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(54) Circuit breaker

(57) A housing of a circuit breaker, which is satisfactory in impact resistance and can be applied to high breaking capacity use, and is satisfactory in flame retardancy and strength properties and exhibits less mottled blooming.

The base of a circuit breaker includes 20 wt% of nylon 66, 9 wt% of nylon 6, 4 wt% of nylon 6T, 42 wt% of a glass fiber, 13 wt% of polybromostyrene, 4 wt% of antimony trioxide, 8 wt% of an ethylene/α-olefin copolymer, and 0.3 wt% of carbon black.

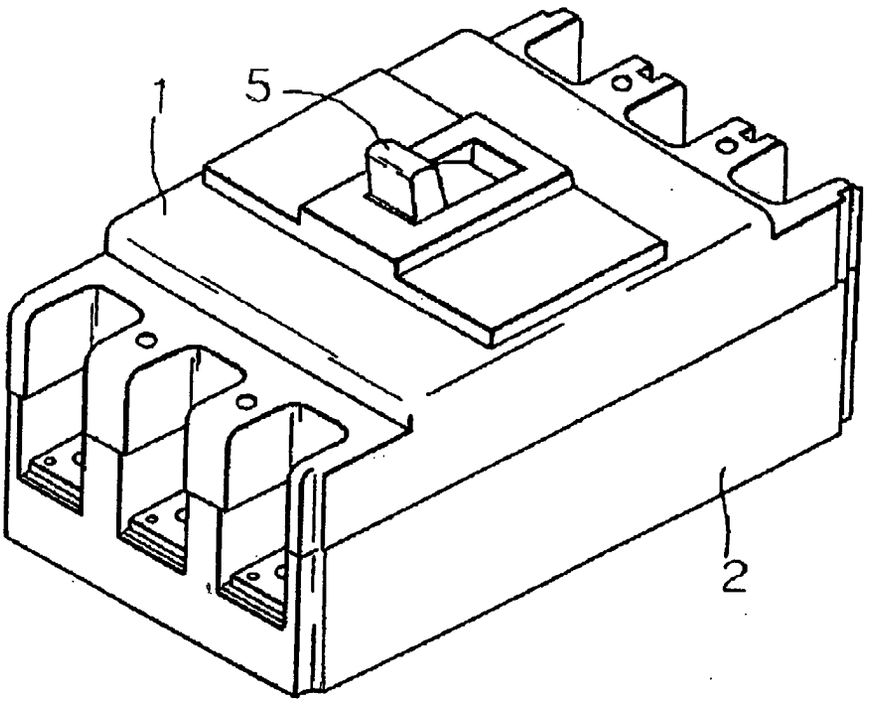

Fig. 1

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to circuit breakers for breaking a circuit upon an overcurrent condition, and specifically, to circuit breakers having a thermoplastic resin housing with satisfactory flame retardancy, impact resistance and strength.

2. Description of the Related Art

[0002] Circuit breakers using molded articles of thermoplastic resins have been recently proposed, since these materials permit molding of minute portions. For example, Japanese Patent Application Laid-open No. 8-171831 discloses a molded article containing nylon 6 and nylon 66 as base resins, such as a molded article containing 35-39 wt% of nylon 6, 8-12 wt% of nylon 66, 1-3 wt% of nylon MXD6, 7-9 wt% of an ethylene/α-olefin copolymer, and 40-45 wt% of a reinforcement. This molded article comprises specific proportions of the elastomer and other components and is therefore suitable as a cover for a circuit breaker with a high breaking capacity, which is resistant to rapidly increasing internal pressure of a housing upon interruption.

[0003] With recent increased requirements to secure the safety of circuit breakers, demands have been made to achieve higher flame retardancy such as flame retardancy satisfying IEC 60947 or UL 746C standards. However, conventional compounds for molded articles of a circuit breaker are still insufficient in flame retardancy, specifically when applied to the base of a circuit breaker.

[0004] The present inventors obtained a molded article with more satisfactory flame retardancy by incorporating about 20 wt% of a flame retardant (including a halogen-based flame retardant and an antimony-based flame retardant aid) into the aforementioned conventional compound for a circuit breaker and molding the resulting compound. However, in the resulting molded article, the housing exhibits a blooming-induced mottled surface, a markedly deteriorated appearance. As a possible solution for avoiding blooming, the compositional ratio of nylon MXD6 may be increased, but several dozen weight percentages of nylon MXD6 is required in this case, and it is speculated that the compositional ratios of the other compounds vary to thereby deteriorate impact resistance and strength properties and that the compositional ratio of nylon MXD6 having an aromatic ring is relatively increased to thereby deteriorate the insulating property after interruption.

