

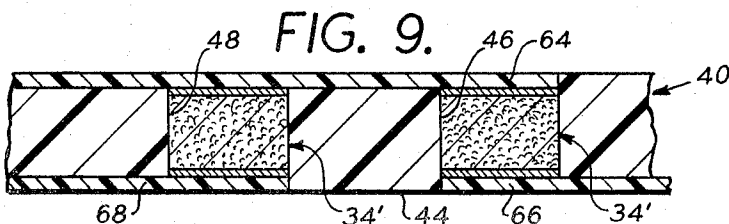
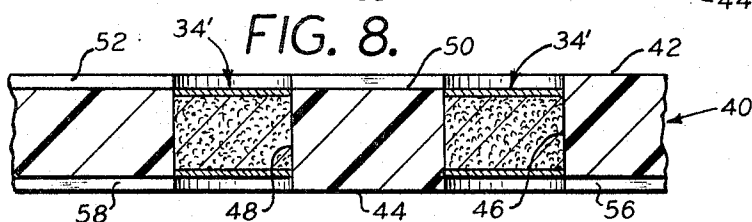
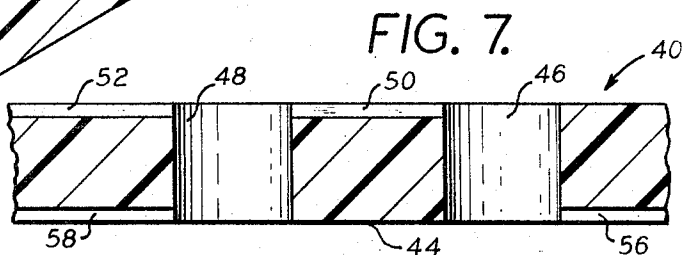
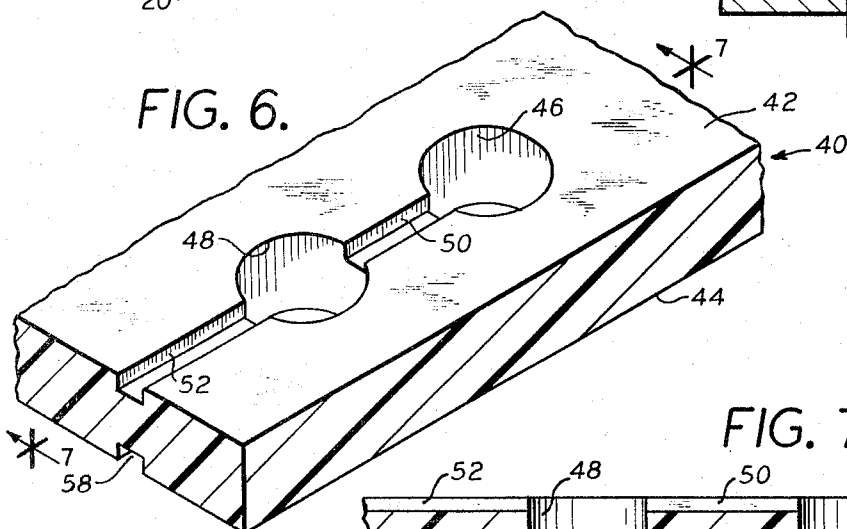
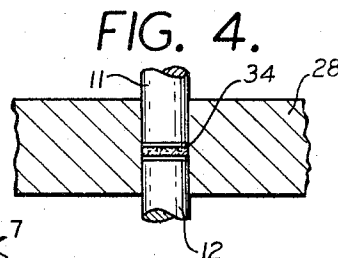
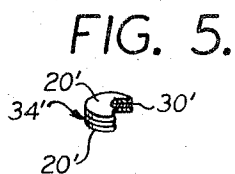
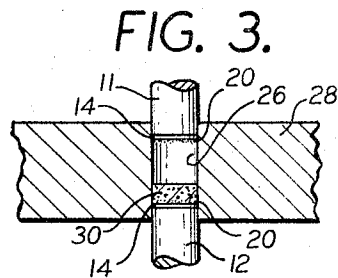
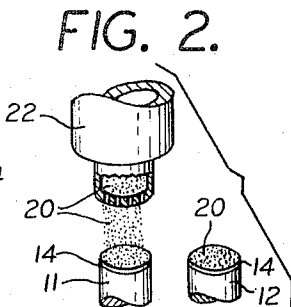
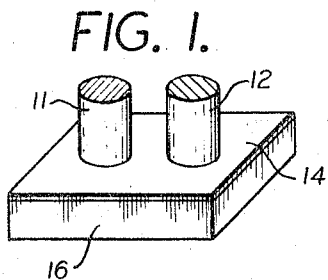
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3,302,272

