Nov. 3, 1964 A. C. PFISTER 3,155,935

SEALED RESISTOR

Original Filed Jan. 30, 1957 2 Sheets-Sheet 1

Fig. 1

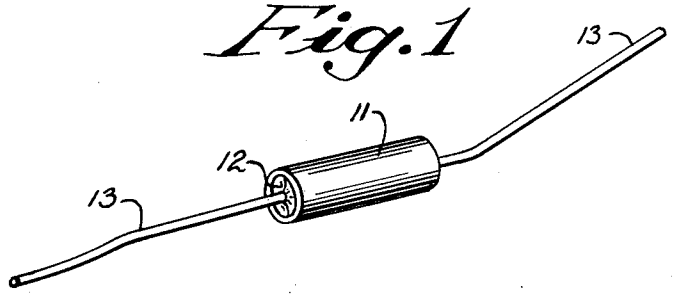



Fig. 2

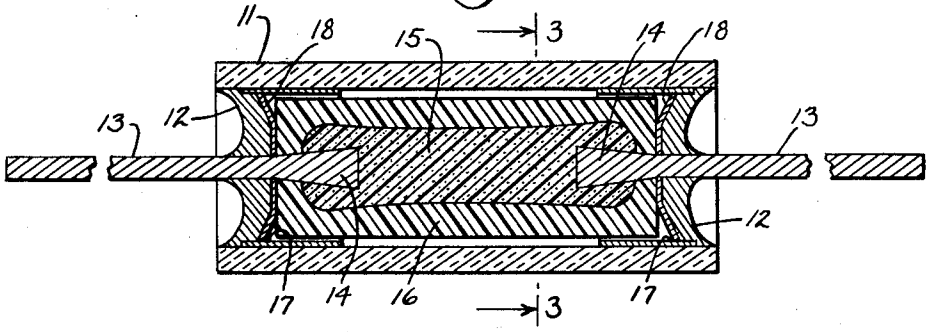



Fig. 4

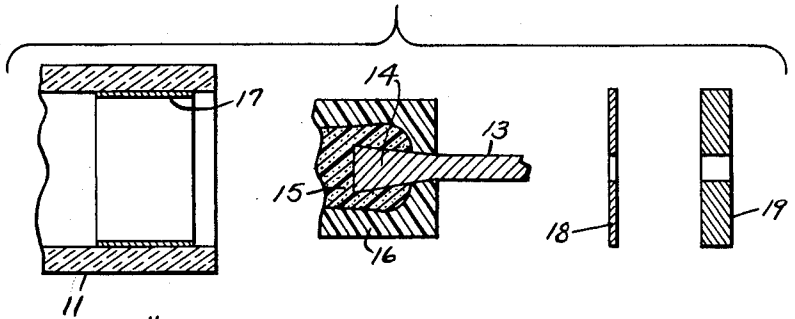
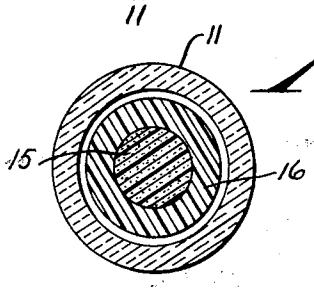



Fig. 3




INVENTOR
ANTHONY C. PFISTER

BY Adrian L. Bateman Jr.

