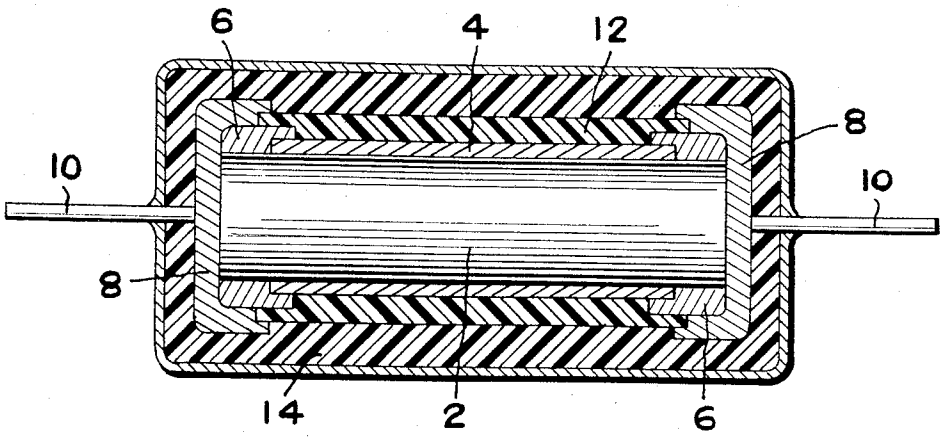
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MOLDED RESISTORS

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MOLDED RESISTORS

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This invention relates to molded resistance elements and more particularly to resin encased resistance elements of the borocarbon film type.

In the April 1951 issue of the Bell System Technical Journal, Grisdale et al., in an article entitled "Pyrolytic Film Resistors: Carbon and Borocarbon," discusses the borocarbon resistor, a resistor of exceptional stability and low temperature coefficient of resistance. As a result, this type has become the subject of considerable study to effect a commercical item of electrical characteristics satisfactory for present day electronic needs. To utilize this resistor in electronic circuits it became necessary to package it in a manner that protects the resistance film from external influences such as moisture, thermal shock, abrasion, etc. An economical method would be to mold the unit but at present such structures suffer from operational instability and process variability. A further consideration is the apparent susceptibility of the borocarbon film to the deleterious action of moisture.

It is an object of this invention to overcome the foregoing and related disadvantages. It is a further object of this invention to produce a molded borocarbon type resistor of exceptionally stable electrical characteristics over a much extended operational life. It is a still further object of this invention to produce a molded borocarbon film resistor in economic fashion which is not susceptible to the deleterious action of external moisture. Still other objects of this invention will be apparent from the following specification and appended claims.

The objects have been achieved in accordance with this invention by the production of a resistor comprising a borocarbon film resistance element having an adherent moisture barrier imposed on the resistance film of said element and a molded casing substantially fully encapsulating said resistance element.

More particularly, the objects of this invention have been achieved by producing a resistor comprising an insulating core having a surface coating of a pyrolytically decomposed borocarbon resistance film, an adherent moisture impervious barrier imposed on the surface of said resistance film, terminal leads connected to said resistance film and a wax impregnated resinous casing substantially fully encapsulating said resistance element.

A preferred embodiment of this invention is a resistor comprising an insulator core having imposed upon its surface a resistance film of borocarbon helixed to a specified value, a film of polyethylene terephthalate shrunk over the surface of said resistance film, terminal leads electrically connected to said resistance film and a wax impregnated thermoset resin layer fully encapsulating the resistance element.

This invention is further featured by a process for the production of boron-carbon film type molded resistors which includes vacuum drying the boron-carbon resistance film and thereafter heat-shrinking a plurality of layers of polyethylene terephthalate film onto the surface of said resistance film.

