United States Patent

[11] 3,568,127

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[21] Appl. No. **771,102**
[22] Filed **Oct. 28, 1968**
[45] Patented **Mar. 2, 1971**
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[54] **ELECTRICAL RESISTORS**
14 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **338/262,** 338/308
[51] **Int. Cl.** **H01c 1/02**
[50] **Field of Search** .... 338/307, 308, 309, 262; 117/212; 174/(H.S); 317/261

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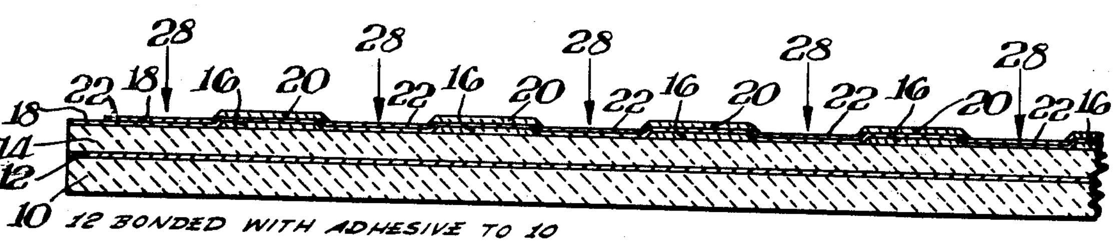
ABSTRACT: In forming a plurality of resistor components a resistive metal film is deposited on an inert, electrically non-conductive base. Parallel electrode strips are deposited on the resistive film and parallel overglaze strips are deposited on the resistive film between and slightly overlapping the electrode strips. This structure is separated into a plurality of resistor components by making a series of parallel cuts down through all the layers along lines at right angles to a line following the longitudinal axis of said glaze strips; annealing the structure to refuse the overglaze; and performing a second series of parallel cuts at right angles to said first cuts and following lines midway of said electrodes strips.



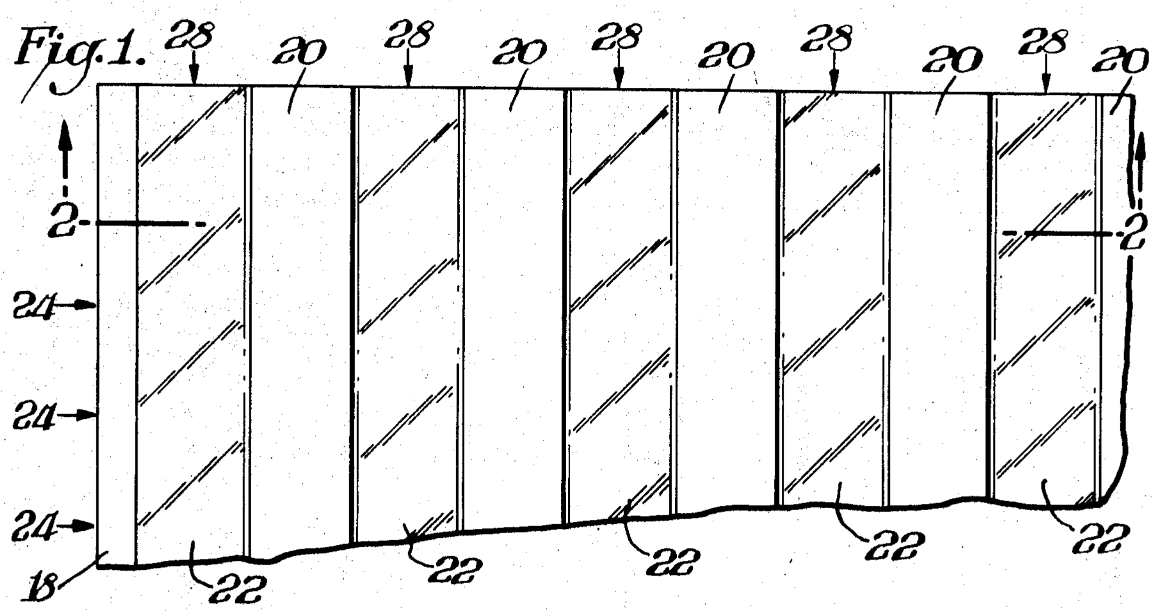


Fig.1.

