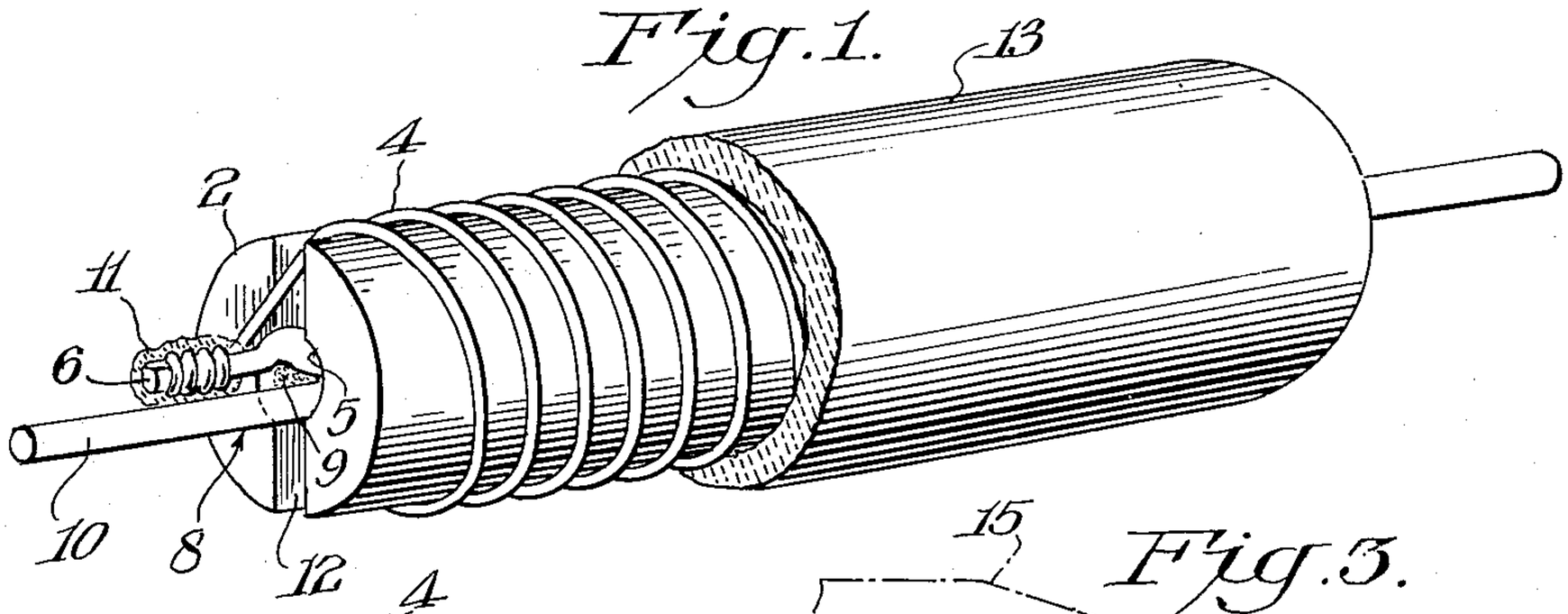
Aug. 8, 1961 R. V. CAHILL 2,994,945

PROCESS FOR WIRE-WOUND RESISTOR

Filed Jan. 31, 1957

Fig. 1.



