



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) **EP 1 009 196 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
14.06.2000 Bulletin 2000/24

(51) Int. Cl.⁷: **H05B 3/20**, H05B 3/14,
H05B 3/03, H05B 3/26

(21) Application number: **97900419.9**

(86) International application number:
PCT/JP97/00052

(22) Date of filing: **13.01.1997**

(87) International publication number:
WO 98/31196 (16.07.1998 Gazette 1998/28)

(84) Designated Contracting States:
DE FI FR GB IT NL SE

(74) Representative:
Jackson, Peter Arthur
GILL JENNINGS & EVERY
Broadgate House
7 Eldon Street
London EC2M 7LH (GB)

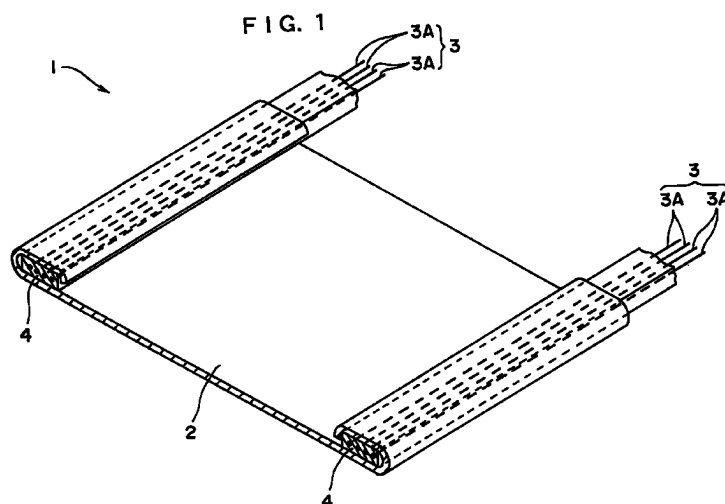
(71) Applicant:
Idemitsu Kosan Co., Ltd.
Tokyo 100-0005 (JP)

(72) Inventor: **SHITAMORI, Eiichi**
Sodegaura-shi Chiba-ken 299-02 (JP)

(54) **PLANAR HEATING ELEMENT**

(57) A sheet-shaped heater is structured by attaching plural electrode covering members 4, each covering electrodes 3, on a sheet-shaped heating resistance sheet 2 to have a predetermined space from each other. At least an area adjacent to the electrode 3 is a PTC layer having positive temperature coefficient characteristics which show increasing electric resistance value with rise in temperature. The heating resistance sheet 2

does not have the positive temperature coefficient characteristics or has the positive temperature coefficient characteristics of which, in a range below the temperature showing the maximum kick-off increase ratio of the PTC layer, the kick-off increase ratio is smaller than that of the PTC layer or the kick-off temperature is higher than that of the PTC layer.



EP 1 009 196 A1

Description

Technical Field

[0001] This invention relates to a sheet-shaped heater having positive temperature coefficient characteristics.

Background Art

[0002] In order to melt snow on a road or the like, a sheet-shaped heater is embedded under the surface of the road and heated. Further, the sheet-shaped heater is used as a unit for heating the floor by integrating with a thermal accumulator.

[0003] The sheet-shaped heater has a pair of electrodes provided in a heating resistance sheet composed of thermoplastic resin and the conductive particles such as carbon black or the like, and when electric current is supplied between the electrodes, the sheet is heated by Joule heat.

[0004] The heating resistance sheet of the sheet-shaped heater has positive temperature coefficient characteristics (PTC characteristics) in which an electrical resistance value increases with the rise in temperature, therefore, a difference of the temperature occurs on a heated part in depending on environmental temperature or the dissipation of heat.

[0005] For example, the heating resistance sheet dissipates heat in its central area in two directions, that is, from the front and back faces, but, in each side area next to the central area, dissipates heat in three directions, that is, from the side face as well as the front and back faces, so that the sheet has propensity to heat the surface of the central area at the higher temperature than the surface of either side area. When the propensity is stronger, where the heating resistance sheet has the positive temperature coefficient characteristics, the temperature of the central area increases extremely higher than the temperature of either side area, resulting in a local heating phenomenon in which the only central area is heated.

[0006] In view of the above points, the conventional art (Japanese Patent Application Laid-open No. Sho54-156242) is considered, in which the local heating is avoided by locating an equalizer plate on the whole heating resistance sheet or locating the equalizer plate on the only parts of the higher-temperature.

[0007] Further, in the conventional sheet-shaped heater, when the heating resistance sheet is formed from thermoplastic resin and the conductive particles, thermal treatment or pressure treatment is carried out in order to decrease a change caused by thermal hysteresis or resistance variation with time.

[0008] As a disadvantage in the various uses, a large difference between a resistance value in a room temperature and a resistance value in a temperature when the heating is stable occurs, which causes a large

difference between rushing power and stabilized power, thus requiring a fully worked-out design for a breaker and large contract demand.

[0009] In the aforementioned conventional art, however, the thick equalizer plate or a complicated shape of the equalizer plate becomes primary factors of not only inconvenient handling but also the large cost of manufacturing. And further, where the equalizer plate is located only in the parts heated in high temperature, the sheet-shaped heater extremely thickens, thus being unsuitable for use as a thin heater.

[0010] And the heating resistance sheet undergoes thermal treatment or pressure treatment when being formed from thermoplastic resin and the conductive particles, so that the manufacturing steps are increased, resulting in the primary factor of the large cost of manufacturing.

[0011] The object of the present invention is to provide a sheet-shaped heater which prevents local heating, reduces resistance variation with time and reduces the cost of manufacturing, and furthermore, has characteristics in which the variation of resistance is low to reach defined heating-temperature and the resistance value increases at more than a certain temperature.

Disclosure of the Invention

[0012] In order to attain this object, the present invention eliminates PTC characteristics from a heating resistance sheet or lets the heating resistance sheet have the PTC characteristics of which a kick-off increase ratio is smaller or kick-off temperature is higher than the PTC characteristics of at least an area adjacent to electrode in an electrode covering member.

[0013] More specifically, the sheet-shaped heater according to the present invention, in which plural electrode covering members each covering electrode, are attached onto a sheet-shaped heating resistance sheet to have a predetermined space from each other, is characterized by including a PTC layer provided on at least an area adjacent to the electrode in the electrode covering member, and having positive temperature coefficient characteristics which show an increase in electric resistance value with the rise in temperature; and a heating resistance sheet without the positive temperature coefficient characteristics or with the positive temperature coefficient characteristics in which, in a range below the temperature showing a maximum kick-off increase ratio of the PTC layer, a kick-off increase ratio is smaller than the kick-off increase ratio of the PTC layer or a kick-off temperature is higher than the kick-off temperature of the PTC layer.

[0014] In the present invention, the heating resistance sheet is heated by supplying electric current between the electrodes. The heating resistance sheet, however, does not have the positive temperature coefficient characteristics or has the positive temperature coefficient characteristics of which the kick-off increase

ratio is smaller than the PTC layer or the kick-off temperature is higher than the PTC layer, so that a local heating does not occur on the heating resistance sheet, although the degree of heating is different between central area and each side area adjacent to the central area on the heating resistance sheet, for example. Furthermore, at least an area adjacent to the electrode in the electrode covering member is the PTC layer having the positive temperature coefficient characteristics, so that advantages of the positive temperature coefficient characteristics of a conventional sheet-shaped heater are allowed to be maintained. And further, by using a member having the high positive temperature coefficient characteristics as the heating resistance sheet, an area having the positive temperature coefficient characteristics, which show large change of the resistance decreases, and the resistance variation with time is allowed to decrease as a whole of sheet-shaped heater. Therefore, the thermal treatment required in forming the heating resistance sheet is not needed, thereby allowing the reduction in the manufacturing cost.

[0015] A ratio and a specific resistance value of the PTC layer (the electrode covering member) in relation to the resistance value of the heating resistance sheet is adjustably changed, thereby the temperature at which the resistance value of the whole of heater increases can be variably defined, thus easily obtaining the characteristics in response to various uses.

[0016] The kick-off increase ratio of the positive temperature coefficient characteristics of the heating resistance sheet can be 0.5 lower than the kick-off increase ratio of the positive temperature coefficient characteristics of the PTC layer in the range below the temperature showing the maximum kick-off increase ratio of the PTC layer. And, kick-off temperature of the positive temperature coefficient characteristics of the heating resistance sheet can be more than 5°C higher than the kick-off temperature of the positive temperature coefficient characteristics of the PTC layer.

[0017] Where the positive temperature coefficient characteristics of the heat-resistance is large, the local heating easily occurs when the difference of temperature on the heating resistance sheet occurs. In order to avoid this phenomenon, the positive temperature coefficient characteristics of the heating resistance sheet are required to be small. Therefore, the kick-off increase ratio of the positive temperature coefficient characteristics of the heating resistance sheet in relation to the PTC layer is defined to be, as described above, less than 0.5 in the range below the temperature showing the maximum kick-off increase ratio of the PTC layer, or the kick-off temperature of the positive temperature coefficient characteristics of the heating resistance sheet is defined to be, as described above, 5°C higher than the PTC layer, thereby avoiding the local heating on the face of the heating resistance sheet and controlling the temperature with the positive temperature coefficient characteristics in the PTC layer.

[0018] In the present invention, the electrode covering member can be structured to have the PTC layer, placed around the electrode and having the positive temperature coefficient characteristics of which the electric resistance value increases with the rise in temperature, and a PTC layer covering member covering the PTC layer, the PTC layer covering member and the heating resistance sheet each being formed by using the same type of resin.

[0019] According to the above structure, the electrode covering member is produced by extruding the PTC layer covering member with the PTC layer, previously formed to be co-extruded with the electrodes. The PTC layer covering member and the heating resistance sheet are each made of the same material, so that the electrode is easily and securely fused to the heating resistance sheet. And further, the endurance of the sheet-shaped heater is achieved.

[0020] The electrode can be structured to be composed of single-wire groups each having plural conductive single-wires for electrodes, and the PTC layer covers each of the single-wires.

[0021] In the above structure, when pressure is applied to the sheet-shaped heater itself, the PTC layer is less deformed, thus improving resistance to pressure. And further, an adverse effect on the performance of the electrode when it is attached on the heating resistance sheet 12 is allowed to be reduced to a minimum.

[0022] According to the present invention, the electrode can be structured to be composed of single-wire groups each having plural conductive single-wires for electrodes, and the PTC layer covers a part of the single-wire group and is formed of more than two types of layer having the different kick-off increase ratio and kick-off temperature.

[0023] In the above structure, by changing the passages of electric current supplied to the conductive single-wires each placed in the plural types of PTC layers, the different positive temperature coefficient characteristics can be selected, thus controlling the heating temperature.

[0024] And further, it can be structured that the electrode is composed of single-wire groups of plural conductive single-wires for electrodes, and the single-wire groups are each composed of plural single-wires each arranged parallel to the heating resistance sheet and each have a different space from the heating resistance sheet.

[0025] In the above structure, by changing the current-carrying single-wire groups, the different positive temperature coefficient characteristics can be selected, thus allowing the control of the heating temperature.

[0026] The aforementioned PTC layer can be formed of a heating composition, consisting of thermoplastic resin and conductive particles, an inorganic material, or a metal material.

[0027] It can be structured that the heating resistance sheet and the PTC layer are connected through an

insulating layer (e.g., a PET film, a PE film) by using a heat-transfer material (e.g., a metal plate) to be thermally integrated with each other.

[0028] When the heating resistance sheet and the PTC layer are mutually connected by using the heat-transfer material, the heat of the heating resistance sheet is directly transferred to the electrode, thereby exerting effects caused by the positive temperature coefficient characteristics. In this point, where the heating resistance sheet and the PTC layer are directly connected to each other by using the heat-transfer material, the electric current is supplied to the heat-transfer material without being supplied the heating resistance sheet, so that the heating does not occur on the heating resistance sheet. In the present invention, however, the insulating layer is placed between the heat-transfer material, and the heating resistance sheet and PTC layer, thereby the electric current is reliably supplied to the heating resistance sheet to secure the effect of heating.

Brief Description of Drawings

[0029]

Fig. 1 is a perspectively cutaway view of a sheet-shaped heater of the first embodiment according to the present invention;

Fig. 2 is a plane view of Fig. 1;

Fig. 3 is a graph showing positive temperature coefficient characteristics of an electrode covering member and a heating resistance sheet;

Fig. 4(A) is a graph showing the positive temperature coefficient characteristics of the electrode covering member, Fig. 4(B) is a graph showing the positive temperature coefficient characteristics of the heating resistance sheet, and Fig. 4(C) is a graph showing the positive temperature coefficient characteristics of the whole sheet-shaped heater;

Fig. 5 is a perspectively cutaway view of a sheet-shaped heater of the second embodiment according to the present invention;

Fig. 6 is a plane view of Fig. 5;

Fig. 7(A) is a graph showing the positive temperature coefficient characteristics of the electrode covering member, Fig. 7(B) is a graph showing the positive temperature coefficient characteristics of the heating resistance sheet, and Fig. 7(C) is a graph showing the positive temperature coefficient characteristics of the whole sheet-shaped heater;

Fig. 8 is a perspectively cutaway view of a sheet-shaped heater of the third embodiment according to the present invention;

Fig. 9 is a plane view of Fig. 8;

Fig. 10 is a sectional view of Fig. 9;

Fig. 11 is a sectional view of a sheet-shaped heater of the fourth embodiment according to the present invention;

Fig. 12 is a sectional view of a sheet-shaped heater

of the fifth embodiment according to the present invention;

Fig. 13 is a sectional view of a sheet-shaped heater of the sixth embodiment according to the present invention;

Fig. 14 is a graph showing the positive temperature coefficient characteristics of the whole sheet-shaped heater according to the sixth embodiment;

Fig. 15 is a sectional view of a sheet-shaped heater of the seventh embodiment according to the present invention; and

Fig. 16 is a graph showing the positive temperature coefficient characteristics of the whole sheet-shaped heater according to the seventh embodiment.

Best Mode for Carrying out the Invention

[0030] The preferred embodiments according to the present invention will be explained below with reference to the attached drawings. Incidentally, in each description of the following embodiments, the same reference numerals will be used to designate the same components, so that the description will be omitted or simplified.

[0031] Fig. 1 and Fig. 2 show a sheet-shaped heater 1 of the first embodiment according to the present invention. Fig. 1 is a perspectively cutaway view of the sheet-shaped heater 1, and Fig. 2 is a plane view of Fig. 1.

