



EXOTHERMIC DEVICE FOR DIFFERENT ELECTRIC SOURCES

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to an exothermic device for different electric source for providing constant heat regardless the voltage applied to the exothermal device which is used, e.g., a heat source for evaporating an insecticidal liquid or paste for an electric mosquito-fuge device.

Description of the Related Art

In a liquid-type electric mosquito-fuge apparatus as shown in Fig. 5, a ceramic core 3 is inserted in a tank 2 filled with an insecticidal liquid 1, and an exothermic device 4 is fitted on the periphery of the core 3 projected above the tank 2. Electricity is supplied to the exothermic device 4 for heating and the heat is transmitted to the core 3 to evaporate the insecticidal liquid 1 sucked up in the core 3, whereby diffusing the vapour of the insecticidal liquid in a room.

The exothermic device 4 includes a positive temperature coefficient thermistor element 5 as the exotherm element. The positive temperature coefficient thermistor element has a sintered body of a ceramic composition in which the substrate is BaTiO_3 and metal oxides are doped in the substrate. As examples of the positive temperature coefficient thermistor element, there are a thermistor element in which electrodes are formed on both faces of a cylindrical body (Japanese Utility Model Publication No. Hei 1-12395) and a thermistor element in which electrodes are formed on both faces of an arc-shaped segment. The exothermic device 4 of the liquid-type electric mosquito-fuge apparatus is normally used by a commercial electric source of 100 V in Japan.

However, the positive temperature coefficient thermistor element incorporated in the exothermic device has such a problem that exothermic temperature varies in proportion to an applied voltage. When 220 V is applied to the exothermic device of a general liquid-type electric mosquito-fuge

apparatus, an exothermic temperature rises more than about 7°C in comparison with the exothermic device to which 100 V is applied.

When the exothermic temperature rises more than 7 °C above a preset temperature, the amount of insecticidal liquid is abnormally evaporated and diffused faster, so that it can not be used for a predetermined effective term of the insecticidal liquid filled in a tank.

In Japan, the voltage of the commercial electric source is unified at AC 100 V. Some countries use AC 220 V as the commercial electric source. Moreover, there are some other countries which use two kinds of voltages for the commercial electric source.

As one example, the commercial electric sources used in the world are shown in the following Table 1. From Table 1, it may be understood that there are many countries which use two kinds of voltages selectively.

Table 1

Area	Country (State)	Voltage (V)	Frequency (Hz)
Asia	Japan	100	50/60
	China	110/220	50
	Hong Kong	200/220	50
	India	220	50
	Indonesia	127/220	50
	Korea	110/220	60
	Philippines	110/220	60
	Singapore	110/230	50
	Taiwan	110	60
	Thailand	240	50
North America	U.S.A.	120	60
	Hawaii	110/120	60
	Canada	120/240	60
Central & South America	Argentina	220	50
	Brazile	127/220	60
	Chile	220	50
	Mexico	125	60
	Peru	220	60

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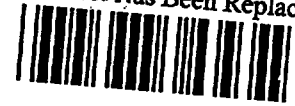


Table 1 (continued)

Area	Country (State)	Voltage (V)	Frequency (Hz)
Europe	Austria	220	50
	Belgium	110/220	50
	Denmark	110/220	50
	France	127/220	50
	Germany	127/220	50
	Greece	220	50
	Italy	110/220	50
	Spain	110/220	50
	Sweden	110/220	50
	Great Britain	240	50
	former USSR	220	50
Africa	Kenia	240	50
Oseania	Australia	240	50
	New Zealand	230	50

According to Table 1, Korea, the Philippines, Singapore, Belgium, Denmark, Italy, Spain and Sweden use two kinds of voltages, i.e., 110 V and 220 V for the commercial electric source. Therefore, when a positive temperature coefficient thermistor is incorporated in an exothermic device of a mosquito-fuge apparatus which is used in these countries, it is necessary to provide a transformer which drops the voltage from 220 V to 110 V of the commercial electric source or to use a transformer to be switched according to the necessity by providing a voltage-switching means to the transformer. To provide the transformer to the apparatus causes the cost-up in manufacturing and increases the weight and volume of the apparatus. Although it has been known that there is an exotherm device which can be used for both AC 110 V and AC 220 V, the purpose of this kind of exothermic device is merely to improve confidentiality and increase maximum rated voltage. In these exothermic devices, the difference of exothermic temperatures caused by the difference of applied voltages is not considered.