ATTORNEY

Nov. 3, 1964 A. C. PFISTER 3,155,935

SEALED RESISTOR

Original Filed Jan. 30, 1957 2 Sheets-Sheet 2

Fig. 5

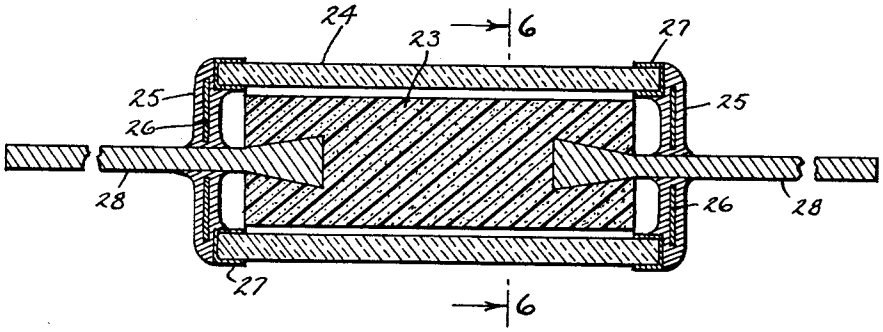



Fig. 6

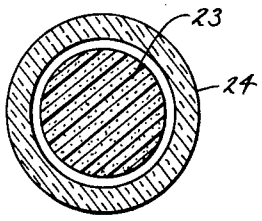
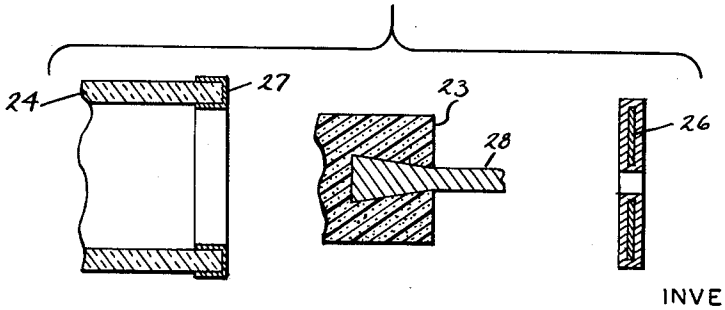



Fig. 7




INVENTOR
ANTHONY C. PFISTER

BY Adrian L. Bateman, Jr.

ATTORNEY

United States Patent Office 3,155,935 Patented Nov. 3, 1964



3,155,935

# SEALED RESISTOR

Anthony C. Pfister, Whitefish Bay, Wis., assignor to Allen-Bradley Company, Milwaukee, Wis., a corporation of Wisconsin

Original application Jan. 30, 1957, Ser. No. 637,222, now Patent No. 3,037,266, dated June 5, 1962. Divided and this application Oct. 9, 1961, Ser. No. 143,915
5 Claims. (Cl. 338—237)

This invention relates to electrical resistors of the type commonly employed in electronic or control circuits, particularly that class known as molded composition resistors, and resides more specifically in the mechanical features of a hermetic encapsulation thereof and in the method of heat treating the molded composition resistance body prior to and during encapsulation. This application is a division of my co-pending application, Serial No. 637,222, filed January 30, 1957, now Patent No. 3,037,266 issued June 5, 1962.

The mechanical details of the encapsulating sleeve, the hermetic seals therefor, and the heat treatment employed prior to and during encapsulation may be varied in some particulars, depending in part upon the physical size of the resistance body, but in its preferred form the capsule is formed from a substantially moisture impervious material, such as an inorganic dielectric, glass or metal enclosure protected against moisture access by seals, such seals in most instances being fused to the encapsulating sleeve and to the resistance body electrodes by a metallic substance having the property of flowability at relatively low temperatures. Similarly, the heat treatment employed prior to encapsulation of the resistance body will vary with the physical size thereof, but the preferred embodiment is calculated to condense or cure the resinous binder of the resistance body far toward completion, following which an additional heat treatment is employed to remove moisture from the resistance body prior to encapsulation. Likewise, during encapsulation, a regionally controlled heat shock may be utilized to stabilize certain of the characteristics of the resistor.

The known advantages of molded composition resistors have resulted in their becoming the most widely used low power dissipation resistors in modern electrical circuits. These advantages include dependability, freedom from likelihood of open circuiting or other catastroptic failure, high mechanical strength and economy and ease of obtaining high resistance values. Because of certain instabilities of resistance value, however, molded composition resistors have heretofore been limited in application to circuits in which resistance stability is not a highly critical factor. Critical applications have heretofore required a class of resistors known as precision resistors, such as those wound from high resistance wire, or film-type resistors formed by the deposition or evaporation of resistive material on an insulating surface. It is the primary object of this invention to improve the resistance stability of molded composition-type resistors so that they may, in many circuit applications, replace precision-type resistors, such improved stability being accomplished without sacrifice of the aforesaid established advantages of molded resistors.

