

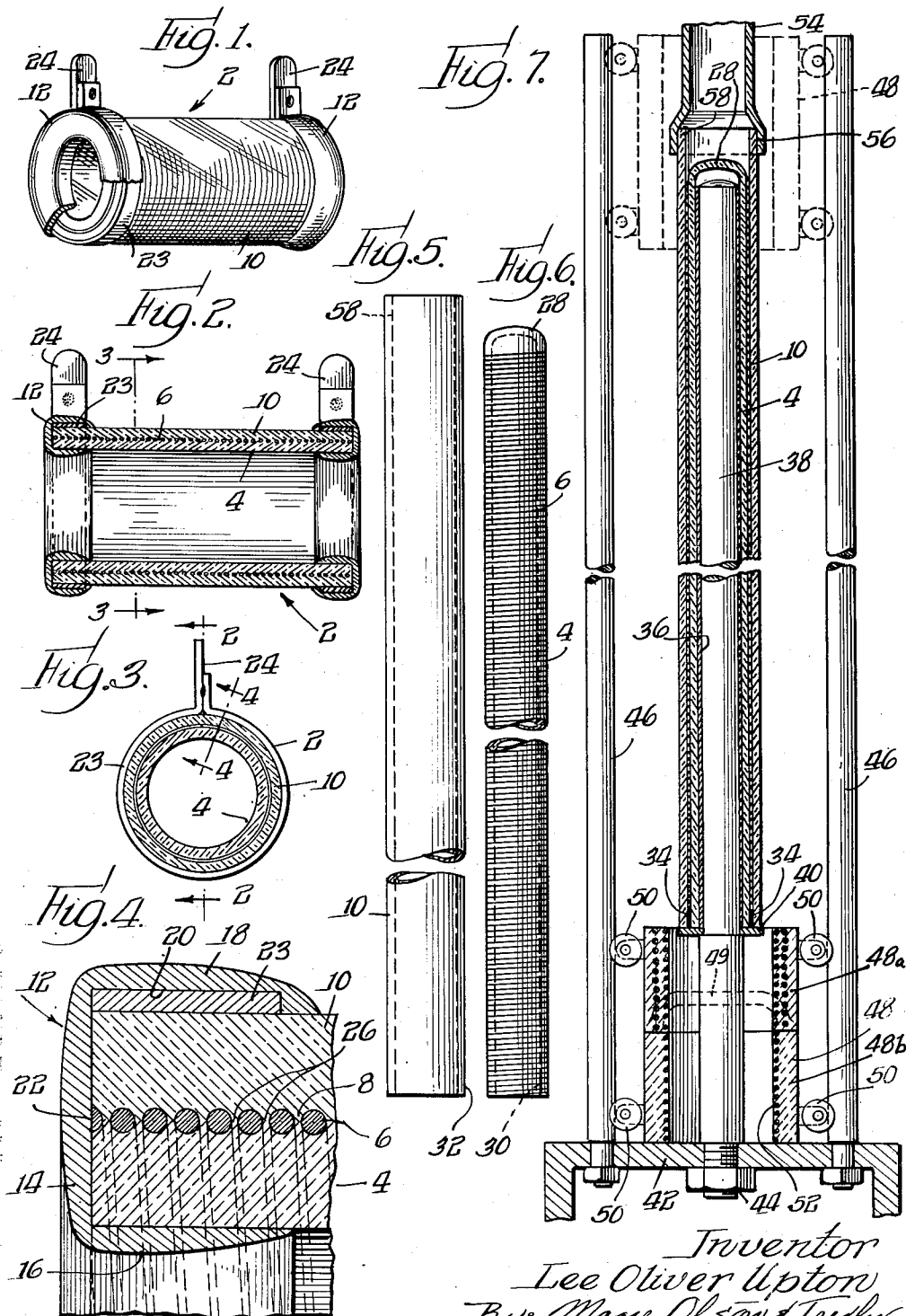
Dec. 23, 1952

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2,623,145

RESISTOR STRUCTURE AND METHOD OF MANUFACTURE

Filed March 22, 1946



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UNITED STATES PATENT OFFICE

2,623,145

RESISTOR STRUCTURE AND METHOD OF MANUFACTURE

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Application March 22, 1946, Serial No. 656,213

18 Claims. (Cl. 201-64)

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This invention relates to an electrical unit and more particularly to a resistor having the resistance element thereof embedded within a homogeneous or integral body of vitreous material, and capable of withstanding high thermal shocks.

