

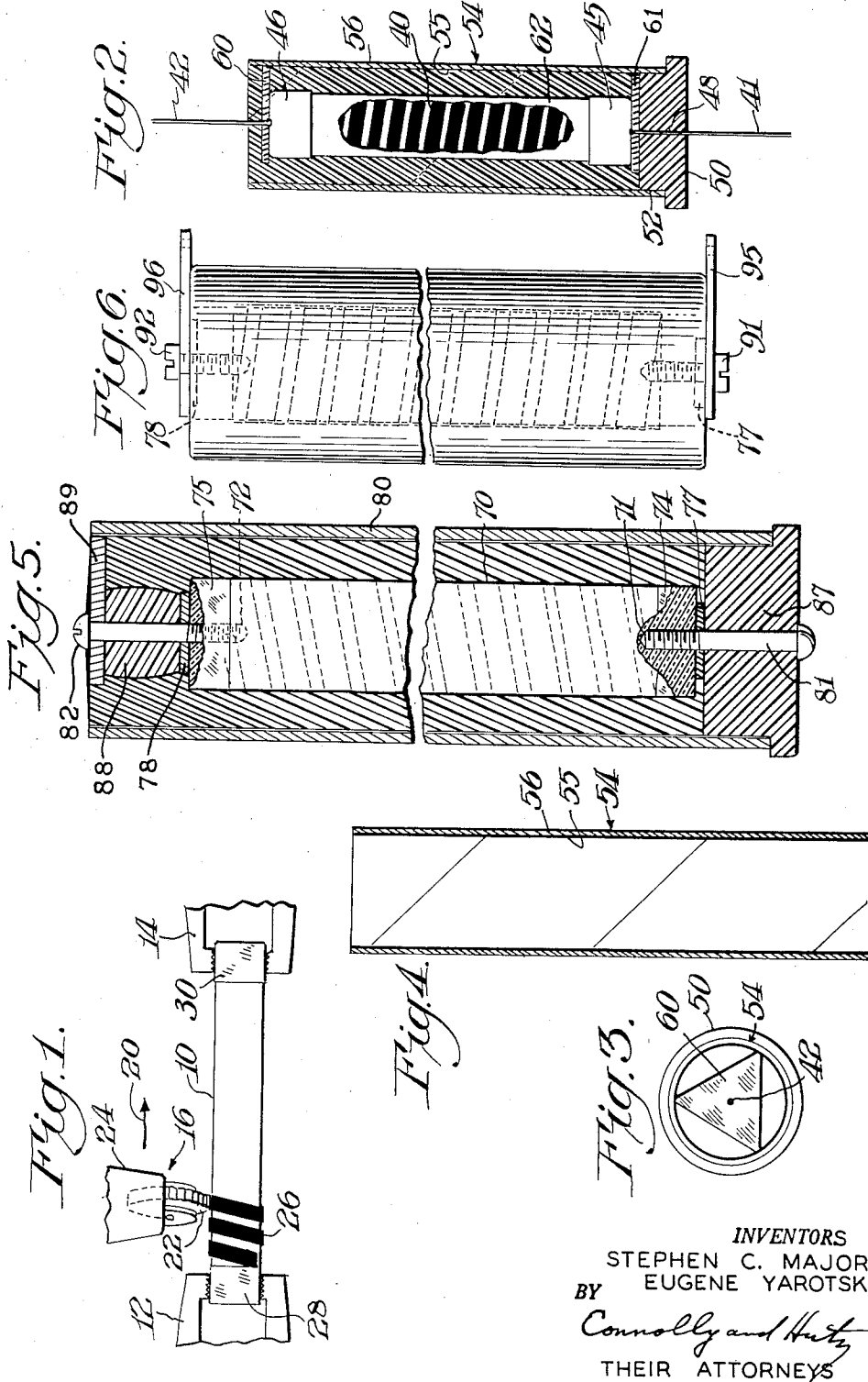
May 5, 1959

S. C. MAJOR ET AL

2,885,522

ELECTRICAL COMPONENT AND CASTING ARRANGEMENT

Filed July 1, 1957



INVENTORS
STEPHEN C. MAJOR
EUGENE YAROTSKY
BY
Connolly and Hart
THEIR ATTORNEYS

1

2,885,522

ELECTRICAL COMPONENT AND CASTING ARRANGEMENT

Stephen C. Major and Eugene Yarotsky, Nashua, N.H.,
assignors to Sprague Electric Company, North Adams,
Mass., a corporation of Massachusetts

Application July 1, 1957, Serial No. 669,155

1 Claim. (Cl. 201-64)

This invention relates to electrical components and particularly to electrical resistors that are encased in resin housings, and also relates to coating methods and equipment for providing such housings.