[0032] In those drawings, the sheet-shaped heater 1 is composed of a heating resistance sheet 2 formed in a flat rectangular shape, two electrode covering members 4 covering electrodes 3 wound at each side-end of the heating resistance sheet 2, and an armor member made of a PET film and so on, provided as necessary.

[0033] The heating resistance sheet 2 is made of: a sheet-shaped metal material such as sheet-shaped nichrome, stainless steel, aluminium etching materials and so on; sheet-shaped conductive-inorganic materials such as a sheet-shaped ITO material and so on; a sheet-shaped organic material; or a composition of carbon black (CB) and amorphous resin such as polystyrene (PS), methacrylate resin (PMMA), vinyl chloride and so on. The heating resistance sheet 2 does not have positive temperature coefficient characteristics (PTC characteristics) which show resistance value increases with the rise in the temperature.

[0034] The heating resistance sheet 2 is 0.1mm-5mm thick, preferably 0.1mm-2mm thick, and 2.5mm-6,000mm wide, but the length of the heating resistance sheet 2 is not limited.

[0035] The electrodes 3 is composed of plural conductor single-wires for electrodes 3A (four single-wires in the drawing) arranged in parallel and flatly so as not to cross mutually. The diameter of the single-wire 3A is more than 0.1 mm and less than 2 mm, but the specific diameter is defined in correspondence to the number of

single-wires 3A. The electrode 3 is not limited to be composed of the conductor single-wire for electrode 3A shown in the drawing, and can be composed of a metallic tape or electrically conductive paste.

[0036] The two electrode covering members 4, 5 formed in a lengthened shape, are each fused in the longitudinal direction on each side-end of the heating resistance sheet 2.

[0037] The electrode covering member 4 is formed in a sectional rectangular shape 0.3mm-5mm thick and 10 0.5mm-30mm wide, preferably 1mm-10mm wide.

[0038] The electrode covering member 4 is produced with a co-extrusion method in which the plural conductor single-wires for electrodes 3A are inserted into a die of extrusion molding apparatus while being arranged parallel so as not to cross mutually, and are extruded with a heating composition. 15

[0039] The electrode covering member 4 is made of the heating composition including thermoplastic resin and conductive particles, and is a PTC layer having the positive temperature coefficient characteristics. 20

[0040] As to the thermoplastic resin used here, the crystalline thermoplastics is desirable, more specifically, polyolefin resin, copolymer resin of polyolefin resin, a polyamide type resin, polyacetal resin, thermoplastic polyester resin, polyphenylene oxide, nonyl resin, polysulfone and so on can be listed. 25

[0041] As to polyolefin resin, for example, a polyethylene class such as a high-density polyethylene, a medium-density polyethylene, a low-density polyethylene, a linear low density polyethylene and so on; a polypropylene class such as isotactic polypropylene, syndiotactic polypropylene and so on; polybutene; 4-methylpentene-1 resin; and so on can be listed. 30

[0042] In the first embodiment, the following can be used: an ethylene acrylate type copolymer such as an ethylene propylene copolymer, an ethylene-vinyl acetate copolymer, an ethylene acrylic acid copolymer, an ethylene ethyl acrylate copolymer (EEA), an ethylene methyl acrylate copolymer and so on; a copolymer of olefin, such as an ethylene-vinyl chloride copolymer and so on, and a vinyl compound; a fluorine-containing ethylene type copolymer; and denatured substance of the aforementioned components. 35

[0043] In the above description, as to a vinyl acetate type resin, for example, a vinyl acetate resin, polyvinyl acetoacetal, polyvinyl butyral and so on can be listed. 40

[0044] As to polyamide resin, for example, nylon 6, nylon 8, nylon 11, nylon 66, nylon 610 and so on can be listed. 45

[0045] Polyacetal may either be a homopolymer or a copolymer.

[0046] As to thermoplastic polyester resin, for example, polyethylene terephthalate, polybutylene terephthalate and so on can be listed. 50

[0047] As to the crystalline thermoplastics, in addition to the above list, for example, diene type polymer

and copolymer, such as trans-1,3-polyisoprene, syndiotactic-1,2-polybutadiene, and so on can be listed.

[0048] Each of the above crystalline thermoplastics may be used alone or as a polymer blend of more than two components.

[0049] As the aforementioned components of the crystalline thermoplastics, an olefin type copolymer such as a high-density polyethylene, a low-density polyethylene, a linear polyethylene or an ethylene-vinyl acetate copolymer, an ethylene ethyl acrylate copolymer and so on, trans-1,4-polyisoprene and so on are desirable. 5

[0050] The aforementioned components of crystalline thermoplastics can be used as a composition with additives or another polymer as necessary.

[0051] As to the conductive particles described above, for example, the following can be listed: particulate matter such as carbon black particles, graphite particles or the like; metallic fine particulate matter of iron (Fe), nickel (Ni), platinum (Pt), copper (Cu), silver (Ag), gold (Au) or the like; metallic powder of the aforementioned elements; powder matter such as oxidized metal powder of the aforementioned elements or the like; fibered matter of carbon fiber or the like; conductive-inorganic materials (ITO or the like); and an inorganic material having the positive temperature coefficient characteristics, such as barium titanate (BaTiO₃), strontium titanate (SrTiO₃) or the like. In the above list, particulate matter such as carbon black particles, graphite particles or the like is preferable, preferably, carbon black particles. 20

[0052] Each of the conductive particles listed above can be used alone or in a mixture of two or more.

[0053] A particle size of a conductive particle is not limited, but the average particle size is, for example, 10nm-200nm, preferably, 15nm-100nm. When the conductive particles are fibrous, the aspect ratio is 1-1,000 generally, preferably, approximately 1-100. 25

[0054] The proportion of a mixture of the crystalline resin and the conductive particles is generally 10-80:90-20 by weight percentage, preferably, 55-75:45-25. When a proportion of conductive particles is below the above range, the resistance value of the electrode covering member 4 increases, so that the sheet-shaped heater 1 may not be sufficiently heated. But when a proportion of conductive particles exceeds the above range, the positive temperature coefficient characteristics do not sufficiently occur. 30

[0055] A specific resistance value of the heating composition of the electrode covering member 4 can be appropriately selected in response to requirement or purpose, but in normal times, it is preferable to select 10Ω • cm-50,000Ω • cm, preferably, 40Ω • cm-20,000Ω • cm. 35

[0056] When the electrode covering member 4 is formed by means of mixing the crystalline resin and the conductive particles, in or after molding, it is desirable that the heating composition is hardened by cross-link-

ing the thermoplastic crystalline resin in the heating composition. By hardening the heating composition, the positive temperature coefficient characteristics improves, and also faults created by heat deformation, thermosoftening and so on, of the sheet-shaped heater can be avoided.

[0057] The cross-linking of the thermoplastic crystalline resin can be carried out by using a crosslinking agent and/or radiation. The crosslinking agent can be appropriately selected from organic peroxide, a sulfur compound, an oxime group, a nitroso compound, an amine compound, a polyamine compound and so on in response to a type of the thermoplastic crystalline resin.

[0058] For example, where the thermoplastic crystalline resin is a polyolefin type resin or the like, organic peroxide can be used as the suitable crosslinking agent. As organic peroxide, for example, the following is listed: benzoyl peroxide; lauroyl peroxide; dicumyl peroxide; tert-butyl peroxide; tert-butyl peroxy-benzoate; tert-butyl cumyl peroxide; 3-butyl hydro-peroxide; 2,5-dimethyl-2,5-di(tert-butyl peroxy)hexyne-3; 1,1-bis-(tert-butyl peroxy isopropyl) benzene; 1,1-bis-(tert-butyl peroxy)-3,3,5-trimethyl cyclohexane; n-butyl-4,4-bis(tert-butyl peroxy) valerate; 2,2-bis-(tert-butyl peroxy) butane; tert-butyl peroxy benzene; and so on.

[0059] In the above list, 2,5-dimethyl-2,5-di(tert-butyl peroxy)hexyne-3 and so on are especially desirable. Incidentally, each of the above organic peroxide can be used alone, and can be used with addition of a crosslinking ancillary agent, such as triallyl cyanurate, di-vinyl-benzene, triallyl isocyanurate and so on, as necessary.

[0060] The proportions of the organic peroxide in the crystalline resin is generally 0.01%-5% by weight, preferably 0.05%-2% by weight, compared to the crystalline resin by weight of 100%. When the proportion decreases to less than 0.01% by weight easily result in insufficient crosslinking, thereby the positive temperature coefficient characteristics does not occur sufficiently, the resistance in a high-temperature area decreases, and so on. On the other hand, when the proportion increases to more than 5% by weight results in over-crosslinking, thereby leading to deterioration of moldability and the positive temperature coefficient characteristics.

[0061] Fig. 3 is a graph showing the positive temperature coefficient characteristics of the electrode covering member 4 and the heating resistance sheet 2. In Fig. 3, P shows the positive temperature coefficient characteristics of the electrode covering member 4, and its kick-off increase ratio X_p is found by the following expression.

$$X_p = R/R_{25}$$

[0062] At this point R shows a resistance value in a temperature T, R_{25} means a resistance value in the

temperature 25°C. The maximum kick-off increase ratio X_p max is shown by $X_p \text{ max} = R_{\text{pmax}}/R_{25}$.

[0063] And, in the drawing, S shows the positive temperature coefficient characteristics of the heating resistance sheet 2. The maximum kick-off increase ratio is zero, and there is no positive temperature coefficient characteristics.

[0064] When the electrode covering member 4 is formed by using an ethylene ethyl acrylate copolymer (EEA) and carbon black (CB), and the heating resistance sheet 2 is formed by using a composition of carbon black and amorphous resin such as polystyrene (PS), the positive temperature coefficient characteristics P of the electrode covering member 4 shows the increasing resistance value with the rise in the temperature as in Fig. 4(A). As shown in Fig. 4(B), the positive temperature coefficient characteristics S of the heating resistance sheet 2 do not change the resistance value notwithstanding the rise in the temperature. In Fig. 4(C), the positive temperature coefficient characteristics (P+S) of the whole sheet-shaped heater 1 shows characteristics of which the resistance value increases with the rise in temperature. Incidentally, in the graph of Fig. 4(C), a dotted line shows the case in which only the heating resistance sheet 2 is used.

[0065] Therefore, according to the first embodiment, the two electrode covering members 4 each covering the electrodes 3 are attached on the sheet-shaped heating resistance sheet 2 to have a predetermined space from each other. And the electrode covering member 4 is the PTC layer having the positive temperature coefficient characteristics in which the electrical resistance value increases with the rise in the temperature. Further, the heating resistance sheet 2 does not have the positive temperature coefficient characteristics. Therefore, when the heating resistance sheet 2 dissipates heat produced by passing electric current between the electrodes 3, the local heating does not occur on the heating resistance sheet 2 although, for example, the degree of heat dissipation differs between the central area and each side area. Furthermore, the positive temperature coefficient characteristics required for the sheet-shaped heater 1 is secured by the electrode covering member 4. And the heating resistance sheet 2 does not have the positive temperature coefficient characteristics, so that, as a whole of sheet-shaped heater 1, an area having the positive temperature coefficient characteristics which show the large change in the resistance, decreases, and the resistance variation with time can be decreased. Therefore, the thermal treatment required in forming the heating resistance sheet 2 is not needed, thereby reducing the manufacturing cost.

[0066] The second embodiment according to the present invention will be explained below with reference to Fig. 5 and Fig. 6. The second embodiment differs from the first embodiment in that the heating resistance sheet has the positive temperature coefficient charac-

teristics, but all other structures are the same as the first embodiment.

[0067] Fig. 5 and Fig. 6 show a sheet-shaped heater 11 according to the second embodiment of the present invention. Fig. 5 is a perspective cutaway view of the sheet-shaped heater. Fig. 6 is a plane view of Fig. 5.

[0068] In the above drawings, the sheet-shaped heater 11 is composed of a heating resistance sheet 12 which is formed by molding the heating composition in a flat rectangular shape, the aforementioned two electrode covering members 4 which covers the electrodes 3 and is provided at each end of the heating resistance sheet 2, and the armor member which is made of a PET film and so on, provided as necessary.

[0069] The heating resistance sheet 12 is formed from the heating composition which is molded into a sheet shape or a film shape by an extrusion molding method, which is 0.1mm-5mm thick, preferably 0.1mm-2mm thick, and 2.5mm-6,000mm wide, but the length of the heating resistance sheet 2 is not limited.

[0070] On both of the end portions of the heating resistance sheet 12, the electrode covering members 4 are fused by heat seal or ultrasonic sealing.

[0071] The heating composition of the heating resistance sheet 12 has the positive temperature coefficient characteristics.

[0072] In the second embodiment, thermoplastic resin used for the heating composition of the heating resistance sheet 12 specifically crystalline thermoplastics, and thermoplastic resin used for the heating composition of the electrode covering member 4 specifically crystalline thermoplastics, may each be either the same type or a different type. In order to secure better adhesion by heat-sealing, it is more desirable to use the same type.

[0073] The type of conductive particles used for the heating composition of the heating resistance sheet 12 and the conductive particles used for the heating composition of the electrode covering member 4 may either be the same type with each other or a different type.

[0074] In order to produce a difference in positive temperature coefficient characteristics between the electrode covering member 4 and the heating resistance sheet 12, a proportion of the blended thermoplastic resin is adapted.

[0075] In Fig. 3, S1 and S2 show the positive temperature coefficient characteristics of the heating resistance sheet 12. S1 means the case when the kick-off increase ratio is smaller than that of the electrode covering member 4 in a range below a temperature shown with the maximum kick-off increase ratio of the electrode covering member 4 composing of the PTC layer, and S2 means the case when the kick-off temperature is higher than that of the electrode covering member 4.

[0076] In the range below the $T_{p\max}$ temperature when the maximum kick-off increase ratio of the electrode covering member 4 is $X_{p\max}$, the positive tem-

perature coefficient characteristics S1 of the heating resistance sheet 12 is smaller than the positive temperature coefficient characteristics P of the electrode covering member 4. In other words, when the kick-off increase ratio of the heating resistance sheet 12 is defined as X_s , it results in $X_s < X_p$, preferably $X_s \leq 0.5X_p$.

