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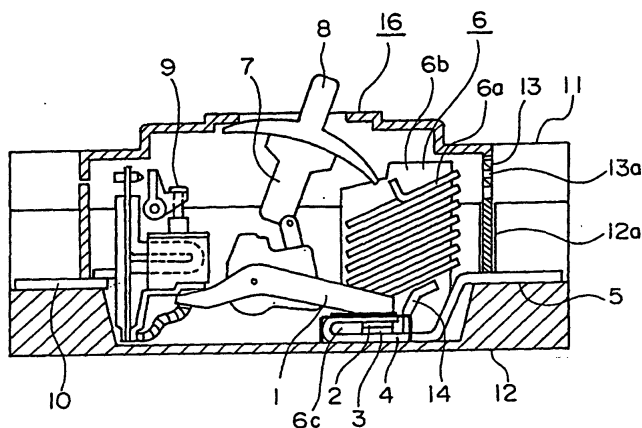
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(54) **CIRCUIT BREAKER**

(57) A circuit breaker includes a stationary contact shoe including a conductor and a stationary contact attached to the conductor; a movable contact shoe carrying a movable contact, which movable contact is separably arranged with respect to the stationary contact and is attached to the movable contact shoe; a switching mechanism for rotating the movable contact; an arc-extinguishing unit for extinguishing an arc generated upon parting of the stationary contact and the movable contact from each other; and a case for housing these com-

ponents. In this circuit breaker, the arc-extinguishing unit includes an arc-extinguishing member so as to cover the entire face of the stationary contact shoe, and the arc-extinguishing member includes a molded arc-extinguishing insulating material mainly containing a non-halogenous flame-retardant resin. The circuit breaker can ensure satisfactory flame retardancy, has satisfactory interruption performances such as overload interruption and short-circuit interruption, and can be miniaturized.

FIG. 1



DescriptionTechnical Field

[0001] The present invention relates to a circuit breaker.

Background Art

[0002] Figs. 1 and 2 are each a sectional view of a circuit breaker, in which Fig. 1 is in its ON position, and Fig. 2 is in its OFF position. Figs. 3A and 3B are a side view and a plan view each showing an enlarged view of the arc-extinguishing member of an arc-extinguishing unit of the circuit breaker. With reference to these figures, movable contact shoe 1 is composed of a conductor such as copper, movable contact 2 is attached to one end of movable contact shoe 1, stationary contact 3 comes into contact with and parts from movable contact 2, stationary contact shoe 4 is composed of a body made of, for example, copper and stationary contact 3 attached to the body, and power-supply-side terminal 5 is formed at the other end of stationary contact shoe 4, and wiring is connected to terminal 5 from an external power source. Arc-extinguishing unit 6 includes plural arc-extinguishing plates (grids) 6a, arc-extinguishing side plates 6b, and arc-extinguishing member 6c shown in Fig. 3. Arc-extinguishing grids 6a are laminated and are arrayed each with spacing, and are composed of a magnetic metal to cool and extinguish an arc generated between movable contact 2 and stationary contact 3. Arc-extinguishing side plates 6b support grids 6a from the both sides. Arc-extinguishing member 6c and arc-extinguishing side plates 6b are each made of an insulating material. Arc-extinguishing member 6c is arranged between movable contact 2 and stationary contact 3 so as to cover the entire face of stationary contact shoe 4 in such a condition that stationary contact 3 is exposed. Switching mechanism 7 rotates movable contact shoe 1 to thereby drive to open and close movable contact shoe 1, and handle 8 is for the manual operation of switching mechanism 7. The circuit breaker also includes trip unit 9 and load-side terminal 10. Cover 11 and base 12 house and affix these components and constitute part of case 16. End plate 13 isolates terminal 5 from the inside of case 16, has exhaust port 13a for exhausting a hot gas formed by arc, and is inserted and mounted into guide groove 12a formed in base 12. Arc runner 14 drives the arc in the direction of terminal 5.

[0003] The operations of the aforementioned circuit breaker will be illustrated below.

