

UNITED STATES PATENT OFFICE

2,526,059

FIXED ELECTRICAL RESISTOR

Harold H. Zabel, Homer G. Thomson, and Bernhard F. Tellkamp, Milwaukee, Wis., assignors to Allen-Bradley Company, Milwaukee, Wis., a corporation of Wisconsin

No Drawing. Application February 13, 1947,
Serial No. 728,370

6 Claims. (Cl. 201—76)

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This invention relates to molded composition electrical resistors of the type composed of finely divided conducting particles dispersed in a non-conducting binder and resides specifically in a novel composition of this type having improved permanence of electrical and physical properties, the binder of said compositions being primarily composed of organo-silicon polymers of the type commonly referred to as silicone resins, and the invention also resides in a new art of compounding and forming the same.

One object of this invention is to provide a composition electrical resistor composed of finely divided conductor particles dispersed in an insulating binder having greater load carrying capacity and greater stability when subjected to increased temperatures.

Another object of this invention is to improve and simplify the procedure by which electrical composition resistors of superior properties may be formed.

This invention is herein described by reference to particular instances of compositions formed in accordance therewith the same being set forth by way of illustration and not of limitation, it being understood that the protection intended to be afforded hereby shall extend to the full limit of the inventive advance herein disclosed as defined by the claims hereto appended.

In forming a composition electrical resistor in accordance with this invention we prefer to employ as the conducting material finely divided carbon, preferably in the form of carbon black but other conducting substances available in finely divided form may also be employed. In the case of compositions having low specific resistivity, the extremely fine degree of subdivision of carbon black offers less advantage, and various forms of finely divided conducting materials including graphite and other forms of carbon such as lamp black may be employed with satisfactory results.

The finely divided conducting material in accordance with this invention is dispersed within a matrix composed of material formed by condensation of organo-silicon polymers with or without the addition of various modifying substances. In practice, the matrix is preferably modified by the presence of inert fillers such as finely divided silica.

In forming a composition resistor in accordance with this invention we first thoroughly mix a suitable proportion of carbon black or other finely divided conductor material with a partially condensed organo-silicon polymer in a liquid or semi-liquid state. Also added to this mixture

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is finely divided filler in proportion best suited to the physical and electrical properties desired in the finished resistor. There may also be added small amounts of lubricant or other substance which may advantageously affect the molding properties of the composition and small amounts of accelerator or substance capable of increasing the rate of condensation reaction of the organo-silicon polymer. The mixture compounded as above is then worked and heated until condensation of the binder takes place to a substantial degree. After the material is thus initially worked and partially condensed, it is permitted to cool and is then preferably ground to form a conveniently handled powder.

In forming composition resistors from material prepared as above described we prefer to first form a solid blank or briquet therefrom approximating the size and shape of the finished resistor to be produced by forming the same under pressure. The briquet thus produced then is subjected to a final molding operation by applying substantial pressure thereto while in a strongly heated mold. During this final pressing operation there may be embedded in the resistor, if desired, metallic terminals treated to form reliable electrical contact with the resistor composition. During this final molding step flow takes place at first but promptly upon further progress of the condensation as heating continues, the thermoplastic properties of the composition become largely eliminated with formation of a strong, solid composition resistor. When this stage is reached the resistor may be removed from the mold and allowed to cool.

In accordance with this invention and for the purpose of producing a resistor composition of adequate mechanical strength the organo-silicon polymer binder is preferably employed in proportions ranging from 10% to 20%. For some purposes the range may be from 5% to 60% of binder. The remainder of the composition of the resistor is made up of inert filler, conductor particles, and small amounts of residues of catalysts employed to influence the rate of condensation, molding lubricants and other incidental ingredients.

As an aid in producing the desired flow properties in the composition, strongly effective accelerators used in exceptionally large proportion are found to be of particular usefulness. For example, triethanolamine or lead naphthenate are preferably employed in proportions amounting to from 1% to 5% by weight of the resin solids employed in the composition. Other accelerators

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known to increase the rate of condensation of organo-silicon polymers may also be employed.

Specific example

As one specific example an electrical resistor may be formed in accordance with this invention by applying to a set of rubber milling rolls a mixture containing approximately 4.91% of carbon black appropriately heat treated to render it suitable for use in electrical resistors, 12.71% of a heat setting silicone resin in a state of condensation where the same is still liquid, dissolved in 8.47% of toluene, 73.15% of finely divided silica as a filler, 0.50% of calcium stearate as a lubricant, and 0.26% of triethanolamine as an accelerator. This material is then worked upon the rolls while the rolls are heated, such rolling being continued until condensation of the resin will have advanced and the toluene solvent largely evaporated. The material may then be removed from the rolls in sheets of relatively thin cross section, which sheets are allowed to cool and harden.

When the sheets have cooled they may be crushed or pulverized to produce a comparatively fine powder. After the powder has been formed by crushing the resin content of the same may be further condensed by additional heating if desired.

