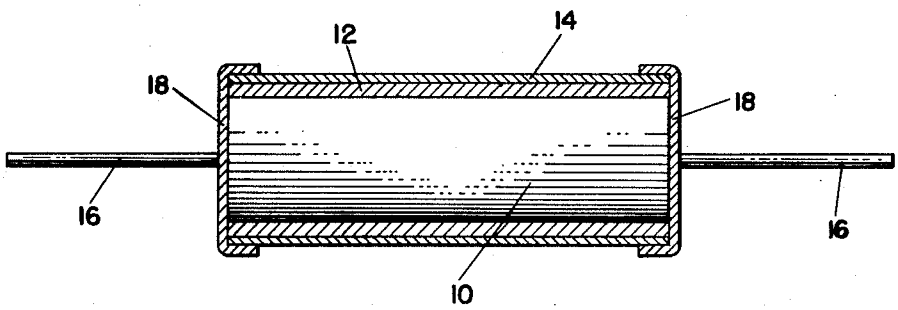
May 3, 1960 B. SOLOW 2,935,717

METAL FILM RESISTOR AND METHOD OF MAKING THE SAME

Filed Nov. 12, 1957



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2,935,717

Patented May 3, 1960

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2,935,717

METAL FILM RESISTOR AND METHOD OF MAKING THE SAME

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Application November 12, 1957, Serial No. 695,856

2 Claims. (Cl. 338—308)

This invention relates to the construction of an improved electrical resistor. More specifically it relates to the construction of a metal film resistor having improved properties.

In the manufacture of electrical resistors it has always been the desire to make a resistor which has a low temperature coefficient of resistance (i.e. a low change in resistance per degree change in temperature) and which is very stable (i.e. does not change in resistance because of changes in temperature, humidity, the load applied, or other operating conditions). In recent years, it has been found that some of these properties could be obtained in metal film type resistors which comprise a base or core of an electrically insulating material with a resistance material film of a metal or alloy of metals coated on the surface of the base or core. One type of metal film resistor is disclosed in U.S. Letters Patent No. 2,440,691, issued May 4, 1948, to Joseph W. Jira entitled "Alloy Metal Film Resistor." This patent to Jira discloses using a resistance material film comprising a noble metal alloy composed of a metal normally having a high positive temperature coefficient of resistance, such as gold, and a metal normally having a high negative temperature coefficient of resistance, such as palladium. The metals are combined in such proportions as to balance the temperature coefficients to obtain a material having a desired low temperature coefficient. The alloy is applied to the base or core in the form of a resinate which is heated to convert the film to the metal alloy. However, this type of metal film resistor has many disadvantages. Because of the metals used, it is expensive. Since the ratio of the metals used is critical to obtain a desired low temperature coefficient, it is difficult to reproduce in large quantities. Most important of all, this type of metal film does not have the desired stability with regard to operating conditions.

Another type of metal film resistor is that in which a thin film of metal or metal alloy is deposited on the base or core by the process of evaporation in a vacuum such as disclosed in U.S. Letters Patent No. 2,586,752, issued February 19, 1952, to E. Weber et al., entitled "Alloy Resistance Element and Method for Manufacturing Same." Although this process permits greater controllability in obtaining a desired thickness of a resistance film, the use of merely a single metal or alloy as the resistance film has certain disadvantages. It is known that certain metals or alloys when applied in thin films provide resistance films having certain of the properties desired but in the mass production of the resistors by the process of evaporation in a vacuum it is very difficult, when using as a resistance film in a single metal or alloy, to obtain a film having both a low temperature coefficient of resistance as well as substantially complete stability.

It is therefore an object of this invention to provide an improved electrical resistor having a low temperature coefficient of resistance and which is stable under operating conditions. It is a further object of this invention to provide an improved metal film resistor having good stability and a low temperature coefficient of resistance. It is still a further object of this invention to provide a method of making a metal film resistor having good stability and a low temperature coefficient of resistance. It is another object of this invention to provide a metal film resistor having improved stability which can be easily reproduced in mass production. It is still another object of this invention to provide a metal film resistor having a double layer resistance film to achieve good stability and a low temperature coefficient of resistance. Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others, and the article possessing the features, properties and the relation of elements, which are exemplified in the following detailed disclosure, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing, in which the figure is a cross-sectional view of the resistor of this invention.

Referring to the drawing, the resistor of this invention comprises a base or core **10** of an electrically insulating material such as a ceramic of the type described in United States Letters Patent No. 2,386,633, issued October 9, 1945, to M. D. Rigterink, entitled "Ceramic Material." A resistance material is coated on the surface of the core **10** and comprises a thin layer **12** of a nickel-chromium alloy having a low temperature coefficient of resistance known by the Wilbur B. Driver Company trademark "Evanohm," which is an alloy with a nominal composition of 74.5% nickel, 20% chromium, 2.75% aluminum, and 2.75% copper, coated directly onto the surface of the core **10** and a second thin layer **14** of chromium coated over the Evanohm layer **12**. To clearly show the two separate layers **12** and **14** in the drawing the thickness of these layers is shown exaggerated. Actually the total thickness of the two layers **12** and **14** is between approximately 200 and 500 Angstrom units. The thin Evanohm layer **12** provides a resistance material having a low temperature coefficient of resistance. However, Evanohm alone is not stable with regard to moisture, electrical load applied and other operating conditions. Chromium has been found to have good stability but in thin films, unless it is applied with great care, its temperature coefficient of resistance varies over a wide range. However, it has been found that in the resistance material film comprising a layer of Evanohm covered by a layer of chromium and particularly with the Evanohm comprising between 80% and 90% of the resistivity of the film, i.e. the resistance per unit area, and the chromium comprising between 10% and 20% of the resistivity of the film, the film will have the good stability of the chromium and yet the chromium does not adversely affect the easily reproducible low temperature coefficient of the Evanohm. In fact, it is found that the chromium even lowers the temperature coefficient of resistance. By lowering the temperature coefficient it is meant that the temperature coefficient becomes numerically closer to zero.

The following table shows the operating characteristics of metal film resistors made according to this invention. This table shows the results of standard tests which simulate the conditions under which the resistors would operate. Each of the results shown is the average of the results obtained from testing a large number of the resistors.

Typical performance characteristics

[½ watt size resistors]

[Results in percent change in resistance value]

Resistance Value	Temperature Cycle	Low Temp. Exposure	Short Time Overload	Moisture	Load Life for 1,000 hrs.	
					at 100° C.	at 125° C.
100 ohms	.11	.04	.17	.15	.07	.15
1000 ohms	.03	.01	.02	.11	.06	.10
0.237 megohms	.04	.04	.01	.09	.13	.18
0.5 megohms	.04	.03	.01	.20	.10	.14

The temperature cycle test comprises placing the resistors in a chamber and varying the temperature in the chamber through a wide range in a defined pattern to see what affect variations in temperature has on the resistance value. The low temperature exposure test comprises placing the resistors in a chamber which is at a temperature of about −65° C. for a defined period. Short time overload comprises applying an electrical load on the resistor of two and one half times its rated load for a short period. The moisture test comprises placing the resistor in a chamber in which the relative humidity is about 90% to 98% and varying the temperature in the chamber with and without a load being placed on the resistor. The load life test comprises placing the resistor in a constant temperature chamber and varying the electrical load placed on the resistor through a preset cycle for a period of approximately 1000 hours. In each test the resistance value of the resistors was measured before and after the test to determine the degree of change in the resistance value. Obviously, the less the resistor changes in value the more stable the resistor. Referring to the above table, it can be seen that the most any resistor changed in value was 0.2% and in most cases the change was 0.1% or less. Thus it is shown that the metal film resistor of this invention will have only a negligible change in resistance value under all operating conditions to provide a very stable resistor. These resistors can be mass produced in accordance with this invention having a temperature coefficient of resistance as low as 0±25 parts per million per centigrade degree change in temperature. This means that for a change in temperature of one centigrade degree the resistance value will change a maximum of 0.0025%. Thus, there is provided a metal film resistor which has a low temperature coefficient of resistance and which is also very stable under all operating conditions.

In the manufacturing of the resistor of this invention, the resistance material film is coated on the base or core **10** by the process of evaporation in a vacuum. This process is used since it permits fine control of the film being coated. Thus, with this process the proper amounts of each of the layers **12** and **14** can be easily obtained. In general, the resistance material film is obtained by placing a base or core **10** in a chamber along with a source of the Evanohm metal. The chamber is sealed tight and evacuated to a pressure of at least 0.5 micron or preferably even less. The Evanohm metal is then heated until it evaporates which is at a temperature of around 1200° C. The Evanohm vapors diffuse throughout the chamber and the vapors which contact the core **14** will con-

dense thereon to provide the first layer **12**. When the proper amount of the Evanohm is coated on the core **10** the evaporation is stopped. The chamber is then brought back to atmospheric pressure and the supply of Evanohm metal is replaced by a supply of chromium metal. The chamber is again evacuated and the chromium is heated until it evaporates which is at a temperature of around 800° C. The evaporation of the chromium is continued until a sufficient amount of the vapors condense on the Evanohm layer **12** to form the outer chromium layer **14**. The evaporation is then stopped and the resistor is removed from the chamber. To complete the resistor terminal lead wires **16** are attached to the resistance material film such as by metal caps **18** to which the lead wires **16** are secured, or in any other well known manner. If desired, a protective covering may be applied around the resistor to protect it against dirt and damage during handling. Such protective covering may be a tube or casing into which the resistor is sealed or a coating of an insulating material or a plastic jacket molded around the resistor, all of which are well known. There are many known specific apparatus which can be used to carry out this method of coating the resistance material film on the core. One such apparatus is shown in United States Letters Patent No. 2,522,272, issued September 12, 1950, to S. A. Johnson et al., entitled "Apparatus for Forming Metallic Films on Tubular Carriers." Another such apparatus is disclosed in the application for Letters Patent Serial No. 490,006, filed February 23, 1955, now U.S. Patent No. 2,847,325, by Jacob Riseman et al., entitled "Apparatus and Method for Evaporating Films on Certain Types of Electrical Components."

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in carrying out the above method and in the article set forth without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. An electrical resistor comprising the combination of a core of electrical insulating material and a resistance material film comprising a layer of a nickel-chromium alloy having a low temperature coefficient of resistance coated on said core from the evaporation in a vacuum of an alloy having a nominal composition of 74.5% nickel, 20% chromium, 2.75% aluminum, and 2.75% copper, and a second layer consisting of chromium coated on said first layer.

2. The combination as set forth in claim 1 in which the layer of the nickel-chromium alloy comprises from 80% to 90% of the resistivity of the resistance material film and the layer of chromium comprises from 10% to 20% of the resistivity of the film.

No references cited.