Molded composition resistors are customarily formed from a uniform homogeneous mixture of fine carbon particles and inert filler material such as silica or finely-ground quartz, the foregoing being bound by a resinous thermo-setting material such as the well-known phenol-aldehydes. It is general practice to form such resistor bodies in a pill-forming die by the application of heat or pressure, or by the simultaneous application of heat and pressure. Where insulation is desired, a jacket of



insulating filler material bound by a phenol-aldehyde resin may be formed about the resistor body. In some instances the resistance body is formed and partially cured prior to the formation of an insulating jacket thereabout, and in other instances a preform is made in which the insulating jacket is applied to the molded resistance body prior to curing. In any event, a heat treatment is applied to the resistance body after molding, whether jacketed or not, in order to condense or cure its resinous binder. If jacketed, the jacket is also cured to partially cure its resinous binder and to securely unite the resistance body to the jacket disposed thereabout. It is during heat treatment that resistance stability characteristics are developed, and heretofore it has been impossible to substantially complete the cure of the resinous binders because, while some of the resistor characteristics are enhanced by continued heat treatment, other characteristics, particularly humidity stability, deteriorate in the advanced stages of curing. It is the discovery of this invention that all of the accepted resistance stability characteristics by which the reliability of resistors is measured can be substantially improved by continuing the heat treatment cycle beyond the point of deterioration of humidity stability and thereafter hermetically encapsulating the substantially-cured resistor. These advantages accrue irrespective of the particular molding technique used, and for the purposes of this invention, it is immaterial whether the resistance body was initially molded by pressure alone or was initially molded under the simultaneous application of heat and pressure. Stated another way, it is immaterial whether the resistance body is of the type characterized in the trade as "cold molded" or "hot molded." Likewise, it is immaterial whether the resistor has an insulating jacket or not, and it is similarly immaterial whether the insulating jacket was applied prior to or after partial curing of the resistor.

At the advanced stages of curing utilized in the present invention, a resistor demonstrates a substantial humidity sensitivity or ability to acquire moisture, which is probably due, at least in part, to the development of porosity or minute fissures as the resin is polymerized. To stabilize the resistor and its encapsulating sleeve prior to sealing, both are dried to a condition of low moisture inclusion, and sealing is completed with the units in this low moisture condition. The improved properties of the sealed resistor are attributable in part to the fact that it is thus operated under low moisture conditions.

The improved properties of the resistor of this invention are likewise attributable in part to the use of an inert, substantailly moisture impervious encapsulating sleeve which is closed by seals in wetted engagement with the resistor electrodes. The improvement in stability characteristic is also attributable in part to heat shock to a portion of the resistance body during the encapsulating and sealing operation.

For the purpose of disclosure two embodiments of the invention are illustrated and described, from which those skilled in the art may learn the critical mechanical considerations and the parameters which determine the time and temperature cycle of the novel steps utilized in heat treatment, both prior to and at the time of encapsulation.

Referring to the drawings:

FIG. 1 is a perspective view of one form of sealed resistor in accordance with the invention;

FIG. 2 is a sectional elevation of the resistor shown in FIG. 1;

FIG. 3 is a cross-sectional view taken on the plane indicated by line 3—3 in FIG. 2;

FIG. 4 is a sectional exploded view of that portion of the resistor to the right of the line 3—3 in FIG. 2,

showing details of the resistor parts prior to assembly;

FIG. 5 is a sectional elevation view of an alternate sealed resistor in accordance with the invention;

FIG. 6 is a cross-sectional view taken on the plane indicated by line 6—6 in FIG. 5; and

FIG. 7 is a sectional exploded view of the portion of the resistor to the right of the line 6—6 in FIG. 5, showing details of the parts prior to assembly.

Referring to the details of FIG. 1, the embodiment of the present invention illustrated thereby may be seen to comprise a tubular sleeve 11 of a ceramic insulating material such as, for example, grade L-3 steatite. Other encapsulating materials may be used but preferably should be selected from those materials which are substantially impervious to moisture, by which is meant ambient humidity as distinguished from liquid. The resistor of FIG. 1 is sealed hermetically adjacent the ends of sleeve 11 as at 12, and wire electrodes or pigtails 13 pass through the central portion of the seals 12 for connection to circuit elements. It may be observed in FIG. 1 that the sealed resistor illustrated is a compact unit. For purposes of illustration its size has been greatly magnified, but in the actual physical embodiment the encapsulated and sealed resistor is comparable in size to previous jacketed molded composition resistors of the same wattage rating and load like characteristic.

In FIG. 2 the details of the resistance, body, encapsulating sleeve and seals are illustrated. It may be observed that the electrodes 13 are formed from wire which may be tinned for easy solderability and which has enlarged frustro-conical head portions 14 embedded in a resistance body 15, the tapered surfaces of the heads being for the purpose of improving retention.

