United States Patent

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[72] Inventor **Walter Helgeland**
Nashua, N.H.

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[73] Assignee **Sprague Electric Company**
North Adams, Mass.

[54] **CYLINDRICALLY MOLDED METAL FILM RESISTOR**
4 Claims, 3 Drawing Figs.

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[51] Int. Cl. **H01c 1/02**
[50] Field of Search 338/195, 274, 275, 276, 308, 309; 174/521

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Primary Examiner—E. A. Goldberg
Attorneys—Connoly and Hutz, Vincent H. Sweeney, James Paul O'Sullivan and David R. Thornton

ABSTRACT: A metal film resistor formed on a flat chip and encapsulated within an insulative compound by a molding process which forms a cylindrical resistor having axial leads.

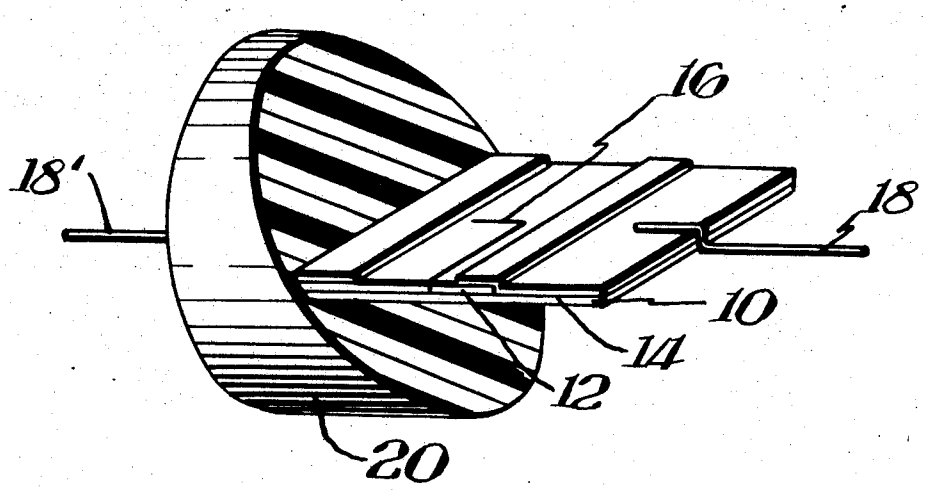


Fig. 1.

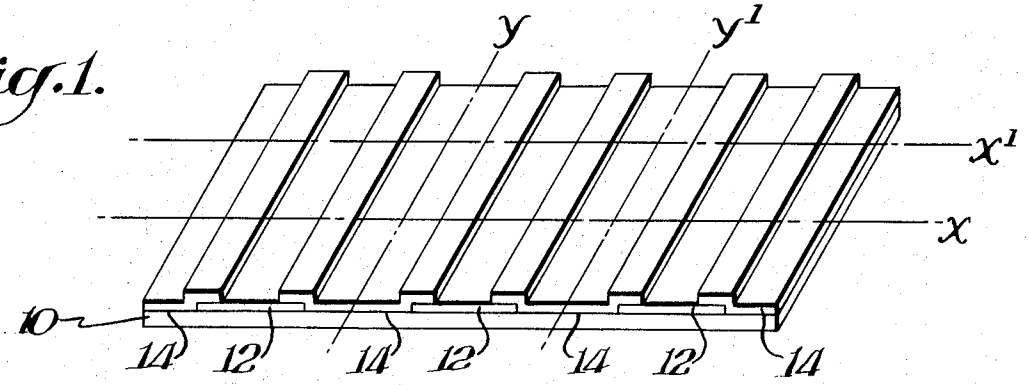


Fig. 2.