[0004] With reference to Fig. 1, when handle 8 is manipulated, switching mechanism 7 trips to rotate movable contact shoe 1 to thereby allow movable contact 2 and stationary contact 3 to come into contact with or part from each other. When terminal 5 and terminal 10 are connected to a power source and a load respectively, and the contacts are brought into contact with each other, power is supplied from the power source to the load. In this condition, movable contact 2 is pressed against stationary contact 3 at a predetermined contact pressure in order to ensure the reliability of energizing. When overcurrents pass through the load side in this state, trip unit 9 detects the overcurrent condition, and switching mechanism 7 trips to allow arc 15 to generate between the two contacts 2 and 3, as shown in Fig. 2.

[0005] In contrast, if large overcurrents pass through the circuit associated with, for example, accidental short circuits, electromagnetic repulsion in an interface between the two contacts 2 and 3 becomes higher and overcomes the contact pressure applied to movable contact 2, and movable contact shoe 1 rotates before the action of trip unit 9 and switching mechanism 7 to invite contacts 2 and 3 to part from each other. The arc voltage increases with an increasing distance (contact parting distance) between stationary contact 3 and movable contact 2, and concurrently, arc 15 is attracted by magnetic power and extends in the direction toward arc-extinguishing unit 6, inviting further increase in arc voltage. Thus, the arc current reaches a current-cut-off to extinguish arc 15 to thereby complete circuit interruption.

[0006] Specifically, each arc-extinguishing grid 6a of arc-extinguishing unit 6 absorbs heat of arc 15 to thereby cool arc 15, and serves to bend arc 15 to increase the contact parting distance between movable contact 2 and stationary contact 3. Additionally, arc-extinguishing member 6c prevents origin shift of arc (arc touch) from movable contact 2 to stationary contact shoe and generates a thermally decomposed gas due to exposure to arc 15 at high temperatures. This thermally decomposed gas serves as an arc-extinguishing gas to cool and blow out arc 15.

[0007] In recent years, circuit breakers themselves have been miniaturized with reducing sizes of switchboards, and plastic materials for use in the circuit breakers require higher levels of flame retardancy.

[0008] Specifically, demands are made to provide products that meet IEC 60947 Standard in Europe or UL 746 Standard in U.S.A. with growing world-wide sales. In Japan, the requirement in flame retardancy of materials that support live parts such as an arc-extinguishing member is relatively low of UL-HB. However, on these materials, IEC 60947 Standard specifies a glow wire ignition (GWI) of 960°C or more and a hot wire ignition (HWI) index of 4 or more in UL 94-V0 or HWI index of 2 or more in UL 94-V2. UL 746 Standard requires V0 or higher in UL 94. Thus, the two standards require the highest level flame retardancy of these materials.

[0009] A possible solution to meet these requirements is the application of flame-retardant resins to arc-extinguishing members. Typical examples of such flame-retardant resins are halogen-containing flame-retardant resins which include a compound of a halogen such as bromine, which produces effects even in a small amount.

[0010] However, the halogen-containing flame-retardant resin markedly corrodes a metal to cause electrode contact failure, and the circuit cannot be energized after repeated interruption. This is probably because a thermally decomposed gas generated from the halogen-containing flame-retardant resin by exposure to an arc contains an active component to the metal. Particularly, a flame-retardant resin containing a halogen compound is poor in arc-extinguishing capability and is deteriorated in interruption (shutdown) performance to thereby fail to interrupt the circuit. This is probably because a decomposed gas which becomes plasma by arc at high temperature (7000°C to 20000°C) contains halogen ions. Alternatively, the distance between the electrodes must be increased to ensure interruption, preventing miniaturization of the circuit breaker (switch breaker).

[0011] Development of non-halogenous flame-retardant resins has been growing in recent years. Known non-halogenous flame-retardant resins include flame-retardant resins containing a phosphorus compound, a silicone resin or an inorganic flame retarder such as aluminium hydroxide, and aromatic resins that have flame retardancy as intact, such as poly(phenylene sulfide).

[0012] Such phosphorus-compound flame retarders are generally difficult to use. Additionally, flame retarders using red phosphor corrode metals more severely than halogen flame retarders, and the circuit cannot be energized after repeated interruption, due to electrode contact failure.

