United States Patent [19]
Rudd et al.
[11] 3,849,878
[45] Nov. 26, 1974

[54] METHOD OF MAKING RESISTANCE ELEMENT

[75] Inventors: **Floyd R. Rudd**, North Wales; **George D. MacKenzie**, Maple Glen, both of Pa.

[73] Assignee: **TRW, Inc.**, Cleveland, Ohio

[22] Filed: **Dec. 4, 1972**

[21] Appl. No.: **311,555**

[52] **U.S. Cl.** **29/610**, 29/412, 29/417, 29/423, 29/424, 338/263
[51] **Int. Cl.** **H01c 17/00**
[58] **Field of Search** 29/610, 412, 417, 620, 29/424, 423; 338/262, 263, 264, 265, 308

[56] **References Cited**

UNITED STATES PATENTS

3,252,205	5/1966	Hancock et al.	29/424 X
3,358,362	12/1967	McElroy	29/620 X

Primary Examiner—Charles W. Lanham
Assistant Examiner—Victor A. DiPalma
Attorney, Agent, or Firm—Jacob Trachtman

[57] **ABSTRACT**

A method of making wire wound electrical resistance elements comprising the steps of winding a respective resistance wire helically around and along each of a plurality of elongated wire cores which cores are coated with an insulating material, coating each of said wound cores with a protective layer, arranging said wound cores in closely spaced parallel relation, encapsulating said arranged wire cores in a block of plastic material, cutting through the block and the wound cores at longitudinally spaced points along planes perpendicular to the longitudinal axes of the wound cores to form a plurality of wafers each of which contains a plurality of resistance elements, and then separating said resistance elements from the plastic of the respective wafers. The disclosure also includes the steps in which prior to separating resistance elements from the plastic of the wafer, the ends of the wire cores are contacted with an etchant to etch away a portion of the ends of the wire cores, after which the ends are coated with a film of an insulating material.

7 Claims, 7 Drawing Figures

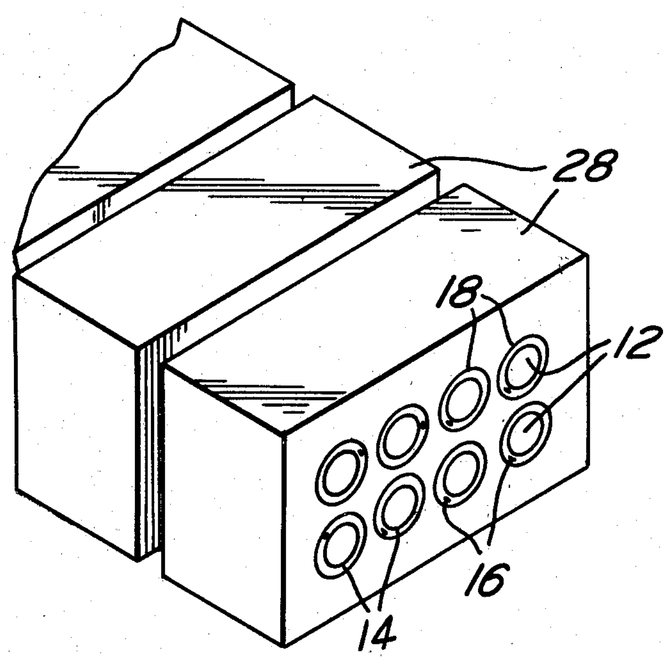
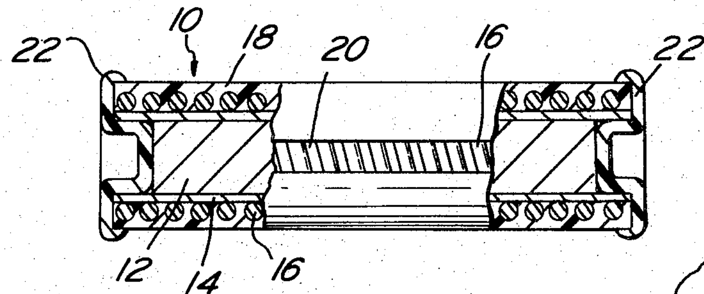


FIG. 1



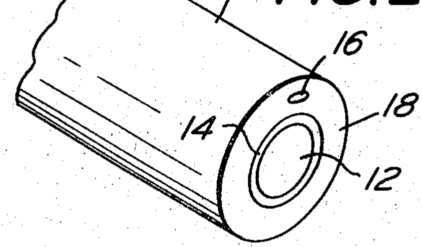
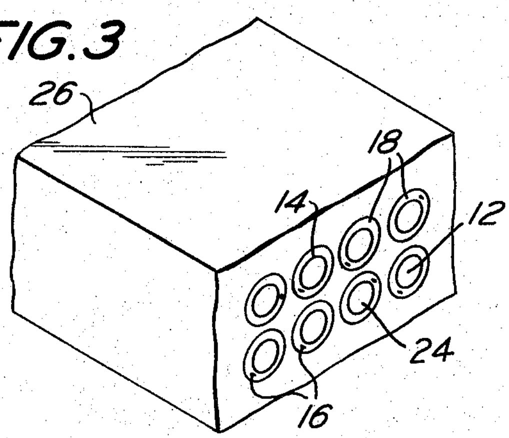


