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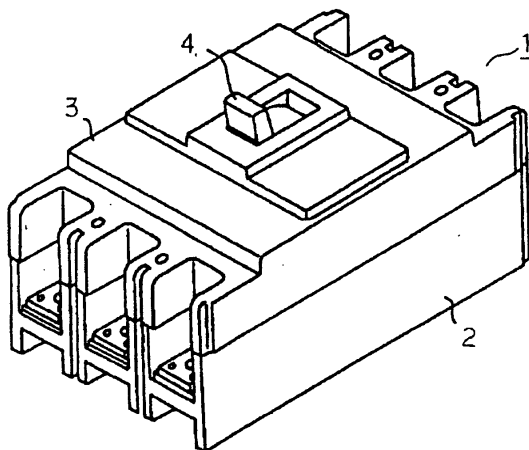
(54) **CIRCUIT BREAKER**

(57) A circuit breaker superior in heat resistance, arc resistance and over-travel characteristic, and suitable for recycling or reuse is provided.

The circuit breaker includes an open/close mechanism (7, 28, 29, 31, 32) for opening and closing a moving contact (5, 25) through a retention holder (6, 26) turnably holding the moving contact (5, 25), and a base (2, 21) for turnably holding the retention holder (6, 26) and hold-

ing a stationary side contact (10, 23). Detection of any over-current causes the moving contact (5, 25) to turn, and an arc-extinguishing device (9, 34) extinguishes arc generated between the contacts. Further the base (2, 21) of the circuit breaker is formed of an insulating molded article, which is mainly composed of a crystalline thermoplastic resin and is irradiated with electron beams after molding.

FIG. 1



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Description

Technical Field

5 **[0001]** The present invention relates to a circuit breaker in which upon detection of an over-current, a moving contact is turned, and an arc generated between contacts is extinguished with the use of arc-extinguishing device.

Background Art

10 **[0002]** In the conventional circuit breaker, a thermosetting resin has been employed as a material of a base because the thermosetting resin is relatively easy to satisfy requirements such as a heat resistance, an arc resistance, a mechanical strength, etc. However, the thermosetting resin needs incineration or reclamation of flashes generated during the step of molding, and sprues, runner or the like generated during the step of injection molding. Therefore recycle or reuse of the flash, sprue, runner and the like has been difficult.

15 **[0003]** On the other hand, employing a molded article whose principal component is a thermoplastic resin has been attempted. For example, the Japanese Laid-Opened Patent Application No. 171847/1996 discloses a molded article containing a thermoplastic resin composed of Nylon 6, Nylon 66 and Nylon MXD6, an inorganic compound dehydrating at not less than 200°C, and any reinforcing material. This molded article is superior in the aspect of flame retardancy or fire resistance and an insulation performance after opening/closing of contacts, and also preferable as a molded
20 article for use in circuit breakers. However, when employing the mentioned molded article as a base of a circuit breaker for a large rated current, it has been found that properties thereof performed as a base are not sufficient, particularly in the aspect of heat resistance.

[0004] In the experiments carried out by the inventors, a base (Nylon6, being a main resin, is 215°C in a melting point), which is described in the mentioned Japanese Laid-Opened Patent Application No. 171847/1996, was applied
25 to a circuit breaker of 225A frame and a rated current of 225A. Then the base was subject to an overload interruption test (where current 6 times as much as the rated current is applied and interrupted (JIS C8370 and C8371), that is, 225A×6=1350A is applied in this case). As a result of this test, it was found that an over-travel value between contacts might decrease and a contact pressure between the contacts might reduce abnormally. At this time, it is recognized that a portion in the vicinity of the surface of the base and to which the stationary contact is fixed to a base side, is
30 fused. It is considered that the decrease in over-travel value, the reduction in contact pressure between the contacts, and fusion at the portion in the vicinity of the base are caused mainly by a heat generation due to arc, which is generated at the moment of interruption. When any fusion takes place in the vicinity of the base where the stationary contact is fixed, not only the contact pressure between the contacts becomes unstable, but also the contact portion of the base with the stationary contact is deformed through repetition of switching. Thus, there remains a possibility that of an over-travel value is further decreased.
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[0005] In this connection, an over-travel value means an amount of traveling the moving contact from contact point with the assumed stationary contact toward to the further progressive position for the direction to the assumed stationary contact when removing the stationary contact under the assumed contact state of these contacts. Accordingly, to maintain a constant contact pressure, an over-travel value is set to be several times as much as thickness of the
40 stationary contact in view of tolerance. Further, a structure for holding the contacts such as the base, the moving contact, the stationary contact and the like are subject to a reaction force of the contact pressure in order to maintain the contact pressure between the contacts. This reaction force causes the structure to be deformed, e.g., creep deformed, resulting in reduction in over-travel value due to use for long years.

[0006] Furthermore, the same test result was obtained when employing polybutyleneterephthalate (hereinafter referred to as PBT, of which melting point is about 220°C), or polyethyleneterephthalate (hereinafter referred to as PET
45 of which melting point is about 255°C), as a thermoplastic resin serving as a principal component.

[0007] Then, even if replacing the above-mentioned resin materials with polyphenylenesulfide (hereinafter referred to as PPS, of which melting point is about 290°C) having a higher melting point and implementing the same over-current trip test, the same problems as those described above occurred.
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Disclosure of Invention

[0008] The present invention was made to solve the above-discussed problems, and has an object of obtaining a circuit breaker, which is superior in heat resistance and arc resistance, and in which there is less occurrence of fusion
55 or heat deformation even if the circuit breaker is subject to a heat history at a high temperature such that a heat is generated particularly at the time of over-current tripping or repetition thereof.

[0009] A circuit breaker in which detection of over-current causes a moving contact to turn, and arc generated between the moving contact and an other contact opposing to the moving contact, is extinguished by an arc-extinguishing

device, the circuit breaker being characterized in that a molded article possessing an insulation performance mainly composed of a crystalline thermoplastic resin, and to which an electron irradiation is applied after molding, is used. As a result, it becomes possible to obtain a circuit breaker in which there is less occurrence of fusion or heat deformation even if the circuit breaker is subject to in a heat history at a high temperature, and which is superior in arc resistance.

[0010] The circuit breaker preferably includes: an open/close mechanism for opening and closing the moving contact with the other contact through a retention holder for turnably holding the moving contact; a base for holding the other contact and the arc-extinguishing device, and for turnably holding the retention holder; and a cover for covering the base to form a housing therewith; wherein the base is formed of the molded article. As a result, the circuit breaker is superior in heat resistance and an over-travel characteristic between the contacts.

[0011] In the circuit breaker according to the invention, the base preferably includes: a bottom portion holding to the retention holder, the other contact and the arc-extinguishing device; and a side wall portion, which is perpendicularly provided intersecting the bottom portion, and defines a boundary between inside and outside of the housing; wherein the bottom portion of the base is irradiated with electron beams, while the side wall portion of the base is not irradiated with the electron beams. As a result, the circuit breaker is superior in heat resistance to an arc heat generated at the time of production of any arc, and in impact resistance to elevation of an inner pressure within the housing.