One object of the present invention is to provide an improved resistor wherein the outer and inner walls of the resistor body in respect to the resistance element are in the form of preformed tubes or cylinders and are of the same or selected vitreous material and are fused together to afford an integral unit.

Another object of the invention is to provide an improved resistor wherein such outer and inner cylinders are not only fused together to form an integral unit, but wherein the resistance element is embedded between the cylinders and is afforded an improved bond with the cylinders.

A further object of the invention is to provide an improved resistor in which a resistance element is hermetically sealed and insulated in a cylindrical body and wherein an improved arrangement is provided for making electrical contact of the resistance element with the terminal lugs of the resistor.

Still another object of the invention is to provide a novel method of making a resistor of the type mentioned above; and wherein during the bonding or fusing together of the outer and inner cylinders air is removed from between the cylinders by suction in order to eliminate formation of air bubbles or defects where the cylinders are fused together and provide an improved and integral line of juncture.

Further objects of the invention will be apparent from the following description and claims taken in connection with the accompanying drawings forming a part of this application.

Referring to the drawings,

Figure 1 is a perspective view of a resistor embodying the invention, certain parts being broken away for illustrative purposes.

Figure 2 is a sectional view of the resistor shown in Figure 1, said section being taken in a vertical plane along the longitudinal axis as indicated by the line 2-2 in Figure 3;

Figure 3 is a transverse cross-sectional view of the resistor shown in Figure 1, said section being taken in the plane indicated by the line 3-3 in Figure 2;

Figure 4 is an enlarged fragmentary sectional view of one end of the resistor, the section being taken in a plane passing through the longitudinal axis of the resistor, as indicated by the line 4-4 of Figure 3;

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Figure 5 is a view in elevation of an outer cylinder or tube used in the invention; and

Figure 6 is a view in elevation of an inner cylinder showing the resistance wire wound about the tube; and

Figure 7 is a sectional view of an apparatus used in making the resistor, said section being taken in a vertical plane bisecting the apparatus.

Referring more particularly to the drawings, the completed resistor 2, Figure 1, may be of conventional cylindrical shape and has its body made of suitable vitreous material which has characteristics of high heat resistance, low thermal expansion, and of affording electrical insulation, such as a boron-silicate glass. The resistor 2 includes an inner body tube or cylinder 4, Figure 2, around which is uniformly wound a resistance element or wire 6, each coil of said winding being spaced from the adjacent coil as at 8, Figure 4. Over the inner cylinder 4 and resistance wire 6 is sleeved an outer body tube or cylinder 10.

At each end the resistor is provided with electrical contact terminal means comprising an annular metallic cap 12 formed on said end in a manner described hereinafter, said cap having an annular end wall 14 with an inner circumferential flange 16 and with an outer circumferential flange 18 inwardly directed to afford a channel which accommodates an end of the resistor as at 20. The terminal cap 12 may be made of any suitable electrical conducting material and its wall 14 provides electrical contact with an adjacent end of the resistance wire 6 as at 22. The outer circumferential flange 18 of the cap 12 overlaps and is electrically connected to a metal band 23 which encircles an end of the outer cylinder 10 and which has a terminal lug 24 affording contact with an associated electrical apparatus.

In Figure 4 the resistance wire 6 has been shown enlarged in proportion to the cylinder to show more clearly how the inner and outer body cylinders are fused together in the spaces between and around the coils of the resistance wire 6 to afford an integral unit. The fused material of the cylinders at 26-26 serves to insulate each coil winding from the adjacent winding and as described hereinafter is bonded with the resistance wire 6.

Referring now to the improved method of making the resistor, the outer cylinder 10 shown in Figure 5 may be cut to any suitable length, preferably a number of times longer than the completed resistor, and has an inner diameter sufficiently great to permit the inner cylinder 4

to be easily sleeved therewithin when the inner cylinder is wound with the resistance wire 6. The inner cylinder 4 as shown in Figure 6 is cut to substantially the same length as the outer cylinder 10, and around it is uniformly wound the resistance wire 6 for substantially its entire length. The wire 6 is wound in any convenient manner which will afford space between adjacent coils of the windings as at 9.

