

Aug. 20, 1957

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2,803,054

METHOD OF RESISTOR CONSTRUCTION

Filed Feb. 13, 1953

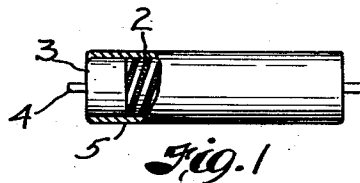


Fig. 1

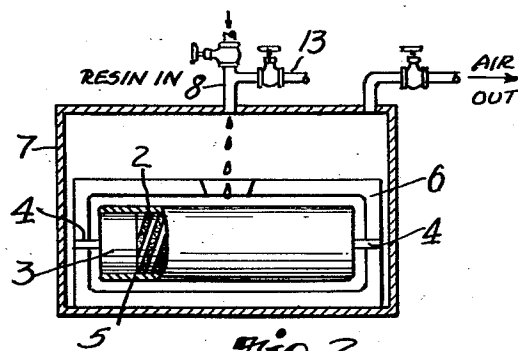


Fig. 2

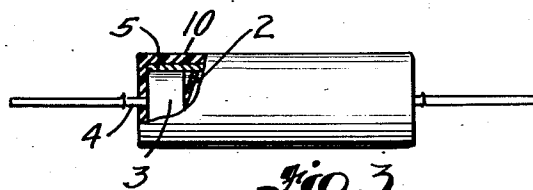


Fig. 3

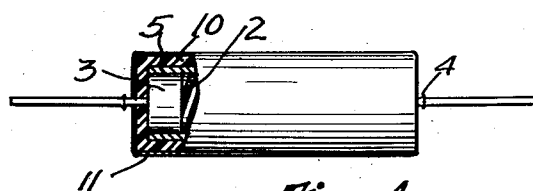


Fig. 4

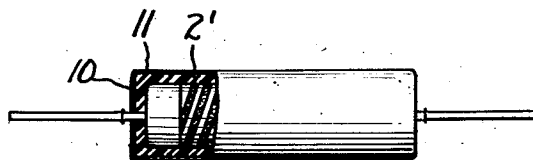


Fig. 5

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2,803,054

METHOD OF RESISTOR CONSTRUCTION

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Application February 13, 1953, Serial No. 336,664

10 Claims. (Cl. 29—155.5)

In some usages resistors are subjected to extremely drastic conditions, such as exposure to high humidity and temperature, and great variations in atmospheric pressure and temperature. In service in the tropics and in aviation and in high altitude usages such as guided missiles and the like, resistor break-down is prone to occur where the construction is of character heretofore customary. In accordance with the present invention however, resistors may be had which are outstandingly durable against unfavorable operating conditions in wide range. Other objects and advantages of the invention will appear from the following description.

To the accomplishment of the foregoing and related ends, said invention, then, comprises the features herein-after fully described and particularly pointed out in the claims, the following description and the annexed drawing setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principle of the invention may be employed.

In said annexed drawing:

Fig. 1 is a side elevational view, partly broken, showing a stage in the manufacture of resistors;

Fig. 2 similarly shows another stage;

Fig. 3 shows the resistor as taken out of the mold from such stage of operation;

Fig. 4 correspondingly shows a resistor with a further finish; and

Fig. 5 shows a modification.

A resistor 2, comprises an insulating core with a resistance element of wire winding or deposited carbon, or metal deposited by fusion of colloidal metals to the surface, as well as metal vacuum-deposited, and silver contacting on the ends for low resistance contact, as desired in any given instance. The terminals, in one form may involve end caps 3 which have projections 4, one opening clear through. And in another form, the end caps may be of polygonal cross-section instead of circular, whereby the cap forced on binds in tight electrical contact with the resistance element but leaves small passages at the polygonal angles. From the caps extend flexible terminals. With this form small end-openings may be ultimately connected. The assemblage next is encased in a pliant air-impervious bag or less desirably in some cases a pre-formed shell which in either case as element 5 covers from end cap to end cap. Materials of which these may be made are for instance polyethylene, polystyrene, etc. The bag-enclosed resistor is preliminarily in some cases heated to 100–110° C. for drying, but in other cases it is directly placed in a sectional mold 6, such as a two-part mold with cavity contoured to provide a space about the resistor in position, there being suitable recesses to accommodate the terminals. Preferably, this should be in a vacuum chamber, that is a container chamber 7 which can be sealed and in communication by a valved connection 8 with a source of vacuum. To the mold is then supplied a liquid settable insulating material, such as phenol-aldehyde synthetic resin, phenol-furfural synthetic resin, etc.,