[0013] In the flame-retardant resins each containing a silicone resin flame retarder or an inorganic flame retarder, an insulating ceramic such as a metal oxide or silicon oxide is generated in a plasma field of the thermally decomposed gas and deposits on electrode contacts and contaminates the electrode surfaces to thereby invite contact failure. Thus, the circuit cannot be energized after repeated interruption. In addition, the resins containing an inorganic flame retarder must contain large amounts of the inorganic flame retarder in order to exhibit flame retardancy. However, conventional inorganic flame retarders such as aluminium hydroxide and magnesium hydroxide have a too low thermal decomposition temperature to be kneaded into a thermally stable high melting thermoplastic resin, and the resulting resin cannot significantly contain large amounts of the inorganic flame retarder and cannot sufficiently exhibit flame retardancy. Alternatively, even if such an inorganic flame retarder is contained in large amounts in a low melting thermoplastic resin, the resulting arc-extinguishing member has decreased mechanical strengths.

[0014] The aromatic resin that exhibits flame retardancy as intact, such as poly(phenylene sulfide), has a high carbon content in the polymer molecule and tends to have deteriorated interruption performance. Thus, the distance between the arc and stationary contact shoe must be increased to ensure sufficient interruption performance, preventing miniaturization of the circuit breaker.

[0015] Under these circumstances, an object of the present invention is to provide a circuit breaker that has satisfactory flame retardancy and interruption performance and that can be miniaturized, by preventing conduction failure due to corrosion or contamination of electrode contacts caused by imparting of flame retardancy, or by preventing deterioration in mechanical strengths and in insulation.

DISCLOSURE OF THE INVENTION

[0016] Specifically, the present invention provides, in an aspect, a circuit breaker which includes a stationary contact shoe including a conductor and a stationary contact attached to the conductor; a movable contact shoe carrying a movable contact, the movable contact being separably arranged with respect to the stationary contact and being attached to the movable contact shoe; a switching mechanism for rotating the movable contact; an arc-extinguishing unit for extinguishing an arc generated upon parting of the stationary contact and the movable contact from each other; and a case for housing these components. In this circuit breaker, the arc-extinguishing unit includes an arc-extinguishing member so as to cover the entire face of the stationary contact shoe, and the arc-extinguishing member includes a molded arc-extinguishing insulating material mainly containing a non-halogenous flame-retardant resin.

[0017] In the circuit breaker, the molded arc-extinguishing insulating material may include an organic triazine compound as a flame retarder.

[0018] The matrix resin of the molded arc-extinguishing insulating material in the circuit breaker may be a polyamide.

[0019] Preferably, the polyamide as the matrix resin of the molded arc-extinguishing insulating material is a non-aromatic polyamide.

[0020] The non-halogenous flame-retardant resin in the circuit breaker may include at least one filler selected from the group consisting of 10% by weight or less of organic fibers relative to the non-halogenous flame-retardant resin, and 15% by weight or less of ceramic whiskers relative to the non-halogenous flame-retardant resin.

[0021] Preferably, the arc-extinguishing member is composed of a laminate including an arc-exposed layer to be exposed to arc, and a backup layer supporting the arc-exposed layer, and the arc-exposed layer is composed of a molded arc-extinguishing insulating material mainly containing a non-halogenous flame-retardant resin, and the backup layer is composed of a flame-retardant resin including at least one selected from the group consisting of glass fibers, inorganic minerals, and ceramic fibers.

[0022] In the aforementioned circuit breaker, part of the backup layer preferably penetrates the arc-exposed layer

at plural points.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

Fig. 1 is a sectional view showing a circuit breaker in an ON condition.

Fig. 2 is a partially sectional view showing the circuit breaker of Fig. 1 in an OFF condition.

Fig. 3A is a side view of an arc-extinguishing member, and Fig. 3B is a plan view of the arc-extinguishing member of Fig. 3A.

Fig. 4 is a perspective view of an arc-extinguishing member.

Fig. 5A is a perspective view showing an embodiment of an arc-extinguishing member of a two-layer structure, and Fig. 5B is a perspective view showing another embodiment of the arc-extinguishing member of a two-layer structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] A circuit breaker according to the invention will be illustrated in further detail with reference to the drawings.

[0025] A feature of the invented circuit breaker is that, in the configuration of principle components illustrated in Figs. 1 to 3A and 3B, arc-extinguishing member 6c comprises a molded arc-extinguishing insulating material mainly containing a non-halogenous flame-retardant resin. Of arc-extinguishing unit 6, arc-extinguishing member 6c is closest to an arc generated between contacts 2 and 3.

[0026] The molded arc-extinguishing insulating material preferably comprises an organic triazine compound as a flame retarder.

[0027] Such organic triazine compounds include, for example, the compounds described in Japanese Unexamined Patent Application Publication No. 53-31759. In preferred compounds, thermally decomposed gases generated from the compounds due to exposure to arc contain neither metal corrosive substance nor metal oxide. Such preferred compounds include, but are not limited to, melamine, ammelide, ammeline, formoguanamine, guanylmelamine, cyanomelamine, arylguanamine, melam, melem, mellon, and other melamine derivatives, melamine compounds, melamine condensates, and other melamines; trimethyl cyanurate, triethyl cyanurate, tri(n-propyl) cyanurate, methyl cyanurate, diethyl cyanurate, and other cyanuric acid compounds, trimethyl isocyanurate, triethyl isocyanurate, tri(n-propyl) isocyanurate, methyl isocyanurate, diethyl isocyanurate, and other isocyanuric acid compounds.

[0028] The content of these organic triazine compounds is preferably from 5% to 20% by weight and more preferably from 10% to 15% by weight relative to a matrix resin described below.

[0029] Matrix resins for use in the molded arc-extinguishing insulating material include, but are not limited to, polyolefins, polyolefin copolymers, polyacetals, polyacetal copolymers, polyamides, and polyamide copolymers as described in, for example, Japanese Unexamined Patent Application Publication No. 7-302535. Among them, preferred matrix resins are such that thermally decomposed gases, which are generated from the resins upon exposure to arc, contain less amounts of components inviting metal corrosion, contamination of electrode contacts, or free carbon and other components deteriorating conduction and arc-extinguishing property. Of these resins, nylon 12, nylon 11, nylon 610, nylon 6, nylon 66, nylon 46, nylon 6T, nylon 9T, and other polyamides are more preferred for their excellent mechanical characteristics and high compatibility with the organic triazine compound, of which nylon 6, nylon 66, nylon 46, and other non-aromatic polyamides are typically preferred, since these non-aromatic polyamides yield less amounts of a surface carbonized layer of the molded arc-extinguishing insulating material upon exposure to arc.

[0030] The non-halogenous flame-retardant resin preferably comprises at least one filler selected from the group consisting of 10% by weight or less of organic fibers and 15% by weight or less of ceramic whiskers, each relative to the non-halogenous flame-retardant resin.

[0031] Such organic fibers for use in the present invention include, but are not limited to, fibers that consume upon combustion, such as ultrahigh molecular weight polyethylene fibers, nylon fibers (polyamide fibers), polyarylate fibers, aramid fibers, poly(p-phenylenebenzobisoxazole) fibers, and phenol fibers. Among them, aramid fibers and poly(p-phenylenebenzobisoxazole) fibers are typically preferred, since they have satisfactory kneading property (miscibility) with the matrix resin, a melting point higher than the molding temperature, an appropriate decomposition temperature and high mechanical characteristics.

[0032] Ceramic whiskers for use in the present invention include, but are not limited to, needle-crystal whiskers having a diameter of several micrometers, such as of alumina, zinc oxide, magnesium hydroxide, silicon nitride, silicon carbide, potassium titanate, aluminium borate, and other metal oxides, hydroxides, nitrides, carbides, or boric acid compounds. Among them, whiskers of magnesium hydroxide and of aluminium borate are preferred, as they do not deteriorate insulating resistance of the molded article, are resistant to arc-induced ionization, and are easily available.

[0033] In general, when a flame-retardant resin containing an organic triazine compound includes a filler such as an inorganic compound or glass fiber, a burnt residue derived from the glass or inorganic compound destroys a char-forming layer that imparts flame retardancy to the organic triazine compound upon combustion. Specifically, flame retardancy is deteriorated by "candle effect" of the burnt residue remained on the surface of the molded article. However, organic fibers or ceramic whiskers are employed in the present invention to avoid these problems, since these substances consume or disappear upon combustion to thereby yield a less amount of burnt residue on the surface of the molded article.

