Dec. 5, 1961 R. W. BRONSON ET AL 3,012,214

GLASS ENCASED RESISTOR AND METHOD OF MAKING SAME

Filed Aug. 7, 1959 2 Sheets-Sheet 1

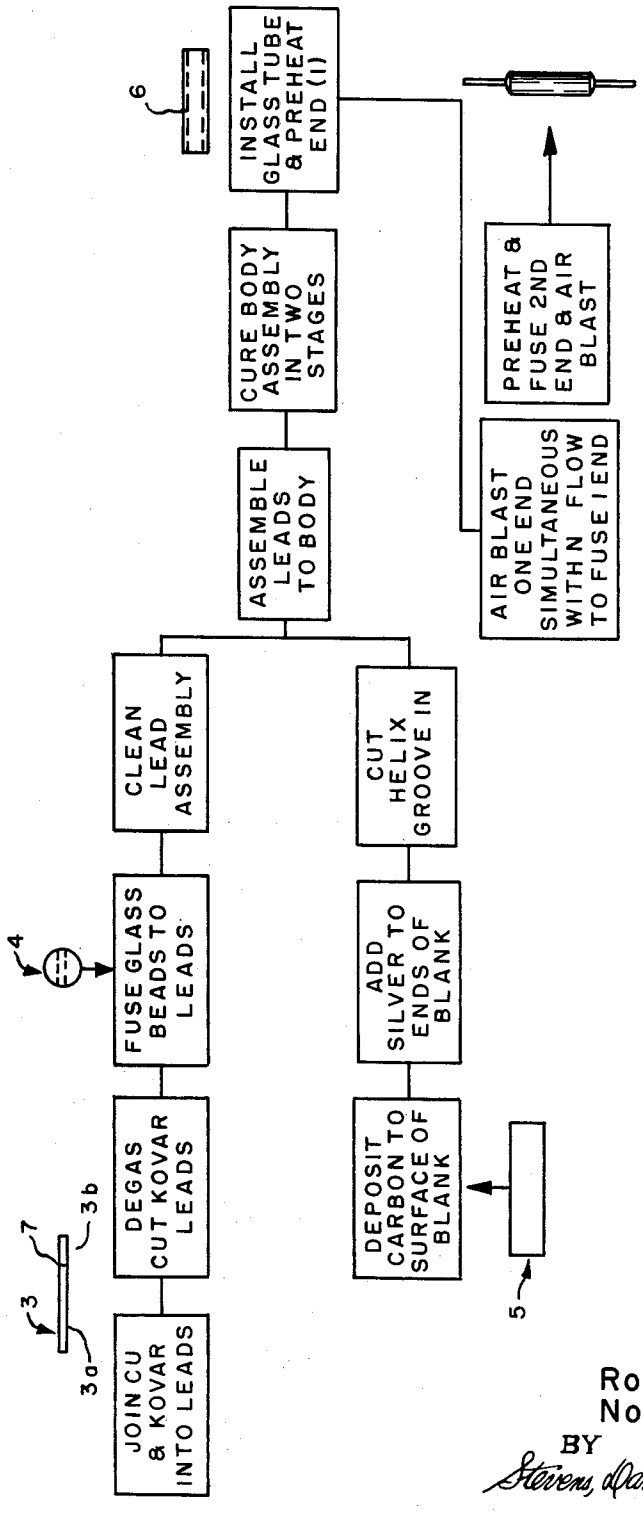


Fig. 1

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Fig. 2

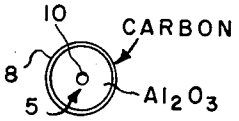


Fig. 3

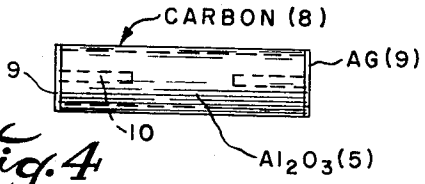


Fig. 4

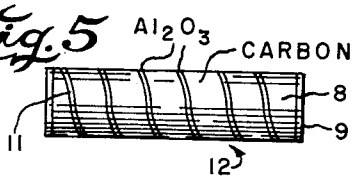


Fig. 5

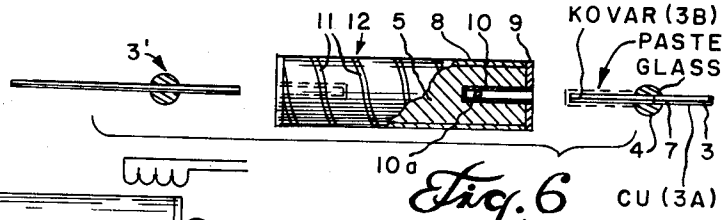


Fig. 6

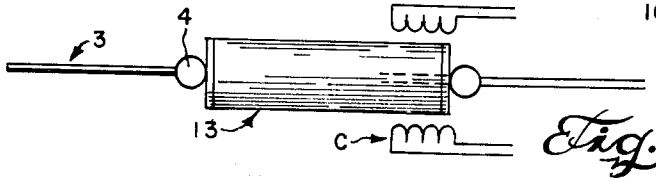


Fig. 7

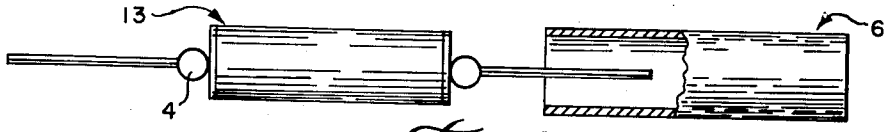


Fig. 8

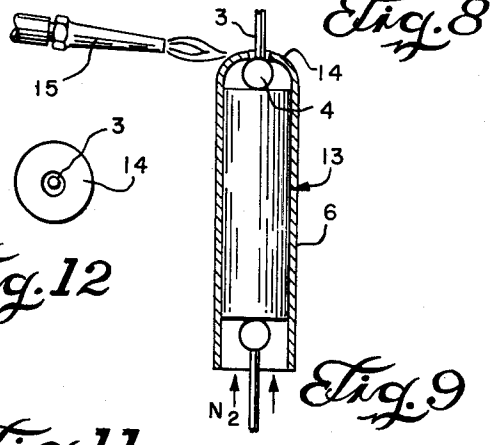


Fig. 9

Fig. 12

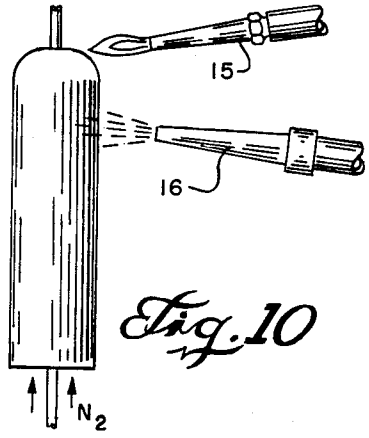


Fig. 10

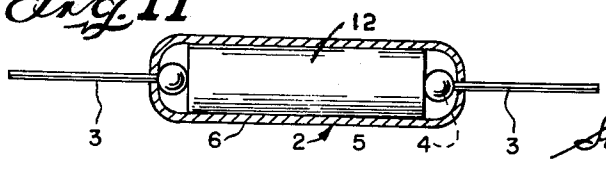


Fig. 11

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GLASS ENCASED RESISTOR AND METHOD OF MAKING SAME

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8 Claims. (Cl. 338—237)

This invention relates generally to electrical components and more particularly to an encapsulated resistor having a fixed value of electrical resistance.

A primary object of this invention is to provide a novel means for encapsulating a resistor in a glass housing.

Another object is to provide a unique structure for an electrical resistor.

A further object is to provide a method of making uniform resistors which are sealed in glass in production quantities.

And another object is to provide a resistor having a resistance body, a pair of end leads in electrical contact with the body, a glass bead at each end of the body, and an airtight glass housing surrounding the body and the beads; and to provide a method of fabricating such a resistor.

A still further object is to provide a high speed, quantity production method for producing a glass encased resistor by using precut glass tubes of the exact length to eliminate waste.

