

95-115-SG
Murata
THIS SHEET HAS BEEN
REPLACED

RTmp

POSITIVE TEMPERATURE COEFFICIENT THERMISTOR

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a positive temperature coefficient thermistor (PTC) device for use in devices for evaporating insecticidal liquids, e.g., liquid type mosquito repellers, or devices for exhaling aromatics.

Description of Related Art

The construction of a conventional positive temperature coefficient thermistor will be described with reference to Figs. 21 and 22.

A positive temperature coefficient thermistor 41 shown in Figs. 21 and 22 has a case 42 which is open at its top as viewed in the figures, which has a cylindrical portion 42a extending vertically from its bottom portion at its center, and in which an annular recess 42b is defined along the entire circumference of the cylindrical portion 42a. An annular positive temperature coefficient thermistor (PCT) element 43 is accommodated in the recess 42b of the case 42 while being interposed between a pair of current supply terminals 44. The recess 42b is further filled with a resin 45. The inside diameters of the PTC element 43 and the current supply terminals 44 are so as to be larger than the outside diameter of the cylindrical portion 42a of the case

This Sheet Has Been Replaced



-2-

THIS SHEET HAS BEEN
REPLACED

42, thereby enabling the cylindrical portion 42a to be easily be passed through the PTC element 43 and the current supply terminals 44 at the time of assembly. A gap is therefore formed between the cylindrical portion 42a and each of the PTC element 43 and the current supply terminals 44. This gap is also filled with resin 45 to form a resin layer 46 shown in Fig. 22. Next, a lid 47 is fitted to the cylindrical portion 42a over the recess 42~~a~~^b to close the case 42. Further, a grommet 48 made of aluminum or the like is passed through the lid 47 and the cylindrical portion 42a of the case 42, and is fixed by being caulked at its opposite ends. Thus, the lid 47 and the case 42 are integrally assembled. The inside diameter of the cylindrical portion 42a of the case 42 is set so as to be larger than the outside diameter of the cylindrical portion of the grommet 48 in order that the grommet 48 can easily be passed through the cylindrical portion 42a at the time of assembly. Also, the grommet 48 is inwardly curved when caulked. Therefore, an air layer 49 is formed between the cylindrical portion 42a of the case 42 and the grommet 48.

If the thus-constructed positive temperature coefficient thermistor device 41 is used in a liquid type mosquito repeller or a device for exhaling an aromatic, (not shown), a liquid absorbing core for drawing up an insecticidal or aromatic liquid is passed through the

This Sheet Has Been Replaced



2/

-3-

THIS SHEET HAS BEEN
REPLACED

grommet 48 and a current is caused to flow through the PTC element 43 via the current supply terminals 44 to cause heat in the PTC element 43. The heat thereby generated is conducted to the grommet 48 through the resin layer 46, the cylindrical portion 42a of the case 42 and the air layer 49 and also through the current supply terminals 44, the case 42, the lid 47 and the air layer 49. The heat is radiated from the grommet 48 to heat the liquid absorbing core so that the insecticidal or aromatic liquid is evaporated and diffused.

The conventional positive temperature coefficient thermistor device 41, however, entails problems described below.

That is, it is difficult to perform molding and firing for forming the annular PTC element ⁴³. Also, the PTC element 43 warps easily because of its annular shape. Therefore, post-working such as lapping is required and the amount of labor for such working is large. *

Also, the heat conduction path from PTC element 43 to grommet 48 through resin layer 46, case 42 and air layer 49 or through current supply terminals 44, case 42 and air layer 49 is long and heat to be conducted to the grommet 48 escapes to the case 42 ~~escapes to the case 42~~, so that the thermal efficiency is low. The thermal efficiency is further reduced because of the conduction through the air

This Sheet Has Been Replaced



31

THIS SHEET HAS BEEN
REPLACED

layer 46 having a small thermal conductivity.

Further, the temperature of the case 42 included in the heat conduction path and occupying a greater part of the positive temperature coefficient thermistor device 41 is so increased that the reliability of the positive temperature coefficient thermistor device 41 is reduced.

Moreover, since the case 42 is heated at such a temperature, the material of the case 42 is limited to certain materials having large heat resistance.

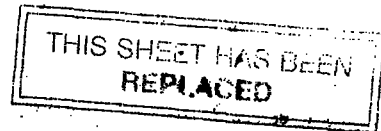
SUMMARY OF THE INVENTION

In view of these problems, an object of the present invention is to provide a positive temperature coefficient thermistor device having an improved thermal efficiency and improved reliability by using a PTC element which can be easily molded and fired and which does not warp easily.

To achieve this object, according to the present invention, there is provided a positive temperature coefficient thermistor device comprising a positive temperature coefficient thermistor element pinched between a pair of current supply terminals, a heat sink having a cylindrical heat radiating portion and a pair of heat collecting portions, and a case. The positive temperature coefficient thermistor element pinched between the pair of current supply terminals is accommodated in the case while being disposed between the pair of heat collecting portions.

This Sheet Has Been Replaced





The case is filled with at least one of an insulating resin and an insulating rubber. The pair of current supply terminals and the pair of heat collecting portions are electrically insulated from each other.

In the above-described device, the insulating resin or insulating resin may have a high thermal conductivity.