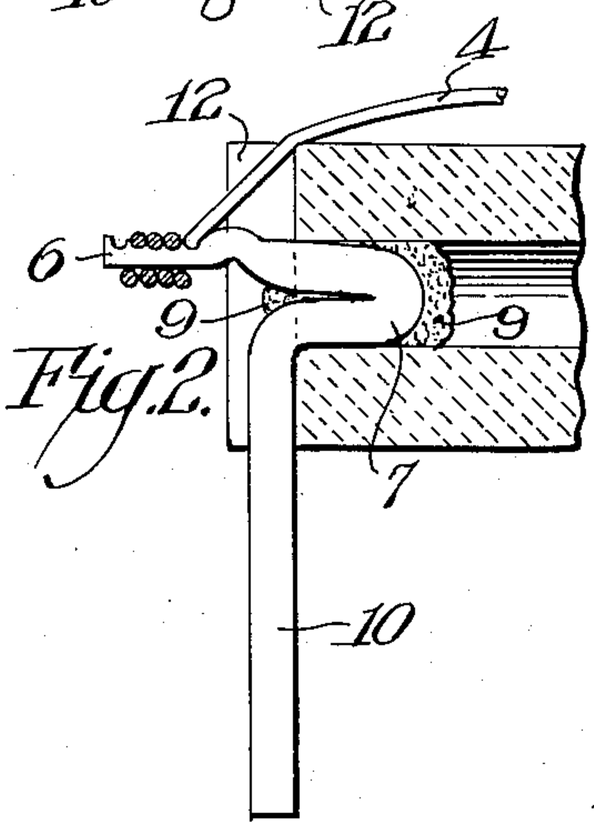
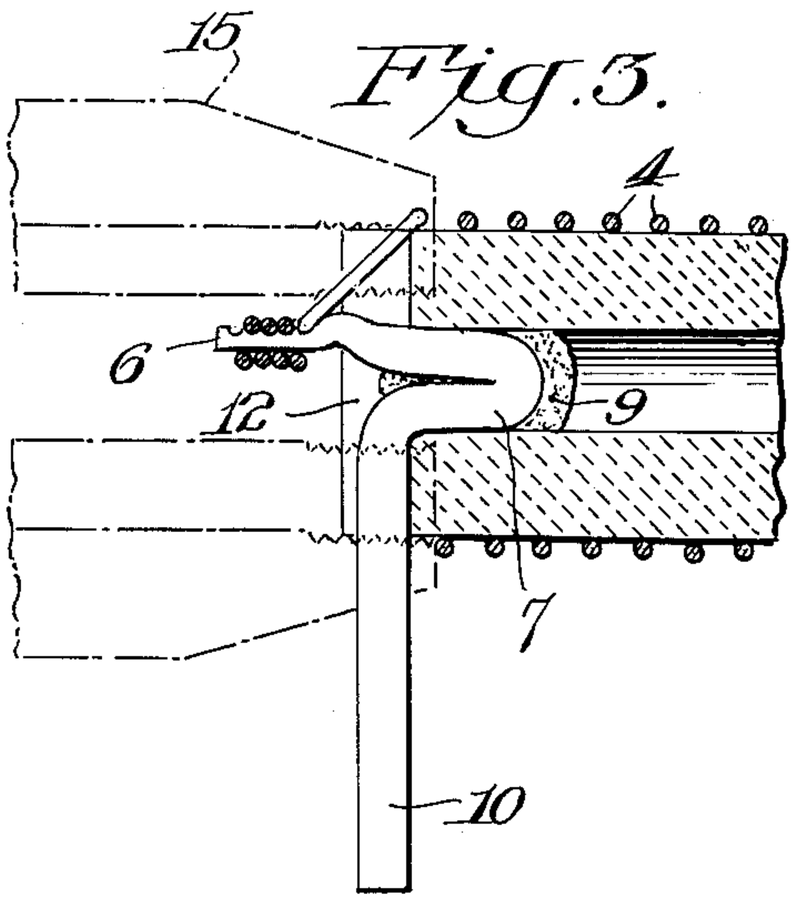


Fig. 2.

Fig. 3.



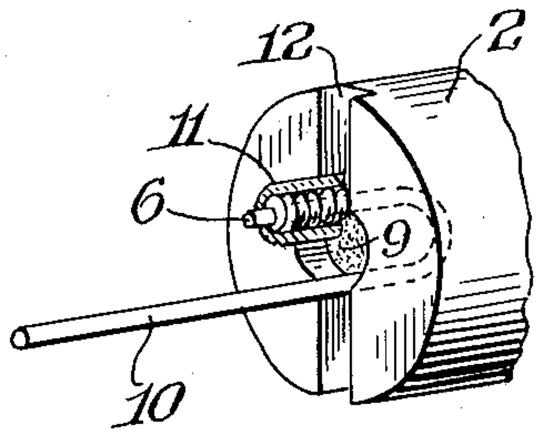


Fig. 4.

