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MINIATURE HIGH POWER, HIGH TEMPERATURE RESISTOR

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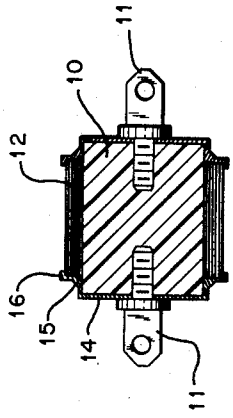


Fig. 1

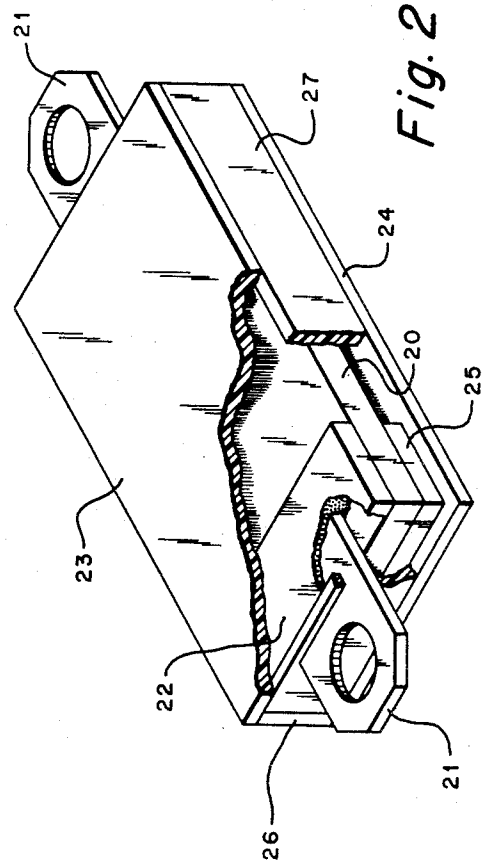


Fig. 2

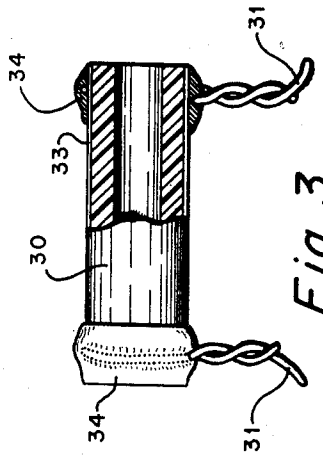


Fig. 3

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MINIATURE HIGH POWER, HIGH TEMPERATURE RESISTOR

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5 Claims. (Cl. 201—63)

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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to miniature electrical resistors, more particularly, it relates to resistors operable at high ambient temperatures.

Previous miniature resistors had poor life characteristics and were inaccurate at high ambient temperatures, necessitating the application of such high wattage derating factors that their use was impractical at these temperatures. Also, results obtained with prior resistors are somewhat undependable because of the difficulty of determining the correct derating factor and because of their large variation in resistance with temperature change. No prior resistor gives completely acceptable electrical and life performance at high ambient temperatures and furnishes sufficient power dissipation. Further, prior art resistors in which the terminals are bonded to the resistive element by adhesive material are subject to high noise level and mechanical failures with variations in temperature and humidity conditions.

It is therefore an object of this invention to provide a miniature resistor which will have constant resistance at high ambient temperatures and good life characteristics.

It is another object of this invention to provide a miniature resistor which will give adequate power dissipation at least up to 200° centigrade.

It is still another object of this invention to provide a miniature resistor having the above characteristics which can be constructed by simple manufacturing techniques.

It is a further object of this invention to provide a resistor having a bond between the resistance element and the terminals which will withstand temperature and humidity changes.

It has been found that the above objects are accomplished by a resistor comprising a ceramic core, which may be solid or partially hollow, having terminals or leads at either end, the core having wrapped around it a resistance element consisting of a fiber glass strip impregnated with a conducting coating. The path from either terminal to the adjacent area of the strip and a portion of the terminal edge or border of the wrapped strip is silver-coated to give a continuous conducting path from the terminal to the strip.

The invention is best understood by reference to the following drawing hereby made a part of this specification and in which,

Fig. 1 is a longitudinal cross-section of the resistor of the invention,

Fig. 2 is an isometric view of a modification of the invention with a section cut away to show the internal construction of the resistor, and

Fig. 3 is an elevational view in partial section of another modification of the invention.

Referring to Fig. 1, there is shown at **10** a core of porcelain or other ceramic material having metal terminals or leads **11** attached to its ends by tapping as shown.

The resistance element itself is formed by wrapping a fiber glass strip **12** around the core **10**. The strip is impregnated with a conductive mixture such as a silicone resin, and graphite or carbon particles in a vehicle of toluene. By impregnation is meant not only a surface coating but complete intermingling of the conductive material with the fibers and particles. The strip may be secured to the core by means of an adhesive glass tape or a high temperature adhesive. In order to form a continuous conducting path from the terminals to the resistance element **12**, the face of the core **14**, the exposed top surface of the core **15** and the edges of the wrapped strip **16** are silvered as shown. This is accomplished by dipping or plating or by any other process which produces an adequate bond between the silver and the edges of the wrapped resistance element. It is an essential feature of this invention that a metal and a method of bonding be used which will ensure a bond between the metal and the edges of the impregnated glass fiber that will withstand temperature and humidity changes. It is to be noted that the leads are secured after the ends of the core have been coated with silver, thus ensuring a good contact between them and the coating.

In the manufacture of the resistance element the fiber glass strip is impregnated with the resin and conductive material by dipping in the conductive mixture and drying until tacky. To ensure complete impregnation of the tape it is subjected to repeated dippings and treatment with a doctor blade. The treatment with the doctor blade ensures a uniform impregnation. The strip is then wrapped around the core with the resin in an unpolymerized state. The length of fiber glass strip and the amount of the conductive material used will depend upon the power dissipation and the resistance value required of the resistor. The resistor at this stage is heated in an oven to its final resistive value, thus completing the polymerization of the resin and ensuring a rigid structure. The temperature and time of curing depend upon the resistance value required. After the curing step, silvering of the conductive path from the terminals to the edge of the wrapped strip is accomplished by the methods as set forth above. If required, as a protection against temperature and humidity changes, the composite resistor may be seal coated with a water resistant high temperature finish.

Referring to Fig. 2, there is shown at **20** a resistance element of fiber glass impregnated with a conducting coating of silicone resin, and carbon and copper particles. The leads **21** of copper foil or sheet are secured to the resistance element **20** by means of a conducting paste **22** of silicone resin and copper powder. The outer sheets of casing material **23** and **24** are sealed to the layers of paste **22** and **25** when the unit is cured. The sides **26** and **27**, also of fiber glass impregnated with silicone resin, complete the structure of the resistor.

The resistance element is made by thoroughly mixing carbon black, copper powder and silicone resin in toluene. The resistance value of the mixture may be varied by changing the relative amounts of carbon black and copper powder with respect to the silicone resin. A representative composition for the preparation of resistors having high resistance values consists of

	Pts. by wt.
Silicone Resin #996	4
Carbon black	2
Copper powder	1

Other silicone resins such as #997 have been used.

The resistance element is formed by impregnating the fiber glass tape with the resistance composition in the manner set forth above. The resistance of the element and the desired power dissipation may be varied by con-

trolling the thickness of the coating applied during impregnation. The impregnated and coated tape is air dried for about one hour and the removal of the solvent completed by heating to about 75° centigrade for another hour. In order to cure the silicone resin so as to render the element moisture proof and capable of withstanding the elevated temperatures, the resin of the dried element is polymerized by maintaining the element at a temperature of about 270° centigrade for about 80 minutes.

The casing material is prepared by impregnating fiber glass tape with the silicone resin. The resin is cured and rendered moisture proof by heat treatment as described in preparing the resistance element.

The paste for securing the copper leads to the resistance element is prepared by saturating a silicone resin composition with copper or silver powder. Sufficient copper powder is added to form a thick, viscous, dough-like mass. A thin layer of the paste is applied adjacent the ends of the resistance element. In assembly, one end of a copper terminal strip is placed over the layer of paste and a thin layer of the paste 22 applied over the end of the copper terminal and the first layer of paste.

To complete assembly a strip of casing material 23 which may be slightly larger than the resistance element is placed over the resistance element and the terminals. The paste is then cured by heat treatment, as by means of infrared lamps, whereby the leads and casing material are securely attached to the resistor element. A thin layer of the paste 25 is also applied to the undersurface of the resistance element adjacent the ends and a strip of casing material 24 is placed over this surface and the resistance element. The paste is cured by heat treatment whereby the casing material is securely attached to the resistance element. The resistance element is hermetically sealed between the casing material strips by applying silicone resin to the ends and along the side edges to form sides 26 and 27. The silicone resin is cured and the entire unit is heated to between 300° and 350° centigrade for about 1 hour.