FIG. 2

FIG. 3



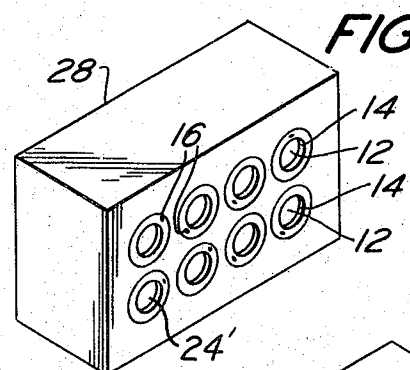


FIG. 5

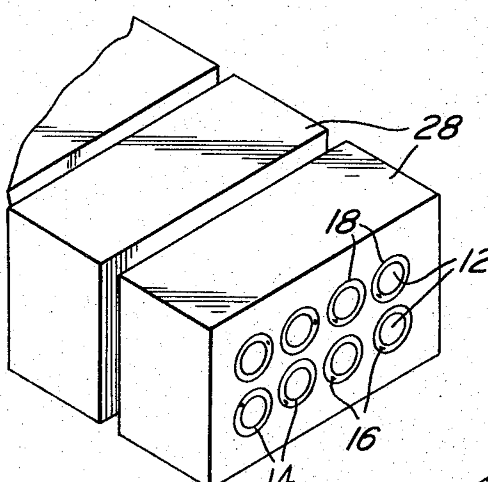


FIG. 4

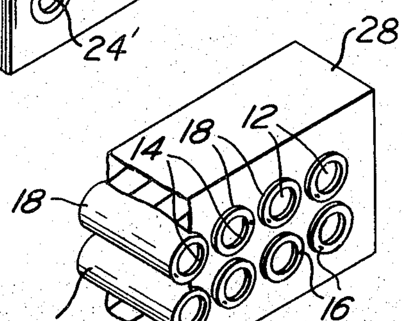


FIG. 6

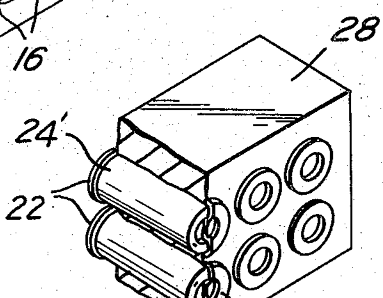


FIG. 7

METHOD OF MAKING RESISTANCE ELEMENT

The present invention relates to an electrical resistance element and a method of making the same. More particularly, the present invention relates to a wire wound resistance element for a potentiometer and a batch method for making the resistance elements.

The wire wound resistance elements used in potentiometers in general, comprise a core having an electrical resistance wire helically wound around the core. One type of core used is a magnet wire, such as copper, having a coating of an insulating material thereover to insulate the resistance wire from the core wire. The resistance wire is generally coated with a strip of an insulating material to hold the turns of the resistance wire in place on the core. These resistance elements are generally made by winding the resistance wire on an elongated length of the core. The insulating strip is then coated and cured on the wound core. The wound core is then cut into the desired lengths for the potentiometer elements, generally with a metal saw. This method has a number of disadvantages. When the wound core is cut into the individual elements, the sawing with a metal saw results in unwinding the resistance wire at the ends of the elements and a smearing of the resistance wire across the ends of the metal core. The unraveled and smeared ends of the resistance wire must be removed by hand labor using tweezers. This slows down the operation and adds considerably to the cost of making the elements. Also, the insulating strips coated on the wound core tend to creep onto the wiper track area of the element during the application of the strip and could ruin the element.

It is therefore an object of the present invention to provide a novel wire wound resistance element for use in a potentiometer.

It is another object of the present invention to provide a wire wound resistance element in which the turns of the resistance wire are secured in position on the core particularly at the ends of the core.

It is a further object of the present invention to provide a novel method of making a wire wound resistance element.

It is a still further object of the present invention to provide a method of making a wire wound resistance element without providing any loose ends of the resistance wire or smearing the ends of the resistance wire across the ends of the core.

