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THEODORE C. BROWNE AND CHARLES J. KAYKO, OF CLEVELAND, OHIO, ASSIGNORS, BY MESNE ASSIGNMENTS, TO SAID THEODORE C. BROWNE

RESISTANCE MATERIAL

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This invention relates to resistance materials having relatively high resistances such as those used in radio circuits, and the compounds used in making said resistance materials are so combined to permit them to be compressed into a dense hard mass.

A further object of the invention is to provide a homogeneous, accurately measured mass of resistance material which, when compressed into proper form, will resist abrasion.

A further object of the invention is to produce a substance which will be neutral to various atmospheric conditions and the resistance of which will not break down at a definite voltage limit.

Another object of the invention is to control the resistance range of the material by the addition of a compound, during the process of mixing, so that the resistance of the resultant element will not be controlled by the natural resistance of the binding material employed.

Resistances as now manufactured have a very limited current carrying capacity. This is true in the case where inks are used which contain carbon as the conducting medium. Another case in which the current carrying capacity is limited is where a sputtered film of metal is used as a resistance unit. This film is made up of an infinite number of metallic junctions of relatively high resistance and, consequently exceedingly limits the capacity of the resistance.

Another objection to the commercial resistances, which utilize ground coke or graphite mixed with a bakelite molding compound, is that the bakelite film between the coke particles is punctured at a definite limit, by the impressed voltage, causing its resistance to drop many thousands per cent within its voltage range. This type of resistance, however, carries considerably more current than the other types mentioned.

It is the purpose of our invention to overcome these deficiencies and objections in the formation of resistance material and primarily this is attained by the employment of compounds having a much higher natural resistance than that of carbon, which are cemented together by a suitable binder and controlling the resistance of the binder by the addition, to the binder, of a small portion of graphite, the amount of which is determined by the natural resistance of the specific compounds used.

For a considerable range of resistances,—25,000–200,000 ohms—we prefer to use as the metallic compound, molybdenum sulphide. It is to be understood, however, that other suitable metallic compounds, depending upon the range of resistance desired, may be used with substantially the same result and effect as the above mentioned substances.

In combining the compounds used in connection with our resistance element we find that it is advisable and preferable to employ as a binding material a ceramic binder rather than a resinous or phenolic binder. By the introduction of this particular kind of binding material with the other compounds making up the resistance element, the resistance of the completed element is not so materially affected by the heat from the current passing therethrough as would be the case if one of the other binders referred to were used in place of the ceramic binder.

A ceramic binder possessing exceptional qualities, for our purpose, and most inexpensive, is Portland cement. The natural resistance of this cement is extremely high, as compared with other similar binders, and its state of division so fine that it readily mixes with and embeds the particles of metallic compounds used. The mixture can be easily handled and formed by moistening and when so formed into the desired shapes, can be left to set, thereby producing elements which are very hard and dry.

However, it is important to note, that when cement is used as a binder and the proportion of cement is above a certain percentage of the entire mixture, the natural resistance of the cement becomes the predominating factor and the naturally high resistance of the metallic compound becomes a secondary factor. It appears that the cement, when used in quantities above this certain percentage, (25% or more), surrounds the metallic particles and insulates them from one another, thereby negativing the resistance of the metallic compound so that the resistance of the completed element is equal only to the resistance of the cement binder.

It is essential to overcome this condition and, yet, at the same time retain the binding qualities of the cement in the resultant element. To accomplish this, we introduce into the mixture of materials a small percentage of graphite, the proportion being determined by the resistance of the metallic compound and the range of resistance desired in the completed element. The addition of this small percentage of graphite, which will hereinafter be explained, coacts with the cement binder to materially reduce the fixed resistance limit thereof. By this method we can determine the resistance limit in the completed element.

Assuming now that elements are to be made in which cement and molybdenum sulphide are the ceramic binder and metallic compound used. By mixing the cement with the molybdenum sulphide, using percentages of cement up to about 25% by weight of the mixture, the rise in resistance is gradual being in proportion to the quantity of cement used, and the resistance limit is determined by the natural resistance of the molybdenum sulphide. When 25% or more, by weight, of cement is used in the mixture, when this amount is necessary to obtain the proper hardness in the resistance element, the resistance of the cement binder becomes the predominating factor and the resistance of the molybdenum sulphide becomes a negative factor so that the resistance of the resultant element equals the natural resistance of the cement binder. The resistance limit of the cement remains substantially the same where the percentage of cement binder used is more than 25% by weight.

To reduce the resistance limit of the cement binder so that the resistance limit of the molybdenum sulphide is the predominating factor, where the percentage of cement used is in excess of 25%, by weight, of the entire amount, the cement is first mixed, while in a dry state, with dry powdered graphite, about 2% by weight, the percentage of course, being determined by the resistance of the molybdenum sulphide and the resistance desired in the resultant element. The addition of graphite to the cement binder depends upon the resistance desired and substantially lowers the resistance of the cement and additional percentages of graphite similarly lower the resistance in proportion to the percentage of graphite used. Graphite may be introduced until the required resistance is reached.