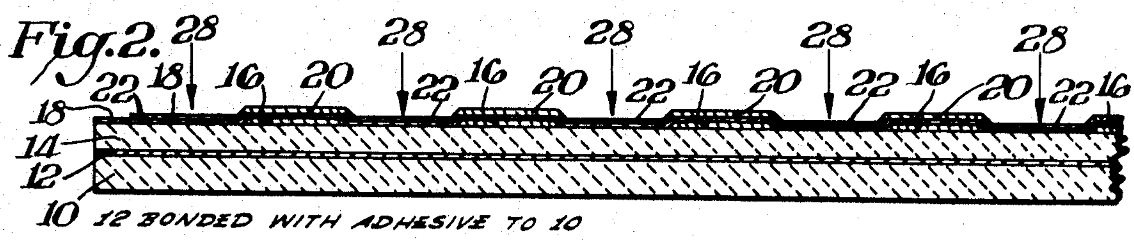


Fig.2.

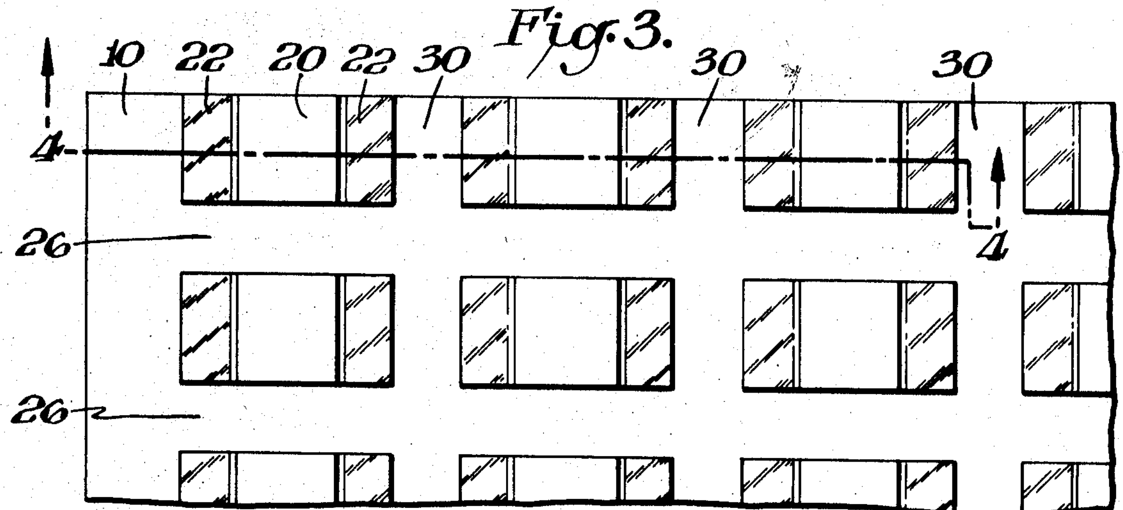


Fig.3.

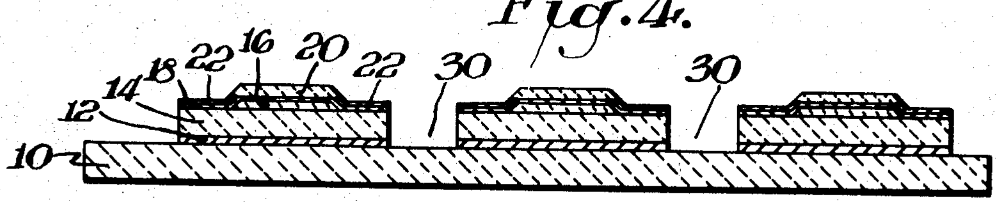


Fig.4.

ELECTRICAL RESISTORS

BACKGROUND OF THE INVENTION

This invention relates to new and improved metal film resistors and more particularly to a plurality of precious metal film resistors in monolithic sandwich configuration and method of forming the same.

In thin film resistor manufacturing techniques it is common practice to deposit individually separated resistors by one means or another and then to adjust these resistors to final tolerances by removal of resistive material from the resistive film. As the requirement for higher and higher packing densities of electrical components per unit volume continues, it becomes more difficult to manufacture the necessarily smaller units. When resistor areas are in the size range of 30 × 50 mils and smaller, it is extremely difficult to control screening or masking techniques for depositing the resistor films and at the same time obtain values reasonably near the desired nominal resistance values.

It is an object of the invention to present a novel multiresistor arrangement.

It is a further object to present a novel thin film resistor component.

It is another object to present a method for preparing thin film resistors.

Still other objects of this invention will become apparent when read in conjunction with the following description.