[0005] In this connection, the term "blooming" as used herein means that glass fiber and other reinforcements, halogen-based flame retardants, antimony-based flame retardant aids, and elastomers bloom out to the surface of a molded article, and the molded article appears white. Blooming particularly deteriorates the appearance of a molded article of a dark color such as black, and does not significantly deteriorate the appearance of a molded article of a light color such as white.

[0006] A base and cover constituting the housing of a circuit breaker each have a thin wall and include, for example, insert runners, ribs, and phase segregation walls. In molding operation of these parts, particularly when the resin flows from a thin wall region to a thick wall region, the flow of the resin changes from a laminar flow to nearly a turbulent flow, and the distribution of the reinforcement, flame retardant, elastomer and other components contained in the resin becomes uneven. Accordingly, this type of part tends to invite blooming as compared with housings composed of flat walls.

[0007] The present invention has been accomplished to solve the above problems, and it is an object of the invention to provide a circuit breaker having a housing that is satisfactory in impact resistance and can be applied to high breaking capacity use, is satisfactory in flame retardancy and strength properties, and exhibits less mottled blooming.

SUMMARY OF THE INVENTION

[0008] A circuit breaker according to this invention includes a movable contact assembly (3) carrying a movable contact, which movable contact is arranged opposite to a stationary contact; a switching mechanism unit (6) which opens and closes the movable contact assembly (3); and a housing (1,2) which houses the movable contact assembly (3) and switching mechanism unit (6). The switching mechanism unit (6) is actuated upon detection of an overcurrent or leakage current to thereby separate the contacts from each other. At least a part of the housing (1,2) is a molded article comprising a crystalline polyamide resin, an amorphous polyamide resin, an elastomer, a reinforcement, a flame retardant, and a coloring agent for black coloring.

[0009] Preferably, in the above circuit breaker, the molded article may include 15-35 wt% of a crystalline polyamide resin, 2-12 wt% of an amorphous polyamide resin, 3-10 wt% of an elastomer, 30-55 wt% of a reinforcement, and 10-20

wt% of a flame retardant.

[0010] Preferably, the crystalline polyamide is at least one of nylon 66 and nylon 6 or a copolymer compound thereof, the amorphous polyamide is at least one of nylon 6T and nylon 6I or a copolymer compound thereof, the reinforcement is a glass fiber, and the flame retardant is a mixture of a halogen-based flame retardant and an antimony-based flame retardant aid.

[0011] Also the crystalline polyamide may be nylon 66.

[0012] In addition, a part of the housing may be a base constituting the housing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Fig. 1 is a schematic external view of a circuit breaker according to Embodiment 1 of the present invention.
Fig. 2 is a schematic view of the circuit breaker of Fig. 1, in which the cover is removed off.

[0014] Reference numbers in the figures are as follows: 1 cover (housing), 2 base (housing), 3 movable contact assembly, 4 crossbar, 5 handle, 6 switching mechanism unit, 7 overcurrent trip device, 9 trip bar, 11 de-ionizing grid device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] The embodiments of the present invention will be illustrated in further detail below.

Embodiment 1

[0016] Fig. 1 is a schematic external view showing a circuit breaker according to Embodiment 1 of the present invention. Fig. 2 is a schematic view of the circuit breaker of Fig. 1, in which a cover is removed. In Figs. 1 and 2, base 2 is covered with cover 1, and cover 1 is monolithically mounted onto base 2 using mounting screws not shown to thereby form a housing. The composition of the housing will be described later. Movable contact assembly 3 is rotatably held by crossbar 4, a molded article of an insulating resin, and at one end of movable contact assembly 3 a movable contact is arranged opposite a stationary contact not shown in the figure. Handle 5 serve to switch movable contact assembly 3 through crossbar 4 from the outside, and is arranged, at the top end of switching mechanism unit 6 in Fig. 2. Switching mechanism unit 6 has a known toggle link mechanism described in, for example, Japanese Patent Application Laid-open No. 9-161641. An overcurrent trip(release) device 7 (a bimetal device and a magnetic coil) rotates trip bar 9 in the clockwise direction in Fig. 2 upon detection of an overcurrent condition. Deionizing grid device 11 is a conventional device for extinguishing an arc.

