

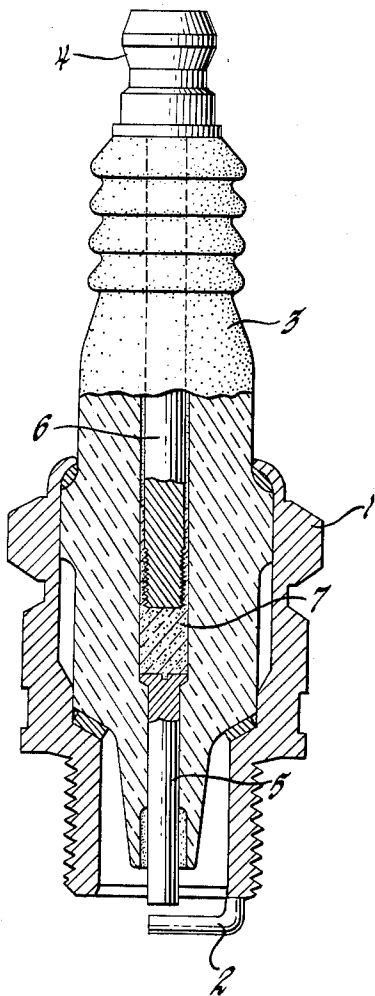
Dec. 28, 1965

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3,226,342

SPARK PLUG AND SEAL THEREFOR

Filed Nov. 9, 1962



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3,226,342

SPARK PLUG AND SEAL THEREFOR

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Filed Nov. 9, 1962, Ser. No. 236,505

4 Claims. (Cl. 252—503)

This invention relates to an improved ceramic-to-metal conductive seal for spark plugs and the like.

It is common practice in the spark plug art to form a part of the center electrode conductive path which extends through the insulator of a fused mass of glass and conductive material which bonds to the ceramic thereby forming an electrically conductive hermetic seal. Such seals are shown, for example, by United States Patents 2,106,578, issued to Karl Schwartzwalder and William Shuford Kirk, and 2,248,415, issued to Karl Schwartzwalder and Alexander S. Rulka. The latter patent discloses a seal consisting of about 50% copper powder and 50% glass, this being the composition which is presently most commonly used for conductive glass seals in high production automotive type spark plugs. In practice a seal of this type is formed by first positioning the metal center electrode in the lower part of the insulator centerbore, injecting into the centerbore over the top of the center electrode a charge of the metal-glass seal mixture in powder form, inserting a metal terminal screw into the centerbore and then heating so as to cause the glass seal mixture to soften while simultaneously pressing down on the terminal screw. In this manner pressure is applied to the softened glass material to cause it to densify and to bond to the insulator, the center electrode and the terminal screw. It has been found that the application of pressure to the seal while it is in the softened condition is essential for the reasons indicated, i.e., to assure non-porosity and good bonding. However, by reason of such pressure having been applied, the finished hardened seal is in something of a stressed condition and if the seal is reheated to a certain temperature, it will rapidly expand and lose its sealing properties. The temperature to which the seal must be reheated to create such condition is referred to as the "backup temperature" and is, of course, characteristic of the particular seal composition used. The fact is, however, that for all glass sealing compositions heretofore known, for example those shown in the aforementioned prior patents, the backup temperature is very much lower than the temperature to which the sealing material must be initially heated in order to cause softening during manufacture. As a typical example, a fifty-fifty mixture of copper and borosilicate glass presently in common use requires heating to 1650–1700° F. to cause softening during processing, and the seal so formed has a backup temperature of only 1200° F. This is a problem since under certain abnormal operating conditions that can occur from time to time the temperature at the location of the seal can reach a temperature of about 1200° F. thereby causing a permanent failure of the seal. It is a relatively simple matter, of course, to formulate a seal composition with a somewhat higher initial softening temperature and with a commensurately somewhat higher backup temperature. However, this is not a satisfactory solution to the problem for the reason that the metal parts involved cannot tolerate processing temperatures much in excess of 1700° F. and it would be prohibitively expensive to make such parts of a more heat resistant metal.

It is an object of the present invention to provide a conductive glass seal which can be pressed to high density at a temperature sufficiently low to be practical for low cost spark plug manufacture and yet which has excellent

and durable sealing properties through an exceptionally wide temperature range.