It is still another object of the present invention to provide a method of making wire wound resistance element on a batch basis. These objects are achieved by providing a resistance element in which the ends of a wire core are spaced inwardly from the ends of an insulating layer on the core, a protection layer is coated around the resistance wire winding, and insulating films are coated on the ends of the wire core and extend over the end portions of the protection layer. The resistance elements are made by placing a plurality of elongated resistance wire wound cores in a plastic block and cutting the block into a plurality of wafers each containing a plurality of the resistance elements. All of the resistance elements in a wafer are treated simultaneously to space the ends of the wire cores from the ends of the insulating layer thereon and to provide an insulating film on the ends of the wire cores. The resistance elements are then separated from the plastic of the wafers.

FIG. 1 is a side elevation view, partially sectioned, of the wire wound resistance element of the present invention.

FIG. 2 is an enlarged perspective view of a portion of an elongated wire wound and coated core from which the resistance elements of the present invention are made and illustrates the first step in the method of the present invention.

FIGS. 3 – 7 are perspective views illustrating the various steps of the method of the present invention.

Referring initially to FIG. **1**, the wire wound resistance element of the present invention is generally designated as **10.** Resistance element **10** comprises a magnet wire core **12,** such as of a copper wire, having a layer **14** of an electrical insulating material, such as a polyimide resin, coated on the surface thereof. The insulating layer **14** extends beyond both ends of the core **12.** An electrical resistance wire **16** is helically wound around the insulating layer **14** along the entire length of the insulating layer **14.** A protection layer **18** of an electrical insulating material, such as a polyimide or epoxy resin, is coated over the resistance wire winding **16.** The protection layer **18** has a narrow opening **20** therethrough which extends longitudinally along the entire length of the resistance element **10.** The opening **20** exposes a portion of the resistance wire winding **16** to provide a track along which a movable contact of a potentiometer can make contact with the resistance wire winding. At each end of the resistance element **10,** a thin film **22** of an electrical insulating material, such as a polymide or epoxy resin, is coated over each end of the core **12.** Each of the insulating films **22** extends across a respective end of the insulating layer **14** and onto the surface of the protection layer **18.**

To make resistance element **10**, according to the method of the present invention, one starts with an elongated length of the magnet wire core **12** having the layer **14** of the electrical insulating material thereon. The resistance wire **16** is helically wound around the elongated length of the insulated core **12** along the entire length of the core. The protection layer **18** is then applied to the wound core, such as by spraying, painting, or dipping. The protection layer **18** is then partially cured by a short heating cycle. For example, a polyimide resin protection layer can be partially cured by heating at a temperature of 200°C to 225°C for 5 to 15 minutes.

FIG. **2** is an enlarged view showing an end portion of an elongated length **24** of the resistance wire wound core with the protection layer **18** thereon. The narrow longitudinal opening **20** is then formed in the protection layer **18** along the entire length of the core so as to expose a portion of the resistance wire. This can be achieved either by buffing the protection layer **18** with a narrow abrasive impregnated rubber belt or by a blast of bicarbonate soda powder. The elongated length **24** of the wound core is then cleaned and the protection layer **18** fully cured. The elongated length **24** can be cleaned by ultrasonic cleaning in freon MT or with methylene chloride or a detergent followed by ultrasonic cleaning in freon MT. The polyimide protection layer **18** can be then fully cured by heating at 200°C for 1 to 4 hours.

A plurality of the length **24** of the wound cores, each typically between 8 and 12 inches long, with the lengths **24** arranged in closely spaced, parallel relation are then encased in a block **26** of a plastic material as shown in

FIG. 3. The plastic material of the block **26** is one which is relatively inexpensive and which is controllably soluble in a solvent which does not attack the material of the lengths **24** of the wound cores. Polyester resins have been found suitable for this purpose. However, epoxy, polyurethane, silicone and thermoplastic resins as well as such waxes as candle wax are also usable depending on the material used for the protection layers **18** and the insulating layers **14** of the wound cores. The material of the block **26** is also preferably filled with particles of a mineral, such as mica, glass beads or silica. As many as 100 length **24** of the wound cores can be included in the block **26.**

As shown in FIG. **4,** the block **26** is then cut completely through at uniformly spaced points along its length, along parallel planes which are perpendicular to the longitudinal axes of the lengths **24** of the wound cores. The cuts can be made with any suitable tool, such as a rotating circular diamond saw. The cuts are spaced apart a distance equal to the desired length of the resistance elements **10** being produced, typically ½ to ¾ inch. Thus, the block **26** is divided into a plurality of wafers **28** with each wafer containing a plurality of lengths **24'** for producing the resistance elements **10.**

The exposed ends of the wire cores **12,** at each end surface of each wafer **28,** is contacted with an etchant to etch away a portion of the ends of the wire cores **12** as shown in FIG. **5.** For wire cores of copper, a suitable etchant may be ammonium persulfate, nitric acid or ferric chloride. As shown in FIG. **5,** this leaves the ends of the insulating layers **14** projecting beyond the ends of the wire cores **12.**