Accordingly, the present invention is to provide an exothermic device which does not cause great degree of exothermic temperature in accordance with



the change of an applied voltage.

Another object of the present invention is to provide a positive temperature coefficient thermistor which possesses a region of a current-voltage characteristic as an exothermic device in which a current drops linearly at an angle of about 45° in accordance with the increase of an applied voltage.

Another object of the present invention is to provide a positive temperature coefficient thermistor which includes a range of from 100 V to 240 V of applied voltages wherein the voltage-current characteristic is damped linearly at an angle of 45° , i.e., which substantially covers the voltage-range of the commercial electric source employed in the countries of the world.

Still another object of the invention is to provide a positive exothermic temperature coefficient thermistor which is formed by a ceramic-material composition having BaTiO_3 as a substrate in which the voltage-current characteristic is damped linearly at an angle of 45° .

SUMMARY OF THE INVENTION

In accordance with the invention, an exothermic device for providing constant heat by electricity is formed. The exothermic device is formed of a sintered body made of a ceramic material of BaTiO_3 containing a metal oxide. The sintered body forms a positive temperature coefficient thermistor and includes in a predetermined voltage range a voltage-current characteristic defined in an equation:

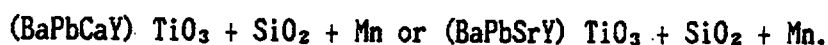
$$V_x + I_y = \underline{a}$$

wherein $\underline{a}$ is a constant value, V_x is a voltage on an axis of abscissa and I_y is a current on an axis of ordinate in a cartesian coordinate. The voltage range extends from a predetermined value to a value at least twice as much as the predetermined value. When a voltage in the voltage range is applied to the sintered body, the sintered body provides heat at a substantially constant value.



The predetermined value for satisfying the equation is at least between 100 volt and 240 volt. Preferably, the ceramic material of BaTiO_3 further contains SiO_2 and Mn or Mn ion. In this case, 0.1 wt% of SiO_2 and 0.020 wt% of Mn or Mn ion are included.

The ceramic composition may have a formula of



In this case, 0.1 wt% of SiO_2 and 0.020 wt% of Mn or Mn ion are included in the ceramic material.

Brief Description of the Drawings

Figure 1 is a graph showing a temperature-resistance characteristic of a positive temperature coefficient thermistor;

Figure 2 is a graph showing a voltage-current characteristic of a positive temperature coefficient thermistor;

Figure 3 is a graph showing a normal resistance-exothermic temperature characteristic;

Figure 4 is an exploded perspective view showing a manner to assemble a positive temperature coefficient thermistor; and

Figure 5 is a cross sectional view of a conventional electric mosquito-fuge apparatus.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

BaTiO_3 ceramic composition has been studied.

In case an amount of specific additives which are to be added to a ceramic-material composition containing BaTiO_3 as a substrate is fixed, e.g., when the additive amounts of SiO_2 and Mn or Mn ion are $\text{SiO}_2 = 0.1\%$ by weight and $\text{Mn} = 0.020\%$ by weight in a positive temperature coefficient thermistor which has $(\text{BaPbCaY})\text{TiO}_3 + \text{SiO}_2 + \text{Mn}$, it is seen a sudden standing-up of temperature-resistance characteristic after the Curie point (T_c) as shown in Fig. 1. Namely, according to Fig. 2, when the thermistor element generates



heat after the T_c , the current value is suddenly decreased in inverted proportion to the voltage value even though the applied voltage is increased and thus, it can be considered that the increase of electric power is suppressed. When the voltage-current characteristic thereof is seen, it has been found that a damping characteristic is very close to a linear line of 45° at the region of at least 100 V to 240 V of applied voltage, as shown in Fig. 2. Namely, it has been found that damping characteristic which satisfies the relationship of

$$V_x + I_y = a \text{ (a is constant)}$$

in Cartesian coordinates having both logarithmic scales of an abscissa axis V_x and ordinate axis I_y . In other words, since consumption of electric power is constant in the specific range of the voltage, the thermistor element is heated at a constant temperature.