Briefly, my invention comprehends a conductive glass seal formed of a composition consisting essentially of about 45% to 55% metal powder, preferably copper, about 9% to 10% carbon black and the remainder a mixture of two borosilicate glasses. One of the borosilicate glasses should preferably constitute about 70% to 80% of the total glass content and should be of a composition containing about 75% to 85% by weight SiO₂ and about 10% to 15% by weight B₂O₃. The other of the borosilicate glasses should preferably constitute about 20% to 30% of the total glass content and should be of a composition containing about 60% to 70% by weight SiO₂ and about 20% to 25% by weight B₂O₃. For both glasses, the remainder of the composition consists predominantly of Al₂O₃ and the alkaline and alkaline earth oxides. I have found that by reason of the carbon black and the mixture of the two borosilicate glasses, the seal can be effectively pressed to high density and into good bonded relationship with the ceramic and the metal parts at temperatures of about 1650° F., and the seal so formed is quite durable up to 1400° F., a temperature which is practically never exceeded at the seal location during spark plug operation, either under normal or abnormal engine operating conditions.

Further particulars will be set forth in the following description of a preferred embodiment made with reference to the accompanying drawing which shows a side view in section of an automotive type spark plug incorporating the invention.

Referring now to the drawing there is shown a spark plug comprising a generally tubular shaped outer metal shell 1 having a ground electrode 2 welded to the lower end thereof, a ceramic insulator 3 secured within the shell in the conventional manner and a conductive path extending through the insulator having a terminal 4 at the top and terminating with a center electrode 5 which extends into spaced spark gap relationship with the ground electrode. The ceramic insulator should preferably be of a high alumina base material containing upwards of 85% aluminum oxide such, for example, as covered by United States Patent 2,760,875, issued to Karl Schwartzwalder and Helen Blair Barlett. Such an insulator has excellent mechanical strength and heat shock resistance along with the ability to form an excellent bond with borosilicate glass, all of these characteristics being of considerable advantage in forming the conductive glass seal of this invention.

In addition to the center electrode 5 the conductive path includes a metal terminal screw 6 and conductive glass seal 7 between the center electrode and the terminal screw. The conductive seal 7 is bonded to the center electrode, the terminal screw and the inner walls of the ceramic insulator to provide an electrically conductive path from the terminal screw to the center electrode and to provide an hermetic seal in the insulator centerbore. In accordance with the present invention, this conductive seal is a dense, fused mass of metal powder, carbon black and two borosilicate glasses preferably in the proportions indicated above. The preferred composition for the seal is as follows in terms of percentage by weight:

	Percent
Copper powder	50.0
Carbon black	9.1
Borosilicate glass #1	30.5
Borosilicate glass #2	10.4
Composition of Borosilicate Glass #1:	
SiO ₂	81
B ₂ O ₃	13
Na ₂ O, K ₂ O, Al ₂ O ₃ , MgO	6

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Composition of Borosilicate Glass #2:	Percent
SiO ₂ -----	65
B ₂ O ₃ -----	23
Na ₂ O -----	7
Al ₂ O ₃ -----	5

In manufacturing the spark plug the center electrode 5 is inserted into the lower end of the insulator centerbore so that its head portion seats on the internal shoulder as shown, and a charge of the aforesaid metal-carbon black-borosilicate glass mixture in powder form is then inserted into the centerbore over the top of the center electrode. The powder charge should preferably be tamped to level it out after which the terminal screw 6 is inserted. The assembly is then heated to about 1650° F. on about a 30-minute schedule, holding at the maximum temperature for about 40 seconds during which pressure is applied to the top of the terminal screw to force the lower threaded end portion downwardly into the then softened conductive glass mixture until the flange adjacent the top of the terminal screw abuts the top of the insulator. As a result of this operation, the softened conductive seal is pressed to high density and into excellent bonded relationship with the insulator and the metal parts. A pressure of about 100 pounds for a centerbore and terminal screw diameter of about one-eighth inch is satisfactory. After this heating and pressing operation the assembly is allowed to cool, the conductive glass mixture thereby hardening to complete the sealing operation.