These and other objects and advantages will be apparent from an examination of the following specification and drawing in which:

FIG. 1 represents a block diagram of the process of making resistors according to this invention;

FIG. 2 is a detail side view of a typical resistor blank used in this invention;

FIG. 3 is an end view of the device of FIG. 2 after a surface of carbon has been deposited thereon;

FIG. 4 is a side view of the device of FIG. 3 after the step of applying silver to the ends thereof;

FIG. 5 is a side view of the device of FIG. 4 after a helical groove has been cut in the carbon shell of the body;

FIG. 6 is an exploded view partly in cross-section showing one step in the method of fabricating the resistor of this invention;

FIG. 7 is a schematic view of the RF heating stage in assembling the leads to the blank;

FIG. 8 is a side view of the completed resistor body assembly being inserted in the glass tube blank;

FIG. 9 is a vertical view, partly in cross-section, of the assembly of the resistor body assembly and the glass tube during one step in this method;

FIG. 10 is an outline view of the method step immediately following the step of FIG. 8 in the production of the resistor shown in its entirety in FIG. 10;

FIG. 11 is an elevational view of the finished resistor of this invention; and

FIG. 12 is an end view of the device of FIG. 11.

The complete resistor assembly, as shown at **2** in FIG. 11, is the product of this invention and is produced by the method of this invention, as hereinafter disclosed. This resistor assembly **2** is seen to include a pair of axially extending leads **3** having a glass bead **4** near the end of the lead which is attached to the resistor body **12**. During fabrication, each bead **4** becomes fused to both the lead **3** and the glass tube **6** to provide a hermetically sealed glass encapsulated resistor assembly.

The principal steps in the process of this invention are depicted in block diagram form in FIG. 1, and the complete process is thus disclosed by reference to the block

diagram in conjunction with the other figures of the drawing.

In FIG. 1, it is seen that the first step in the process of this invention is to join a short length of copper wire 3A to a much shorter piece of Kovar wire 3B by butt welding at **7** to form a lead **3** for subsequent assembly into each end of the assembly **2**. Each of these leads **3** is then degassed and degreased in a hydrogen furnace at 900° C. for 15 minutes. A glass bead **4** made from a borosilicate glass known in the trade as Corning Glass Works 7052 is next slipped over the lead **3** to a position at or over the weld junction **7** and heated and fused thereto to form a lead assembly **3'** as shown in FIG. 6.

This lead assembly **3'** is next cleaned in a nitric acid wash. While the above process steps are being performed to produce the lead assemblies **3'**, a series of process steps are also being performed on the resistor blank **5** so that at the conclusion of each of these parallel operations the leads and body may be joined prior to encapsulation. The resistor blank **5** is a solid cylindrical member of aluminum oxide into each end of which has been drilled a short length axial hole indicated at **10** in FIG. 2. Since the aluminum oxide has insulating properties, some conducting or semiconducting material must be added to provide the desired degree of resistance to the assembly. This is accomplished by vapor depositing a surface coating of carbon to the desired thickness (the estimated thickness range being from .01 to 5×10^{-4} cm.) on the cylindrical periphery of the resistor blank **5** by the decomposition of methane gas in contact with the blank in an enclosed furnace to form the thin surface shell **8** of carbon, as shown in FIG. 3. The next step in the process of preparing the blank **5** is to paint a layer **9** of silver onto each end and into the counterbore **10** as shown in FIG. 4 and then bake in the silver to insure uniform coverage. At this point, the prepared blank is placed in a groove cutting machine and the helical groove **11** is cut completely through the carbon shell **8** to provide an increased resistance path having a specific ohmic value between the silvered ends **9** of the blank to thus form the unit identified as resistor body **12** as shown in FIG. 5.

Having completed the two separate parallel process paths shown in FIG. 1, the two subassemblies **3'** and **12** are then assembled by first dipping the Kovar end **3B** of the lead assemblies **3** into silver paste and then inserting this end into the counterbore **10** over a small tin ball **10***a* to form the complete body assembly **13** as shown in FIGS. 6 and 7.