The pair of current supply terminals may have a flat terminal structure, and the positive temperature coefficient thermistor element and the current supply terminals may contact each other in a surface contact manner by being bonded to each other with a conductive adhesive.

At least one internal side surface of the above-mentioned case is inclined so that the width of a cavity in the case is increased from a bottom surface side to an opening side of the case.

The positive temperature coefficient thermistor element pinched between the pair of current supply terminals may be pinched between the pair of heat collecting portions of the heat sink having the cylindrical heat radiating portion and the heat collecting portions with an insulating member interposed between the thermistor element and the heat collecting portions. Also, the pair of heat collecting portions of the heat sink may be accommodated in the case while the heat radiating portion is placed outside the case.

The insulating member is made of an elastic material.

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

The insulating member may be a tube made of an elastic material.

The insulating member may be a tube made of a thermally-contractive elastic material.

Each of the pair of current supply terminals may have a resilient portion to be brought into contact with the positive temperature coefficient thermistor element. Also, the positive temperature coefficient thermistor element and the current supply terminals may contact each other in a surface contact manner when the positive temperature coefficient thermistor element, the pair of current supply terminals and the insulating member are accommodated in the case.

The positive temperature coefficient thermistor element, the pair of current supply terminals and the insulating member may be pinched between the pair of heat collecting portions so as to contact each other in a pressed state.

The sum of the thicknesses of the portions of the PTC element, the pair of current supply terminals and the insulating member to be pinched between the pair of heat collecting portions may be set so as to be larger than the distance between the pair of heat collecting portions of the heat sink so that the positive temperature coefficient thermistor element, the pair of current supply terminals and

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

the insulating member are pinched between the pair of heat collecting portions so as to contact each other in a pressed state.

According to another aspect of the present invention, there is provided a positive temperature coefficient thermistor device comprising a positive temperature coefficient thermistor element, a pair of current supply terminals between which the positive temperature coefficient thermistor element is pinched, a heat sink having a heat radiating portion and a pair of heat collecting portions formed continuously with the heat radiating portion, an insulating member, and a case in which the positive temperature coefficient thermistor element is accommodated. The positive temperature coefficient thermistor element and the current supply terminals are inserted into the insulating member. The insulating member is disposed between the pair of heat collecting portions. At least one elastic supporting member is disposed between the pair of heat collecting portions and an inner surface of the case.

In this positive temperature coefficient thermistor device, the supporting member may be a spring terminal.

According to still another aspect of the present invention, there is provided a positive temperature coefficient thermistor device comprising a positive temperature coefficient thermistor element, a pair of

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

current supply terminals between which the positive temperature coefficient thermistor element is pinched, a heat sink having a heat radiating portion and a pair of heat collecting portions formed continuously with the heat radiating portion, and a case in which the positive temperature coefficient thermistor element is accommodated. The positive temperature coefficient thermistor element and the current supply terminals are inserted into a block made of an elastic insulating material. The block is disposed between the pair of heat collecting portions of the heat sink. Further, the pair of heat collecting portions are accommodated in the case while the heat radiating portion of the heat sink projects out of the case.

According to a further aspect of the present invention, there is provided a positive temperature coefficient thermistor device comprising a positive temperature coefficient thermistor element, a pair of current supply terminals between which the positive temperature coefficient thermistor element is pinched, a heat sink having a heat radiating portion and a pair of heat collecting portions formed continuously with the heat radiating portion, and a case in which the positive temperature coefficient thermistor element is accommodated. The positive temperature coefficient thermistor element, the current supply terminals and the pair of heat collecting portions of

This Sheet Has Been Replaced



-9-

THIS SHEET HAS BEEN
REPLACED

the heat sink are inserted into a block made of an elastic insulating material, and the block is accommodated in the case.

In the positive temperature coefficient thermistor devices of the present invention arranged as described above, heat generated in the positive temperature coefficient thermistor element is conducted to the heat sink through the current supply terminals and the insulating resin, the insulating member or the like. By the elasticity of the insulating member or the block, the positive temperature coefficient thermistor element, *the current supply terminals, and the heat sink* are pressed against each other and maintained in close contact with each other, thereby improving the thermal conductivity. ✕

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an exploded perspective view of a positive temperature characteristic thermistor device in accordance with a first embodiment of the present invention;

Fig. 2 is a perspective view of the external appearance of the thermistor device shown in Fig. 1;

Fig. 3 is a cross-sectional view of the internal structure of the thermistor device shown in Fig. 1;

Fig. 4 is a cross-sectional view taken along the line Y-Y' of Fig. 2;

Fig. 5 is an exploded perspective view of a positive temperature characteristic thermistor device in accordance

This Sheet Has Been Replaced



4

with a second embodiment of the present invention;

Fig. 6 is a cross-sectional of the thermistor device shown in Fig. 5;

Figs. 7A, 7B, and 7C are enlarged sectional views of portions of the thermistor device shown in Fig. 5;

Fig. 8 is a perspective view of a positive temperature characteristic thermistor device in accordance with a third embodiment of the present invention;

Fig. 9 is an exploded perspective view of the thermistor device shown in Fig. 8;

Fig. 10 is a partially sectional top view of the thermistor device shown in Fig. 8 in a state where a lid is removed;

Fig. 11 is a partially sectional top view of an example of a modification of the thermistor device shown in Fig. 8 in a state where a lid is removed;