[0077] The kick-off temperature in the positive temperature coefficient characteristics S2 of the heating resistance sheet 12 is higher than that of the electrode covering member 4. More specifically, when the kick-off temperature is defined as a temperature when the resistance value R is $2 \times R_{25}$, the kick-off temperature of the electrode covering member 4 in $2 \times R_{p25}$ is t_p , and the kick-off temperature of the heating resistance sheet 12 in $2 \times R_{s25}$ is t_s . The kick-off temperature t_p is lower than the kick-off temperature t_s ($0^\circ\text{C} < t_s - t_p$), in which the preferable difference between t_p and t_s is more than 5°C ($5^\circ\text{C} \leq t_s - t_p$), preferably, more than 10°C ($10^\circ\text{C} \leq t_s - t_p$).

[0078] Where the electrode covering member 4 is formed from the heating composition of ethylene ethyl acrylate copolymer (EEA) and carbon black (CB), and the heating resistance sheet 12 is formed from the heating composition of high-density polyethylene (HDPE) and carbon black, the positive temperature coefficient characteristics P of the electrode covering member 4 is changed to increase the resistance value with the rise in the temperature as shown in Fig. 7(A), and also, the positive temperature coefficient characteristics S2 of the heat-resistance 12 is changed to increase the resistance value with the rise in the temperature as shown in Fig. 7(B), but the degree of the change of S2 differs from the positive temperature coefficient characteristics P of the electrode covering member 4.

[0079] In Fig. 7(A), the kick-off temperature t_p of the electrode covering member 4 is 67°C , and in Fig. 7(B), the kick-off temperature t_s of the heating resistance sheet 12 is 120°C , in other words, the kick-off temperature t_p of the electrode covering member 4 is 53°C higher than the kick-off temperature of the heating resistance sheet 12.

[0080] As a whole of sheet-shaped heater 1, as in Fig. 7(C), the characteristics showing the increasing resistance value with the rise in the temperature is shown. The characteristics, specifically, the temperature causing increase in resistance value changes in response to the specific resistance value and the ratio of the electrode covering member 4 (the PTC layer). Incidentally, in the graph in Fig. 7(C), the dotted line shows the case when only the heating resistance sheet 12 is used.

[0081] Therefore, according to the second embodiment, the two electrode covering members 4 each covering the electrodes 3 are attached on the sheet-shaped heating resistance sheet 12 to have a predetermined space from each other. And, the electrode covering member 4 is the PTC layer having the positive temperature coefficient characteristics. Further, the

heating resistance sheet 12 has the positive temperature coefficient characteristics of which the kick-off increase ratio X_s is smaller than the kick-off increase ratio X_p of the electrode covering member 4 in the range below the T_p max temperature showing the maximum kick-off increase ratio X_p max of the electrode covering member 4, or in which the kick-off temperature t_s is higher than the kick-off temperature t_p of the electrode covering member 4. Therefore, in the same as the first embodiment, the local heating does not occur on the heating resistance sheet 12, and the positive temperature coefficient characteristics required for the sheet-shaped heater 1 is secured by the electrode covering member 4. Furthermore, as a whole of sheet-shaped heater 1, an area having the positive temperature coefficient characteristics which show the large change in the resistance, decreases, and the resistance variation with time can be decreased. Therefore, the thermal treatment required in forming the heating resistance sheet 12 is formed is not needed, thereby allowing the reduction of the manufacturing cost.

[0082] And further, in the second embodiment, in the range below the T_p max temperature showing the maximum kick-off increase ratio X_p max of the electrode covering member 4, when the kick-off increase ratio X_s of the heating resistance sheet 12 is less than 0.5 for the kick-off increase ratio X_p of the electrode covering member 4, or when the kick-off temperature t_s of the heating resistance sheet 12 is more than 5°C higher than the kick-off temperature t_s of the electrode covering member 4, the local heating on the heating resistance sheet 12 is securely avoided, and the temperature control is possible by using the positive temperature coefficient characteristics in the electrode covering member 4.

[0083] The third embodiment according to the present invention will be explained below with reference to Fig. 8 to Fig. 10.

[0084] Fig. 8 to Fig. 10 show a sheet-shaped heater 21 according to the third embodiment of the present invention. Fig. 8 is a perspective cutaway view of the sheet-shaped heater 21. Fig. 9 is a plane view of Fig. 8, and Fig. 10 is a sectional view of Fig. 8.

[0085] In the above drawings, the sheet-shaped heater 21 has the aforementioned heating resistance sheet 12, the aforementioned two electrode covering members 4 covering the aforementioned electrodes 3, an insulation layer 22 covering the heating resistance sheet 12 and the electrode covering member 4, and a heat-transfer material 23 further covering the both sides of the heating resistance sheet 12 and the electrode covering member 4 from the outside of the insulation layer 22, in which the heating resistance sheet 12 and the electrode covering member 4 are connected to each other by the heat-transfer material 23 through the insulation layer 22 to be thermally integrated with each other.

[0086] The heat-transfer material 23 effectively

transfers heat, produced in the heating resistance sheet 12, to the electrode covering member 4 as the PTC layer, which is formed to be a flat shape or a sheet shape by using metal, such as copper, gold, silver, aluminium, iron, stainless steel or the like, and secured on the insulation layer 22 with an adhesive tape, adhesive or the like.

[0087] The insulation layer 22 ensures electric current to flow into the heating resistance sheet 12, which is formed by using a film having the high insulation effect, such as polyethylene terephthalate (PET), polyethylene (PE) or the like. More specifically, when the heating resistance sheet 12 and the electrode covering member 4 are directly connected by using the heat-transfer material 23, electric current is supplied to the heat-transfer material 23 without being supplied to the heating resistance sheet 12, resulting in the disadvantage that the heating resistance sheet 12 is not heated. But the insulation layer 22 is located between the heat-transfer material 23, and the heating resistance sheet 12 and electrode covering member 4, thereby avoiding the above disadvantage.

[0088] According to the third embodiment, in addition to the same effects of the second embodiment, the heating resistance sheet 12 and the electrode covering member 4 as the PTC layer are connected through the insulation layer 22 by using the heat-transfer material 23 to be thermally integrated with each other, so that the heat of the heating resistance sheet 12 is directly transferred to the electrode 3, thereby efficiently exerting the effect caused by the positive temperature coefficient characteristics.

[0089] The fourth embodiment according to the present invention will be explained below with reference to Fig. 11.

[0090] In the fourth embodiment, the point of difference from the second embodiment is the structure of the electrode covering member, and the other structures are the same as the second embodiment.

[0091] Fig. 11 shows a sheet-shaped heater 31 according to the forth embodiment of the present invention.

[0092] In Fig. 11, the sheet-shaped heater 31 has the heating resistance sheet 12, an electrode covering members 34 provided on each side-end of the heating resistance sheet 12 to cover the electrodes 3, and the armor member made of a PET film or the like, provided as necessary.

[0093] The electrode covering member 34 is composed of a PTC layer 34A, placed around the electrode 3 and having the positive temperature coefficient characteristics which show the increasing electrical resistance value with the rise in temperature, and a PTC layer covering member 34B covering the PTC layer 34A.

[0094] The PTC layer 34A is formed in an approximately sectional oblong shape to cover the electrode 3 composed of the conductive single-wires 3A aligned in horizontal direction.

[0095] The PTC layer covering member 34B is made of the same resin as the heating resistance sheet 12.

[0096] Therefore, according to the fourth embodiment, in addition to the same effects as the second embodiment, the materials of the PTC layer covering member 34B and the heating resistance sheet 12 are the same, so that the heat-seal between the member 34B and the sheet 12 is easy, thereby allowing the variability in the manufacturing to be decreased. And further, a material having a higher heat-resistance than the EEA used for the electrode covering member 4 is used for the PTC layer covering member 34B, thus improving endurance and the stability of performance.

[0097] The fifth embodiment according to the present invention will be explained below with reference to Fig. 12.

[0098] Fig. 12 shows a sheet-shaped heater 41 according to the fifth embodiment of the present invention. In the fifth embodiment, what is differ from the fourth embodiment is that the conductive single-wire 3A is each covered with the PTC layer 34A, but all the other structures are the same.

[0099] Fig. 12 is a sectional view of the sheet-shaped heater 41.

[0100] In Fig. 12, the sheet-shaped 41 is composed of the heating resistance sheet 12, an electrode covering member 44 provided on each side-end of the heating resistance sheet 12 to cover the electrode 3, and the armor member made of a PET film or the like, provided as necessary.

[0101] The electrode covering member 44 has a PTC layer 44A, placed around the electrode 3 and having the positive temperature coefficient characteristics in which the electrical resistance value increases with the rise in temperature, and the PTC layer covering member 34B covering the PTC layer 44A.

[0102] The positive temperature coefficient characteristics of the PTC layer 44A is either the same as or different from the electrode covering member 4. And the PTC layer 44A covers each of the aligned four conductive single-wires 3A of the electrode 3.

[0103] According to the fifth embodiment, in addition to the effects of the fourth embodiment, each of the conductive single-wires 3A composing the electrode 3 is independently covered with the PTC layer 44A, so that the periphery of the PTC layer 44A can be covered with the PTC layer covering member 34B which can be formed by using a material having a larger strength than the PTC layer 44A which allows the less deformation of the PTC layer 44A, which is caused when the sheet-shaped heater 41 itself is pressured, resulting in the improvement of resistance to pressure. Furthermore, each position of the conductive single-wires 3A of the electrode 3 can be held, thereby allowing any adverse effect on the performance of the electrode 3 when it is attached on the heating resistance sheet 21 to be reduced to a minimum.

[0104] The sixth embodiment according to the present invention will be explained below with reference to Fig. 13 and Fig. 14.

[0105] Fig. 13 shows a sheet-shaped heater 51 according to the present invention. In the sixth embodiment, the point of difference from the fourth embodiment is that the conductive single-wires 3A are covered with the plural types of the PTC layers, but the other structures are the same.

[0106] Fig. 13 is a sectional view of the sheet-shaped heater 51.

[0107] In Fig. 13, the sheet-shaped heater 51 is composed of the heating resistance sheet 12, electrode covering members 54 provided on each side-end of the heating resistance sheet 12 to cover the electrode 3, and the armor member made of a PET film or the like, provided as necessary.

[0108] The electrode 3 is composed of single-wire groups each having plural, six in Fig. 13, conductive single-wires 3A aligned in the horizontal direction.

[0109] The electrode covering member 54 has a first PTC layer 54A covering a part of the single-wire group, more specifically, three conductive single-wires 3A, a second PTC layer 54B covering the other three conductive single-wires 3A, and the PTC layer covering member 34B covering the first and second PTC layers 54A and 54B.

[0110] The conductive single-wires 3A covered with the first PTC layer 54A and the conductive single-wires 3B covered with the second PTC layer 54B are adapted to carry electric current simultaneously or selectively.

[0111] The first PTC layer 54A has the same positive temperature coefficient characteristics as the aforementioned PTC layer 34A, and the second PTC layer 54B has the positive temperature coefficient characteristics in which the kick-off increase ratio and the kick-off temperature differ from the first PTC layer 54A.

[0112] Fig. 14 shows the positive temperature coefficient characteristics of the sheet-shaped heater 51 when the first and second PTC layers 54A and 54B are used.

[0113] In Fig. 14, $P + S_A$ means the case when only the electrode 3 covered with the first PTC layer 54A is supplied with electric current, which is the same as $P + S_2$ in Fig. 7(C). And $P + S_B$ means the case when only the electrode 3 covered with the second PTC layer 54B is supplied with electric current.

[0114] In the sixth embodiment, the PTC layer can be structured not only with two types of the first and second PTC layers, but also with more than three types as well.

[0115] According to the sixth embodiment, in addition to the effects of the second embodiment, the different positive temperature coefficient characteristics are selected by changing the passages of electric current supplied into the conductor wires for electrodes 3A provided in the plural types of the PTC layers 54A and 54B, thus making it possible to control the heating tempera-

ture of the sheet-shaped heater 51.

[0116] The seventh embodiment according to the present invention will be explained below with reference to Fig. 15 and Fig. 16.

[0117] Fig. 15 shows a sheet-shaped heater 61 according to the present invention. In the seventh embodiment, the point of difference from the second embodiment is that the conductive single-wires 3A are placed in plural rows in the vertical direction, and all other structures are the same as the second embodiment.

[0118] Fig. 15 is a sectional view of the sheet-shaped heater 61.

[0119] In Fig. 15, the sheet-shaped heater 61 has the heating resistance sheet 12, the electrode covering member 4 of thickness T, provided on each side-end of the heating resistance sheet 12 to cover the electrode 3, and the armor member made of a PET film or the like, provided as necessary.

[0120] The electrode 3 has the first and second single-wire groups 31 and 32, each composed of the plural, five in Fig. 15, conductive single-wires 3A, in which the single-wire groups 31 and 32 are placed parallel to the heating resistance sheet 12 to be respectively spaced in distance D_1 and D_2 .

[0121] The aforementioned single-wire groups 31 and 32 are adapted to be energized simultaneously or selectively.

[0122] Between where the electric current is passed only through the first single-wire group 31 and where the electric current is passed only through the second single-wire group 32, each distance of the single-wire groups 31 and 32 from the heating resistance sheet 12 as the heating portion is different from each other, so that the positive temperature coefficient characteristics of the sheet-shaped heater 61 is different.

[0123] Fig. 16 shows the positive temperature coefficient characteristics of the sheet-shaped heater 61 when the first and second single-wire groups 31 and 32 are energized.

[0124] In Fig. 16, $P + S_C$ means the case when the only first single-wire group 31 is energized, and $P + S_D$ means when the only second single-wire group 32 is energized. In Fig. 16, a difference between $P + S_C$ and $P + S_D$ is temperature Δt .

[0125] Incidentally, in the seventh embodiment, the single-wire group can be provided with not only the two types of the first and second single-wire groups but also more than three types.

[0126] Therefore according to the seventh embodiment, in addition to the effects of the second embodiment, the electrode 3 is composed of the single-wire groups of the plural conductive wires for electrodes 3A, and the single-wire group is structured of the plural single-wire groups 31 and 32 each placed in parallel to the heating resistance sheet 12 in the different distance from the heating resistance sheet 12 from each other, so that the different positive temperature coefficient

characteristics can be selected by changing between the electric current-carrying single-wire groups 31 and 32, thereby controlling the temperature heating the sheet-shaped heater 61.

[0127] Experiments in order to verify the effects of each of the embodiments will be described below.

Experiment 1

[0128] Experiment 1 corresponds to the first embodiment, in which the heating resistance sheet 2 is formed by using aluminium etching materials. The aluminium etching material is 245mm wide $\times$ 1m length in shape, of which the resistance value is $1K\Omega/m$.