The resistance body 15 has an integral insulating jacket 16 and may be molded in the presence of heat or pressure or by the simultaneous application of heat and pressure in a manner described in greater detail hereafter. In their assembled relationship, resistance body 15 with its insulating jacket 16 and electrodes 13 is centrally disposed in an encapsulating sleeve 11 and is hermetically sealed in the aforesaid position by identical seals adjacent the end portions of the encapsulating sleeve, said seals being indicated generally by the numeral 12.

The construction of the seals is best understood by simultaneous reference to FIGS. 2 and 4. As shown in FIG. 4, the tubular sleeve 11 of ceramic material has an internal peripherally disposed metalized area 17 adjacent its end portion, which metalized area is in intimate wetted engagement with the internal periphery of the cylindrical sleeve and is preferably formed from metallic silver in a glass matrix, which is fired onto the ceramic sleeve at high temperature. If desired the silver metalized area may then be copper plated and hot solder dipped, or if desired a tin plate may be applied over the copper plate before solder dipping. The seal 12 is completed by crimping in metallic washers 18, which may be solder plated steel that has been dipped in flux prior to crimping, following which a solder washer 19 is crimped into the sleeve 11. It may be observed that the diameter of washers 18 and 19 is made larger than the internal diameter of the metalized encapsulating sleeve 11, so that the washers have an interference fit within metalized area 17. After mechanical insertion, heat is applied to fuse solder washer 19 to metalized areas 17, electrodes 13 and solder plated washer 18, thereby completing the hermetic seal. Further details of the method utilized in forming this seal are described hereafter in greater detail.

FIGS. 5, 6 and 7 illustrate an alternate mechanical embodiment of the invention. In this instance the resistor 23 is formed as a molded composition body with electrodes 28 embedded therein, but without an insulating jacket. As before the resistance body is centrally disposed in a moisture impervious sleeve 24 and hermetic seals 25 are employed adjacent the ends of the sleeve. In this embodiment, however, the end portions of the interior and exterior cylindrical surfaces, as well as the annular end surfaces of sleeve 24 are metalized as at 27 in the manner previously described. The seal is formed by a washer 26 which may be of copper with a generous coating of solder alloy plated thereon. Instead of being crimped inside the sleeve 24 the washers 26 are placed adjacent the annular end surfaces of sleeve 24 with electrodes 28 projecting through the central portion thereof and heated to cause the solder film thereon to flow and adhere to metalized areas 27 and electrodes 28, forming a hermetic seal at each end of the sleeve. This construction is particularly well suited to extremely small resistors of the type used in miniature equipment, such as hearing aids and the like. Even after encapsulation and sealing the resistor of the type illustrated in FIGS. 5, 6 and 7 is smaller than any known resistor of comparable electrical characteristic and freedom from catastrophic failure. The elements in FIGS. 5, 6 and 7 have been enlarged many times to facilitate illustration.



Referring again to FIG. 2, it may be observed that resistor body 15 with its insulating jacket 16 and electrodes 13 is superficially representative of the jacketed molded composition resistors which constitute a substantial portion of present resistor manufacture. Similarly, resistor body 23 in FIG. 5 is superficially representative of nonjacketed molded composition resistors. In both cases, however, the resistor bodies are given a heat treatment or annealing subsequent to molding which is in excess of that customarily employed heretofore. Since the size and composition of the resistor body are factors which influence this novel annealing cycle, a specific illustrative example will be given which includes previously known preparatory steps in order to furnish a background for explaining the novel steps utilized in the present invention.

Thus, in forming the resistor body of FIG. 2 with its integral insulating jacket, the jacket material may be a phenol-aldehyde composition in the form of a molding resin, which is placed on heated milling rolls and powdered silica is mixed therewith during milling. The rolls are preferably maintained above about 225° F. and milling is continued until the composition is very stiff and plastic. The resin and filler after mixing are preferably present in the following proportions by weight: resin 25% and filler 75%. If desired minor amounts of lubricants such as montan wax, stearic acid, etc., may be included. The material is delivered from the rolls in sheets and after cooling is broken up and pulverized. The powder thus formed is fed in measured amounts to a jacket forming pill die.

For the core a phenol-aldehyde resin, the same as that used for the jacket or similar thereto, is applied in like manner to milling rolls maintained above about 200° F. and carbon black and filler such as powdered silica is added while milling in the following approximate proportions by weight: resin 25%, carbon black 13% and filler 62%. Small amounts of lubricants and other ingredients may be included if desired. When the composition attains a stiff, plastic condition it is cut from the rolls, cooled, broken up and pulverized. The powder thus formed is then compressed in a pill die in appropriate quantities to produce a fill for the previously formed jacket. For higher or lower resistance values the proportion of carbon black may be decreased or increased in a manner well-known in the art.