Fig. 12 is a perspective view of a positive temperature characteristic thermistor device in accordance with a fourth embodiment of the present invention;

Fig. 13 is an exploded perspective view of the thermistor device shown in Fig. 12;

Fig. 14 is a partially sectional top view of the thermistor device shown in Fig. 12 in a state where a lid is removed;

Fig. 15 is an exploded perspective view of an example



THIS SHEET HAS BEEN
REPLACED

of a modification of the thermistor device shown in Fig. 12;

Fig. 16 is an external perspective view of a positive temperature characteristic thermistor device in accordance with a fifth embodiment of the present invention;

Fig. 17 is an exploded perspective view of the thermistor device shown in Fig. 16;

Fig. 18 is a partially sectional top view of the thermistor device shown in Fig. 16 in a state where a lid is removed;

Fig. 19 is an exploded perspective view of an example of a modification of the thermistor device shown in Fig. 16;

Fig. 20 is a cross-sectional view of a liquid type mosquito repeller in which a positive temperature coefficient thermistor device in accordance with the present invention is mounted;

Fig. 21 is an exploded perspective view of a conventional positive temperature coefficient thermistor device; and

Fig. 22 is a cross-sectional view of the conventional positive temperature coefficient thermistor device shown in Fig. 21.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A positive temperature coefficient thermistor device in accordance with a first embodiment of the present invention will be described with reference to Figs. 1 to 4. Referring

This Sheet Has Been Replaced



-12-

THIS SHEET HAS BEEN
REPLACED

to Fig. 1, a disk-like PTC element 2 having two major surface~~X~~ 2a and a side surface 2b is pinched between a pair of current supply terminals 1a made of stainless steel and treated by degreasing, with the entire major surfaces ^{2a}~~2a~~ in contact with the current supply terminals 1a. A heat sink 3 is made of aluminum and has a heat radiating portion 4 which is substantially cylindrical, and a pair of heat collecting portions 5 in the form of a pair of flat plates.

The PTC element 2 pinched between the pair of current supply terminals 1a is pinched between the pair of heat collecting portions 5 of the heat sink 3. The pair of heat collecting portions 5 are accommodated in a case 6a formed of an insulating material such as polyphenylene sulfide (PPS).

After the PTC element 2, the pair of current supply terminals 1a and the heat sink 3 have been accommodated in the case 6a as described above, the case 6a is filled with a ^{insulated} resin or rubber having a high thermal conductivity, e.g., a room temperature vulcanizing (RTV) silicon rubber, thus forming a sealing structure.

The case 6a has a cavity 8a for accommodating the PTC element 2, the pair of current supply terminals 1a and the pair of heat collecting portions 5. As shown in Fig. 4, inner surfaces 9a facing the cavity 8a are inclined so that the width of the opening is larger than that of the bottom.

This Sheet Has Been Replaced



5/

-13-

THIS SHEET HAS BEEN
REPLACED

The insulating resin is thereby enabled to flow smoothly into the case 6a so that no unfilled portion (air layer) remains after resin sealing. Consequently, the thermal conductivity to the heat sink 3 can be increased.

An elongated projection 10a is formed on a central portion of the bottom surface of the case 6a so that case 6a and the PTC element 2 contact with each other in a line contact manner. If such a projection is formed, the filling insulating resin can flow to the bottom surface of the PTC element 2 to conduct heat from the bottom surface of the PTC element 2 so that the heat sink 3 can be heated efficiently. *to the heat sink 3*

The case 6a further has recesses 11a and projections 12a in its bottom surface. The recesses 11a serve for positioning of the heat sink 3. The recesses 11a can be used to constantly maintain the distance (A) between the current supply terminals 1a and the heat collecting portions 5 of the heat sink 3, thereby reducing a temperature non-uniformity of the heat sink 3 relating to assembly.

The projections 12a are formed at such positions as to extend along the opposite sides of the pair of current supply terminals 1a between which the PTC element 2 is interposed. The minimum electrical path between the current supply terminals 1a and the heat collecting portions 5 of the heat sink 3 is thereby set to the length B-C shown in

This Sheet Has Been Replaced



6/

-14-

THIS SHEET HAS BEEN
REPLACED

Fig. 4 ~~shown in Fig. 4~~ when the case formed of the insulating material is filled with the insulating resin. In this manner, the condition of a voltage of 4 kV, prescribed as external withstand voltage with respect to 200 V devices, can be satisfied without increasing the distance (A) between the current supply terminals 1a and the heat collecting portions 5. *to more than 4mm*

In this embodiment, stainless steel is used as the material of the pair of current supply terminals 1a. However, any other metallic material, specifically a copper alloy such as beryllium copper or phosphor bronze nickel-plated may be used to improve heat diffusion from the PTC element ² so that heat can be efficiently conducted to the heat sink 3. As the material of the heat sink 3, a material such as brass or copper having a high thermal conductivity may be used.

A positive temperature coefficient thermistor device in accordance with a second embodiment of the present invention will be described below with reference to Figs. 5 to 7. The components equivalent or identical to those of the first embodiment are indicated by the same reference characters and the description for them will not be repeated.

