

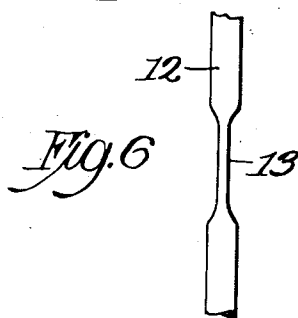
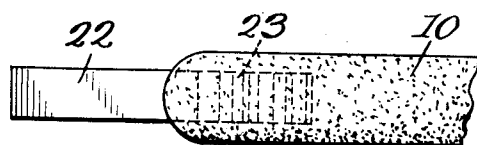
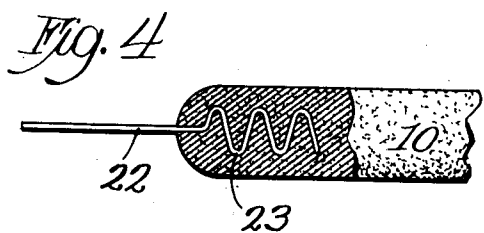
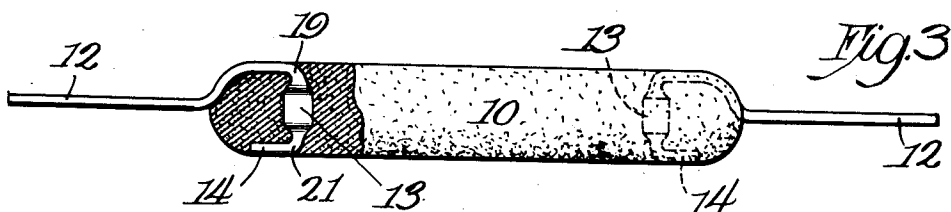
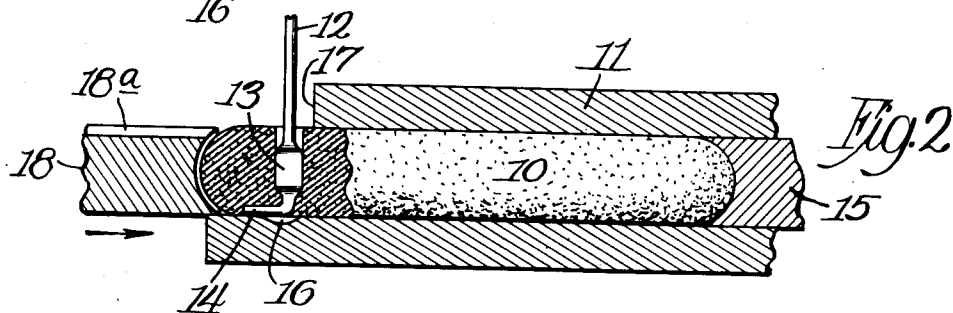
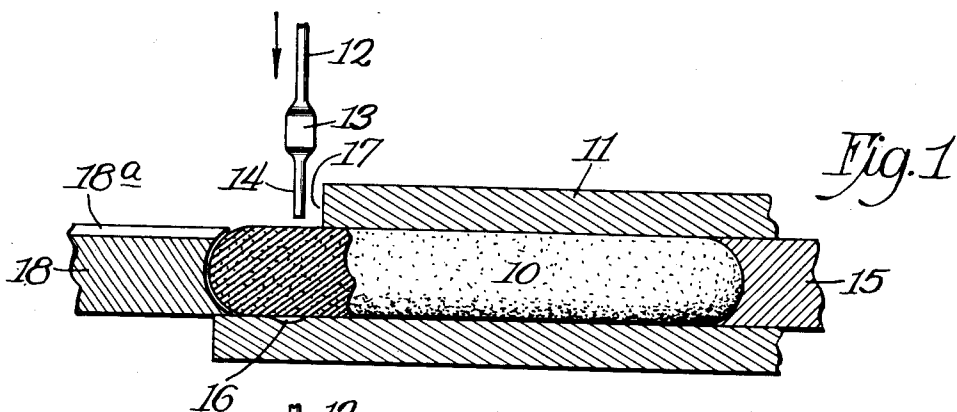
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T. C. BROWNE ET AL

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ELECTRICAL CONDUCTIVE ELEMENT AND PROCESS OF MANUFACTURE

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Inventors
Theodore C. Browne
Oliver Bruggmann

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ELECTRICAL CONDUCTIVE ELEMENT AND
PROCESS OF MANUFACTURETheodore C. Browne, Chicago, Ill., and Elmer
Brugmann, Cambridge, Mass.

