June 15, 1971 G. H. LOOSE 3,584,379

METHOD OF FORMING A FUSED SUBSTRATE RESISTOR

Filed Dec. 27, 1968 2 Sheets-Sheet 1

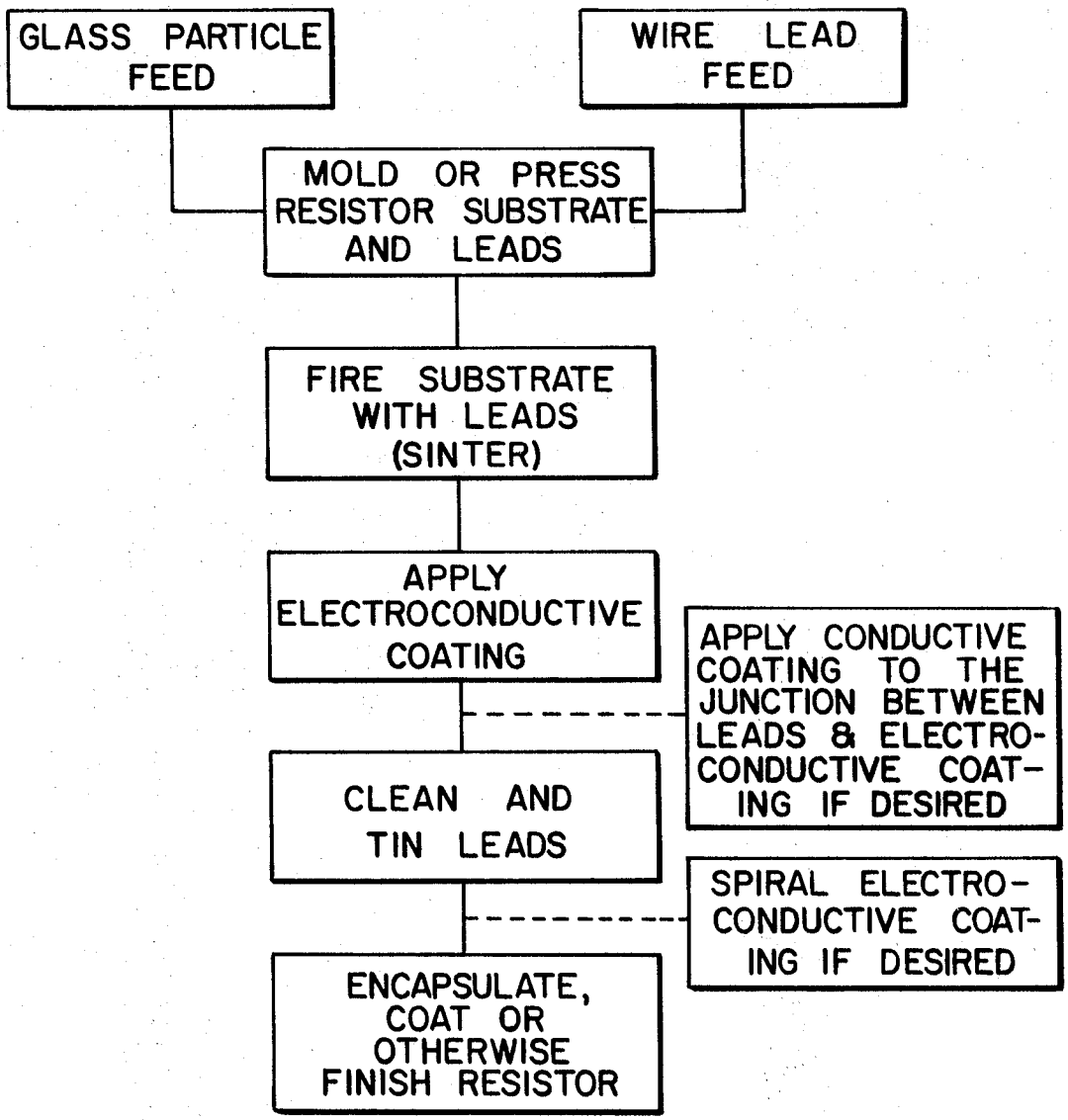


Fig. 1

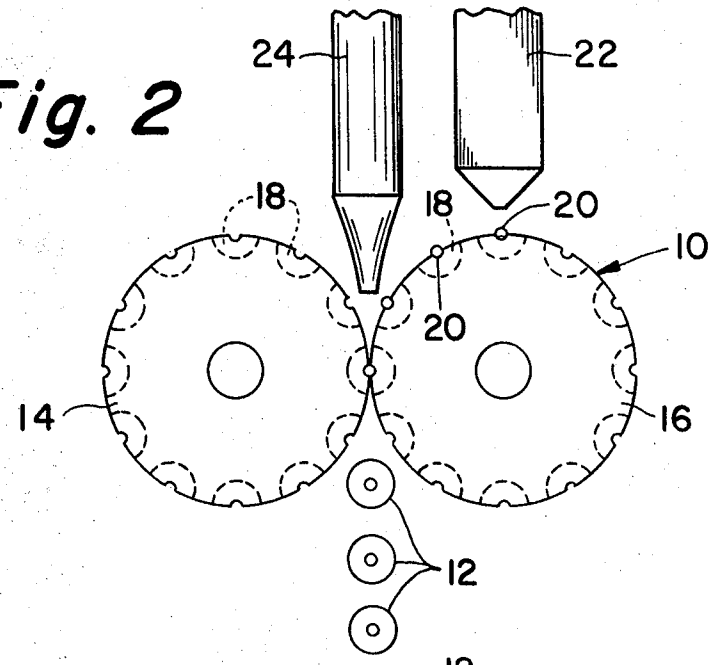
INVENTOR.
Guenter H. Loose
BY
Walter S. Zabrowski
ATTORNEY

June 15, 1971 G. H. LOOSE 3,584,379

METHOD OF FORMING A FUSED SUBSTRATE RESISTOR

Filed Dec. 27, 1968 2 Sheets-Sheet 2

Fig. 2



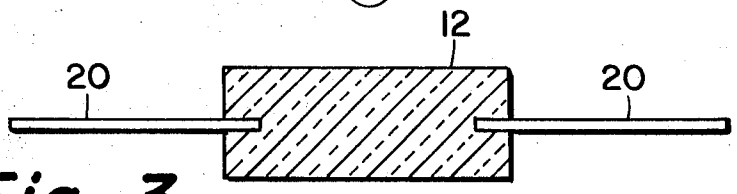


Fig. 3

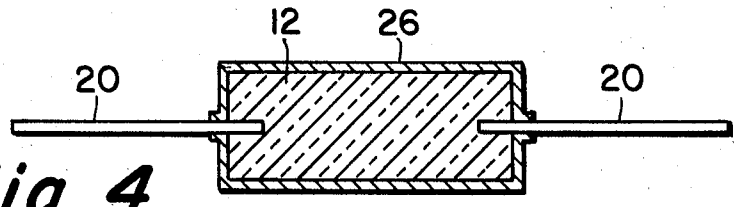


Fig. 4

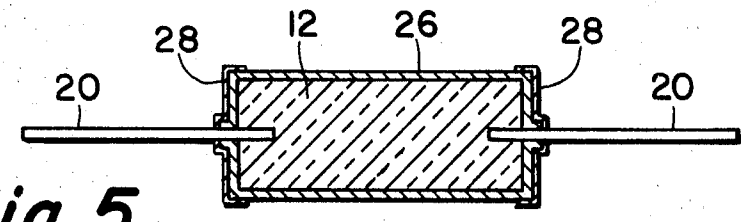


Fig. 5

INVENTOR.
Guenter H. Loose
BY Walter S. Zebrowski
ATTORNEY

United States Patent Office 3,584,379 Patented June 15, 1971

3,584,379

METHOD OF FORMING A FUSED SUBSTRATE RESISTOR

Guenter H. Loose, Webster, N.Y., assignor to Corning Glass Works, Corning, N.Y.

Filed Dec. 27, 1968, Ser. No. 787,312
Int. Cl. H01c 17/00
U.S. Cl. 29—610 7 Claims

ABSTRACT OF THE DISCLOSURE

A capless electroconductive coating resistor. The resistor dielectric substrate is formed of particulate material by pressing or molding within which substrate wire leads are embedded. The green body so formed is fired to coalesce or sinter the particles and volatilize any organic constitutents. Thereafter, an electroconductive coating is applied over the suface of the substrate in electrical contact with the leads.