[0017] Next, the operations of overcurrent breaking will be illustrated below.

[0018] When the circuit is energized and an overcurrent greater than or equal to a predetermined level occurs, overcurrent trip device 7 actuates trip bar 9 to rotate in the clockwise direction in Fig. 2. The rotation of trip bar 9 unlatches the latch engagement between trip bar 9 and switching mechanism unit 6, and switching mechanism unit 6 actuates movable contact assembly 3 to move in such a direction as to separate the movable contact from the stationary contact (this operation is generally referred to as "tripping"). In the tripping, an arc is generated between the stationary contact and movable contact depending on the magnitude of the overcurrent. This arc permits the periphery of the two contacts and inside the housing to generated decomposed gases, and the pressure inside the housing rises suddenly. The risen pressure impacts cover 1 and base 2 constituting the housing.

[0019] Next, the compositions of cover 1 and base 2 constituting the housing will be described below.

[0020] The housing is a molded article comprising, for example, a crystalline polyamide resin, an amorphous polyamide resin, an elastomer, a reinforcement, a flame retardant, and a coloring agent for black coloring. Preferably, the housing is a molded article comprising 15-35 wt% of at least one of nylon 66, nylon 6 and nylon 46, a blend or a copolymer thereof as the crystalline polyamide resin, 2-12 wt% of nylon 6T and/or nylon 6I or a copolymer thereof as the amorphous polyamide resin, 3-10 wt% of an ethylene/α-olefin copolymer or an ionomer of a polyolefin copolymer as the elastomer, 30-55 wt% of a glass fiber or a ceramic fiber as the reinforcement, 12-20 wt% of a halogen-based flame retardant (e.g., polybromostyrene) and an antimony-based flame retardant aid (e.g., antimony trioxide, antimony pentoxide, and sodium antimonate) as the flame retardant, and 0.1-1.0 wt% and preferably 0.2-0.5 wt% of carbon black as the black coloring agent.

[0021] This molded article has satisfactory impact resistance upon arc-extinguishing equal to that of the molded article described in the conventional technology, has high processing and molding accuracy, and is satisfactory in flame retardancy and strength properties. Additionally, the surface of the molded article exhibits less mottled blooming and

does not gives the impression that the molded article is defective, although it has less luster and appears somewhat white, as compared with molded articles mainly containing luster thermosetting resins. Accordingly, the molded article is suitable as the housing of a circuit breaker. The molded article is preferably used as cover 1 and base 2 as the housing of the circuit breaker, since the insides of these parts have high processing accuracy to thereby yield a minutely molded article.

[0022] Additionally, nylon 6, nylon 66 and nylon 46 have no aromatic ring and are therefore satisfactory in insulating properties after interruption.

[0023] The combined use of nylon 6 and nylon 66 or the use of nylon 6 alone as the crystalline polyamide slows down the rate of crystallization of the resin and invites less blooming, and is preferred specifically as cover 1, since the appearance of cover 1 imparts a strong impression to a viewer, as compared with the use of nylon 66 alone or the combined use of nylon 6 and nylon 66, respectively. In contrast, the use of nylon 66 and/or nylon 46 as the crystalline polyamide yields a high melting point with satisfactory momentary heat resistance and is preferable as base 2.

[0024] The compositional ratios in the molded article are specified for the following reasons.

[0025] If the total amount of nylon 66 and nylon 6 is less than 15 wt%, kneading and molding of the compound is difficult, and if it exceeds 35 wt%, the compositional ratios of the flame retardant, reinforcement and elastomer are relatively decreased and the resulting molded article is low in flame retardancy, strength, or impact resistance. When the compositional ratio of nylon 66 is 18-22 wt%, the resulting molded article is superior in flame retardancy, heat resistance and strength.

[0026] If the total amount of nylon 6T and nylon 6I is less than 2 wt%, the resulting molded article exhibits striking blooming, and if it exceeds 12 wt%, the compositional ratios of the flame retardant, reinforcement and elastomer are relatively decreased and the resulting molded article is low in flame retardancy, strength, or impact resistance.

[0027] If the amount of the ethylene/α-olefin copolymer or the ionomer of polyolefin copolymer is less than 3 wt%, the molded article has low impact resistance, and if it exceeds 10 wt%, the compositional ratios of the flame retardant and reinforcement are relatively decreased and the molded article has low strength or flame retardancy.

