

June 3, 1941.

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2,244,548

RESISTOR AND METHOD FOR MAKING SAME

Filed Sept. 9, 1939

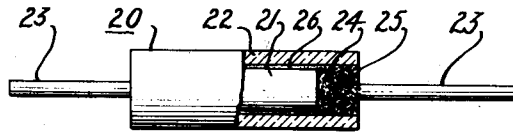


Fig 1

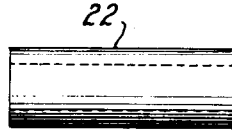
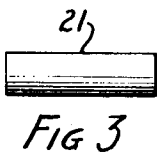
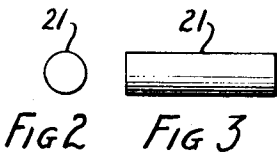


Fig 4



Fig 5

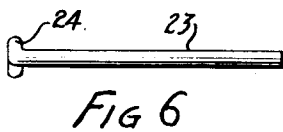


Fig 6

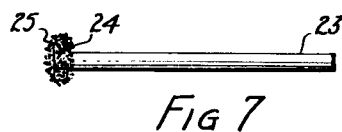


Fig 7

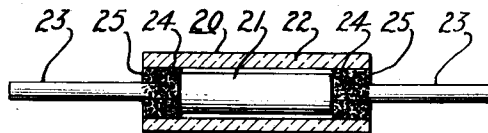


Fig 8

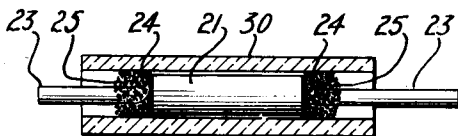


Fig 9

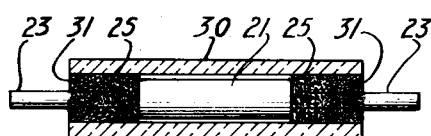


Fig 10

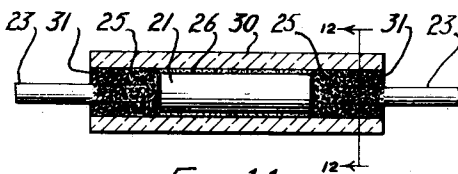


Fig 11

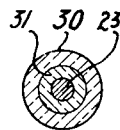


Fig 12

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2,244,548

RESISTOR AND METHOD FOR MAKING SAME

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Application September 9, 1939, Serial No. 294,167

5 Claims. (Cl. 201—64)

My invention relates in general to resistor units and more particularly to resistor units which have terminal conductors mechanically and electrically connected thereto, and the method of making the same.

An object of my invention is the provision of protecting a resistance element by mounting the element in an insulating tube and then fastening the resistance element in the tube.

Another object of my invention is the provision of mounting a resistance element in an insulating tube and of electrically and mechanically connecting the terminal conductors to the end surfaces of the resistance element and of mechanically connecting the terminal conductors and the resistance element in the insulating tube.

Another object of my invention is the provision of mounting a resistance element in a hollow insulating tube and of sealing the end of the tube with water-repellant material.

Another object of my invention is the provision of surrounding the resistance element with a suitable water-repellant material to prevent the moisture from affecting the electrical characteristics of the resistance element.

Another object of my invention is the provision of mechanically strengthening the connection between the terminal conductors and the end surfaces of the resistance element.

Another object of my invention is the provision of a resistor unit having an excellent connection between the terminal conductors and the resistance element with a substantially constant and fixed minimum resistance.

Another object of my invention is the provision of an improved electrical and mechanical connection between the terminal conductors and the ends of the resistance element.

