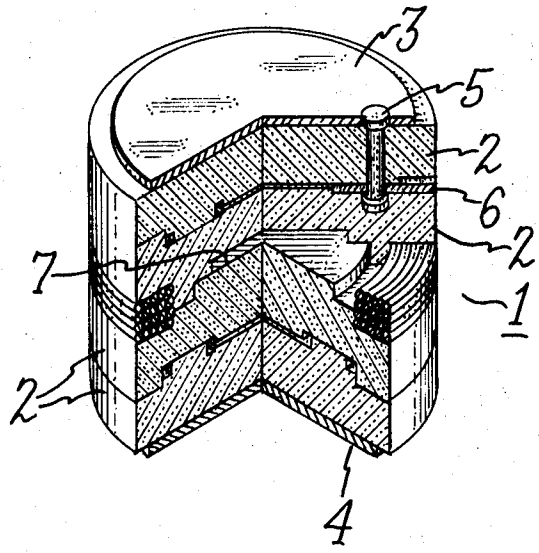
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POROUS CERAMIC INSULATING MATERIAL AND METHOD OF MAKING EMPLOYING WAX

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ABSTRACT OF THE DISCLOSURE

Porous insulating material suitable for forming arching gap plates of lightning arresters is made from a mixture of aluminum oxide grains of selected particle size to provide increased porosity, molten wax and powdered glass, the warm mixture being cooled at a controlled rate to produce a homogeneous mass of free-flowing particles which are thereafter pressed into desired shape and fired at elevated temperature.

It is an object of the invention to provide porous insulating refractory material of the above type which has increased porosity and is particularly suitable for use in electrical apparatus such as lightning arresters in which the material is subjected to the action of electrical arcing.

It is another object of the invention to provide an improved method of making insulating material of the above type which results in products made of the material which are mechanically strong, precise in dimension, and of good electrical characteristics, especially arc-extinguishing properties.

It is still another object of the invention to provide an improved mixture composition for making refractory insulating material of the above type which facilitates the process of making the insulating material.

Other objects and advantages will become apparent from the following description and the appended claims.

With the above objects in view, the present invention in one of its aspects relates to a porous refractory insulating material made from a shaped, fired mixture of aluminum oxide particles of a predetermined range of sizes, powdered glass, and molten wax.

In another of its aspects, the invention relates to the process of treating the above described mixture to provide a homogeneous mass of particles of relatively uniform size which has good plasticity and flow characteristics, which lends itself to ready forming of shaped pieces of high uniform porosity provided by open interconnected pores, good mechanical strength and sharply defined form, and which facilitates handling while being processed.

The invention will be better understood from the following description taken in conjunction with the accompanying drawing, in which:

The single figure is a perspective view, partly in section, of a spark gap device in which the refractory insulating material of the present invention may be embodied.

Referring now to the drawing, there is shown a spark gap assembly **1** adapted for use in a lightning arrester and comprising a stacked series of plates **2** of porous insulating material having open interconnected pores and made from a mixture and by process in accordance with the present invention. The assembly illustrated includes upper terminal plate **3**, lower terminal plate **4**, rivets **5**, interior electrodes **6**, and spark chambers **7**. The structure of the spark gap device **1** or the particular shape and arrangement of the insulating plates **2** or other components thereof form no part of the present invention,

such a device being shown, for example, in the patent to Stetson et al. 3,151,273. It will be understood, of course, that the present invention is applicable to various other types of spark gap devices, and other electrical equipment where control, attenuation and extinguishing of electrical arcing is necessary or desirable, such as in arc chambers of circuit breakers, switches and the like.

In a device of the type shown, it is desirable that gap plates **2** be made of a hard, refractory, thermally conducting electrically insulating material of good porosity and with open interconnected pores for the purpose of lengthening, attenuating and cooling the arcs produced in the device by high surge voltages due to lightning, switching or fault currents, so as to extinguish the arcs after the voltage surge passes, the gap device thereby returning to normal open circuit condition, as more fully explained in the aforementioned Stetson et al. patent.