[0129] The electrode covering member 4 is formed by using the heating composition of 55% by weight of an ethylene ethyl acrylate copolymer (EEA) (DPDJ6182: made by Nippon Unicar Co., Ltd.) and 45% by weight of carbon black (CB) (DIA-BLACK E: made by MISTUBISHI KASEI KOUGYOU Co., Ltd.). Each of the electrodes 3 is formed to arrange the ten single-wires 3A in parallel so as not to cross mutually.

[0130] In the sheet-shaped heater 1 having the above structure, a heating value changes depending upon environmental temperature, and the fine positive temperature coefficient characteristics is shown as in the case of the conventional sheet-shaped heater which the heating composition is used for the heating resistance sheet. This positive temperature coefficient characteristics is the same as Fig. 4(C). The reason is that the temperature of the electrode covering member 4 rises by transferring the temperature of the heating resistance sheet 2 to the electrode 3, thus letting the positive temperature coefficient characteristics work in the electrode covering member 4.

[0131] One face of the sheet-shaped heater 1 is covered along the electrode 3 with a heat insulator (foamed styrol) to produce a different temperature 20°C on the face, but, the local heating produced in the conventional sheet-shaped heater does not occur.

[0132] In the range between a lower limit temperature -20°C and an upper limit temperature 70°C , thermal hysteresis is carried out in fifteen cycles (speeds of increase and decrease of the temperature: the temperature is retained for 50 min. after being increased and decreased at $1^\circ\text{C}/\text{min}$ for 10 min., and moves to a next step), with the result that a change of the resistance value, caused by heat hysteresis, is -0.5% in Experiment 1, but is -20% in the conventional sheet-shaped heater, that is to say, Experiment 1 is less than a fortieth the change of the resistance value, caused by heat hysteresis, of the conventional sheet-shaped heater.

Experiment 2

[0133] Experiment 2 corresponds to the second embodiment, in which the heating resistance sheet 12 is formed by using the heating composition of 80% by

weight of a high density polyethylene (HDPE) (IDEMITSU HDPE 230J; made by IDEMITSU PETRO-CHEMICAL Co., Ltd.) and 20% by weight of carbon black (CB) (DIA-BLACK E: made by MISTUBISHI KASEI KOUGYOU Co., Ltd.), and the electrode covering member 4 is formed by using the same heating composition of an ethylene ethyl acrylate copolymer (EEA) and carbon black (CB) as Experiment 1. Each of the electrodes 3 is formed by arranging the ten single-wires 3A in parallel so as not to cross mutually.

[0134] The sheet-shaped heater 11 having the above structure shows the fine positive temperature coefficient characteristics with a similar reason to Experiment 1. This positive temperature coefficient characteristics is the same as Fig. 7(C).

[0135] One face of the sheet-shaped heater 11 is covered along the electrode 3 with a heat insulator (foamed styrol) to create 20°C difference in temperature on the face, but, the local heating seen in the conventional sheet-shaped heater does not occur. The reason is that a melting point of the resin used for the heating resistance sheet 12 is more than 120°C, so the large kick-off of the resistance value (the positive temperature coefficient characteristics) is not created at less than 100°C.

[0136] Simultaneously, an experiment of heat hysteresis is carried out under the same conditions as Experiment 1, with the result that, in Experiment 2, the change of the resistance value which is caused by heat hysteresis is less than a tenth of the resistance value seen in the conventional sheet-shaped heater.

Experiment 3

[0137] Experiment 3 corresponds to the fourth embodiment, in which the PTC layer 34A is the same structure as the electrode covering member 4 of Experiment 1, and the PTC layer covering member 34B is formed by using 55% by weight of a high density polyethylene (HDPE) and 45% by weight of carbon black (CB). The specific resistance value of the PTC layer covering member 34B is small and does not contribute to heating. The other structures of Experiment 3 are the same as Experiment 2.

[0138] In the sheet-shaped heater 31 having the above structure, the PTC layer covering member 34B and the heat-resistance 2 are made of the same material, so that the heat-seal between the member 34B and the sheet 12 is easy, thereby decreasing the variability in the manufacturing by 20%. As compared with EEA used for the electrode covering member 4, HDPE has a heat resistance, thereby improving endurance and the stability of performance in high temperature by 30°C.

Experiment 4

[0139] Experiment 4 corresponds to the fifth embodiment, in which the structure is similar to Experiment 3 with the exception that each of the conductive

single-wires 3A is independently covered with the PTC layer 44A.

[0140] In the sheet-shaped heater 41 of the above structure, the pressure resistance performance is improved.

[0141] More specifically, in Experiments 1 and 2, where the pressure is added to the electrode 3, a space between the conductive single-wire 3A and the heating resistance sheet 12 easily changes and the positive temperature coefficient characteristics changes on a large scale.

[0142] On the other hand, in Experiment 4, however, by using HDPE having larger strength than EEA, position of the conductive single-wire 3A is kept and the deformation of the PTC layer 44A is controlled.

[0143] More specifically, when pressure of 10kg/cm² is added on an area, where the electrode 3 is placed in the sheet-shaped heater 1, with a press in a room temperature, 20% change in resistance is seen in Experiment 1, but only less than 3% change is seen in Experiment 4.

Experiment 5

[0144] Experiment 5 corresponds to the sixth embodiment. The first PTC layer 54A has the same structure as the PTC layer 34A of Experiment 3, and the second PTC layer 54B uses a liner low density polyethylene (LLDPE)(trade name;FW1650 made by DOW Co., Ltd.) as thermoplastic resin, and the method of producing and composing carbon black (CB) is the same as Experiment 1.

[0145] In the sheet-shaped heater 51 having the above structure, by changing the passages of electric current through the conductive single-wire 3A covered with the first PTC layer 54A and the conductive single-wire 3A covered with the second PTC layer 54B, the positive temperature coefficient characteristics can be selected from two types, thereby allowing the control of the heating temperature. More specifically, the maximum temperature of the sheet-shaped heater 51 is approximately 80°C in the first PTC layer 54A and 100°C in the second PTC layer 54B. Especially, for heating the floor and so on, a required amount of heat changes depending on season, therefore, Experiment 6 is suitable as a method for controlling the amount of heat.

Experiment 6

[0146] Experiment 6 corresponds to the seventh embodiment, which has the same structure as Experiment 2 with the exception that two types of the single-wire groups 31 and 32 which is located respectively at different distances D₁ and D₂ from the heating resistance sheet 12 are used.

[0147] In Experiment 6, the thickness T of the elec-

trode covering member 4 is defined as 1.0mm, D_1 and D_2 are respectively defined as 0.2mm and 0.4mm. In this case, the difference in temperature Δt between $P + S_C$ and $P + S_D$, shown in Fig. 16, is 20°C.

[0148] In the sheet-shaped heater 61 having the above structure, by switching the electric current-carrying single-wire groups 31 and 32, the heating temperature changes by 20°C.

Comparison

[0149] The heating resistance sheet is formed from the heating composition of 60% by weight of an ethylene ethyl acrylate copolymer (EEA) (DPDJ6182: made by Nippon Unicar Co., Ltd.) and 40% by weight of carbon black (GB) (DIA-BLACK E: made by MISTUBISHI KASEI KOUGYOU Co., Ltd.). The sectional rectangular electrode covering member of a lengthened-shape is formed by co-extruding the similar composition to above and the electrode. And the electrode covering member and the heating resistance sheet are mutually fused by heat-sealing or the like.

[0150] After an equalizer plate is provided on the aforementioned sheet-shaped heater, the electric current is supplied, with the result that the fine positive temperature coefficient characteristics is shown depending upon the change in temperature.

[0151] When one face of the sheet-shaped heater is, however, covered along the electrode with the heat insulator (foamed styrol) and the 20°C difference in temperature is produced on the face, the local heating is produced, resulting in the inferior heating. And further, the change caused by thermal hysteresis is observed at several tens of percentages.

[0152] Incidentally, the present invention is not intended to be limited to the aforementioned embodiments, and insofar as the object of the present invention is attained, the following modifications are included in the scope of the present invention.

[0153] For example, in each of the aforementioned embodiments, the electrode covering member 4 is formed by co-extruding the heating composition and the electrode 3, which is formed by arranging the plural single-wires 3A in parallel and flatly, and in the sectional rectangular shape. But in the present invention, the electrode provided in the electrode covering member 4 may be formed in a sectional circular shape by twisting the plural single-wires or may be formed by using one thick single-wire. And further, the sheet-shaped heaters 1, 11 and 21 may be structured to provide one thick electrode-wire or an electrode wire formed to the heating resistance sheets 2, 12 and 22 themselves by twisting the conductor single-wires for electrodes.

[0154] The two electrode covering members 4 are fined on each of the heating resistance sheets 2, 12 and 22, but the number of the electrode covering member 4 may be more than three.

[0155] A sectional shape of the electrode covering

member 4 may be various shapes such as a trapezium, a triangle, a pentagon or the like.

[0156] According to the present invention, the sufficient avoidance of the local heating, the low resistance variation with time and the small cost for manufacturing are attained, because the plural electrode covering members, each covering the electrodes, are attached on the sheet-shaped heating resistance sheet in a predetermined space from each other; at least an area adjacent to the electrode in the electrode covering member is the PTC layer having the positive temperature coefficient characteristics in which the electric resistance value increases with the rise in the temperature; and the heating resistance sheet is structured without the positive temperature coefficient characteristics or with the positive temperature coefficient characteristics in which, in the range below the temperature showing the kick-off increase ratio of the PTC layer, the kick-off increase ratio is smaller than the PTC layer or the kick-off temperature is higher than the PTC layer. And further, the kick-off temperature of the resistance is allowed to be selectively controlled by changing the ratio and the specific resistance value of the PTC layer in relation to the heating resistance sheet, so that there is an advantage that the change in the resistance until the kick-off point can be lowered.

Industrial Availability

[0157] As described thus far, the present invention is applicable in the use of a heater for melting snow on a road or a roof, a heater for the floor, a heater for preventing a mirror from fogging, and so on.

Claims

1. A sheet-shaped heater, in which plural electrode covering members, each covering an electrode, are attached onto a sheet-shaped heating resistance sheet to have a predetermined space from each other, comprising:

a PTC layer provided as at least an area adjacent to the electrode in the electrode covering member, and having positive temperature coefficient characteristics which show increase in electric resistance value with the rise in temperature; and

a heating resistance sheet without the positive temperature coefficient characteristics or with the positive temperature coefficient characteristics of which, in a range below the temperature showing a maximum kick-off increase ratio of said PTC layer, a kick-off increase ratio is smaller than the kick-off increase ratio of said PTC layer or a kick-off temperature is higher than the kick-off temperature of said PTC layer.

2. The sheet-shaped heater according to Claim 1, wherein the kick-off increase ratio of the positive temperature coefficient characteristics of said heating resistance sheet is lower than 0.5 of the kick-off increase ratio of the positive temperature coefficient characteristics of said PTC layer in the range below the temperature showing the maximum kick-off increase ratio of said PTC layer. 5
3. The sheet-shaped heater according to Claim 1, wherein the kick-off temperature of the positive temperature coefficient characteristics of said heating resistance sheet is more than 5°C higher than the kick-off temperature of the positive temperature coefficient characteristics of said PTC layer. 10 15
4. The sheet-shaped heater according to any one of Claim 1 to Claim 3, wherein said PTC layer is formed of a heating composition consisting of thermoplastic resin and conductive particles. 20
5. The sheet-shaped heater according to any one of Claim 1 to Claim 3, wherein said PTC layer is formed of inorganic material. 25
6. The sheet-shaped heater according to any one of Claim 1 to Claim 5, wherein said heating resistance sheet is formed of a heating composition consisting of thermoplastic resin and conductive particles. 30
7. The sheet-shaped heater according to any one of Claim 1 to Claim 6, wherein the electrode covering member has said PTC layer, placed around the electrode and having the positive temperature coefficient characteristics which show the increase in electric resistance value with the rise in temperature, and a PTC layer covering member covering said PTC layer, the PTC layer covering member and said heating resistance sheet each being formed by using same type of resin. 35 40
8. The sheet-shaped heater according to Claim 7, wherein the electrode is composed of single-wire groups each having plural conductive single-wires for electrodes, and wherein said PTC layer covers each of the single-wires. 45
9. The sheet-shaped heater according to any one of Claim 1 to Claim 8, wherein the electrode is composed of single-wire groups each having plural conductive single-wires for electrodes, and wherein said PTC layer covers a part of the single-wire group and is formed of more than two types of PTC layer having the different kick-off increase ratio and kick-off temperature. 50 55
10. The sheet-shaped heater according to any one of Claim 1 to Claim 9, wherein the electrode is composed of single-wire groups each having plural conductive single-wires for electrodes, and wherein the single-wire groups are each composed of plural single-wires each single-wires arranged in parallel to said heating resistance sheet and each located at a different space from said heating resistance sheet.
11. The sheet-shaped heater according to any one of Claim 1 to Claim 10, wherein said heating resistance sheet is formed of inorganic material.
12. The sheet-shaped heater according to any one of Claim 1 to Claim 10, wherein said heating resistance sheet is formed of metallic material.
13. The sheet-shaped heater according to any one of Claim 1 to Claim 12, wherein said heating resistance sheet and said PTC layer are connected through an insulating layer by using a heat-transfer material to be thermally integrated with each other.