Other objects and a fuller understanding of my invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawing, in which:

Figure 1 illustrates a resistor unit made in accordance with the provision of my invention, a portion of the resistor unit being cut away at one end to show its internal construction;

Figure 2 shows an end view of a resistance element of my resistor unit;

Figure 3 shows a side elevational view of the resistor unit in Figure 2;

Figure 4 shows a side elevational view of a hollow insulating tube into which the resistance element may be mounted;

Figure 5 is an end view of the hollow insulating tube shown in Figure 4;

Figure 6 is a side view of a terminal conductor adapted to be connected to the end surface of the resistance element;

Figure 7 is a view of a terminal conductor having cement material upon the abutting end thereof, preparatory to insertion in the hollow insulation tube;

Figure 8 is a cross-sectional view of my resistor unit as it appears during the final stages of the process of construction thereof;

Figure 9 is a cross-sectional view of a modified form of my resistor unit as it appears during the process of manufacture thereof;

Figure 10 is a view similar to Figure 9 and shows my modified resistor unit as it appears during a next subsequent operation of its manufacture;

Figure 11 is a cross-sectional view similar to Figures 9 and 10 and shows the construction of my resistor unit as it appears when finally constructed; and

Figure 12 is a cross-sectional view taken along the line 12—12 of Figure 11.

With reference to Figure 1 of the drawing, my resistor unit is indicated generally by the reference character 20 and comprises a resistance element 21, mounted in an insulating tube 22 with terminal conductors 23 connected to the opposite end surfaces of the resistance element 21 by suitable cement material indicated by the reference character 25. As illustrated, the abutting ends of the terminal conductors 23 may be provided with an enlarged head 24 such as, for example, by deforming the end of the terminal conductor. The views in the drawing are an enlargement of the resistor units from which the illustrations were made and the terminal conductors 23 appear somewhat large in diameter but in actual practice the terminal conductors are smaller in diameter and are readily bendable to facilitate easy connection to electrical circuits.

The insulating tube 22 may be made of any suitable insulating material and constructed with sufficient wall thickness and strength to keep it from crushing when being handled and installed. In actual practice, I preferably construct the insulating tube of ceramic material having a low porosity. As an alternative, the insulating tube 22 may be constructed of glass or a phenol condensation product such for example as Bakelite.

The resistance element 21 may be of any desired shape and size and may comprise any suitable material having the desirable characteristics. In one form of my invention, the resistance element may comprise a small rod of porcelain or

glass having a film of conducting material like graphite, colloidal graphite, or amorphous carbon deposited thereon. In another form, the resistance element 21 may comprise any suitable conducting material mixed with a fine insulating filler like silica and a cementing bond to form a homogenous structure. The resistance values of the resistance element may vary in the order of one-tenth ohm to a thousand mehoohms, carrying relatively small currents of one thousand milli-amperes or less. I will describe my invention by utilizing the resistance element 21 comprising a homogenous structure molded into rods as illustrated in the drawing. It is understood that other shapes may be formed and that the resistance element 21 may comprise a film of conducting material like graphite, colloidal graphite, or amorphous carbon deposited on a small rod of porcelain or glass, as set forth above.

The first step in constructing the preferred form of my resistor unit is to mold a resistance rod or element 21 for conducting material, as amorphous carbon mixed with a fine insulating filler like silica and a cementing bond into a homogenous structure. The cementing bond may be Bakelite or any other suitable phenol condensation produce. In the initial stages this resistance element 21 is in a green state, meaning that the Bakelite or phenol condensation produce bond of the resistance element has not set, or in other words has not been polymerized. The final step in making the resistance element 21 is to heat it to polymerization and set the bond.

The next step of my invention is to insert the resistance element 21 in the hollow insulating tube 22 and to electrically and mechanically connect the terminal conductors 23 to the end surfaces of the resistance element 21 and to mechanically connect the terminal conductors and the resistance element in the insulating tube 22. As illustrated, the terminal conductors are bent at one end to form an abutting head 24. The plane of the head 24 is disposed laterally of the general longitudinal length of the terminal conductors and is arranged to abut against the lateral end surfaces of the resistance element 21. The mechanical and electrical connections may be accomplished by utilizing a paste or cement consisting of substantially 50% graphite, 50% Bakelite resin or phenol condensation product, and enough alcohol to make the cement paste-like. In making the electrical and mechanical connections, the cement or paste may be applied in the ends of the insulating tube 22 in one of three alternative manners. The preferred way is to dip the head 24 of the terminal conductors into the paste, collecting a certain amount thereon as indicated in Figure 7, and then inserting same into the opposite ends of the hollow insulating tube 22 such as shown in Figure 8 with the abutting heads 24 pressing against the end surfaces of the resistance element 21. In this manner, the paste or cement fills the ends of the insulating tube 22. Another way of applying the cement or paste would be to first insert the heads of the terminal conductors in the opposite ends of the hollow insulating tube 22 against the end surfaces of the resistance element 21, after which the paste may be inserted therein by any suitable means. Another method would be to fill the ends of the insulating tube 22 with the cement or paste and then push the terminal conductors in through the paste or cement until the head 24 engages the end surfaces of the resistance element. The ce-