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and the supply of such material should be arranged to flow in thin stream or drop-wise from its container outside or within the chamber, such that the liquid on its way to the mold, as well as the mold itself is subjected to high vacuum. Thereby, minute air bubbles and passages are prevented from occurring in the insulating material which, filling the mold cavity makes a complete casing about the bag or cast shell enclosed resistor. It is advantageous after applying a high vacuum for a few minutes, e. g., 30 in. or higher, to then abruptly lessen the vacuum to a lower value, thereby shock vibrating the mold contents and promoting consolidation. This can be repeated if desired. Then the vacuum is applied for a few minutes at full value. The synthetic resin finally is set by heating to 100–400° C. Such a resistor structure, as shown at Fig. 3 is then characterized by an immediately close-fitting enclosing bag or preformed shell 5, directly outside of which is a molded-on casing 10 of synthetic resin insulation, which is peculiar in that having been subjected to vacuum and freed from air completely, it has no microscopic air pockets or passages, subject to admission of moisture. In one form of procedure the hubs 4 of the end caps are held by the mold sections and one open, so that in the vacuum chamber, the interior of the resistor is correspondingly de-aired. If a permanently fluid insulative material, such as helium, is desired, this is now admitted to the vacuum chamber by valved branch 13 of the connection 7, any interstitial spaces within the bag or envelope are filled. In another form of procedure the resistor is taken out of the mold and immersed in such a permanently fluid insulative material as oil, which works into any interstitial spaces. Terminals are driven into the hubs.

For particularly drastic operating conditions, I prefer then to further encase the structure with deposited metal. In some instances this may be applied by electrodeposition, using plating methods. More desirably, it is applied by vacuum depositing, vaporizing the metal and applying it to the resistor in a vacuum using the known techniques, as for instance "Vacuum Technique" by Saul Dushman (pub. by John Wiley & Sons, Inc., N. Y., 1949), pages 757–764. Metals which may be used are for instance aluminum, chromium, titanium, etc. The structure then as in Fig. 4 involves bag or envelope 5 closely fitting the resistor body, and interstices containing helium or other permanently fluid insulative material. And in enveloping relation about the bag surface is the synthetic resin encasement 10, and finally outside thereof is a layer of metal 11. Short-circuiting contact of the latter on the terminals is obviated by preliminarily applying masking material about the terminals where projecting from the insulation, and after deposition of the metal the masking material is removed, thereby leaving the metal spaced back from contact with the terminals. Any suitable material for such masking may be applied, its properties requiring that it be inert and that it be relatively easily broken away after having served its purpose. For instance such material may be wax, plaster of Paris or a water glass composition with filler of mineral powder, ground asbestos, silica flour, or the like.

In some cases the bag or shell 5 and fluid insulative filling may be omitted; and in such event the resistor assembly of core and resistance element and terminals is placed directly in the mold without an enveloping bag, and the synthetic resin is flowed in for the outer casing. Here, the terminals need not necessarily involve hubs and driven-in terminal extensions, but can also be end caps with extending flexible terminals. The mold may be in a vacuum chamber as described foregoing so that the synthetic resin as supplied is de-aired along with the mold and resistor assembly. The alternate high and lower vacuum shock may be applied if desired. Or, in some

cases less desirably the vacuum may be omitted. On heating and setting the synthetic resin, the resistor 2' is directly encased in the synthetic resin 10', Fig. 5, which if vacuum was applied has the peculiarity that it is free from minute air pockets and passages such as would otherwise occur. An exterior layer of metal 11', may be deposited finally to cover the synthetic resin if desired, the terminals being masked for the deposition as above described.

As an example: A resistor assembled of an insulating core and a resistance winding connecting to end caps, one having an opening to the interior, is enclosed in a polyethylene bag. This is placed in a mold which in turn is in a chamber to which a vacuum exhaust is connectible, and in which liquid synthetic resin is flowed in through a connection above such as to drop in very thin stream into the mold in the vacuum, the synthetic resin material being de-aired on its way to the mold, while the mold and contents are likewise being de-aired. By finally heating the mold and contents to around 200° C., the synthetic resin, for instance phenolic-aldehyde, is solidified. By a valved branch to the vacuum draw-off connection, helium gas is admitted to the chamber and to any interstitial spaces within the resistor. The terminals are completed by driving extensions into the hubs. The structure then is suitable for duty under drastic conditions; but for still further protection it is finished by applying temporary masking about the terminals to prevent metal deposition thereagainst, aluminum is vaporized by electric heating means, such that the aluminum vapor in the vacuum chamber equipment deposits on and covers the encased condenser. On removal from the metal depositing vacuum chamber, the masking covering on the terminals is taken off, and the outside metal layer is complete over the insulative casing, except that it does not touch the terminals.