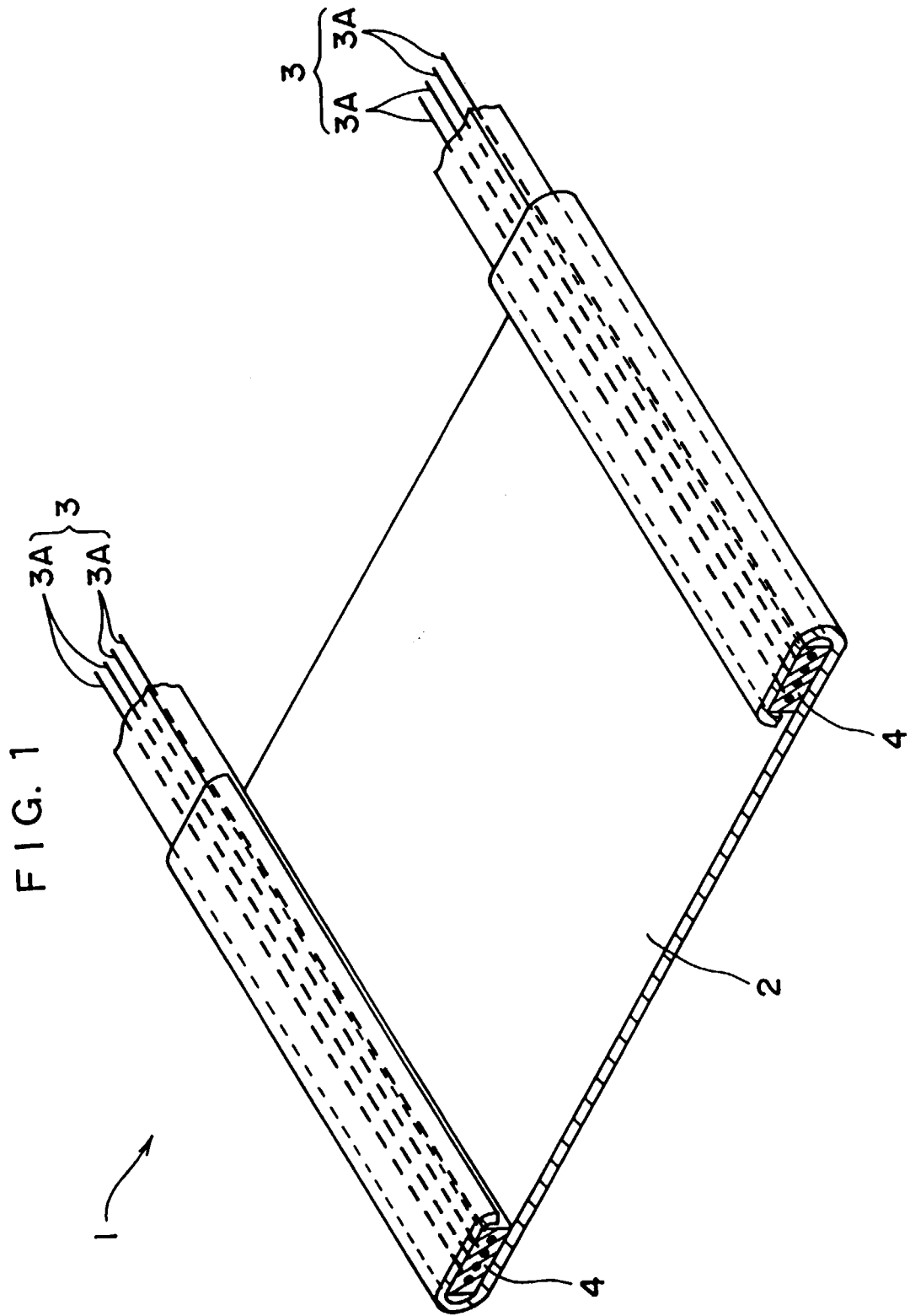


FIG. 2

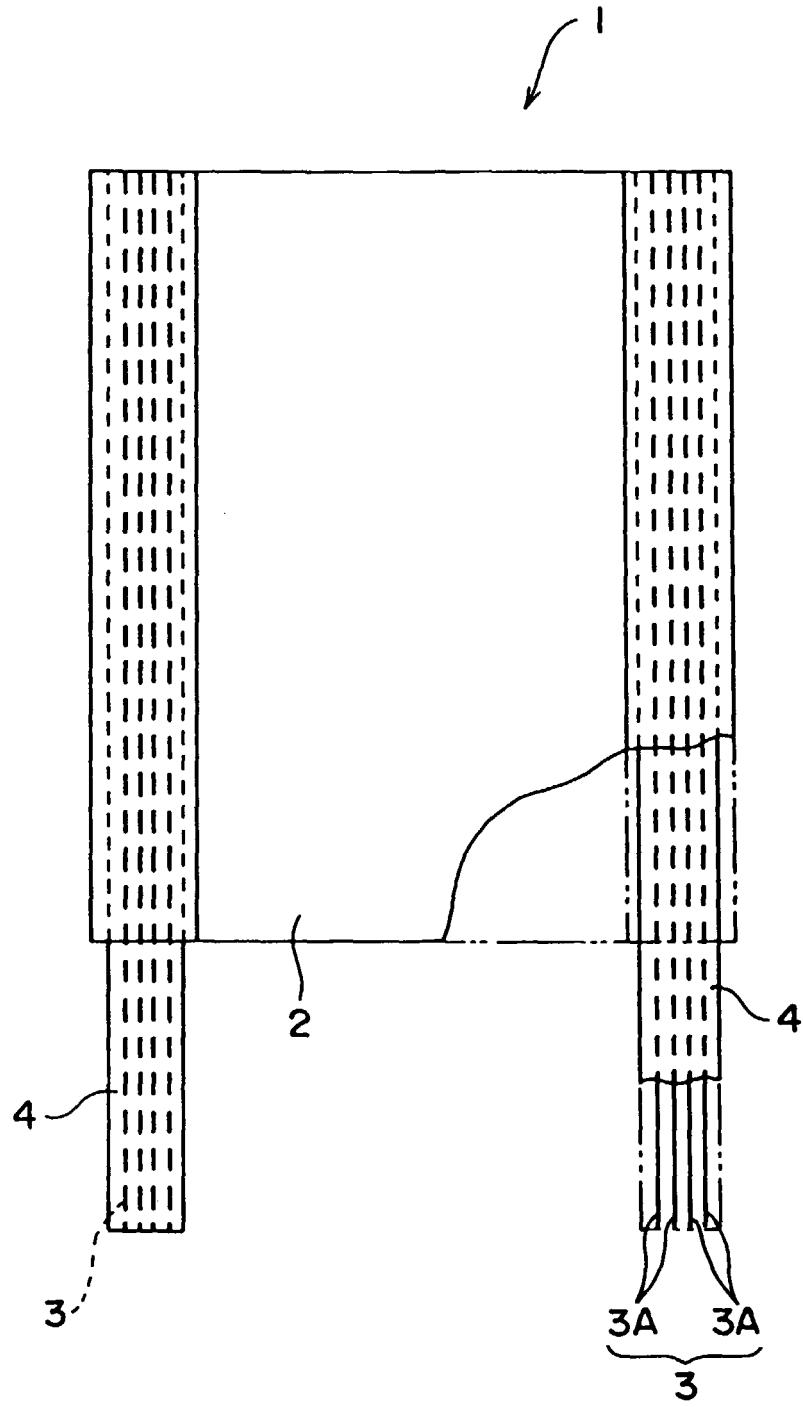
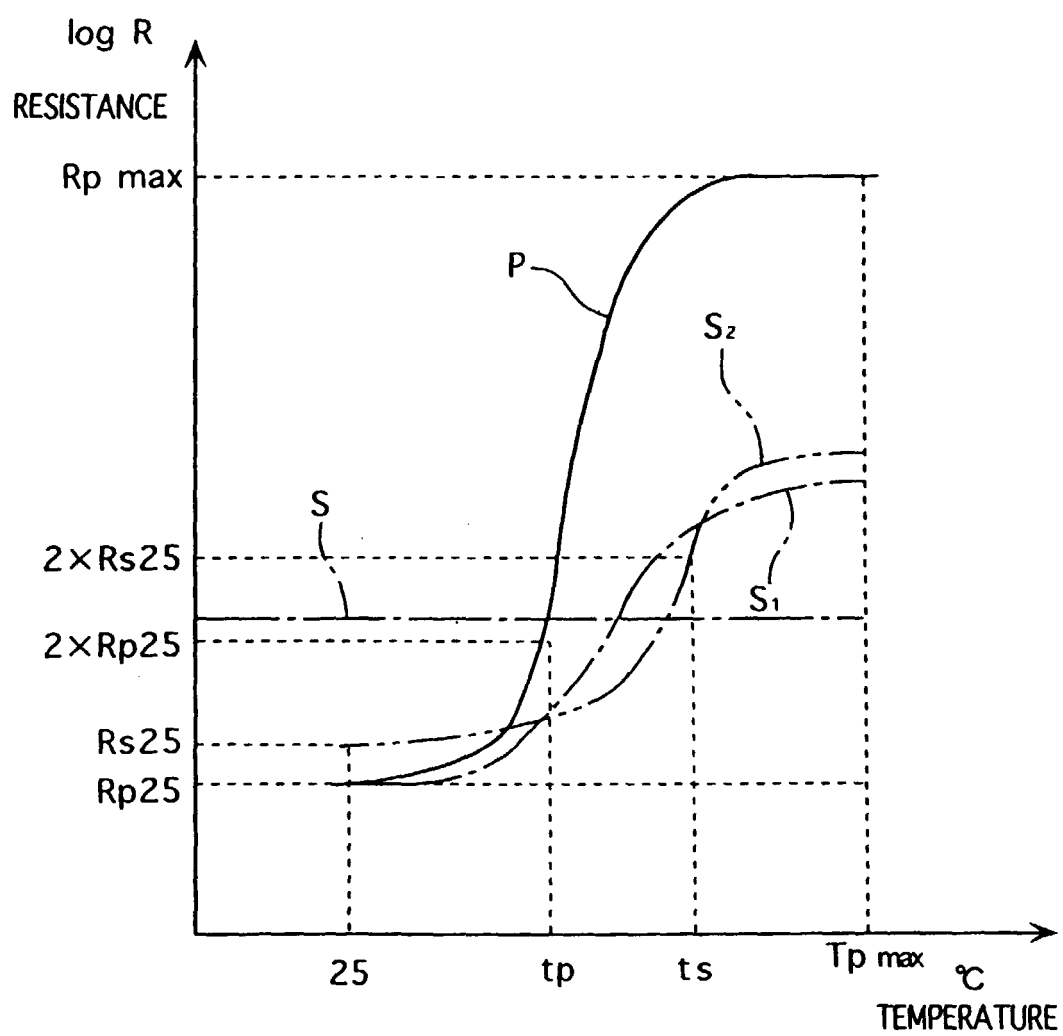
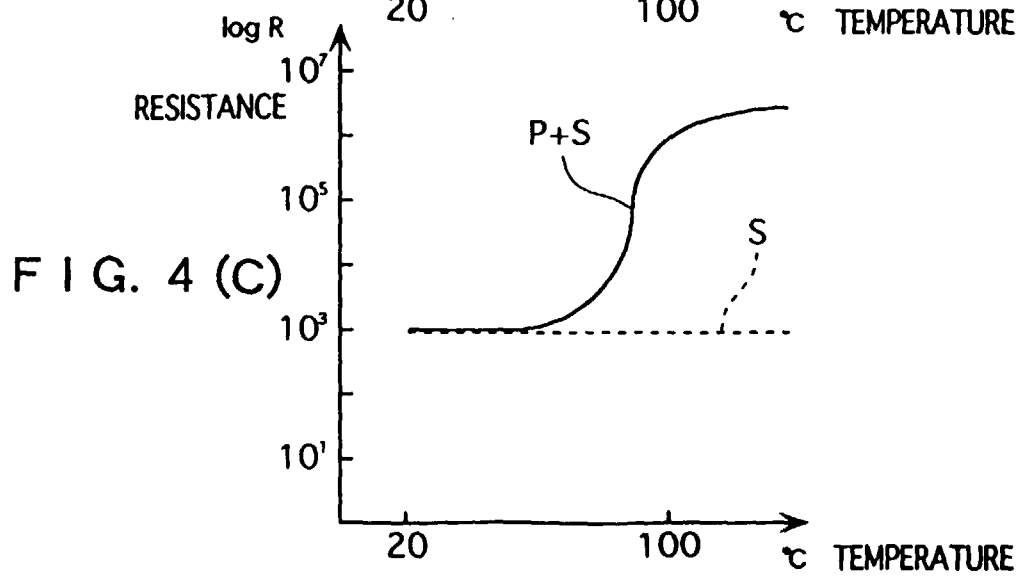
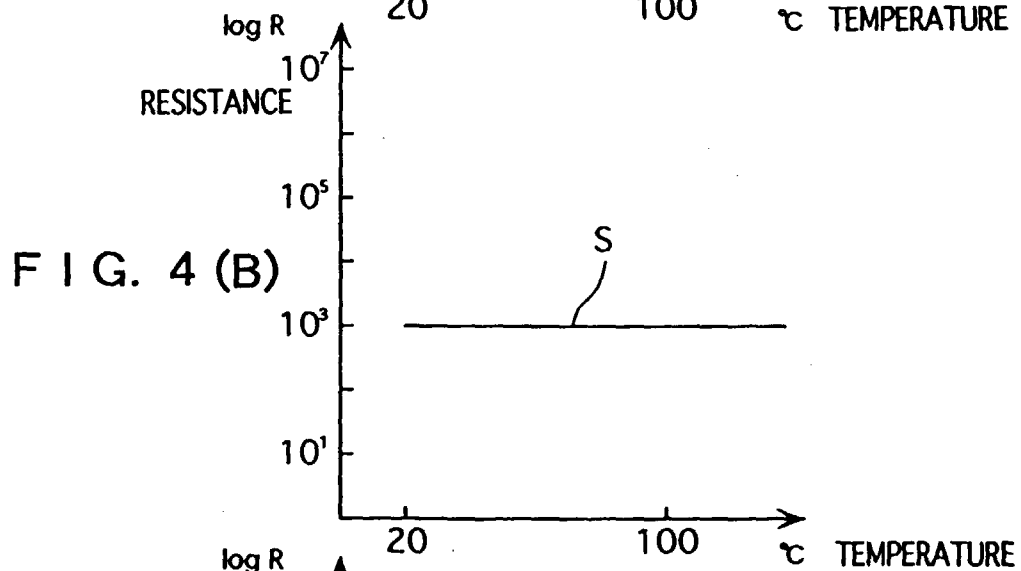
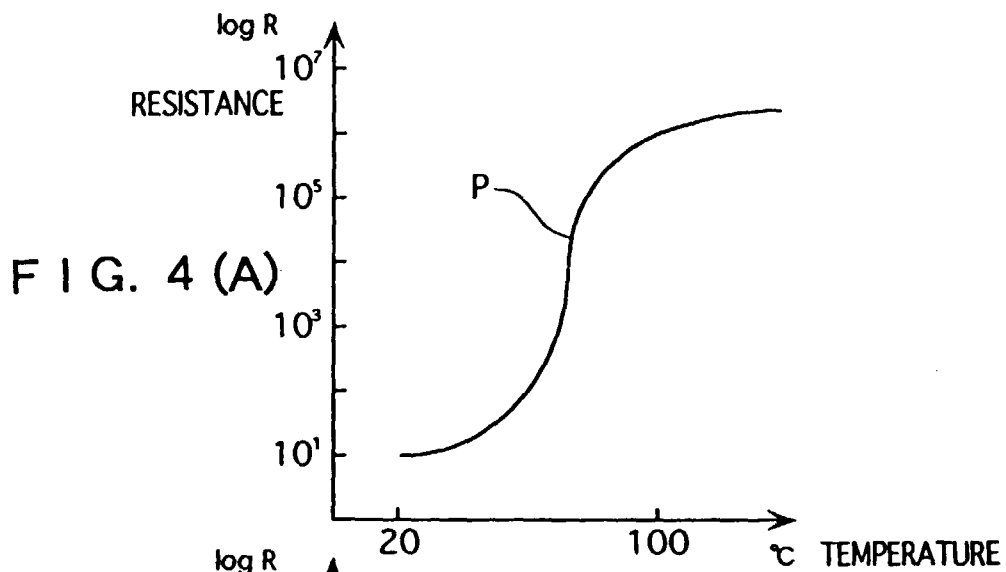