Prior art attempts to efficiently encase electrical components, particularly electrical resistors, have suffered from the need for expensive forms or molds, and from the difficulties involved in providing means for releasing the potted or encapsulated component from the casting form. Prior release means have included the use of mold release compounds, such as silicone oils, which required painting the surfaces of the casting forms with great care to ensure covering relatively inaccessible areas without depositing such a quantity of the compound as to hinder or contaminate the resin potting operation.

Among the objects of the present invention is the provision of electrical resistors that are simple to manufacture, have a high degree of uniformity, and are of high quality.

Additional objects of the invention include the provision of simplified casting techniques and equipment for casting resin housings.

The above as well as additional objects of the present invention will be more clearly understood from the following description of several of its exemplifications, reference being made to the accompanying drawings wherein:

Fig. 1 is a side view showing a step early in the preparation of a resistor pursuant to the present invention;

Fig. 2 is a partly broken away side view of a later step in the preparation of the resistor;

Fig. 3 is an end view of the setup of Fig. 2;

Fig. 4 is a sectional view of one component of the equipment shown in Figs. 2 and 3;

Fig. 5 is a view similar to Fig. 2 of a modified arrangement for casting housings in accordance with the present invention; and,

Fig. 6 is a side view partly in phantom showing a completed resin-encased resistor exemplifying the present invention.

The objects of this invention are generally attained by casting an electrical component in resin in a disposable tubular casting form constructed of spiralled, easily separable, material and which is lined with a plastic film spiralled in the same manner as the tube material, so as to be removable therewith upon separation of the tube.

While this invention may be practised with many electrical components such as capacitors, magnetic devices, and wire wound resistors, it is especially advantageous for elongated film-type resistors. In particular this invention is adapted for use with a film-type resistor in which the film of resistance material must be effectively isolated from the encapsulating resin and in which the cast unit be easily and economically removed from the casting form.

According to a still more particular aspect of the present invention, a resistor is made by applying a resistance ink layer to the surface of an elongated non-conductive

2

body, connecting electrical leads to spaced portions of the ink coating, covering the intervening surface of the layer with a barrier coating, and potting the unit in a resin to which the barrier coating is inert. The barrier coating, when of polyethylene terephthalate, makes an especially desirable combination for resistors made with inks that have an epoxy resin binder, and in which the potting resin is also of the epoxy type. The non-conductive body can be ceramic, as for example a rod with threaded sockets at each end to receive anchoring screws that hold terminal tabs in place. Washers secured to the socket mouths as by soldering to a fired silver coating, can act as contact surfaces to which terminals may be clamped by threaded engagement with the socket threads.

A feature of the present invention is the process of casting elongated electrical components in resin by providing a plug of material to which the casting resin does not adhere, frictionally fitting on the plug a disposable casting form comprising a tube of easily torn material having an internal space wider than the component, inserting the component into said space with one terminal against the plug, pouring a fluent casting resin into the tube to surround the body of the component, curing the casting resin, tearing the tube away from the cured resin, and detaching the plug from the adjacent terminal. A highly effective form of tube is made of paper with a thin internal liner of a resin such as polyethylene terephthalate. Thin spacers can be secured to either or both ends of the component to help hold it in place in the tube during the casting. Where the component has a lead extending from one or both ends, the plug can have an aperture to receive such a lead.

Referring now to the drawings, Fig. 1 shows a cylindrical ceramic rod 10 gripped at each end in lathe-like rotating jaws 12, 14 for rotation while held against an ink applicator 16. The applicator moves longitudinally of the rod during the rotation, as indicated by the arrow 20, and carries a rotatable toothed applicator wheel 22 supplied by a reservoir 24 and arranged to apply a helical stripe 26 of electrically resistant ink.