In accordance with a preferred embodiment of the present invention, gap plates **2** are made from a mixture of aluminum oxide grains, powdered glass and molten wax, the mixture having the range of composition and a particularly preferred composition as follows, in percent by weight:

TABLE I

	Percent	
	Range	Preferred
Ingredient:		
Aluminum oxide (granular)	60–85	77
Glass (powder)	10–30	16
Wax	5–10	7

In accordance with a significant feature of the invention, the aluminum oxide grains are selected to be within a particular range of size distribution as follows, the amounts (in percent by weight) being shown in terms of cumulative maximum and minimum quantities retained by U.S. standard sieves as listed below:

TABLE II

	Percent	
U.S. Standard Sieve No.	Minimum	Maximum
50	5	10
60	6	35
70	40	60
80	65	85
100	85	97
120	95	100

By way of explanation of the foregoing table, the sizes of all the aluminum oxide grains are such, for example, that when screened through a #50 sieve, at least about 5% but not more than about 10% of the total amount of the grains are retained by the sieve, while in the use of a #120 sieve, between about 95% and 100% of the grains are retained by the sieve. By virtue of the use of such selected grain sizes and the process carried out in accordance with the invention, the fired refractory ceramic material produced by the invention has a porosity of about 25% to 32% characterized by open interconnected pores, a property which enhances the capability of the material of spreading, attenuating, and cooling the electrical arcs therein for a more effective and reliable arc extinguishing function.

The foregoing porosity values are as measured by ASTM procedure designated ASTM C20–46.

While optimum results for making spark gap devices of the type described are obtained by the size distribution of refractory grains as shown in Table II above, the invention in a broader aspect may be defined simply by a size distribution wherein a #50 sieve retains between 5%–10% of the grains, and a #120 sieve retains no less

than 95% of the grains, which thus have a particle size of at least about 0.125 mm.

The wax employed in the described composition is refined paraffin scale wax having a melting point of 55–56° C. and containing a maximum of 0.1% oil. Such wax, which is generally white in color, is commercially available under the designation "Moore and Munger No. 5612."

The powdered glass employed in the described composition is selected to have a thermal expansion coefficient which substantially matches that of the aluminum oxide particles. The glass is finely divided by ball-milling or other suitable process so that the glass particles are generally finer than the finest particles of the aluminum oxide. A particular glass composition found suitable for use with aluminum oxide particles is a borosilicate glass made from the following composition, in percent by weight:

TABLE III

	Percent	
	Range	Preferred
Ingredients:		
SiO_2	46–49	47.5
B_2O_3	13.5–16.5	15.0
Al_2O_3	18.0–22.0	20.0
CaO	8.0–12.0	10.0
MgO	6.0–9.0	7.5

The softening point of such a glass is about 1150° C., it is completely liquid at 1300° C., and its coefficient of thermal expansion is about 5.5×10^{-6} per ° C. (300° C.–700° C.), compared to 5.1×10^{-6} per ° C. (300° C.–700° C.) for aluminum oxide.

While aluminum oxide is particularly preferred for use as the refractory material in making arc extinguishing devices such as illustrated, other refractory material may be used within the scope of the invention in place of, or in addition to, aluminum oxide, as appropriate for the purposes desired, as for example mullite, cordierite, zirconia, magnesia, beryllia, or the like. As will be understood, the glass employed with any such other refractory material will be selected to have matching thermal expansion characteristics.

In a typical process employed in practicing the invention, aluminum oxide grains having sizes within the distribution range of Table II and in an amount within the described composition range are heated to about 75° C., or somewhat higher than the melting point of the wax to be used, and the hot grains are transferred to a mixing bowl. Molten wax in the described proportion is added to the aluminum oxide grains, which are stirred until all the grains are coated with the wax. The powdered glass in the descrbied proportion is then added to and mixed with the wax coated grains. When the still warm mixture is homogeneous, heat is removed therefrom by cooling the mixing container. The wax coating hardens as a result of such cooling, and during this time the mixture is continuously stirred until its temperature drops to about 40–45° C. Thereafter, the mixture is screened through a No. 16 sieve which is vibrated, producing a free-flowing, homogeneous press powder material.

The cooling rate in the above described cooling stage should be carefully controlled, it being found that an optimum period for cooling a 60 pound batch from about 75° C. to about 45° C. is about 8 minutes, i.e., a cooling rate of about 3 to 4° centigrade per minute. An excessively high rate of cooling tends to result in the mixture particles adhering to the walls of the container and to each other, forming agglomerates which cause difficulty in screening the material. On the other hand, an excessively slow cooling rate may unduly prolong the stirring process and result in an abrasive action of the mixture particles on the metal or other material of which the mixing container is made and thereby possibly introduce contaminating particles into the mixture.