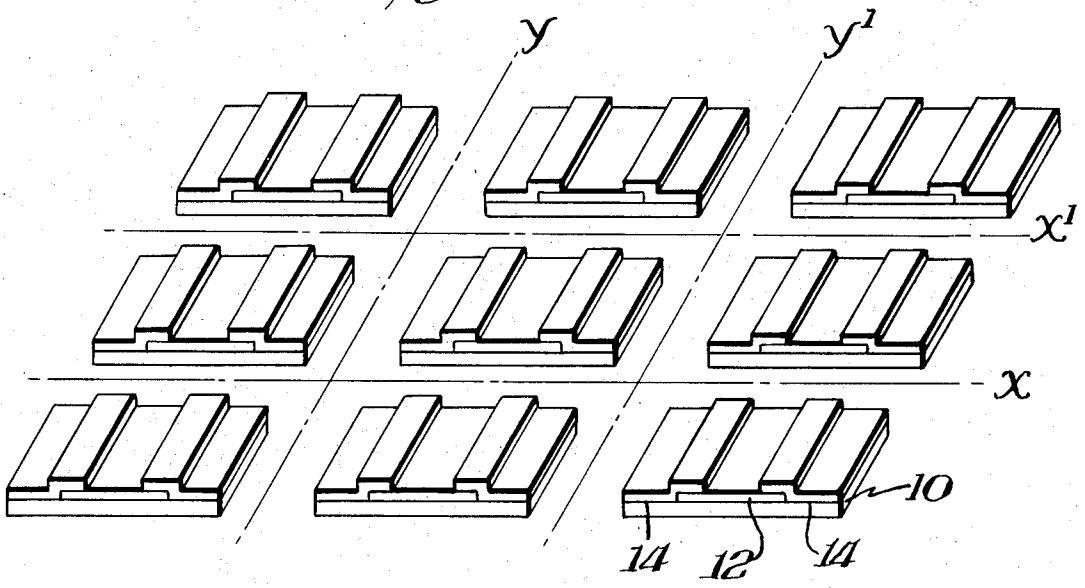
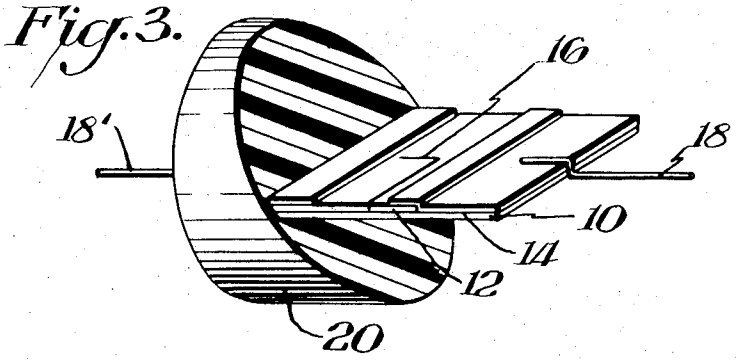


Fig. 3.



CYLINDRICALLY MOLDED METAL FILM RESISTOR

BACKGROUND OF THE INVENTION

This invention in general relates to metal film resistors and more particularly to metal film resistors formed on flat chips which are subsequently encapsulated in insulative compounds which are molded to form cylindrical shapes. The cylindrical shape of the resistor permits the resistor to be installed by commercially available resistor insertion equipment which is generally used for the automatic insertion of cylindrical carbon resistors.

Recent metal film resistor manufacturing techniques have permitted the production of metal film resistors at a cost that is commercially competitive with that of molded carbon resistors. Metal film resistors are normally formed on a flat chip thereby having a considerable size advantage over the larger cylindrical shape of carbon resistors. However there are many applications and uses for resistors where size is not deemed critical and where the larger cylindrical carbon resistor can be suitably utilized. In fact many automated manufacturing processes utilize equipment designed for the automatic insertion of cylindrical carbon resistors into their respective places in the circuitry being produced. Such equipment cannot handle the small flat chip of the metal film resistor and consequently its use is limited solely to insertion of carbon resistors.

Therefore it is an object of this invention to produce a metal film resistor having a molded cylindrical shape so as to permit its use with automatic resistor insertion equipment.

It is a further object of this invention to produce cylindrical-shaped metal film resistors at a cost that is commercially competitive with that of carbon resistors.

SUMMARY OF THE INVENTION

In accordance with the present invention metal film resistors are formed starting with an inert electrically nonconducting base upon which a thin resistive coating is deposited by any such conventional method as screening, evaporation or sputtering. Spaced-apart electrode terminals in electrical contact with the resistive film are deposited and leads are attached to the terminals. The leads are preformed so as to extend away from the ends of the resistor chip in the same line as the center axis of the chip. The chip is then encapsulated in a compound which is molded into a cylindrical shape with the leads extending from the ends of the cylinder in the same line as the center axis of the cylinder.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective view showing a segment of a ceramic substrate overlaid with resistive and conductive strips before cutting into individual resistor chips.

FIG. 2 is a perspective view showing the substrate of FIG. 1 after it has been cut into several individual resistor chips.

FIG. 3 is a cut away perspective view showing an individual resistor chip with leads attached after the chip has been molded to form a cylinder.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment of this invention is a resistor structure made up of a thin resistive film deposited from a metallo-organic composition on a fused inorganic nonconducting layer. The organic resinate is burned out of the composition leaving a metal resistive film. Suitable electrodes in contact with the resistive film are provided. Electrical leads are attached to the electrodes so as to extend from the resistor in an axial direction after the resistor chip has been molded to form a cylinder.

In accordance with the preferred embodiment of this invention a plurality of metal film resistor chips are formed on one inert electrically nonconductive base in the following manner:

FIG. 1 shows a segment of inert electrically nonconductive ceramic base **10** which is composed of alumina and has the approximate dimensions 25×1,000×2,000 mils. The surface of substrate **10** is suitably cleaned and prepared for the reception of the layers thereon. A thin coating of an organometallic compound is next screened onto substrate **10** to form parallel strips **12** which are 100 mils wide and spaced 20 mils apart. The organometallic compound is made up of an organic resinate of the alloy of the resistive film. Firing of the resinate provides a resistive film having the desired electrical characteristics. The resinates include as constituents natural occurring resinates, resins and synthetic preparations. The metal resinates are precious metal compounds reacted with natural or synthetic resins or simply reactive organic compounds. The metal resinate is suitably prepared for use in the production of the resistive film **12** by known methods, for example by simple solution, a dispersion of the resin in a base vehicle followed by addition to one or more precious metal salts.

