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Kahn

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[54] **PTC RESISTOR PACKAGE**

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[52] **U.S. Cl.** **338/22,** 29/613

[51] **Int. Cl.** **H01c 7/04**

[58] **Field of Search** 338/22, 23, 24, 25; 317/40, 41; 29/612, 613

[56] **References Cited**

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[57] **ABSTRACT**

A PTC resistor body is metallized on two opposite and parallel surfaces. The body is sandwiched between two paddle-shaped metal plates making intimate electrical and thermal contact therewith. The handle-shaped portions of the plates extend radially from the package and serve as press-on-type terminals. This assembly is further sandwiched between broad thin layers of insulative material. This double sandwich structure is held in the recess of a hat-shaped metal bracket to which the top insulation layer is adhered. The bottom insulation layer adheres to a metal disc that is approximately flush with the brim portion of the metal bracket.

10 Claims, 3 Drawing Figures

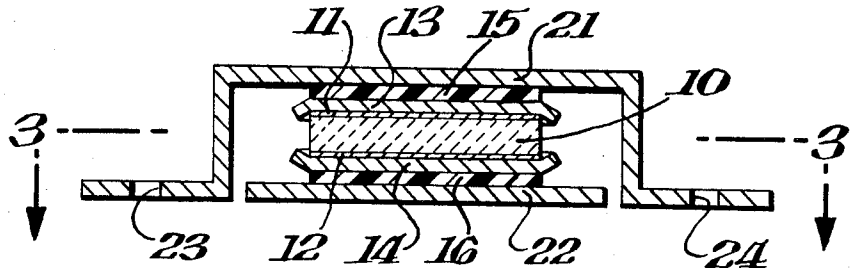


Fig. 1.

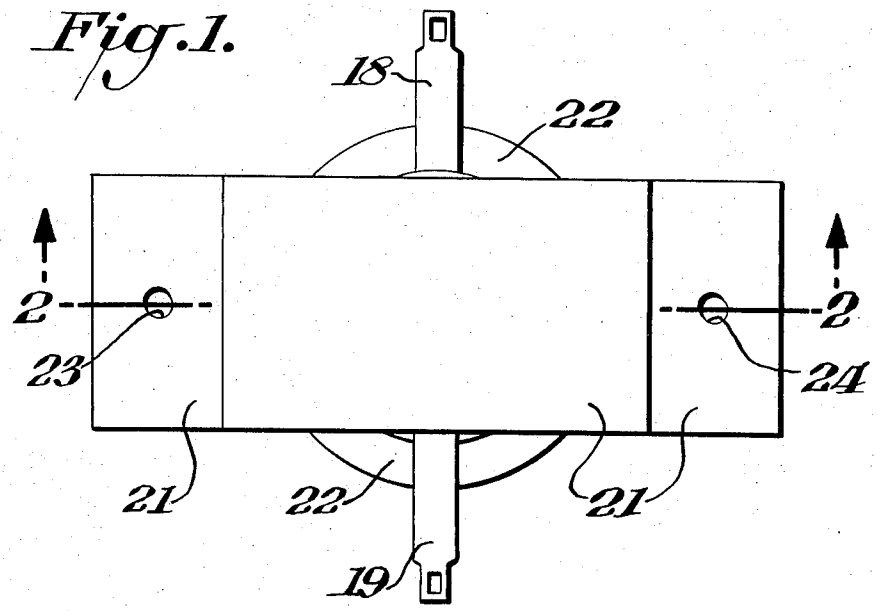


Fig. 2.