The cement and graphite, having been mixed in proper proportions, are next mixed with the molybdenum sulphide. So far as described the mixture is in a dry powdered condition and contains considerable quantities of air and is practically impossible to handle. The mixture must however, be granular to be fed through an automatic pill machine, which we desire to use for this purpose, but must also be damp before the cement will set and act as a binder. For this purpose we employ sodium silicate (Na_2SiO_3), of a fixed specific gravity, the mixture being made moist enough to conveniently handle.

This mass is next formed into pills of a predetermined size and equal weight and of a density which can be later built up into the desired resistance elements.

To build up one of these resistance elements a certain number of these pills are introduced into a glass tube of uniform diameter and known cross section and pressed into a homogeneous, accurately measured mass, by means of a press. The resistance of this mass of material, therefore, is definitely known, this fact being determined by the cross section of the tube and the number of pills introduced therein. Contacting cushions are provided on each end of this mass to thereby prevent microphonic noises which would necessarily be set up between a metallic contactor and a hard resistance material. These contacting cushions may be a strip of flexible conducting material built up from rubber cement and carbon or graphite or may be comprised of metallic particles which are introduced into a dissolved or softened mass of rubber. When these contacting cushions have been applied the entire mass may be thoroughly dried and the ends of the glass tubing properly capped and sealed to exclude moisture. This particular unit is adaptable as a grid leak or other resistance in a radio or electrical circuit where such resistances are needed.

The use of cement, as a binder, in building up this resistor element has proven satisfactory where the mixed mass is supported by means of a glass tube as heretofore described. This glass tube affords the proper transverse strength which the material itself lacks, so that it has been found difficult to use this resistance material without this means of support where it is desirous of utilizing this material for resistance elements for rheostats, potentiometers and the like where the glass tube is dispensed with.

We have found that to eliminate this difficulty in forming a resistance material for use in connection with rheostats or where the resistance mass is to be unsupported, by using calcium fluoride as a binding material, in place of the cement previously described, the resultant mass has a transverse strength greater than that afforded by the cement binder.

The procedure of introducing this calcium fluoride as the binding material is substantially the same as was heretofore described in the use of cement. The calcium fluoride is mixed, while in a dry state, with a small percentage of amorphous graphite (1 or 2% by weight) the percentage of graphite being determined by the resistance of the compounds and the resistance desired in the completed element. When the calcium fluoride and the graphite have been thoroughly mixed together, dry molybdenum sulphide is introduced into the mixture. The graphite being mixed with the calcium fluoride has a tendency to materially lower the resistance thereof and to bring the resistance of the calcium fluoride below the natural resistance of the molybdenum sulphide so that the resistance of the molybdenum sulphide is the predominant or controlling factor and the resistance of the calcium fluoride the secondary factor. The addition of similar percentages of graphite to the calcium fluoride tends to lower the resistance thereof so that the amount of graphite used depends upon the resistance desired in the completed element.

The mixing to this point has been carried on with the material in a dry state and therefore contains a considerable amount of air making it difficult to handle. To permit this mixture to be conveniently handled, it is moistened with a solution of sodium silicate of a fixed specific gravity.

When these elements have been pressed into the desired forms and shapes they are placed on a sheet metal base plate and permitted to bake slowly for about an hour in an oven, the temperature of which is approximately 200° F. It is desirable to further bake the elements, at the expiration of this period, at a temperature of about 400° F. For a further period of approximately fifteen minutes without fear of warping or blistering, at the end of which time the elements should be sufficiently hard.

Having described our invention, we claim:

1. A composition for the manufacture of electrical resistance including a mixture of molybdenum sulphide and cement, said mixture having adhesive qualities due to the addition of sodium silicate.

2. The method of making resistance material which comprises mixing cement and molybdenum sulphide of naturally high resistance in a dry state, adding a small percentage of graphite to the cement to decrease the resistance thereof to below the natural resistance of molybdenum sulphide, moistening said mixture with sodium silicate to cause the particles to cohere and aid in expelling the air therefrom, forming into pills of a predetermined size and baking at a low temperature for a period of time and further baking at a higher temperature until hard.

3. A composition for the manufacture of electrical resistances including molybdenum sulphide and cement, the specific resistance per unit volume of the cement being reduced to an amount not greater than the specific resistance of the same unit volume of the sulphide by the addition of graphite to the cement.

4. An electrical resistance consisting of a mass which comprises grains of molybdenum sulphide held in fixed relation by a cementing agent to which has been added graphite to an amount not exceeding 2% of the said cementing agent.

5. That method of producing electrical resistors which consists of mixing molybdenum sulphide with cement, adding a substance which will form therewith a plastic mass, forming the resistors from said plastic mass, drying the resistors to expel moisture, and baking the resistors at a temperature not exceeding 800° C. until hard.

In testimony whereof, we hereunto affix our signatures.

THEODORE C. BROWNE.
CHAS. J. KAYKO.