Fig. 6.

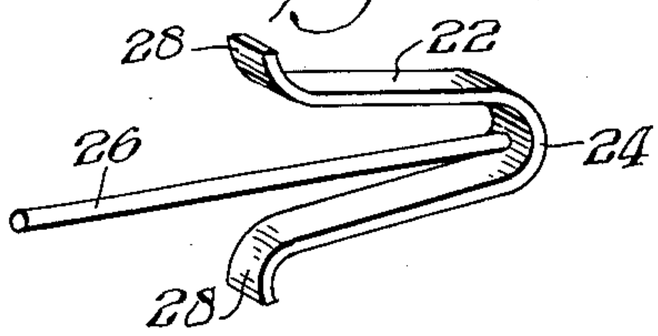
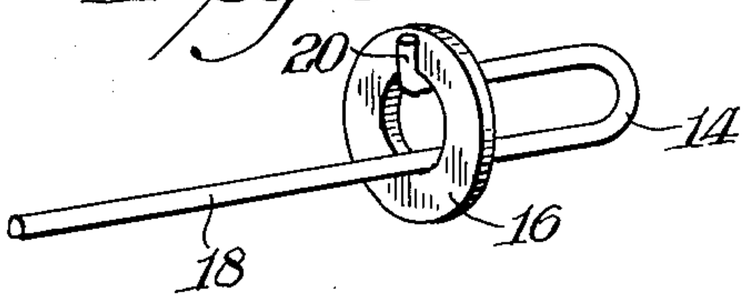


Fig. 5.



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PROCESS FOR WIRE-WOUND RESISTOR

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2 Claims. (Cl. 29—155.71)

This invention relates to electrical resistors and more particularly to wire wound resistors. This application is a continuation-in-part of parent application S.N. 390,900, filed November 9, 1953, and now forfeited.

One standard form of wire wound resistor utilizes a single layer of space wound resistor wire mechanically protected by an outer coating of vitreous enamel or cement. The usual practice has been to connect the ends of the resistance winding to tabs or ears such as are illustrated by the Deyrup United States Patent No. 2,425,032, issued August 5, 1947. The mounting hardware required for such tabs takes up appreciable space and requires inefficient utilization of the core surface area. Furthermore, in most cases external leads are needed so that extra handling is resorted to for the purpose of connecting them to the tabs.

It is an object of this invention to overcome the foregoing and related disadvantages. It is a further object of this invention to provide a relatively simple technique for connecting terminals to wire wound resistors. It is a still further object of this invention to produce a vitreous enamel coated wire wound resistor convenient for mounting on an electrical chassis without need for additional mounting hardware and one which can withstand substantial twisting of the terminal wires without suffering failure of the unit. Further objects will become apparent from the following description and claims.

These objects are attained in accordance with the teachings of the present invention, by providing a cylindrical insulator with recesses at each end, securing in each of these recesses the bight portion of an elongated lead conductor bent into the general shape of a U with one arm of the U much shorter than the other but long enough to be wound with a plurality of turns of a resistance conductor, each short arm projecting out only a short distance from the end of the insulator, bending the long arm of the lead conductor away from the cylindrical axis of the insulator, gripping the ends of the insulator in an axially rotating device, rotating the gripped insulator by the device, winding a resistance conductor around the rotating insulator, winding a plurality of turns at each end of the resistance conductor around each short arm, dip soldering the wound ends of the resistance conductor to the respective short arms, then bending the long arms of the lead conductors back to the axial position, and covering the final product with a solid heat-resistant protective surface.

This invention will be more apparent from the appended drawings in which FIG. 1 is a partly cut-away view of a wire wound resistor according to the invention; FIGS. 2 and 3 are fragmentary views showing steps in the making of the resistor of FIG. 1, and FIGS. 4, 5 and 6 are detail views of alternative constructions.