An end 28 of the inner cylinder 4 is closed and sealed by heating and drawing an end portion of the cylinder together. It is understood, of course, that end 28 of the inner cylinder may be sealed either before or after the resistance wire is wound around the inner cylinder. The inner cylinder 4 with the resistance wire 6 wound upon it is then inserted into the outer cylinder 10 for substantially its entire length. The open end 30 of the inner cylinder and the adjacent end 32 of the outer cylinder are then sealed or fused together as at 34, Figure 7, by heating in any convenient manner.

Within the inner cylinder is inserted a thin sleeve 36 of suitable material such as pressed asbestos or graphite paper to keep the inner cylinder when heated as will be presently described from wetting the mandrel 38 upon which it is mounted. The sleeve 36 also serves to insulate the inner cylinder during heating and to facilitate removal from the mandrel after heating.

After insertion of the sleeve 36, the joined cylinders are mounted on the mandrel 38, as shown in Figure 7, which has an annular shoulder 40 near its lower end to afford a support for the cylinders. The mandrel 38 is preferably mounted in a vertical position to minimize undesired flowing of the vitreous material of the cylinders and to prevent sagging of the cylinders when subjected to heat. The mandrel 38 is supported from a base 42 by any suitable means such as a bolt and nut arrangement 44.

Projecting vertically upwards from the base 42 are spaced columns 46—46 affording rails or tracks along which a furnace 48 may be vertically raised and lowered by any suitable handle 49 or operating means, the spaced wheels 50—50 engaging the columns 46—46 and thus guiding the furnace along the mandrel. The furnace 48 is shown in its normal lowered position in full lines and in its topmost raised position by diagrammatic lines at the top of Figure 7.

The furnace 48 is preferably an internally wound resistance heating unit of cylindrical form having an opening 52 throughout its length and through which the mandrel with the cylinders mounted thereon may be passed. It consists of an upper fusing section 48a and a lower annealing section 48b, for a purpose later to be described.

At the top of the structure in Figure 7 is partially shown a connecting hose or tube 54 of an associated vacuum pump. The connecting tube 54 is securely and tightly fitted at 56 over the open end 53 of the outer cylinder 10. It is apparent from the drawings that a chamber is formed by sealing the end 28 of the inner cylinder and by the adjacent ends 30 and 32 of the inner and outer cylinders respectively, which consists of the spaces between the outer cylinder and the inner cylinder; from which the associated vacuum pump extracts air through the tube 54.

In operation, the furnace 48 is heated and moved upwardly so as to subject the cylinders to a softening temperature to fuse them together

progressively upwardly as the furnace is raised. Preferably the furnace section 48a has a temperature considerably higher than such softening temperature to thereby provide quick heating of the cylinders to softening temperature as the furnace moves progressively upwards. The cylinders are subjected to the action of the heating section 48a sufficiently, but not in excess, so as to effect the softening and fusion of the glass. Quick heating is desirable so that flow of the glass may be controlled more closely. The annealing section 48b which is brought into juxtaposition with the glass immediately after the fusion thereof permits the glass to cool below the fusion point, and provides for its gradual and partial cooling before engagement with the atmosphere.

At the same time as the furnace 48 progresses upwards along the cylinders, the vacuum pump operates to withdraw or suck the air from the chamber between the two cylinders. It will be apparent that as the cylinders are heated and that as the air is extracted from the chamber between the cylinders producing a vacuum, the walls of the cylinders as they reach softening temperature will tend to flow toward each other because of atmospheric pressure exerted on the outside of the outer cylinder and from the inside of the inner cylinder, the walls thus becoming integrally fused together and around the resistance wire. The principal flow occurs in the outer sleeve which is subjected to the greatest heat and loosely encompasses the resistance wire. The outer sleeve in effect collapses onto and fuses to the inner sleeve and the resistance wire coil.

Before heating a loose or sloppy fit is desirable between the two cylinders so that progressive fusion will take place and formation of air pockets by inadvertent pre-sealing of the cylinders will be prevented. It will be readily seen that the above described operation causes the vitreous material of the two cylinders to unite by flowing together in the spaces provided between the adjacent coil windings of the resistance wire, and thus the cylinders become an integral unit.