In making the conductive seal mixture, I prefer to use metal powder and glass powder of about 325 mesh grain size and carbon black of about 200 mesh. An excellent carbon black for the practice of the invention is that commercially known and available as Thermax. If desired, a small amount of organic binder such as hydrogenated cotton seed oil may be admixed with the powder and the mixture then compressed into a self-sustaining pellet which will serve as a convenient manner of inserting the desired amount of powder mixture into the insulator centerbore. Of course, the organic binder decomposes and goes off as a gas during the heating and pressing operation.

In addition to providing a high backup temperature, the seal is advantageous in that the carbon black serves to assure against any oxidation of the metal powder during heating, this because the carbon powder constitutes a reducing agent.

It will be understood that while in the embodiment shown the center electrode conductive path consists of only three elements, namely, the center electrode, the terminal screw and the conductive glass seal, other elements such as resistors, series spark gaps and the like may be included if desired. Also, the precise structures of the metal elements, i.e., the center electrode and the terminal screw, to which the conductive seal is bonded, are not essential to the practice of the invention though it is, of course, desirable that those portions of the metal elements which are in contact with the conductive glass seal be formed so as to provide a good amount of surface area. For some types of spark plugs, for example resistor plugs, it may be desirable to use two layers of the conductive glass seal with a layer of some other material interposed therebetween. In such structures only one metal element is bonded to each of the conductive seal layers, the interposed material serving as the other contact for each layer.

Hence, it will be understood that while the invention has been described specifically with reference to one par-

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ticular embodiment thereof, various changes and modifications may be made all within the full and intended scope of the claims which follow.

I claim:

1. A sealing composition for forming an electrically conductive hermetic seal in a ceramic insulator, said hermetic seal being capable of operating hermetically at temperatures up to 1400° F., said composition consisting essentially of about 45% to 55% by weight copper powder, about 9 to 10% by weight powdered carbon black and the remainder a mixture of two borosilicate glasses, one of said borosilicate glasses constituting about 60% to 70% by weight of the total glass content and consisting substantially of 75% to 85% by weight SiO₂ and 10% to 15% by weight B₂O₃ and the other of said borosilicate glasses consisting substantially of 60% to 70% by weight SiO₂ and about 20 to 25% by weight B₂O₃.

2. A sealing composition for forming an electrically conductive hermetic seal in a ceramic insulator, said hermetic seal being capable of operating hermetically at temperatures up to 1400° F., said sealing composition consisting essentially of about 50% by weight copper powder, about 9% powdered carbon black, and the remainder a mixture of two borosilicate glasses, one of said borosilicate glasses constituting about 75% by weight of the total glass content and consisting substantially of 81% by weight SiO₂, 13% B₂O₃ and the remainder Na₂O, K₂O, Al₂O₃ and MgO, and the other of said borosilicate glasses containing about 65% by weight SiO₂, 23% B₂O₃, 7% Na₂O and 5% Al₂O₃.

3. A spark plug comprising a ceramic insulator having a bore therethrough, a metal member in said bore and a dense, fused, electrically conductive mass bonded to said metal member and bonded to said ceramic insulator to form a hermetic seal on said bore, said hermetic seal being capable of operating hermetically at temperatures up to 1400° F., said mass consisting essentially of about 45 to 55% by weight copper powder, about 9% to 10% by weight powdered carbon black and the remainder a mixture of two borosilicate glasses, one of said borosilicate glasses constituting about 60% to 70% of the total glass content and consisting substantially of 75% to 85% by weight SiO₂ and 10% to 15% by weight B₂O₃ and the other of said borosilicate glasses consisting substantially of 60% to 70% by weight SiO₂ and about 20% to 25% by weight B₂O₃.

4. A spark plug as defined in claim 3 wherein said mass consists essentially of about 50% by weight copper powder, about 9% carbon black, and the remainder a mixture of two borosilicate glasses, one of said borosilicate glasses constituting about 75% by weight of the total glass content and containing about 81% by weight SiO₂, 13% B₂O₃ and the remainder Na₂O, K₂O, Al₂O₃ and MgO, and the other of said borosilicate glasses containing about 65% by weight SiO₂, 23% B₂O₃, 7% Na₂O and 5% Al₂O₃.

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