In Fig. 1, characteristics of the conventional thermistor element containing a ceramic material composition having $BaTiO_3$ used as a substrate are shown as a comparative example.

In view of Fig. 2, when a ceramic composition in which the additive amount of SiO_2 of $(BaPbCaY)TiO_3 + SiO_2 + Mn$ or Mn ion is 0.1 % by weight and that of Mn or Mn ion is 0.020 % by weight is sintered to produce a positive thermistor element and this element is used as an exothermic device, change in consumed electric power $P = VI$ is small at the applied voltage between 100 V and 240 V. Thus, there causes almost no difference of the exothermic temperature at least within the range of from 100 V to 240 V of applied voltage.

In general, in a normal positive temperature coefficient thermistor, as shown in the comparative example in Fig. 2, the damping characteristic is generally lower than the linear line of 45° , and as a result, the greater the applied voltage is, the more the consumed electric power increases and the higher the exothermic temperature becomes.

This specific characteristics according to the present invention have been obtained from the results of the experiments. According to the above-described composite, the range in which 45° linear line characteristic is



about from 70 °C to 250 °C. Conventionally, this range includes the range of 100 V to 240 V of the commercial electric source-voltage. The other feature of the above-described composition is to obtain high dielectric strength. Moreover, the exothermic temperature can be arbitrarily controlled by increasing or decreasing the amount of Pb in the composition.

On the other hand, in a composition of $(\text{Ba}, \text{Pb}, \text{Ca}, \text{Y})\text{TiO}_3 + \text{SiO}_2$ (0.1 % by weight) + Mn (0.020 % by weight), it is recognized that similar damping characteristic is obtained in voltage-current characteristic even though a composition in which Ca is replaced with Sr is used. As shown in the comparative example of Fig. 3, an exothermic temperature generally changes in inverted proportion to a normal temperature-resistance R_{25} . However, in the present invention as shown in Fig. 3, even in a case of the composition in which Ca is replaced with Sr, there is almost no change of exothermic temperature within the range of the normal temperature-resistance R_{25} which can be normally used. This means that when more than two sets of the positive temperature coefficient thermistors according to the composition of the present invention are used as an exothermic device, even though the normal temperature-resistances R_{25} of the respective thermistors are not the same, the same exothermic amount can be obtained.

Accordingly, the positive temperature coefficient thermistor according to the present invention can be made with a shape of cylinder or segment and electrodes can be fitted to both faces of the thermistor.

The examples of the present invention are explained below.

Example 1

Table 2 shows the result of normal temperature-resistance (KΩ), exotherm temperatures (°C) of applied voltages 220 V and 100 V, dielectric strength(V) and Curie point (°C) measured with respect to positive temperature coefficient thermistors sintered by fixing $x = 7.0$ mol.% and changing y , z and α , β in a ceramic composite of $(\text{Ba}_{1-x-y-z}\text{Pb}_x\text{Ca}_y\text{Y}_z)\text{Ti}_{1.000}\text{O}_3 + \alpha \text{ wt\% SiO}_2 + \beta \text{ wt\% Mn}$.