If the outer and inner cylinders 4 and 10 are formed of the same material, it will be seen that a homogeneous resistor body is provided externally and internally of the resistance coil, providing a body structure of uniform expansion characteristics and highly resistant to thermal shock. By selecting the outer and inner body tubes of different materials, any desired relative coefficients of expansion or other physical or chemical properties may be obtained. In any event, the fusion of the two cylinders provides an integral body fused together and integrally united to the resistance wire to firmly hold it in position.

The resistance wire 6 preferably is given an insulating oxidized coating so that as the cylinders are heated and the vitreous material of the cylinders flows together between the coil windings, the oxide of the wire fuses into the vitreous oxide material and a strong and integral bond is obtained between the wire and the cylinders. The cylinders are thus fused to the wire, and to each other through the wire, as well as by their contact in the spaces between the wire coils. The spacing of the coils is of course optional, depending upon the pitch of the coil winding.

After the cylinders have been fused throughout their entire length, and partly annealed as above described, they are placed in an annealing

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furnace whereby strains are removed, and then are permitted to slowly cool to room temperature over a period of hours or such other time as may be required. At room temperature the cylinder may be cut into any suitable lengths or segments to form resistors of desired length, depending upon the capacity of the resistor desired.

As the cylinder is cut into segments a coil winding of the resistance wire is cut as shown at 22 in Figure 4 and exposed at each end of the segment. Electrical contact between the terminal lug band 23 and the exposed portion of the resistance wire 6 is then made by forming the terminal cap 12 earlier described. This cap is preferably formed by spraying a metalized paint onto the resistor end, whereby to firmly unite with the wire end; or the metal cap may be formed by electroplating or dipping the resistor ends into a metalized paint solution. The sprayed metal not only is afforded an intimate contact with the exposed portion of the wire but also partly penetrates the walls of the cylinders to afford a secure and tight fit for the cap 12.

By omitting the lugs and bands 23-24 the metal caps 12 will form fuse clip type end terminals for the resistor.

It is apparent that many variations of this invention may be made without departing from the spirit and scope thereof, and therefore it is not intended to be limited except as indicated in the appended claims.

The invention is hereby claimed as follows:

1. An electrical unit comprising a body having an outer unitary sleeve member of insulating material, and an inner preformed base member of insulating material nested therein, said members being fused together, an electrical element disposed in the form of a helical coil between the two members and retained in position thereby, and a metallic contact member carried by said body and electrically and physically contacting said electrical element at the point of juncture between said members.

2. An electrical unit comprising a body having an outer unitary sleeve member of insulating material, and an inner unitary base member of insulating material nested therein, said members being fused together, an electrical element disposed in the form of a helical coil between the members and retained in position thereby, a terminal lug carried by said body, and a metal film carried by the body and electrically and physically interconnecting said terminal lug and said electrical element.

3. An electrical unit comprising a body having an outer unitary sleeve member of insulating material, and an inner complementary base member of insulating material nested therein, said members being fused together, an electrical element disposed between the members and retained in position thereby, a band-like terminal lug encompassing said sleeve member and exteriorly of all insulating material, and an annular metal film carried by the body and electrically interconnecting said terminal lug and said electrical element at the point of juncture between said members.

4. The method of making an electrical unit which comprises preforming an outer substantially cylindrical sleeve member of insulating material, preforming an inner complementary sleeve member of the same insulating material, nesting the inner sleeve member within the outer sleeve member, arranging an electrical element between

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the members, and fusing said members together to retain said electrical element in position therebetween while internally supporting the inner sleeve member on an inserted mandrel.

5. The method of making a resistor unit which comprises preforming an outer integral sleeve member of vitreous material, preforming an inner integral sleeve member of vitreous material, nesting the inner sleeve member within the outer sleeve member, arranging a coil of resistance wire between the sleeves, and fusing said sleeves together to retain said coil in position therebetween while internally supporting the inner sleeve member on an inserted mandrel.

6. The method of making an electrical unit which comprises preforming an outer sleeve member of insulating material, preforming an inner base member of insulating material, nesting the inner base member within the outer sleeve member, arranging an electrical element between the members, fusing said members together progressively axially of their length whereby to bond the members and retain said electrical element in position therebetween, and cutting off said members and said electrical element to a predetermined length leaving said electrical element partially exposed at one end of said members.