The composition having been thus prepared in powder form small briquets containing an appropriate quantity of material for the formation of electrical resistors may then be formed from the powder by cold pressing. The small briquets thus formed are then ready for treatment rendering them suitable for use as resistors. This treatment consists in molding the briquets while contained in a heated die maintained at a temperature of about 400° F. to 550° F. While the briquets are thus held in the heated die, plungers, preferably carrying metallic terminals intended to be embedded in the finished resistor, are forced into the die to apply to the briquet a very substantial pressure. Under these conditions the briquets will flow under the influence of the temperature and pressure imposed and then set up into a hard, dense solid with the terminals carried by the plungers firmly embedded therein and forming electrical contact therewith. At the end of the molding treatment the resistor is removed from the die and may be immediately put to use or if a resistor of higher quality is desired, it is useful to bake the same at a temperature of about 350° F. to 450° F.

In the specific example above given, resistors will result having a resistivity determined by the quantity of carbon black or other conductor contained. Resistors of both high and low resistivity, of course, may be formed by decreasing or increasing the amount of carbon contained. For example, practically the entire silica content of the composition may be replaced with carbon to produce resistors of very low resistivity or the silica content may be increased to replace practically all of the carbon for the purpose of producing resistors having extremely high resistivity.

While in the specific example the quantity of resin employed amounts to approximately 14% of the composition of the finished resistor this proportion may be considerably varied. It has been found, however, that resistors of greater strength are obtained when the resin content is maintained within the range of 10% to 20% by weight of the finished resistor. However, if desired, very much larger quantities of resin may

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be employed. In some instances it may be desirable to employ from 5% to 60% of resin in the composition.

In the specific example above given the quantity of triethanolamine which acts as a catalyst or accelerator is approximately 2% by weight of the weight of resin present in the composition. It has been found that the employment of a catalyst or accelerator in substantial quantity is an aid to the formation of resistors of improved quality. Other catalysts or accelerators, of course, may be employed such, for example, as lead naphthenate.

If desired, the resistor of this invention may be formed by cold molding of the partially reacted or condensed molding composition by simply briquetting the same under extreme pressure. Whereupon the resistor may be completed by subjecting the same to prolonged heating at gradually increasing temperatures below its softening point. Such treatment, however, suffers certain disadvantages from the standpoint of economy because of the long time required to complete the condensation of the resistor and furthermore, a resistor formed in this fashion may be of inferior quality.

In referring to the organo-silicon polymers herein the term is intended to apply to alkyl-silicones or aryl-silicones or alkyl-aryl-silicones suitable for the formation of heat setting resins. Included among the same are the ethyl, methyl, propyl, butyl, amyl, phenyl, xylyl and naphthyl silicones alone or co-condensed with one another or in the form of mixtures of the same. Also organo-silicon polymers carrying halogen substituted molecules may also be employed.

We claim:

1. In a composition electrical resistor a solid conductive body composed of a matrix of heat condensed alkyl-aryl-silicone resin in which there is dispersed finely divided carbon.

2. The method of forming a composition electrical resistor employing a silicone resin binder which consists in mixing while fluid a heat condensable silicone resin material with finely divided conductor particles and while mixing and mechanically working said resin and conductor material heating the same to cause condensation of said resin, cooling the composition thus formed to solidify the same, then pulverizing said cooled composition, and then subjecting said composition to high temperature and pressure rapidly applied to form a dense, mechanically strong conductive solid.

3. The method of forming a composition electrical resistor employing a silicone resin binder which consists in mixing while fluid a heat condensable silicone resin material with finely divided conductor particles and while mixing and mechanically working said resin and conductor material heating the same to cause condensation of said resin, cooling the composition thus formed to solidify the same, and then subjecting said composition to high temperature and pressure rapidly applied to form a dense, mechanically strong conductive solid.

4. The method of forming a composition electrical resistor employing a silicone resin binder which consists in mixing with a heat condensable silicone resin material, while fluid, finely divided carbon, a filler, an accelerator, and a lubricant to form a composition and while mixing and mechanically working said composition heating the same to cause condensation of said resin; cooling the composition thus formed to

solidify the same; then pulverizing said cooled composition; and then subjecting said composition to high temperature and pressure rapidly applied to form a dense, mechanically strong conductive solid.

5. The method of forming a composition electrical resistor employing a silicone resin binder which consists in mixing while fluid a heat condensable silicone resin material with finely divided conductor particles, a filler and an accelerator and while mixing and mechanically working said materials heating the same to cause condensation of said resin; continuing said heating and mechanical working until the composition upon cooling will become solid and brittle; cooling the composition thus formed to solidify the same; then pulverizing said cooled composition; then heating said composition at a temperature below which the same will become softened to further advance condensation of said resin; and then subjecting said pulverized and condensed material to high temperature and pressure rapidly applied to form a dense, mechanically strong conductive solid.

6. The method of forming a composition electrical resistor employing a silicone resin binder which consists in mixing while fluid a heat condensable silicone resin material with carbon

black, silica powder, an accelerator and a lubricant and while mixing and mechanically working said materials heating the same to cause condensation of said resin; continuing said heating until the composition upon cooling will become solid and brittle; cooling the composition thus formed to solidify the same; then pulverizing said cooled composition; then heating said composition to further advance condensation of said resin; and then subjecting said pulverized and condensed composition to high temperature and pressure rapidly applied to form a dense, mechanically strong solid conductive body.

HAROLD H. ZABEL.
HOMER G. THOMSON.
BERNHARD F. TELLKAMP.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,258,219	Rochow	Oct. 7, 1941
2,258,220	Rochow	Oct. 7, 1941
2,377,600	Barker et al.	June 5, 1945