The press mix thus obtained is then placed in steel dies for press molding the material into desired shape, and thereafter the shaped material is fired at a temperature in the range of about 1180°–1300° C., preferably about 1200°–1230° C. As a result of such firing, the wax is entirely volatilized and thus removed, and the aluminum oxide particles are cemented together by fusion of the glass particles, resulting in a hard, mechanically strong, precisely dimensioned refractory ceramic piece of high, uniform porosity.

The firing temperatures mentioned are not necessarily used in all cases since these will depend on the glass material used. The firing temperature should be sufficient to result in fusion of the particular glass employed for bonding the refractory particles.

The use of wax in molten form as described above is a significant feature of the invention in that it uniformly coats the aluminum oxide particles with an adequate amount of wax to firmly hold the glass particles in place on the individual aluminum oxide particles, and it imparts good plasticity to the mixture for facilitating the formation of the material into desired intricate shapes. As a result, the mixture is more homogeneous and produces a fired product of precise shape and dimension, uniform density and high uniform porosity provided by open interconnected pores.

While the present invention has been described with reference to particular embodiments thereof, it will be understood that numerous modifications may be made by those skilled in the art without actually departing from the scope of the invention. Therefore, the appended claims are intended to cover all such equivalent variations as come within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A composition for making a hard, mechanically strong, highly porous ceramic insulating material consisting essentially of a mixture of granular electrically insulating refractory material, refined paraffin scale wax, and powdered glass, at least 95% of the grains of said granular refractory material having a particle size of at least about 0.125 mm.

2. A composition as defined in claim **1**, wherein said wax is in molten form.

3. A composition as defined in claim **2**, wherein said refractory material is aluminum oxide.

4. A composition as defined in claim **3**, wherein the ingredients are present in the following range of proportions, in percent by weight:

	Percent
Aluminum oxide	60–85
Wax	5–10
Glass	10–30

5. A composition as defined in claim **4**, and consisting essentially of about 77% aluminum oxide, about 7% wax, and about 16% glass.

6. A composition as defined in claim **1**, wherein the refractory material grains are within the following range of size distribution, in percent by weight:

U.S. Standard Sieve No.	Percent	
	Minimum	Maximum
50	5	10
60	6	35
70	40	60
80	65	85
100	85	97
120	95	100

7. A composition as defined in claim **6**, wherein said refractory material is aluminum oxide and said glass is a borosilicate glass having a thermal expansion coefficient approximately that of said aluminum oxide.

8. A hard, mechanically strong, highly porous ceramic insulating material composed essentially of fired granular electrically insulating refractory material bonded by glass,

the grains of said refractory material being within the following range of size distribution, in percent by weight retained by the sieves indicated:

U.S. Standard Sieve No.	Percent Minimum	Percent Maximum
50	5	10
120	95	100

9. A ceramic material as defined in claim 8, wherein the refractory material grains are further characterized by the following size distribution:

U.S. Standard Sieve No.	Percent Minimum	Percent Maximum
60	6	35
70	40	60
80	65	85
100	85	97

10. A ceramic insulating material as defined in claim 9, wherein said refractory material is aluminum oxide and said glass has a thermal expansion coefficient approximating that of said aluminum oxide.

11. A ceramic insulating material as defined in claim 9, and characterized by open interconnected pores and a porosity of about 25–32%.

12. A method of making a hard, mechanically strong, highly porous ceramic insulating material which comprises mixing together the ingredients of the composition as defined in claim 1, wherein the wax in molten form is added initially to the granular refractory material, cooling said mixture of refractory material, molten wax and powdered glass, and firing said mixture at elevated temperature sufficient to remove said wax and fuse said glass for bonding said granular refractory material.

13. A method as defined in claim 12, wherein said refractory material is in the form of grains within the following range of size distribution, in percent by weight retained by the sieves indicated:

U.S. Standard Sieve No.	Percent Minimum	Percent Maximum
50	5	10
60	6	35
70	40	60
80	65	85
100	85	97
120	95	100

14. A method as defined in claim 13, wherein said cooling step is carried out at a cooling rate of about 3°–4° centigrade per minute.

15. A method as defined in claim 14, wherein after said cooling step said mixture is passed through a sieve for producing a free-flowing, homogeneous press powder material, and pressing said material into predetermined shape prior to said firing step.

16. A method as defined in claim 15, wherein prior to the addition of said molten wax said granular refractory material is heated to a temperature higher than the melting point of the wax.

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