In the case of the nonjacketed resistor body 23 of FIGS. 5 and 7, similar forming operations are performed except, of course, the insulating jacket is not included.

The preform body, as it is generally called, is then provided with electrode leads, which in the FIG. 2 embodiment are generally inserted into previously prepared cavities in the preform body, and in the FIG. 5 embodiment are forced into the preform by pressure. In either case, heat and pressure are then applied in order to flow the resistor body into intimate engagement with the heads

of the electrodes. For the purposes of this invention it is immaterial whether the preform body is initially formed by the "hot mold" process in which heat and pressure are supplied to the pill forming die or by the "cold mold" process in which high pressures are used to form the molded preform body.

After molding, the resistor body is heat treated or annealed. The time and temperature cycle used in this annealing process varies, depending upon the size and composition of the resistor. Thus, a larger resistor generally requires a longer annealing cycle and a higher temperature than does a resistor of small proportions. In the case of the jacketed resistor of FIGS. 2, 3 and 4, which, for example, may be a one-half watt size and have an overall diameter of about 5/32 inch and overall length of about 13/32 inch, the usual annealing cycle would be approximately 16 hours at a temperature of about 350° F. minimum. During this annealing cycle the resin binder is condensed or polymerized and the purpose in continuing the annealing cycle is to advance or condense the resin to a point at which the resistor will exhibit a fairly stable resistance value. At this point the resistor is completed according to present methods.

Heretofore it has been necessary to stop condensation of the resinous binder substantially short of completion because a resin that is substantially completely cured exhibits a pronounced humidity sensitivity. As a matter of fact "over annealed" resistor bodies have been used as the sensing element in humidity measuring devices because of their substantial resistance change under ambient humidity conditions.

According to the present novel method, the resistor body illustrated in FIGS. 2, 3 and 4 is given a further intensive annealing treatment, which is preferably performed in a nonoxidizing atmosphere. This further annealing is preferably continued for about 16 hours at a temperature of about 400° F. minimum, and in order to exclude oxygen, may be accomplished in a bath of molten wax or oil. After this additional annealing the resin binder of the resistor body will be substantially completely cured as contrasted with the partial cure of previous molded composition resistors and under these circumstances the resistor will exhibit a pronounced moisture sensitivity or ability to acquire moisture. Following the additional annealing, the resistor is subjected to a spray or bath of a cleaning substance to remove any wax or oil residue left on the surface of the resistor body or electrodes from the annealing bath.

Following cleaning, the resistor is dried in air at a temperature that will not appreciably alter the degree of condensation of the resin binder or the ohmic value of the resistor. It has been found that, for a resistor body of the size, type and composition illustrated in FIGS. 2, 3 and 4, sufficient drying may be accomplished by heating the body for about 15 hours at a temperature of about 300° F., or alternatively, for 24 hours at about 210° F. Following the drying step, the resistors may be classified as to ohmic resistance value and then either be encapsulated immediately or stored in a desiccant or in low humidity cabinets, in order to preserve the state of dryness accomplished in the drying operation.

The ceramic encapsulating sleeves may be dried in a similar manner and used immediately or stored as set forth above so that both the resistor and sleeve are substantially dry at the time of sealing.

In the case of the mechanical embodiment of FIGS. 2, 3 and 4, sealing is accomplished by coating washer 18 with a solder flux, mechanically crimping washers 18 and 19 in place and subsequently applying heat in the localized area of the washers in order to cause the solder washer 19 to flow and complete the seal. In performing the sealing operation it is important to avoid temperatures that will burn the resistor body, but at the same time it is desirable to bring the resistor and encapsulating sleeve up to a temperature between about 400 and 450° F. in order to expand the air filling the voids within the encapsulating sleeve. The actual sealing may be accomplished by supplying heat by means of an induction coil to the localized area of the seal including the metalized areas 17. In the case of the embodiment of FIGS. 2, 3 and 4 the washer 18 is preferably made of steel or other metal having relatively high losses in the presence of an induction coil so that the temperature of washer 18 will be raised more rapidly than will be the temperature of the solder washer, thus causing a heat transfer from the washer 18 to washer 19. When sufficient heat has been supplied to cause the solder washer 19 to become molten, the heat supply is interrupted and the solder is allowed to cool, becoming intimately bonded to metalized area 17, washer 18 and electrode 13. It may be noted in FIG. 2 that the electrodes 13 are tapered slightly so as to increase the diameter adjacent the ends of the resistor body. This taper aids in centering the resistor body and seals when the washers are crimped into position. It may also be noted in FIG. 2 that washers 18 are preferably spaced somewhat from the ends of the resistor body so that heat transfer by direct conduction is avoided during the sealing operation.