ment 25, after it is applied in the ends of the insulating tube 22, is set or fixed by heating the entire combination as shown in Figure 8 to a temperature in the neighborhood of 150 to 170 degrees centigrade for approximately one-half an hour. The cement or paste has a greater conductivity than that of the resistance element 23 and makes a good electrical contact between the terminal conductors and the end surfaces of the resistance element with a substantially constant and fixed minimum resistance. The cement or paste permeates the pores upon the ends of the resistance element and produces a good mechanical connection between the terminal conductors and the end surfaces of the resistance element. The paste also permeates the pores of the insulating tubes 22 and forms a good mechanical anchorage for the terminal conductors and the resistance unit 21 in the tube 22. Therefore, the applied cement with the abutting heads 24 of the terminal conductors 23 embedded therein provides, when once set and hardened, for mechanically and electrically connecting the terminal conductors 23 to the end surfaces of the resistance element 21 and for mechanically connecting the terminal conductors and the resistance element in the insulating tube 22. This means that after the cement 25 is set the terminal conductors 23 may withstand a considerable amount of pull without disturbing the mechanical and electrical connections.

As shown in Figures 1 and 8, the resistance element 21 is slightly smaller in diameter than the internal diameter of the insulating tube 22 which leaves a circumferential air space about the resistance element within the insulating tube 22. The next operation in the manufacture of my resistor unit is to fill the circumferential space with a suitable water-repellant material indicated by the reference 26 which may be of any one of three types: namely, a solid, a semi-solid, or a liquid of low viscosity. Suitable solid materials may comprise, although not limited thereto, paraffine hydro-carbons of high molecular weight, or synthetic resin such as chlorinated diphenyls or para-coumarineindene. Suitable semi-solid materials may comprise, although not limited thereto, plastic pitches. Suitable liquids may comprise, although not limited thereto, anhydrous butyl stearate or chlorinated diphenyls of low chlorine content. The water-repellant material keeps the moisture of the atmosphere from affecting the electrical characteristic of the resistance elements. When a solid or semi-solid material is used, it is heated to form a liquid of low viscosity. In order to fill the circumferential air space around the resistance element 21 in the hollow insulating tube 22, the assembly as shown in Figure 8 is immersed in a water-repellant material under vacuum to evacuate the air from the assembly. When a solid or semi-solid water-repellant material is employed the material may be heated up to 120 degrees to 150 degrees centigrade and the units as shown in Figure 8 may remain immersed for a period of from 15 to 20 minutes. The vacuum is subsequently broken with the resistance units still submerged, and with the re-establishment of atmospheric pressure, the water-repellant material flows through the pores in the cement 25 until it completely fills the void spaces including not only the circumferential space around the resistance element inside of the insulating tube but also the pores of the cement 25. After the resistance elements are removed from the water-

repellant material, the water-repellant material contained in the void spaces solidifies, producing the resistor shown in Figure 1 of the drawing. In this type of construction, the cement connection which holds the heads 24 to the end surfaces of the resistance element 21, is materially strengthened mechanically by reason of the fact that the cement is also anchored to the inside of the insulating tube.

