Aug. 4, 1953

W. KASTEN ET AL

2,647,976

ELECTRICAL RESISTOR

Filed March 25, 1949

2 Sheets-Sheet 1

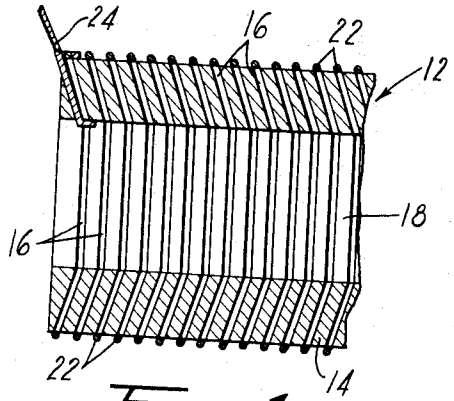


Fig. 1

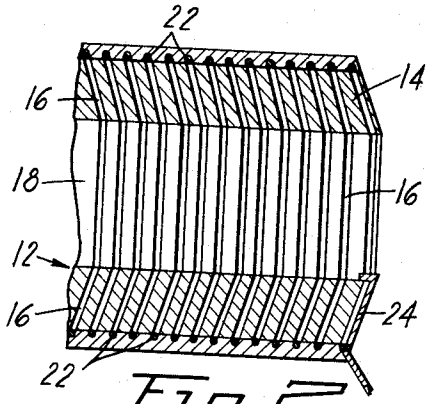


Fig. 2

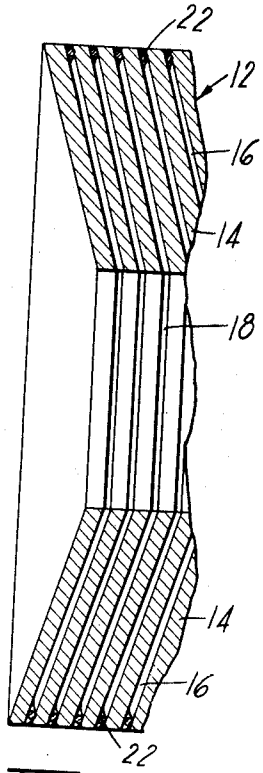


Fig. 3

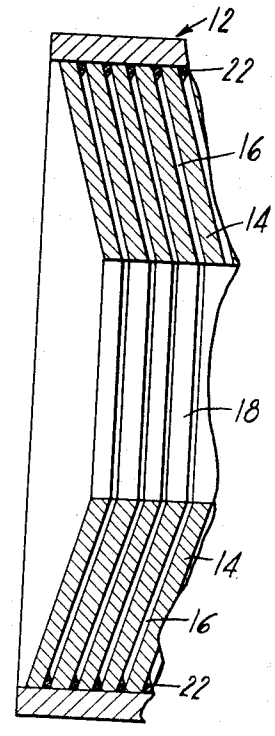


Fig. 4

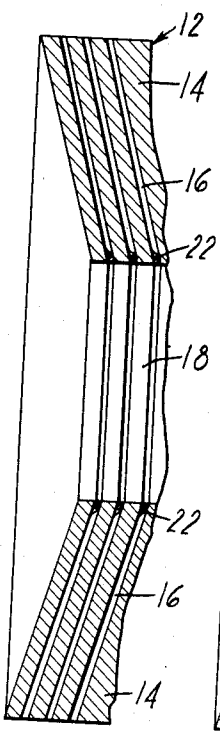


Fig. 5

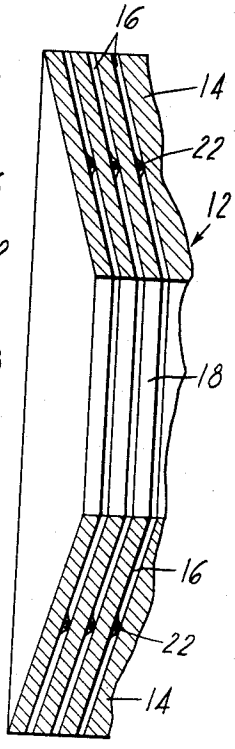


Fig. 6

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Aug. 4, 1953 W. KASTEN ET AL 2,647,976