BACKGROUND OF THE INVENTION

Resistors having electroconductive coatings have heretofore been made by forming a dielectric resistor substrate, ordinarily in cylindrical shape, applying thereto a film of electroconductive or resistive material, and thereafter cutting the dielectric substrate into individual resistor blanks. The resistor blanks would have a coating of silver or other conductive material applied to the ends thereof, be fired to fuse the conductive material, and the blanks would thereafter be spiralled if desired to increase the resistance value thereof. A metallic cap with a lead attached thereto would be fitted over the ends of the resistor blanks so that electrical contact could be made between the lead and the electroconductive or resistive material through said conductive material. The resistor would then be suitably coated or encapsulated. Such a method would require the diameter of the dielectric substrate to be maintained within close tolerances so that caps could thereafter be properly fitted onto the ends thereof. The lead and cap combinations result in an expensive means for providing electrical continuity between the electroconductive coating and the leads. In addition, the caps increase the diameter of the overall device. Furthermore, the method requires expensive capping machines to fit the caps over the ends of the resistor blanks and cut-off machines for cutting off individual resistor blanks from the continuous substrate material.

SUMMARY OF THE INVENTION

The objects of the present invention are to provide a simplified, direct, and inexpensive method of manufacturing electroconductive coating or film resistors which are are capless, rugged, and inexpensive and which overcome the hereinabove noted disadvantages.

Briefly, according to the present invention, a capless electroconductive coating resistor can be formed by first pressing or molding a quantity of particulate dielectric material within which wire leads are embedded to form a resistor blank. The green body so formed is fired to coalesce or sinter the particles forming a cohesive substrate for the resistor and to volatilize any organic constituents. Thereafter an electroconductive or resistive coating is applied over the surface of the substrate in contact with the leads. The resistor so constructed may have conductive material applied at the ends of the resistor body to improve the electrical conductivity between the leads and the electroconductive coating. Thereafter, the leads may be cleaned and tinned, the electroconductive material spiraled to increase the resistance thereof, and the resistor encapsulated, coated or otherwise finished.

Additional objects, features, and advantages of the present invention will become apparent to those skilled in the art from the following detailed description and the attached drawings on which, by way of example, only the preferred embodiment of this invention is illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flow diagram illustrating the process of the present invention.

FIG. 2 is a fragmentary elevation of an apparatus for pressing resistor blanks of the present invention.

FIG. 3 is a cross sectional elevation of a resistor blank of the present invention.

FIG. 4 is a cross sectional elevation of a resistor blank of the present invention having an electroconductive coating applied to the surfaces thereof.

FIG. 5 is a cross sectional elevation of the resistor blank of FIG. 4 having a coating of conductive material applied to the ends thereof.

DETAILED DESCRIPTION

For the purposes of simplicity, the present invention will be described in connection with forming a capless resistor having a glass dielectric and an electroconductive coating of metallic oxide. As is readily understood the present invention is in no way limited to such materials. Dielectric materials suitable for the present purposes may be glass, glass-ceramics, ceramics, plastics, and the like. For a clear understanding of metallic oxide films as electro conductive coatings, their characteristics, and at least one example of their application, reference is made to U.S. Pats. No. 2,564,706 and 2,564,707 issued to John M. Mochel, the disclosure of which patents is incorporated herein by reference.

Referring to FIG. 1, there is shown a flow diagram of the method of the present invention. Referring additionally to FIG. 2 there is shown an apparatus **10** by which resistor blanks **12** may be pressed or molded. A pair of forming wheels **14** and **16** have, about the periphery thereof, a plurality of matching recesses, cavities, or mold compartments **18**. Forming wheels **14** and **16** are aligned so that the mold compartments **18** substantially form cylindrical cavities at the point where the wheels are tangent to one another. Wheels **14** and **16** may be driven by any suitable driving means, not shown, well known in the art. Resistor leads **20** are positioned about the periphery of forming wheel **16** by means of a lead feed device **22**. The leads are positioned so that a portion of one end thereof extends into cavity **18**. Suitable lead materials are copper, Dumet, Kovar, nickel, or the like, and one familiar with the art can readily select a suitable lead material for a particular application. Particulate dielectric material is fed to mold compartments **18** by means of a dielectric material feed mechanism **24**. As is readily understood, lead feed device **22** and dielectric material feed mechanism **24** may be any suitable feed devices well known in the art, and no particular device or feed means are contemplated or form part of the present invention. The particulate material is fed to mold compartments **18** at such a rate and at a time before the particulate mold compartments are caused to be in register with one another at the point where forming wheels **14** and **16** are tangent to one another. By providing a proper amount of dielectric material to the mold cavities the forming wheels will cause the dielectric material to be compressed thereby forming a cylindrical shape having a lead **20** embedded in each end thereof forming green resistor blanks **12**. In order that sufficient green strength is obtained in the compressed resistor blank, a binder is added to the particulate dielectric material. Such a binder may be organic materials such as starch, glycerin, ethylene glycol, cellulose nitrate, cellulose acetate, amyl and butyl alcohols,

paraffin, polyethylene glycol or the like. The binder is added in quantities sufficient to provide green strength of a desired value in the resistor blank.