The illustration of FIGS. 5, 6 and 7 exemplifies a sealed resistor that may have very small dimensions and is, therefore, readily adaptable to miniaturized electronic equipment. The resistor body 23 of FIG. 5 has a diameter of about 1/16 inch and a length of about 9/64 inch, and a unit of this size may be annealed to have the properties previously mentioned by heating it in a bath of molten oil or wax for about 16 hours at a temperature of about 350° F. minimum. After annealing the resistor body should be cleaned as previously described and thereafter dried in air for about 15 hours at a temperature of about 200° F. The ceramic encapsulating sleeve 24 is also dried as previously set forth and the sleeve and resistor body may then be assembled and sealed immediately or stored prior to encapsulation in a desiccant or low humidity cabinet in order to maintain their state of dryness. Sealing is accomplished by disposing the resistor body 23 centrally within sleeve 24, and thereafter placing washers 26 in abutting relationship with the ends of the sleeve, with electrodes 28 projecting through the central aperture in the washers. With the units thus assembled they are then heated as in the previously described embodiment to about 400° F. in order to expand the air filling the voids within the assembly. While in this heated condition, additional heat is supplied, as by an induction coil, in the localized area of washer 26 in order to melt the solder plate thereon and complete a hermetic seal by intimately bonding the washer to metalized areas 27 and electrodes 28. It is preferable to space the washers 26 from the ends of the resistor body to avoid direct heat conduction during sealing.

As a measure of the resistance stability improvement gained by the novel mechanical features and method of the present invention, it is helpful to compare the characteristics of the present resistor with those of previous resistors having resistance elements of the same size. The most generally accepted current standards for high quality molded composition resistors are those set forth in military specification Mil–R–11B, which permits a resistance change due to humidity of 10 percent, a resistance change due to temperature cycling of 3 percent, a short time overload resistance change of 2.5 percent, a soldering effect resistance change of 3 percent, and a resistance change of 6 percent during a standard load life test. The resistor of the present invention under these standard tests exhibits a resistance change of less than 1 percent on all of the tests except load life, in which case the resistance change is 2 percent. Thus, the performance of the resistor of the present invention exhibits characteristics improved by as much as ten times over

previous resistors of the molded composition type. For further comparison it is helpful to compare the present resistor with the military specifications (Mil–10509B) for precision film-type resistors. These requirements are, resistance change due to moisture 5 percent, temperature cycling 1 percent, shot-time overload 0.75%, and effect of soldering, 0.5 percent. From these standards it may be seen that the resistor of the present invention exceeds the requirements for precision film-type resistors in one instance, equals it in another, and approaches it in two other respects. In addition the present resistor is not subject to open circuiting or other catastrophic failure, a major handicap of most film-type resistors.

In addition, to the foregoing improved characteristics the sealed resistors of the present invention demonstrate greatly reduced microphonic noise under dynamic vibration tests. This noise reduction is due, at least in part, to improved mechanical rigidity, particularly in the lead wires. Thus, the double support given the electrodes in FIG. 2 by the phenolic jacket 16 and the seal 12 and ceramic sleeve 11, or the additional support given by the seal 25 and sleeve 24 in FIG. 5, prevent substantial vibration of the electrodes at their junction with the resistor bodies..

It has been found that resistors encapsulated according to the foregoing procedure may be rated for higher power dissipation than a standard molded composition resistor of the same size. For example, the jacketed resistor 15 of FIG. 2, which in the size described has heretofore been rated at ½ watt, may be rated at one watt and still have a resistance change under standard load life tests of less than 6 percent, which is the tolerance prescribed by the previously mentioned standards for molded composition resistors. If an encapsulated resistor in accordance with FIG. 2 is rated at one watt, then its overall outside dimensions including the sealed tube 11 correspond with the smallest of presently available one watt jacketed molded composition resistors. In other words, the advantages of the present invention may be gained without increase in physical dimension, an important consideration in electronic components. This increase in power rating is accomplished even though the encapsulating sleeve is made of ceramic material having poor heat conducting properties, and may be attributed in part to the advanced cure of the resinous binder and in part to the use of relatively massive metallic seals.