Prior to application of stripe 26, each end of the rod is given a coating 28, 30 of electrically conductive material, such as silver fired in place. Stripe 26 is applied so that it extends over each of coatings 28, 30. Suitable electrically conductive coatings can be made in the manner shown in National Bureau of Standards Circular 468, "Printed Circuit Techniques," pages 6 and 7, although such coatings can also be applied by vacuum evaporation, metal spraying, metal precipitation, electrochemical deposition, and metallo-organosol firing, as described in National Bureau of Standards Miscellaneous Publication 192, "New Advances in Printed Circuits." The silicone-silver paint described in U.S. Patent 2,744,988, granted May 8, 1956, is also satisfactory.

After the helical stripe 26 has been cured, terminal connectors in the form of caps carrying outwardly-projecting leads, are secured over the coatings 28, 30. The caps can be metallic and solder-sweated in place. A barrier coat is provided over stripe 26 as a protection against contamination during subsequent processing steps. The unit is now ready for casting.

Fig. 2 shows a casting arrangement in which the resistive unit is indicated at 40 with terminal leads 41, 42 projecting from the end caps 45, 46. Lead 41 is passed through an aperture 48 in a plug 50 of a resin, such as polytetrafluoroethylene, to which the casting resin substantially does not adhere. Although polytetrafluoroethylene is the preferred material for plug 50, because it permits easy removal from the cast unit, a less desirable substitute material such as polyvinyl chloride may be

used. Plugs 50 may be preformed, as by molding, or may be machined, as by cutting from a cylinder. A boss 52 of reduced diameter receives a tube 54 that acts as a form or cavity for the casting operation. To help assure the proper positioning of unit 40 in tube 54, apertured spacers 60, 61 are slipped over leads 42, 41, and the unit is placed into the open end of the tube. For electrical resistors the spacers should be fairly resistant to elevated temperatures and can be made of glass fiber cloth stiffened by impregnation with a resin, such as an epoxy resin, or can merely be mica, for example. Inasmuch as these spacers become integral parts of the finished resistor, it is important that they be of a material which is compatible with the casting resin. As shown in Fig. 3 these spacers are made triangular in plan view. This does a good job of centering and at the same time provides sufficient open space for a fluent casting resin mixture to pass through. Since the lower end of unit 40 is to be covered, spacer 61 can be placed between the unit and the top of the plug to ensure uniform lateral stability and uniform wall thickness.

In order to protect the electrically resistive stripe 26 from the casting resin, particularly where they are to be subjected to elevated temperatures, it is very desirable to apply a barrier coating around the unit 40. It is particularly important to provide barrier 62, when resistance stripe 26 has constituents common to the casting resin, in order to prevent instability in the form of constantly increasing resistance. This barrier coating is shown at 62 in Fig. 2 and extends over the entire helix, and up against the inner margins of the caps 45, 46. Ribbons of polyethylene terephthalate no more than 3 to 5 mils thick and preferably even thinner, make very good barriers and can be very simply cemented in place. The cement does not have to make a permanent seal since the housing cast around it will provide all the sealing that is necessary. The width of the ribbon is not important, in fact relatively narrow widths may be used, particularly if the barrier ribbon is wound around the unit with at least about $\frac{1}{8}$ inch or $\frac{1}{4}$ inch overlap. However, the use of a ribbon having a width corresponding to the distance between the inner margins of the caps, and having a pressure-sensitive adhesive coating, makes a very convenient way to apply the barrier. The ribbon cut to the desired length is then merely laid down on a flat surface with the adhesive coating facing upwardly, the resistor unit placed over one end of the adhesive coating on the ribbon and then rolled along the remainder of the ribbon to wind the ribbon around the unit. Any pressure-sensitive adhesive such as those described in U.S. Patent 2,750,316 granted June 12, 1956, can be used since they do not appear to adversely affect the operation of the unit. The product made according to Example II of that patent, using the primer of Example I in U.S. Patent No. 2,647,843, is particularly effective, although the longitudinally-extending reinforcing strands of Patent No. 2,750,316 can be omitted. The helix can be covered by a preliminary protective coating, such as the silicone resin of U.S. Patent 2,258,218, or those of Examples 2, 3, 5, 7, 8, 9 and 13 of U.S. Patent 2,661,348. Any silicone paint or resin is effective for this purpose.

The casting operation is carried out by pouring a fluent casting mixture such as those described in the "Epoxide Resins" article by W. J. Marmion of the September 1954 issue of Research, pages 351, 355; the Narracott article in the October 1951 issue of British Plastics, pages 341, 345; the Scheibli et al. article in July 1952 issue of Official Digest, pages 491 to 503; as well as U.S. Patents 2,324,483, granted July 20, 1943, 2,444,333 granted June 29, 1948, 2,506,486 granted May 2, 1950, 2,510,885 granted June 6, 1950, and 2,594,979 granted April 29, 1952.