Table 2 $\text{I}(\text{Ba}_{1-x-y-z}\text{Pb}_x\text{Ca}_y\text{Y}_z)\text{Ti}_{1.000}\text{O}_3 + \alpha \text{ wt \% SiO}_2 + \beta \text{ wt \% Mn}$

	P b	C a	Y	SiO ₂	Mn	Sintering pattern	Normal temperature resistance	Exotherm temperature (°C)			Dielec- tric strength (V)	Curier point (°C)
	(mol%) x	(mol%) y	(mol%) z	(wt%) α	(wt%) β			1 0 0 V	2 2 0 V	Difference of temperature		
HX-14	7. 0	2. 0	0.37	0. 1	0.020	1330°C×1hr	1.61-2.24	161.8-161.9	166.6-167.3	4. 8-5. 4	780V	
HX-15	"	"	0.40	"	"	"	1.45-2.26	160.5-161.8	163.8-165.7	3. 3-3. 9		
HX-16	"	"	0.43	"	"	"	0.63-1.00	161.4-161.7	165.3-168.3	4. 6-4. 9		
HX-17	"	4. 0	0.37	"	"	"	2.03-2.35	159.5-159.9	162.0-162.6	2. 5-2. 7		
HX-18A	"	"	0.40	"	"	"	1.94-2.77	160.2-160.7	162.0-162.7	1. 8-2. 1	1300V	1 5 1
HX-18B	"	"	"	"	"	"	1.37-1.78	160.2-161.4	162.6-163.3	1. 9-2. 6		
HX-19	"	"	0.43	"	"	"	0.76-1.18	159.7-160.0	163.0-163.9	3. 0-4. 0		
HX-40	"	5. 0	0.40	"	"	"	2.77-4.05	157.0-158.7	160.4-160.9	1. 9-3. 4		
HX-41	"	6. 0	"	"	"	"	1.21-1.48	157.3-159.8	159.7-162.3	2. 4-2. 8		
HX-42	"	4. 0	0.42	0. 2	"	"	0.44-0.70	181.5-163.8	166.6-169.6	5. 1-5. 8		
HX-43	"	"	"	"	0.021	"	0.86-1.03	159.6-162.2	163.6-166.0	3. 8-4. 3		
HX-44	"	6. 0	0.40	0. 2	0.020	"	0.52-0.92	160.0-162.2	164.0-167.0	4. 0-5. 3		
HX-45	"	"	"	"	0.021	"	0.89-1.17	160.0-161.2	164.2-165.8	4. 1-4. 6		

Specimens HX-12, HX-13, HX-24, HX-25, HX-26, HX-28 to HX-32 were not used for the experiment since they were destroyed in their forms or their electrodes were separated at the time when they were molded into a pattern of an arc-shaped segment or at the sintering time. Specimens HX-18A and HX-18B are experimental data in cases that normal temperature resistances were differentiated.



From the result of Table 2, when it was preset that the additive amount of SiO_2 is $\alpha = 0.1\%$ by weight and the additive amount of Mn or Mn ion is $\beta = 0.020\%$ by weight, the temperature difference of exothermic temperature between at the applied voltage of 220 V and 100 V is greatly reduced to less than 7°C . When either one of the amount of α and β is increased even slightly, the temperature difference of the exothermic temperatures is also lower than 7°C , but there is a tendency of increase in the temperature difference. Although the measured values are not constant, when the values of dielectric strength and normal temperature resistance are judged in total, it can be said that specimen HX-18A, i.e., thermistor sintered by presetting substantially $\alpha = 0.1\%$ by weight, $\beta = 0.020\%$ by weight, $x = 7.0\%$ by weight, $y = 4.0\%$ by weight and $z = 0.40\%$ by weight, is excellent in voltage-current damping characteristic. Thus, these compositions can be used in the invention.

Table 3 shows measured results in case that the additive amount of SiO_2 is fixed to 0.4% by weight and the additive amounts of other ingredients are varied. As apparent from Table 3, the temperature difference between exothermic temperatures at 220 V and 100 V of applied voltage, is remarkably increased in comparison with Table 2. Thus, these compositions can not be used in the invention.