In order for the metallic seals to function with maximum effectiveness in dissipating heat developed during operation of the resistor, it is desirable that the various seal elements be bonded together with a wetted seal over all areas of contact so as to act as a unitary heat extracting thermal conductor. Fusible metal for this bonding may be supplied by solder coating and wetting each of the various elements as previously mentioned. Since the resistor electrodes inevitably transfer a portion of the heat supplied during seal fusion to the resistor body, which in most instances will have a different expansion coefficient from that of the electrode, it is important that the fusible metal be selected from metals or alloys which fuse at relatively low temperatures, but above the operating temperature of the units.

The most advantageous melting point will vary depending upon the physical dimensions of the resistor body and seal, but melting points within the range of 350° F. to 600° F. are most suitable. For example, in FIG. 4, metalized area 17 and washer 18 may be coated with a solder of 60% tin and 40% lead, which has a melting point of about 370° F. Electrodes 13 may be coated with a 10% tin and 90% lead solder having a melting point of about 580° F. The solder washer 19 may be composed of 30% tin, 3% silver and 67% lead, which alloy begins to soften at about 354° F. and is completely molten at about 500° F.

In the miniaturized embodiment of FIG. 7, metalized area 27 and washer 26 may be coated with 60% tin and 40% lead solder and electrodes 28 may be coated with a solder composed of 10% tin and 90% lead.

By using fusible metals have melting points within the ranges indicated, intimate wetted bonding will be obtained between the various seal elements and also a sturdy hermetic seal will be formed attended by a desirable heat shock, but devoid of adverse heating effects within the resistor bodies, and the seals after fusion will retain their bonds without adverse effect from heat supplied in subsequently soldering the resistor into a circuit.

Since the time and temperature cycles utilized in annealing the resin binder vary with resistor size and composition, relative terms have been utilized in parts of the description, and the degree of polymerization of the resin has been expressed in terms of moisture sensitivity. Stated more precisely, the moisture sensitivity of the fully annealed resistor body may be expressed in terms of standard humidity stability tests at 40° C. and 55 percent relative humidity. Under such tests, the ohmic resistance of a resistor will change rather rapidly from its dry value until a relatively stable value is reached, after which there is little further change. Resistors annealed according to the present novel method reach this steady state of resistance at a value of 10% or more change from the dry resistance value.

Similar relative terminology has been utilized in describing the state of dryness of the resistors after the drying step. Stated more precisely, the desired state of dryness is reached when resistance change due to the removal of water vapor reaches a steady value.

While but two embodiments of the invention have been illustrated and described in detail, others are contemplated. For example, the encapsulating sleeve and seal may be composed of a single glass tube crimped to form a seal about the electrodes. In such an embodiment, either the entire electrode or at least that portion passing through the crimped glass seal should be a metal having the characteristic of being wettable by the glass encapsulating sleeve when it is heated for crimping. Other forms of encapsulating sleeves may, likewise, be used, including metal. In such an embodiment, insulation must be provided by the seals, which may be glass or other ceramics having a metalized periphery and central aperture which can be soldered to the metal sleeve and electrodes by known techniques. Thus, the mechanical embodiments and methods described in connection therewith are intended to be exemplary of the novel features of the invention and will suggest other alternatives to those skilled in the art. It is, therefore, intended that the scope of the invention be limited, not by the examples used for disclosure purposes, but only by the following claims.

I claim:

1. A molded composition electrical resistor having improved stability of resistance value comprising; a dried cylindrical resistance body of dispersed carbon particles bonded by a substantially cured resin binder, said resistance body exhibiting a substantial ability to acquire moisture from ambient humidity; a high conductivity metallic electrode embedded in the resistance body adjacent each of the ends thereof and projecting therefrom; a cylindrical, non-conductive sleeve of substantially moisture impervious composition disposed about the resistance body and extending beyond the ends thereof, said sleeve having open ends through which the electrodes extend; a metalized area in intimate wetted engagement with a portion of the sleeve adjacent the ends thereof; a metallic washer adjacent each of the end portions of the sleeve, each washer having an aperture through which one of the electrodes extends; and fused metallic seals intimately bonding each washer to one of the metalized areas and to the electrode extending therethrough.

