United States Patent

Brandi

[15] **3,643,200**

[45] **Feb. 15, 1972**

[54] HERMETICALLY SEALED RESISTOR

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[22] Filed: **June 1, 1970**

[21] Appl. No.: **41,810**

[52] **U.S. Cl.**.....**338/329,** 338/258, 338/331, 338/332

[51] **Int. Cl.**.....**H01c 1/14**

[58] **Field of Search**.....338/258, 260, 308, 329, 327, 338/332, 331

[56] **References Cited**

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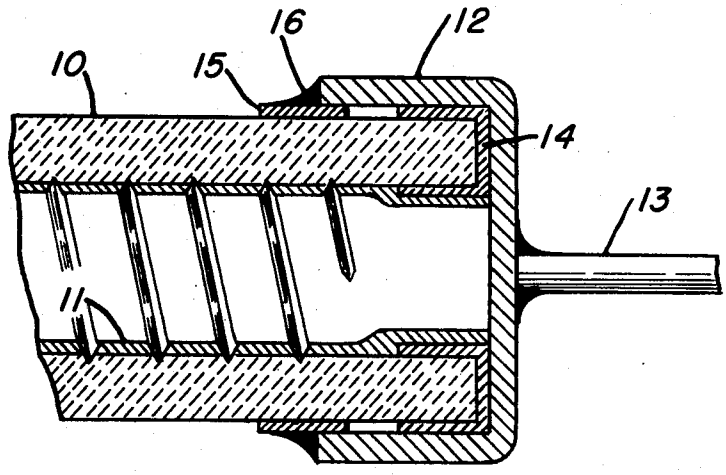
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Primary Examiner—E. A. Goldberg
Attorney—Rudolph J. Jurick

[57] **ABSTRACT**

A resistance film is formed on the inner surface of tube of dielectric material. End terminals interfused with the tube provide electrical continuity between the resistance film and metallic end caps closing the ends of tube, which end caps are soldered in place to provide heretic seals.

2 Claims, 4 Drawing Figures



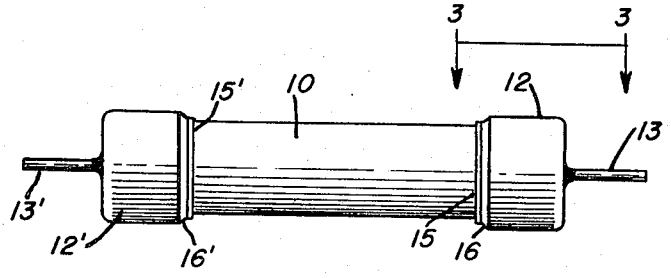


FIG-1

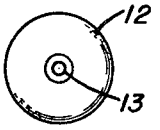


FIG-2

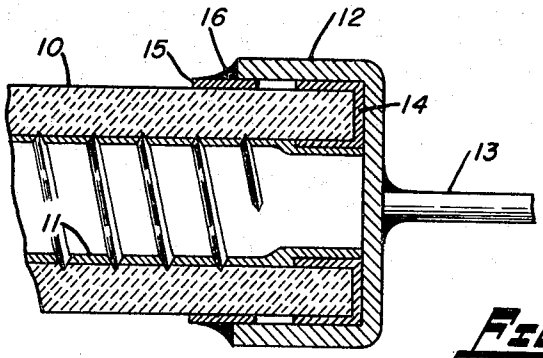


FIG-3

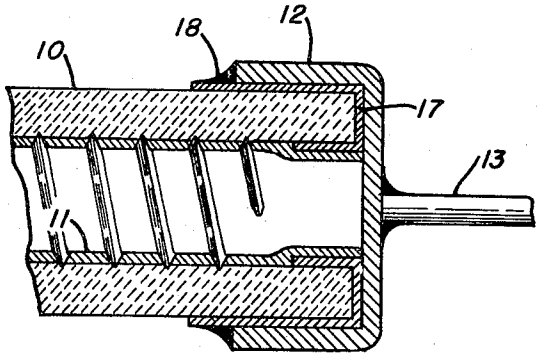


FIG-4

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HERMETICALLY SEALED RESISTOR

BACKGROUND OF THE INVENTION

Electrical resistors comprising a metallic film deposited on the inner surface of a tube and provided with metallic end caps are well known. In the case of a ceramic tube, end terminals are interfused with the tube and serve to provide electrical continuity between the resistance film and the end caps. Heretofore, silver plated end caps have been press-fitted over the end terminals. After the tube has been heated and cooled, the silver alloy joins together the contiguous walls of the end caps and the underlying portions of the end terminals. In many cases, such joint provides a hermetic seal but often the joint is defective as pinholes develop in the silver seal. Such pinholes develop under the end cap and there is no certain way of locating or eliminating them. Thus, the seal is either perfect of defective when first made, resulting in a costly rejection of resistors which have proceeded to the final step in the manufacture thereof.

The present invention eliminates the present uncertainty in the manufacture of hermetically sealed resistors to meet military specifications. The hermetic seal can readily be tested for leakage and defective seals are visually detectable and easily corrected.

ABSTRACT OF THE INVENTIon

End terminals are interfused with a ceramic tube having a resistance film deposited on the inner surface thereof. The end terminals, which extend from the inner surface of the tube to the outer surface thereof, provide electrical continuity between the film and metal end caps press-fitted over the end terminals which have been coated with a solder alloy. Upon heating and then cooling the tube, the contiguous surfaces of the end caps and the end terminals are joined together. In accordance with one embodiment of this invention, the exterior portions of the end terminals project beyond the edges of the end caps and a bridge of solder alloy is formed between such edges and the projecting portions of the associated end terminals thereby resulting in a visible solder joint of substantial mass. In another embodiment of the invention, outer metallic bands are interfused with the ceramic tube, which bands are proximate to, but spaced from, the exterior portions of the end terminals. These bands project beyond the edges of the end caps and the solder alloy bridge is formed between the edges of the end caps and the projecting portions of the associated bands. In both embodiments of the invention, the bridging solder joint has a substantial thickness at the critical area, namely, the circumferential region defining the area of contact between the end cap and the underlying metallic band, or the underlying exterior portion of the end terminal.