FORMING A RESISTOR WITH THIN, COMPRESSED, CONTACT PORTIONS

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3,302,272

FORMING A RESISTOR WITH THIN, COMPRESSED, CONTACT PORTIONS

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1 Claim. (Cl. 29—155.71)

This invention relates to electrical resistors, and more particularly to leadless resistors having electrically-conductive terminal material at both ends and having resistor body composition material sandwiched between the terminals in a unitary molded product. Such resistors are the invention of C. H. Krellner and are fully disclosed in United States Patent 2,903,666, assigned to the same assignee as the present invention. The present invention relates to novel button-type resistors of this general class which are of very short axial length in comparison with their diameter, such resistors being useable in boards having printed circuits. This invention relates further to novel circuit boards including such resistors.

The resistors of this invention are made in sizes down to 0.030 inch in length, and sometimes with diameters as large as four or five times the length of the resistor. The ends of the resistor are made of metal which is a good electrical conductor, and the body of the resistor between the metal end terminals is made of any standard resistor body composition suitable for making molded resistors.

The manufacture of resistors of the character indicated presents difficult problems in keeping the metal powder, which is used for molding the terminals, from commingling with the body composition along the side surfaces of the short resistor body with resulting short-circuiting or substantial reduction in the resistance of the unit.

It is an object of the invention to provide an improved method of making resistors, and especially very short resistors, with metal terminals at reliable spacing from one another across the entire resistor element including the peripheral edges of the terminals where they merge with the side surface of the resistor.

Another object is to provide an improved button-type resistor that is of substantial cross section in proportion to the length of the resistor and with very limited spacing of the metal end terminals from one another.

Another object is to provide a simplified and improved circuit board incorporating such novel resistors.

Other objects, features and advantages of the invention will appear or be pointed out as the description proceeds.

In the drawing, forming a part hereof, in which like reference characters indicate corresponding parts in all the views:

FIGURE 1 is a diagrammatic view showing the step of coating the end faces of plungers with a release material;

FIGURE 2 is a diagrammatic view illustrating the step of placing powdered terminal material on the coated faces of the plungers;

FIGURES 3 and 4 are sectional views illustrating the step of making a resistor by compressing material between the plungers in a die;

FIGURE 5 is an isometric view, partly broken away and in section, of the resistor made in the die illustrated in FIGURES 3 and 4;

FIGURE 6 is an enlarged, fragmentary view showing a board in which the resistors are used;

FIGURE 7 is a sectional view taken on the line 7—7 of FIGURE 6;

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FIGURE 8 is a view similar to FIGURE 7 but with resistors located in the holes in the board of FIGURE 7; and

FIGURE 9 is a view similar to FIGURE 8 with electrically conductive material placed in the channels of the board and over the terminal surfaces of the resistor shown in FIGURE 8.

FIGURE 1 shows two plungers 11 and 12 which have their end faces brought into contact with a liquid coating 14 which is poured out in a thin layer on a supporting surface 16. This coating 14 adheres to the end faces of the plungers 11 and 12; and the plungers are then turned upside-down, as shown in FIGURE 2.