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Table 3 (Ba_{1-x-y-z}Pb_xCa_yZr_z)Ti_{1.002}O₃+0.4 wt % SiO₂+β wt % Mn

	Pb (mol%) x	Mn (wt%) β	Ca (mol%) y	Y (mol%) z	Sintering pattern	Normal temperature resistance	Exotherm temperature (°C)			Dielec- tric strength (V)	Curier point (°C)
							100 V	220 V	Difference of temperature		
HX-10A	10.5	0.022	16.0	0.40	1320°C×1hr	2.44-2.95	154.9-155.7	164.4-165.5	9.8-10.7		155
-10B	"	"	"	0.37	"	1.53-2.04	157.7-158.7	167.0-167.7	8.9- 9.3		
-10C	"	"	"	0.34	1330°C×2hr	2.46-3.65	158.5-160.8	166.8-169.1	8.3- 8.9		
-10D	"	"	"	0.31	"	1.06-1.22	165.7-166.1	174.1-174.5	8.4- 8.6		
HX-1	12.0	0.022	13.5	0.54	1330°C×1hr	14.6-19.9	150.5-152.8	167.7-169.2	15.3-17.2		
-2	"	"	"	0.50	"	1.75-2.00	166.9-168.5	172.9-174.5	5.7- 6.4		138
-3	"	"	"	0.46	1320°C×1hr	3.48-4.87	160.1-162.1	172.0-173.0	10.9-12.2		
-3A	10.5	"	"	0.43	1330°C×2hr	2.11-3.60	160.1-162.1	168.5-170.3	8.2- 8.4		
-3B	"	"	"	0.40	"	0.83-1.50	166.4-167.6	173.5-175.5	7.1- 7.9		
-3C	"	"	"	0.37	"	0.63-1.22	168.3-169.2	175.7-176.8	7.4- 7.6		
-3D	"	"	"	0.34	"	0.98-1.47	167.4-168.9	175.3-175.8	7.6- 8.2		
HX-4	11.0	0.022	10.0	0.46	1310°C×1hr	1.29-1.94	167.3-168.9	176.4-177.3	8.4- 9.1		
-5	"	"	"	0.47	"	1.22-1.86	168.9-170.5	176.4-177.0	6.3- 7.5		
HX-6	11.0	0.022	6.0	0.46	1320°C×1hr	0.41-0.47	179.4-179.6	187.2-187.9	7.8- 8.5		
-7	"	"	"	0.48	"	0.68-0.78	176.9-177.6	184.0-184.8	7.1- 7.2		
HX-8	11.0	0.022	2.0	0.46	1310°C×1hr	1.43-1.76	179.8-180.4	188.4-187.5	7.7- 8.4		
-9	"	"	"	0.50	1320°C×1hr	0.81-1.47	177.0-177.6	182.3-183.3	5.8- 5.9		
-9A	7.0	"	"	0.53	1330°C×2hr	1.13-2.02	162.0-163.0	167.8-168.7	5.5- 5.9		
-9B	"	"	"	0.56	1330°C×2hr	1.14-1.50	159.8-161.8	165.6-167.2	5.0- 6.1		
-9C	"	"	"	0.59	"	1.52-1.89	160.3-162.7	165.6-168.0	5.2- 5.7	700-	
-9D	"	"	"	0.62	1330°C×1.5hr	1.64-2.42	158.8-160.8	163.9-166.0	4.6- 6.0	700-	
-9E	8.5	"	"	0.62	1320°C×1.5hr	0.79-2.10	160.3-164.0	169.2-173.3	7.1- 8.6		
-9i	7.0	0.024	"	0.61	1330°C×2hr	1.24-1.74	159.9-161.1	165.9-167.2	5.9- 6.2		
-9j	"	0.026	"	0.61	"	2.56-3.03	161.0-161.9	168.8-167.9	5.6- 6.0		
HX-11A	7.0	0.024	0	0.62	1330°C×2hr	0.25-0.31	169.5-171.8	181.4-184.5	11.0-12.7		
-11B	"	"	"	0.64	"	0.56-0.83	163.7-166.0	175.1-180.3	10.8-14.3		

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Example 2

Table 4 shows the result of normal temperature-resistance ($K \Omega$), exothermic temperatures ($^{\circ}C$) of applied voltages 220 V and 100 V, dielectric strength (V) and Curie point ($^{\circ}C$) measured with respect to positive temperature coefficient thermistors sintered by fixing the additive amount α of SiO_2 to $\alpha = 0.1\%$ by weight and the additive amount of β of Mn to $\beta = 0.02$ and changing mol % of x , y and z in a ceramic composite of $(Ba_{1-x-y-z} Pb_x Sr_y Y_z) Ti_{1.000} O_3 + \alpha \text{ wt\% } SiO_2 + \beta \text{ wt\% } Mn$.