ELECTRICAL RESISTOR

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2 Sheets-Sheet 2

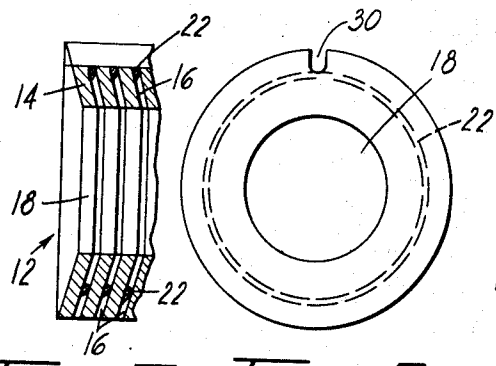


Fig. 7

Fig. 8

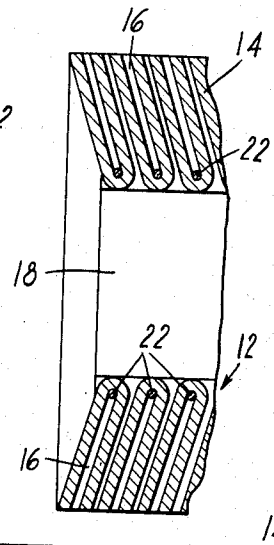


Fig. 9

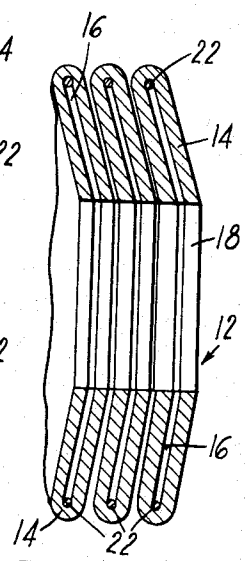


Fig. 10

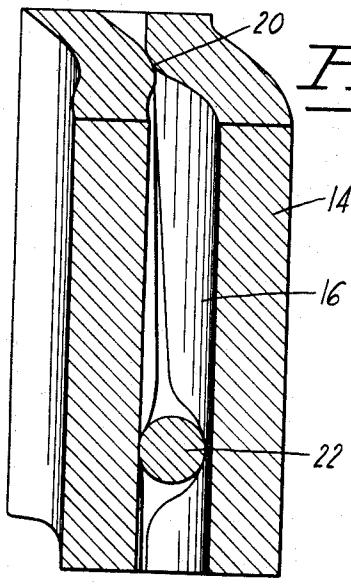


Fig. 11

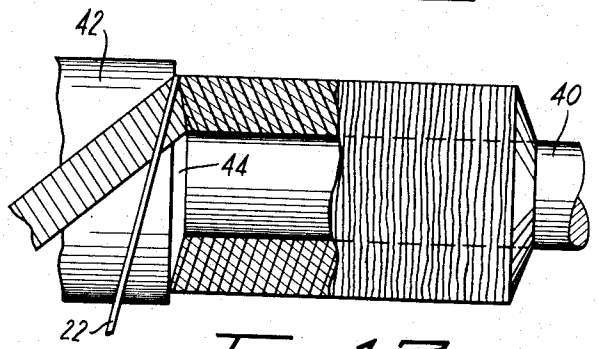


Fig. 12

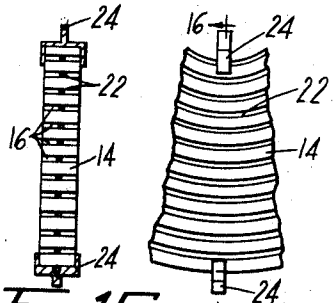


Fig. 16

Fig. 15

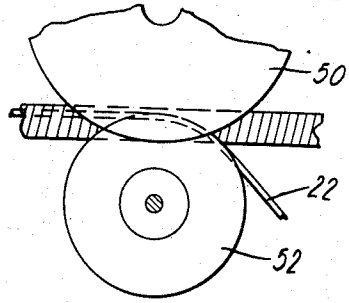


Fig. 14

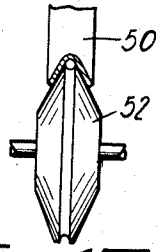


Fig. 13

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ELECTRICAL RESISTOR

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Application March 25, 1949, Serial No. 83,442

10 Claims. (Cl. 201—63)

1

The present invention relates to electrical devices, and more particularly to electrical resistors, rheostats and the like, and to a method of making the same.

One of the principal objects of the present invention is to provide electrical resistors, rheostats and the like which are comparatively light in weight and relatively sturdy and which have good heat dissipating properties. Another object of the invention is to provide a relatively light weight, easily fabricated electrical heating element. Another object of the invention is to provide a method of making the aforementioned articles in which the core is fabricated and the resistance wire assembled thereon in a single operation and in which said operation may be continued without interruption from one article to another. Further objects and advantages of the present invention will become apparent to one skilled in the art from the following description and accompanying drawings, wherein:

Figures 1 to 6 are cross-sectional views of various modifications of resistors embodying our invention, showing the resistor wire assembled in or on the core;

Figures 7 and 8 are cross-sectional views of a rheostat embodying our invention;

Figures 9 and 10 are cross-sectional views of resistors showing additional modified forms of our invention;

Figure 11 is an enlarged cross-sectional fragmentary view of a resistor showing the wire embedded in the core material;

Figure 12 illustrates a method of making the resistors or rheostats shown in Figures 1 to 8, inclusive;

Figures 13 and 14 illustrate one of the first steps in the production of the resistors shown in Figures 9 and 10; and