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18 Claims. (Cl. 201—76)

The objects of the invention are to produce an element which is physically strong, chemically stable, electrically constant and dependable; to provide a method whereby the elements are caused to have a known and substantially unvarying resistance; to provide a novel, dependable process of affixing terminals thereto; to provide a new, inexpensive method of cure to harden the piece and to secure the advantage of simple, low cost production on automatic machinery.

Further objects of the invention will become apparent from the specification and the drawing in which

Fig. 1 illustrates the initial step in the attachment of the terminal;

Fig. 2 illustrates a further step;

Fig. 3 shows a completed resistor unit with one end in section;

Fig. 4 is a section through the end of an alternative form of terminal;

Fig. 5 is an elevation of the form illustrated in Fig. 4, and

Fig. 6 is an elevation of the contact end of one form of lead.

Ordinarily, radio resistors possess a comparatively high resistance. The disparity of this resistance compared to the low value of resistance in the metal contacts and the physical difference between the metal and the material composing the resistor body gives rise to great variation in the product, for the variable contact resistance often dominates the effect. The mechanical expedients to obviate this are frequently costly and but partially effective. Among the various expedients are those which endeavor to reduce the current density at the union and spread out the area of contact by some such means as electroplating the end of the resistor and soldering the terminal to the metal coat.

It has proved difficult, in practice, to develop a simple, electrically accurate, secure and cheap means of affixing the contacts or terminals.

In the design of a resistor, the first problem to be faced is to stick the conductive particles together in some permanent way. The cement used must be relatively chemically inert, must withstand moderate heating, must not ionize because of the passage of the electric current, or break down because of the voltage difference at the two terminals. It must lend itself too to destroying the errors of "contact resistance."

We have solved these two problems simultaneously by choosing a cement which has the required chemical and electrical characteristics, but which in addition also possesses the power of

"wetting" metal. Explanations of the phenomenon of "wetting" are not consistent. For the purposes of this specification, we may define it as that relationship which exists between two substances which causes one of the substances to adhere to the surface of the other or even to spread out and creep over the other surface.

The degree of adhesion which the cement exhibits towards some metals, notably copper, appears to approximate the self adhesion or cohesion of the cement itself. To elaborate and explain, if certain common commercial resins having a metal insert moulded therein are hit with a hammer, the compound will fly away from the metal leaving large areas of the insert bare and clean. Such is not the case if the resin wets the metal. The break may occur anywhere and large patches of the cured compound stick tenaciously to the insert. Consequently, therefore, if a metallic contact is thrust into a uniform mixture of cement and conductive material, the resistance at the point of contact will be a function of the surface area involved which is predictable and constant.

We use for such a cement the resins arising from the action of phthalic anhydrid and glycerol. These resins are well known and form the basis of a considerable chemical literature. Throughout the specification, therefore, they will be referred to as glycerophthalate resins which is understood to mean any resin, oil modified or not, which possesses the general characteristics of a resin produced by the action of polybasic acid on a polyhydric alcohol.

In addition to the desirable qualities enumerated above, these resins possess valuable physical characteristics which if taken advantage of in the manner subsequently to be brought out, make a very simple process of manufacture possible.

Manufacture of the resistor

The conductive material which we prefer is commonly lamp black or carbon black, although for certain ranges of resistance, metallic compounds are very useful. For such resistances, any metallic compound, or finely divided metallic powder, which conducts electricity and is otherwise unobjectionable may be used. We prefer, however, to use finely divided oxides of iron (ferrous, ferric, etc.) and also molybdenum sulphide.

The filler performs no necessary mechanical function. Electrically, however, its presence is essential since it acts as a dispersive agent to the carbon grains. The electrical resistance is determined by the mutual proportion of non-con-

ductive filler and conductive particles. In the specification and claims, the term "non-metallic" is not intended to exclude metallic compounds or even finely divided metal powders if cemented together in the manner described.

The filler may be any finely divided relatively inert substance. We prefer such substances as silica, keiselguhr, infusorial earth, bentonite, slate flour, or fine sand. The sand, we have found useful when "low" resins are used and passages must be left through the mass for the evolution of gas.

A typical mixture is

	Parts
15 Silica	4
Sand	4
Carbon black	2
Resin	1

The ingredients are mixed in a heated pug mill long enough to insure that a uniform mixture is produced. If necessary, the mass from the pug mill may be briquetted in a suitable press and then the mass is fed into the forming machine. For this operation, we prefer to use a standard rubber tube extruding machine because the process is continuous and cheap, although to produce other than straight shapes, it is necessary to follow either a moulding process or to use a tablet machine.

Resins ordinarily used require a heated feed screw, cylinder and die, the temperatures of which are preferably independently adjustable.

A long dense rod of the material is then forced out of the machine. The rods are then cut into lengths corresponding to one completed resistor. The cutting may be done as a special step, or as part of the process of extrusion, in which case a "progressive" knife is used which travels during its cut at the same speed as that with which the rod issues from the extruding die. Or it may be done in a step corresponding to a blanking operation in the press which inserts the terminals.

To prevent confusion with the metal lead, we prefer to denote the means by which the current enters and leaves the conductive elements by the term leads. Its connotation is not confined to wires or strips, but to plugs, inserts, caps, collars, and means by which electrical conduction is secured.

The operation of inserting terminals is indicated diagrammatically at Figs. 1 and 2. A clean wire, 12, preferably copper, is flattened at 13 adjacent its end. The length of the unflattened portion 14 equals approximately one diameter of the resistor slug 10. The slug is inserted in a split die indicated by 11. A stop plunger 15 initially positions the piece. A shallow groove 16 is provided in the lower wall of the die which causes the end 14 of the wire 12 to be turned over as shown on Fig. 2, when the wire is driven down the proper distance. The plunger 18 now moves inward while the stop 15 moves outwardly, resisting, however, this outward movement with a definite pressure. The wire 12 then engages the face 17 and is folded over falling into the clearance slot 18a provided in the plunger.

After the plunger 18 has passed the face 17, the plunger 15 is arranged to resist such movement to a considerable degree. The plastic material is thus forced into intimate contact with the wire and fills any voids which the wire may have caused.

When the pig-tail terminal has already been applied to one end of the slug and while the second terminal is being applied, the pig tail wire

is laid in a clearance slot provided in the stop plunger.

If desired, the wires may be further driven into the slug by an operation which produces the form shown in Fig. 3.

Since the material of the slug is plastic (its consistency is about that of vulcanized rubber, but with little elasticity), the bends 19 and 21 might occur in the wire at any place were the flattened portion 13 not provided. With the portion 13 flat and stiff along the only plane where bending can occur, bending will occur where the stiffness ceases. The same amount of wire imbedded in precisely the same way will, therefore, always be imbedded in the piece.

An alternative form of terminal is shown in Figs. 4 and 5. A thin strip of metal 22 bears the corrugations or pleats 23 upon its end. This terminal is driven edgewise into the slug. In such a case, the compacting plungers 15 and 18 are split to receive the shank of 22, but the mass is compacted around the corrugations by pressure as before.

At slug or die temperatures which are convenient and practical, certain of the harder resins will not "wet" the wire. We have secured adhesion by heating the wire in a reducing gas flame and plunging the hot wire into the slug.

Where very hard resins are initially used, sometimes a good bond between the resistor slug and lead wire is difficult to secure. We avoid this difficulty by dipping the ends of the lead wires into a cement composed of a low resin and finely divided conductive material preferably of the same nature as that used in the slug. The dipped ends are inserted in the slug as previously described.

When resistors of quite high resistance are to be manufactured, it is helpful at times to increase the surface area and decrease the potential drop at the contact between the resistive material and the lead wire. If granulated, sintered petroleum coke is added to the cement above described, and the ends of the lead coated therewith before insertion into the slug, the intimacy of contact is increased enormously, and in case the conductive material of the cement does not have the requisite conductivity, colloidal or flake graphite may be added in small amounts.

In all cases where cemented leads are required, it is helpful to bake the lead wires slightly to harden the cement. All ingredients recommended for the cement are not essential,—sand could be substituted for petroleum coke if the concentration of fine conductive particles were increased. It is essential only that in the restricted zone of contact both conductivity and surface area be increased. We strongly prefer, however, to use a resin in the cement which is in the same general series as the resin bonding the slug, since this saves the interjection of variables in the final operation of curing.

The pieces, now provided with pigtails at either end, are ready for the curing operation. In the operations previously described, the so-called "low" resins have been used first because a plastic stage is desirable for the application of the terminals and second because hard, flinty resins are not easily workable in extrusion machines. The pieces could be finished by being inserted in or supported by moulds during cure. If cured without support, the "low" resins soften so much on heating before polymerization commences that the pieces slump down to useless shapes. Some soft resins contain solvents which are vaporized on heating. Polymerization is accom-

panied by some evolution of gas. The outermost portion of the piece hardens or "skins" first. These conditions give rise to a chain of difficulties, the most serious of which is the popping open of the piece, for the gas, released from the uncured center, pressing on the skin actually causes the piece to explode. In experimental development, the pieces were first obtained only by polymerizing in an atmosphere saturated with solvents of the resin.

To handle large quantities expeditiously, and cheaply, and to avoid the expense of curing moulds, we prefer the following procedure in which difficulties with slumping, blow holes and skin cracks are avoided. After attaching the leads and before curing, the pieces are placed on a bed of moulding sand, (a convenient fixture is an ordinary foundry flask) and fine sand sprinkled over them which is tamped down. Several layers are thus built up. The sandpacked pieces are then placed in an oven and allowed to bake for a suitable time. It is to be understood that the resins as obtained in the trade are more or less polymerized. Therefore, no curing temperature or time can be stated. Both may vary over wide limits depending on the degree of cure sought and the degree of polymerization of the resin used.

The sand acts first as a mechanical support, preventing the softened pieces from slumping and retains their original shape; and secondly, because gases diffuse but slowly through the sand, a gas atmosphere is maintained against the surface of each individual piece which is made up of vapors of such solvents or plasticizers of the resin that the skin does not form. True "saturated atmosphere drying" is thus simply secured. The piece cures uniformly and without bubbles or voids (which cause electrical eccentricities) if the rate and time of heating are properly controlled.

After baking, the contents of the flask are dumped on a riddle and the sand shaken out. The parts may be brushed, electrically tested and finished by painting, labelling or otherwise.

Where very low resistance is required, as in brushes for small motors, we omit the dispersive agent entirely and change to another allotropic form of carbon, namely, graphite. Excellent contact is obtained between the pigtail and cemented graphite mass due to the previously explained bonding characteristics of the resin and the lead wire metal.

Such a brush is particularly suitable for the low voltage high current conditions met in automotive requirements. The term "green" as used in the accompanying claims is intended to cover raw material without any cooking whatever, and also any material which contains sufficient volatile solvents to cause blistering under the heat of the curing process, or which contains sufficient solvent to cause the molded article to melt and lose its shape while being heated for curing purposes.

What we claim, therefore, is:

1. An electrical conductive element comprising a metallic electrical lead-in conductor cured therein, and a mass of finely divided conductive particles held together by a resinous bond having the power to wet the surface of the metal lead with an adhesion substantially equal to the cohesive force of the resinous material.

