

- [54] UNITARY RESISTOR AND SHUNT
[75] Inventor: Sergei Schebalin, Ambler, Pa.
[73] Assignee: Honeywell Inc., Minneapolis, Minn.
[22] Filed: June 12, 1972
[21] Appl. No.: 261,971

Related U.S. Application Data

- [62] Division of Ser. No. 122,777, March 10, 1971, Pat. No. 3,743,997.
[52] U.S. Cl. 117/212, 117/217, 117/227, 333/49
[51] Int. Cl. B44d 1/18, H01c 13/00
[58] Field of Search 117/212, 217, 227; 338/49

References Cited

UNITED STATES PATENTS

- | | | | |
|-----------|---------|---------------|---------|
| 3,274,669 | 9/1966 | Place | 117/212 |
| 3,381,255 | 4/1968 | Cobb | 117/212 |
| 3,567,507 | 3/1971 | Youmans | 117/212 |
| 3,699,650 | 10/1972 | Cocca | 117/212 |

Primary Examiner—Leon D. Rosdol
Assistant Examiner—Michael F. Esposito
Attorney, Agent, or Firm—Arthur H. Swanson;
Lockwood D. Burton; J. Shaw Stevenson

[57] **ABSTRACT**

A method of producing a distributed shunt for resistor film. The steps of this method comprising the selection of a conductive material whose sintering temperature is substantially lower than the sintering temperature of the resistive material; locating the conductive material in single or segmented form on the surfade of the resistive material intermediate end portions of the latter and firing the conductive material on the resistive material at the sintering temperature of the conductive material whereby the tendency to diffusion between said conductive and resistive materials is minimized and the resistivity of the resistive material is reduced while maintaining substantially constant the temperature coefficient of resistivity and stability of the resistive material.