2. A molded composition electrical resistor having improved stability of resistance value comprising; a dried cylindrical resistance body of dispersed carbon particles

bonded by a substantially cured resin bsnder, said resistance body exhibiting a substantial ability to acquire moisture from ambient humidity; a high conductivity metallic electrode embedded in the resistance body adjacent each of the ends thereof and projecting axially therefrom; a cylindrical, non-conductive sleeve of substantially moisture impervious composition disposed about the resistance body and extending beyond the ends thereof, said sleeve having open ends through which the electrodes extend; a metalized area in intimate wetted engagement with the interior periphery of the sleeve adjacent each of the ends thereof; a metallic washer in each of the end portions of the sleeve and in circumferential engagement with one of the metalized areas, said washers each having a limited aperture through which one of the electrodes extends; and fused metallic sealing means forming a hermetic seal between each of the washers and its adjacent metalized area and with the electrode projecting therethrough.

3. A molded composition electrical resistor having improved stability of resistance value comprising; a dried cylindrical resistance body of dispersed carbon particles bonded by a substantially cured resin binder, said resistance body exhibiting a substantial ability to acquire moisture from ambient humidity; a pair of metallic electrodes embedded in the resistance body adjacent the ends thereof and projecting therefrom; a cylindrical, non-conductive sleeve of substantially moisture impervious composition disposed about the resistance body and extending beyond the ends thereof, said sleeve having open ends through which the electrodes extend; a metalized area in intimate wetted engagement with the annular end surfaces of the sleeve; a metallic washer adjacent each of said metalized end surfaces of the sleeve, each of said washers having an aperture through which one of the electrodes extends; and metallic sealing means intimately bonding the peripheral portion of one of the faces of each of said metallic washers to the adjacent metalized surface and intimately bonding a peripheral portion of each of said electrodes adjacent the aperture in the washer.

4. A molded composition electrical resistor having improved stability of resistance value comprising; a dried,



resin bonded resistance body of dispersed carbon particles, said resistance body exhibiting a substantial ability to acquire moisture from ambient humidity; a pair of electrodes in electrical contact with said body and projecting therefrom; a substantially moisture impervious sleeve disposed about said resistance body in encapsulating relationship thereto, said sleeve having openings through which the electrodes project; a metallic surface in intimate wetted engagement with said sleeve and adjacent the openings therein; and metallic seals disposed between said metallic surfaces and the projecting electrodes to hermetically seal the openings in said sleeve.

5. A molded composition electrical resistor having improved stability of resistance value comprising; a dried, relatively porous moisture sensitive resistance body of dispersed carbon particles bonded by a substantially cured resin, said resistance body exhibiting a substantial ability to acquire moisture from ambient humidity; a pair of electrodes in electrical contact with said body and projecting therefrom; a substantially moisture impervious non-conductive sleeve disposed about said resistance body in encapsulating relationship thereto, said sleeve having openings through which the electrodes project; a metallic surface in intimate wetted engagement with said sleeve and adjacent each of the openings therein; and relatively massive metallic seals disposed between said metallic surfaces and the projecting electrodes to hermetically seal the openings in said sleeve, each of said seals including metallic stiffening means and fused metallic means bonding the stiffening means to the metallic surface and the electrode.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 1,835,582 | Allen | Dec. 8, 1931 |
| 2,176,604 | Bankelman | Oct. 17, 1939 |
| 2,271,774 | Megow et al. | Feb. 3, 1942 |
| 2,282,651 | Haberberger | May 12, 1942 |
| 2,407,171 | McFarren | Sept. 3, 1946 |
| 2,635,162 | Kohring | Apr. 14, 1953 |
| 2,640,903 | Kohring | June 2, 1953 |
| 2,745,930 | Reisman | May 15, 1956 |

UNITED STATES PATENT OFFICE

# CERTIFICATE OF CORRECTION

Patent No. 3,155,935 November 3, 1964

Anthony C. Pfister

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 51, for "washer" read -- washers --; column 8, line 3, for "have" read -- having --.

Signed and sealed this 30th day of March 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents

# UNITED STATES PATENT OFFICE

# CERTIFICATE OF CORRECTION

Patent No. 3,155,935 November 3, 1964

Anthony C. Pfister

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 51, for "washer" read -- washers --; column 8, line 3, for "have" read -- having --.

Signed and sealed this 30th day of March 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents