Sept. 28, 1943. O. J. MORELOCK 2,330,782

METHOD OF ADJUSTING AND SEALING RESISTANCE ELEMENTS

Filed July 1, 1942

Carbon deposited on ceramic base and terminals applied

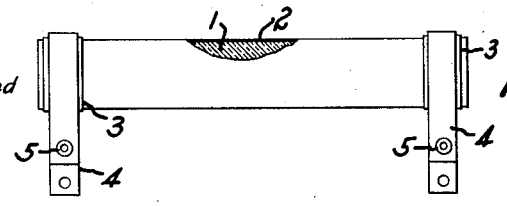


Fig. 1.

Dried and coated with waterproof varnish

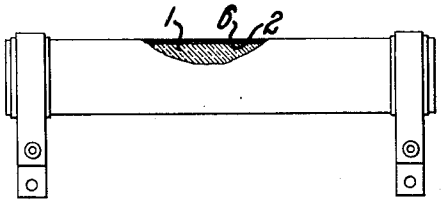


Fig. 2.

Spirally cut to adjust resistance to less than desired value

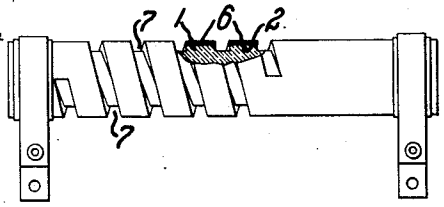


Fig. 3.

Dried and coated with waterproof varnish

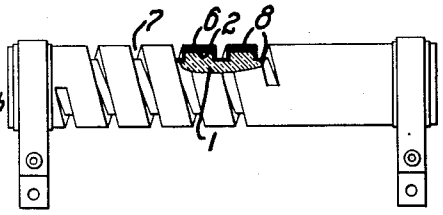


Fig. 4.

Spirally cut to increase resistance to approximately desired value

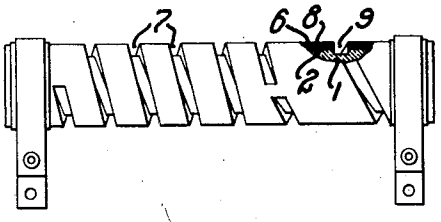


Fig. 5.

Dried and coated with waterproof varnish

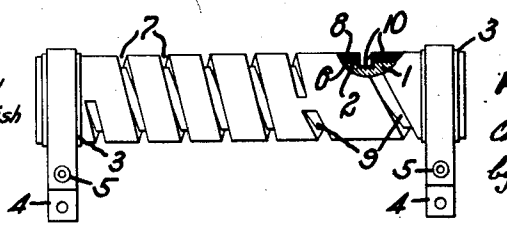


Fig. 6.

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METHOD OF ADJUSTING AND SEALING RESISTANCE ELEMENTS

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Application July 1, 1942, Serial No. 449,299

9 Claims. (Cl. 201—75)

This invention relates to improvements in the method of manufacturing electrical resistance elements and more particularly to a method of accurately adjusting a carbon layer resistor to a desired ohmic value and stabilizing the unit to preserve the original adjustment accuracy throughout its normal period of usefulness.

A durable resistor may be made by the known method of depositing carbon on a ceramic base that is preferably in the form of either a solid or hollow rod. The rod is placed in a furnace in the presence of a hydrocarbon gas and heated to above the dissociation temperature of the gas, whereupon carbon particles are deposited upon the ceramic surface. The resulting carbon coating forms a current conducting path of relatively high ohmic resistance and the hardness of the coating and ceramic base makes such a unit suitable for almost any type of service, and especially for use at high temperatures. By careful control of the various steps in the carbonizing process the resistance of the carbon layer will fall within a given range but it is accepted practice to adjust the resistance of each unit by grinding a spiral groove through the resistance material. There is thus formed, in effect, a helical ribbon of resistance material and by proper choice of the spacing between convolutions it is relatively simple to adjust the ohmic value of the resistor fairly close to a desired, final value. However, many variables affect the accuracy of the final resistance adjustment. These variables include the heat generated during the grinding operation, the absorption of moisture, the change in resistance due to the application of protective lacquer coatings and other factors. As the resistor units made by this carbonizing process have a high resistance of the order of megohms, these variables produce a considerable change in the basic resistance of the unit. Although various proposals have been advanced for eliminating the objectionable effects mentioned, the problem has not been solved in a satisfactory manner and consequently these resistors have not been acceptable for use in precision electrical instruments and in other systems where a high order of permanent accuracy is required.

The hereindescribed method of adjusting and stabilizing such resistance elements results in a product that remains accurate within ±1% of the original ohmic value under all conditions of normal use. Consequently, the resistors are suitable for use in precision instruments in place of the present wire wound spools which are very expensive.

An object of this invention is the provision of a method of adjusting and sealing a resistance element whereby the ohmic value of resistance will be permanently maintained within an accuracy tolerance heretofore unobtainable.

An object of this invention is to provide a resistance element of the carbon layer type which may readily be adjusted to an accuracy of ±1%.

An object is to provide a resistance element of the carbon layer type adjusted to a high order of accuracy by grinding multiple, spiral grooves in the carbon layer

Specifically, an object is to provide a method of alternate grinding and sealing to produce a carbon layer resistor having a high order of accuracy and stability.

These and other objects and advantages will be apparent from the following specification when taken with the accompanying drawing in which:

Figs. 1 to 6, inclusive, are side elevations, with parts in section, of resistor blanks at the completion of successive steps in the manufacturing process of this invention.

Resistors of the class falling within the scope of this invention comprise a ceramic base 1 which may be a solid or hollow rod made of porcelain or other vitrified ceramic. The rod is placed in a furnace in the presence of a hydrocarbon gas and heated to the dissociation temperature of the gas whereupon carbon particles are deposited upon the ceramic surface, as is well known in the art. The carbon layer 2 is very thin but also very hard and any alteration thereof is best undertaken by a grinding operation. The drawing is not to scale as the thickness of the carbon layer 2, and of the other coatings, must be greatly exaggerated in a drawing of small size.

The first step in the process comprises the application of narrow bands 3, of a material having good electrical conductivity, to the ends of the unit. This may be done by brushing on, or by dipping the ends in, a graphite suspension such as, for example, "Aquadag." Upon drying, the graphite layer forms good electrical contact with the carbon layer 2 and at the same time provides a somewhat resilient bed to establish good contact with the terminal connector strips 4 which may be staked tightly around the rod by rivets 5. The contact bands may also be provided by spraying the ends of the resistor with any of the metallic, conducting paints that are known in the art.

The resistance unit is next dried and coated with a layer 6 of protective lacquer or other suitable material, which may be air dried but is pref-

erably baked. The lacquer coating seals the carbon resistance layer against absorption of moisture and prevents injury to the carbon layer by chips which may form during subsequent grinding operations.

The resistor is then placed in a lathe and electrical connections are made to the contact bands 3 or terminals 4 so that the resistor forms part of a series electrical circuit that includes a constant current source and an electrical indicating instrument. The amount of current flowing in the circuit depends upon the ohmic value of the resistor, hence, the indication of the electrical instrument provides a means for adjusting the resistor to a desired value, as is well known. Associated with the lathe is a small grinding wheel which rotates at a relatively high speed and is displaceable axially relative to the resistor under the action of a suitable gearing arrangement. A spiral groove 7 is thus ground through the carbon layer in the known manner, and the resistor blank then has a form such as shown in Fig. 3. The constants of the lathe and grinder are preferably so selected that the ohmic value of the resistor will be approximately 90% of the desired final value when the spiral groove extends approximately 75% of the full length of the resistor. The purpose for this relationship will become apparent as the description proceeds.

The resistor is now removed from the lathe and heated in an oven to drive out any moisture that has been absorbed through the freshly cut groove. Next, a second lacquer coating 8 is baked over the entire unit. This again seals the carbon path against moisture and especially closes the freshly cut edges of the spiral groove, see Fig. 4. As indicated above, the ohmic resistance of the unit is increased somewhat by the heating process and by the second protective coating 8. These changes are permanent and, although small, are not accurately predictable and preclude a close adjustment of the resistance of the Fig. 4 blank to a definite value on the basis of the measured resistance at the completion of the grinding of the groove 7.

The resistor blank is replaced in the lathe and a second spiral groove 9 is cut therein; this groove may be a continuation of the first cut or may be entirely separate as shown in the drawing. It is to be noted that the groove 9 is cut at a wider pitch than the groove 7 so that the resultant change in resistance per unit rotation of the resistor blank will be much smaller than that of the original grind. Consequently, the operator may confidently approach the desired adjustment value with a high order of accuracy and assurance that the final value will not rise above the upper limit. The second spiral groove is extended until the resistance value is within minus one percent (−1%) of the desired final value. The second cut is stopped short of, but within −1% of the desired final value, as I have found that the resistance will increase a fraction of a percent during the subsequent operations. The resistor blank then appears as shown in Fig. 5.

It is to be noted that a major portion, for example 90 percent, of the resistance adjustment is otbained by the first grinding operation, after which the element is sealed and stabilized to eliminate the effect of all variables that were effective up to that point in the manufacturing process. Thus, any variables which enter during the second grinding operation will have only a negligible effect upon the total resistance of the unit. Specifically, if the combined effect of all variables after the first grinding is 1%, the effect of these variables will be only 0.1% of the total resistance value after the second grinding as the second grinding is performed only on 10% of the entire element. It can be seen, therefore, that the double grinding operation permits the production of resistors having a high accuracy.