2 Claims, 3 Drawing Figures

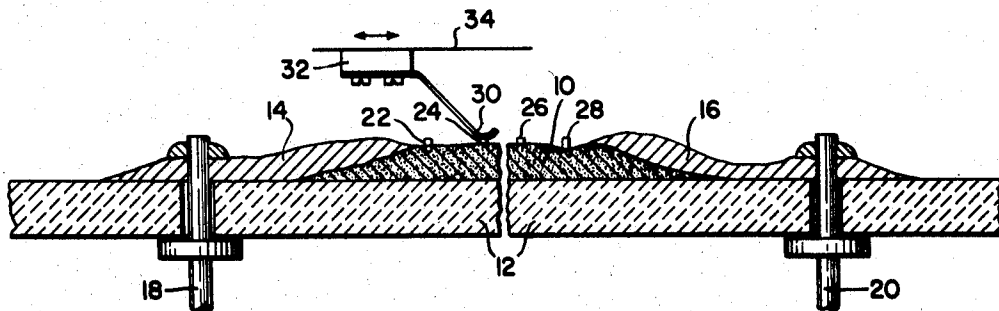


FIG. 1

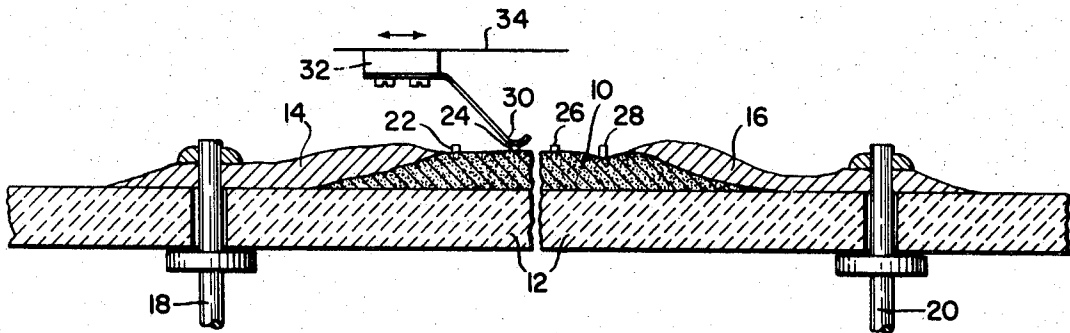


FIG. 2

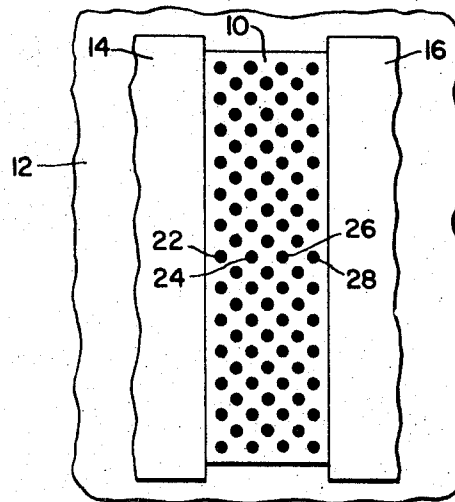
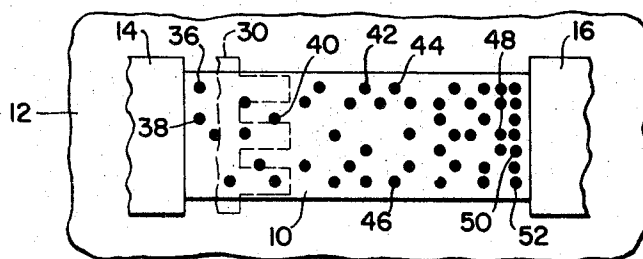


FIG. 3



UNITARY RESISTOR AND SHUNT

This application is a divisional application of Ser. No. 122,777 filed on Mar. 10, 1971, now U.S. Pat. No. 3,743,997.

It is an object of the present invention to provide a unique resistor film and shunt and the method by which this unit can be manufactured.

More specifically, it is another object of the invention to provide a resistor film distributed shunt for an electrical circuit that employs conductor material fired on a resistor film in a characteristic manner.

It is still another object of the present invention to provide a distributed shunt of the aforementioned type for a resistor film that requires less space than conventional shunts since it eliminates the requirement for an external resistance and allows all of its shunting action to take place within a single resistor.

Another object of the invention is to provide a resistor film such as e.g. that which is disclosed in my copending patent application Ser. No. 120,199 filed Mar. 2, 1971, now U.S. Pat. No. 3,788,891 and its related divisional application, Ser. No. 334,956, filed Mar. 26, 1973, with characteristically spaced apart conductive material fired thereon and thereby provides a method by which the resistivity of the resistor described in the aforementioned referred to application can be lowered without incurring any change in the temperature coefficient of resistivity and its stability.

Another object of the present invention is to provide a unique distributed shunt of the aforementioned type having an array of polka-dots printed on a resistor film and which may have open portions passing there-through between the rows of dots which form the array and thereby be able to create an extremely light weight resistor.

More specifically it is another object of the present invention to provide the aforementioned resistor with a number of small spots of disc shape conductive material that are spaced from one another in a characteristic pattern.

Another object of the invention is to screen conductive ink spots onto the aforementioned resistor so that they can be jointly fired with the resistor at the same time and at the same temperature as that described for the two terminal conductors set forth in my copending application.

It is another object of the present invention to provide a means of reducing the size of presently available characterized resistor film or wire wound variable resistors by providing a modified form of the aforementioned distributed shunt in which a desired diminishing concentration of disc shaped conductors are formed along the length of the resistor.

A better understanding of the invention may be had from the following detailed description when read in connection with the accompany drawing in which:

FIG. 1 is a cross-sectional view taken through the resistor film and through the unique array of conductive dots which are fired on this resistor.

FIG. 2 is a detailed plan view of a preferred form of the thick film resistor distributed shunt showing how conductors formed in polka-dot pattern are printed on the thick film resistors shown in FIG. 1 and

FIG. 3 shows how a variable resistor can be formed by the addition of arrays of conductive dots of increasing density between one end of the resistor and another.

