tendency to form agglomerates. The blended powder is loaded into a die cavity having the desired gasket shape and a press used to provide loading pressure on the die to compact the powder. Press pressures on the die will vary from 35 to 60 tons per square inch, depending on the type of powder used, with 35 tons per square inch being generally the pressure required to achieve the desired density results. Density may vary from 6.95 gm./cc. to 7.05 gm./cc., with 7.0 gm./cc. being the desired or optimum density. By way of example, a typically dimensioned gasket would be about 0.080 inch in thickness and about 0.627 inch in outside diameter and 0.527 inch inside diameter.

The resulting gasket is then subjected to a sintering treatment in a reducing atmosphere at a relatively high temperature. A cracked ammonia atmosphere and a temperature of at least 2400° F. are quite suitable and adequate for use in obtaining the desired results. While higher temperatures above 2400° F. may be used, we do not find the added costs warrant the use of temperatures beyond 2475° F. The gasket is sintered for a period of three quarters of an hour to one hour and a quarter, with all impurities being burnt off during the sintering process, wherein the ductile compact resultant gasket is 99.6% and higher pure iron, depending on the percentage of impurities burnt off. The gasket is cooled in the working furnace to prevent oxidation and after cooling is ready for assembly. It is understood that a powder iron of lesser purity could be used but, as the iron purity goes down, desired ductility likewise goes down.

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 the upper shoulder and the shell is the gasket of our invention shown at **9** and a lower conventional gasket shown at **10**. If the upper gasket is an adequate enough seal, the lower gasket can be eliminated to further cut the cost of manufacture. By use of a powdered iron seal as herein proposed, the lower seal can be completely eliminated.

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 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 gasket or seal described is effective because the material produced is ductile or spongy and, therefore, conforms to the sealing area with only 5% to 50% of the total required pressure being applied to obtain a proper seal. Because of the ductility, the gasket will collapse and conform to the area in which it is used. As a result, it is able to absorb or have embedded therein any burrs or imperfections on the insulator that would otherwise prevent a seal between the two.



Gaskets made from aluminum or copper are generally not able to absorb any impurities or burrs that may be left on the insulator during manufacture and, therefore, the insulator must be held to a very close tolerance and be burr free. As a result, there is an increase in cost.

A low sealing pressure will obviously prevent and preclude breakage of the ceramic insulator which is a common problem during assembly of the upper gasket to the insulator body. Further, known gaskets used in a similar application are generally stamped from sheet material and, as a result, the material from the punched hole becomes scrap. Since the present invention is made from powdered material, there is relatively little, if any, scrap; and, therefore, the cost per pound for material is less than if the gasket were made from sheet material.

The present invention, therefore, provides an inexpensive scrap-free means of obtaining a spark plug upper sealing gasket that is ductile and resilient and thereby can absorb any burrs left on the ceramic insulator, allows minimum pressure to be applied on the insulator to obtain a seal between the insulator and body shell, thereby avoiding breakage of the insulator, is easy to manufacture at a cost savings over the presently used similar gaskets, and because of the high temperatures it can withstand the lower gasket is not necessary, which will also give a cost savings.

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.

We claim:

**1.** In a spark plug including a generally tubular shaped metal shell having an internal annular upper and lower shoulder therein, a ceramic insulator in said shell also having an upper and lower external annular shoulder positioned adjacent the internal annular shoulder of said shell wherein the improvement comprises the use of a compact ductile gasket pressed tightly between the upper shoulders to form a seal between said insulator and said shell, said annular gasket being metallurgically formed of a pure powdered iron having a density of 6.95 to 7.05 gm./cc.

**2.** In a spray 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 wherein the improvement comprises a ductile compact uniformly dimensioned annular gasket between the upper shoulder of said insulator and the upper shoulder of said shell forming a hermetic seal between said insulator and said shell, said second-mentioned gasket being formed from a 99.4% or higher pure powdered iron and heat treated by sintering to mantain said gasket at the desired purity and of a density of 6.95 to 7.05 gm./cc.

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NATHAN KAUFMAN, Primary Examiner

U.S. Cl. X.R.

313—119

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(5/69)

# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 3,705,951 Dated December 12, 1972

Inventor(s) John T. Rausch and Michael Skunda

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 27, "insulator. To be one hundred percent effective, the seal" should read -- The problem is complicated by the fact that the steel --.

Column 2, line 46, "Schwartzalder et al" should read -- Schwartzwalder et al --.

Column 4, line 42, "spray" should read -- spark --.
line 56, "mantain" should read -- maintain --.

Signed and sealed this 15th day of May 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

PO-1050
(5/69)

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