With reference to FIG. 1, the resistance element here shown has a tubular core **2**, which in the preferred embodiment is steatite, about which is wound a resistance wire **4**. The wire is connected at each end to a terminal **8** fitted within an axial opening **5** in each end of the core. Each terminal has a short arm **6** and a long arm **10**, both projecting outwardly and joined by a generally U-shaped bight portion **7** which is the portion that fits in the core end. The bight can be anchored in place as by means of an inorganic enamel or cement **9**. The ends of the core are advantageously slotted as indicated at **12** diametrically or radially from the axial opening **5** to the cylindrical surface, and the resistance wire ends are laid in the slots which serve as wire positioning means for the connections to the shorter arms **6** of the terminals **8**. Simple notches in the cylindrical edge can also be used without having the notches extend to the axis of the core. Several turns of resistance wire are wound around the short arms **6** to hold the ends in place until they are permanently secured as by the solder **11**. The temporary anchorage is improved by shaping the arms **6** with ribs or teeth **14** which help keep the wound-on turns from slipping along the arm until the permanent anchorage is effected.

In the winding of the resistance element, the terminals are first inserted in the core ends, and if cement is used, the bight is dipped into the cement before insertion, or the cement inserted before the terminal. The long arms **10** of the terminals are bent away from the axial direction preferably after the cement has hardened, and the assembly gripped by its ends between the jaws **15** of an axial rotating arbor. The jaws are segmental with the segments spaced from each other to permit the bent away arms to extend out radially. The resistance wire is then applied by winding several turns around the short arm **6** of one terminal, with the arbor not rotating, so as to secure the wire end, then bringing the wire out through a slot to the cylindrical surface. The arbor is then rotated to wind up the proper number of turns on the cylindrical surface in order to provide the desired resistance, after which the terminal portion of the wire is passed through the adjacent slot and wound about the shorter arm **6** of the remaining terminal **8**. To permanently secure the resistance wire ends to the arms **6**, **6**, the wrapped connections, after removing the assembly from the winding arbor, are dipped into molten solder **11** and removed, so as to solder the connection together. After the dip-soldering or the alternative procedure of welding have taken place, the longer arm **10**, **10** of the terminals are bent so as to project out axially from the core. The assembly is then given an enamel coating **13** as described below.

FIG. 2 indicates the assembly as it is inserted in the arbor for winding. By bending or positioning the longer arm **10** in the slot **12** it is possible to readily insert the assembly in place for winding, whereas if the longer arm **10** were in an axial position, more precise handling and additional time would be needed to insert the longer arm in a suitable arbor hole, thus slowing down production and resulting in increased cost of the units.

FIG. 3 shows the assembly as the principal portion of the resistance wire is wound on it. After winding the principal portion and permanently securing the wire ends, the longer arm of the terminals are bent back to the axial direction, and the units are dipped into a protective coating such as vitreous enamel and fired at the temperature and for a time appropriate to give the desired type of outer coating. This outer coating then serves to maintain the wire turns on the cylindrical core surface in spaced relationship and to protect them from adverse mechanical forces.

According to a preferred embodiment of the invention, the wound assembly is cleaned as by dipping in a caustic solution, for example, a 10% sodium hydroxide aqueous solution at 180° F. for two minutes, then is rinsed in water and thereafter dipped into an enamel slip such as one in which the enamel consists of 50% PbO, 20% SiO_2, 14% B_2O_3, 12% Al_2O_3, 2% Na_2O, 1% TiO_2, and 1% Co_2O_3. The coated assembly is now fired for about 1 hour to about 1250° F. to fuse and flow the enamel particles together giving an impervious surface. The resulting coat of enamel may be covered by a second enamel layer by repeating the last dipping and firing steps. Other

enamels such as those containing from about 28 to 55% lead oxide, 5 to 20% zinc oxide, 10 to 30% boric oxide, 4 to 10% aluminum oxide, and 11 to 32% silicon dioxide, can also be used.