The room temperature curing resins are liquids that are poured into tube 54, preferably above the level of spacer 60, as shown in Fig. 2. They will generally become completely cured by standing overnight, after which the tube 54 is removed. The simplest way to remove the tube is

to merely tear it off. Inasmuch as epoxy resins are very adhesive, the tube is advantageously provided with an inner surface or liner 55 of a material such as polyethylene terephthalate to which the epoxy resins do not adhere very strongly and which can be readily peeled from the cured casting. For greater ease in removing the tube, it is made principally of easily tearable material such as paper.

One preferred embodiment of tube 54 is illustrated in Fig. 4 and has an external paper cylinder 56 with a wall about 8 mils thick and a liner 55 of one mil thick polyethylene terephthalate. The liner need not be cemented or securely cemented in place, and any adhesive such as ordinary casein glue, animal glue or fish glue can be used. If a water soluble glue is used, the tubes can be removed from the cured units by soaking in water prior to the tearing operation. The liner is shown as helically wound on the inner face of the paper shell, and an overlap of no more than $\frac{1}{4}$ inch between turns of the helix is satisfactory. The paper shell itself can also be helically wound in a similar manner, preferably with a plurality of wall laminations, each lamination having a helical joint between turns offset from the corresponding helical joint of adjacent laminations and from the joint of the liner. The tube is readily made by winding ribbons of the liner and paper material on a rotating mandrel, first winding the liner and then the paper layers, with an adhesive to cement the layers together. The adhesive can be carried by the outer surface of each winding ribbon. The polyethylene terephthalate can for example be the same pressure-sensitive ribbon used as protective coating 62. After the winding of the tube is completed, the mandrel is removed and the cement in the wound tube permitted to cure, if this is necessary. The well-known types of collapsing mandrels can be used to simplify the removal operation. The tube 54 can be made of the proper length so that when completely filled with casting resin, it provides the desired encasing and no separate measuring is needed.

Plug 50 is readily removable from the encapsulated unit, as by simply pulling the plug from the tube along lead 41, because of the incompatibility of the plug, the encapsulating resin, and the tube lining. A tube of the above kind is readily torn off from the cured resin casting. The spiral material of the liner makes it easy to peel the liner away from the casting. After removal of the tube the resistor is ready for use, shipment, or packaging.

The casting technique of the present invention can also be used with electric circuit components that do not have the oppositely projecting leads shown in the Fig. 2 construction. Figs. 5 and 6 show a modified embodiment of the invention wherein the helical ink spiral is applied to a ceramic rod 70, in each end of which is a threaded socket 71, 72, as in conventional stand-off insulators. Electrically conductive coatings 74, 75 in this construction extend not only over the cylindrical margin of the rod, but also over the flat end walls. Each of these walls carries a washer 77, 78, adherently held as by soldering to the coatings 74, 75. The washers have openings aligned with the respective sockets 71, 72. The washers can be held in place for soldering by screws threaded in these sockets, so that they are properly aligned.

During casting, screw 81 holds the resistor unit aligned in place in tube 80, by clamping the unit against a bottom plug 87 of similar construction to plug 50 of Fig. 2. In order to ensure that the finished unit will be provided with a resin casing that is flush with washer 78, an elongated washer 88 of polytetrafluoroethylene, or other suitable material which does not bond with the encasing resin, is utilized. A triangular spacer member 89 is positioned above washer 88, and is preferably of the same material. While spacer 89 functions like spacer 60 in Fig. 2 to provide uniform wall thickness, it should be noted that spacer 89, unlike spacer 60, does not become

an integral permanent part of the encased unit. Hence spacer 89 is made of a material which does not adhere to the resin. Although the resin is shown in Fig. 5 as completely filling tube 80, it is important only that the resin, which cures with a concave meniscus, cover washer 78. The casting operation can be carried on in the same way described in connection with Fig. 2.