Resistors of the above type having a resistance value of from 50 ohms to 100 megohms were found operative at ambient temperatures up to 180° centigrade.

Referring to Fig. 3, there is shown at 30 a tubular core of high temperature plastic such as trifluoromonochloro ethylene ("Kel F") having "pigtail" leads 31 secured to it. Integral with the core is the resistance element 33 of conductive coating. A coating of silver 34 covers the sector of the leads surrounding the core and the circumferential surface area between the leads and the end of the core. If required, the composite unit may be coated with a high temperature resistant coating such as a silicone resin.

In the manufacture of the device a strip of copper wire is wound around each groove of the core and secured to form the "pigtail" leads. The dimensions of the tubing will depend on the required resistor. The unit is dipped into a solution of toluene, silicone resin and finely divided conductive material such as carbon or graphite. For example, a solution of 1 part finely divided carbon or graphite such as "Statex B" or "Dag Dispersion 22," 1 part silicone resin as "Dow Corning silicone resin #996" and 3 parts toluene may be used. Following the dipping operation, the unit is baked in an oven at a temperature of 60° centigrade for one-half hour. Upon removal, the unit is painted around the circumference at each end with a silver paint. Conducting substances other than silver may be used. The resistor is next heated in an oven at a temperature of approximately 220° centigrade for approximately 4 hours. It is then coated with a silicone resin followed by a final curing step.

During the heating process, welding or fusion of the core and coating occurs and a conductive surface layer which is integral with the core is formed. Some diffusion of the conductive materials into the surface portion of the core takes place during the fusion process so that welding or fusion is effected simultaneously with the polymerization of the resin. The bond is effected at about the transition temperature of the plastic, in this case about 220° centigrade. Due to this welding or fusion between the core surface and the applied coating material, the conductive layer becomes integral with the core. Such a body, consisting of a core and an integral surface layer possesses extremely high resistance to thermal and mechanical shocks.

It is to be noted that all materials used in fabricating the resistors of this invention are capable of withstanding elevated temperatures without changes in their charateristics and that there is a heating of the assembled unit in each case to ensure polymerization and thus a rigid structure and a bonding between the elements of the resistor which will withstand severe humidity and temperature changes.

The principal advantage of the resistors of this invention is the fact that they may be used at high ambient temperatures without a derating of the resistor. They have good life characteristics and furnish adequate power dissipation. Further, their construction ensures a low noise level and a minimum of mechanical failures. They may be used with various printed or miniaturized circuits for terminal board surfaces and since the resistor is cured during manufacture, the entire assembly need not be cured subsequent to assembly. This is a distinct advantage over the usual printed circuit terminal boards where resistors are formed by painting. This painting technique requires curing of the circuit elements other than the painted units and in many cases destroys certain of the elements.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A miniature resistor comprising a core of ceramic material; at least one lead attached to each end of said core; a fiber glass strip impregnated with a coating of silicone resin, carbon and copper particles wrapped around said core, a coating of silver bonded to the edges of said wrapped strip, and a coating of silver covering the path between each of said leads and said silver coated edges.

2. A miniature resistor comprising a resistance element of fiber glass impregnated with a coating of carbon and copper particles and a silicone resin, terminals at either end of said resistance element, an outer casing of fiber glass and silicone resin hermetically enclosing said resistance element and layers of a coating of silicone resin, carbon and copper particles attaching one end of said terminals to said resistance element and to the interior surface of one side of said outer casing.

3. A miniature resistance element comprising a core of trifluoromonochloro ethylene, pigtail leads attached circumferentially to each end of said core, a resistance element consisting of a coating of silicone resin and carbon on said core, and a coating of silver covering the surface area of that portion of said core between its ends and the pigtail leads.

4. A resistor comprising, a resistance element composed of a fiber glass strip impregnated with a mixture of conductive particles suspended in a binder of silicone resin, electrical lead means at the end of said element for imposing current across said element, and dielectric material supporting said resistance element.

5. A miniature resistor comprising a core of dielectric material, at least one lead attached to each end of said core, a fiber glass strip impregnated with a conducting coating supported on the outer surface of said core, a conducting path between each of said leads and said fiber

glass strip, and a water resistant high temperature finish covering said fiber glass strip.

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