Referring to Fig. 5, a pair of current supply terminals 1b are each formed into a generally L-like shape and pinch a PTC element 2 between their portions at one end. A

This Sheet Has Been Replaced



7/

THIS SHEET HAS BEEN
REPLACED

resilient holding portion 1p is provided by being cut and raised from the portion of each current supply terminal 1b that contacts the PTC element 2. The pair of current supply terminals 1b in a state of pinching the PTC element 2 are inserted into a tube T1, which is formed of an insulating material, such as a rubber material, e.g., a silicon or fluorine rubber material or Kapton.

Referring also to Fig. 5, a pair of heat collecting portions 5 of a heat sink 3 have projections 5p provided in the vicinity of a heat radiating portion 4.

The PTC element 2, the pair of current supply terminals 1b and the tube T1 combined as described above are pinched between the pair of heat collecting portions 5 of the heat sink 3, and the pair of heat collecting portions 5 are accommodated in a case 6b made of an insulating material such as PPS. The case 6b has a cavity 8b which accommodates the PTC element 2, the pair of current supply terminals 1b, the tube T1 and the heat sink 3 (excepting the heat radiating portion 4). The case 6b has projections 9b formed on its inner side surface so as to define portions which contact the heat sink 3 in a line contact manner. Slits 7b are formed in a side wall of the case 6b on the left-hand side as viewed in Fig. 5. Through the slits 7b, the heat radiating portions 5 of the heat sink 3 project out of the case 6b. Also slits 10b are formed in a side wall portion

This Sheet Has Been Replaced



of the case 6b on the right-hand side as viewed in Fig. 5 to allow the other ends of the pair of current supply terminals 1b to project out of the case 6b. In this structure, projections 5p are provided in the pair of heat collecting portions 5 of the heat sink 3 to prevent the heat sink 3 from coming off after the heat sink 3 has been inserted into the case 6b.

A lid 11b made of PPS or the like is attached to the case 6b from above to form a simple sealing structure.

The projections 9b, provided inside the case 6b, can reduce the amount of heat conducted from the PTC element 2 to the case 6b through the heat sink 3. Accordingly, it is possible to reduce the loss of heat conducted to the heat radiating portion 4 of the heat sink 3 and to reduce the temperature at which the case 6b is heated.

The holding portions 1p of the pair of current supply terminals 1b are formed as springs as shown in Fig. 7A, so that, as shown in Fig. 7B, each of the pair of current supply terminals 1b contacts the PTC element 2 in a surface contact manner when the PTC element 2, the pair of current supply terminals 1b and the tube T1 are accommodated in the case 6b (not shown in Fig. 7B).

As shown in Figs. 7B and 7C, the sum D of the thickness of the PTC element 2 and the thicknesses of the portions of the pair of current supply terminals 1b and the tube T1 to



be pinched between the pair of heat collecting portions 5 of the heat sink 3 is set so as to be larger than the distance E between the pair of heat collecting portions 5 of the heat sink 3.

Therefore, the PTC element 2, the pair of current supply terminals 1b and the tube T1 are pinched between the pair of heat collecting portions 5 with the pressing force of the spring action of the holding portions 1p of the pair of current supply terminals 1b and the pressing force due to the resiliency of the tube T1 so that these parts contact each other in a pressed state, thereby improving the reliability with respect to sparking or the like.

The tube T1 may alternatively be made of an elastic insulating material having a high thermal conductivity different from that mentioned above. Also, an insulating sheet made of a silicon resin, Kapton or the like may be wrapped around the PTC element 2 and the current supply terminals 3 pinching the PTC element 2. Further, the tube T1 may be made of an elastic insulating material having a thermally contractive property (a silicon resin or the like). In such a case (not shown), the component parts may be assembled in such a manner that the PTC element 2 is pinched between a pair of current supply terminals 1b having spring portions, the PTC element 2 and the current supply terminals 1b are inserted into the tube T1, and the tube T1



is thermally contracted by heating before these parts are pinched in the heat sink 3. Thus, the tube T1 made of a thermally-contractive elastic insulating material is used to facilitate positioning of the PTC element 2 and the pair of current supply terminals 1b and, hence, assembly of the component parts. ^{becomes easier.}

In this embodiment, the lid 11b is used to form a simple sealing structure in the case 6b. Alternatively, the cavity of the case 6b may be tightly closed by being filled with a resin such as a silicon or epoxy resin instead of using lid 11b.

The construction of a positive temperature coefficient thermistor device in accordance with a third embodiment of the present invention will next be described with reference to Figs. 8 to 10. Portions corresponding or identical to those of the first or second embodiment are indicated by the same reference characters and the description for them will not be repeated.

Referring to Figs. 8 and 9, in the positive temperature coefficient thermistor device of the third embodiment, a PTC element 2 is inserted into a tube T1 while being pinched between one of the two pairs of opposed ends of a pair of current supply terminals 1b. The tube T1 in which the PTC element 2 and the pair of current supply terminals 1b are inserted is pinched between a pair of heat collecting



-19-

THIS SHEET HAS BEEN
REPLACED

portions 5 of a heat sink 3 and accommodated in a case 6c having an ^{cavity} opening 8c and made of an insulating material such as PPS. At this time, the other ends of the pair of current supply terminals 1b project out of the case 6c through first slits 10c formed in a side portion 6p of the case 6c. Also, a heat radiating portion 4 of the heat sink 3 projects out of the case 6c through second slits 7c formed in a side portion 6q of the case 6c. As shown in Fig. 10, spring terminals ^{R1} made of stainless steel or the like and having a resiliency are inserted as supporting members in gaps between opposite inner surfaces 6r of the case 6c and the heat collecting portions 5. By a pressing force of the spring terminals R1, the pair of heat collecting portions 5 firmly pinch the tube T1, so that the tube T1, the current supply terminals 1b and the PTC element 2 contact each other in a pressed state.

To close the ^{cavity} opening 8c of the case 6c in which the parts are accommodated, a lid 11b is fitted to the opening 8c.

In this embodiment, the spring terminals R1 are used as supporting members to achieve a high adhesion strength between the parts by being inserted into the gaps between the pair of heat collecting portions 5 and the inner surfaces 6r of the case 6c in a simple manner.

The assembly process is not limited to that described

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

above. For example, the pair of heat collecting portions 5 of the heat sink 3 may be inserted into the case 6c after the tube T1 in which the PTC element 2 is inserted has been accommodated in the case 6c.

A positive temperature coefficient thermistor device may also be arranged in a similar manner as shown in Fig. 11. That is, projections 9c for supporting the heat collecting portions⁵ of the heat sink 3 are provided on one of opposite inner surfaces 6r of the case 6c, as in the second embodiment, while a spring terminal R1 is provided at the other inner surface 6r. In the positive temperature coefficient thermistor device thus arranged, ^{the heat collecting portions 5,} the tube T1, one of the pairs of opposed ends of the pair of current supply terminals 1b and the PTC element 2 contact each other in a pressed state by interaction of the projections 9c and the spring terminal R1. Since the projections 9c contact the heat collecting portion 5 of the heat sink 3 in a point ^{or} ~~of~~ line contact manner, the conduction of heat from the heat collecting portion 5 to the case 6c is limited.

The construction of a positive temperature coefficient thermistor device in accordance with a fourth embodiment of the present invention will next be described with reference to Figs. 12 to 14. Portions corresponding or identical to those of the first, second or third embodiment are indicated by the same reference characters and the description for

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

them will not be repeated.

In the positive temperature coefficient thermistor device of the fourth embodiment, a PTC element 2 is pinched between ~~one of~~ the two pairs of opposed ends of a pair of current supply terminals 1b, with its entire major surfaces 2a in contact with the current supply terminals 1b. The PTC element 2 and the pair of current supply terminals 1b are inserted into an insertion hole V2 formed in a block V1. The block V1 is formed of an elastic insulating material such as silicon rubber having a high thermal conductivity, and the insertion hole V2 may be formed through the block V1 so as to be open in both two opposite faces of the block V1 or may be formed so as to be open only in one face of the block V1. The width F of the insertion hole V2 of the block V1 is smaller than the sum G of the thicknesses of the PTC element 2 and the pair of current supply terminals 1b. The PTC element 2 and the pair of current supply terminals 1b are inserted into the insertion hole V2 by utilizing the elasticity of the block V1, so that inner surfaces of the insertion hole V2, the PTC element 2 and the pair of current supply terminals 1b contact each other in a pressed state.

The block V1 in which the PTC element 2 and the pair of current supply terminals 1b are inserted in this manner is pinched between a pair of heat collecting portions 5 of a heat sink 3. The distance E between the pair of heat

This Sheet Has Been Replaced



-22-

THIS SHEET HAS BEEN
REPLACED

collecting portions 5 is smaller than the external width H of the block V1. The block V1 is pinched between the pair of heat collecting portions 5 by utilizing its elasticity, so that the pair of heat collecting portions 5 and the block V1 are maintained in close contact with each other, and so that the adhesion strength between the PTC element 2 and the pair of current supply terminals 1b in the block V1 is increased.

The block V1 and the pair of heat collecting portions 5 of the heat sink 3 are accommodated in a case 6d which is made of an insulating material such as PPS. An ^{cavity} opening 8d is formed in the case 6d and is open upward as viewed in Fig. 13. The case 6d has an upper lid fitting section 6s defined above a pair of ^{inner surfaces} steps 6r formed in its inner surfaces in the vicinity of the ^{cavity} opening 8d, and also has a lower accommodation section 6t below the ^{inner surfaces} steps 6r. Further, a pair of recesses 6u are formed in the inner surfaces of the lid fitting section 6s, and a pair of slits 7d communicating with the accommodation section 6t are formed on one side portion 6v. When the heat sink 3 and the block V1 are accommodated in the thus-constructed case 6d, the other ends of the pair of current supply terminals 1b project out of the ^{cavity} opening 8d, the heat radiating portion 4 of the heat sink 3 projects out of the slits 7d, and the pair of heat collecting portions 5 are passed through the

This Sheet Has Been Replaced



9/

-23-

THIS SHEET HAS BEEN
REPLACED

slits 7d of the case 6d to be inserted into the accommodation section 6t. The width I of the accommodation section 6t of the case 6d is smaller than the sum J of the external width H of the block V1 and the thicknesses of the pair of heat collecting portions 5 of the heat sink 3. The heat sink 3 and the block V1 are inserted into the accommodation section 6t by utilizing the elasticity of the block V1, whereby the pair of heat collecting portions 5 of the heat sink 3, the block V1 and the pair of current supply terminals 1b and the PTC element 2 contact each other in a pressed state.