An object of this invention is the provision of an arrangement for making a hermetically sealed resistor and a resistor made by such method.

An object of this invention is the provision of a hermetically sealed resistor of the class having a resistance film formed on the interior surface of a tube.

An object of this invention is the provision of an improved arrangement for hermetically sealing a resistor having metal end caps closing the ends of a ceramic tube carrying an internal resistance film, a solder alloy bridging the edges of the end caps and metallic members interfused with the tube.

The above-stated and other objects and advantages of the invention will become apparent from the following description when taken with the accompanying drawings. It will be understood, however, that the drawings are for purposes of illustration and are not to be construed as defining the scope or limits of the invention, reference being had for the latter purpose to the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings wherein like reference characters denote like parts in the several views:

FIG. 1 is a side elevational view of a resistor made in accordance with this invention.

FIG. 2 is an end elevational view thereof;

FIG. 3 is a fragmentary cross-sectional view taken along the line 3—3 of FIG. 1 and drawn to an enlarged scale; and

FIG. 4 is a similar cross-sectional view showing another embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIGS. 1–3, a resistor made in accordance with this invention comprises a tube **10** made of suitable dielectric material, preferably a ceramic, and having a resistance film **11**, formed on the inner surface thereof. The ends of the tube are sealed by bronze, silver-plated end caps **12** and **12'**, which caps have lead wires **13** and **13'** welded thereto.

Referring particularly to FIG. 3, the end portion of the tube **10** is first coated with a metal paste or frit, preferably a silver frit, thereby forming an end terminal **14**. A silver frit also is applied to the outer surface of the tube to form the band **15**, which band is spaced from the end terminal **14**. The other end of the tube is similarly treated to provide a corresponding end terminal and outer band. The unit is fired at an elevated temperature, whereby the silver frit coatings are interfused with the tube. Thereafter, the resistance film is formed by depositing a metal onto the inner surface of the tube and over the inner portions of the end terminals. Preferably, a nickel-chrome alloy is evaporated onto the tube surface by methods well known in this art. Next, the ohmic resistance of the film is adjusted to a desired value as, for example, by grinding the illustrated helical groove through the film. The band **15** and the outer surface of the end terminal **14** are plated with copper after which the silver plated end cap **12** is pressed over the band, it being noted that the outer band **15** extends beyond the end of the end cap.

With the two end caps in place the unit is evacuated and then filled with an inert gas at about 30 pounds per square inch above atmospheric pressure, after which the pressure is released to 14.7 p.s.i. to establish equilibrium with the atmospheric pressure. A soldering flux is applied to the exposed portions of the bands **15** after which the unit is rolled on the surface of a hotplate and into a mass of solder alloy carried by the hotplate and maintained in a liquid state. The solder alloy bridges the edges of the end caps and the associated outer bands to form a readily visible joint **16**. Also, the solder alloy flows between the contiguous surfaces of the end caps, the outer bands and the end terminals.

The described arrangement for closing the ends of the tube creates a hermetic seal which, under test has an average leakage rate of 1×10^{-9} cubic centimeters per second, whereby the resistor meets the seal test for hermetically sealed resistors under military specifications. Furthermore, when the finished resistor is subjected to the leak test an incomplete hermetic seal is detected by the formation of minute bubbles on the joint **16**. In a majority of cases, such resistor can be salvaged by repeating the above-described soldering procedure. The completed resistor may be externally insulated by encapsulating the body of the resistor in a nonflammable epoxy resin or by means of a plastic shrink tube.

A modification of the sealing arrangement is shown in FIG. 4. Here, the outer portion of the end terminal **17** extends beyond the end cap **12**, with the solder joint **18** bridging the edge of the cap and the extended surface of the end terminal. The end terminal **17** is formed by applying a silver frit to the tube surfaces by means of a brush, thereby to form the inner portion of the terminal of a relatively short axial length (in order not to undesirably reduce the effective axial length of the resistance film) while, at the same time, forming the outer portion of the terminal of a desired, longer axial length. In the embodiment of the invention shown in FIG. 3, the ends of the tube may be dipped in the silver frit to form the end terminals which serve primarily to establish electrical continuity between the resistance film and the end caps

Having now described the invention what I desire to protect by Letters Patent is set forth in the following claims.

1. A resistor comprising,

a. a tube of dielectric material,

b. metallic end terminals on the ends of the tube and interfused therewith, each terminal including an interior portion on the inner wall of the tube and an exterior portion on the outer wall of the tube,

c. a metallic resistance film on the inner wall of the tube and overlying at least a portion of the interior portions of the said end terminals,

d. a pair of metallic bands on the outer wall of said tube, each band being interfused with the tube and spaced from the exterior portion of one of the said end terminals,

e. metallic end caps closing the ends of the tube, each end cap extending over the exterior portion of the associated end terminal and the edge of each end cap terminating at a point intermediate the ends of the proximate one of said metallic bands, and

f. a solder alloy joining together the contiguous surfaces of each of the end caps, the associated metallic band and the exterior portion of the end terminal, said solder alloy also bridging the edges of the end caps and the projecting portions of the associated metallic bands.

2. The invention as recited in claim 1, wherein the tube is made of a ceramic, and wherein the end caps are silver-plated and have connection leads welded thereto.

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