Figures 15 and 16 are fragmentary views of a further embodiment of our invention.

Referring more specifically to the drawings, and to Figure 1 in particular, numeral **12** designates the core of a resistor, heating element or the like composed of a plurality of axially arranged layers or convolutions **14** having radial pores or ducts **16** extending from the hollow interior portion **18** to the surface of the core. These pores or ducts are best seen in the enlarged fragmentary view of the resistor shown in Figure 11 at numeral **16**. The layers or convolutions are bonded to one another at their points of contact as shown at numeral **20** in Figure 11. In the embodiment shown in Figure 1, the resistance wire **22** is wound on the surface of the core, each convolution being spaced from the adjacent convolutions, and is secured at each end of the core to suitable electrical contacts such as those shown at numeral **24**, said contacts being rigidly secured to each end of the core by any suitable means. The resistance wire may be left uninsulated and exposed as shown in Figure 1, or the assembled wire and core may be coated by a heat resisting material, preferably of a porous substance, such as that shown in Figure 2.

2

In the embodiment shown in Figure 3, the wire is embedded between the convolutions of the core material near the outside surface thereof. In this arrangement, no external coating is required since the resistance wire is held rigidly in place between the convolutions of the core and is embedded sufficiently to be substantially insulated by the core material; however, a coating, preferably of a porous material, may be used if it is desired to fully insulate the unit, as shown in Figure 4.

In Figure 5, the resistance wire is embedded between the convolutions of the core adjacent the hollow center thereof, the construction of this unit being otherwise the same as that shown in Figure 3. In the unit shown in Figure 6, the wire is embedded between the convolutions and is spaced inwardly from each edge of the material forming the convolutions to provide a substantial degree of insulation and protection to the resistance wire. It is seen that in the embodiment shown in Figures 5 and 6, an insulating coating, such as that shown in Figures 2 and 4 would give very little additional protection to the wire.