Powdered metal 20, such as electrolytic copper powder or a mixture of copper powder and tin powder, with any binder which is desired for the purpose, is then applied over the coating 14 on the upturned end faces of the plungers 11 and 12. FIGURE 2 shows the electrically-conductive powder 20 sprinkled from a container 22 to form a thin layer on top of the coating 14.

After applying sufficient powdered material 20 to the end faces of the plungers 11 and 12, these plungers are then inserted into opposite ends of a cylindrical die cavity 26 in a die 28 with a quantity of powdered resistor body composition 30 on the top of plunger 12 which is at the bottom of the die. The amount of resistor body composition 30 which is inserted into the cavity 26, before putting the top plunger 12 into the die, depends upon the length of resistor being manufactured. Ordinarily, the depth of resistor body composition 30 will be quite small because this invention is primarily concerned with the manufacture of button-type resistors having a length substantially less than their diameters.

The layer of powdered metal 20 is located directly over the coating 14 on the lower plunger 11, and there is a definite interface between the layer of powdered metal 20 and the quantity of resistor body composition 30 in the die.

The top plunger 11 is then brought downward into contact with the mass of resistor body composition 30. This can be done without moving the lower plunger 12 or the lower plunger 12 may be moved upward, or both of the plungers 11 and 12 may move toward one another to obtain a compression of the resistor body composition 30, a bonding of the layers of powdered metal 20 to the resistor body composition 30, and a molding of the resistor in situ in the die.

The coatings 14 not only serve the purpose of initially holding a thin layer of powdered metal 20 on the end faces of the plungers 11 and 12, but also serve as a release which enables the plungers 11 and 12 to pull away cleanly from the metal powder 20 after molding of the resistor. This release may result from the powdered metal 20 having much stronger adherence to the resistor and to itself than it has to the coating 14 after molding, or it may result from evaporation of the coating 14 during the molding process. While it is contemplated that many slightly viscous liquids will perform satisfactorily as the plunger coating composition 14, it has been found that light oils are particularly good for this use and more specifically that a light vegetable oil, such as a cooking or salad oil is preferred.

The pressure employed in the molding operation will be sufficient to mold a resistor body and its terminals to the desired self-sustaining form and this may vary from a moderate pressure, for example, about 1300 lbs./sq. in. on up to pressures much higher, depending on the materials used, the dimensions of the resistor, and other factors. Following the molding operation the resistor will be ejected from the mold, for example, by the plunger

12 which is long enough to push the molded resistor out of the die.

FIGURE 4 shows the material in the die cavity 26 compressed and molded to form a resistor 34. No further description of the material of the resistor is necessary for a complete understanding of this invention, since materials for molding resistors are well known to those skilled in the art. Such resistor compositions typically comprise (1) material of high specific resistance, for example calcined carbon black, or graphite, or both, (2) filler material, for example silica powder, and (3) a binder, for example a thermosetting resin of the phenol-formaldehyde type. It will be evident that the process disclosed thus far provides a resistor 34 having a mid portion of resistor body composition sandwiched between end portions of higher electrical conductivity and with the distance between the end portions uniform across their entire width. The process lends itself to the manufacture of resistors having extremely short lengths; and the ultimate is a construction in which the distance between the molded end portions of the resistor is no greater than the diameter of the powdered particles of which the resistor body composition is made. In practice this has proved practical for making button-type resistors having a total length of only 0.030 inch.

Following removal from the die, the molded resistors then will be cured in an oven to cause the resin to set. The curing temperature may vary depending on the particular thermosetting resin used, the time of curing, the size of the resistors, and other factors, but for phenol formaldehyde resin may be in the neighborhood of 475° F. If desired, the curing may be done in a neutral (nitrogen) atmosphere, or in a reducing (hydrogen) atmosphere, although with the preferred compositions described hereinabove this was not found to be necessary to prevent oxidation of the metal terminals.