SUMMARY OF THE INVENTION

Each resistor component has an inert electrically nonconductive base having a fired-on electrically resistive metal film extending over one broad surface of said base. In an alternative arrangement a fired-on, continuous, nonconductive underglaze is located over a central area of said base beneath said resistive film. Thus, the resistive film will extend over and beyond the underglaze. In either arrangement a pair of spaced electrodes extend over the resistive film from opposite ends of the unit. A fired-on, continuous, nonconductive overglaze film extends over the inner edge of each electrode and covers completely the active portion of the resistive film. Optionally a metal film is fired-on the surface of the base opposite to that supporting the resistive film. In a preferred embodiment of the present invention a plurality of physically separated resistors are adhesively bonded to a support plate.

The method of forming the resistors includes the following steps: Depositing and firing-on an electrically resistive metal film over one broad surface of an inert, electrically nonconductive base. Depositing and firing-on parallel electrode strips over said resistive film. Depositing and firing-on parallel overglaze strips so as to cover all of the exposed resistive film and extend slightly onto the edges of said electrode strips. Separating the structure into a plurality of resistor components by making a first series of parallel cuts down through all layers, said cuts being along lines at right angles to a line following the longitudinal axis of said overglaze strips; firing said structure so as to refuse said overglaze; and performing a second series of parallel cuts at right angles to said first cuts and following lines midway of said electrode strips.

In one preferred embodiment, the resistive metal film extends over all of the broad surface of the nonconductive base. In another embodiment the resistive film is deposited in parallel strips. Whichever embodiment is employed, it is further preferred to include parallel strips of an underglaze between the resistive film and the nonconductive base. When parallel strips of resistive material are employed, the resistive films should extend over the width and slightly beyond both edges of the underglaze strips. Furthermore, when parallel strips of resistive film are employed, either with or without the underglaze, the parallel electrode strips should extend between and slightly overlap adjacent resistive film strips. Since the unit is subjected to a final firing or annealing step in order to refuse the overglaze layer, the overglaze should have a lower fusing range than the underglaze material. This will eliminate deleterious changes which otherwise would occur in the resistance film.

Prior to separating the buildup into individual components it is preferred that the buildup be adhesively bonded to a support plate so that the electrode and overglaze strips are outermost from said support plate. This firmly anchors the structure to the support plate during the cutting sequence.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a plan view partly broken away, of the resistor buildup of the present invention.

FIG. 2 is a sectional view along lines 2–2 of the unit of FIG. 1.

FIG. 3 is a plan view, partly broken away, of the resistor buildup after separation into individual units.

FIG. 4 is a sectional view along lines 4–4 of FIG. 3 and partly broken away, showing individual resistor components of the present invention.

In FIGS. 1 and 2 there is shown a layered buildup mounted on a support plate. Support plate **10** may conveniently be glass or other inert material. Metal film **12** is preferably gold which is fired on inert electrically nonconductive base **14**. Base **14**, with its fired on metal film **12**, is adhesively bonded to support plate **10** by an adhesive layer which is not shown. Parallel underglaze strips **16** are fired-on base **14**. Resistive metal film **18** extends over and between underglaze strips **16**. Parallel electrode strips **22** are located in contact with resistive film **18**. Parallel overglaze strips **20** are fired on resistive film **18** so as to slightly overlap electrode strips **22**. Arrows **24** indicate the parallel cut-paths that a suitable device would follow in the first step for separating the structure into a plurality of physically separated resistor components. Such a device would produce paths **26** through all layers, down to support plate **10** as shown in FIGS. **3** and **4**. Arrows **18** indicate the spaced, parallel cut-paths, at right angles to the first cut-paths, that a suitable device would follow in the second step for separating the structure into a plurality of separated resistor components. This would produce paths **30** following a line midway of said electrode strips.

FIG. **4** shows in cross section, isolated resistor components, adhesively bonded to support plate **10**.

DETAILED DESCRIPTION OF THE INVENTION

Before the application of the several layers of the resistor buildup of the present invention, the surface of substrate **14** is suitably cleaned and prepared for the reception of the layers thereon. Underglaze layer **16** is preferably of a finely divided material such as a mixture of borosilicate with powdered Pyrex glass. Suitable other inorganic nonconducting materials may be used. This material may be applied by mixing it with a suitable carrier or binder, the combination being applied by an desired process such as printing, screening, painting or rolling. For the purpose of this description, screening is preferred. The preferred material of this embodiment is a borosilicate of a general formula Na_20, BaO, B_2O_3, $A1_2O_3$, SiO_2, mixed with equal parts of Pyrex glass. A suitable carrier may consist of 5 percent ethyl cellulose and 95 percent pine oil. The overall mixture may be 25 percent carrier and 75 percent finely divided inorganic material, depending upon the consistency desired for the method of application being employed. All elements of the carrier are evaporated or burned out during subsequent operations.