In Figures 9, 10, 11, and 12 I show a modified arrangement of my invention in that the insulating tube, which is identified in these views by the reference character 30, is made longer than the insulating tube shown in the previous views of the drawing. The method as shown in Figure 9 of mounting the resistance unit 21 in the elongated tube 30 and of mechanically and electrically connecting the terminal conductors 23 to the end surfaces of the resistance element 21 and of mechanically connecting the terminal conductors and the resistance element 21 to the inside of the insulating tube 30 by the applying of cement in the innermost part of the open ends of the insulating tube 30 is the same as that described with reference to the previous views of the drawing. After the invention is constructed as shown in Figure 9 the outermost part of the spaces in the ends of the insulating tube 30 are filled with a suitable hardening water-repellant material 31 to seal the ends of the tube from moisture. The sealing material 31 may comprise a ceramic water-repellant material or a resin water-repellant material. The ceramic sealing material 31 may be set or hardened by baking the assembly to approximately 100 degree centigrade for thirty or forty-five minutes, or it may be set or hardened by air drying without heat. The resin sealing material may be applied by melting same with a flame and allowing a portion to drop in the open end spaces of the insulating tube, which readily solidifies upon cooling. After the sealing material 31 is applied as shown in Figure 10, the unit is immersed in the heated or liquid water-repellant material under vacuum as previously described which fills the void spaces between the resistance 21 and the insulating tube 30 as well as the pores of the cement material 25 and the sealing material 31, producing the resistor as shown in Figure 11. When using the resin sealing material it is preferable to immerse the assembly as shown in Figure 10 and fill the void spaces with the water-repellant material 26 prior to sealing the ends of the tube, as the resin sealing material does not allow the water-repellant material 26 to go therethrough as readily as the ceramic sealing material.

Although I have described my invention with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

I claim as my invention:

1. The method of constructing a resistor unit which comprises the steps of molding in a green state a heat setting phenol condensation product having finely distributed electrical conducting particles into a resistance element having end surfaces, heating the molded resistance element to set and harden same, providing an insulating tube of greater length than the resistance element to receive the latter with space in both ends thereof and with a small clearance space

between the resistance element and the insulating tube, providing for each end surface of the resistance element a terminal conductor with an abutting end smaller than the opening in the insulating tube, providing a heat setting cement of a phenol condensation product having finely distributed electrical conducting particles and having a greater electrical conductivity than the resistance element, applying the cement in the space in both ends of the insulating tube to each said end surface of the resistance element and embedding the abutting end of each of said terminal conductors in the applied cement to electrically connect the terminal conductors to the end surfaces of the resistance element, heating the insulating tube, the resistance element and the applied cement with the abutting ends of the terminal conductors embedded therein to set and harden the cement to electrically and mechanically connect the terminal conductors to the end surfaces of the resistance element and to mechanically connect the terminal conductors and the resistance element in the insulating tube, immersing the combined resistor unit in melted water-repellant material under vacuum to create voids in the unit by evacuating through the pores of the unit the air from the small clearance space between the resistance element and the insulating tube as well as from the pores themselves, releasing the vacuum to fill the voids with the melted water-repellant material, and removing the resistor unit from the melted water-repellant material and allowing the material in the resistor unit to solidify.

2. The method of constructing a resistor unit which comprises the steps of making a resistance element having end surfaces, providing an insulating tube of greater length than the resistance element to receive the latter with space in both ends thereof and with a small clearance space between the resistance element and the insulating tube, providing for each said end surface of the resistance element a terminal conductor with an abutting end smaller than the opening in the insulating tube, providing a heat setting cement having finely distributed electrical conducting particles and having a greater electrical conductivity than the resistance element, applying the cement in the space in both ends of the insulating tube to each said end surface of the resistance element and embedding the abutting end of each of said terminal conductors in the applied cement to electrically connect the terminal conductors to the end surfaces of the resistance element, heating the insulating tube, the resistance element and the applied cement with the abutting ends of the terminal conductors embedded therein to set and harden the cement to electrically and mechanically connect the terminal conductors to the end surfaces of the resistance element and to mechanically connect the terminal conductors and the resistance element in the insulating tube, immersing the combined resistor unit in melted water-repellant material under vacuum to create voids in the unit by evacuating through the pores of the unit the air from the small clearance space between the resistance element and the insulating tube as well as from the pores themselves, releasing the vacuum to fill the voids with the melted water-repellant material, and removing the resistor unit from the melted water-repellant material and allowing the material in the resistor unit to solidify.

