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ELECTRICAL RESISTOR

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FIG. 1.

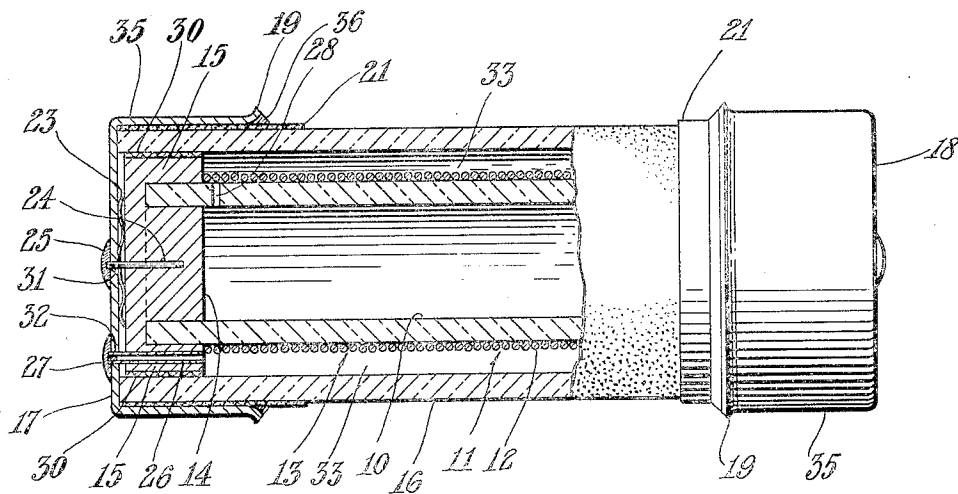


FIG. 2.

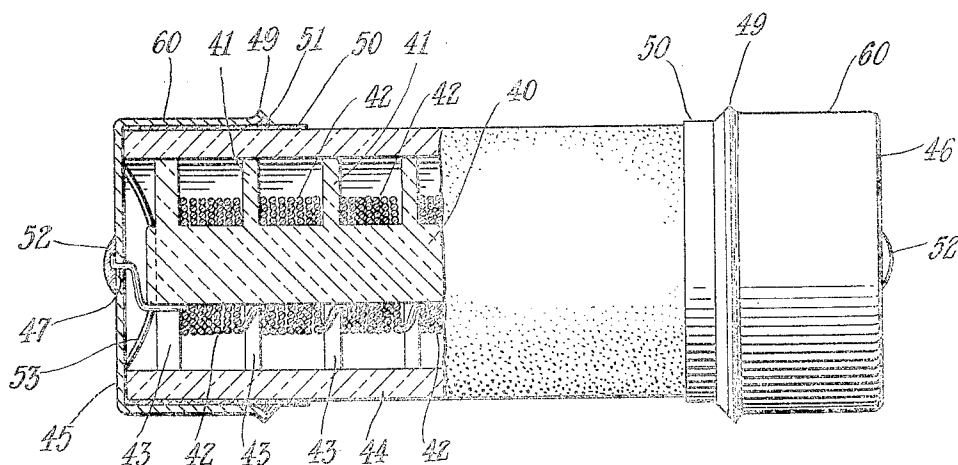
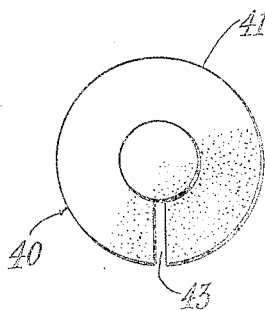


Fig. 3.



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ELECTRICAL RESISTOR

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9 Claims. (Cl. 201—67)

The present invention relates to electrical resistors and to an improved method of constructing resistors, particularly those of high wattage and of high ohmic resistance.

Such resistors are subjected in operation to high temperature rises, of 250° C. or more, which place severe requirements on the resistor, and must be met in a manner to insure long life and constancy in electrical characteristics of the resistor. For example, such high temperature rises cause important differential expansion of the resistor components resulting in severe stresses therein. Moreover, the high operating temperatures limit the choice of materials for the components, particularly in high-voltage applications.

To protect the resistor element, its insulating medium and its other components against humidity, oxidation and corrosion, it is desirable to hermetically seal the resistor, whereby, however, the above problems are further aggravated.

It is an object of the invention to provide a hermetically sealed resistor meeting all of the above requirements, and which at the same time is rugged, simple to manufacture and of low cost.

This and further objects of the invention will appear as the specification progresses.

The invention comprises the novel features of construction, combination of elements, and arrangement of parts hereinafter pointed out, and will be described with reference to the appended drawing forming part of the specification and in which:

Figure 1 is a partly sectionalized view of a wire-wound resistor in accordance with the invention.

Fig. 2 is a partly sectionalized view illustrating a second embodiment of the invention.

Fig. 3 is an end view of one form of core for the resistor of Fig. 2.

Referring to Fig. 1, the resistor shown comprises a cylindrical core 10 supporting a resistance element 11 which extends substantially to the ends of the core. Core 10 consists of a non-hydroscopic, heat-resistant and electrical-insulating material such as porcelain, "Isolantite" or of other ceramic material, or of a heat-resistant electrical glass such as "Electrical Pyrex." The core 10 is preferably hollow as shown, but may also be solid throughout.

The resistor element 11 is shown to consist of a wound resistance-metal wire 12, for example, nickel-chrome wire. The dimensions of the wire 12 are determined in known manner by the desired resistance value and current carrying re-

quirements of the resistor element. For resistors of comparatively low ohmic value the wire is wound in a single layer as shown, whereas for resistors of high ohmic value a multilayer type winding is preferred. Adjacent turns of the wire 12 are insulated from each other by a suitable temperature-resistant insulating medium, such as a vitreous enamel or glass or other refractory insulating material, preferably formed as an adherent coating 13 on the wire.

The resistance-element, instead of being wire-wound, may be of other type, for example a sprayed or adhesively bonded coating of carbon provided on the core 10, or may consist of a solid matrix of a suitable resistance material, for example of a molded mixture of carbon and "Bakelite," requiring no supporting core.

Cast over each end of the core 10 are metal cups 14—14 which by means of their flanges 15—15 make electrical connections with the respective ends of the element 11. The cups 14—14 are preferably of an alloy having a melting point of about 275° C. to 325° C. and may be an alloy of zinc with approximately 4% aluminum and 5% magnesium by weight. For reasons later to be pointed out, the flanges 15—15 have a thickness in excess of the height of the element 11.

The element 11 with its core 10 is enclosed within a cylindrical casing 16 consisting of a moisture- and heat-resistant insulating material such as glazed porcelain, "Isolantite" or "Electrical Pyrex." "Electrical Pyrex" and particularly if it is specially annealed, is exceptionally suitable because of its ruggedness, low temperature-coefficient of expansion, and its resistance to mechanical and thermal shock.

As a feature of the invention, the casing 16 is so positioned relative to the core 10 by the flanges 15—15 that a void or space 23 is formed between the casing and the resistance-element which affords unrestricted temperature expansion of the resistance element thereby obviating stresses in same during operation. The space 23 preferably contains a gaseous medium to be referred to more fully later, and in addition may be filled with a suitable heat transfer medium such as quartz powder.

Preferably the casing 16 and the flanges 15—15 engage each other with a snug fit, which may be provided by the interposition of a heat-resistant gasket 20, for example of glass cloth.

For the moisture-proof hermetical sealing of the entire resistor, the ends of the casing 16 are closed by metal cap members 17 and 18, for example ferrules of brass, bronze or the like, the flanges

35 of which are formed with integral radially-extending lips 19—19. Each of the ferrules 17 and 18 is provided with a central aperture 31, and the ferrule 17 in addition has an offset aperture 32. The purpose of these apertures will later be pointed out.

The ends of the casing 16 are provided with coatings 21—21 of lead, tin, silver, or of other suitable bonding medium by which the flanges 35—35 of the ferrules are secured to the casing by soldering, brazing or the like as at 36. Coatings 21 may be applied, for example, by spraying or by chemical or electrochemical deposition, and preferably the ends of the casing are suitably roughened as by sand-blasting, to facilitate the adherence of the coating.

To prevent end-play of the core 10 with its superimposed resistance element within the casing 16, a flexible backing member, for example a spring washer 23, is interposed between each cast cap 14 and the inside surface of its adjacent ferrule.

External electrical connection to the respective ends of resistor element 11 is made by wire conductors 24—24, which are embedded in the cast caps 14—14 and which pass through the aperture 31—31. Solder plugs 25—25 affix the respective wires to the ferrules 17—18 and seal the apertures 31—31.

By closing the aperture 32 of the ferrule 17 a hermetically-sealed resistor assembly is obtained which is capable of satisfactory operation under normal conditions. I have found, however, that where severe operating conditions are encountered, the gaseous medium permeating the space 33 and other spaces within the resistor must not be permitted to develop a pressure significantly greater than the pressure of the atmosphere surrounding the resistor. If this occurs the seal between the caps 17 and 18 and the casing 16 may be disrupted or at least weakened and the performance of the resistor correspondingly affected. It is therefore an important feature of the invention that the space 33 and other voids, for example, the space within the core 10, are at least partially evacuated, so that at the highest resistor operating temperature the pressure within the casing is not significantly greater and is preferably less than that of the surrounding atmosphere.

For this purpose the resistor of Fig. 1 comprises a temporary vent consisting of a metal tube 26 forming a path through the cast cap 14 connecting the space 33 with the exterior of the resistor through the aperture 32.

The space 33 is in turn interconnected with the space within the core 10 by one or more apertures 28 provided in the core. In some instances the vent-tube 26 may be dispensed with, in which case the path of the gas to be removed is through the porous gasket 30. Similarly, the resistor may be evacuated through the aperture 31 prior to the sealing thereof instead of through the aperture 32 as shown.

The resistor is evacuated preferably by operating the same at its rated or slightly higher than its rated power. This causes the enclosed gas to expand and flow through the tube 26. When equilibrium is reached and while the resistor is at the so induced temperature, the aperture 32 and tube 26 is sealed by a solder plug 27.

The resistor may also be evacuated to the required degree, by a vacuum pump applied to the aperture 32. In general, for a resistor which in operation assumes a temperature of approxi-

mately 275° C., and which is operated in a surrounding atmosphere at normal pressure of 760 mm., the pressure within the casing at room temperature should be approximately 76 mm.

In certain applications it is necessary to prevent entirely any oxidation whatever of the resistor element. To meet this requirement the resistor is filled with inert gas such as nitrogen, for example by first completely evacuating the resistor and thereafter filling the same with the inert gas to the required pressure.

The resistors of the invention are rugged and simple to manufacture and remain hermetically sealed under even the most severe operating conditions. Such resistors withstand without damage ten and even more cycles of the following treatment.

1. Operate resistor at rated power for six (6) hours.
2. Immediately immerse resistor in water at 0° C.
3. Operate resistor at rated power for two (2) hours.
4. Immediately immerse resistor into a saturated sodium chloride solution at a temperature of 100° C., and maintain resistor immersed for two (2) hours.
5. Immediately immerse resistor into a saturated sodium chloride solution at 0° C., and maintain immersed for two (2) hours.
6. Wash in clear water.
7. Immediately apply rated power to resistor for six (6) hours.

The resistor of the invention is characterized by other important advantages.

Because the resistor remains hermetically sealed under even the most rigorous conditions, corrosion of the resistance element is minimized to a negligible extent. This makes possible the use of resistance wire of even the smallest diameter for the winding without incurring any significant change in the life and service of the resistor. By means of the invention, compact resistors are obtained having a high ohmic value and being capable of withstanding highly corrosive atmospheres, such as salt spray.

Moreover, the invention has made possible for the first time resistors with high ohmic values and power ratings utilizing complex types of windings, for example, of the bank and progressive universal types, thereby obtaining the most efficient utilization of the winding space within the resistor.

Fig. 2 illustrates a second embodiment of the invention as applied to resistors of the multiplier type having high ohmic values and suitable for operation at high voltages, for example of the order of nine thousand (9000) volts.

The resistor shown comprises a cylindrical core 40 in the form of a series of interconnected spools having individual winding spaces defined by integral barriers 41 and within which a resistor element is contained. Core 40 consists of a suitable refractory insulating material such as porcelain, or "Isolanite" or of electrical glass.

The resistor element is divided into a plurality of individual interconnected sections to minimize voltage stresses, each of said sections consisting of a multilayer type resistance wire winding 42 disposed within the space defined by two adjacently disposed barriers 41.

For the passage of the wire interconnecting the windings, the barriers 41 are formed with a radial slot 43, such being shown in greater detail in Fig. 3.

The core 40 and windings 42 are enclosed within a moisture- and heat-resistant insulating casing 44 consisting preferably of annealed "Electrical Pyrex" for the reasons previously pointed out in connection with the resistor of Fig. 1.

For the moisture-proof hermetical sealing of the resistor, the ends of the casing 44 are closed by ferrules 45 and 46 of brass, bronze or the like, the flanges 60 of which are each formed with an integral radially-extending lip 49. Each of the ferrules 45 and 46 is provided with a central aperture 47.

Each end of the casing 44 is provided with a coating 50 of lead, tin, silver or other suitable bonding medium by which the flanges 60—60 of the ferrules are secured to the casing by soldering, brazing or the like, for example as shown at 51. Coatings 50—50 may be applied, for example, by spraying or by chemical or electrochemical deposition, and preferably the ends of the casing are suitably roughened, for example by sand-blasting, to facilitate the adherence of the coatings.

External electrical connection to the respective ends of the resistor windings is made by connecting wires which pass through the apertures 47—47 and are secured to the ferrules 45—46 respectively, by solder plugs 52—52, which plugs also seal the apertures.

To prevent end-play of the core 40 with its superimposed windings within the casing 44, a resilient backing member, for example a spring washer 53 is interposed between the inside surface of each ferrule and the respective end of the core 40.

The resistor is evacuated by means of a heat treatment or by means of a vacuum pump as previously described, whereby the enclosed gases are removed through one or both of the apertures 47 which are thereafter sealed by the solder plugs 52—52.

In the following claims the terms "normal temperature" or "atmospheric temperature" and "normal pressure" or "atmospheric pressure" should be understood to refer to standard atmospheric conditions as established in engineering practice, i. e. a temperature of approximately 25° C., and a pressure of approximately 760 mm. The term "operating temperature of the resistor" is to be understood to refer to the temperature assumed by the resistor when rated power is applied thereto, and the term "operating pressure" is to be understood to be the pressure within the resistor casing at the operating temperature of the resistor.

While I have described my invention by means of specific examples and in specific embodiments, I do not wish to be limited thereto, for obvious modifications will occur to those skilled in the art without departing from the spirit and scope of the invention.

What I claim is:

1. An electrical resistor comprising a resistance element, an open-ended insulating casing spacedly surrounding said element and extending to the ends thereof, cap members closing each end of the casing, means hermetically sealing said cap members to the casing, and a gaseous filling within said casing, said sealing means being rupturable when subjected to a substantial gaseous pressure differential at the operating temperature thereof, and said gaseous filling at the operating temperature of the resistor having a pressure value approximately equal to the pres-

sure value of the medium surrounding the resistor.

2. An electrical resistor comprising a resistance element, an open-ended insulating casing spacedly surrounding said element and extending to the ends thereof, a metallic layer forming an integral coating over each end of the casing, cap members closing each end of the casing, means hermetically sealing said cap members to said coatings, and a gaseous filling within said casing, said sealing means being rupturable when subjected to a substantial gaseous pressure differential at the operating temperature thereof, and said gaseous filling at the operating temperature of the resistor having a pressure value approximately equal to the pressure value of the medium surrounding the resistor.

3. An electrical resistor comprising a core, a resistance element on the core and extending to the ends thereof, an open-ended insulating casing surrounding the core and the resistance element, said casing comprising a glass having a low-temperature coefficient of linear expansion and having its end portions formed with a roughened surface, metallic layers forming an integral coating over each of said roughened surfaces, cap members closing each end of the casing, means hermetically sealing said cap members to said coatings, and a gaseous filling within said casing, said sealing means being rupturable when subjected to a substantial pressure differential at the operating temperature thereof and said gaseous filling at the operating temperature of the resistor having a pressure value approximately equal to the pressure value of the medium surrounding the resistor.

4. An electrical resistor comprising a resistance element, an open-ended insulating casing spacedly surrounding said element and extending to the ends thereof, cap members closing each end of the casing, means hermetically sealing said cap members to said casing, and an inert gaseous filling within said casing, said sealing means being rupturable when subjected to a substantial gaseous pressure differential at the operating temperature thereof and said gaseous filling at the operating temperature of the resistor having a pressure value approximately equal to the pressure value of the medium surrounding the resistor.

5. An electrical resistor comprising a resistance element, an open-ended insulating casing surrounding said element, means spacedly positioning said element in said casing, a porous heat-transferring electrical insulating medium within the space, cap members closing each end of the casing, means hermetically sealing said cap members to said casing, and a gaseous filling permeating said heat-transfer medium, said sealing means being rupturable when subjected to a substantial gaseous pressure differential at the operating temperature thereof and said gaseous filling at the operating temperature of the resistor having a pressure value approximately equal to the pressure value of the medium surrounding the resistor.

6. An electrical resistor comprising an insulating core comprising spaced radially-extending barrier portions, individual resistance wire windings on the core each interposed between two adjacently disposed barriers, an insulating casing consisting of a glass having a low temperature coefficient of linear expansion surrounding the core and extending to the ends thereof, a roughened surface on each end of the casing, metallic

bonding layers forming integral coatings over the roughened surfaces, cap members closing each end of the casing, means hermetically sealing said cap members to said coatings, and a gaseous filling within the casing and permeating the spaces defined by said barriers, said sealing means being rupturable when subjected to a substantial pressure differential at the operating temperature thereof and said gaseous filling at the operating temperature of the resistor having a pressure value approximately equal to the pressure value of the medium surrounding the resistor.

7. In the manufacture of an electrical resistor, the steps comprising disposing about a resistance element an open-ended casing of a heat-resistant gas-impervious insulating material, heating said element to a temperature approximating the operating temperature of the element and for an interval sufficient to reach heat equilibrium in the resistor and thereafter without substantially cooling the resistor hermetically sealing the casing.

8. An improved resistance element, capable of operating at high temperatures and of withstanding the thermal shock produced by suddenly reducing said temperature, which comprises in combination an electrical resistance element positioned so that it is capable of substantially unrestricted temperature expansion, an open-ended casing of heat-resistant insulating material having a metallic layer bonded on the outside surface at the ends thereof, said casing spacedly surrounding said resistance element, cap members closing said casing and hermetically sealed to the metallic bonding layer thereon, a gaseous filling within said casing, said sealing means being rupturable when subjected to a sub-

stantial pressure differential at the operating temperature thereof but permitting sudden and marked cooling of said resistor from its operating temperature without rupturing the casing, the pressure differential between the inside and outside of said resistor at its operating temperature being insufficient to rupture the aforesaid hermetic seal.

9. An improved resistance element capable of operating at high temperatures and of withstanding the thermal shock produced by suddenly and markedly reducing the temperature of the casing thereof from said operating temperature, which comprises in combination a core upon which is coiled an electrical resistance wire coated with a temperature-resistant insulating medium and so positioned that it is capable of substantially unrestricted temperature expansion, an open-ended cylindrical insulating casing of moisture and heat-resistant specially annealed glass spacedly surrounding said resistance coil, a metallic layer bonded on the outside surface of said casing at either end and extending beyond the hereinafter described cap members, cap members closing said casing and hermetically sealed to the metallic bonding layer thereon, a gaseous filling within said casing, said sealing means being rupturable when subjected to a substantial pressure differential at the operating temperature thereof but permitting sudden and marked cooling of the resistor from its operating temperature without rupturing the casing, the pressure differential between the inside and outside of said resistor at its operating temperature being insufficient to rupture the aforesaid hermetic seal.

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