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METHOD AND MEANS FOR PRODUCING FILM RESISTORS

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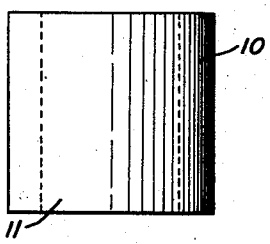


Fig-1

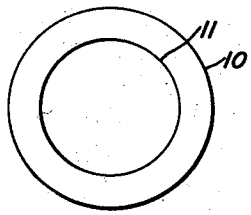


Fig-2

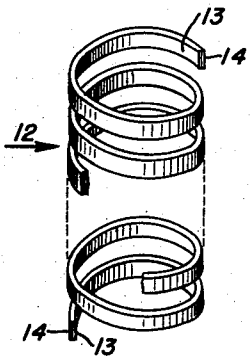


Fig-3

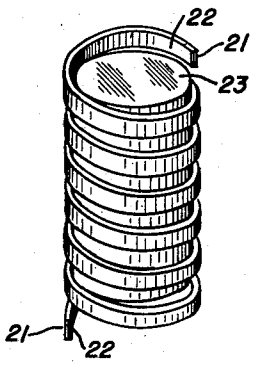


Fig-5

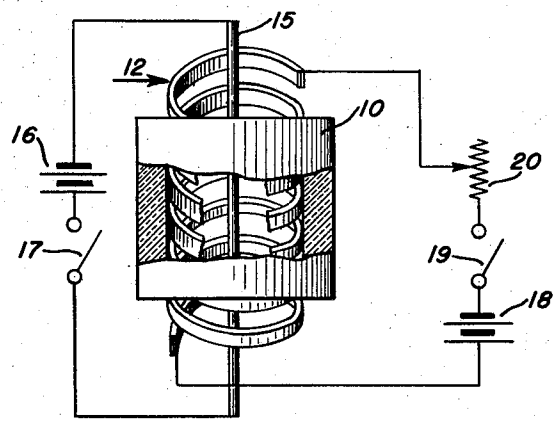


Fig-4

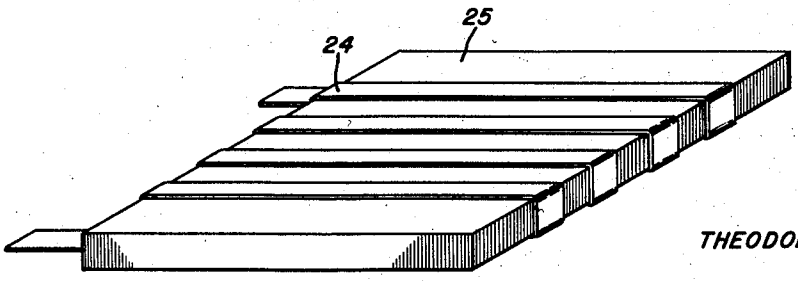


Fig-6

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METHOD AND MEANS FOR PRODUCING FILM RESISTORS

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7 Claims. (Cl. 117—212)

This invention relates to electrical resistors and more particularly to apparatus useful in manufacturing resistors wherein the resistance element is in the form of a helical ribbon deposited on a suitable carrier of insulating material.

Resistors of the class contemplated by this invention comprise a tubular member made of glass, ceramic, or etc., upon the surface of which is deposited a thin resistance film of a suitable metal or alloy. The resistance film is deposited on the tubular member by the process of metal evaporation, or metal sputtering, carried out in a vacuum chamber. In the metal evaporation process the metal to be transferred to the carrier is heated to the vaporization point, whereas in the sputtering process, a suitable voltage difference is maintained between the metal and the carrier. In either case, the metal is transferred to the proximate surface of the carrier thereby forming on the carrier a thin, substantially uniform metallic film. When such metallic film is formed on the entire surface of the carrier a resistance film of desired ohmic value may be formed by grinding, or otherwise cutting, through the film to form same into a helix. Alternatively, the helical form of the resistance film may be formed by using a suitable mask disposed over the surface to be coated so that the evaporated metal will be deposited over the mask and the exposed surface portions of the carrier. Removal of the mask results in a removal of the overlying film thereby leaving on the carrier surface a resistance film of helical form.

When using a mask over the surface of the carrier it is essential that all portions of the mask be in intimate contact with the carrier surface. Otherwise, the metal, during the depositing process, will accumulate between the mask and the carrier surface thereby defeating the purpose for which the mask was employed in the first instance. It has been proposed to overcome this defect by using a mask made of a spring material and having dimensions such that when the mask is inserted into position spring tension is effective to maintain the mask in flush, intimate contact with the carrier surface. Such spring tension masks have been found to have only a limited field of application for several reasons. Such spring tension mask is difficult to install into the operating position when the resistance film is to be deposited on the inner wall of a hollow, tubular carrier. Also, a mask which is maintained in contact with the carrier surface by spring tension during the formation of the resistance film is difficult to remove without damaging the film. Still further, the formation of the resistance film on the carrier surface is carried out at elevated temperatures and consequently the spring material of the mask loses its tension charactertistic and/or is deformed after a relatively few cycles of operation.

It is the primary object of this invention to provide a mask for use in making film resistors which mask overcomes the defects of masks heretofore used for this purpose.

An object of this invention is the provision of a mask

for use in making film resistors which mask is made of a bimetallic material.

An object of this invention is the provision of a helical, bimetallic mask for use in making a helical resistance film on a surface of an insulating carrier.

An object of this invention is the provision of a method for forming a helical resistance film on a surface of a tubular carrier, which method comprises placing a bimetallic, helical mask along the surface of the carrier to be coated by the resistance film, said mask being made of two metals having different coefficients of expansion with the metal having the lower coefficient of expansion closest to the carrier surface, heating the mask to an elevated temperature at which the mask expands and is brought into intimate contact with the carrier surface, depositing a resistance film over the mask and carrier surface while said mask is at the elevated temperature, and cooling the mask to a lower temperature at which the mask contracts away from the carrier surface.

These and other objects and advantages will become apparent from the following detailed description when taken with the accompanying drawings illustrating several embodiments of the invention. It will be understood 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.

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

Figure 1 is an elevation of a tubular carrier;

Figure 2 is an end view thereof;

Figure 3 is an isometric view of a helical, bimetallic mask made in accordance with this invention;

Figure 4 is a view, with parts broken away, showing the mask and carrier in assembled relation for the formation of the resistance film on the inner wall of the carrier;

Figure 5 is a view showing a helical, bimetallic mask encircling a cylindrical carrier when the resistance film is to be formed on the outer surface of the carrier; and

Figure 6 is an isometric view showing a bimetallic mask useful for the formation of the resistance film on a flat carrier.

Generally, it is preferable to form the resistance film on the inner wall of a hollow, tubular carrier as in such arrangement the film is protected against damage, and also, such unit readily can be sealed to form a moisture-proof resistor. Figures 1 and 2 illustrate a hollow, tubular member, or carrier **10**, which may be made of glass, ceramic, or other refractory material, and having an axial hole **11** extending therethrough. It is proposed to form a helical ribbon of resistance film on an inner wall of the tube. For this purpose I provide a helical mask **12** as shown in Figure 3. Such helical mask is formed of two, thin strips of metal **13** and **14** intimately bonded together throughout their entire length. The individual metal strips **13** and **14** comprise metals, or alloys, having different coefficients of thermal expansion and, in the present instance, the inner metal strip **13** has a higher expansion coefficient than the outer strip **13**. In such arrangement, when the helical coil is heated the inner strip expands at a greater rate than the outer strip thereby resulting in an increase in diameter of each convolution of the coil, that is, an effective increase in the outside diameter of the helix.

I prefer to form the helical, bimetallic mask **12** such that the outside diameter at room temperature is slightly smaller than the diameter of the hole in the carrier. Such mask can then readily be inserted through the carrier **10**, as shown in Figure 4. As also shown in Figure 4, the metal or alloy to be evaporated on to the wall of the carrier may comprise a filament **15** which passes through the helical coil. Such filament is supported in

position by means of a suitable fixture, not shown, and the filament ends are connected by leads to a source of voltage, such as a battery 16 upon closure of the switch 17. The ends of the helical mask are also connected to a suitable source of voltage, such as a battery 18, upon closure of the switch 19.

The assembly shown in Figure 4 is placed into a chamber which is then evacuated to the extent required for metal evaporation, the connection leads from the filament and mask passing outwardly of the chamber through a suitable insulator member. Current is then caused to flow through the mask by closure of the switch 19 and magnitude of the current being controlled by the adjustable resistor 20. In any event, the current flowing through the mask is made sufficient so as to heat the mask whereupon the mask expands in diameter and presses against the wall of the carrier 10. Such expansion of the mask within the confine of the carrier hole results in a tight intimate contact between the illustrated outer smooth surface of the mask and the inner surface of the carrier wall. It may here be pointed out that the bimetallic mask is very thin, of the order of 10–20 thousandths of an inch, and that the wall defining the hole in the carrier is smooth, whereby there is assured a flush contact between contacting surfaces through the entire length of the hole. When the mask has been heated to the proper point, the switch 17 is closed thereby causing a current to flow through the filament 15. The magnitude of such current is chosen so as to bring the temperature of the filament to or above the vaporization point of the metal or alloy of which the filament is made. Consequently, metal is evaporated from the filament on to the relatively cooler surface of the mask and carrier wall. It will be apparent that the metal film deposited directly on the carrier wall will be in the form of a helix.

When the deposited film is of sufficient thickness the switch 17 is opened thereby terminating the evaporation process after which the switch 19 is opened permitting the mask and the carrier to cool down. As the mask is cooled it contracts in diameter and pulls away from the wall of the carrier. Since the deposited film is very thin such contraction of the mask causes the mask to break away from the film adhering to the carrier wall. The mask may now be removed without damage to the remaining portion of the film and there remains on the inner wall of the carrier a helical resistance film having cleanly cut side edges. Those skilled in this art will understand that the helical film deposited on the inner wall of the carrier may be reduced in thickness, as by a reaming operation, to adjust the ohmic resistance of the film to a desired value and that suitable terminals may be connected to the ends of the film to complete a resistor adapted for connection in an electrical circuit.

In Figure 4, I have shown an arrangement wherein the bimetallic mask is heated electrically. Generally, in the production of a film resistor the carrier is heated to an elevated temperature in vacua but below the temperature at which vaporization of the filament takes place. The elevated temperature to which the carrier is brought is more than sufficient to cause an expansion of the bimetallic mask to assure a tight, press fit of the mask against the inner wall of the carrier. Consequently, the arrangement for electrically heating the mask by the passage of an electrical current therethrough is not necessary to the practice of this invention.

When it is desired to form the helical resistance film on the outer surface of a cylindrical carrier the mask may take the form shown in Figure 5. Here the mask is formed with elements reversed, that is, the outer thin strip 21 has a higher coefficient of thermal expansion than the inner strip 22. At room temperature the inner diameter of the mask is slightly larger than the outer diameter of the cylindrical carrier 23 thereby facilitating the placement of the mask over the carrier. Upon heating the mask now contracts to tightly grip the carrier surface during the process of depositing the resistance film. Upon completion of the film formation and a subsequently cooling of the carrier and mask, the mask expands to break away from the film deposited directly on the surface of the carrier thereby leaving a helical resistance film on the carrier.

In Figure 6, there is shown a bimetallic mask 24 so formed as to loosely encircle a flat carrier 25 at room temperature. Except for the specific form of the mask, the mask 24 shown in Figure 6, is made in the same manner as the mask 12, shown in Figure 5, that is, the metal having the higher coefficient of thermal expansion constitutes the outer thin ribbon of the mask. Thus, upon heating, the mask of Figure 6 will contract to an effectively smaller diameter thereby forming a uniform, intimate contact with the adjacent surfaces of the carrier and preventing metal from depositing under the edges of the mask during the film depositing process.

Having now described my invention in detail those skilled in this art will have no difficulty in modifiyng the construction and formation of a bimetallic mask to fit a particular application. Such modifications may be made without departing from the spirit and scope of the invention as set forth in the following claims.

I claim:

1. An arrangement for making a film resistor said arrangement comprising an insulating carrier, a bimetallic mask of generally helical form and having its convolutions slightly spaced from a surface of the carrier at room temperature, and means to heat the bimetallic mask, said mask being constructed such that upon heating thereof the mask will intimately contact the adjacent wall of the carrier.

2. An arrangement for making a tubular, film resistor said arrangement comprising an insulating carrier having an axial hole extending therethrough, a bimetallic mask of helical form having an outside diameter at room temperature that is slightly less than the diameter of the said hole, said mask extending through the said hole and the elements forming the mask being such that the element having the higher coefficient of thermal expansion constitutes the inner member of the mask, and means to heat the mask while the latter is positioned within the said hole, the arrangement being such that heating of the mask results in an expansion thereof against the surface defining said hole.

3. The invention as recited in claim 2, wherein the mask is heated electrically by connecting the ends of the mask to a source of electrical potential.

4. An arrangement for making a film resistor said arrangement comprising a cylindrical insulating member, a bimetallic mask of helical form loosely encircling the cylindrical member at room temperature said bimetallic mask being formed with the outer element having the higher coefficient of thermal expansion, and means to heat the mask while positioned over the cylindrical member, the arrangement being such that heating of the mask results in a contraction thereof against the outer surface of the said member.

5. The invention as recited in claim 4, wherein the said mask is heated electrically by connecting the ends of the mask to a source of electrical potential.

6. An improved method of forming a helical resistance film on a surface of an insulating carrier, which method comprises placing a helical mask of bimetallic material proximate to a surface of the carrier, placing a metal filament proximate to the mask and the said surface of the carrier, heating said mask to cause the mask to come into tight intimate contact with the said surface of the carrier, heating said filament to the vaporization temperature to form a resistance film on the exposed surface of the mask and the carrier, terminating the heating of the filament, and cooling the said mask to the point where the mask contracts away from the said surface of the carrier.

7. An improved method of forming a helical resistance

film on the surface of an insulating carrier, which method comprises placing a helical mask of bimetallic material proximate to the surface of the carrier, heating said mask to cause it to come to a tight intimate contact with the said surface of the carrier, depositing a resistance film on the exposed surface of the mask and the carrier, and cooling the said mask to a point where it contracts away from the said surface of the carrier.

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