[0028] If the amount of the glass fiber is less than 30 wt%, the molded article has deteriorated strength, and if it exceeds 55 wt%, the molded article readily invites blooming, and the kneading and molding of the compound becomes difficult. Additionally, the compositional ratios of the flame retardant, reinforcement and elastomer are relatively decreased and the resulting molded article is low in flame retardancy or impact resistance.

[0029] If the total amount of the halogen-based flame retardant and the antimony-based flame retardant aid is less than 12 wt%, the molded article has insufficient flame retardancy, and, in contrast, if it exceeds 20 wt%, the molded article readily invites blooming and the compositional ratios of the reinforcement and elastomer are relatively decreased and the molded article has deteriorated strength or impact resistance.

EXAMPLE 1

[0030] The present inventors have found a suitable composition for the housing of a circuit breaker as a result of the following tests.

1. Compound

[0031] The following compounds were used in the compositional ratios shown in Table 1.

(1) Polyamide Resin

Nylon 66 and nylon 6 were used as the crystalline polyamide resins, and nylon 6T and nylon 6I were used as the amorphous polyamide resins.

(2) Elastomer

An ethylene/α-olefin copolymer was used as the elastomer.

(3) Reinforcement

Reinforcement is used for improving strength and rigidity and is at least one selected from glass fibers and ceramic fibers. A glass fiber was used in Example 1.

Glass fibers have satisfactory miscibility with the base resins, nylon 6 and nylon 66, and can be homogeneously incorporated into the molded article to avoid the formation of partial weak portions to thereby improve impact resistance. Additionally, glass itself is a material that has satisfactory heat resistance, so that heat resistance of insulating components of the resulting molded article is good, being resistant to explosive gas pressure and heat generated by arcing. The glass fibers are fibrous articles composed of glass materials, and such glass materials include, for example, E-glass, S-glass, D-glass, T-glass or silica glass. Glass fiber products include, for example, continuous fibers, staple fibers (short fibers) or glass wool. Staple fibers are preferred as the reinforcement for use with the nylon family. The glass fibers preferably have a diameter of 6-13 μm and an aspect ratio of equal to or

more than 10, in view of compressive strength. The glass fibers are also preferably subjected to treatment with treatment agents such as silane coupling agents, in view of compressive strength.

(4) Flame Retardant

A mixture of polybromostyrene, a halogen-based flame retardant, with antimony trioxide, an antimony-based flame retardant aid, was used as the flame retardant.

(5) Black Coloring Agent

[0032] Carbon black was used as the black coloring agent.

[0033] In this connection, the compositional ratio of carbon black was as small as 0.3 wt%, and it is indicated as being included in the compositional ratio of nylon 66.

Composition of Samples 01-03

[0034] Sample 01 comprised 20 wt% of nylon 66, 9 wt% of nylon 6, 4 wt% of nylon 6T, 42 wt% of glass fiber, 13 wt% of polybromostyrene, 4 wt% of antimony trioxide, and 8 wt% of ethylene/α-olefin copolymer.

[0035] Sample 02 comprised 20 wt% of nylon 66, 8 wt% of nylon 6T, 2 wt% of nylon 6I, 42 wt% of glass fiber, 16 wt% of polybromostyrene, 4 wt% of antimony trioxide, and 8 wt% of ethylene/α-olefin copolymer.

[0036] Sample 03 comprised 18 wt% of nylon 66, 6 wt% of nylon 6, 5 wt% of nylon 6t, 55 wt% of glass fiber, 10 wt% of polybromostyrene, 3 wt% of antimony trioxide, and 3 wt% of ethylene/α-olefin copolymer.

Compounds of Comparative Examples 1-4

[0037] Comparative Example 1 had a composition according to the conventional molded article described in Japanese Patent Application Laid-open No. 8-171831 and comprised nylon 66, nylon 6, nylon MXD6, a glass fiber and an elastomer.

[0038] Comparative Example 2 had a composition according to the molded article described in Japanese Patent Application laid-open No. 6-299068 and comprised nylon 66, nylon 6, nylon 6T, a glass fiber, and clay of inorganic mineral.

[0039] Comparative Example 3 had a composition according to the molded article described in Japanese Patent Application Laid-open No. 6-299068 and comprised nylon 66, nylon 6T and a glass fiber.

[0040] Comparative Example 4 had a composition according to the present invention, except that no amorphous nylon was contained. This example comprised nylon 66, a glass fiber, an elastomer and a flame retardant.

[0041] Japanese Patent Application laid-open No. 6-299068 neither discloses nor indicates the use of a black coloring agent, but a small amount of carbon black was added in the same manner as in Samples 01 and 02, for comparison of blooming with Samples 01, 02 and 03 according to Example 1.

[0042] Japanese Patent Application Laid-open No. 6-299068 cited in the description of Comparative Examples 2 and 3 simply discloses a composition including polyamide 66 and polyamide 6T and does not discuss blooming. Additionally, the molded article described in this publication cannot be used as the housing for a circuit breaker, since it comprises a large amount of kaolin clay and has low impact resistance.

Table 1

	Nylon 66	Nylon 6	Nylon MXD6	Nylon 6T	Nylon 6I	Glass Fiber	Halogen	Antimony	Elastomer	Clay
Comparative Example 1	37	10	2	0	0	42	0	0	9	0
Comparative Example 2	29	15	0	15	0	15	0	0	0	26
Comparative Example 3	30	16	0	16	0	38	0	0	0	0
Comparative Example 4	30	0	0	0	0	42	16	4	8	0
01	20	9	0	4	0	42	13	4	8	0
02	20	0	0	8	2	42	16	4	8	0
03	18	6	0	5	0	55	10	3	3	0

2. Molding Procedure and Test Specimen

[0043] Each of the test specimens and base 2 of housing was molded by kneading a resin compound using a 250-ton molding machine at 280°C and pouring the kneaded resin compound into a mold at 70°C, and cooling the poured resin compound for 80 seconds.

3. Evaluation Method

(1) Flame Retardancy

[0044] The test was performed according to IEC 60695-2-1/2 Standard.

[0045] Test specimens 70 mm long x 70 mm wide x 1 mm thick were prepared, and the test was performed using a glow wire ignition tester (a product of Suga Test Instruments) with a 960°C glow wire tip temperature. In this procedure, a test specimen was accepted when it satisfied both the following two conditions, and was rejected when it did not satisfy any of the two conditions.

[0046] Condition 1: When the tip of the glow wire is pressed to a sample specimen for 30 seconds, and then separated therefrom, the flame or glow of the test specimen extinguishes within 30 seconds.

[0047] Condition 2: When a thin wrapping paper is placed under the test specimen, it does not ignite.

(2) Impact Resistance

[0048] A circuit breaker was assembled using base 2 (90 mm wide, 130 mm long, and 35 mm high) of a circuit breaker of a 100-ampere frame, and the circuit breaker was twice subjected to a short-circuit breaking test at AC 460 V and 25 kA. After this procedure, the test specimen was accepted when base 2 did not crack.

(3) External Blooming

[0049] The external blooming was quantitatively evaluated by color difference of the appearance of base 2 of the circuit breaker.

[0050] Base 2 of a circuit breaker of a 100-ampere frame was used as a test sample.

[0051] The color at six points of the test sample including three points at each of the side not shown in the figure of base 2 on the power-supply side and of the side 2b (refer to Fig. 2) on the load side was determined using an S&M Color Computer SM-4 (a product of Suga Test Instruments) under the condition of two optical paths and of mask diameter of 10.

[0052] A reference sample was prepared by molding a composition mainly containing a thermosetting resin (25 wt% of an unsaturated polyester, 56 wt% of aluminum hydroxide, 18.7 wt% of a glass fiber, and 0.3 wt% of carbon black) in a mold for base 2 for a 100-ampere frame. The color of the reference sample was determined at six points including three points at each of the side on the power supply side and of side 2b on the load side in the same manner as in the test sample. This reference sample mainly contained a thermosetting resin and had a luster surface and exhibited extremely low blooming.

[0053] The test sample was accepted when the color difference between the mean of measurement values at six points of the reference sample and the mean of measurement values at six points of the test sample was equal to or less than 8.5, and it was rejected when the color difference exceeded 8.5.

[0054] This criteria corresponds to the criteria of visual inspection of the appearance of base 2 of the circuit breaker, in which a test sample is accepted when the area of mottled blooming region is equal to or less than about 5% of the total area.

4. Test Results

[0055] The test results obtained according to the evaluation methods are shown in Table 2.

[0056] Samples 01, 02 and 03 were satisfactory in flame retardancy, impact resistance, strength and blooming properties and were suitable as housings of circuit breakers. Sample 02 was somewhat superior to Sample 01 in heat resistance, and was suitable as base 2. In contrast, Sample 01 was somewhat superior to Sample 03 in blooming property, and was suitable as cover 1. Sample 03 was satisfactory in creep resistance, and was suitable as base 2 of a circuit breaker on which high stress acts at high temperatures.

[0057] Comparative Example 1 was low in flame retardancy, Comparative Examples 2 and 3 were low in flame retardancy and impact resistance, and Comparative Example 4 exhibited blooming-induced mottles on most of its surface and was low in external blooming property. Accordingly, these comparative examples were inferior to Samples

01, 02 and 03 as the housings of circuit breakers.

Table 2

	Flame Retardancy	Impact Resistance	Blooming
Comparative Example 1	rejected	accepted	accepted
Comparative Example 2	rejected	rejected	accepted
Comparative Example 3	rejected	rejected	accepted
Comparative Example 4	accepted	accepted	rejected
01	accepted	accepted	accepted
02	accepted	accepted	accepted
03	accepted	accepted	accepted

ADVANTAGEOUS EFFECT OF THE INVENTION

[0058] The circuit breaker according to the present invention includes a movable contact assembly (3) having a movable contact, which movable contact is arranged opposite to a stationary contact; a switching mechanism unit (6) which opens and closes the movable contact assembly (3); and a housing (1,2) which houses the movable contact assembly (3) and switching mechanism unit (6), and the switching mechanism unit (6) is actuated upon detection of an overcurrent or leakage current to thereby separate the contacts from each other, in which at least a part of the housing is a molded article of a compound comprising a crystalline polyamide resin, an amorphous polyamide resin, an elastomer, a reinforcement, a flame retardant, and a coloring agent for black coloring. The invention therefore can provide a circuit breaker having a housing which is satisfactory in impact resistance and can be applied to breaking of circuits of high breaking capacities, and is excellent in flame retardancy and strength properties and exhibits less mottled blooming.

[0059] When the molded article includes 15-35 wt% of the crystalline polyamide resin, 2-12 wt% of the amorphous polyamide resin, 3-10 wt% of the elastomer, 30-55 wt% of the reinforcement, and 10-20 wt% of the flame retardant, the circuit breaker is satisfactory in impact resistance, as well as in flame retardancy, strength and blooming properties.

[0060] When the crystalline polyamide is at least one of nylon 66 and nylon 6 or a copolymer compound thereof, the amorphous polyamide is at least one of nylon 6T and nylon 6I or a copolymer compound thereof, the reinforcement is a glass fiber, and the flame retardant is a mixture of a halogen-based flame retardant and an antimony-based flame retardant aid, the circuit breaker is satisfactory in impact resistance, as well as in flame retardancy, strength and blooming properties.

[0061] When the crystalline polyamide is nylon 66, nylon 6 or a copolymer compound thereof, the circuit breaker is satisfactory in heat resistance.

[0062] Additionally, when the part of the housing is a base constituting the housing, the resulting circuit breaker is satisfactory in impact resistance, as well as in flame retardancy, strength and blooming properties, with a high level of safety.

Claims

1. A circuit breaker comprising a movable contact assembly (3) carrying a movable contact, said movable contact being arranged opposite to a stationary contact; a switching mechanism unit (6) which opens and closes said movable contact assembly; and a housing (1,2) which houses these movable contact assembly (3) and switching mechanism unit (6), and said switching mechanism unit (6) being actuated upon detection of an overcurrent or leakage current to thereby separate said contacts from each other,

   wherein at least a part of said housing (1,2) is a molded article comprising a crystalline polyamide resin, an amorphous polyamide resin, an elastomer, a reinforcement, a flame retardant and a coloring agent for black coloring.

2. A circuit breaker according to claim 1, wherein said molded article comprises 15-35 wt% of the crystalline polyamide resin, 2-12 wt% of the amorphous polyamide resin, 3-10 wt% of the elastomer, 30-55 wt% of the reinforcement, and 10-20 wt% of the flame retardant.