[0034] The molded arc-extinguishing insulating material for use in the present invention can be obtained in the following manner. Initially, a resin pellet containing a flame retarder, or a powdery flame retarder and a neat resin pellet are concurrently introduced into the hopper of an extruder, and a predetermined amount of an organic fiber or ceramic whisker is fed from the side feeder of the extruder into a molten region of the resin to yield pellets of non-halogenous flame-retardant resin, and the resin pellets are molded by a conventional injection molding technique.

[0035] Alternatively, the arc-extinguishing member in the present invention may be composed of a laminate including an arc-exposed layer to be exposed to arc, and a backup layer to support this arc-exposed layer.

[0036] For example, when molded arc-extinguishing insulating material 6a as shown in Fig. 4 is used as the arc-extinguishing member, molded arc-extinguishing insulating material 6a can comprise, for example, arc-exposed layer 6a-1 and backup layer 6a-2, as shown in Fig. 5A. The arc-exposed layer 6a-1 is composed of a molded arc-extinguishing insulating material mainly containing a non-halogenous flame-retardant resin, and the backup layer 6a-2 is composed of a flame-retardant resin containing at least one selected from the group consisting of glass fibers, inorganic minerals, and ceramic fibers. In a preferred embodiment as shown in Fig. 5B, part of the resin constituting backup layer 6a-2 penetrates arc-exposed layer 6a-1 at plural points, for example, in the form of comb. This configuration enhances a bonding force between arc-exposed layer 6a-1 and backup layer 6a-2.

[0037] Fillers for reinforcing the flame-retardant resin contained in backup layer 6a-2 are not specifically limited and can be selected from conventional glass fibers, inorganic minerals and/or ceramic fibers, as far as they do not deteriorate the insulating resistance of the molded article. The content of the filler is preferably from 5% to 50% by weight and more preferably from 15% to 30% by weight relative to a matrix resin mentioned below. According to necessity, an appropriate amount of a halogenous flame retarder can be used in this layer. Backup layer 6a-2 is arranged on the back of arc-exposed layer 6a-1 with respect to arc or is located at a distance from an arc core having a large energy, and is therefore only exposed to relatively weak arc winds turning around. Accordingly, this layer is less thermally decomposed or less forms a carbonized layer by action of arc, and the flame retarder contained in this layer is not specifically limited as far as it exhibits flame retardancy of glow wire ignition of 960°C and of V0 or higher in UL 94 Standard and it does not deteriorate the mechanical strengths of the backup layer.

[0038] Matrix resins for use in backup layer 6a-2 include, but are not limited to, polyolefins, polyacetals, polyamides, aromatic polyamides, aromatic polyesters, aromatic polyethers, aromatic polysulfones, copolymers of these polymers, and other thermoplastic resins; epoxy resins, unsaturated polyester resins, phenol resins, melamine resins, urea resins, allyl resins, and other thermoplastic resins. Among them, thermoplastic resins are preferred for their satisfactory moldability, of which aromatic polyamides are typically preferred, since they have satisfactory heat resistance and impact resistance and have a high compatibility with the resin constituting arc-exposed layer 6a-1.

[0039] In the embodiments shown in Figs. 5A and 5B, the molded arc-extinguishing insulating material composed of arc-exposed layer 6a-1 and backup layer 6a-2 can be integrally molded by, for example, a known two-color injection molding technique. Alternatively, the molded arc-extinguishing insulating material can be prepared by any other technique such as a technique, in which arc-exposed layer 6a-1 and backup layer 6a-2 are separately molded, and the two layers are bonded using, for example, an adhesive to yield the molded arc-extinguishing insulating material.

EXAMPLES

[0040] The present invention will be illustrated in further detail with reference to several examples and comparative examples below, which are not intended to limit the scope of the invention. All percentages are by weight unless otherwise specified.

EXAMPLE 1

[0041] A non-halogenous flame-retardant resin for use in this example was composed of a matrix resin nylon 66 and 10% of cyanomelamine as a flame retarder relative to the matrix resin. Specifically, the non-halogenous flame-retardant resin was prepared by dry-blending a predetermined amount of a cyanomelamine flame retarder (produced by DSM, under the trade name of melapur MC) and a resin pellet (produced by Toyobo Co., Ltd., under the trade name of T-662), and the blend was kneaded in a biaxial extruder. A plate 1.6 mm thick obtained by injection molding was cut into the form of each test piece, and the resulting test pieces were subjected to evaluation of flame retardancy. Separately,

a molded arc-extinguishing insulating material in the shape shown in Fig. 4 having a wall thickness of 1.6 mm was prepared by injection molding and was subjected to a simulated test using an actual device for evaluating interruption performance.