The opening ^{Cavity} 8d of the case 6d having the parts accommodated in this manner is closed with a lid 11c which is made of PPS or the like and which has a pair of lead-out slits 11d and a pair of projections 11e. The lid 11c is fitted in the lid fitting section 6s of the case 6d by being placed on the upper surfaces of the ^{inner surfaces} steps 6r to close the case 6d, with the other ends of the pair of current supply terminals 1b projecting from the lead-out slits 11d. The lead-out slits 11d are sealed with a resin or the like. (not shown). The depth K of the accommodation section 6t of the case 6d is smaller than the height L of the block V1. The projections 11e of the lid 11c are fitted in the recesses 6u of the case 6d by utilizing the elasticity of the block V1. The block V1, the lid 11c and the bottom of the

This Sheet Has Been Replaced



10/

THIS SHEET HAS BEEN
REPLACED

-24-

accommodation section 6t are thereby maintained in close contact with each other so that no gap is formed therebetween. Thus, a simple sealing structure can be formed around the PTC element 2 without sealing the contact portions of the case 6d and the lid 11c in contact with each other.

The order in which the component parts are assembled is not limited to that in the above-described embodiment. For example, the pair of heat collecting portions 5 of the heat sink 3 may be inserted into the block V1 accommodated in the case 6d after the block V1 having the PTC element 2 and the pair of current supply terminals 1b inserted therein has been accommodated in the case 6d.

A positive temperature coefficient thermistor device may also be arranged in a similar manner as shown in Fig. 15. That is, a PTC element 2 and a pair of current supply terminals 1b are inserted into a block V1 through an opening of an insertion hole V2 in a horizontal direction as viewed in Fig. 15, and the block ^{V1} is pinched between a pair of heat collecting portions 5 of a heat sink 3. The heat sink 3 and the block V1 are accommodated in a case 6d, with the ends of the pair of current supply terminals 1b opposite from the ends on the PTC element 2 side projecting out of ^{slits} ~~cuts~~ 10d provided in a side portion 6w of the case 6d. In this positive temperature coefficient thermistor device, the

This Sheet Has Been Replaced



11/

-25-

THIS SHEET HAS BEEN
REPLACED

insertion hole V2 of the block V1 is open continuously with the slits 7d and ~~cuts~~^{slits} 10d of the case 6d. Therefore, there is, for example, a risk that insecticidal liquid or the like evaporated and diffused will enter the insertion hole V2 to attach to the PTC element 2 if the device is used in a liquid type mosquito repeller. To prevent such a foreign material from entering the insertion hole V2, the slits 7d and the ~~cuts~~^{slits} 10d of the case 6d are sealed with a resin or the like (not shown). No lead-out slits 11d are provided in the lid 11^c of this positive temperature coefficient thermistor device.

In the thus-constructed positive temperature coefficient thermistor device, the block V1, the case 6d and the lid 11^c are maintained in close contact with each other by the effect of the elasticity of the block V1, and the pair of heat collecting portions 5 of the heat sink 3, the block V1, the pair of current supply terminals 1b and the PTC element 2 are also maintained in close contact with each other, as in the case of the above-described positive temperature coefficient thermistor device of the fourth embodiment.

The construction of a positive temperature coefficient thermistor device in accordance with a fifth embodiment of the present invention will next be described with reference to Figs. 16 to 18. Portions corresponding or identical to

This Sheet Has Been Replaced



12/

THIS SHEET HAS BEEN
REPLACED

-26-

those of the first, second, third or fourth embodiment are indicated by the same reference characters and the description for them will not be repeated.

In the positive temperature coefficient thermistor device of this embodiment, a pair of insertion slits V3 are newly provided in a block V1 in such a manner as to extend on the opposite sides of an insertion hole V2, and the direction of depth of each insertion slit V3 is perpendicular to the direction of depth of the insertion hole V2. The insertion slits V3 may be open both in two opposite faces of the block V1 or only in one face of the block V1. A pair of heat collecting portions 5 of a heat sink 3 are inserted into the insertion slits V3.

In other respects, the construction of this embodiment is the same as that of the fourth embodiment. A PTC element 2 is pinched between ~~one~~ of the two pairs of opposed ends of a pair of current supply terminals 1b, with its entire major surfaces 2a in contact with the current supply terminals 1b. The PTC element 2 and the current supply terminals 1b are inserted into the insertion hole V2 formed in the block V1, and the heat sink 3 and the block V1 are accommodated in a case 6d, and an ^{Cavity} opening 8d of the case 6d is closed with a lid 11c. Lead-out slits 11d are sealed with a resin or the like (not shown).

In the positive temperature coefficient thermistor

This Sheet Has Been Replaced



13/

THIS SHEET HAS BEEN
REPLACED

-27-

device of the fifth embodiment, heat is conducted through both the two major surfaces of each of the pair of heat collecting portions 5 of the heat sink³, because the heat collecting portions 5 are inserted into the pair of insertion slits V3 of the block V1. Therefore, heat generated in the PTC element 2 can be extracted more efficiently.