3. A circuit breaker according to claim 1 or 2, wherein said crystalline polyamide is at least one of nylon 66 and nylon 6 or a copolymer compound thereof, said amorphous polyamide is at least one of nylon 6T and nylon 6I or a copolymer compound thereof, said reinforcement is a glass fiber, and said flame retardant a mixture of a halogen-based flame retardant an antimony-based flame retardant aid.

4. A circuit breaker according to claim 3, wherein said crystalline polyamide is nylon 66.

5. A circuit breaker according to any one of claims 1 to 4, wherein said part of housing (1,2) is a base (2) constituting the housing (1,2).

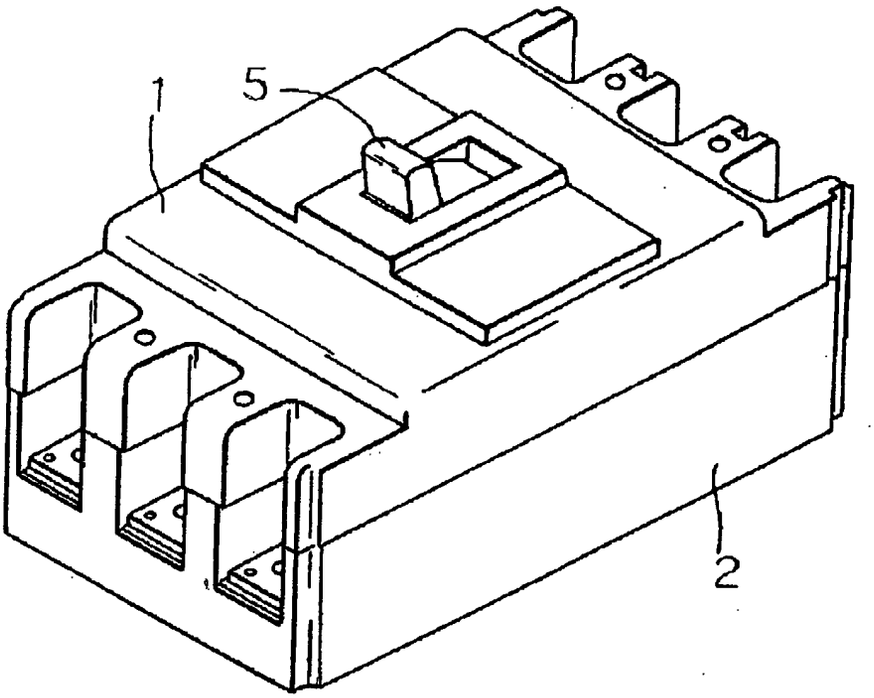

Fig. 1

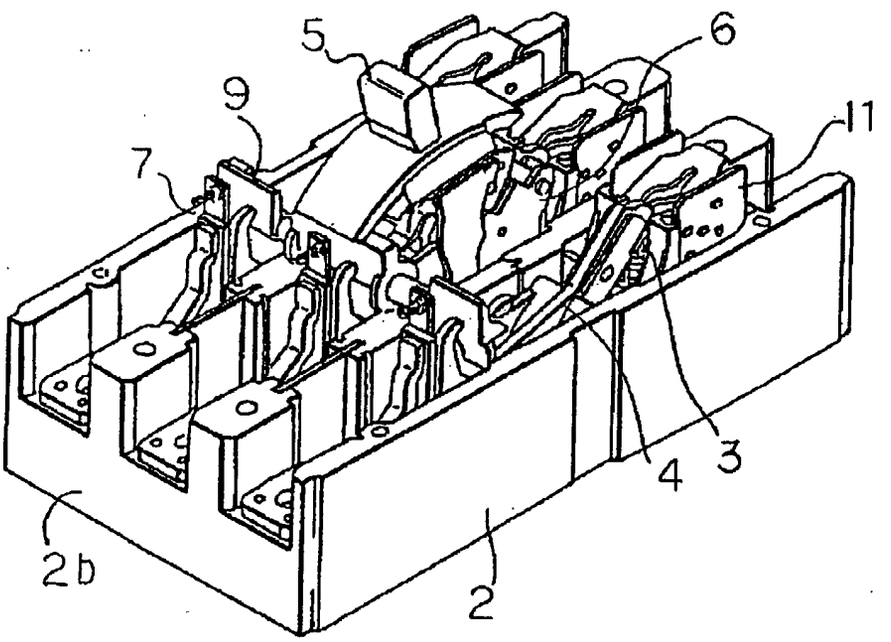

Fig. 2