[0012] In the circuit breaker, the retention holder, the other contact and the arc-extinguishing device are preferably disposed along a section of the base defining a turning plane of the moving contact; and the section of the base is irradiated with electron beams. As a result, the circuit breaker is superior in the heat resistant and arc resistance, and a micro-machining is made possible, which contributes to small-sizing of an outer diameter and fabricating parts of high density.

[0013] In the circuit breaker, the molded article preferably contains 60-200 parts by weight of reinforcing material with respect to 100 parts by weight of resin component. As a result, there is less occurrence of fusion or heat deformation, and the circuit breaker is superior in arc resistance and in strength.

Brief Description of Drawings

[0014]

Fig. 1 is a perspective view showing an exterior appearance of a circuit breaker according to a first preferred embodiment of the present invention.

Fig. 2 is a perspective of the circuit breaker with a cover removed from the exterior view of Fig. 1.

Fig. 3 is a schematic perspective view showing an exterior appearance of a retention holder of Fig. 2.

Fig. 4 is a sectional view showing an enlarged contact point portion of Fig. 1.

Fig. 5 is a top plan view showing a frame format of a base of Fig. 1.

Fig. 6 is a view for explaining an electron irradiation toward the base shown in Fig. 5.

Fig. 7 is a schematic plan view showing a positional relation between the base and an electron beam-shielding jig at the time of electron irradiation.

Fig. 8 is a schematic perspective view showing another example of the electron beam-shielding jig of Fig. 6.

Fig. 9 is a schematic perspective view showing a further example of the electron beam-shielding jig of Fig. 6.

Fig. 10 is a view showing a mold for molding a base of 225A frame according to the first example of this invention.

Fig. 11 is a view showing an exterior appearance of a circuit breaker according to a second preferred embodiment of the invention.

Fig. 12 is a partially cutaway view for explaining the circuit breaker of Fig. 11.

Best Mode for Carrying Out the Invention

Embodiment 1.

[0015] Fig. 1 is a perspective view showing an exterior appearance of a circuit breaker according to a first preferred embodiment of the present invention; Fig. 2 is a perspective of the circuit breaker with a cover removed from the exterior view of Fig. 1; Fig. 3 is a schematic perspective view showing an exterior appearance of a retention holder of Fig. 2; Fig. 4 is a sectional view showing an enlarged contact point portion of Fig. 1; and Fig. 5 is a top plan view showing a frame format of a base of Fig. 1.

[0016] In the drawings, reference numeral 1 designates a circuit breaker, and numeral 2 designates a base formed of an insulating resin molded article. Numeral 3 designates a cover, which is formed of an insulating resin molded article, and placed over the base 2 to form a housing together with the base 2. Numeral 4 designates a handle for opening and closing a moving contact 5 via an open/close mechanism 7 and a retention holder 6 from outside of the cover 3. Numeral 6 designates a retention holder for turnably holding the moving contact 5 on a moving contact retention

portion 6A (Fig. 3). Numeral 7 designates an open/close mechanism of which metal frame 7A is supported on the base 2, and which drives opening and closing operation of the retention holder 6. Numeral 8 designates an over-current detector that detects an over-current and causes the open/close mechanism to trip. Numeral 9 designates an arc-extinguishing device for carrying out extinction of an arc generated between contact portions 5A and 10A. In this arc-extinguishing device, a plurality of metal arc-extinguishing plates 9A (Fig. 4) are supported by an insulating grid side plate 9B. Numeral 10 designates a base side contact (acting as a stationary contact) provided with a contact portion 10A opposite to a moving contact portion 5A. Numeral 11 designates a support member that turnably supports the base side contact 10 round a support pin 12, and forms cable way. Numeral 13 designates a flexible copper wire for electrical connection between the support member 10 and a stationary conductor 14. Numeral 15 designates an insulating member covering the stationary conductor 14.

[0017] Now, the base 2 is described.

[0018] The base 2 is provided with a bottom portion 2C. The base side contact portion 10A is disposed on the bottom portion 2C thereof (Figs. 5 and 7) through the support member 11. The open/close mechanism 7, the over-current detector 8 and the arc-extinguishing device 9 are disposed above the bottom portion 2C. Further, terminal strips 14A, 16 (Fig. 4, Fig. 2) are disposed at terminal strip retention parts 2D, 2E, and a rotary shaft 6B of the retention holder 6 (Fig. 3) is supported by a retention holder bearing 2F. Among these components, the arc-extinguishing device 9 and the base side contact portion 10A are located in a region near the arc generated between the contact portions 5A and 10A, and considerably affected by a heat generation due to the arc. This region is indicated by reference numeral 2G (Fig. 5). Furthermore, a side wall portion 2A defining a boundary between the inside and the outside of housing, and inter-phase wall portions 2B for insulation between phases are formed in an integral molding such that the walls intersect the bottom portion 2C perpendicularly. A large force acts on a contact portion with the support member 11 for the base side contact 10 on which the contact portion 10A is provided, a support portion for the open/close mechanism, and a support portion for the rotary shaft 6B of the retention holder 6.

[0019] The base 2 is formed of a molded article of which main resin is a crystalline thermoplastic resin, and is irradiated with electron beams. In this embodiment, the electron beams are the ones substantially in a straight line by making an electron flow thin, and is widely utilized in the field of medical items for the purpose of sterilization

[0020] The crystalline thermoplastic resin is not particularly limited as far as it is a crystalline one. Considering, however, that a circuit breaker is continuously used over 10 to 15 years in the marketplace, polyester and polyamide of which heat resistant continuous use temperature is preferably not lower than 120°C. From the viewpoint very little influence due to moisture absorption, polyester is preferably used and polyethylene terephthalate (PET) and polybutylene terephthalate (PBT) are suitable. Furthermore, an alloy of these thermoplastic resins is preferably used. From the viewpoint of good tracking performance and insulation performance after interruption, a resin which does not have any benzene ring such as polyamide is preferably used, and Nylon 12, Nylon 6, Nylon 66 or the like is suitable.

[0021] A crosslinking accelerator is added in the amount of 0.5 to 2 parts mainly for the purpose of accelerating crosslinking between amorphous portions in the crystalline thermoplastic resin by electron irradiation. As a crosslinking accelerator, a polyfunctional monomer such as triallyl isocyanurate (abbreviated to TAIC), tris(hydroxyethyl)isocyanuric acrylate (abbreviated to THEICA), tris(hydroxyethyl)isocyanuric methacrylate (abbreviated to THEICM), or trimethylolpropane triacrylate (abbreviated to TMPTA), is preferably used. Furthermore, it is preferable that these monomers are combined and added.

[0022] Addition of TAIC or THEICA is preferable in view of high gel fraction under the electron irradiation of same amount.