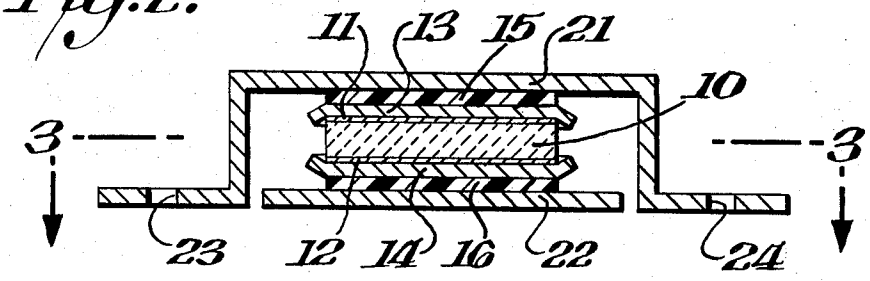
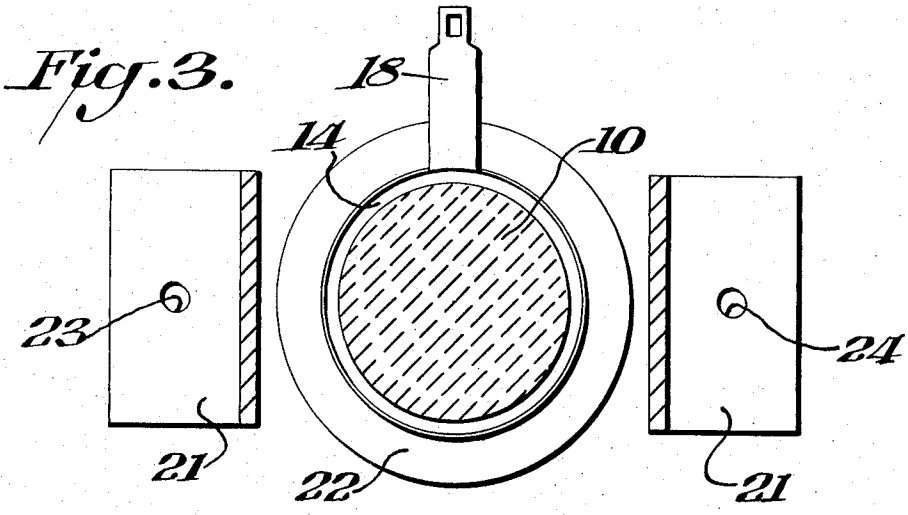


Fig. 3.



PTC RESISTOR PACKAGE

BACKGROUND OF THE INVENTION

This invention relates to a thermally conducting package for a resistor component and more particularly to a package for a positive temperature coefficient (PTC) resistor.

PTC resistor bodies normally consist of doped barium titanate bodies to which electrodes are attached. The resistance of the body, as measured between two electrodes, remains relatively constant as the body temperature increases until the so-called anomaly temperature is reached. This anomaly temperature is a characterisitc of the particular PTC body employed and is a function of its formulation. A further increase in temperature causes the body resistance to increase sharply, typically three or four order of magnitude. It is well known to use such PTC resistors as temperature sensors or as self regulating heaters with a constant voltage applied.

The need for intimate thermal connection between a PTC resistor and the machine or thing whose temperature is to be sensed or controlled, is much greater than for a simple electrical resistor or a resistive heating element. In the case of the PTC resistor, the goal is to keep the PTC resistor at the same temperature as the machine whereas for the simpler resistors the primary goal is to prevent the resistor from exceeding a temperature that will damage it.

Historically the lead and electrode connection to the ceramic PTC resistor body has proven mechanically fragile. Thus the electrical connections to the body are normally designed so as to prevent the mechanical forces, incurred in connecting the PTC resistor into a circuit, from being transmitted to the body itself. This requirement usually results in added complexity of the package structure. This is particularly true of packages designed with terminals that are suitable for connection by standard quick disconnect or press-on type connectors such as for example STA-KON terminals made by Thomas and Betts Co., Elizabeth, New Jersey. The application of PTC resistors in mass produced domestic appliances, for example, calls for quick disconnect terminals and a low cost PTC resistor package. These two requirements are thus seen to be incompatible using the principles of known constructions and prior art.

Also, it is important to provide for efficient thermal coupling between the PTC element and the machine or thing whose temperature is to be regulated or sensed. Most materials having inherently low thermal resistance also have a low electrical resistance such that the realization of efficient thermal coupling and effective electrical insulation is made especially difficult.

It is therefore an object of this invention to provide a simple low cost PTC resistor package whose terminals are suitable for connection by normal press-on type electrical connectors.

It is a further object of this invention to present a PTC resistor package that is capable of providing efficient thermal coupling and effective electrical insulation between the PTC resistor and the machine or other device to which the package may be attached.

These and other objects of the invention will become apparent in the following description.

SUMMARY OF THE INVENTION

A PTC resistor body is metallized on two opposite and parallel surfaces, which surfaces have areas that taken together are greater than half the total surface area of the PTC body. The body is sandwiched between two electrodes making intimate electrical and thermal contact therewith. The electrodes are comprised of metal plates having extensions that exend radially from the package and serve as electrical terminals that are capable of being connected by standard press-on type connectors. This assembly is further sandwiched between layers of insulative material. This electrically insulated double sandwich structure is contacted by a thermally conductive housing or bracket that may further comprise or may be itself the machine or thing whose temperature is to be sensed. The insulative layers provide electrical insulation, a broad thermal path, and a widely distributed mechanical connection between the PTC resistor body and the housing. This package is capable of being simply mounted to a flat surface in intimate thermal connection therewith.

BRIEF DESCRIPTION OF THE DRAWINGS

In FIG. **1** is shown a top view of a PTC resistor package, representing preferred embodiments of this invention.

In FIG. **2** is shown a sectional view of the package, taken in section **2—2** as indicated in FIG. **1.**

In FIG. **3** is shown a sectional view of the package, taken in section **3—3** as indicated in FIG. **2.**

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. **1** is shown the top view of the PTC resistor package of this invention. In FIG. **2** is shown in cross section the section **2—2** as indicated in FIG. **1.** In a first preferred embodiment of this invention the PTC resistor body **10** has a cylindrical shape, and a top and bottom surface that are mutually parallel. These surfaces each have metallized films **11** and **12** deposited thereon. Adjacent to flim **12** is a ping-pong paddle-shaped metal plate **14** whose circular portion is concentrically registered with the cylindrical body **10.** Furthermore, this plate is flared, forming a shallow cup in which the body **10** is partially contained.

Similarly, a second paddle-shaped metal plate **13,** having the same dimensions as plate **14,** lies adjacent to the film **11** and is concentrically registered with the cylindrical body **10.** The plates **13** and **14** are reflow soldered to the metallized surfaces of the PTC resistor body **10.** Each metallized surface and adjacent plate comprises one of the electrodes of the PTC resistor. The handle or extended portion **18** of plate **14** extends away from the body radially, and the handle or extended portion **19** of plate **13** also extends away from the body radially but in the opposite direction.

An insulative layer **16** adheres to the outer or bottom face (as shown in FIG. **2**) of the bottom electrode being comprised of metallized surface **12** and metal plate **14.** Similarly an insulative layer **15** adheres to the outer or top face of the top electrode being comprised of metallized surface **11** and metal plate **13.**

A metal disc **22** having a diameter greater than the circular portions of the metal plates **14** and **13** is adhered to the insulative layer **16.** The disc **22** is registed

or essentially centered with respect to the body **10** and circular portions of plates **13** and **14.**

A formed metal bracket **21,** having a hat-like shape in profile fits over the above described assembly. The top inside surface of the bracket **21** (as shown in FIG. **2**) is adhered to the insulative layer **15.** The assembly is so positioned in the concave region of the bracket **21** that disc **22** is substantially flush with the brim portions of the hat-shaped bracket. In practice, it is preferred that the disc protrude slightly beyond the flush position (downward as seen in FIG. **2**), so that when the package is mounted to a machine, the disc is in good pressure contact with a flat surface of the machine being held so in attachment by the brim of the bracket. The bracket **13** is thus slightly bent to provide the needed compressive force. Holes, such as **23** and **24** may be provided in the brim of the bracket **21,** facilitating the use of mounting fasteners.

The extended portions **18** and **19** of plates **14** and **13,** respectively, are designed to serve as the PTC resistor terminals. They are preformed so as to be suitable for connecting with a standard press-on type connector. In FIG. **3** is shown a sectional view as indicated in FIG. **2** by section **3—3.** The complete paddle shaped outline of the plate **14** is shown in FIG. **3** including its extended or handle portion **18** that serves as a terminal lead.

In a specific illustrative example of this first preferred embodiment, the PTC resistor body is of a well known composition of doped barium titanate and has an anomaly temperature of about 125° C. It has a thickness of 0.25 inches and a diameter of 1.25 inches. Its top and bottom surfaces are metallized by applying palladium, zinc and silver as taught in U.S. letters Pat. No. 3,716,407 by M. Kahn, filed Sept. 23, 1969. These metallized surfaces are solder coated by applying solder to the heated body **10.** A 60 percent tin 40 percent lead solder will be suitable when the package operating temperatures will not exceed about 180° C. The metal plates are made of brass. The brass may be stamped from sheet metal stock of about 0.020 inch thickness and is coated at least on one side with solder. The flared perimeter may be formed in a die press leaving a shallow cavity whose diameter is equal to or slightly larger than the diameter of the PTC resistor body. The shallow cup-like cavity serves to register the plates **13** and **14** with the body **10.** The plates are reflow solder connected to the metallized surface of the PTC body. The insulation layers consist of MYLAR having an adhesive coating on both sides. The MYLAR layer has a thickness of about 0.002 inch, but may be as thin as 0.0005 inch. (MYLAR is a tradename of the E. I. DuPont Co.)

The bracket **21** and disc **22** are formed from 0.030 inch sheet aluminum and have smooth surfaces so as to avoid distortion of the adjacent insulative layers and so that the smooth bottom surface of the disc will provide good thermal contact to its mounting surface. The disc will contact the mounting surface first and when the bracket is fastened to the mounting surface, the bracket bends slightly, maintaining a spring pressure on the stack and the interface between the disc and the mounting surface.

In the second preferred embodiment, as also illustrated in FIGS. **1, 2** and **3,** the insulative layer **15** is bonded to the plate **13** and to the bracket **21** by means of an epoxy resin. Likewise insulative layer **16** is bonded to the plate **14** and the disc **22.** Finally the PTC resistor body **10** having a smooth coating of solder or other conductive metal on either side in regions **11** and **12,** is registered and pressed within the cup-like cavities of the flared elements **13** and **14.** The body **10** is not reflow soldered, in this second preferred embodiment, to plates **13** and **14,** but rather is held in compression and in intimate electrical and thermal contact with the adjacent plates when the package is mounted to the flat surface of a machine. Electrically and thermally conductive grease can be used to help assure intimate thermal contact between the PTC body **10** and the plates **13** and **14.** Silicone grease being loaded with electrically conducting particles such as carbon or silver particles is used for this purpose. In this embodiment, the terminals **18** and **19** are capable of withstanding the physical forces exerted when mechanical press-on type connectors are fastened thereto, by virtue of the bonded insulative layers and the high starting friction connection between the disc and mounting surface held in compression.

In those temperature controlling applications wherein the PTC resistor is called upon to deliver heat at a high rate to the machine or thing to which it is mounted, the application of the principles of this invention are especially appropriate. In this situation large thermal gradients tend to develop within the PTC resistor body itself. It has been shown experimentally that taking heat from both surfaces of a pellet shape PTC body as employed in the preferred embodiments, results in almost twice the maximum rate of heat delivery in comparison with the case where heat is taken from only one side. Furthermore, the speed of response of the temperature control system, in which the PTC package would be used, in greatly increased. More generally, and for all applications, it is desirable to thermally couple to at least half of the total surface area of the PTC resistor body.

The package of this invention provides an excellent thermal coupling between the electrically insulated PTC resistor body and a flat surface of a machine to which it may be mounted. When the diameter to thickness ratio of the cylindrical body is made greater than 2, then over 50 percent of the total surface of the body is advantageously in direct thermal contact with the electrodes. The large contact areas of the insulation layers in turn provide a low resistance thermal path to the disc and the bracket. The bracket brim and the disc then provide large surface areas of contact with a mounting surface.

This package presents a structure requiring a few simple well known steps in manufacture. The package is, furthermore, simple to mount and electrically connect.

A key feature of the package of this invention is its simple rugged terminals, **18** and **19,** that are suitable for connection by a normal quick disconnect or press-on type electrical connector. The large area of contact between the PTC resistor body **10** and the elements **13** and **14,** broadly distribute the mechanical loading due to the large shear forces that may be exerted between these parts when a stiff connector is being pressed on a terminal. In addition some of this force is also shared by the large surface contact between the insulating layers and the metal elements. This force is passed on to the bracket and to the disc which is in compressed contact with a mounting surface.

Thus the insulative layers serve three important roles, providing collectively a low resistance thermal path, providing high electrical insulation resistance, and providing a widely dispersed mechanical connection.

According to the principles of this invention, the insulative layers **15** and **16** are in intimate thermal contact with the entire outer sides of the metal plates **13** and **14,** respectively. In a variation from the preferred embodiments, the plates **13** and **14** may be substantially larger than the PTC body **10.** In this case the insulative layers **15** and **16** are correspondingly enlarged as is the bracket **21** and disc **22.** The advantage of this construction is to further improve the thermal transfer efficiency by providing an even larger surface area and lower thermal resistance of the insulative layers **15** and **16.** In any case the layers are made thick enough to provide adequate electrical insulation between the metal plates and the bracket or disc. Typical voltages are 110 VAC and 220 VAC at 60Hz and typical plastic insulator materials can withstand more than 1,000 volts per mil. On the other hand the insulation layers are made thin so as to minimize the thermal resistance between the electrodes and the bracket or disc.

In the practice of this invention, a variety of materials and assembly techniques may be chosen other than those described above. For example, the insulave layers may be formed by applying a liquid insulative bonding material to the other sides of the plates, pressing the bracket and disc in place and curing the bonding material. Alternatively the insulative layers may consist of a plastic tape having an adhesive applied to both sides, such as a "B-stage" epoxy coating. Upon suitable heating, such coatings first soften, then set and finally cure. A wide variety of insulative materials will be suitable for use as the insulative layers. A polyimide resin such as KAPTON will be effective especially for high temperatures. (KAPTON is a trademark of the E. I. DuPont Co.). A berylia or alumina layer could be used whereby its bonding to bracket **21,** PTC body **10** and disc **22** could be achieved by metallizing the layers and reflow soldering thereto. The bracket, plates and disc may be made of sheet steel. Also the user has the option of varying the position of the terminal **19** relative to terminal **18** to suit his particular spacial requirements.

It will also be appreciated that the disc **22,** may be conveniently omitted when the machine surface to which the package is to be mounted is properly flat and smooth. In this case, the bottom insulating layer **16** (as seen in FIG. **2**) will be made to lie in about the same plane with the brim portion of the bracket **21** such that both lie flush with the flat metal mounting surface of the machine.

In another alternative construction, the bracket and disc may be replaced by a single thermally conducting metal part, having a cavity into which the electrically insulated and electroded PTC resistor may be fitted. These two parallel faces of the cavity would lie in intimate thermal contact with the insulative layers of the resistor assembly. Further, this single thermally conductive housing or part may be an integral part of the machine whose temperature is to be controlled or monitored by the PTC resistor.

Although various modes for practicing this invention have been described, the principles involved may be applied in a variety of other ways by those skilled in the art. The invention is, therefore, to be limited only by the scope of the appended claims.

What is claimed is:

1. A PTC resistor package comprising:

a. a PTC resistor body having two essentially parallel surfaces, the area of said two parallel surfaces taken together being greater than half the total surface area of said PTC resistor body;

b. first and second electrodes each lying adjacent to and in intimate thermal and electrical contact with essentially the entire area of one of said surfaces;

c. first and second insulative layers lying adjacent to and in intimate thermal contact with the outer sides of said first and second electrodes, respectively;

d. a metal housing having a cavity into which said PTC resistor body is fitted, said first and second insulative layers lying adjacent to and in intimate thermal contact with two inner faces, respectively, of said metal housing, such that said layers provide electrical insulation and intimate thermal contact between each of said electrodes and said housing; and

e. connective means for mounting and making thermal connection between said housing to a flat surface or an object whose temperature is to be regulated or sensed.

2. The package of claim **1** wherein the area of contact between each said insulative layer and said adjacent metal housing is substantially greater than the area of contact between each said insulating layer and said adjacent electrode.

3. The package of claim **1** wherein each of said electrodes is comprised of a metal film deposited on one of said parallel surfaces, and a metal plate lying adjacent thereto in intimate thermal and electrical contact with said film.

4. The package of claim **3** wherein said metal plates have extended portions that extend radially from said package, being suitable for connection by standard press-on electrical connectors.

5. The package of claim **3** wherein said intimate thermal and electrical contact between said metal plate and said metal film is achieved by a reflowed solder connection therebetween.

6. The package of claim **3** further comprising a means for causing a compressive force between each said metal plate and said intimately contacting metal film, whereby said thermal and electrical contact is achieved therebetween.

7. The package of claim **3** wherein said PTC body is cylindrical and wherein a portion of each said plate has a circular shape being concentrically positioned with respect to said cylindrical body, said circular portion of said plate having a larger diameter than that of said cylindrical body.

8. The package of claim **7** wherein the periphery of said circular portion of said plate is flared and the shallow cup thus formed partially contains said body.

9. The package of claim **1** wherein said metal housing is comprised of a sheet metal part having a hat shape in profile; and a sheet metal disc shaped part, said hat shaped part containing said body, the brim portions of said hat shaped part being approximately in the same plane as said disc shaped part, such that said package may be connected by said brim portion and thus mounted in intimate thermal contact with a flat portion of a machine.

10. The package of claim **9** wherein said means comprises said brim portion of said housing having a plurality of holes therein for fastener mounting to said flat surface of said object.

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