Following the curing operation the resistors may be impregnated and coated with a wax or other resin to make them more resistant to the effects of moisture. This treating material may, for example, be of the type disclosed in the Valey Patent 2,313,853, March 16, 1943. It should be noted, however, that for the purpose of some uses of the resistor, such impregnation and coating is not necessary.

FIGURE 5 shows the finished resistor 34 after it is removed from the die 28 and the different layers of the resistor in FIGURE 5 are indicated by the same reference characters as the materials of which the layers are made, but with a prime appended.

FIGURE 6 shows a board 40 with which a resistor 34' is advantageously used. This board 40 has a top face 42 and a bottom face 44. There are holes 46 and 48 in the board 40 and opening through the top and bottom faces 42 and 44, respectively. The holes 46 and 48 are connected by a channel 50. Another channel 52 extends from the hole 48 to another hole in the board or to some part of an electric circuit.

In the construction illustrated there are other channels 56 and 58 (FIGURE 7) in the bottom face 44 of the board 40. These channels 56 and 58 are for holding electrically conductive material leading from the holes 46 and 48 respectively, to different parts of an electric circuit.

Resistors 34' (FIGURE 8) are inserted into the holes 46 and 48. These resistors 34' preferably fit tightly into the holes 46 and 48 with a press fit. In the preferred construction the resistors 34' are shorter than the thickness of the board 40 so that the terminal end faces of the resistors are at a level inward from the level of the top face 42 and the bottom face 44 of the board. In

the construction illustrated the terminal faces of the resistors 34' are substantially flush with the bottoms of the channels 50, 52, 56 and 58.

The board 40 can be made of any kind of material which is a non-conductor of electricity, but it is preferably made of a resin which is a non-conductor of electricity.

FIGURE 9 shows electrically-conductive material 64 filling the channels in the board 40 and covering the terminal ends of the resistors 34'. This electrically-conductive material 64 can be metal but is preferably a conductive resin, such as an epoxy resin. Other and similar electrically-conductive material 66 and 68 is used to fill the channels 56 and 58 in the bottom face 44 of the board. This electrically-conductive material 66 and 68 also fills the holes 46 and 48 where the resistors 34' are depressed below the end edges of the holes.

In placing the electrically-conductive material 64, 66 and 68 in the depressions in the board 40, the electrically-conductive material is preferably poured into the depressions in a liquid condition and allowed to harden. This is accomplished by first orienting the board 40 so that the top face 42 is uppermost; and after the electrically-conductive material 64 has hardened, the board 40 is turned over so as to locate the bottom face 44 uppermost for filling the depressions in the bottom face.

The electrically-conductive material 64, 66 and 68 adheres firmly to the terminal end surfaces of the resistors 34'. The electrically-conductive material 64 connects the resistors 34' together at their upper ends, but there is no channel between these resistors at the bottom of the board and their lower ends are connected by the electrically-conductive materials 66 and 68 to other parts of an electric circuit, depending upon the wiring diagram.

The preferred embodiment of the invention has been illustrated and described, but changes and modifications can be made and some features can be used in different combinations without departing from the invention as defined in the claim.

What is claimed is:

In the manufacture of electrical resistors by compressing a resistor body composition in a cylindrical die cavity between circular end faces of plungers, said resistor body composition comprising a mixture of conductive material of high specific resistance, a filler, and a binder, the improvement which comprises: coating the end faces of the plungers with a liquid release agent coating; applying electrically conductive terminal powder to the liquid coating on said plungers wherein said terminal powder is retained on the plungers by said liquid coating; placing in said die cavity a quantity of said resistor body compositions; compressing said resistor body composition in said die cavity with the coated end faces of the plungers whereby an electrical resistor is molded in situ with said resistor body composition being bonded at both ends to said conductive terminal powder and with the sides of said resistor body composition being free of any coating of said terminal material; and removing said plungers and ejecting said electrical resistor from said die.

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