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CERAMIC RESISTOR

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14 Claims. (Cl. 201—75)

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This invention relates to ceramic resistors, and more particularly to ceramic resistors used at elevated temperatures, for example as suppressors in spark plugs.

A primary object of the invention is to provide ceramic resistors that are of simple composition, that combine good mechanical strength and requisite electrical resistivity with the ability to be operated at elevated temperatures without objectionable impairment of those properties, and that may be made easily from readily available materials.

Another object is to provide such resistors that additionally are adapted to carry repeated electrical surges at temperatures up to about 500° F. with minimum change in resistance.

A further object is to provide a method of making ceramic resistors embodying the foregoing properties and characteristics and which is simple and easily practiced using conventional equipment.

Other objects will appear from the following description.

The invention is predicated upon my discovery that resistors in accordance with its objects are provided by vitrified refractory bodies formed from clay, talc and zircon through which carbon in finely divided form is uniformly distributed to permit electrical leakage to the extent necessary to supply the desired resistance. More particularly, the bodies of resistors in accordance with the invention are made from ceramic compositions comprising about 8 to 15 per cent of talc, about 35 to 45 per cent of clay, most suitably a ball clay, and about 40 to 57 per cent of zircon, all by weight. Preferably the bodies are formed from, by weight, about 10 per cent of talc, 40 per cent of ball clay, and 50 per cent of zircon.

Such compositions when vitrified provide ceramic bodies that are mechanically strong and of high electrical resistance and, importantly, they are stable mechanically and electrically when exposed to elevated temperatures, for instance as high as 500° F. Compositions of clay and talc do not suffice for these purposes because they are mechanically weak and their electrical properties are insufficient for resistor purposes: furthermore, they do not satisfactorily withstand use at elevated temperatures or the application of repeated electrical surges. Although zircon is highly refractory and has very high dielectric strength, it can not be used alone for making resistor bodies because it cannot be vitrified at any practicable temperature. Nor do compositions

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of zircon and talc or zircon and clay provide satisfactory resistor bodies. I have discovered, however, that the clay and talc react to vitrify readily and serve as a permanent bond for zircon, and that the product forms resistor bodies of adequate mechanical strength, the necessary electrical resistance for resistor purposes, and retention of those properties at elevated temperatures. Not only does the zircon contribute high dielectric strength to the bodies thus produced, but also it reduces the porosity of clay-talc compositions alone.

In accordance with the invention carbon in finely divided form is distributed throughout the resistor body. The amount used will, of course, depend upon the specific resistance desired, i. e., the more carbon that is present, the lower the resistance will be. For most purposes I prefer to add to the ceramic body composition from one to ten parts by weight of finely divided carbon per 100 weight parts of the ceramic body constituent. Preferably there is used for this purpose a calcined carbon black. The following table shows how the resistance may be varied by alteration in the amount of carbon added to a body of the foregoing preferred composition.

Parts by weight carbon per 100 parts body mix	Spec. Res. Ohms/In. Cube
1	8,000
5	3.2
10	0.5

All of the materials used should be in finely divided form. The zircon is preferably supplied in initially milled condition, and it is important that the zircon be in the form of rounded particles because if the zircon is in the form of particles with sharp points there is a tendency to cause concentration of electric field stress that is undesirable in a resistor. In making resistors in accordance with the invention the ceramic constituents and carbon are intimately mixed so that there is homogenous distribution of all of them throughout the batch. Most suitably this is accomplished by ball milling, and preferably the mixture is ground so that the particles do not exceed about 10-micron size. A temporary binder is then added, suitably in a kneading type mixer. Preferably the binder is one that will be completely burned out during the firing of the resistor bodies. A wide variety of such binders

are known and used in the ceramic trade such, for example, as molasses, lignin residue from the wood pulping industry, and others, such as diglycol stearate. Likewise, a mixture of tricresyl phosphate with a silicone resin, such as "DC 2103 resin" has been found to give satisfactory results because it affords adequate temporary bonding and decomposes during firing without depositing any appreciable carbonaceous residue that might alter the electrical characteristics desired.

After the batch has been thoroughly mixed with the temporary binder the material is granulated through a 20-mesh screen and then molded to size and shape. After molding the bodies are fired between 2000° and 3000° F., depending upon the composition of the body, in a non-oxidizing atmosphere, preferably in a reducing atmosphere such as hydrogen or cracked ammonium.

According to the provisions of the patent statutes, I have explained the principle and mode of practicing my invention and have described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

I claim:

1. That method of making ceramic resistors that comprises the steps of forming a batch consisting essentially, by weight, of 8 to 15 per cent of finely divided talc, 35 to 45 per cent of finely divided clay, and 40 to 57 per cent of milled zircon in the form of finely divided rounded particles, together with 1 to 10 parts by weight of finely divided carbon based on the weight of said mixture, mixing said batch with a temporary binder, then molding resistors therefrom, and heating the molded resistors in a non-oxidizing atmosphere to vitrify them.

2. That method of making ceramic resistors that comprises the steps of forming a batch consisting essentially, by weight, of 8 to 15 per cent of talc, 35 to 45 per cent of clay, and 40 to 57 per cent of milled zircon, all in the form of particles not over about 10 micron size, together with 1 to 10 parts by weight of finely divided carbon based on the weight of said mixture, mixing said batch with a temporary binder, then molding resistors therefrom, and heating the molded resistors in a non-oxidizing atmosphere to vitrify them.

3. A method according to claim 2, said carbon being calcined carbon black.

4. A method according to claim 2, said zircon being in the form of rounded particles.

5. A method according to claim 2, said zircon being in the form of rounded particles, and said carbon being calcined carbon black.

6. A method according to claim 2, said atmosphere being a reducing atmosphere.

7. A method according to claim 2, said zircon being in the form of rounded particles, and said atmosphere being a reducing atmosphere.

8. That method of making ceramic resistors that comprises the steps of forming a batch consisting essentially, by weight, of 10 per cent of finely divided talc, 40 per cent of finely divided ball clay, and 50 per cent of milled zircon in the form of finely divided rounded particles, together with 1 to 10 parts by weight of finely divided carbon black based on the weight of said mixture, mixing said batch with a temporary binder, then molding resistors therefrom, and heating the molded resistors in a non-oxidizing atmosphere at 2000° to 3000° F. to vitrify them.

9. A method according to claim 8, said atmosphere being reducing.

10. A method according to claim 8, said talc, ball clay and zircon being not over about 10 micron size.

11. A method according to claim 8, said talc, ball clay and zircon being not over about 10 micron size, and said atmosphere being reducing.

12. Ceramic resistors consisting essentially of a vitrified body of a mixture of, by weight, 8 to 15 per cent of talc, 35 to 45 per cent of clay, and 40 to 57 per cent of milled zircon, together with 1 to 10 parts by weight of finely divided carbon based on the weight of said mixture.

13. Ceramic resistors consisting essentially of a vitrified body consisting essentially, by weight, of a mixture of 10 per cent of finely divided talc, 40 per cent of finely divided clay, and 50 per cent of milled zircon, together with 1 to 10 parts by weight of finely divided carbon based on the weight of said mixture.

14. Ceramic resistors consisting essentially of a vitrified body of an intimate mixture, by weight, of 10 per cent of talc, 40 per cent of ball clay, and 50 per cent of milled zircon in the form of rounded particles, all in the form of particles not over about 10 micron size, together with 1 to 10 parts by weight of finely divided carbon black based on the weight of said mixture.

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