7. The method of making an electrical unit which comprises preforming an outer sleeve member of insulating material, preforming an inner sleeve member of insulating material, nesting the inner sleeve member within the outer sleeve member, arranging an electrical element between the members, and applying heat to the outer sleeve while internally supporting the inner sleeve member on an inserted mandrel to collapse the outer sleeve onto the inner sleeve member and simultaneously expand the inner sleeve member to fuse the members together to retain said electrical element in position therebetween.

8. The method of making an electrical unit which comprises preforming an outer sleeve member of insulating material, preforming an inner sleeve member of insulating material, nesting the inner sleeve member within the outer sleeve member, arranging an electrical element between the members, and applying heat progressively longitudinally thereof to the outer sleeve while internally supporting the inner sleeve member on an inserted mandrel to effect the progressive collapse of the outer sleeve onto the inner sleeve member and the fusion of the two members together longitudinally thereof.

9. The method of making an electrical unit which comprises preforming an outer sleeve member of insulating material, preforming an inner sleeve member of insulating material, nesting the inner sleeve member within the outer sleeve member, arranging an electrical element between the members, evacuating the space between the members and applying heat to the members while internally supporting the inner sleeve member on an inserted mandrel to effect the fusion of the members together to retain said electrical element in position therebetween.

10. The method of making an electrical unit which comprises preforming an outer sleeve member of insulating material, preforming an inner sleeve member of insulating material, nesting the inner sleeve member within the outer sleeve member, arranging an electrical element between the members, evacuating the space between the members, and heating the members progressively longitudinally thereof while in-

ternally supporting the inner sleeve member on an inserted mandrel to effect the progressive fusion of said members together longitudinally while maintaining said evacuation.

11. The method of making an electrical unit which comprises preforming an outer substantially cylindrical sleeve member of insulating material, preforming a substantially complementary inner base member of insulating material, nesting the inner base member within the outer sleeve member, arranging an electrical element in the form of a helical coil between the members, fusing said members together to form a body with said electrical element embedded therein, and applying a metallic film to the body in electrical contact with said element at the point of juncture between said members.

12. An apparatus for making an electrical unit comprising an elongated mandrel adapted to receive a pair of sleeve members to be sealed, means arranged for connection with the sleeves to evacuate the space therebetween, a heating furnace, and guide means for guiding the furnace along a path of travel parallel to the mandrel to effect the progressive fusion of the sleeves longitudinally thereof.

13. An apparatus as defined in claim 12, wherein means is provided for supporting the mandrel in substantially vertical position.

14. An electrical unit comprising a body having an outer unitary sleeve member of insulating material, and an inner base member of insulating material nested therein, said members being fused together, an electrical element disposed in the form of a helical coil between the two members and retained in position thereby, and an annular metallic contact band embracing the sleeve member and base member at the ends thereof, and electrically and physically contacting said electrical element at the point of juncture between said members.

15. An electrical unit as defined in claim 2, wherein said metal film is in electrical and physical contact with said electrical element at the point of juncture between said sleeve and base members.

16. The method of making an electrical unit as defined in claim 5, wherein an insulating sleeve is arranged upon the mandrel prior to the mounting of the inner vitreous sleeve thereon to facilitate removal of said inner vitreous sleeve from the mandrel structure.

17. An electrical unit comprising an outer preformed sleeve member of insulating material, an inner preformed sleeve member of insulating material loosely nested therein to form an annular chamber between said sleeves, an electrical element comprising a wire coil embracing the

inner sleeve member and lying within the annular chamber between said sleeve members, and sealing means at the opposite ends of the inner sleeve member for sealing the interior thereof from said chamber, whereby said chamber may be evacuated by vacuum pressure applied thereto to collapse the outer sleeve member without subjecting the inner sleeve member to corresponding collapsing pressure, the sealing means at one end of the inner sleeve comprising an annular fused connection between said sleeves.

18. An electrical unit comprising an outer preformed sleeve member of insulating material, an inner preformed sleeve member of insulating material loosely nested therein to form an annular chamber between said sleeves, an electrical element comprising a wire coil embracing the inner sleeve member and lying within the annular chamber between said sleeve members, and sealing means at the opposite ends of the inner sleeve member for sealing the interior thereof from said chamber, whereby said chamber may be evacuated by vacuum pressure applied thereto to collapse the outer sleeve member without subjecting the inner sleeve member to corresponding collapsing pressure, said sleeve members being formed of similar vitreous material so that they may be fused by the application of heat into a substantially homogeneous mass.

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