A particular advantage of a final protective covering of deposited metal is that whereas synthetic resin insulation in exposure to the atmosphere tends to progressively deteriorate by accelerated aging, the sealing off of the synthetic resin surface and the metallic layer prevents this, and prevents fungus development which may occur on some insulating materials, and also provides a particularly thorough protection against atmospheric moisture, etc.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims or the equivalent of such be employed.

I therefore particularly point out and distinctly claim as my invention:

1. In making a resistor, assembling a core and resistance element and end caps, one having an opening, enclosing the assemblage in a pliant impervious bag from cap to cap, placing the whole in a space-providing mold and the latter in a vacuum chamber, applying a vacuum to the mold and contents and also to liquid insulating material on its way to the mold, abruptly lessening the vacuum in shock alternation, solidifying the insulating material, supplying to the interior a permanently fluid insulative material, sealing the resistor, and depositing metal on its exterior.

2. In making a resistor, assembling a core and resistance element and end caps, one having an opening, enclosing the assemblage in a pliant impervious bag from cap to cap, placing the whole in a space-providing mold and the latter in a vacuum chamber, applying a vacuum to the mold and contents and also to liquid insulating material on its way to the mold, abruptly lessening the vacuum in shock alternation, solidifying the insulating

material, supplying to the interior a permanently fluid insulative material, and sealing the resistor.

3. In making a resistor, assembling a core and resistance element and end caps, one having an opening, enclosing the assemblage in an impervious preformed shell, placing the whole in a space-providing mold and the latter in a vacuum chamber, applying a vacuum to the mold and contents and also to liquid insulating material on its way to the mold, abruptly lessening the vacuum in shock alternation, solidifying the insulating material, supplying to the interior a permanently fluid insulative material, sealing the resistor, and depositing metal on its exterior.

4. In making a resistor, assembling a core and resistance element and end caps, one having an opening, enclosing the assemblage in an impervious preformed shell, placing the whole in a space-providing mold and the latter in a vacuum chamber, applying a vacuum to the mold and contents and also to liquid insulating material on its way to the mold, solidifying the insulating material, supplying to the interior a permanently fluid insulative material, sealing the resistor, and depositing metal on its exterior.

5. In making a resistor, assembling a core and resistance element and end caps, one having an opening, enclosing the assemblage in an impervious preformed shell, placing the whole in a space-providing mold and the latter in a vacuum chamber, applying a vacuum to the mold and contents and also to liquid insulating material on its way to the mold, solidifying the insulating material, supplying to the interior a permanently fluid insulative material, and sealing the resistor.

6. In making a resistor, assembling a core and resistance element, placing the whole in a space-providing mold and the latter in a vacuum chamber, applying a vacuum to the mold and to liquid insulating material on its way to the mold, abruptly lessening the vacuum in shock alternation, solidifying the insulating material, and depositing metal on the exterior.

7. In making a resistor, assembling a core and resistance element, placing the whole in a space-providing mold and the latter in a vacuum chamber, applying a vacuum to the mold and to liquid insulating material on its way to the mold, abruptly lessening the vacuum in shock alternation, and solidifying the insulating material.

8. In making a resistor, assembling a core and resistance element, placing the assemblage in a space-providing mold and the latter in a vacuum chamber, applying a vacuum to the mold, abruptly lessening the vacuum in shock alternation, solidifying the insulating material, and depositing metal on the exterior.

9. In making a resistor, assembling a core and resistance element, placing the assemblage in a space-providing mold and the latter in a vacuum chamber, applying a vacuum to the mold, abruptly lessening the vacuum in shock alternation, and solidifying the insulating material.

10. In making a resistor, assembling a core and resistance element, placing the whole in a space-providing mold and the latter in a vacuum chamber, applying a vacuum to the mold and to liquid insulating material on its way to the mold, and solidifying the insulating material.

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