[0042] In flame retardancy tests, test pieces were evaluated according to UL 94 Standard, UL 746 Standard: HWI (hot wire ignition test) and IEC 707 Standard: GWI (glow wire ignition test), respectively using specific testing machines, UL 94 flammability testing machine (produced by Suga Test Instruments), HWI ignitability testing machine (produced by Suga Test Instruments), and GWI flammability testing machine (produced by Suga Test Instruments).

[0043] As interruption performance tests, the following overload test and short-circuit test were performed by using a prototype of a circuit breaker simulating an actual device.

[0044] Overload test: An electric current six times as much as a rated current (e.g., 600 A in a circuit breaker for 100 A circuit) was allowed to pass through a circuit breaker including the arc-extinguishing unit having the above configuration in an ON condition, and movable contact 2 was parted from stationary contact 3 at a contact parting distance L (distance between movable contact 2 and stationary contact 3) of 25 mm. In this procedure, a test piece that successfully interrupted an arc current the predetermined number of times (twelve times) passed the test.

[0045] Short-circuit test: An overcurrent of 50 KA at a voltage from 230 V to 690 V was allowed to pass in an ON condition, and the movable contact shoe was parted to generate an arc current. In this procedure, a test piece that successfully interrupted the arc current the predetermined number of times (three times) and exhibited no damage (specifically, no deficit in the case) passed the test.

[0046] Assuming a circuit breaker of a class of 100 to 250 AF, Overload Test 1, Overload Test 2, and Overload Test 3 were performed at three-phase 720 V/600 A, three-phase 720 V/1050 A, and three-phase 720 V/1500 A, respectively. Short-circuit Test 1, Short-circuit Test 2, and Short-circuit Test 3 were performed at three-phase 500 V/30 KA, 500 V/50 KA, and 440 V/65 KA, respectively.

[0047] The composition of this resin, and the results of the flame retardancy test and interruption performance test are shown in Table 1. The table shows the number of times of successful circuit interruption in the overload test, and show the number of times of successful circuit interruption and the presence or absence of damage.

[0048] The test pieces in this example had V0 in accordance with UL 94 Standard, a HWI index of 4, and GWI of 960°C and were acceptable according to each of the standards for flame retardancy. Regarding interruption performance, the test piece successfully interrupted the circuit the predetermined number of times (twelve times) in Overload Tests 1, 2 and 3, and successfully interrupted the circuit the predetermined number of times (three times) in Short-circuit Tests 1 and 2. However, in Short-circuit Test 3, the test piece successfully interrupted the circuit only twice and part of the case exhibited a crack. This is probably because the arc had a high energy in Short-circuit Test 3, and part of the arc-extinguishing member dropped off by the pressure of arc winds and was involved in an arc field to increase the formation of a thermally decomposed gas to thereby damage the case; and the arc-extinguishing member was chipped in the second short-circuit interruption, and could not generate a sufficient amount of a thermally decomposed gas as to blow out the arc current and could not interrupt the circuit in the third short-circuit operation. When the resin having the composition as in Example 1 is applied to a highly rated circuit breaker having severe interruption requirements, that is, in order to pass Short-circuit Test 3, the gap distance between the normal of the stationary contact and the movable contact constituting the core of the arc, and the face of the arc-extinguishing member to be arced must be increased (i.e., the arc-extinguishing unit must be upsized), or the arc-extinguishing member must be reinforced in order to avoid deficit by the pressure of arc winds.

EXAMPLES 2 TO 5

[0049] In Examples 2 to 5, neat resins of different types of nylons containing neither reinforcement nor flame retarder were used as the matrix resins. Resin pellets and test pieces were prepared in the same manner as in Example 1 except for the type of the matrix resin, and flame retardancy and interruption performance of these were evaluated. The test results are shown in Table 1.

