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# METAL FILM RESISTOR

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The present invention relates to a new and improved variety of metal film resistor.

It is common knowledge at the present time that various thin metal layers can be satisfactorily used as resistance elements. A great deal of work has been done in attempting to determine the optimum type of metallic composition for use with such resistors. Unfortunately, this work has not been extremely successful to date; and prior to the present invention, it is not believed that anyone produced a metal film resistor possessing as low a temperature coefficient of resistance over wide ranges of resistance values as desired for many purposes. Further, it is not believed that prior to the present invention that anyone had produced metal film resistors exhibiting extreme stability to load life tests.

It is an aim of the present invention to produce new and improved metal film resistors having very low temperature coefficients of resistance. Further, it is an object of the invention to produce resistors which are highly stable over long load life tests, and which can be easily and conveniently made without the high degree of control necessary in forming the prior art related units. Further objects of the invention, as well as the advantages of it, will be apparent from the body of this specification and the appended claims.

The basic feature of the instant invention rests upon the discovery that the addition of approximately 2½% of rhodium to gold-palladium resistance compositions containing from 40 to 70 parts of gold and 30 to 60 parts of palladium greatly improved the characteristics of resistance films of these alloys so as to achieve the objects indicated above.

Surprisingly enough, no equivalents are known for the rhodium used for the purpose of stabilizing a gold-palladium resistance film composition as indicated above. While the figure 2½% is indicated above, it is to be understood that from 1½% to about 3½% of rhodium can be employed without departing from the scope of the instant invention.

To illustrate the function of rhodium within gold-palladium resistance films, it should be mentioned that the new resistance films are subject to a change of less than 0.2% in resistance value over a 500 hour life test, whereas the prior art films exhibited a change of at least 1% over the same test. Further, the temperature coefficients of resistivity of the new films of the invention is about 0.025% per ° C., whereas the temperature coefficients of the prior art gold-palladium compositions is about 0.035% per ° C. Also, the addition of rhodium as specified herein decreases the tendency of metals used for terminal elements to diffuse into the main resistance layer changing the resistance value of the portion of the layer adjacent to the terminals. Thus, in the prior art the



silver end caps used with gold-palladium film resistors tended to effect a change in the composition of the alloy film adjacent to these caps. For some unknown reason the small proportion of rhodium added in accordance with this invention prevents this diffusion. Also, the new composition films of the invention are less sensitive to changes in manufacturing conditions than the prior art film resistors.

The procedure used in forming new film resistors described herein is substantially that known to the prior art. Briefly it involves making up a resinate solution containing the metals used in the final film in the proportion in which they are used in this film, spraying this resinate onto an inert core, such as a steatite core, and drying the deposited resinate as by the use of infra-red lamps. This coating cycle is repeated until the desired thickness of the resinate is built-up upon the inert base. Then this coated base is dried at a temperature in excess of the boiling point of the solvent, but below about 250° C., for a short period until all traces of the solvent are gone. Finally, the unit is fired at a temperature of from about 320 to about 400° F. for a period of from 5 to 30 minutes. Appropriate terminals are attached using known procedures. If desired, metal films as produced above can be cut into small thin bands as by the use of a lathe or a milling machine.

It is to be realized that the unusual effect of the addition of rhodium to the alloy useful as thin metallic resistance films is not solely limited to three component alloy systems, but may be extended to alloy systems having four or more metallic components. As an example of this, the addition of a minor amount of rhodium to an alloy having a major amount of gold and palladium with a further minor amount of platinum results in a four-component system which is characterized by the formation of thin metallic films of large resistivity per unit volume, low chemical reactivity, much improved temperature coefficients of resistance over the prior art cases, and exceptional operational stability over long periods of use.

As an example of the hereinbefore described invention, a ceramic core was coated by spraying with six successive coats of metal organo resinate solution containing 10½ parts of palladium, 15.8 parts of gold, and .7 part of rhodium. After the final coating was placed on the ceramic rod the unit was fired to decompose the organo resinate composition and leave the surface film of the metal alloy. Silver paint was placed on the opposed ends of the metal film and was fired thereafter to fuse the silver so that low resistance contacts were made with the metal film. On ten units made in this manner the initial resistance of the films was found to vary from 600 to 900 ohms and thereafter each individual unit was spiralled to 100,000 ohms resistance. The units were placed on a 1 watt load test with an ambient temperature of 40° C. being maintained and after 750 hours had an average change of less than 1/10 percent with none of the units in excess of this figure.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope hereof, it is to be understood that the invention is not limited to the specific embodiments hereof, except as defined in the appended claims.

What is claimed is:

1. An electrical resistance having an inert electrically non-conductive base with a fired-on thin film of an alloy consisting of essentially of from about 40% to about 70% by weight of gold, from about 30% to about 60% by

weight of palladium and from about 1.5% to about 3.5% by weight of rhodium and having a temperature coefficient of resistivity of the order of 0.025% per ° C.

2. An electrical resistor comprising the electrical resistance element of claim 1 with metal terminal connections attached to spaced portions of said film, the metal of said terminal connections being substanially undiffused into said electrical resistance element.

3. The combination of claim 2 in which the terminal connections include fired-on silver coatings on the alloy film.



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