FIG. 1 shows a resistor film 10 that has been selected from any one of a number resistor ink mixes for firing onto a non-electrically conductive substrate 12 at 1000°C. The material that is employed for the substrate is an aluminum oxide that is preferably ninety six percent pure. One example of a positive coefficient of resistivity resistor ink that can be used to make part of the mix for resistor 10 is 40 percent by weight ruthenium, 20 percent by weight ruthenium oxide, RuO_2 , and the remainder 40 percent by weight formed from glass frit. An example of a negative coefficient of resistivity resistor ink that can be used to make the remaining part of the desired mix for resistor 10 is comprised of substantially 40 percent by weight of RuO_2 , 20 percent by weight of Ru and 40 percent by weight of glass frit.

FIG. 1 also shows a pair of conductors 14, 16 fired onto associated opposite ends of the resistor 10 for connecting the resistor to terminals 18, 20.

FIGS. 1 and 2 show disc shaped conductors e.g. 22, 24, 26 and 28 which protrude from the upper surface of the resistor 10.

These conductors are preferably made of the same silver-glass conductive ink material as the terminal conductors set forth in my copending application Ser. No. 120,199 filed Mar. 2, 1971, now U.S. Pat. No. 3,788,891 and its related divisional application, Ser. No. 334,956, filed Mar. 26, 1973. It should be understood that although the resistor 10 is made into a distributed shunt by the firing on of the polka-dots in the preferred fashion shown in FIG. 2 other forms of conductors such as strips, squares, etc. could be used for this purpose.

The polka-dot arrangement is considered the preferable form because they insure that most uniform distribution of the conductor material over the resistor.

It should be understood that the resistor 10 is first fired at 1,000°C onto the electrically non-conductive substrate 12. The conductive disc, for example 22, 24, 26, and 28, and the other remaining conductive discs shown in a polka-dot fashion in FIG. 2 are thereafter jointly fired along with the terminals conductors 14, 16 and the resistor 10 at 550°C.

The aforementioned unique firing method allows the conductive discs, for example 22, 24, 26, and 28, to be fired onto the resistor 10 with an negligible amount of diffusion taking place between these conductive disc and their associated resistor 10. The polka-dot pattern has the advantage over the other aforementioned conductors, in that any small amount of diffusion that occurs between a conductive disc 22, 24, 26, or 28 and the resistor 10 will always be uniform.

It is to be understood that the addition of the conductive discs such as the conductors 22-28 shown in FIGS. 1 and 2 to the outer surface of the resistor 10 provides a way of keeping its size, such as its width and length of an abnormally small dimension. These conductors e.g. 22-28 also retain the basic parameters such as temperature coefficient of resistivity and the stability of resistor 10 substantially constant and at the same time provide a method to decrease by as much as ten the resistivity of the resistor 10.

If it is desired to use the resistor 10 and its associated disc shaped conductive dots e.g. 22, 24, 26 28 etc. as a resistance distributed shunt in a miniaturized printed circuit the array of conductive discs formed thereon can be covered by means of a flexible material such as a flexible silicone polmer and a second hard outer cov-

ering such as glyptal 1201B paint in the same manner as the resistor and the terminal conductors are covered in my copending application Ser. No. 334,956. This encapsulating structure will protect the resistor 10 from ambient air, water vapor, water and hydrogen sulfide (H_2S) and ambient temperature that may vary from the standard reference level of $25^\circ C \pm 50^\circ C$ so that no more than $\pm 1\%$ change in value of the resistor can occur.

In another application it may be desirable, as is shown in FIG. 1, to employ the resistor 10 and its associated disc shaped conductive dots as a shunted slide wire along which a metallic wiper 30 and a support member 32 for same can be moved in the direction of the arrows along the surface 32. The wiper 30 can be of a multiple contacting type in which some of contacts formed by wiper 30 in contact with some of the conductive dots 22, 24, 26, or 28 etc. as it is moved along the top surface of resistor 10. This will be so because the multiple fingers arrangement of this wiper 30 will allow it to always contact some of the dots in a row of dots as it travels across the dots 22-28 on the resistor 10 because of the polka-dot pattern of these dots. The distance between each row of dots is 0.20 inches, the distance between each dot in any row is .030 inches and the diameter of the each conductive dot is .020 inches. It can therefore be seen that contacts formed by the wipers 30 are of sufficient width that some one or more of them will always be in contact with at least one half of one of the dots of each row along which it is brought into contact.

The height of the dots e.g. 22-28 above the surface of the resistor 10 is .00035 inches.

One thumb rule method of calculating the amount of resistance which is afforded by a resistor having equally distributed conductive dots, can be derived as follows:

$$R \text{ with dots} = R \text{ no dots } A - \Delta A/A + \Delta A K$$

wherein ΔA is equal to the total area of deposited evenly distributed dots.

A is equal to the total area of the resistor before the dots are fired thereon and K is a factor which for the distribution shown in FIG. 2 is equal to 2.

From the aforementioned it can be seen that the conductive dots such as dots 22-28, provide a precise way of causing electrical fields to move in a arcuate fashion between adjacent pairs of dots and thereby affect an internal shunting action.

FIG. 3 shows a resistor 10 mounted on a substrate 12. The resistor 10 as shown in FIG. 3 has its end portions connected to terminals 18-20 by means of conductive materials 14, 16 in the same manner as that shown in FIG. 1. FIG. 3 differs from FIGS. 1 and 2 in the manner in which the dots shown in FIG. 3 are positioned on the resistor 10. For example, the dots 36, 38, 40 that are located near the left-end of the resistor are widely spaced apart from one another. The conductive dots 42, 44, 46 mid-way between the ends of the resistor are spaced closer to their adjacent dots than the adjacent dots with which dots 36, 38, 40 are associated and the spacing of the conductor dots 48, 50, 52 are spaced in a still more closely related dense fashion with their adjacent dots that they are associated than any other preceding group of dots.

With the aforementioned construction shown in FIG. 3 it can be seen that a much greater degree of shunting of the aforementioned electrical field will take place between the dots near conductor 16 than those near conductor 12.

It can also be seen that as the multipoint contacting wiper 30, previously described under the description of FIG. 1, is moved along the resistor 10 in a left to right direction that a characterized decreasing resistance will be encountered. It should be understood that other different arrays and shapes of conductive material can be employed for those shown in FIG. 3 in order to provide either a characteristic resistor per se or an adjustable resistor for a circuit that is employed as a slidewire along which a wiper 30 can be moved.

From the aforementioned description it can be seen that a resistor film has been provided which has conductive dots fired onto its outer surface so that a distributed shunt is provided within the resistor so that the resistivity of the resistor can be reduced by as much as a factor of ten without changing its size and without changing its basic parameters such as its temperature coefficient resistivity and stability.

Although not shown in the drawing it should be understood that apertures can be formed in the resistor 10 between the conductive dots, e.g. 22-28 when an extremely light weight resistor is desired.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. The method of producing a distributed shunt for resistor film comprising the steps of selecting a silver-glass conductive material and a ruthenium-ruthenium oxide-glass frit resistive material which conductive material has a sintering temperature substantially lower than the sintering temperature of said resistive material, locating said conductor material on said resistive material intermediate end portions of the latter, and firing the said conductive material on said resistive material at the sintering temperature of said conductive material whereby the tendency to diffusion between said conductive and resistive materials is minimized and the resistivity of said resistive material is reduced while maintaining substantially constant the temperature coefficient of resistivity and stability of said resistive material.

2. The method of producing a distributed shunt for resistor film, comprising the steps of firing a ruthenium-ruthenium oxide-glass frit resistor material onto an electrically non-conductive substrate at the sintering temperature of approximately 1000 degrees C of said resistive material, and thereafter firing silver-glass conductive material in segmented form on the surface of said fired resistive material intermediate end portions of the latter, said second firing being at the sintering temperature of approximately 550 degrees C of said conductive material, whereby the tendency to diffusion between said conductive and resistive materials is minimized and the resistivity of said resistive material is reduced due to the shunting effect of said conductive material on said resistive material, and whereby the temperature coefficient of resistivity and stability of said resistive material is maintained substantially constant.

* * * * *