A plurality of resistors is formed in the following manner: an inert electrically nonconductive base **14**, such as alumina, having the approximate dimensions 1000 × 1000 × 8 mils, has approximately **14** equally spaced parallel strips of the above-described underglaze screened on the surface thereof. The underglaze strips should have the approximate dimensions 1000 × 30 × 1 mil. The applied frit is fired on the alumina substrate at a temperature capable of forming a continuous film by fusion. One, two or more applications may be made to buildup the thickness of the underglaze strips to the desired thickness.

If a metal mounting film 12 is to be employed, it should be fired on the opposite side of the alumina base. Any proprietary gold, etc. film may be utilized. A thin coating of an organo-metallic compound is then applied across the upper surface of the alumina and the surface of the underglaze strips. The organo-metallic compound is made up of an organic resinate of the alloy of resistive film. Firing of the resinate provides a resistive film 18 having the desired electrical characteristics. The resinates include as constituents natural occuring resinates, resins and synthetic preparations. The metal resinates are precious metal compounds reacted with natural or synthetic resins or simple reactive organic compounds. The metal resinate is suitably prepared for use in the production of the resistive film 18 by known methods, for example by simple solution or dispersion of the resin in a base vehicle followed by addition of one or more precious metal salts.

After the coating, comprising the metal resinate compound and the base vehicle, is applied to the alumina and the underglaze, the organo-metallic compound is subjected to a first stage of heat treatment to drive off the vehicle and decompose the organic portion of the metal compound. A second heating step is performed to completely oxidize the ash or residue of the resistive film, to insure a thorough precipitation of the precious metal film. Subsequent applications of the organo-metallic composition are applied to the surface to insure that after firing there is a continuous resistive film. A typical resistive film will be about 200—1500 angstroms thick. As an example of the resistive material of the present invention the precious metal component of the resinate may be about 69 percent platinum, 30 percent iridium and 1 percent rhodium. Any prior art platinum group metal, alloys of this group with each other or with gold can be employed as the resistive film.

A series of parallel electrode strips 22 is deposited on the resistive film in registration with the spaces between the underglaze strips. The electrode strips should be about 0.1—1 mil thick. As an example of the electrode material, a platinum-gold alloy can be utilized. The platinum-gold formulation is then fired on the surface of the unit in order to effect a strong bond between it and the resistive material. A suitable overglaze material of a lower melting or fusing frit than the underglaze is then applied to the unit in the spaces between adjacent electrode strips. This film should slightly overlap the electrode strips. This material is then fired in place at a temperature which produces a continuous fused film. The overglaze should be about 0.1—1 mil thick. It is necessary that the overglaze have a lower fusing range than the underglaze so that on firing-on of the overglaze and during a subsequent refusing step, the component buildup and the desired resistance values are distributed as little as possible.

The completed buildup is then adhesively bonded to a suitable support plate 10 preferably glass. The buildup is mounted on the support plate with the gold layer 12 in contact with the support plate as shown in the drawing. Any suitable strong prior art adhesive may be employed to effect the bond. Using a diamond saw having a thickness between 10 to 15 mils, a series of parallel cut paths is made down through all layers and to the support plate. These cut paths are along lines at right angles to the glaze strips. After the first cut it is necessary to send the buildup through an annealing kiln set at the overglaze settings in order to refuse fractured or crazed edges of the overglaze. If this annealing step is not performed the ragged or crazed edges of the overglaze sets up strains and stresses adjacent to the edge of the resistive film and this condition adversely affects the resistance value of the resistor. Moreover, the refusing effectively seals the edges of the resistor. Following the annealing step, a second series of parallel cut paths are formed at right angles to the first cut paths and following lines midway of the electrode strips. In the example given the individual resistor component will have the approximate dimensions of 20 mils wide and 50 mils long. The active resistor area will be about 20× 30 mils and the electrodes 10× 20 mils.

The resistors can be left on the support plate and shipped to the customer as is or the units may be removed from the support plate by means of the use of a suitable solvent. They may then be graded according to resistance value and then sent to the customer.

The purpose of optional metal film 12 of the individual resistor component, which film preferably is gold, is that this serves not only as an excellent mounting means for the unit but it also provides an excellent intermediate layer for the mounting of the unit on an appropriate heat sink surface. The gold and the alumina are both excellent conductors of heat and the heat can be transmitted away from resistor proper which is located either between the two glaze layers or between the overglaze layer and the alumina. This film may be eliminated if the user of the resistor employs a different mounting means.