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Table 4 $\Pi(\text{Ba}_{1-x-y-z}\text{Pb}_x\text{Sr}_y\text{Y}_z)\text{Ti}_{1.000}\text{O}_3 + \alpha \text{ wt \% SiO}_2 + \beta \text{ wt \% Mn}$

	P b (mol%)	S r (mol%)	Y (mol%)	SiO ₂ (wt%)	Mn (wt%)	Sintering pattern	Normal temperature resistance	Exotherm temperature (°C)			Dielec- tric strength (V)	Curier point (°C)
	x	y	z	α	β			1 0 0 V	2 2 0 V	Difference of temperature		
HX-20	10.0	3. 0	0. 4	0. 1	0.020	1350°C×2hr	1.30-3.14	164.4-165.8	166.6-169.8	2.2-4.3	1000	
HX-21A	"	4. 0	"	"	"	"	1.71-3.36	160.0-162.0	162.4-165.6	2.3-3.6	"	
HX-21B	"	"	"	"	"	1340°C×2hr	2.15-4.31	159.0-161.4	162.2-164.3	2.9-3.8	1000	
HX-22	"	5. 0	"	"	"	"	1.14-1.80	158.7-159.6	161.8-163.0	3.0-3.7	"	
HX-23	"	4. 0	0.43	"	"	"	0.86-1.20	159.4-161.4	163.0-164.9	2.9-3.9	"	
HX-39A	9.88	"	0.40	"	"	1340°C×2hr	0.83-1.23	159.4-161.4	163.0-164.9	2.4-3.8	1100	
HX-39B	"	"	"	"	"	"	1.20-1.94	158.3-160.4	160.1-163.5	2.4-3.8	1200	
HX-39C	"	"	"	"	"	"	1.31-2.01	159.2-161.2	161.9-163.7	2.4-3.4	1400	146

Specimens HX-21A and HX-21B, and specimens HX-39A, HX-39B and HX-39C are experimental data in which normal temperature resistances were differentiated.

From the result of Table 4, it is recognized that the temperature difference of the exothermic temperatures of 220 V and 100 V of the applied voltage is relatively stable, though it is inferior in comparison with the Example 1. Thus, these compositions can be used in the invention.

Table 5 is an example in which α and β as well as x, y and z are variously changed.

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Table 5 $\text{IV}(\text{Ba}_{1-x-y-z}\text{Pb}_x\text{Sr}_y\text{Y}_z)\text{Ti}_{1.002}\text{O}_3 + \alpha \text{ wt \% SiO}_2 + \beta \text{ wt \% Mn}$

	Pb (mol%) x	Sr (mol%) y	Y (mol%) z	SiO ₂ (wt%) α	Mn (wt%) β	Sintering pattern	Normal temperature resistance	Exotherm temperature (°C)			Dielec- tric strength (V)	Curier point (°C)
								100 V	220 V	Difference of temperature		
HX-27	9.0	3.0	0.4	0.1	0.023	1320°C × 1hr	3.99-7.23	161.7-162.8	170.8-172.4	9.1-9.6		
HX-33	10.0	"	"	0.1	0.021	1350°C × 1hr	0.70-1.06	161.9-164.2	168.1-172.0	6.2-7.8		
HX-34	"	"	"	0.2	"	"	0.73-0.97	163.0-163.8	169.4-170.3	6.4-6.5		
HX-35	"	"	0.43	0.1	0.022	"	0.74-0.98	160.9-161.5	165.0-166.2	4.1-4.7		
HX-36	9.5	"	0.4	"	0.021	"	0.71-1.08	160.7-161.5	165.2-166.9	4.5-5.4		
HX-37	"	"	"	0.2	"	"	0.47-0.68	162.0-163.0	167.4-169.3	5.4-6.3		
HX-38	"	"	0.43	0.1	0.022	1350°C × 1hr	3.34-5.13	156.6-155.1	161.4-162.4	6.3-6.8		

As apparent from the result of Table 5, it is recognized that the deviations from $\alpha = 0.1$ and $\beta = 0.020$ increases, the temperature differences of exothermic temperatures of positive temperature coefficient thermistors between 220 V and 100 V of the applied voltage, become great. Thus, these compositions can not be used in the invention.