The green resistor blanks are then fired to volatilize the organic constituents, coalesce or sinter the particles of dielectric material forming a cohesive substrate for a resistor, and to bond the leads firmly thereto as illustrated in FIG. 3.

Thereafter, an electroconductive coating **26**, such as the metallic oxide films of the heretofore noted Mochel patents is applied over the surface of the substrate or blank **12** in electrical contact with leads **20** as illustrated in FIG. 4.

The resistor so constructed may thereafter have a conductive material **28** applied at the ends of the resistor body and to the junction between the leads and the electroconductive coating to ensure electrical conductivity therebetween. Coating **28** may be any highly conductive material such as silver, conductive frit, conductive paint, conductive plastic, or the like. Conductive material **28** is illustrated in exaggerated thickness in FIG. 5 and is merely a coating or film.

Leads **20** of a resistor so formed, are thereafter suitably cleaned and tinned by any method well known in the art. Coating **26** may be spiraled to increase the length to width ratio of the film and thereby increase the resistance thereof. In addition, the resistor may be encapsulated, coated, or otherwise finished and suitably marked.

As a typical example a quantity of particulate glass having a composition by weight of 60% SiO_2, 15% Al_2O_3, 10% CaO, 5% MgO, 5% BaO, and 5% B_2O_3, to which was added polyethylene glycol as a binder, was compressed within a mold to form a cylindrical resistor blank having a copper wire lead embedded in each end thereof. The binder comprised about 2% by weight of the total material. The green resistor blank was then fired to volatilize the organic constituents and to coalesce or sinter the particles in accordance with the following schedule: 350° C. for 18 minutes, 450° C. for 18 minutes, and 900° C. for 18 minutes. The resistor blank was cooled and a coating of tin and antimony oxide was applied to the outer surface of the blank and in contact with the leads in accordance with the method taught by the heretofore noted Mochel patents. The tin and antimony oxide film was spiraled to increase the resistance thereof and the completed assembly was coated with an encapsulating resin.

Although the present invention has been described with respect to specific details of certain embodiments thereof, it is not intended that such details be limitations upon the scope of the invention except insofar as set forth in the following claims.

I claim:

1. A method of forming a resistor comprising the steps of

forming a substantially cylindrical dielectric resistor substrate of glass in particulate form and a binder in quantities sufficient to impart green strength thereto,

embedding a wire lead in each end of said cylindrical substrate substantially along the longitudinal axis thereof,

firing the unit so formed to sinter the glass particles and bond said wire leads firmly to said substrate, and thereafter

applying a coating of electroconductive material to the surface of said substrate and a portion of said leads whereby electrical contact is made between said leads and coating, the electroconductive coating only forming the resistive path of said resistor.

2. The method of claim **1** further comprising the step of applying a coating of highly conductive material to the juncture of each lead and coating of electroconductive material.

3. The method of claim **1** further comprising the steps of cleaning and tinning the leads following the firing step and before said step of applying a coating of electroconductive material.

4. The method of claim **1** further comprising the step of spiralling the coating of electroconductive material to increase the resistance thereof.

5. The method of claim **2** wherein said highly conductive material is silver.

6. The method of claim **1** further comprising the step of applying a coating of an encapsulating material to the structure so formed.

7. The method of claim **6** wherein said electroconductive material is tin and antimony oxide.

References Cited

UNITED STATES PATENTS

2,416,599	2/1947	Victoreen	338—309X
2,472,801	6/1949	Barfield et al.	29—610UX
3,167,451	1/1965	Tierman	29—620UX
3,257,709	6/1966	Fernan et al.	29—610
3,305,821	2/1967	Manley	338—309X
3,373,486	3/1968	Cox	29—610
3,382,574	5/1968	Chadwick	29—610

JOHN F. CAMPBELL, Primary Examiner

V. A. DI PALMA, Assistant Examiner

U.S. Cl. X.R.

29—620, 621; 338—308