Referring to Figures 7 and 8, a rheostat, which is similar in construction to the unit shown in Figure 6, includes a longitudinal U-shaped groove **30** extending from the surface of the core to the surface of the wire **22**. This groove is adapted to receive the movable contact member or arm of the rheostat.

In Figures 9 and 10, the wire is substantially enclosed by the material forming the convolutions of the core. This arrangement is preferable where it is necessary to fully insulate and protect the resistance wire.

In a method of producing the resistor, rheostat or heating element, sheets of crepe paper, cloth, asbestos or other similar material impregnated with a phenolic condensation product are cut transversely of the rugosities thereof into ribbons of a width approximately equal to the thickness of the walls of the core. The ribbon so formed is wound edgewise into a cylindrical core,

as shown in Figure 12, using a rotatable mandrel **40** for receiving the material and a stationary collar **42** for guiding the ribbon into place on the mandrel as the latter is rotated. The angle of face **44** of collar **42** relative to the axis of the mandrel determines the lateral angle assumed by the ribbon in the final core. In the winding operation, the transverse rugosities of the ribbon are reduced a slight amount progressively from the inner edge adjacent the mandrel to the outside edge of the ribbon. As shown in Figure 12, the resistance wire is fed simultaneously with the ribbon between the convolutions of the core so that the final article consists of alternate layers of paper or the like, and the resistance wire, such as shown in Figures 3 to 8, inclusive. The rugosities of the material are compressed slightly by the wire, as shown in Figure 11, to permit adjacent convolutions to be bonded together to form a rigid compact unit. As the ribbon and wire are wound into place on the mandrel, the element formed thereby moves axially on said mandrel and is preferably supported at the outer end by a rotatable member which is adapted to yieldably resist at a substantially constant force the axial movement of the element away from collar **42**. In making the resistors shown in Figures 1 and 2, the wire, instead of being wound between the convolutions of the material, is wound on to the surface of the core as the core is formed by the method shown in Figure 12.

The article formed by the foregoing steps is then heated to a temperature and for a time sufficient to polymerize the phenolic condensation product. This heating step may be carried out in an oven after the loosely wound article has been removed from the mandrel and assembled on suitable holding means, or the heating may be accomplished by the use of an oven or induction heating element placed about the mandrel in spaced relation to collar **42**. When the polymerizing step has been completed, the article is rigid and the convolutions are bonded together at the points of contact, as shown at numeral **20** in Figure 11, leaving the radial pores **16** between the convolutions substantially unobstructed and the wire secured rigidly in place between the convolutions. The size of the radial pores formed by the transverse rugosities of the material forming the core can be regulated within limits to suit requirements in any particular type of article by properly controlling the longitudinal pressure on said article before and during the polymerizing step. It is thus seen that the final article consists of a core made of a spirally wound element having embedded between the convolutions thereof the resistor wire held rigidly in place by the convolutions cemented or bonded integrally to one another.

In the method for making the units shown in Figures 9 and 10, the paper or other material having transverse rugosities is folded over the wire as shown in Figures 13 and 14 by a pair of coacting rollers **50** and **52** so that the wire is substantially enclosed by the material. After this step has been completed, the material having the enclosed wire is wound onto the mandrel as shown in Figure 12 and then heated to polymerize the phenolic condensation product in the core material.

In the present method, the material and wire are continuously wound on the mandrel and the article formed thereby moves longitudinally on the mandrel. As the article builds up on the mandrel, the operator may remove a section of

any desired length while the machine continues to operate. After the article has been produced by either the process disclosed in Figure 12 alone or in Figures 12, 13 and 14, and thence heated to polymerize the phenolic condensation material, it is cut into the desired length and the ends of the wire embedded in the article are connected, preferably by soldering, to suitable contacts such as those shown at numeral **24**.