Although the preferred core material is steatite, this invention is also suitable for use with insulating cores of porcelain, magnesium silicate, magnesium aluminum silicate, other ceramic material and even resins such as those of the epoxy type, with substantially the same advantages.

The resistance wire may be of any suitable type including Nichrome, copper, nickel-copper alloys, chromium-aluminum-iron alloys or other chromium alloys. This invention is not limited to the space wound single layer type windings but is equally suitable for overlap and progressive windings, although in the latter types an insulated wire such as one coated with ceramic as in U.S. Patent 2,650,975 should be used.

The space wound resistance elements prepared according to the teachings of this invention encompass units having resistance ranges of from 1 ohm or less to 50,000 ohms, and wattage ratings up to and in excess of 10 watts.

For the purpose of suitably bonding the terminals in the axial openings **5**, conventional cements such as the inorganic cement available commercially under the trade name "Sauereisen," or even aqueous sodium silicate are suitable. An effective cement is also made by mixing 5 pounds iron filings, 1 ounce ammonium chloride, 2 ounces flowers of sulfur and sufficient water to provide the desired consistency. These types of cement dry fairly readily so that after the terminals are inserted, standing for a few hours will sufficiently harden the cement to permit free handling. As an alternative for such spontaneously drying cements, enamel or other firing cements can be used. Suitable firing can then be carried out without the prior provision of the desired bond strength.

Instead of starting with a terminal in the shape illustrated in FIG. 1 the original terminal can be manufactured in a form in which it is shown in FIG. 2, that is with the long arm **10** prebent. However, when a cementing operation is used with such a prebent terminal, care should be taken to keep the cement from holding any part of the prebent arm in the prebent shape, if this arm is to be bent back into axial position. Unless precaution is taken some cement will tend to cover the desired bending portion of the long arm and a subsequent attempt to bend the arm into axial position will cause the bend to take place some distance from the bending center. The resulting resistor will then have the leads in improperly centered position. When no cement is used the U-shaped portion **8** of the terminals can be dimensioned so as to closely fit the openings **5** and frictionally hold the terminals in place. This type of anchorage is not too secure, however, and the bending operations should then be practiced in a relative gentle way. After the external enamel coating is applied and fired however, the terminals will be quite securely anchored and will meet commercial standards.

The flowing of the external enamel over the terminals generally takes place very freely. In fact, if the short arms **6** project out more than about ⅛ of an inch, a relatively heavy bead of enamel will form around them at each end of the resistor core. Such a bead is sometimes not desirable, since it may tend to crack at the site where the long arms emerge, when the long arms are bent. This difficulty can be minimized by having the short arms project out as little as possible and preferably not more than ⅛ of an inch.

The external enamel also covers both long arms **10**, **10**, when the enamel is applied by dipping operation. The excess enamel on these arms is usually removed to present a better appearance and the removal can be accomplished by scraping after the enamel is fused. However, the enamel removal is very greatly simplified if the terminals or at least the surfaces of the long arms **10** are made of nickel. A very simple buffing operation will then very rapidly remove the fused enamel. The presence of the enamel on the terminals helps protect them against oxidation during the enamel firing operation. It is accordingly desirable to have the entire resistor, terminals and all, dipped into the enamel slip before the firing. Where the terminal protection is not needed however, the dipping can be carried out with the long arms bent in a position shown in FIG. 2, so that the arms are not immersed in the slip. The arms can then be re-turned to the axial position before the firing. If desired, after the bending, a dab of slip can be applied at the core site exposed by the bending operation, so as to make a more uniform enamel coating. Alternatively the dipping can be carried out by keeping only one long arm **10** out of contact with the slip, so that only the other long arm needs to be cleaned.

Where the core material is a resin, resinous cements are also suitable for holding the terminals in place. Although resinous cements will not withstand as high an operating temperature as inorganic cements, they can be made to withstand just as high a temperature as the resinous core, and in some applications where relatively low operating temperatures can be tolerated, they make suitable constructions. For example, a solid epoxy resin core can be used with terminals cemented by epoxy type cements, and can have a molded epoxy resin covering.

A suitable solder for bonding the resistance wire to the short arms **6** is one that has a melting point above the maximum temperature to which the resistor is to be exposed, not only in operation but in the course of the enamel firing treatment. A desirable solder melting point is 1450° F. Solders of this type are described in National Bureau of Standards, Circular 492, issued April 28, 1950, pages 9 to 12. For best results the joint should be subjected to the action of a flux such as borax or potassium fluoborate or any of the other fluxes referred to in the above-identified circular. The flux can either be applied to the joint by a preliminary dip or it can be floated on top of a molten solder bath.

FIG. 4 illustrates an alternative terminal structure in which the ribs or teeth are omitted from the short arms. The wrapping of the wire ends around these arms does not provide as secure a temporary anchorage but this form can be used if desired.

FIG. 5 illustrates a further modified terminal having folded lead portion **14** secured to a washer **16**. The folded lead portion has a long arm **18** which acts as a terminal lead and a short arm **20** which can be used as in the constructions of FIGS. 1 and 4. Alternatively, the short arms can be fastened to the washer **16** and such terminal structure can be secured to the end of a metal film resistor in place of the terminal end caps presently used for this type of resistor. Furthermore, the washer **16** could be an end cap having a central opening with the terminal lead secured thereto.

FIG. 6 shows a terminal having a U-shaped anchor or body portion **22** which has secured to its center point **24** a terminal wire **26**. The body of this terminal is bonded to the insulating core of the resistor which may be either the metal film type or wire wound type and the connection of the resistance film or wire is readily made to the ends **28** of the U-shaped portion **22**.

The U-shaped bight portions of the present invention can vary from gradually curving constructions as in FIG. 4 to relatively sharply bent ones as in FIG. 1. Furthermore, the short arm can be projected outwardly in any desired direction. It is preferred, however, that there be at least two teeth in these arms and that they be about 5 mils high and spaced 10 to 20 mils apart. In the construction of FIG. 1 the short arms are flattened so that the teeth-carrying portion is wider than the remainder of the terminal, but unflattened arms are also suitable.

As indicated above, numerous advantages are inherent in this invention among which the more important are that wire wound power resistors are available for connecting to electrical components without need of mounting brackets or additional mounting hardware, the core

can be more efficiently used, as it is not necessary to place terminating tabs or ears about the end of the core and thus use up a substantial segment of the peripheral area of the core that would otherwise be available for heat dissipation. Moreover, the present invention provides an increased surface area for winding. A further important advantage of this invention is its ease of manufacturing inasmuch as it can be readily inserted into a winding arbor and the ends of the resistance wire are readily anchored to the terminal leads by a simple dip-soldering. Furthermore the terminal leads are directly supported by the core rather than the resistance wire and so can withstand large and continuous stresses without damage to the electrical connection between the terminals and the resistance wire.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope hereof, it is to be understood that the invention is not limited to the specific embodiments hereof except as defined in the appended claims.

What is claimed:

1. A process of preparing a resistor, comprising the steps of providing a cylindrical insulator with recesses at each end, securing in each of these recesses the bight portion of an elongated lead conductor bent into the general shape of a U with one arm of the U much shorter than the other but long enough to be wound with a plurality of turns of a resistance conductor, each short arm projecting in substantial alignment with the long axis of the insulator and extending only a short distance from the end of the insulator, bending the long arm of the

lead conductor away from the long axis of the insulator, gripping the ends of the insulator for rotation about the long axis in an axially rotating device, winding a plurality of turns of a resistance conductor around one projecting short arm rotating the gripped insulator by the device, winding the resistance conductor around the rotating insulator, winding a plurality of turns of the resistance conductor around the other short arm, dip soldering the wound ends of the resistance conductor to the respective short arms, then bending the long arms of the lead conductors back to the axial position, and covering the final product with a solid heat-resistant protective surface.

2. A process for preparing a resistor as defined in claim 1 wherein the short arms of the generally U-shaped conductors are provided with a plurality of ribs, and the windings around the short arms are located between adjacent pairs of said plurality of ribs.

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