The next process step is to cure the body assembly **13** and simultaneously rigidly attach the leads in place by first baking the assembly **13** in an air oven at 200° C. for two hours and then placing each end in a radio frequency induction heating coil C to thoroughly solder the leads to the body by a complete soldering of the tin to both the silver surface and the silver paste covered Kovar leads, and to decompose any organic material present (FIG. 7). The body assembly **13** is now ready to be encapsulated within a glass tube **6** and the latter is slipped over one end as shown in FIG. 8. The now enclosed but unsealed assembly is passed by a burner **15** to preheat and start the closing operation. The flame of burner **15** includes sufficient pressure to force the upper end **14** of the tube **6** in a direction to close about the bead **4** and the tube **6** and body assembly **13** are simultaneously rotated while the flame is applied so that a smooth rounded closure tip as shown in FIG. 9 will result. During this heating and closing operation, nitrogen is being circulated in and through the shell **6** so that an inert atmosphere inside the shell **6** will result. The flow of nitrogen (N_2) through the shell **6** must be care-

fully controlled because if the ratio of oxygen to nitrogen within the shell becomes too large, the oxygen and carbon may ignite and this will change the resistance value of the finished unit; also if the nitrogen pressure becomes too large it will prevent proper closing of the sealed end of the tube **6**. The nitrogen flow during the sealing operation also accomplishes another desired result in that it leaves a bright finish on the silver plated surface. A cold air blast nozzle **16** is trained upon the periphery of the shell **6** at a point just below that at which the flame from burner **16** is applied and this combination of simultaneous heat forming and cooling will prevent the formation of air bubbles in the molten portion of the glass as shown in FIG. 10. As the top open end approaches a complete closure of the open end, the internal atmosphere is cooled by the air blast and the internal pressure is thus reduced until the seal is completed and the combination of the flame pressure and the external atmospheric pressure will form a smooth closure about the bead **4** and wire **3** and also the tendency for air bubbles to form in the glass will be reduced since the bubbles will pass on into the reduced internal pressure area before the pressure can be built up through the restricted passage between the body **13** and the shell **6**. A view of the sealed end of the resistor is shown in FIG. 12. After one end is completely sealed by this operation, which takes approximately three seconds to complete, the assembly is inverted and the other end is then fused around its bead and wire in the same manner as that described above for the first end to form a complete resistor assembly. At this stage, nitrogen is no longer being circulated through the assembly, however, due to the short time involved and due to the confined passages around the body **12**, there will be a concentrated nitrogen atmosphere remaining within the shell which will expand during the heat sealing operation and provide a substantially neutral atmosphere within the sealed shell **6**.

It will be recognized that a resistor assembly manufactured by the process of this invention will have the following advantages due to the method conditions under which it was made:

(*a*) The use of glass beads, together with the application of cold air, prevent heat from the flame of burner **15** and from the molten area of the glass tube from damaging the ends of the resistor.

(*b*) The glass-to-glass seal insures an airtight enclosure.

(*c*) The oxidized Kovar wire provides a proper bond for the glass bead whereas a copper wire would not.

(*d*) The Kovar wire is receptive to induction heating so that the heating occurs internally where needed to fuse the bead to the wire and thus the fusing can be accomplished with less heat than if applied externally to the bead.

(*e*) The formed portion of the glass shell will not pick up air bubbles due to the reduced internal pressure created by the cold air jet.

(*f*) The use of cut length glass tubes will provide a more economical construction than afforded by other methods using continuous tube processes.

While this method contemplates the use of Kovar material lead wire section ("Kovar" being the commercial name of a particular iron-nickel-cobalt alloy) together with a hard glass bead, a similar satisfactory result may be obtained by using a Dumet material lead wire and a soft glass, "Dumet" being the trade name for a nickel-iron alloy having a copper coating thereon. A suitable soft glass for use with Dumet wire has been found to be that known in the trade as Corning Glass Co. G-12.

Although certain specific embodiments of the invention have been shown and described, it is obvious that many modifications thereof are possible. The invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the scope of the appended claims.

What is claimed is:

1. A method of making a glass encased resistor assembly comprising: joining separate material sections of lead wire materials together to form complete leads in which only a portion thereof is fusible to glass, degassing said leads and fusing a glass bead to the fusible portion of said leads, depositing conductive material on one external surface of a non-conductive blank, adding a solderable conductive material to other surfaces of said blank and in electrical continuity with said first named conductive surface, placing said leads into engagement with said solderable material and into a recess adjacent each of said other surfaces and heating said inserted leads to bond the leads to said blank, and encasing said blank, beads, and a portion of said leads in a glass shell by fusing the ends of said shell to said beads.

2. A method of making a glass encased resistor assembly as in claim 1 wherein said bonding step is carried out by inductively heating the inserted portion of said leads through the surrounding blank.