A positive temperature coefficient thermistor device may also be arranged in a similar manner as shown in Fig. 19. That is, as in the fourth embodiment, a block V1 having an insertion hole V2 and insertion slits V3 extending parallel with each other in the longitudinal direction of the block V1 is used along with a case 6d having a pair of ~~cuts~~^{slits} 10d opposite from the slits V3, and the ends of a pair of current supply terminals 1b opposite from the ends inserted into the insertion hole V2 are set so as to project out of the ~~cuts~~^{slits} 10d. No lead-out slits 11d are formed in a 11d ⁰ of this positive temperature coefficient thermistor device.

The operation of the positive temperature coefficient thermistor devices of the first to fifth embodiments of the present invention will be described with respect to an example of an application to a liquid-type mosquito repeller with reference to Fig. 20. The same components of the positive temperature coefficient thermistor device as those

This Sheet Has Been Replaced



14/

THIS SHEET HAS BEEN
REPLACED

of the first to fifth embodiments are indicated by the same reference characters, and some of them are omitted in Fig.

20.

A liquid type mosquito repeller^{3/} shown in Fig. 20 has a case 32 which accommodates an insecticidal liquid bottle 34 filled with an insecticidal liquid 33. One end of a liquid absorbing core 35 for absorbing the liquid by capillary action is immersed in the insecticidal liquid 33 in the insecticidal liquid bottle 34, while the other end of the core 35 projects out of the insecticidal liquid bottle 34. Further, a positive temperature coefficient thermistor device X1 in accordance with one of the first to fifth embodiments is accommodated in the case 32, with the liquid absorbing core 35 passed through the heat radiating portion 4 of the heat sink 3.

In the positive temperature coefficient thermistor device X1 mounted in the liquid type mosquito repeller 31, a voltage is applied to the PTC element 2 through the pair of current supply terminals 1a or 1b to cause the PTC element 2 to generate heat by constant-temperature heating operation. Heat thereby generated is conducted from the two major surfaces 2a of the PTC element 2 to the pair of heat collecting portions and to the heat radiating portion 4 of the heat sink 3 through the pair of current supply terminals 1a or 1b and the insulating resin, the tube T1 or the block

This Sheet Has Been Replaced



V1. By diffusion of heat from the heat radiating portion 4, the liquid absorbing core 35 passed through the heat radiating portion 4 is heated so that the insecticidal liquid 33 permeating into the liquid absorbing core 35 is evaporated and diffused.

In the above-described positive temperature coefficient thermistor devices of the present invention, the shape of the PTC element 2 is not limited to an annular shape, and a PTC element having such a shape as to be easily molded and fired while warping is limited, e.g., a plate-like shape, may also be used.

The heat conduction path is formed from the PTC element 2 to the heat sink 3 through the pair of current supply terminals 1b and through the insulating resin, tube T1 or block V1 and is thus short. Also, the two major surfaces 2a of the PTC element 2 are used as heating portions. It is therefore possible to efficiently extract heat generated in the PTC element 2. Moreover, in the positive temperature coefficient thermistor devices of the second to fifth embodiments, no air exists in the heat conduction path and the thermal efficiency is high because the heat conducting parts are pressed and maintained in close contact with each other by the effect of the elasticity of the tube T1 or the block V1.

The above-described positive temperature coefficient



thermistor device of the present invention has advantages described below.

First, the heat conduction path is formed from the PTC element to the heat radiating portion through current supply terminals and through the insulating resin or the tube or block made of an insulating material and is thus short, so that the thermal efficiency is high. Since the case occupying a greater part of the thermistor device is not included in the heat conduction path, there is substantially no risk of the case being deformed or damaged by being heated at a high temperature. Therefore, the reliability of the device is improved. Also, there is no need to limit the material of the case to those having improved heat resistance, so that the design freedom is increased.

Because the two major surfaces of the electrodes of the PTC element are used as a heat radiating portion, heat can be efficiently extracted from the PTC element. It is therefore possible to lower the Curie point of the PTC element used as well as the heat resisting temperature of a material used to form the insulating case, an insulating resin and so on. Further, the surface temperature of each used component part other than the heating portion can be reduced, so that the reliability and safety can be improved.

In the case where the insulating case is filled with an insulating resin, the heat conduction efficiency is high and



there is substantially no variation in heat conduction efficiency, because no air layer exists in the heat conduction path from the PTC element to the heat radiating portion through the current supply terminals and the insulating resin. It is therefore possible to provide a positive temperature coefficient thermistor device in which a temperature non-uniformity in the heating portion relating to assembly is small. If in this case an inner side surface of the insulating case is inclined so that the width of the cavity is increased toward the opening, the a resin for filling the insulating case can flow smoothly so that no unfilled portion (air layer) remains after sealing with the resin. As a result, the efficiency of heat conduction to the heating portion can be further improved.

If the elasticity of a spring terminal, a tube or a block is utilized as a means for bringing the PTC element and the current supply terminals into contact with each other (pressing means), a simple sealing structure can be formed without sealing the periphery of the PTC element with a resin or the like and, therefore, there is no risk of a resin or the like attaching the PTC element to cause a deterioration of the PTC element or entering a gap between the PTC element and the current supply terminals to cause contact failure. As a result, the reliability with respect to safety or occurrence of sparks between the contacts can



be improved. It is also possible to improve the reliability of the contact surfaces of the PTC element and the current supply terminals without using an adhesive. A structure may also be adopted in which a holding portion of each current supply terminal has a resiliency such that the PTC element and the current supply terminals contact each other in a surface contact manner after being inserted into the insulating case, whereby the PTC element and the current supply terminals are pressed against each other more strongly, so that the heating efficiency is further improved.