[0023] An antioxidant is added in the amount of 0.2 to 0.9 parts for the purpose of preventing the crosslinking accelerator from being self-cross-linked when kneading the materials. Preferably, addition thereof is in the amount of 0.4 to 0.6 parts. Preferably used as an antioxidant, for example, a hindered phenolic antioxidant including 2,6-di-*t*-butyl-*p*-cresol (hereinafter referred to as to BHT), triethylene glycol-bis[3-(3-*t*-butyl-5-methyl-4-hydroxyphenyl)propionate], 1,6-hexanediol-bis[3-(3,5-di-*t*-butyl-4-hydroxyphenyl)propionate], penta-erythrityl tetrakis[3-(3,5-di-*t*-butyl-4-hydroxyphenyl)propionate], *N,N'*-hexamethylene-bis(3,5-di-*t*-butyl-4-hydroxy-hydrocinnamamide), 3,5-di-*t*-butyl-4-hydroxy-benzyl phosphonate-diethyl ester and the like.

[0024] It is preferable that either a single antioxidant is added, or a combination thereof is added.

[0025] The reinforcing material is typically a glass fiber. A glass fiber is the one that is made of glass and is fiber like. Glass material includes E glass, S glass, D glass, T glass, a silica glass or the like. As is generally known, it is preferable from the viewpoint of improvement in impact-resistant strength that the glass fiber is 6-13 micrometers in diameter, and not less than 10 in an aspect ratio.

[0026] The inorganic filler includes alumina, calcium carbonate, mica, clay, talc, kaolin, wollastonite and the like.

[0027] The flame-retardant material includes red-phosphorus-based, phosphate esters, halide-based and the like. From the viewpoint of extremely little metallic corrosions, phosphate esters and halide-based materials are preferably employed for the parts including the contact portions 5A, 10A. Further, the halide-based materials are preferable from the viewpoint of performing flame retardancy by adding a small amount of them as compared with phosphate esters.

Furthermore, even in the event of occurrence of any retention in cylinder during molding, dibromopolystyrene is preferable from the viewpoint of difficulty in decomposition.

[0028] As a flame-retardant assistant, antimony trioxide is preferably used from the viewpoint of increase in synergistic effect with halide-based material.

[0029] Now, application of electron beams to the base is described.

[0030] Fig. 6 is a schematic diagram showing application of electron beams to the base shown in Fig. 5. Fig. 7 is a plan view showing a positional relation between the base and an electron beam-shielding jig at the time of electron irradiation of Fig. 6. The base is shown by broken lines. Figs. 8 and 9 are schematic views showing further examples of the electron irradiation jig of Fig. 6.

[0031] In the drawings, numeral 40 designates an electron irradiation device. Numeral 41 designates electron beams. Numeral 50 designates an electron beam-shielding jig, which is provided with a passage hole 51 for causing the electron beams 41 to pass through an iron plate of 4mm plate in thickness, for example. As shown in Fig. 7, the passage hole 51 opens toward the bottom portion 2C of the base 2, and the side wall portion 2A and the terminal strip retention parts 2D, 2E of the base 2 are masked or shielded by the electron beam-shielding jig 50. Although an example of the electron beam-shielding jig 50 being separated from the base 2 is shown in Fig. 6, it is also preferable that the electron beam-shielding jig is crossly placed onto the base 2.

[0032] The electron beams 41 irradiated from the electron irradiation device 40 in parallel to one another, are applied straight to the base 2 being an object of irradiation, and penetrate through the bottom portion 2C. As a result of interposing the electron beam-shielding jig 50, the bottom portion 2C of the base 2 is cross-linked. On the other hand, the sidewall portion 2A and the terminal strip retention parts 2D, 2E are not cross-linked due to the fact that the electron beams 41 are blocked. Generally, a crystalline thermoplastic resin contains non-crystalline parts depending upon the degree of crystallinity. When the molded article (base 2) is irradiated with the electron beams 41, the non-crystalline parts in the molded article are cross-linked resulting in formation of three-dimensional network structure.

[0033] A crosslinking accelerator and an antioxidant are added to the mentioned molded article resin material, in addition to the typical materials composing a resin such as a base resin, reinforcing material, inorganic filler, flame-retardant material, flame-retardant assistant.

[0034] Although the non-crystalline parts are cross-linked by irradiation of the electron beams 41, a problem still exists in that electrons remain in the internal part of the molded article, if strength of the electron beams 41 is small and the electron beams 41 do not penetrate through the molded article. It is therefore desirable that the electron beams 41 are strong enough to get through the molded article.

[0035] An acceleration voltage of the electron irradiation is preferably not less than 2MV on conditions that the electron beams penetrate through a plate of 2mm in thickness of the bottom portion 2C of the base 2, as well as provides a cross-link. However, an optimum acceleration voltage thereof is in the range of 3 to 5MV so as not to leave any irradiation electron beam in the material as a space charge.

[0036] From a viewpoint of not remaining any electron, it is preferable that the inter-phase walls 2B are not irradiated with the electron beams except the thin retention holder bearing 2F. That is, as the electron beam-shielding jigs 55, 56 (Figs. 8, 9), it is preferable that a jig configured to shield the entire inter-phase wall portions 2B, or the inter-phase wall portions 2B except for the retention holder bearing 2F parts, is used.

[0037] When occurring any over-current under the state of a closed circuit as shown in Fig. 4, the over-current detector 8 detects the over-current and transmits a trip command to the open/close mechanism 7. Thus, the open/close mechanism 7 turns the retention holder 6 counterclockwise in Figs. 2 and 4 due to a charged energy of a toggle link mechanism. Further, the moving contact 5 also turns in the same direction as the retention holder 6 following the retention holder 6, and the contact portions 5A and 10A come to be separated, whereby arc is generated between the contact portions 5A and 10A. This arc is electromagnetically attracted to the arc-extinguishing device 9, and the arc is extinguished. In addition, when the over-current is exceedingly large, the contact portions 5A and 10A are separated due to an electromagnetic repulsion before separation of the open/close mechanism 7. A region considerably affected thermally by the arc at the time of generation of arc, is the region 2G (Fig. 5) where the arc-extinguishing device 9 and the contact portions 5A, 10A are located above. Moreover, a large force acts on the region 2G with the support 11 for the base side contact 10 on which the contact portion 10A is provided, the support portion for the frame 7A of the open/close mechanism 7, and the support portion for the rotary shaft 6B of the retention holder 6.

[0038] As described above, in the invention, an insulating base 2 whose main resin is a crystalline thermoplastic resin and which is irradiated with the electron beams after molding is used. As a result, it becomes possible to obtain the base 2 which is superior in heat resistance and arc resistance while performing such advantages as micro-fabrication and recycle of a sprue, runner and the like incidental to the thermoplastic resin. Furthermore, it was possible to obtain the base 2 in which there is less fusion or heat deformation and which is excellent in creep-resistant characteristic even if the base is subject to in a heat history at a high temperature, thereby not negatively affecting on the contact pressure between the contact portions 5A and 10A. Additionally, the retention holder bearing 2F is also irradiated with the electron beams, thus being excellent in heat resistance and over-travel characteristic between the contact portions.