Referring to the individual resistor shown in FIG. 4 it will be noted that the active portion of the resistor is that portion sandwiched between the two glaze layers 16 and 20. The electrodes 22 are bonded to the active portion of the resistor at the edge of the underglaze. The contact is protected by the slight overglaze overlap.

The use of an underglaze film in the units of the present invention will depend upon the electrical characteristics and physical structure desired in the resistor component. Questions of economy, function and electrical tolerance will dictate whether or not the underglaze will be employed. Elimination of the underglaze makes for better heat dissipation because the glaze is comparatively good heat insulator. In addition, higher resistance values may be obtained without the underglaze because resistance film deposition on a comparatively rough surface, such as alumina, yields an effectively thinner resistor. Moreover, it is obviously more economical to eliminate the underglaze since time and material are saved. On the other hand, elimination of the underglaze introduces the problem of control of resistance values. One of the primary advantages gained by employing an underglaze is excellent control of resistance values due to deposition of the resistance film on the comparatively smooth underglaze surface. The use of both an over and underglaze also gives greater assurance that the active portion of the resistance film will be hermetically sealed.

All of the materials employed herein are readily available commercially and equivalent materials may be substituted for the materials specifically mentioned herein.

It should be understood that the above identified embodiments of this invention are for purposes of illustration only and that modifications may be made without departing from the spirit of the invention. It is intended that this invention be limited only by the scope of the appended claims.

I claim:

1. A resistor component comprising an inert electrically nonconductive base having a fired-on electrically resistive metal film coextensive with a broad surface thereof and in direct contact with at least a substantial portion thereof; a pair of spaced metal electrodes in electrical contact with said resistive film on the top surface thereof; a fired-on, continuous, nonconductive overglaze covering all of the active resistor between said electrodes and slightly overlapping said electrodes; an edge of said overglaze being refused and strain-relieved; and a metal film fired-on the surface of the nonconductive base which is opposite the broad surface having the resistive film thereon.

2. The resistor component of claim 1 having a fired-on, continuous, nonconductive underglaze extending over a central area of the broad surface of said base beneath all of the active portion of said resistive film, said resistive film extending beyond said underglaze and wherein said nonconductive base has greater thermal conductivity than said underglaze.

3. The resistor component of claim 2 wherein said base is alumina, said resistive film is either a platinum group metal, an alloy of one or more members of this group or an alloy of this group with gold, and wherein the overglaze has a lower fusing range than that of the underglaze.

4. A plurality of physically separated resistor components adhesively bonded to a support plate, each resistor component comprising an inert electrically nonconductive base having a fired-on electrically resistive metal film coextensive with a broad surface thereof and in direct contact with at least a substantial portion thereof; a pair of spaced metal electrodes in electrical contact with said resistive film on the nonbase-contacting surface thereof; and a fired-on, continuous, nonconductive overglaze covering all of the active resistor between said electrodes and slightly overlapping said electrodes; an edge of said overglaze being refused and strain-relieved; and said resistor components being adhesively bonded to said support plate so that the electrodes are outermost.

5. The resistor arrangement of claim 4 wherein each component has a metal film fired-on the broad surface of the nonconductive base which is opposite to that having the resistive film thereon.

6. The resistor arrangement of claim 4 wherein each component has a fired-on, continuous, nonconductive underglaze extending over a central area of the broad surface of said base beneath all of the active portion of said resistive film, said resistive film extending beyond said underglaze and wherein said nonconductive base has greater thermal conductivity than said underglaze.

7. The resistor arrangement of claim 6 wherein each component has a metal film fired-on the broad surface of the nonconductive base which is opposite to that having the resistive film thereon.

8. The resistor of claim 1 wherein both edges of said overglaze adjacent the edges of said active resistor are refused and strain-relieved.

9. The resistor of claim 2 wherein both edges of said overglaze adjacent the edges of said active resistor are refused and strain-relieved.

10. The resistor of claim 3 wherein both edges of said overglaze adjacent the edges of said active resistor are refused and strain-relieved.

11. The resistor arrangement of claim 4 wherein both edges of said overglaze a adjacent the edges of said active resistor are refused and strain-relieved.

12. The resistor arrangement of claim 5 wherein both edges of said overglaze adjacent the edges of said active resistor are refused and strain-relieved.

13. The resistor arrangement of claim 6 wherein both edges of said overglaze adjacent the edges of said active resistor are refused and strain-relieved.

14. The resistor arrangement of claim 7 wherein both edges of said overglaze adjacent the edges of said active resistor are refused and strain-relieved.