[0050] Used matrix resins were nylon 6 (PA 6; produced by Toyobo Co., Ltd., under the trade name of T-803) in Example 2, nylon 46 (PA 46; produced by DJEP, under the trade name of Stanyl TS-300) in Example 3, nylon 6T (PA 6T; produced by Toyobo Co., Ltd., under the trade name of TY-502 NZ) in Example 4, and nylon 9T (PA 9T; produced by Kuraray Co., Ltd.) in Example 5.

[0051] In Examples 2 and 3, the test pieces successfully interrupted the circuit only twice in Short-circuit Test 3. This is probably because part of a slit member (arc-extinguishing member) was chipped by the arc winds as in Example 1, since the matrix resin was a neat resin containing no reinforcement. However, these test pieces showed satisfactory results in the other short-circuit tests and overload tests. In Examples 4 and 5, the test pieces successfully interrupted the circuit eleven times, slightly less than the predetermined number of times, in overload Test 3. This is probably because the resins contained an aromatic moiety and this component invited carbonization of the surface of the slit member (arc-extinguishing member). However, these test pieces showed satisfactory results in the other overload

tests and short-circuit tests.

EXAMPLES 6 TO 9

[0052] As a reinforcement, resin pellets for use in Examples 6 and 7 contained 5% and 10% of a chopped strand aramid fiber (produced by Teijin Ltd., under the trade name of Technora) relative to a matrix resin, and resin pellets for use in Examples 8 and 9 contained 10% and 15% of an aluminium borate whisker (produced by Shikoku Kasei Kogyo Co., Ltd., under the trade name of Aluborex). These resin pellets contained the non-halogenous flame-retardant resin used in Example 1 as the matrix resin, and were prepared by adding and kneading a predetermined amount of the reinforcement to the matrix resin from the side feeder of a biaxial extruder. Test pieces were then prepared and were subjected to the tests in the same manner as in Example 1. The test results are shown in Table 1.

[0053] As a result, all the test pieces according to these examples passed the flame retardancy tests and interruption performance tests. This is probably because 10% or less of the aramid fiber or 15% or less of the aluminium borate whisker added as the reinforcement improved impact resistance of the arc-extinguishing member, without deteriorating flame retardancy.

COMPARATIVE EXAMPLES 1 AND 2

[0054] In Comparative Examples 1 and 2, a halogenous brominated polystyrene (Br-PS) was used as the flame retarder. The flame-retardant resin for use in Comparative Example 1 contained a matrix resin nylon 66 (PA 66; produced by Toyobo Co., Ltd., under the trade name of T-662), 25% of brominated polystyrene (produced by Tosoh Corp., under the trade name of Flame-cut 210R) and 10% of antimony trioxide (Sb_2O_3) as a flame retardant assistant. The flame-retardant resin for use in Comparative Example 2 was composed of the flame-retardant resin used in Comparative Example 1 and further comprised 30% of a glass fiber.

[0055] These flame-retardant resins containing a halogenous flame retarder, brominated polystyrene, exhibited satisfactory flame retardancy. The test piece according to Comparative Example 2 containing a glass fiber passed UL 94 Standard and GWI Standard, and the test pieces according to Comparative Examples 1 and 2 had a very satisfactory HWI index of 2, as compared with a resin containing cyanomelamine of an index of 4 to 3. However, the test piece according to Comparative Example 1 passed none of the overload tests and short-circuit tests in any test condition. The test piece according to Comparative Example 2 became incapable of conducting after interruption procedures half or less of the required number of times of successful interruption in Short-circuit Test 3 on short-circuit interruption performance and all the tests on overload interruption performance. This is probably because a gas generated upon exposure to arc contained bromine, and the bromine corroded a contact metal to thereby invite incapable conduction in the overload interruption tests; and an arc-extinguishing gas contained bromine ions that prolonged an arc extinguishing time and consumed the grids of the arc-extinguishing unit to thereby deteriorate interruption performance.