3. The method of constructing a resistor unit which comprises the steps of making a resistance element having end surfaces, providing an insulating tube of greater length than the resistance element to receive the latter with space in both ends thereof and with a small clearance space between the resistance element and the insulating tube, providing for each said end surface of the resistance element a bendable terminal conductor with a deformed abutting end smaller than the opening in the insulating tube, providing a heat setting cement having finely distributed electrical conducting particles and having a greater electrical conductivity than the resistance element, applying the cement in the space in both ends of the insulating tube to each said end surface of the resistance element and embedding the abutting end of each of said terminal conductors in the applied cement to electrically connect the terminal conductors to the end surfaces of the resistance element, heating the insulating tube, the resistance element and the applied cement with the abutting ends of the terminal conductors embedded therein to set and harden the cement to electrically and mechanically connect the terminal conductors to the end surfaces of the resistance element and to mechanically connect the terminal conductors and the resistance element in the insulating tube, immersing the combined resistor unit in melted water-repellant material under vacuum to create voids in the unit by evacuating through the pores of the unit the air from the small clearance space between the resistance element and the insulating tube as well as from the pores themselves, releasing the vacuum to fill the voids with the melted water-repellant material, and removing the resistor unit from the melted water-repellant material and allowing the material in the resistor unit to solidify.

4. The method of constructing a resistor unit which comprises the steps of making a resistance element having end surfaces, providing an insulating tube of greater length than the resistance element to receive the latter with space in both ends thereof and with a small clearance space between the resistance element and the insulating tube, providing for each said end surface of the resistance element a terminal conductor with an abutting end smaller than the opening in the insulating tube, providing a heat setting cement having finely distributed electrical conducting particles and having a greater electrical conductivity than the resistance element, applying the cement in the innermost part of the space in both ends of the insulating tube to each said end surface of the resistance element and embedding the abutting end of each of said terminal conductors in the applied cement to electrically connect the terminal conductors to the end surfaces of the resistance element, heating the insulating tube, the resistance element and the applied cement with the abutting ends of the terminal conductors embedded therein to set and harden the cement to electrically and mechanically connect the terminal conductors to the end surfaces of the re-

sistance element and to mechanically connect the terminal conductors and the resistance element in the insulating tube, providing an insulating material and applying same into the remaining outermost space in both ends of the insulating tube to seal the ends of the tube, immersing the combined resistor unit in melted water-repellant material under vacuum to create voids in the unit by evacuating through the pores of the unit the air from the small clearance space between the resistance element and the insulating tube as well as from the pores themselves, releasing the vacuum to fill the voids with the melted water-repellant material, and removing the resistor unit from the melted water-repellant material and allowing the material in the resistor unit to solidify.

5. The method of constructing a resistor unit which comprises the steps of molding in a green state a heat setting phenol condensation product having finely distributed electrical conducting particles into a resistance element having end surfaces, heating the molded resistance element to set and harden same, providing an insulating tube of greater length than the resistance element to receive the latter with space in both ends thereof and with a small clearance space between the resistance element and the insulating tube, providing for each said end surface of the resistance element a terminal conductor with an abutting end smaller than the opening in the insulating tube, providing a heat setting cement of a phenol condensation product having finely distributed electrical conducting particles and having a greater electrical conductivity than the resistance element, applying the cement in the innermost part of the space in both ends of the insulating tube to each said end surface of the resistance element and embedding the abutting end of each of said terminal conductors in the applied cement to electrically connect the terminal conductors to the end surfaces of the resistance element, heating the insulating tube, the resistance element and the applied cement with the abutting ends of the terminal conductors embedded therein to set and harden the cement to electrically and mechanically connect the terminal conductors to the end surfaces of the resistance element and to mechanically connect the terminal conductors and the resistance element in the insulating tube, providing an insulating material and applying same into the remaining outermost space in both ends of the insulating tube to seal the ends of the tube, immersing the combined resistor unit in melted water-repellant material under vacuum to create voids in the unit by evacuating through the pores of the unit the air from the small clearance space between the resistance element and the insulating tube as well as from the pores themselves, releasing the vacuum to fill the voids with the melted water-repellant material, and removing the resistor unit from the melted water-repellant material and allowing the material in the resistor unit to solidify.

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