In the embodiment shown in Figures 15 and 16, sheet material, preferably ribbon having transverse rugosities, is wound on itself and a continuous strand of wire is embedded between the layers, as shown in the drawings. The sheet material may be the same as that used in the embodiments shown in the preceding figures. The method used in fabricating this unit is similar to the method previously described, i. e. the sheet material and wire are wound together to form a cylindrical or disc-shaped article and the article is heated to bond the layers to one another.

It is apparent from the foregoing that relatively simple, light weight, easily constructed resistors, rheostats, or heating elements and a relatively simple method have been devised, and that various changes may be made in the form and construction of said articles and the steps in the method for making said articles without departing from the spirit and scope of the invention. For example, while phenolic condensation material has been mentioned as the bonding material, any other suitable bonding or cementing agent may be used to secure the convolutions or layers to one another to form a rigid article.

We claim:

1. An electrical resistor or the like comprising a plurality of axially aligned continuous convolutions of an electrically nonconducting material forming a hollow tubular member, radial pores between said convolutions extending from the hollow interior of said member to the outside surface thereof, a continuous resistance wire fully embedded between said convolutions, and contacts mounted at each end of said member and connected to said wire.

2. An electrical resistor, heating unit or the like comprising a plurality of axially aligned convolutions of a fibrous material held together by a noncontinuous bond and forming a hollow tubular member with radial pores between the convolutions, and a plurality of convolutions of a resistance wire supported by said member.

3. An electrical resistor or the like comprising a plurality of axially aligned convolutions of an electrically nonconducting material held together by a noncontinuous bond and forming a hollow tubular member, radial pores between said convolutions extending from the hollow interior of said tubular member to the outside surface thereof, and a continuous resistance wire embedded between said convolutions in spaced relation to the inside and outside edges thereof.

4. An electrical resistor, heating unit or the like comprising a plurality of axially aligned convolutions of a resinous impregnated paper ribbon having transversely arranged rugosities in the surfaces thereof, the convolutions of said ribbon being held together by a noncontinuous bond formed by said resinous material, said rugosities forming radially extending pores between said convolutions, and a resistance wire embedded between said convolutions in spaced relation to the inside and outside edges of said ribbon.

5. An electrical resistor or the like comprising a plurality of axially aligned convolutions of an

electrically nonconducting material held together by a noncontinuous bond and forming a hollow tubular member with radial pores between the convolutions, a continuous resistance wire embedded between said convolutions in spaced relation from either edge thereof, and a longitudinal groove in said tubular member adapted to expose a portion of each convolution of said wire.

6. An electrical resistor, heating unit or the like comprising ribbon having transverse rugosities wound into radially aligned layers joined together by a noncontinuous bond to form a porous member, and an electrical resistance wire embedded between said layers.

7. A method of making electrical resistors and the like comprising helically winding a ribbon-like material having transverse rugosities in a substantially edgewise manner, simultaneously winding a resistance wire between the convolutions of said ribbon, and bonding the convolutions of said material to one another to form a rigid structure.

8. A method of making electrical resistors and the like comprising winding a fibrous ribbon impregnated with a resinous material in a substantially edgewise manner to form a tubular member, simultaneously winding a resistance wire between the convolutions of said ribbon, and thereafter heating the tubular member so formed to bond the convolutions of said ribbon to one another.

9. A method of making electrical resistors and the like comprising helically winding in a substantially edgewise manner a fibrous ribbon impregnated with a synthetic resin and having transverse rugosities to form a tubular member, simultaneously therewith winding a resistance wire between the convolutions of said ribbon, and thereafter heating the tubular member so formed to cause said synthetic resin to bond the convolutions of said ribbon to one another.

10. A method of making electrical resistors and the like comprising helically winding a ribbon-like material having transverse rugosities in a substantially edgewise manner to form a tubular member, simultaneously therewith winding a resistance wire on the surface of said tubular member, and bonding the convolutions of said material to one another to form a rigid structure.

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