Example 3

In this Example, normal temperature-resistance R_{25} K Ω of compositions obtained by variously changing sintering temperatures and exothermic temperatures in which the applied voltages are preset at 100 V and 220 V were measured about ceramic material composite ((BaPbSrY) TiO₃ + SiO₂ (0.1 % by weight) + Mn (0.020 % by weight)). The measured results are shown in Table 6.

Table 6

Sintering temperature	Normal temperature resistance	100 V Exotherm	220 V Exotherm	Difference of temperature
1320°C × 2hr	1.65 ~1.75	159.1~162.9	161.5~163.8	0.8~3.0
1340°C × 2hr	0.99 ~1.30	159.0~160.0	162.6~163.5	2.8~3.6
1350°C × 2hr	0.96 ~1.10	160.0~160.4	163.3~163.8	3.3~3.5
1360°C × 2hr	1.05 ~1.15	159.3~160.1	162.7~163.5	3.2~3.4
1370°C × 2hr	1.23 ~1.39	159.5~160.2	162.1~163.1	2.8~3.1
1380°C × 2hr	1.62 ~1.92	158.8~159.8	161.8~162.6	2.7~3.2

"1320°C × 2hr" element was insufficient sintering and exotherm temperatures change greatly depending on examples.

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As apparent from the result in Table 6, positive temperature coefficient thermistor elements sintered at 1320°C of the sintering temperature for two hours greatly changed exothermic temperatures depending on the elements due to insufficient sintering, but the width of change or deviation in normal temperature resistance R_{25} was smaller than normal width within the range of sintering temperatures of 1340°C to 1380°C . It was clarified that the deviation of the temperature differences of the positive exothermic temperatures at the applied voltages of 220 V and 100 V is small and exothermic temperature was almost not affected by the sintering temperature.

Normally, the positive temperature coefficient thermistors change exothermic temperature in inverse proportion to normal temperature resistance R_{25} . The positive temperature coefficient thermistor which uses the above-mentioned composition does not substantially change exothermic temperature within the range of the normal temperature resistance R_{25} which is normally used. Therefore, there is no great variation for the exothermic temperature characteristic of the element even though the sintering temperature becomes slightly up and down and the normal temperature resistance R_{25} is varied, at the mass production. The exothermic devices used in Table 6 are included in the present invention.

Example 4

Specimen HX-18A which is shown in Table 2 of the Example 1 was formed in an arc-shaped segment of 1.32 cm in outer diameter, 0.78 cm in inner diameter, 0.35 cm in thickness and 100° at a central angle. The specimen was sintered at 1330°C for two hours. As shown in Fig. 4, both sides of the obtained elements 5' were applied with electrodes 6', and the elements were fixed between a pair of terminal plates 7' under pressure to prepare an exothermic device 4'.

As in the embodiment as shown in Fig. 5, the exothermic device 4' was set around a core 3 in the tank 2 (Fig. 5). Insecticidal liquid (45 ml in every cases) was filled in the tank and consuming time of the total amount of the insecticidal liquid was measuring when the exothermic device 4' was heated at



100 V and 220 V. The result is shown in Table 7.

Table 7

		Evaporating and diffusing time of insecticidal liquid (hr.)		
	R_{25} (K Ω)	applied voltage of 100 V	applied voltage of 220 V	difference
1	0. 4 5	3 1 0	2 8 3	2 7
2	0. 4 7	3 0 7	2 8 2	2 5
3	0. 5 2	3 1 1	2 8 5	2 6
4	0. 5 9	3 1 8	2 8 9	2 9
5	0. 6 9	3 1 1	2 8 1	3 0
6	0. 7 1	3 2 0	2 8 8	3 2
7	0. 8 2	3 4 5	3 1 1	3 4
8	1. 0 0	3 6 0	3 2 5	3 5
9	1. 2 5	3 6 2	3 2 8	3 4
1 0	1. 3 2	3 7 8	3 4 1	3 7
avarage	—	3 3 2	3 0 1	3 1