For a better understanding of this invention reference

should now be made to the sole drawing which pictures in cross-sectional view the preferred embodiment of this invention. In this representation of the preferred structure of the invention 2 refers to the insulator core formed of a non-porous ceramic having a temperature coefficient of expansion substantially that of the imposed boron-carbon film. Deposited on the surface of this insulating core 2 is the boron-carbon film 4 which serves as the resistance means for the structure. This boron-carbon film is the pyrolytic decomposition product of methane and boron trichloride as discussed in the Grisdale et al. article. The terminal portions of the borocarbon film include a silvered terminal section 6 functioning as the connecting medium between the boron-carbon resistance film 4 and the endcap 8 which includes the lead portion 10. After the silvered portion 6 is placed on the terminal portion of the borocarbon film 4 and the unit helixed to its desired resistance value, the moisture barrier 12 is wrapped or otherwise disposed over the surface of the borocarbon film 4 so as to completely cover all the exposed film 4 by the simple expedient of having the film 12 overlap onto the silvered terminal sections 6. In our preferred structure this moisture barrier is a polyethylene terephthalate film having a thermoset adhesive layer adherent to the side of the barrier 12 which is disposed against the film. To avoid contact of the film 4 with the molding powder or other external agents, the moisture barrier 12, where the preferred structure is used, is thermally shrunk onto the resistance film 4. About the entire assembly there is a layer of thermoset resin 14 functioning as the encapsulating material for this device. To avoid moisture penetration during the operational life of this device the outer surface of the molded casing 14 is further impregnated with a high temperature wax.

As indicated in the foregoing, the insertion of the moisture barrier between the film and the outer molded casing has produced the superior load life stability characteristics of the structure concurrent with reduction in in the variation of the product during the molding phase of our operation. Although it is not completely understood, it is believed that the presence of minute amounts of moisture brings about substantial degradation of the resistance film when the unit is put into electrical operation. Whether its function is catalytic or reactive is not known, however its removal results in a remarkably improved product. Even when the film was retained in a dry atmosphere prior to molding and protected with a barrier so as to avoid mechanical injury to the film, the superior characteristics did not result. It is believed that the moisture resulting from the polymerization of the thermoset resin which forms the molding casing is generated in an amount sufficient to injure film. Hence it is vital to remove all moisture initially and thereafter impose on the film a barrier impervious to moisture to obtain the device of the invention.

The preferred moisture barrier for enclosing the deposited resistance film is several layers (from 0.25 to 1.0 mil thick) of polyethylene terephthalate film. This resin has the property of disorientation upon subjection to heat at a temperature sufficient to relax the orientation of the film which results in a tightly shrunk casing of polyethylene terephthalate about the resistance element when the oriented film is wound about the resistance film and thereafter heated to a temperature of about 150° C. Aside from the disorientation phenomena polyethylene terephthalate has excellent moisture barrier characteristics, high resistance to electrical stress, exceptional stability of electrical characteristics upon lengthy exposure to elevated temperatures and unusually high abrasion resistance. The deleterious action of the molding operation and mechanical damage previously incurred during processing through abrasion of the resistance film

is avoided by the high tear resistance of the polyethylene terephthalate moisture barrier. Such abrasion has been discovered in units not so protected, and results in unpredictable changes in electrical characteristics. Briefly then, the properties requisite for a moisture barrier for the resistance film include chemical inertness, thermal stability, high leakage resistance, water vapor imperviousness, resistance to abrasion, and preferably an oriented nature susceptible to disorientation by heat. Other representative materials include, in tape or other form, polytetrafluoroethylene resin, polytrifluoromonochloroethylene resin, paper impregnated with an epoxy resin, cross-linked cellulose acetate, cellulose triacetate, vinyl coated nylon, and polyvinylidene chloride. To facilitate the winding of the moisture and mechanical barrier upon the resistance film, an adhesive coated film is preferred which adhesive must not yield moisture during the thermoset phase for such would deleteriously affect the resistance film.