Upon completion of the second grinding, the resistor blank is again heated to drive out moisture absorbed during the cutting operation and a final coating 10 of baked lacquer applied. I have found that the resistance of the unit will increase a fraction of a percent after the application of the final lacquer coating. That is why I stop the second spiral groove when the measured resistance is approximately 1 percent below the desired final value. The ultimate resistance of the finished resistor will, therefore, fall within 1% of the desired value.

It will be apparent that a still higher order of accuracy may be had by cutting a third spiral groove, with a still wider pitch, in the resistance material. This increased accuracy is usually unnecessary as the double grinding and multiple sealing process provides resistors having an accuracy of ±1% in the range of 1 to 5 megohms, and of 1½% accuracy in the range of 5 to 50 megohms, with assurance that the original adjustment will remain within acceptable limits throughout the life of the element. Resistors of this order of accuracy are entirely satisfactory for use in precision electrical instruments in place of the present expensive wire wound spools.

As a final step in the completion of the resistance element the unit may be coated with a decorative paint or enamel.

Having now described my invention and the preferred method of practicing it, various modifications and variations will be apparent to those skilled in the art. Such variations may be made without departing from the scope and spirit of the invention as set forth in the appended claims.

I claim:

1. In the manufacture of a resistor of a desired value by cutting through the carbon layer of a resistor blank comprising carbon deposited upon an insulating base; the process which comprises the performance of a plurality of cycles of applying a waterproof coating of insulating material to the resistor blank, cutting through the carbon layer, and heating the resistor blank to eliminate moisture; and then applying a waterproof coating of insulating material to the resistor blank.

2. In the manufacture of a resistor of a desired value by cutting through the carbon layer deposited on the ceramic base of a resistor blank, the process which comprises interrupting the cutting operation when the effective resistance is at an intermediate value substantially less than the desired value, stabilizing the resistance of the resistor blank by heating the same and applying a waterproof varnish, cutting through the varnish coating and the carbon layer to increase the resistance of the resistor blank, and stabilizing the resistance at approximately the increased value by heating the blank and applying thereto a second coating of a waterproof varnish.

3. In the adjustment of the effective resistance of a carbon-coated ceramic resistor blank to a desired value, the process which comprises applying to the resistor blank a waterproof coating, cutting through the waterproof coating and carbon coating to increase the effective resist-

ance to substantially less than the desired value, applying a second waterproof coating to the cut blank, cutting through the several coatings to increase the effective resistance to approximately the desired value, and applying a waterproof coating to the blank.

4. In the adjustment and stabilization of the resistance of a cylindrical carbon-coated ceramic resistor blank, the process which comprises cutting a spiral groove through the carbon coating to increase the resistance to a value substantially less than the desired value, waterproofing the spirally cut blank to stabilize the resistance thereof, cutting a spiral grove through the carbon coating to increase the resistance to approximately the desired value, and waterproofing the spirally cut blank to stabilize the resistance thereof.

5. In the adjustment and stabilization of the resistance of a cylindrical carbon-coated ceramic resistor blank, the invention as recited in claim 4 wherein the pitch of the second spiral cut is substantially greater than that of the first spiral cut.

6. In the adjustment of the resistance of a carbon-coated resistor blank to a desired value, the process which comprises applying a waterproofing protective coating to the blank, cutting a spiral groove through the protective and the carbon coatings to increase the resistance to a value substantially less than the desired value, drying the spirally cut resistor blank to eliminate moisture absorbed by the carbon coating, applying a second waterproofing protective coating to the dried resistor blank, cutting through the several coatings to increase the resistance to approximately but less than the desired value, drying the resistor blank, and applying another waterproofing protective coating to the resistor blank.

7. In the adjustment of the resistance of a carbon-coated resistor blank to a desired value, the invention as recited in claim 6 wherein the resistance is increased to about 90% of the desired value by the first spiral cut.

8. In the adjustment of the resistance of a carbon-coated resistor blank to a desired value, the invention as recited in claim 6 wherein the the resistance is increased to substantially 1% less than the desired value by the second spiral cut.

9. A resistor of preselected ohmic resistance value comprising a cylindrical ceramic base, a layer of carbon on said base, said layer being provided with a spiral groove, a waterproof coating on the grooved portion of the carbon layer to seal the cut edges thereof, said carbon layer being provided with a second spiral groove that extends through both the carbon layer and the waterproof coating, and a waterproof coating sealing the edges of the carbon layer where cut by the second groove.

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