The wafer **28** is washed and rinsed in water for removing residual etchant. Each wafer **28** is then immersed in a suitable solvent for a period of time necessary to dissolve or soften the plastic material at the surfaces of the wafers **28.** As previously stated, the solvent is one which will slowly dissolve the particular plastic being used, but does not attack the materials of the wound cores. When the plastic is a polyester resin, methylene chloride has been found to be a satisfactory solvent. Chlorinated solvents can be used for epoxy and silicon resins, alcohols or ketones for polyurethane, and various hydrocarbon solvents for waxes. When the wafers **28** are removed from the solvent, they are washed with water to remove the softened surface layer of the plastic and any of the solvent. This exposes a portion of the protection layer **18** at each end of each of the lengths **24'** as shown in FIG. **6.** The amount of the protection layers **18** which are exposed will depend on the length of time that the wafers **28** are immersed in the solvent. For example, using methylene chloride as a solvent for a polyester resin, leaving the wafers **28** in the solvent for approximately 10 minutes will dissolve sufficient amount of the plastic to expose approximately 10 mils of the protection layer **18** at each end of each of the lengths **24'.**

As shown in FIG. **7,** a thin film **22** of an heating. The material is coated on each end of each of the wire cores **12** with the film extending over the exposed dissolved so of the protection layer **18.** The insulating material films **22** are cured by heating.The wafers **28** are then immersed in the solvent bath and left in the solvent until all of the plastic is dissolvedso as to separate the individual lengths **24'** in the wafers. After the plastic is completely dissolved, the lengths **24'** proving the individual resistance elements **10** are removed from the solvent and washed to remove the solvent. The resistance elements **10** are then ready to be used in potentiometer assemblies.

Although the method of the present invention has been described with regard to making straight resistance elements **10,** it can also be used to make resistance elements which are in the form of a helix. For helical resistance elements, the elongated wound cores **24** are wound in a helix and a plurality of the helically wound cores **24** are molded in a plastic block **26.** The block is then handled in the same manner as previously described.

The method of the present invention has many advantages some of which are the following:

1. It allows large batch processing of the resistance elements so as to reduce the per unit cost of manufacturing the resistance elements.

2. It eliminates the need of peeling back by hand the loose ends of the resistance wire of each of the resistance elements, since the resistance wire is firmly held in place by the protection layer and the plastic block when the wound core is cut into the individual elements.

3. The insulating film on each end of the wound core insulates the wire core so as to prevent the resistance wire from shorting across the ends of the wire core, and also helps hold the ends of the resistance wire in place.

4. The buffing operation which exposes the resistance wire path improves the noise characteristics of the resistance element.

5. By cutting the wafers from a large block, all of the resistance elements in each wafer are of the same length.

Thus, the method of the present invention provides for the mass production of the resistance elements **10** with greater ease of handling the resistance elements, with greater speed, at a lower cost per resistance element and with uniformity of size. Also, it provides a resistance element in which the resistance wire is firmly held in place on the core and will not short out across the ends of the wire core.

We claim:

1. A method of making electrical resistance elements comprising the steps of

winding a respective resistance wire helically around and along each of a plurality of elongated wire cores which cores are coated with an insulating material,

coating each of said wound cores with a protection layer,

arranging said wound cores in closely spaced parallel relation,

encapsulating said arranged wound cores in a block of plastic material,

cutting through said block and the wound cores at longitudinally spaced points along planes perpendicular to the longitudinal axes of the wound cores to form a plurality of wafers each of which contains a plurality of resistance elements, and

then separating said resistance elements from the plastic of the respective wafers.

2. The method in accordance with claim **1** in which prior to separating the resistance elements from the plastic of the wafers, the ends of the wire cores are contacted with an etchant to etch away a portion of the ends of the wire cores.

3. The method in accordance with claim 2 in which after the ends of the wire cores are etched away the ends are coated with a film of an insulating material.

4. The method in accordance with claim 3 in which prior to coating the etched ends of the wire cores, a portion of the surface of each wafer is removed to expose the end portions of the protection layer on each resistance element, and the films of the insulating material coated on the etched ends of the wire cores are also coated over the exposed end portions of the protection layers.

5. The method in accordance with claim 4 in which the portion of the plastic of each wafer is removed by immersing the wafers in a solvent which dissolves the plastic but does not affect the materials of the resistance elements.

6. The method in accordance with claim 1 in which prior to assembling the wound cores in parallel relation, a narrow opening is formed in the protection layer longitudinally along the entire length of the wound core to expose a track of the resistance wire winding.

7. The method in accordance with claim 6 in which the opening in the protection layer is formed by buffing the protection layer.

* * * * *