After the film has been disposed upon the surface of the film as a protective layer, both mechanically and from moisture penetration aspect, any of the well-known thermoset molding compounds of high leakage resistance can be used to form the outer resinous casing. Included among these are filled and unfilled urea formaldehydes, phenol formaldehydes, melamine formaldehydes, silicones, epoxy types and the polyesters such as the polyester of maleic acid and ethylene glycol. Where desired, the resinous casing can be a polyester material incorporating a percentage of a polyhydric alcohol or polybasic acid so as to facilitate cross-linking of the resin to a higher degree with improved thermal characteristics. Filling material includes mica, silica, cellulosics as wood flour, and glass particles. After the resinous casing has been placed about the resistance element it is preferred to impregnate the surface of the polyester casing with a high temperature wax or a silicone so as to produce a device having excellent resistance against moisture penetration. Preferred casings are: injection molded—phenol formaldehyde; cast—epoxy type; preform molded—polyesters.

As a specific embodiment of our invention a nonporous porcelain rod is coated with the product resulting from the pyrolytic decomposition of methane and boron trichloride in the gaseous phase. After the film has been prepared it is retained in a moisture-free atmosphere until the terminal portions of the film are coated with silver. After helixing of the film to the required value, the unit is wound with a minimum of two and a maximum of three turns of ¼ mil thick adhesive polyethylene terephthalate film. This film is so located that it encloses the complete area of the helixed borocarbon film and extends onto the silver terminals to a position such that the thereafter imposed endcaps will slightly overlap the tape. After subjection to vacuum drying at a pressure of 1000 microns or less for 15 minutes, the units are heated to 150° C. for approximately 1 hour while still under vacuum. The endcaps are then pressed onto the assembly and the units compressively molded by means of a conventional molding operation for thermoset resins. Finally the unit is vacuum impregnated in a low temperature wax (melting point approximately 80° C.) at from 100 to 105° C. for 5 minutes. Units prepared as discussed above exhibit less than 1% resistance change over 1000 hours life on load test at 70° C. ambient temperature as compared with a 10% change found with comparable commercially available units.

Although the reason for this is not fully understood, the removal of moisture from the resistance film prior to imposition of the moisture barrier upon the film is critical as this yields molded resistors with definitely superior load life stability characteristics over other known

units. This phenomena was apparently obscured by the moisture resulting from the molding operation which moisture penetrated to the film but which penetration has now been avoided by the barrier film imposed in accordance with this invention.

It should thus be apparent from the above description that there has been devised a novel molded borocarbon film type resistor which not only exhibits exceptional operational long life characteristics but is moisture protective of the resistance film both during and after the molding operation. Not only does this device have an extended operational life coincident with superior electrical stability, both of which are extremely vital to certain types of electronic equipment, but it can withstand extreme operating conditions such as found in the humid tropical areas and shipboard operations.

While this invention has been ascribed both in general and preferred embodiments, it is to be understood that the words used are words of description rather than words of limitation and that changes within the purview of the appended claims may be made without departing from the true scope and spirit of this invention.

What is claimed is:

1. A process for producing an electrical resistor, which process includes the steps of pyrolytically depositing a carbon resistance film on the surface of a support, drying the film, covering the film by a protective wrapping of a moisture-impervious, abrasion resistant, relatively inert, thermally stable, high leakage resistance resin tape, then heat treating the taped assembly to shrink the tape, and then molding an encapsulating resin casing around the taped assembly.

2. A resistor having an electrically non-conductive support, a pyrolytic carbon resistance film on said support, spaced terminals connected to said film, a moisture- and abrasion-resistant resin tape wound around and completely covering the otherwise exposed surface of the film, and an in situ molded resin casing molded entirely around the taped assembly.

3. A resistor having a ceramic core, a carbon film pyrolytically deposited on the surface of the core, terminals connected to opposite ends of the film, the exposed film surface being completely covered by an in situ shrunk polyethylene terephthalate tape, and an in situ molded resin casing molded entirely around the taped assembly.

4. The process of claim 1 in which the resin tape is polyethylene terephthalate.

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