[0039] Further, when the molded article contains 60-200 weight parts of reinforcing material in a ratio of 100 weight parts of resin component, occurrence of fusion or heat deformation of the base 2 is less, and the base 2 is superior in creep-resistant characteristic and in strength. As a result, reduction in contact pressure is especially less. In this manner, it is very useful to apply a structural material containing a large amount of reinforcing materials to the base 2, which

[0040] Furthermore, the bottom portion 2C of the base 2 is cross-linked, and the sidewall portion 2A is shielded from the electron beams not to be cross-linked. Therefore, there is less fusion or heat deformation at the bottom portion 2C of the base 2, which is prone to be heated to a high temperature by interrupting any overload on the circuit breaker, resulting in superior creep-proof characteristic. On the other hand, if the sidewall portion is reduced in impact resistant characteristic due to formation of cross-link, the sidewall portion receives an internal pressure that occurs at the time of a short circuit interruption, and may be damaged. In this first embodiment, however, since the base sidewall portion 2A is not cross-linked and superior in impact resistant characteristic, it is now possible to obtain the base 2 possessing both heat resistance and impact resistance.

Example 1.

[0041] Hereinafter, a specific example according to the present invention is described. However, the invention is not limited to this example. In the first example, a circuit breaker for 225A frame is described.

[0042] Fig. 10 is a schematic perspective view showing a die for molding a base for a 225A frame according to the first example of the invention. Referring to Fig. 10, reference numeral 90 designates a die consisting of a stationary die 90A and a moving die 90B, and an internal part of which is formed in conformity with a configuration of the base 2. Numeral 91 designates an injection port (filler hole) for injecting a mixture material therethrough, which is provided through the stationary die 90A. The mixture material was injected through the fill port 91 located at the center of the stationary die 90A, using a 250t injection molding machine on the conditions of a moving die temperature being 85 to 95°C, a stationary die temperature being 85 to 95°C, a cylinder temperature being 230 to 280°C, and a total of pressurizing time and injection time being 10 seconds. In this manner, the base 2 was molded.

[0043] Subsequently, by the method shown in Fig. 6, the foregoing molded article was subject to the electron irradiation at an acceleration voltage of 2MV using NISSIN-HIGH VOLTAGE Electron Irradiation Equipment under the condition that four sidewalls 2A, 2D, 2E (Fig. 5) are covered with the iron electron beam-shielding jig 50 of 4mm in thickness.

[0044] Now, a test method, a determination method, and results thereof are described.

[0045] With the use of the base sample (11) to (15) molded and irradiated with the electron beams by the above-mentioned method, a circuit breaker (225A frame) was assembled. Then an overload interruption test (6 times as large as current rating ($225A \times 6 = 1350A$) was applied) was carried out on the foregoing circuit breaker.

[0046] After the test, in the case where a surface layer of a contact portion of the stationary contact and proximate portions thereto (i.e., a part of the region 2G in Fig. 5 being the support portion 11 for the base side contact 10 and the bottom portion 2C of the base 2 were not fused, it was determined as being acceptable. Whereas in the case of the foregoing portions being fused, it was determined as being rejectable.

[0047] Test results are shown in Tables 1 to 2. A resin in the tables is indicated with the number of parts including both flame retardant and flame retardant assistant. To samples (11) to (15) and comparative examples (21) to (24), 15 parts of dibromopolystyrene were added as a flame retardant, and 5 parts of antimony trioxide were added as a flame retardant assistant. Further, to the samples (11) to (15) and the comparative examples (22), (24), triallyl isocyanurate (abbreviated to TAIC) was added as a crosslinking accelerator, and 2,6-di-t-butyl-P-cresol (abbreviated to BHT) was added as an antioxidant. Furthermore, the samples (14) to (15) and the comparative examples (23), (24), contain 8 parts of ethylene/propylene copolymer acting as a shock absorber.

[0048] In addition, the samples (11) to (15) and the comparative examples (21), (23) were irradiated with the electron beams, while the comparative examples (21), (23) were not irradiated therewith.

(Table 1)

Classifica- tion		Sample			Comparative example	
No		(11)	(12)	(13)	(21)	(22)
P O L Y M E R O C O M P O S I T I O N	Resin	Nylon 6 (55 pts.)	Nylon 6 (55 pts.)	Nylon 6 (55 pts.)	Nylon 6 (55 pts.)	Nylon 6 (55 pts.)
	Reinfor- cing material	glass fiber (33 pts.)	glass fiber (45 pts.)	glass fiber (110 pts.)	glass fiber (45 pts.)	glass fiber (45 pts.)
	Inorganic substance	No	No	No	No	No
	Cross- linking agent	TAIC (0.5pt.)	TAIC (1 pt.)	TAIC (2pts.)	No	TAIC (1 pt.)
	Antioxi- dant	BHT (0.5 pt.)	BHT (0.7 pt.)	BHT (0.7 pt.)	No	BHT (0.7 pt.)
Electron beam		Irradi- ated	Irradi- ated	Irradi- ated	Irradi- ated	Not irradi- ated
Determina- tion		Accept- able	Accept- able	Accept- able	Reject- able	Reject- able

(Table 2)

Classification		Sample		Comparative example	
No		(14)	(15)	(23)	(24)
E N G I N E E R I N G	Resin	Nylon 6 (30 pts.)	Nylon 6 (30 pts.)	Nylon 6 (55 pts.)	Nylon 6 (30 pts.)
	Shock absorber	ethylene/ propylene copolymer (8 pts.)	ethylene/ propylene copolymer (8 pts.)	ethylene/ propylene copolymer (8 pts.)	ethylene/ propylene copolymer (8 pts.)
	Reinforcing material	No	No	No	No
	Inorganic substance	Talc (45 pts.)	Talc (45 pts.)	Talc (45 pts.)	Talc (45 pts.)
	Cross-linking agent	TAIC (0.5 pt.)	TAIC (1 pt.)	No	TAIC (1 pt.)
	Anti-oxidant	BHT (0.5pt.)	BHT (0.7 pt.)	no	BHT (0.7 pt.)
Electron beam		Irradiated	Irradiated	Irradiated	Irradiated
Determination		Acceptable	Acceptable	Rejectable	Rejectable

[0049] As shown above, a circuit breaker with the use of samples (11) to (15) comprised of the base 2 made of Nylon 6 composite material to which a crosslinking accelerator and an antioxidant were added, was not fused at the stationary contact and proximate portions thereof on the base 2 after carrying out the overload interruption test. Accordingly, the foregoing circuit breaker was superior in heat resistance and arc resistance as compared with the circuit breaker using the base to which any electron beam was not applied. Therefore, it is easily presumed that the circuit breaker using the samples (11) to (15) are also superior in over-travel characteristic between the contact points throughout the use for long years.

[0050] In addition, the circuit breaker employing the samples (14) to (15) was also superior in impact resistant characteristic. Particularly in the case of the base 2, which was molded with a die of Fig. 10, a mechanical strength was increased at the bottom 2C of the base 2 due to the cross-link by irradiation with the electron beams (however, the impact resistance was decreased), and the sidewall portion 2A without irradiation with the electron beams was superior in impact resistance. Accordingly, the foregoing circuit breaker was a quite satisfiable one sufficiently resistant to any internal pressure elevation generated accompanying the occurrence of arc.

[0051] Whereas, the comparative examples (22), (24), which were not irradiated with any electron beam, were inferior to the foregoing samples (14) to (15) in heat resistance characteristic.

Embodiment 2.

[0052] Hereinafter a second preferred embodiment according to this invention is described. Fig. 11 is a view showing an exterior appearance of a circuit breaker according to a second preferred embodiment of the invention. Fig. 12 is a partially cutaway view for explaining the circuit breaker of Fig. 11.

[0053] In the drawings, reference numeral 20 designates an insulating housing consisting of a base 21 and a cover 22, which are formed of the same material as the base 2 described in the foregoing first embodiment and the first example. The base 21 is formed by integral molding of a side face part (layout section) 21A making up one side face of the circuit breaker, and a wall part 21B that intersects perpendicularly with the side face part 21A from a peripheral edge of the side face part 21A. Inside of the side face part 21, an arc-extinguishing device 38 and a stationary contact 23 is disposed along a turning plane of a moving contact 25. The cover 22 is formed into a flat plate shape, and is disposed opposite to the side face part 21A of the base 21 to form the other side face of the circuit breaker. This cover 22 is secured to the base 21 with a screw or rivet.

[0054] In addition, the side face part 21A of the base 21 and the cover 22 are irradiated with electron beams in the same manner as in the foregoing first embodiment and example. When the electron beam-shielding jig 50 is used as shown in Fig. 6 and the tubular wall part 21B is not irradiated with any electron beam at all, at the time of applying the electron beams to the base 21, portions coming in contact with the cover 22 do not become too hard. Accordingly, crack or chip is difficult to occur. On the other hand, from the viewpoint of working efficiency of electron irradiation, it is preferable that the electron beam-shielding jig 50 is not used.

[0055] The interruption circuit is provided with a stationary contact 23, a stationary contact point 24 fixed to the stationary contact 23, and a moving contact 25 having a moving contact portion 25a that performs contact/separate operation with respect to the stationary contact 24. Numeral 26 designates an arm for integrally supporting the moving contact 25 (i.e., holding member for turnably holding the moving contact 25). The arm 26 is formed with a U-shaped groove 26a, a stopper engaging part 26b, and a slot 26c with which a shaft 27 engages.

[0056] Numeral 27 designates a shaft acting as a rotational center of the arm 26 (holder) and the moving contact 25, and this shaft 27 is supported in the insulating housing 20. Numeral 28 designates a main spring provided in a tensioned manner giving an impetus in such a direction as to separate at all times the moving contact 25 from the stationary contact 24. Numeral 29 designates a handle, which is formed of a synthetic resin and allows an open/close operation from outside. Numeral 30 designates a reset spring giving an impetus counterclockwise to the handle 29. Numeral 31 designates a manipulation link formed by bending a rod material into a U-shape, and one end of the manipulation link 31 is engaged with the handle 29, and the other end thereof is engaged with a link engagement groove 32a of a latch 32. Furthermore, the handle 29 is constituted of a handgrip 29b, which protrudes outside the insulating housing 20, and a protrusion 29c, which connects the manipulation link 31.

[0057] Numeral 32 is a latch pivotally mounted on the shaft 27. This latch 32 is provided with a link engaging groove 32a for engagement with the other end of the manipulation link 31, a trigger finger 32b for receiving a pressure provided by a rod 37 of an electromagnetic trip section 34, and a trigger member 32c for receiving a force in a direction of releasing the engagement between the manipulation link 31 and the link engaging groove 32a by the pressure due to flexure of a bimetal 33. Further, between the arm 26 and the latch 32, a return spring 32d is disposed in a compressed manner. This return spring 32d gives an impetus to the latch 32 counterclockwise with respect to the arm 26 at all times. The other end of the manipulation link 31, which is fitted in the U-shaped groove 26a, is engaged with the link engaging groove 32a of the latch 32 due to a spring force provided by the spring 32d, thereby achieving a locking state. Then, the moving contact portion 25a comes elastically in contact with the stationary contact 24 resulting in formation of an interruption circuit (in the state of Fig. 12).

[0058] In this manner, the above-mentioned arm 26, main spring 28, handle 29, reset spring 30, manipulation link 31, and latch 32 are formed into an open/close mechanism.

[0059] Numeral 33 designates a bimetal, which is heated and flexed rightward in Fig. 12 in response to a current applied. Numeral 34 designates an electromagnetic trip device including a plunger 36 driven by an electromagnetic force due to application of a current to the electromagnet 35 and a rod 37 protruding in the left direction of Fig. 12 by an attractive operation of this plunger 36. The bimetal 33 and the electromagnetic trip device 34 are formed into an over-current trip device. Numeral 38 designates an arc-extinguishing device. Numeral 39 designates an arc-extinguishing plate of the arc-extinguishing device 38. Numeral 40 designates an arc generation chamber that includes the mentioned stationary contact 24 and moving contact 25, and this arc generation chamber 40 is filled with arc generated at the time of separation of the moving contact 25. Numeral 41 designates an arc runner for inducing the arc toward the arc-extinguishing device 38.

[0060] In the circuit breaker of above construction, when a short-circuit current flows to a cable way, the electromagnet 35 of the electromagnetic trip device 34 detects the short circuit and starts its operation, thereby the plunger 36 is attracted, and the rod 37 interlocking with the plunger 36 moves leftward. Then, the trigger member 32b is pressed by the rod 37, and the latch 32 turns clockwise against the spring force of the return spring 32d. The other end of the

manipulation link 31, which has been fitted in the locked state by the link engaging groove 32a in the U-shaped groove 26a, comes to be free with respect to the arm 26 when the latch 32 turns clockwise. Therefore, the arm 26 is forced to turn clockwise about the shaft 27 by a spring force provided by the main spring 28 acting as an opening mechanism to perform a trip operation. In this manner, the moving contact 25 separates at a high speed and performs an interruption operation.

[0061] Now, parts of the base 21 on which stress acts from the accessories located in the base 21, for example, a protrusion 21a integrally provided at the base 21, a handle shaft bearing 21b, an arm shaft bearing 21c, and an electromagnetic trip fixing part 21d are described.

[0062] The protrusion 21a is provided extendedly so as to support one end of the main spring 28, and the force provided by the main spring 28 acts on the protrusion 21a. The handle shaft bearing 21b is provided so as to pivotally mount the rotary shaft of the handle 29 thereon, and the force from this rotary shaft acts on the handle shaft bearing 21b. The arm shaft bearing 21c is provided so as to pivotally mount the rotary shaft 27 of the arm 26 and the moving contact 25 thereon, and the force from the rotary shaft 27 acts on the arm shaft bearing 21c. The electromagnetic trip fixing part 21d is in the form of a rib, which is provided so as to position the electromagnetic trip device 34 at the base 21. The force from the moving contact 25 acts on the electromagnetic trip fixing part 21d via the stationary contact 23 and the electromagnetic trip device 34.

[0063] As described above, since the side face part 21A (layout section) of the base 21 is irradiated with the electron beams, it becomes possible to secure such advantages as micro-fabrication properties incidental to the thermoplastic resin or recycling properties of sprue, runner and the like. Further advantages of improving heat resistance and arc resistance are assured. Furthermore, since the cover 22 is also irradiated with the electron beams, heat resistance and arc resistance are also improved.

[0064] Additionally, in the circuit breaker in which the arm 26, the stationary contact 23 or the arc-extinguishing device 38 are disposed along the turning plane of the moving contact 25 as is arranged in the second embodiment, interruption capacity may be small and an arc energy may be small at the time of interruption as compared with the circuit breaker in which the retention holder, the other contact point and the arc-extinguishing device are disposed on the bottom of the base as is arranged in the foregoing first embodiment. Accordingly, the insulating molded article such as the base 21 and cover 22 tends to be located more proximate to the arc.

[0065] The side face part 21A of the base 21 and the cover 22 are irradiated with the electron beams, thereby improving mechanical strength, heat resistance, and arc resistant characteristic. As a result, it becomes possible to obtain a circuit breaker in which energy of the arc is small, and which has a sufficient resistance to a heat generation due to the arc rather than to a pressure elevation in an internal part due to a strong pressure caused by arc generation.

[0066] In addition, since heat resistance and arc resistance are improved, the arc-extinguishing device 38 can be constructed just by fitting the arc-extinguishing plate 39 directly into the grooves of the base 21 and cover 22 and any arc-extinguishing sidewall is not required to secure the arc-extinguishing plate 39. As a result, not only number of parts can be reduced but also the arc-extinguishing plate 39 can be lengthened in widthwise dimension (in the direction of perpendicularly passing through the plane of Fig. 12) of the circuit breaker making it possible to contribute to improvement in arc-extinguishing performance.

[0067] Furthermore, the protrusion 21a, the handle shaft bearing 21b, the arm shaft bearing 21c and the electromagnetic trip fixing part 21d are also improved in mechanical strength due to the electron beam irradiation, thereby making it possible to cover the disadvantages of thermoplastic resin, particularly nylon, which is softer and less accurate in positioning than in thermosetting resin.

[0068] In addition, in the second embodiment, the circuit breaker in which the base 21 is box-shaped, and the cover 22 is flat plate-shaped, is described. The circuit breaker, however, is not limited to such configuration, and it is preferable that both of the base 21 and cover 22 are box-shaped.

[0069] Further, in the second embodiment, a single electrode circuit breaker is described. However, it is preferable to employ a double electrode circuit breaker in which the two poles are provided in parallel in the direction of thickness of the circuit breaker between the base 21 and the cover 22. In this case, it is preferable that a center base for providing an insulation between the two parallel electrodes is disposed, and further the moving contact 25, the handle 29, the electromagnetic trip device 34 and the like are disposed at this center base. In such an arrangement, it is preferable to employ a center base molded in the same composition as the base in the second embodiment and which is irradiated with electron beams.

Industrial Applicability

[0070] The present invention is applicable to any molded circuit breaker that requires heat resistance, arc resistance and over-travel characteristic, the circuit breaker being mainly composed of a thermoplastic resin, and in which a flash, sprue, runner and the like can be recycled or reused.

Claims

1. A circuit breaker in which detection of over-current causes a moving contact to turn, and arc generated between the moving contact and an other contact opposing to the moving contact, is extinguished by an arc-extinguishing device,
the circuit breaker being **characterized in that** a molded article possessing an insulation performance mainly composed of a crystalline thermoplastic resin, and to which an electron irradiation is applied after molding, is used.
2. The circuit breaker according to claim 1 comprising: an open/close mechanism for opening and closing the moving contact with the other contact through a retention holder that turnably holds the moving contact;
a base for holding the other contact and the arc-extinguishing device and for turnably holding the retention holder; and
a cover for covering the base to form a housing therewith;
wherein the base is formed of the molded article acts.
3. The circuit breaker according to claim 2, wherein the base includes:

a bottom portion holding to the retention holder, the other contact point and the arc-extinguishing device; and
a side wall portion, which is perpendicularly provided intersecting the bottom portion, and defines a boundary between inside and outside of the housing;

wherein the bottom portion of the base is irradiated with electron beams, while the sidewall portion of the base is not irradiated with the electron beams.
4. The circuit breaker according to claim 2, wherein the retention holder, the other contact and the arc-extinguishing device are disposed along a section of the base defining a turning plane of the moving contact; and the section of the base is irradiated with electron beams.
5. The circuit breaker according to claim 1, wherein the molded article contains 60-200 parts by weight of reinforcing material with respect to 100 parts by weight of resin component.

FIG. 1

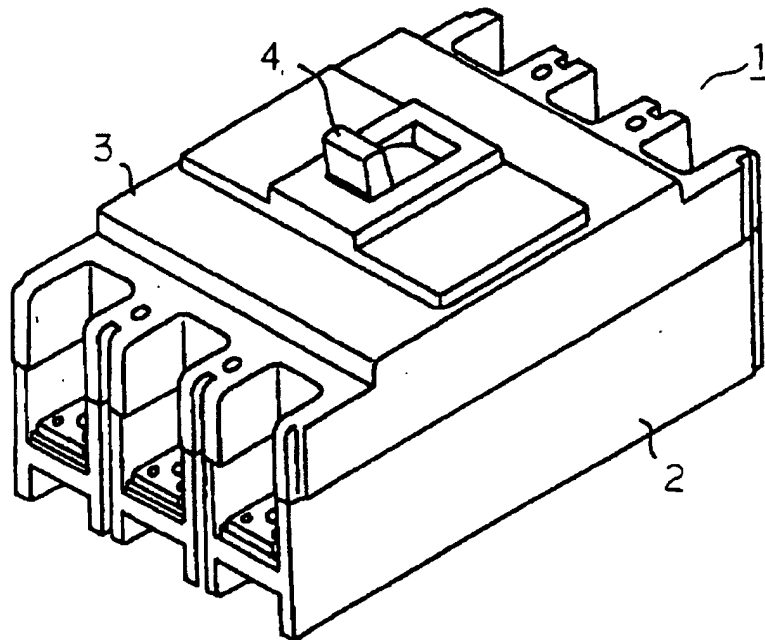


FIG. 2

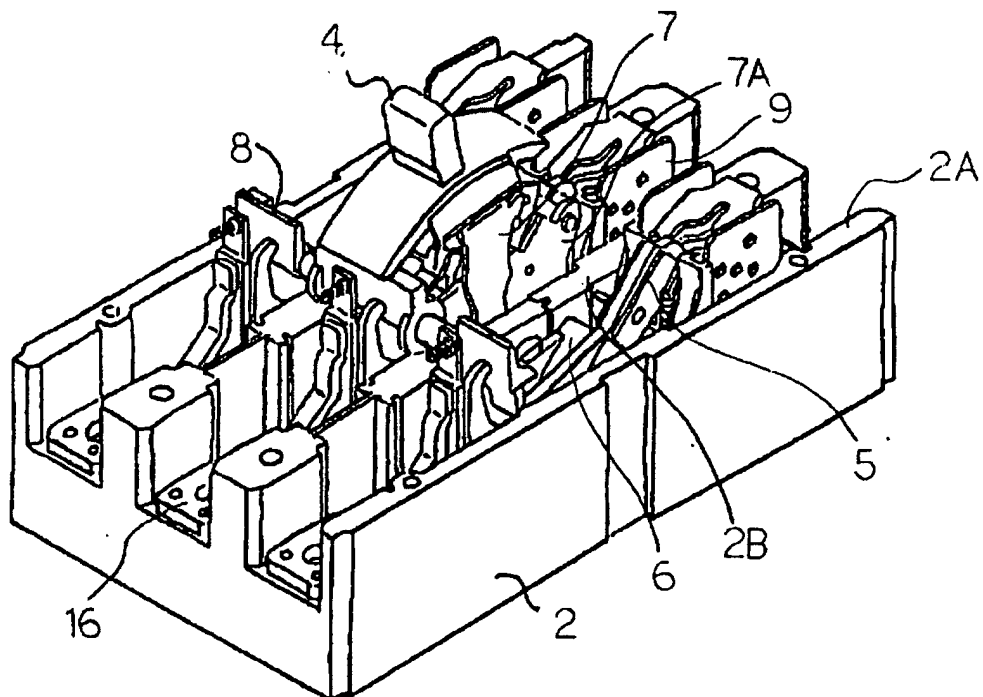


FIG. 3

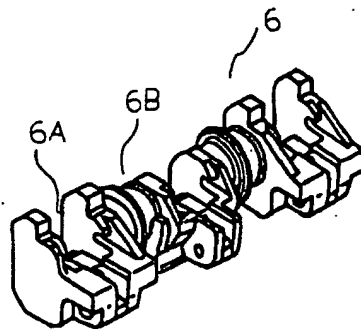


FIG. 4

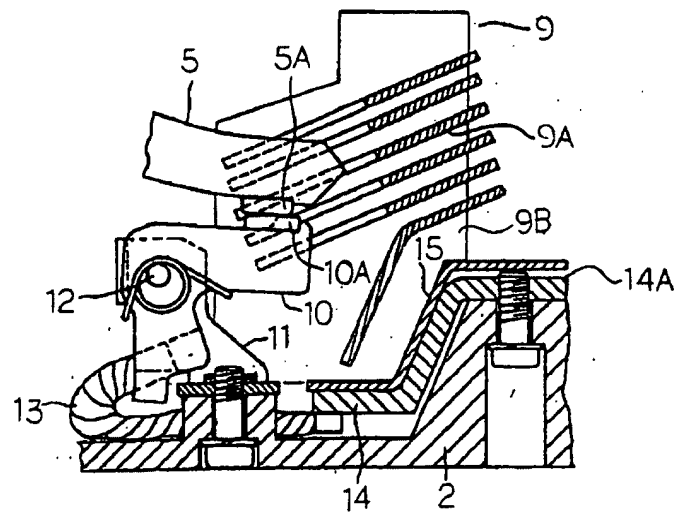


FIG. 5

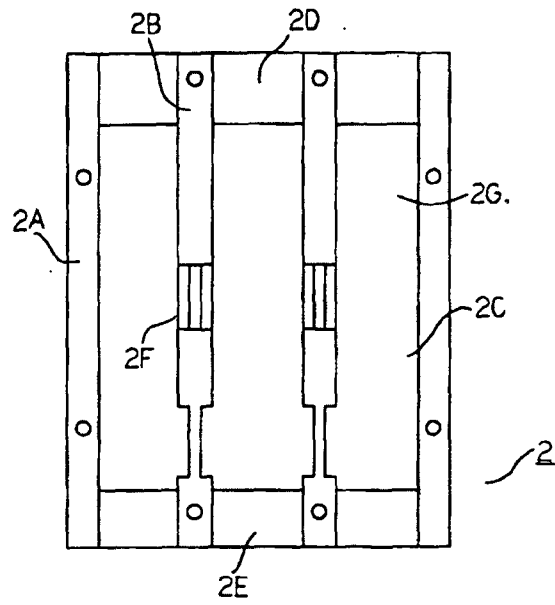


FIG. 6

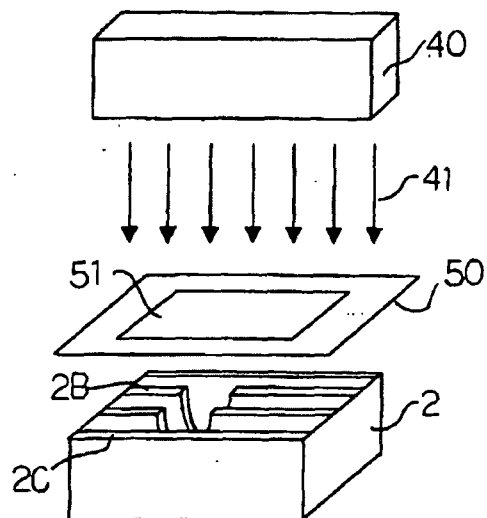


FIG. 7

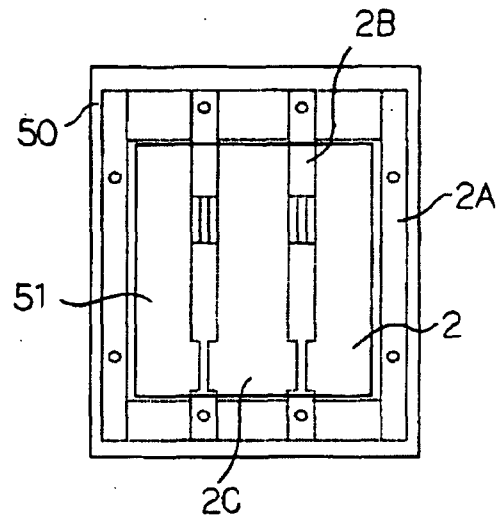


FIG. 8

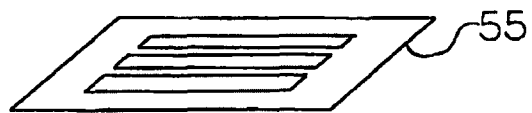


FIG. 9

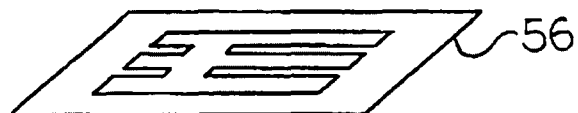


FIG. 10

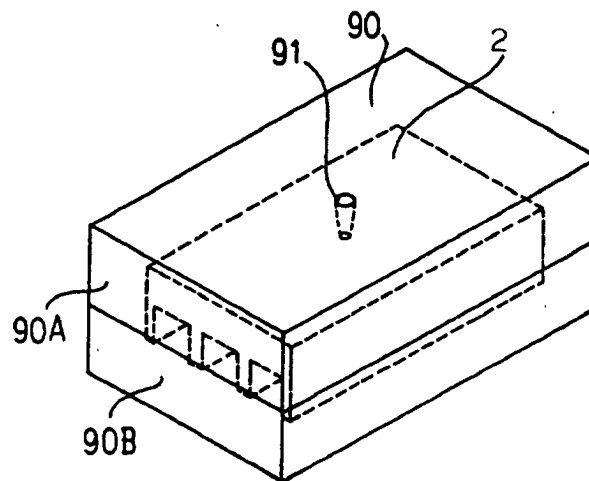


FIG. 11

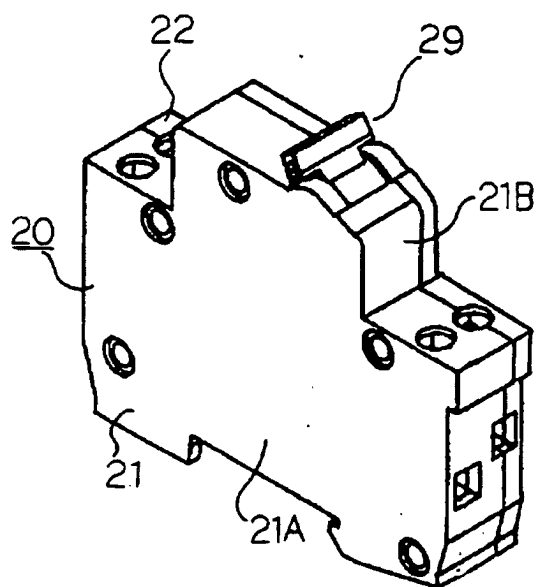
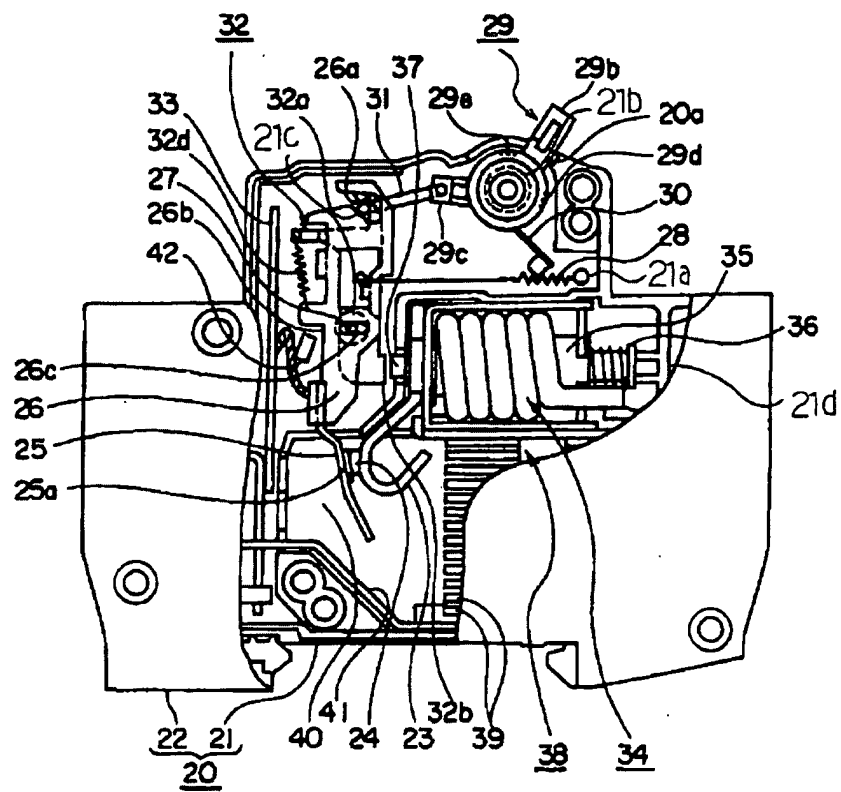


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP01/10134

A. CLASSIFICATION OF SUBJECT MATTER Int. Cl ⁷ H01H73/06, H05K5/02, B29C71/04, H01B3/30		
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. Cl ⁷ H01H69/00-83/22, H05K5/02, B29C71/04, H01B3/30		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1926-1996 Jitsuyo Shinan Toroku Koho 1996-2002 Kokai Jitsuyo Shinan Koho 1971-2002 Toroku Jitsuyo Shinan Koho 1994-2002		
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.
Y A	JP 2901249 B (Idemitsu Kosan Co., Ltd.), 19 March, 1999 (19.03.1999), Column 2, line 10 to Column 3, line 37; Column 8, lines 8 to 45 & US 5286762 A & US 5373031 A	1-2, 5 3-4
Y A	EP 663679 A2 (Schurter AG), 19 July, 1995 (19.07.1995), Column 3 & JP 7-220615 A & CH 689681 A	1-2, 5 3-4
Y A	JP 2001-176372 A (Mitsubishi Electric Corporation), 29 June, 2001 (29.06.2001), Column 1, lines 25 to 28; Column 4, lines 19 to 28 (Family: none)	1-2, 5 3-4
Y A	JP 2001-307612 A (Kawamura Denki Sangyo K.K.), 02 November, 2001 (02.11.2001), Column 2, lines 24 to 33 (Family: none)	1-2, 5 3-4
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* "A" "E" "L" "O" "P"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance earlier document but published on or after the international filing date 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) document referring to an oral disclosure, use, exhibition or other means 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 02 February, 2002 (02.02.02)		Date of mailing of the international search report 19 February, 2002 (19.02.02)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP01/10134

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 6-251688 A (TOSHIBA LIGHTING & TECHNOLOGY CORPORATION), 09 September, 1994 (09.09.1994), Column 1, line 50 to Column 2, line 27 (Family: none)	1-2, 5 3-4
Y A	JP 7-21897 A (Fuji Electric Co., Ltd.), 24 January, 1995 (24.01.1995), Column 2, lines 1 to 10; Column 4, lines 46 to 50 (Family: none)	1-2, 5 3-4
A	JP 8-59862 A (Yamahito KOGURE), 05 March, 1996 (05.03.1996) (Family: none)	1-5
A	JP 54-131689 A (Teijin Limited), 12 January, 1979 (12.01.1979) (Family: none)	1-5

Form PCT/ISA/210 (continuation of second sheet) (July 1992)