3. A method of making a glass encased electrical circuit component assembly comprising: fabricating a component body having leads projecting therefrom and having a glass bead at juncture of each lead, enclosing said body and beads and a gas in a glass shell, sealing the ends of said shell by fusion with the glass beads, and applying a jet of cold air to the external surface of the shell near the end being sealed at such a rate as to prevent an undesirable temperature rise of the gas inside the shell during the sealing operation.

4. A method of making a glass encased electrical circuit component assembly comprising: placing a component body having leads projecting therefrom and having a glass bead at the juncture of each lead, enclosing said body and beads and a gas in a glass shell, passing nitrogen through said shell while sealing one end of said shell to one of said beads, and then sealing said other end of said shell to said other bead while a substantial portion of said nitrogen remains within said shell, and applying a jet of cold air to the external surface of said shell near each end as it is being sealed at such a rate as to prevent an undesirable temperature rise of the gas inside the shell during the sealing operation.

5. A method of making a glass encased electrical circuit component assembly comprising: placing a component body having leads projecting therefrom and having a glass bead at the juncture of each lead, enclosing said body and beads and a gas in a glass shell, passing nitrogen through said shell while flame sealing one end of said shell to one of said beads, and then flame sealing the other end of said shell to said other bead while a substantial portion of said nitrogen remains within said shell, and applying a jet of cold air to the external surface of said shell near each end as it is being sealed at such a rate as to prevent an undesirable temperature rise of the gas inside the shell during the sealing operation, and rotating said shell and body during both sealing operations.

6. A method of making a glass encased resistor assembly comprising: joining separate material sections of lead wire materials together to form complete leads in which only a portion thereof is both fusible to glass and receptive to induction heating, degassing said leads in a hydrogen atmosphere, fusing a glass bead to the fusible portion of said leads, depositing conductive material on one external surface of a non-conductive blank, adding a solderable conductive material to other surfaces of said blank and in electrical continuity with said first-named conductive surface, coating the ends of said leads with silver paste, placing said coated ends of said leads into engagement with said solderable material and into a recess adjacent each of said other surfaces to form a resistor body unit and curing said body unit at a low temperature, and inductively heating said inserted lead ends to solder the leads to said blank, placing a glass shell entirely over the body unit and partly over said

leads, rotating said shell and body unit and passing nitrogen therethrough, directing a pressure flame against the upper end of said shell in a direction to cause said glass end to form toward the lead and bead while in its molten state, and applying a jet of cold air to the external surface of said shell at the instant the glass becomes pliable to assist the closing action of the flame, and then flame sealing the other end of said shell to form a complete resistor assembly.

7. A method of making a glass encased resistor assembly comprising: butt-welding separate sections of Kovar and copper wire together to form lead wires, degassing said lead wires in a hydrogen furnace at approximately 900° C. for about fifteen minutes, fusing a glass bead over the fusible portion of said leads and overlapping said butt-weld, depositing a thin layer of carbon on the peripherial surface of a non-conductive cylindrical blank having axial counterbores, adding a layer of silver to each end of said blank including said counterbores and in electrical continuity with said carbon surface, cutting a helical groove through the surface layer of said carbon to form an increased resistance path on said coated blank, dipping the Kovar ends of said leads in silver paste and inserting said dipped ends into said counterbores to form a resistor body unit and curing said body unit in an air oven at approximately 200° C. for about two hours, placing each end of said body unit in a radio frequency induction heating coil and soldering said leads into firm attachment with said blank, placing

a glass tube over said body unit and rotating said tube and body unit and passing nitrogen therethrough, directing a pressurized flame against the upper end of said tube in a direction to form said glass toward said lead and fusing said end to said glass bead, and applying a blast of cold air to the external surface of said shell at the instant the glass becomes pliable to assist the closing action of the flame, and sealing the other end of said shell within a time when a substantial portion of the nitrogen passed through the shell during the first sealing step remains entrapped therein.

8. A hermetically sealed electric component assembly, comprising: an electrical element, leads extending from opposite surfaces of said element, a fusible glass bead abutting each said surface and fused to each said lead, a fusible glass shell surrounding said element, said beads and a portion of said leads, said shell being hermetically sealed to both said bead and said lead and being spaced from said element by the presence of said beads.

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