After the coating, comprising the metal resinate compound and the base vehicle, is applied to the alumina, the organometallic 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 organometallic composition are applied to the strip surfaces to insure that after firing there are continuous resistive film strips. A typical resistive film strip will be about 200–1,500 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.

Although the preferred embodiment describes resistive films deposited from metallo-organic compositions because of their present commercial attractiveness, other embodiments of the present invention may be made using other standard techniques. Alternate embodiments of the present invention would include resistive films deposited by such conventional processes as screening, evaporation and sputtering. Examples of other highly suitable resistive films would be nickel chromium alloys and sputtered tantalum nitride films.

The preferred embodiment of parallel resistive strips permits the deposition of parallel electrode strips **14** so as to have part of the surface of the electrode strip in contact with ceramic substrate **10** thereby providing an improved structure because of the stronger adhesive bond between the electrode and ceramic substrate than between the electrode and resistive film. In an alternate embodiment of the invention however ceramic substrate **10** could be covered with a continuous resistive film and have the parallel electrode strips deposited on top of the resistive film.

The electrode strips **14** of the preferred embodiment are deposited so as to be centered on the spaces between the resistive strips. The electrode strips are approximately 60 mils wide with an overlap of approximately 20 mils onto the resistive strip on each side together with a thickness in the order of 0.1–1 mil. 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 ceramic and resistive material.

Next using a diamond saw having a thickness between 10 to 15 mils a series of parallel cut paths is made down through all layers. A first series of parallel cut paths are made at right angles to the resistive and terminal strips along lines *x*, *x'* etc., which are spaced approximately 50 mils apart. A second series of parallel cut paths are formed at right angles to the first cut paths along lines Y, Y' etc., which are midway of the electrode strips thereby producing the individual resistor components as shown in FIG. 2.

In the example given the individual resistor components will have the approximate dimensions of 50 mils wide and 110 mils long. The active resistor area will be about 50 mils by 60 mils and the electrodes 50 mils by 25 mils.

FIG. 3 shows a cutaway view of a single molded resistor chip after leads have been attached. L-shaped cut 16 is made to adjust the resistance to the desired value by isolating portions of the resistance film rather than by removing part of the resistor material. Leads 18 and 18' are performed as shown in FIG. 3 in order that they may emerge from the resistor near its center axis. Leads 18 and 18' are soldered to the terminal strips in a manner common to the art so as to extend away from the ends of the base in a line identical to the center axis of the base. It is desirable to use fluxes to reduce the oxidation of the solder and the lead, which may be of any metal; for example, tinned copper. The solder may be fed in wire form to the joint, may be performed, or may be dropped as a liquid on the joint. Provision must be made to apply heat gradually to the resistor in order to prevent heat shock. After the solder has flowed and bonded to the metal parts, they are allowed to cool.

Soldering the leads directly to the terminals eliminates the necessity of end caps which present many disadvantages in both the use and manufacture of film resistors. The use of end caps automatically creates an additional step in the assembly of a resistor. Also the end caps are generally of thin, delicate construction, particularly when used with resistors of small physical size and present serious difficulties in attaching a lead thereto. Also end caps would be expensive and increase the cost of the resistor therefore considerable advantage is gained by their elimination.

After the leads have been attached the resistor chip is encapsulated in an insulative compound, preferably epoxy, so as to form the cylindrical-shaped resistor shown in the cutaway view of FIG. 3. The resistor is encapsulated by a standard molding procedure, whereby the resistor chip is inserted into a cylindrical mold with both leads extending from the ends of the mold. The mold is next filled with an epoxy and allowed to set. After sufficient time has been allowed for the epoxy to cure, the mold is removed leaving the cylindrical-shaped resistor 20 as shown in FIG. 3. The diameter of the mold is only slightly larger than the 50-mil width of the resistor chip and the performed leads are attached so as to emerge from the cylinder at its center axis. Phenolics or silicones may also be used instead of epoxy as the encapsulating material.

What is claimed is:

1. A resistor comprising an electrically nonconductive flat thin ceramic base having an electrically resistive noble metal film deposited over the full width of a broad substantially rectangular surface thereof; a pair of spaced metal electrodes having the full width of said base and in electrical contact with said resistive film at opposite ends of said base; a pair of metal leads soldered in direct electrical contact to said pair of electrodes, said leads being shaped and oriented in axial alignment along the long axis of said base; and an insulative substance molded around said base, entirely encapsulating it so as to form a cylinder having its center axis in the same line as said leads and of approximately the same length as said base and having a diameter approximately equal to the width of said base.

2. The resistor of claim 1 wherein said base is alumina, said resistive film is selected from a platinum group metal, an alloy of members of this group, and an alloy of one or more members of this group with gold.

3. The resistor of claim 1 wherein the resistance value is adjusted by an L-shaped cut through said resistive film, said cut originating from the side of said film and terminating in a right angle cut toward one of said electrodes.

4. The resistor of claim 2 wherein said insulative substance is selected from epoxy, phenolic and silicone.

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