As apparent from the result of Table 7, the time for consuming the total amount of the insecticidal liquid in every specimens is short in the case of the applied voltage of 220 V in comparison with the case of the applied voltage of 100 V. However, the difference of time is only thirty one hours at the longest. According to the tests, it was recognized that there caused the difference of twelve hours for the consuming time of the total insecticidal liquid of 45 ml if there is a difference of 1 °C at the exothermic temperatures of the applied voltages 220 V and 100 V. Therefore, if the temperature difference is 7 °C, the difference of the consuming time is eighty four hours. The exothermic devices used in Table 7 are included in the present invention.

As described above, according to the present invention, there is

almost no difference at the exothermic temperature of the exothermic device, and stable characteristic can be obtained according to the difference of the applied voltages. In case more than two positive temperature coefficient thermistor elements are incorporated in the exothermic device, it is not necessary to arrange the normal temperature resistance in the respective elements. Thus, it can assemble the exothermic device by arbitrarily selecting elements. In the above-mentioned examples, the exothermic device of a liquid-type electric mosquito-fuge apparatus is described, but the present invention is not limited thereto. The present invention can be widely utilized to a heater for preventing freezing and other heating sources.

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WHAT IS CLAIMED IS:

1. An exothermic device for providing heat by electricity, comprising:
a sintered body formed of a ceramic material of BaTiO_3 containing a metal oxide, said sintered body forming a positive temperature coefficient thermistor and having in a predetermined voltage range a voltage-current characteristic defined in a following equation:

$$V_x + I_y = a$$

wherein a is a constant value, V_x is a voltage on an axis of abscissa and I_y is a current on an axis of ordinate in a cartesian coordinate, said voltage range extending from a predetermined value to a value at least twice as much as the predetermined value so that when a voltage in said voltage range is applied to the sintered body, the sintered body provides heat at a substantially constant value.

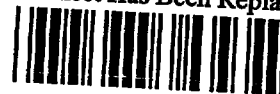
2. An exothermic device according to claim 1, wherein said predetermined value for satisfying said equation is at least between 100 volt and 240 volt.

3. An exothermic device according to the claim 1, wherein said ceramic material of BaTiO_3 further contains SiO_2 and Mn or Mn ion, the voltage-current characteristic of the positive temperature coefficient thermistor being decided by additive amounts of SiO_2 and Mn or Mn ion which are contained in the composition.

4. An exothermic device according to claim 3, wherein 0.1 wt% of SiO_2 and 0.020 wt% of Mn or Mn ion are included in the ceramic material.

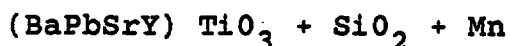
5. An exothermic device according to claim 1, wherein said ceramic composition has a formula of





0.1 wt% of SiO_2 and 0.020 wt% of Mn or Mn ion being included in the ceramic material.

6. An exothermic device according to claim 1, wherein said ceramic composition has a formula of



0.1 wt% of SiO_2 and 0.020 wt% of Mn or Mn ion being included in the ceramic material.

7. A mosquito - fuge apparatus having the exothermic device according to any of the preceding claims.

8. An electric heating element comprising a sintered body formed of a ceramic material comprising BaTiO_2 containing a metal oxide, the sintered body forming a positive temperature coefficient thermistor and having in a predetermined voltage range a voltage - current characteristic defined by the following equation:

$$(V/V) + (I/A) = \underline{a}$$

where $\underline{a}$ is a constant, V is the voltage in Volts and I is the current in Amps, the predetermined voltage range extending from a predetermined value to a value at least twice the predetermined value, whereby when a voltage falling in the predetermined voltage range is applied to the sintered body, the sintered body provides heat at a substantially constant value.