2. An electrical conductive element comprising a lead cured therein, a mass of conductive particles dispersed and adjusted in electrical resistance by non-conductive particles, and bonded

together by a resinous cement having the power to wet the surface of the metal lead with an adhesion substantially equal to the cohesive force of the resinous material.

3. An electrical conductive element comprising a metallic lead cured therein and a non-metallic conductive mass having contact between the lead and the mass secured by a coating on the lead of finely divided conductive material suspended in a resin having the power to wet the surface of the metal with an adhesion substantially equal to the cohesive force of the resinous material.

4. An electrical conductive element comprising an elongated non-metallic conductive body having metallic wire terminals, a flattened portion on the wire embedded in the conductive body with the plane of its flattened portion parallel to the longitudinal axis of the body, said wire immediately adjacent the flattened portion being bent through a substantial angle.

5. That method of curing formed shapes of polymerizable material containing vaporizable solvents which consists of packing said shapes in a green state in finely divided material, and heating said shapes thus packed, whereby, because of the slow rate of diffusion of gases through said finely divided material, a saturated gaseous atmosphere is maintained against the surface of said polymerizable piece.

6. That method of producing articles from condensable resins containing vaporizable solvents which consists in mixing the resin with a filler, forming desired shapes of such mixtures, packing said shapes in a green state in finely divided material, and heating said shapes thus packed until the desired degree of polymerization is obtained.

7. That method of securing contact between a metallic lead and a non-metallic conductor which consists in coating the lead with finely divided conductive material suspended in a resin having the power to wet the surface of the metal with an adhesion substantially equal to the cohesive force of the resin, and curing the mass by the application of heat.

8. That method of uniting a non-metallic current carrying element and a metallic conductor which consists of coating said conductor with a polymerizable resin having the power to wet metal with an adhesion substantially equal to the cohesive force of the resin, using a resin of the same series as the bond for the non-metallic conductive mass, inserting the conductor in the mass, and subsequently polymerizing the whole mass.

9. That method of securing uniform contact resistance between a metallic conductor and a non-metallic conductive mass which consists of bonding the conductive particles with a resin having the power to wet the conductor with an adhesion substantially equal to the cohesive force of the resin, inserting the conductors in the mass, and subsequently polymerizing the resin binder.

10. A resistor containing a polymerized resin of the glycerophthalate group, finely divided conductive material, and an inert dispersive agent and provided with metallic contacts cured therein; the surface of which is wet by the resin.

11. That method of preventing skin coating during cure and consequent rupture of moulded material having vaporizable ingredients which consists of packing the green moulded article in finely divided material, and subsequently heating

both the article and the packing until the cure is complete.

12. That method of polymerizing soft resin containing vaporizable solvents which consists of packing the formed article in a green state in finely powdered material and heating the packed mass, thereby causing a blanket of solvent to surround the piece during the major portion of its cure.

13. In an electrical conductive element, a non-metallic conductive mass, and a metallic terminal comprising a strip of metal of uniform thickness having a corrugated end which end is embedded in the mass.

14. That method of inserting terminals in non-metallic conductive masses which consists of providing a strip of metal, bending that portion adjacent one end of the strip through a substantial angle to its axis, driving the formed strip edgewise into the plastic conductive mass, and subsequently hardening the mass.

15. The method of inserting terminals in non-metallic conductive masses which consists of

providing a strip of metal, corrugating one end of said strip transversely of its longitudinal axis, driving the formed strip edgewise into the plastic conductive mass, and subsequently hardening the mass.

16. A resistor containing a resin of the glycerophthalate group, finely divided conductive material, and provided with metallic contacts inserted therein before curing and cured therein, the surface of which is wet by the resin.

17. A resistor containing a polymerized resin of the glycerophthalate group, finely divided carbon, and provided with metallic contacts inserted therein before curing and cured therein, the surface of which is wet by the resin.

18. A resistor containing a polymerized resin of the glycerophthalate group, finely divided carbon, and an inert filler, said resistor being provided with imbedded metallic contacts inserted therein before curing and cured therein, the surface of which is wet by the resin.

THEODORE C. BROWNE.
ELMER BRUGMANN.

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