FIG. 3





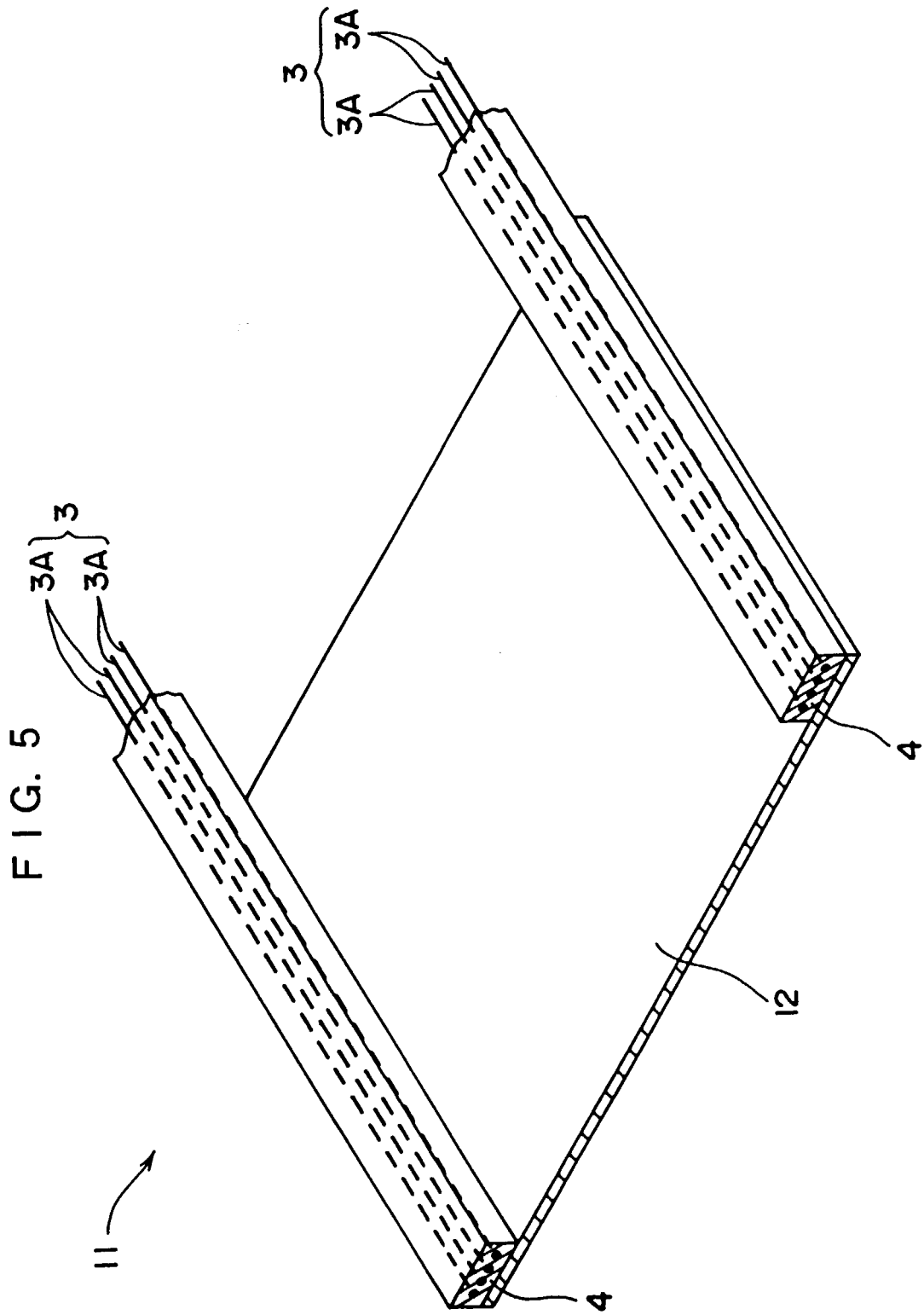


FIG. 6

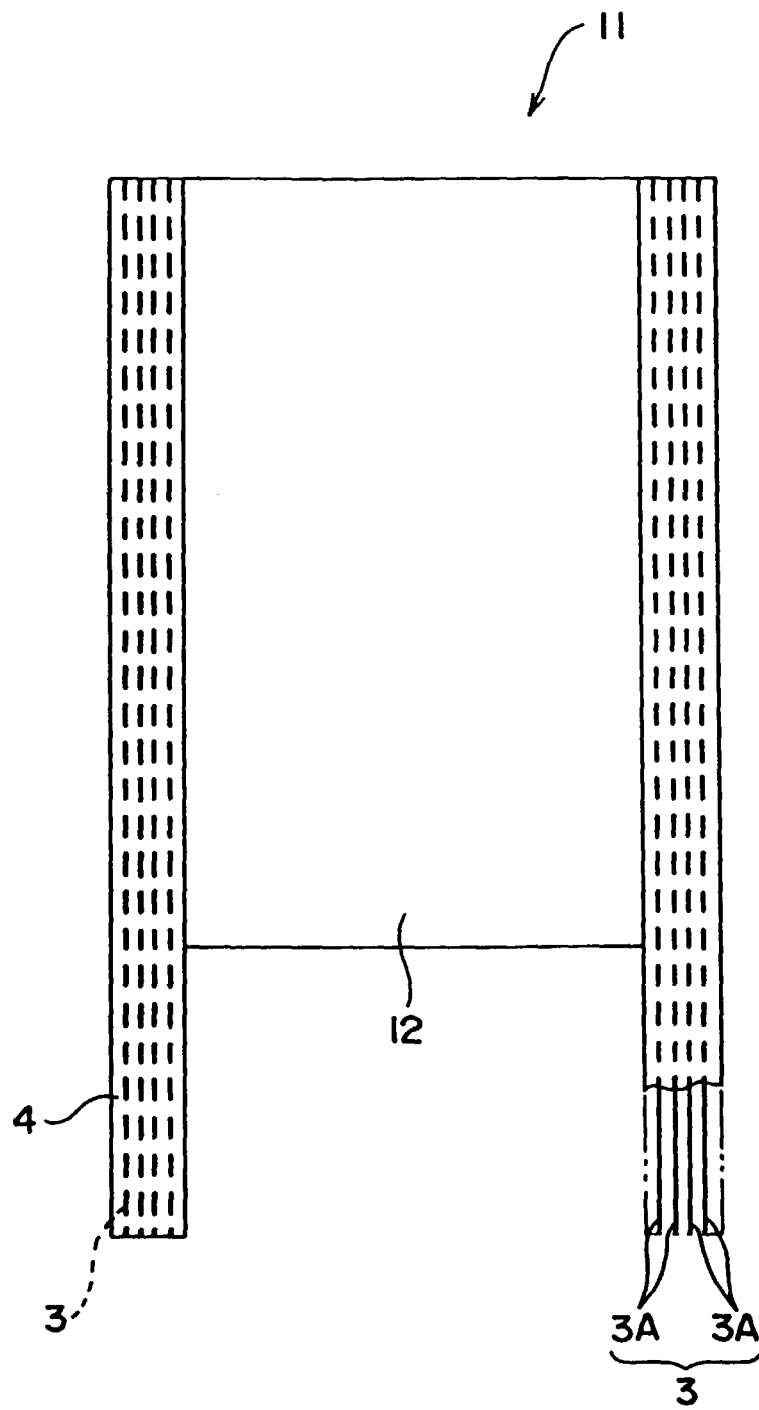


FIG. 7(A)

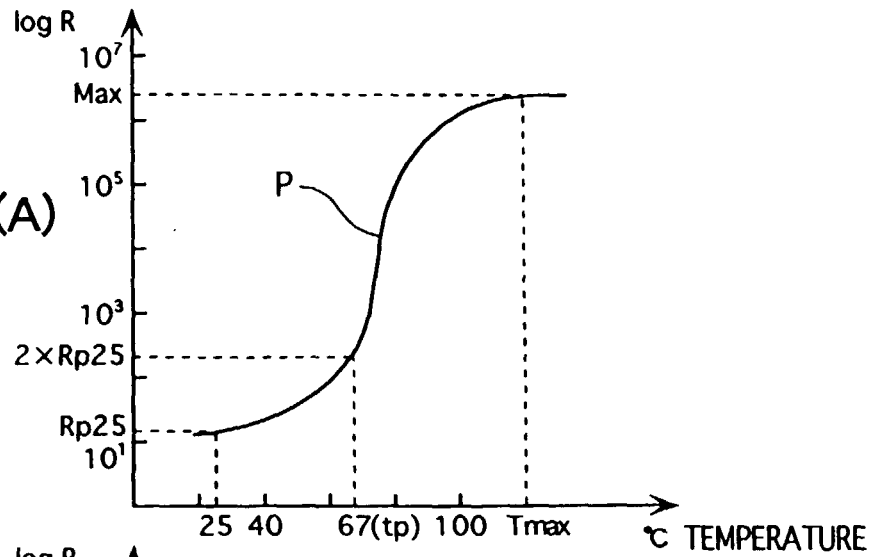


FIG. 7(B)

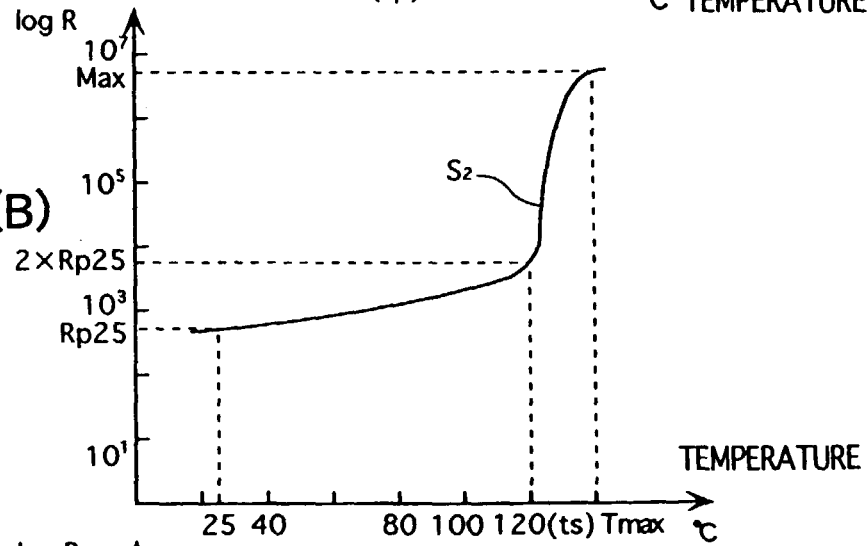
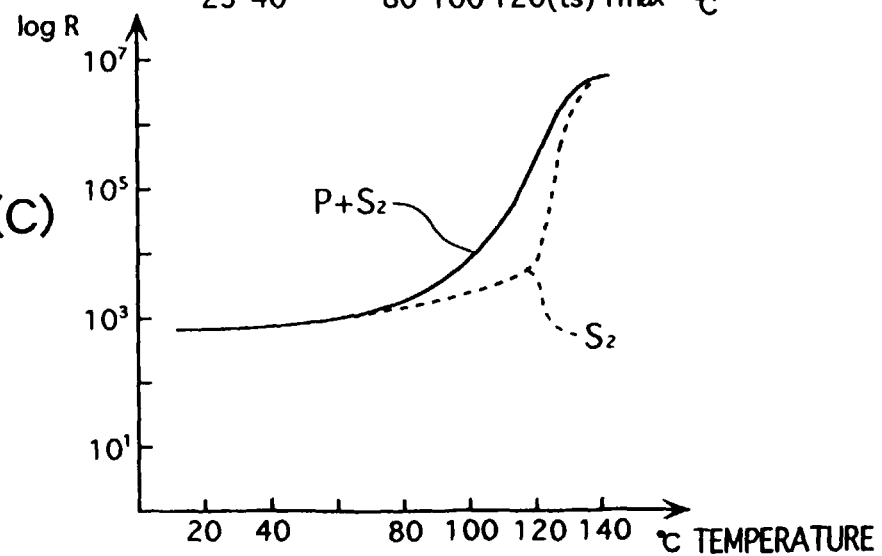


FIG. 7(C)