If the heat collecting portions of the heat sink are inserted into a block, heat is conducted through both the two major surfaces of the heat collecting portions, whereby heat generated in the PTC element can be extracted more efficiently.





WHAT IS CLAIMED IS:

1. A positive temperature coefficient thermistor device comprising:

a positive temperature coefficient thermistor element pinched between a pair of current supply terminals;

a heat sink having a cylindrical heat radiating portion and a pair of heat collecting portions; and

a case,

wherein said positive temperature coefficient thermistor element pinched between said pair of current supply terminals is accommodated in said case while being disposed between said pair of heat collecting portions, said case is filled with at least one of an insulating resin and an insulating rubber, and said pair of current supply terminals and said pair of heat collecting portions are electrically insulated from each other.

2. A positive temperature coefficient thermistor device according to Claim 1, wherein each of said insulating resin and said insulating rubber has a high thermal conductivity.

3. A positive temperature coefficient thermistor device according to Claim 1, wherein said pair of current supply terminals have a flat terminal structure, and said





positive temperature coefficient thermistor element and said current supply terminals contact each other in a surface contact manner by being bonded to each other with a conductive adhesive.

4. A positive temperature coefficient thermistor device according to Claim 1, wherein at least one internal side surface of said case is inclined so that the width of a cavity in said case is increased from a bottom surface side to an opening side of said case.

5. A positive temperature coefficient thermistor device ~~according to Claim 1~~, wherein said positive temperature coefficient thermistor element pinched between ^a ~~said~~ pair of current supply terminals is pinched between ^a ~~said~~ pair of heat collecting portions of ^a ~~said~~ heat sink with an insulating member interposed between said thermistor element and said heat collecting portions, and wherein said pair of heat collecting portions of said heat sink are accommodated in ^a ~~said~~ case while ^a ~~said~~ heat radiating portion ^{of said heat sink} is placed outside said case.

6. A positive temperature coefficient thermistor device according to Claim 5, wherein said insulating member is made of an elastic material.





7. A positive temperature coefficient thermistor device according to Claim 5, wherein said insulating member comprises a tube made of an elastic material.

8. A positive temperature coefficient thermistor device according to Claim 1, wherein said insulating member comprises a tube made of a thermally-contractive elastic material.

9. A positive temperature coefficient thermistor device according to Claim 5, wherein each of said pair of current supply terminals has a resilient portion to be brought into contact with said positive temperature coefficient thermistor element, and wherein said positive temperature coefficient thermistor element and said current supply terminals contact each other in a surface contact manner when said positive temperature coefficient thermistor element, said pair of current supply terminals and said insulating member are accommodated in said case.

10. A positive temperature coefficient thermistor device according to Claim 5 or 9, wherein said positive temperature coefficient thermistor element, said pair of current supply terminals and said insulating member are





pinched between said pair of heat collecting portions so as to contact each other in a pressed state.

11. A positive temperature coefficient thermistor device according to Claim 10, wherein the sum of the thicknesses of the portions of said PTC element, said pair of current supply terminals and said insulating member to be pinched between said pair of heat collecting portions is set so as to be larger than the distance between said pair of heat collecting portions of said heat sink so that said positive temperature coefficient thermistor element, said pair of current supply terminals and said insulating member are pinched between said pair of heat collecting portions so as to contact each other in a pressed state.

12. A positive temperature coefficient thermistor device comprising:

a positive temperature coefficient thermistor element;

a pair of current supply terminals between which said positive temperature coefficient thermistor element is pinched;

a heat sink having a heat radiating portion and a pair of heat collecting portions formed continuously with said heat radiating portion;

an insulating member; and





a case in which said positive temperature coefficient thermistor element is accommodated,

wherein said positive temperature coefficient thermistor element and said current supply terminals are inserted into said insulating member, said insulating member is disposed between said pair of heat collecting portions, and at least one elastic supporting member is disposed between said pair of heat collecting portions and an inner surface of said case.

13. A positive temperature coefficient thermistor device according to Claim ~~11~~¹², wherein said supporting member comprises a spring terminal.

14. A positive temperature coefficient thermistor device comprising:

a positive temperature coefficient thermistor element;

a pair of current supply terminals between which said positive temperature coefficient thermistor element is pinched;

a heat sink having a heat radiating portion and a pair of heat collecting portions formed continuously with said heat radiating portion; and

a case in which said positive temperature coefficient thermistor element is accommodated,





wherein said positive temperature coefficient thermistor element and said current supply terminals are inserted into a block made of an elastic insulating material, said block is disposed between said pair of heat collecting portions of said heat sink, and said pair of heat collecting portions are accommodated in said case while said heat radiating portion of said heat sink projects out of said case.

15. A positive temperature coefficient thermistor device comprising:

a positive temperature coefficient thermistor element;

a pair of current supply terminals between which said positive temperature coefficient thermistor element is pinched;

a heat sink having a heat radiating portion and a pair of heat collecting portions formed continuously with said heat radiating portion; and

a case in which said positive temperature coefficient thermistor element is accommodated,

wherein said positive temperature coefficient thermistor element, said current supply terminals and said pair of heat collecting portions of said heat sink are inserted into a block made of an elastic insulating material, and said block is accommodated in said case.