After the casting is completed, screws 81, 82 are removed and the encased assembly is withdrawn from the mold. The ends of the unit are then cleaned as by grinding flush with washers 77, 78, and the same or different screws 91, 92 used to attach terminal tabs 95, 96 directly against the end washers 77, 78. To anchor the tabs in a more permanent manner, they, as well as the screws, can be soldered to the washers. Where the resistors of the invention are to be subjected to elevated temperatures, any solder used in the final assembly should be of the high temperature type or so-called hard solder. These are described in National Bureau of Standards Circular No. 492 issued April 28, 1950.

The helical resistor stripes of the above examples are particularly desirable for the preparation of high-ohm resistance such as those having resistances of $\frac{1}{4}$ megohm or higher. As much as 600 megohms or more are readily provided in a resistor having over-all length of about 5 inches. The encased unit readily dissipates about 1 watt per inch of over-all length even with a resin wall thickness of $\frac{1}{8}$ inch. The completed resistors of the invention will also withstand very high voltages and a unit 2 inches long can carry as much as 8 or more kilovolts. However, the casting technique can also be used for resistors having a uniform resistance layer extending unbroken over the entire outer surface of the form on which it is applied. Furthermore, such a continuous coating can be helically cut to form a helix rather than having the coating applied as a helix, although the cutting is not as desirable.

The casting technique of the present invention does not significantly affect the resistance of the resistor unit, so that if resistance adjustments are desired, they can be made very simply after the ink is cured. By way of example, the original application of the stripe can be arranged to provide a resistance that is somewhat on the low side. The resistance can be adjusted by extending the curing operation, or by scraping away some of the coating. Abrasive grit blasting as described in the Bayha article on pages 78 through 80, 153 through 156 and 158 of the September 1953 issue of Tele-Tech is also very helpful.

The resistor inks of the present invention give more reproducible results if they are roller milled as in a conventional paint roller mill. For example, highly effective milling is accomplished in six passes through a three roller mill with a medium spring urged spacing between rollers, the rollers being rotated at 40, 100 and 200 linear surface feet per minute. The resistors made in accordance with the present invention are also more uniform than similar ones made with conventional types

of mold release agents in place of resin lining 55 in tube 54. For example, the use of silicone greases such as those sold commercially under the trade designation DC-7, and similar polysiloxane type lubricants either in dissolved or undissolved form does not produce as good a product and is more awkward to use.

Although triangular mold spacers are shown in Fig. 3, they can be in any other form such as polygonal, or they can have additional perforations, so long as they provide the desired positioning and permit passage of fluent, that is liquid or finely divided pourable material. However, since they give good spacing with a minimum amount of spacer material and can be punched out of sheets with a minimum of waste, the triangular shape is preferred.

Obviously many other modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claim, the invention may be practiced otherwise than as specifically described.

What is claimed is:

An electrical resistor having an electrically non-conductive rod with electrically conductive coatings on each end, a helical layer of epoxy base resistor ink between the coatings, a polyethylene terephthalate barrier tape wound around the helical layer, terminals connected to the respective coatings, and an epoxy resin cast about the covered rod and the adjacent portions of the terminals.

References Cited in the file of this patent

UNITED STATES PATENTS

1,256,599	Schoop	Feb. 19, 1918
2,136,609	Butterfield et al.	Nov. 15, 1938
2,286,161	Rights et al.	June 9, 1942
2,496,346	Haayman et al.	Feb. 7, 1950
2,552,626	Fisher et al.	May 15, 1951
2,641,592	Hofrichter	June 9, 1953
2,677,165	Copenhagen et al.	May 4, 1954
2,713,700	Fisher	July 26, 1955
2,742,551	Kohring	Apr. 17, 1956
2,776,625	Cook et al.	Jan. 8, 1957
2,795,680	Peck	June 11, 1957

OTHER REFERENCES

- Hopper: American Ink Maker, October 1951, pages 61, 63, 113 and 115. Published by Mac Nair-Dorland Co., New York, N.Y.
- Narracott: British Plastics, October 1951, pages 341-345. Published by Iliffe and Sons, Ltd., London, England.
- Formo et al.: Modern Plastics, vol. 32, No. 11, July 1955, pages 99-102 and 104. Published by Breskin Publications, Inc., Bristol, Conn.
- Crandell: SPE Journal, vol. 12, No. 7, July 1956, pages 20-23. Published by the Society of Plastics Engineers, Athens, Ohio.
- Lee et al.: "Epoxy Resins," 1957, pps. 183-202 and 296. Published by McGraw-Hill Book Co., Inc., New York, N.Y.