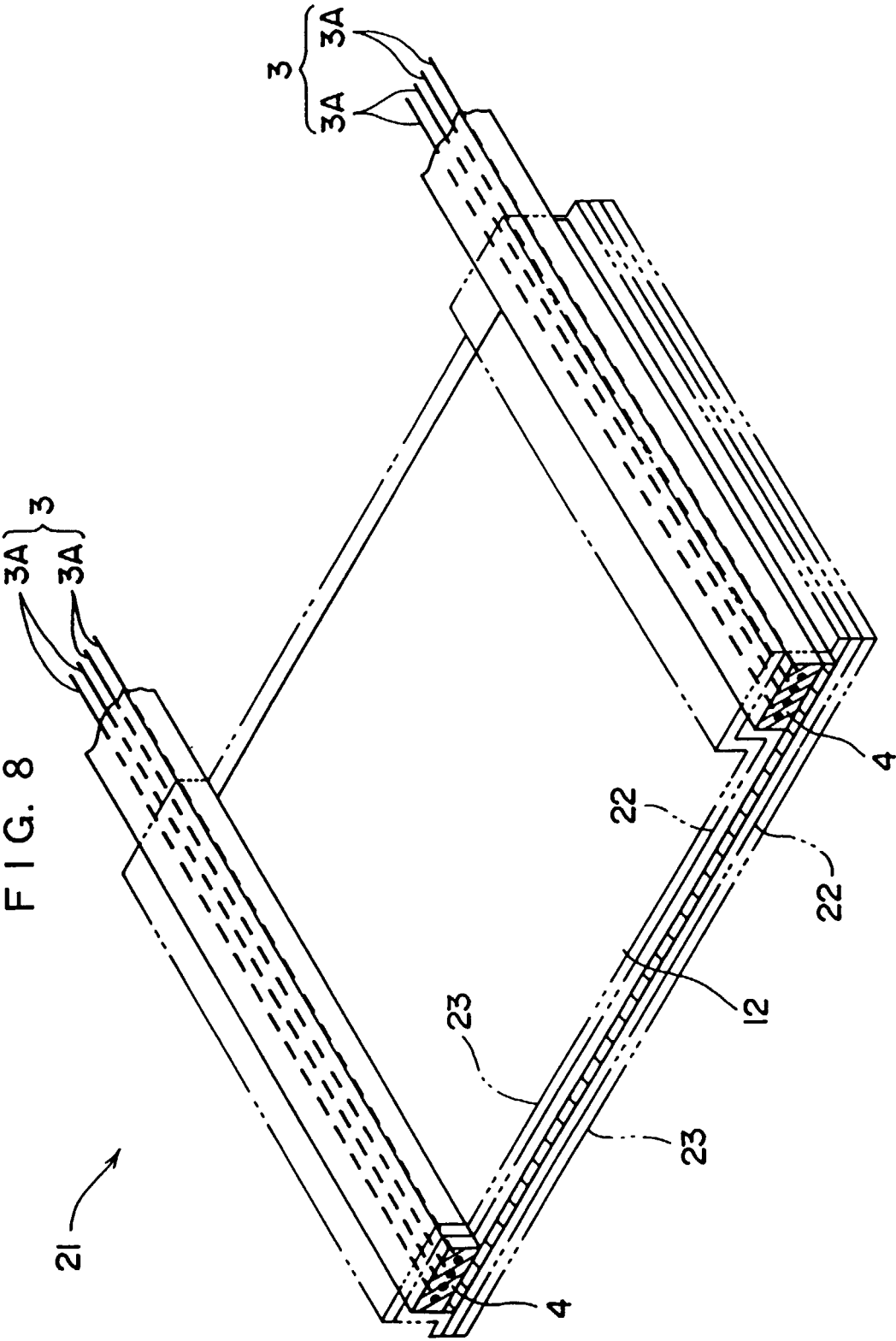


FIG. 9

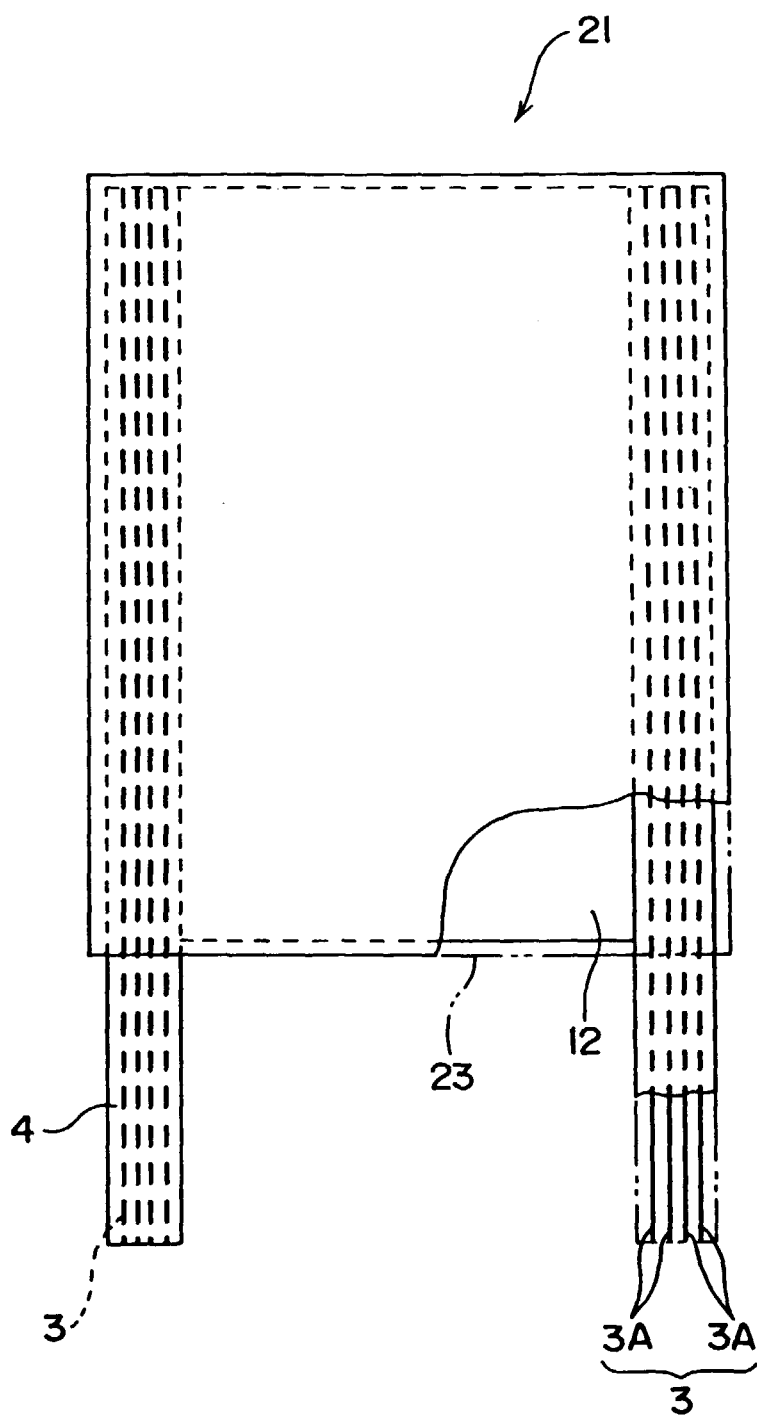


FIG. 10

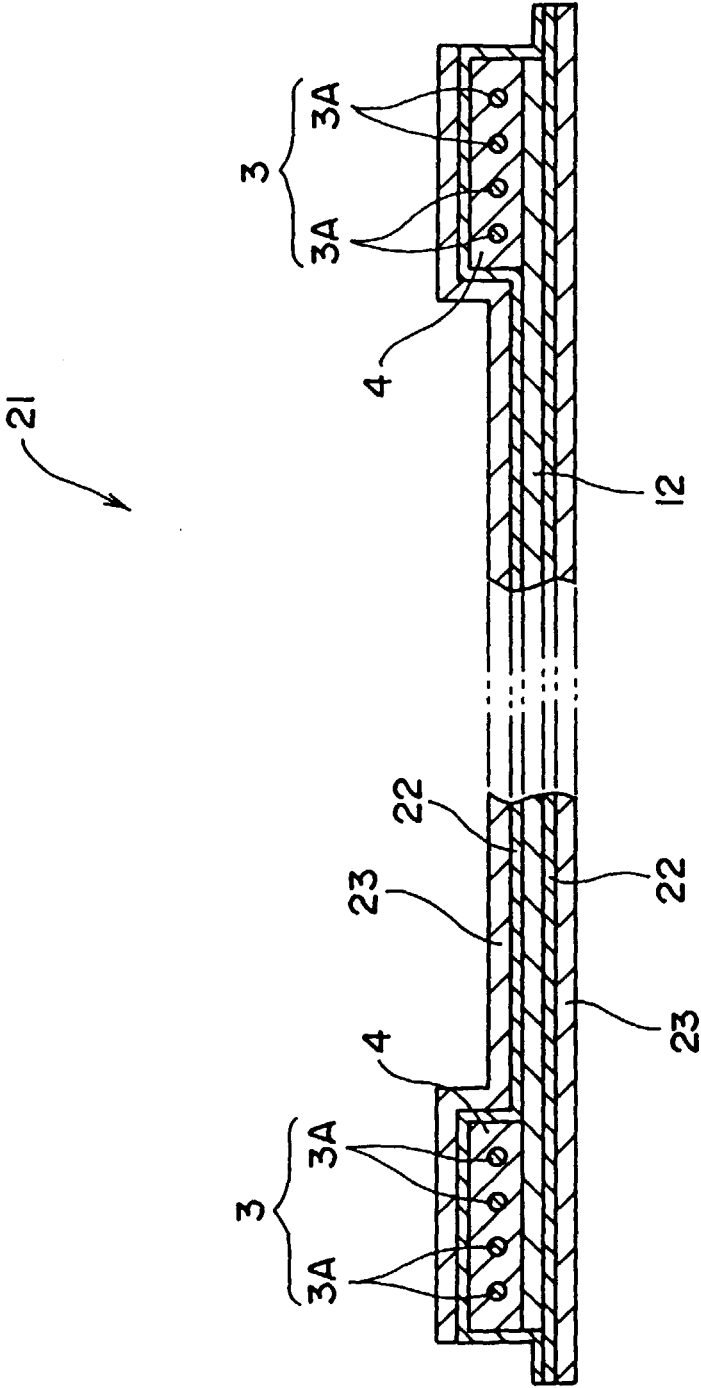


FIG. 11

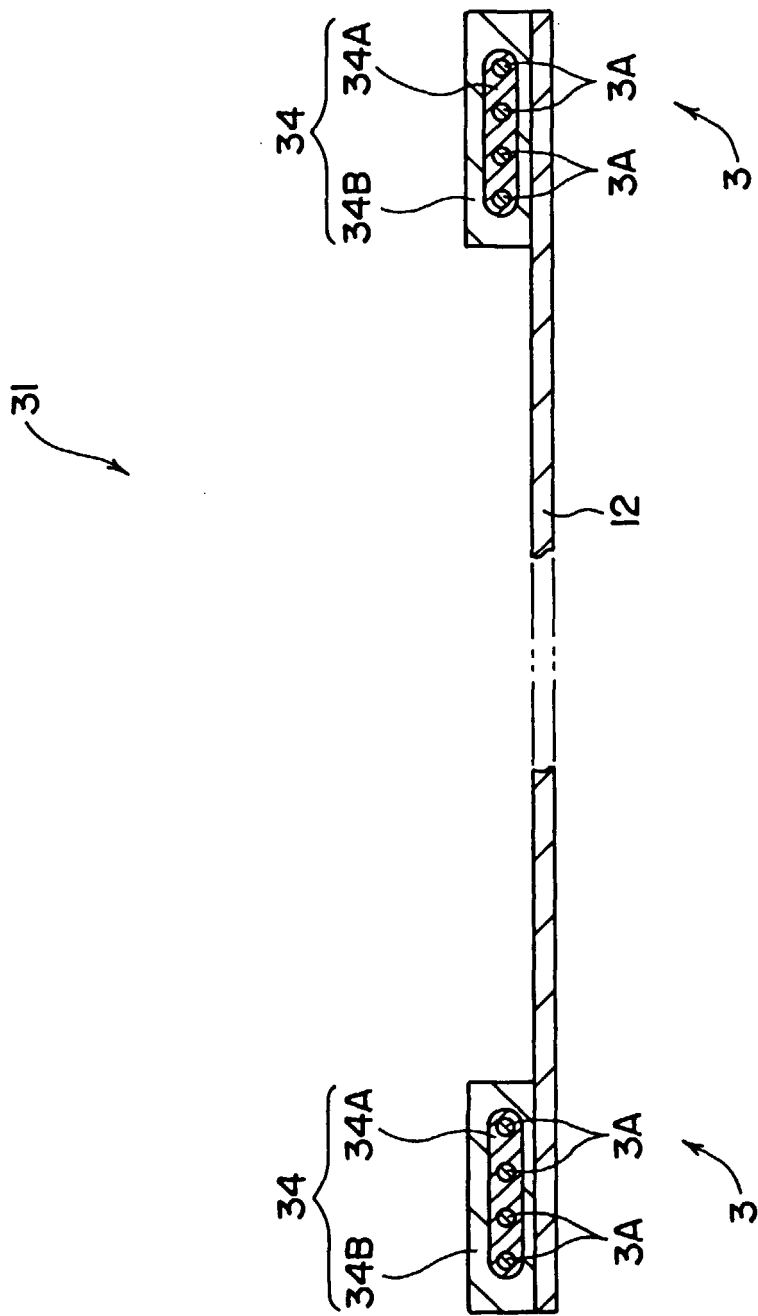


FIG. 12

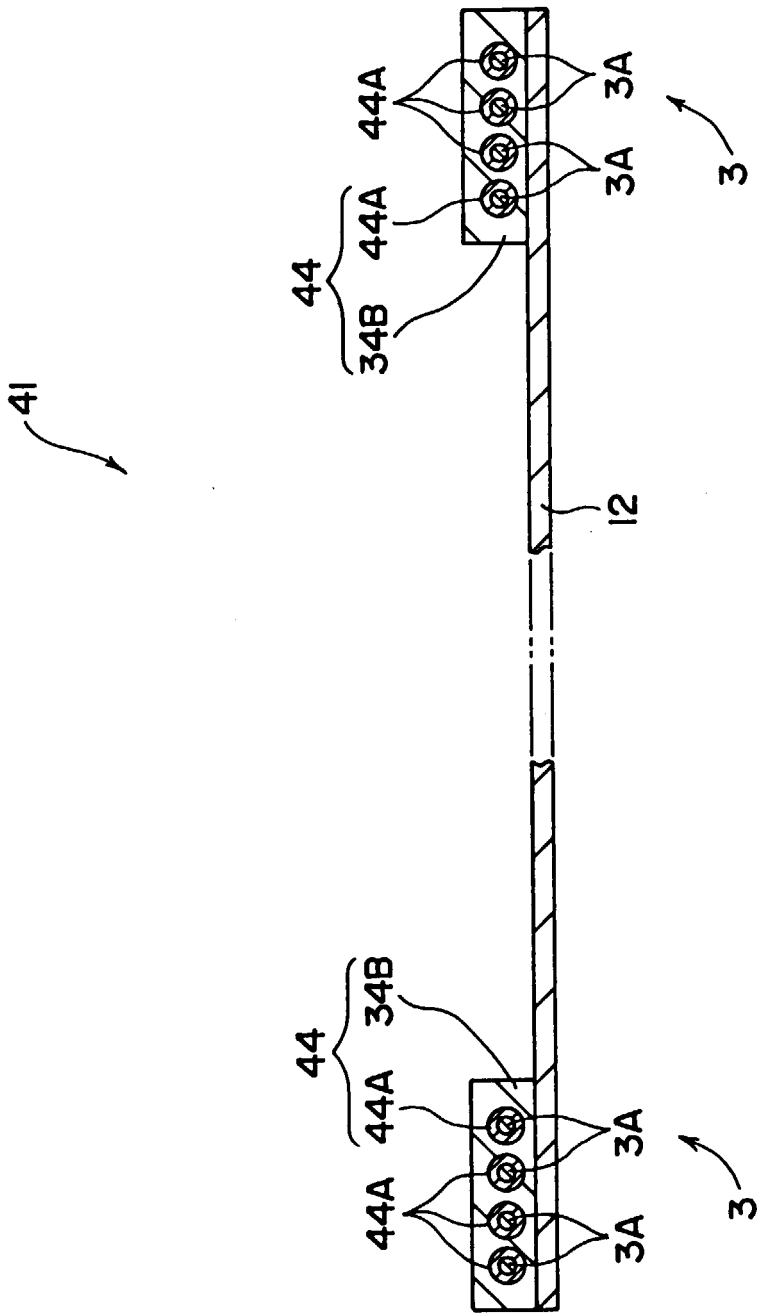


FIG. 13

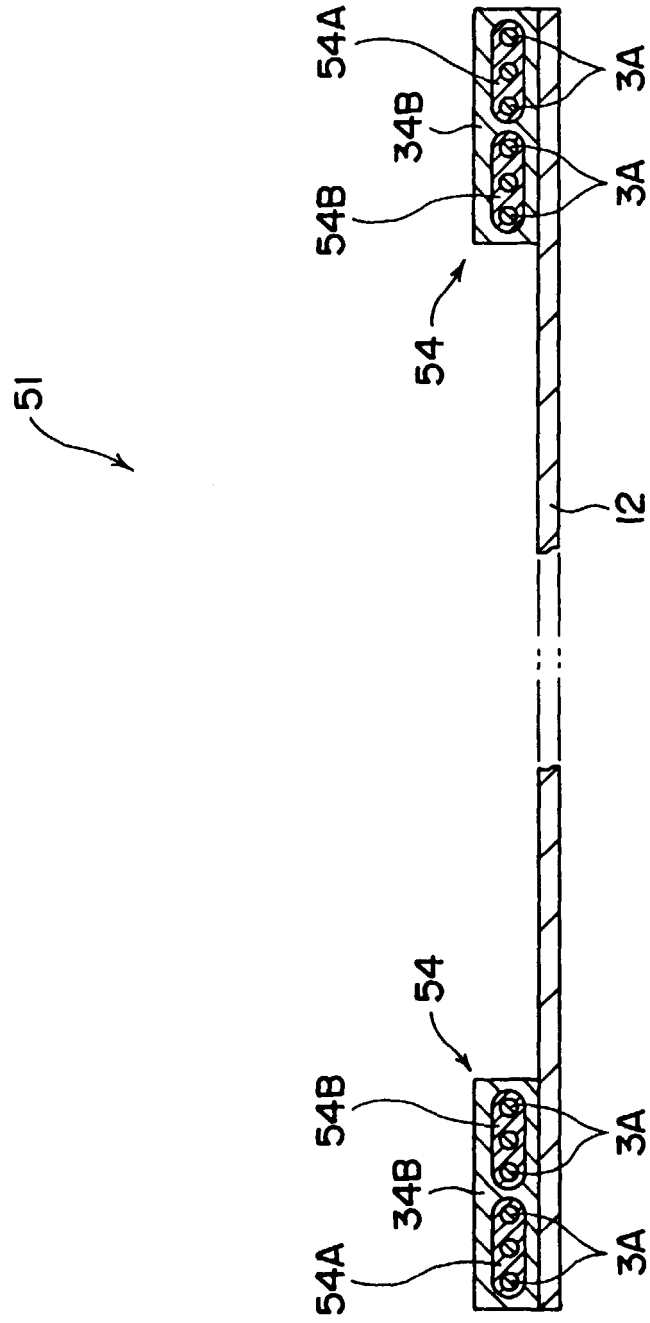


FIG. 14

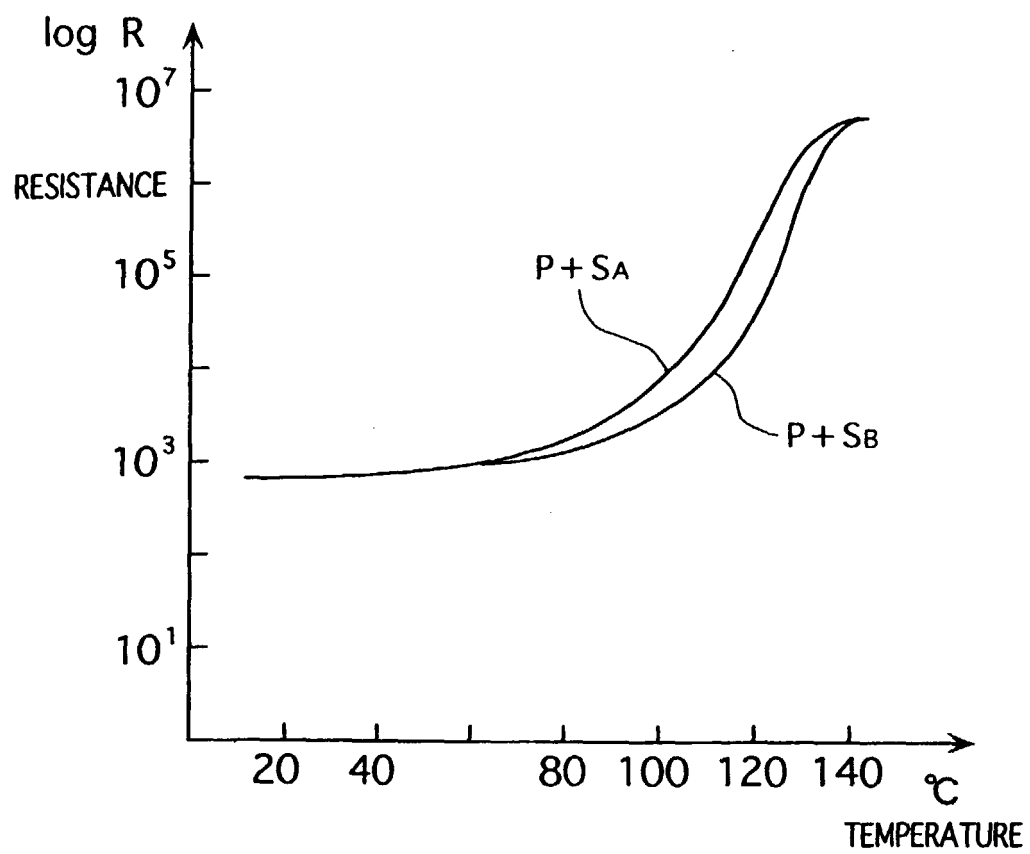


FIG. 15

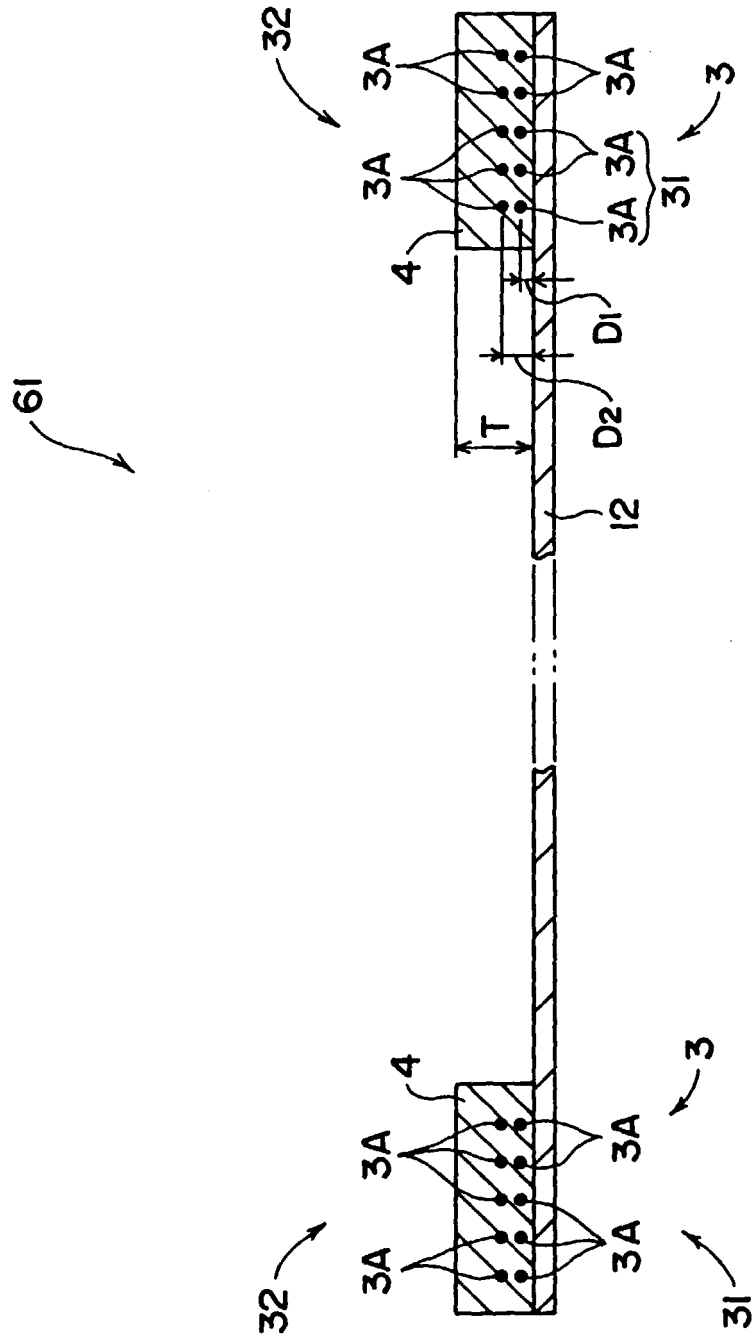
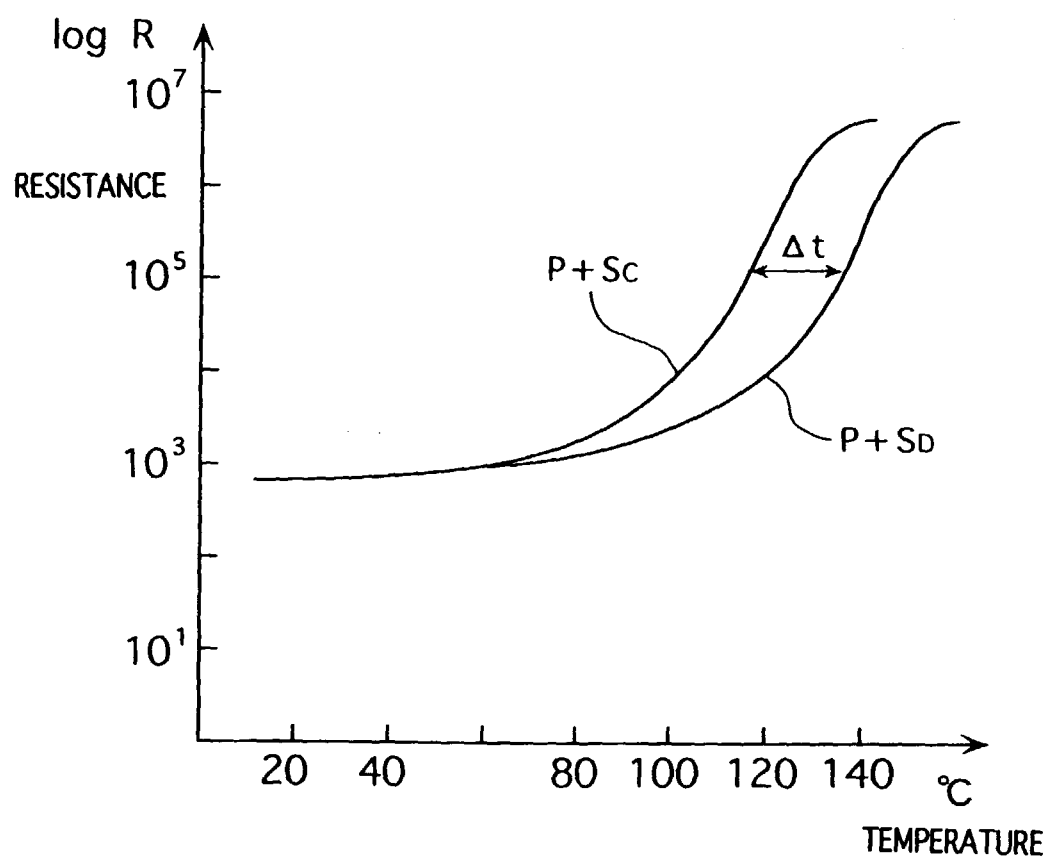


FIG. 16



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP97/00052

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl⁶ H05B3/20, 3/14, 3/03, 3/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl⁶ H05B3/00-3/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1940 - 1997
Kokai Jitsuyo Shinan Koho	1971 - 1995
Toroku Jitsuyo Shinan Koho	1994 - 1997

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 3-53486, A (Matsushita Electric Works, Ltd., etc.), March 7, 1991 (07. 03. 91) (Family: none) Claim 1; page 3, lower right column, lines 12 to 13	1, 2
X	Page 4, upper left column, line 9 to upper right column, line 7	4, 5
X	Page 3, lower right column, line 12 to page 4, upper left column, line 9	6, 12
Y	Claim 1; page 3, lower right column, lines 12 to 13	7, 11
X	Page 5, upper right column, lines 4 to 12	13
Y	JP, 8-106971, A (Idemitsu Kosan Co., Ltd.), April 23, 1996 (23. 04. 96) (Family: none) Page 4, column 5, lines 35 to 41	7
A	Fig. 6	8 - 10
Y	JP, 59-203390, A (Matsushita Electric Works, Ltd.), November 17, 1984 (17. 11. 84),	11

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
March 19, 1997 (19. 03. 97)

Date of mailing of the international search report
April 1, 1997 (01. 04. 97)

Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.