Table 1

Number	Resin Composition of Arc-extinguishing Insulating Material			Flame Retardancy		Overload Interruption Performance			Short-circuit Interruption Performance		
	Matrix Resin	Flame retarder	Reinforcement	UL 94	HWI 960°C	Inter-ruption in Overload Test 1	Inter-ruption in Overload Test 2	Inter-ruption in Overload Test 3	Short-circuit Interruption/ Damage Test 1	Short-circuit Interruption/ Damage Test 2	Short-circuit Interruption/ Damage Test 3
Ex. 1	PA 66	cyano-melamine (10%)	none	V0	4 pass	12	12	12	3/absent	3/absent	2/present
Ex. 2	PA 6	cyano-melamine (10%)	none	V0	4 pass	12	12	12	3/absent	3/absent	2/present
Ex. 3	PA 46	cyano-melamine (10%)	none	V0	4 pass	12	12	12	3/absent	3/absent	2/present
Ex. 4	PA 6T	cyano-melamine (10%)	none	V0	4 pass	12	12	11	3/absent	3/absent	3/absent
Ex. 5	PA 9T	cyano-melamine (10%)	none	V0	4 pass	12	12	11	3/absent	3/absent	3/absent
Ex. 6	PA 66	cyano-melamine (10%)	aramid fiber (5%)	V0	4 pass	12	12	12	3/absent	3/absent	3/absent
Ex. 7	PA 66	cyano-melamine (10%)	aramid fiber (10%)	V0	4 pass	12	12	12	3/absent	3/absent	3/absent
Ex. 8	PA 66	cyano-melamine (10%)	aluminum borate whisker (10%)	V0	4 pass	12	12	12	3/absent	3/absent	3/absent
Ex. 9	PA 66	cyano-melamine (10%)	aluminum borate whisker (15%)	V0	3 pass	12	12	12	3/absent	3/absent	3/absent
Com. Ex. 1	PA 66	Br-PS/Sb ₂ O ₃ (25/10%)	none	V0	2 pass	6	5	5	2/present	2/present	1/present
Com. Ex. 2	PA 66	Br-PS/Sb ₂ O ₃ (25/10%)	glass fiber (30%)	V0	2 pass	6	6	5	3/absent	3/absent	2/absent

EXAMPLES 10 TO 14

[0056] In Examples 10 to 14, arc-extinguishing members according to the embodiments shown in Figs. 5A and 5B were subjected to the tests. Molded articles according to Examples 10 to 13 had a simple two-layer structure, as shown in Fig. 5A, obtained by laminating arc-exposed layer 6a-1 containing nylon 66 with cyanomelamine as used in Example 1, and backup layer 6a-2 containing a halogen flame-retardant resin reinforced with an organic compound or a glass fiber indicated in Table 2. These arc-extinguishing members were prepared by a two-color molding technique in which the arc-exposed layer 0.8 mm thick was initially injection-molded and then the backup layer was injection-molded to a total wall thickness of 1.6 mm. The arc-extinguishing member according to Example 14 had a partially penetrating two-layer laminated structure in which part of backup layer resin 6a-2 penetrated the surface of arc-exposed layer 6a-1 to thereby enhance the bonding force between the arc-exposed layer and backup layer, as shown in Fig. 5B. Specifically, part of the backup layer penetrated, in the form of comb in cross section, the arc-exposed layer comprising a non-halogenous flame-retardant resin.

[0057] Backup layer resins used in Examples 10 to 14 were commercially available flame-retardant resins that exhibit V0 in UL 94 Standard and meet the requirements in HWI and GWI. Used backup layer resins were a bromine-containing flame-retardant polyamide 66 (PA 66) containing 25% of a glass fiber (produced by E. I. du Pont de Nemours and Company, under the trade name of Zytel FR50) in Example 10, a bromine-containing flame-retardant polyamide 66 (PA 66) containing 30% of talc (produced by E. I. du Pont de Nemours and Company, under the trade name of Zytel FR70 M30) in Example 11, a bromine-containing flame-retardant polyamide 46 (PA 46) containing 20% of a glass fiber (produced by DJEP, under the trade name of Stanyl TS 250 F40) in Example 12, a bromine-containing flame-retardant polyamide 46 (PA 46) containing 45% of a glass fiber (produced by DJEP, under the trade name of Stanyl TS 250 F90) in Example 13, and the bromine-containing flame-retardant polyamide 66 (PA 66) containing 25% of a glass fiber (produced by E. I. du Pont de Nemours and Company, under the trade name of Zytel FR50) in Example 14 which was the same resin as in Example 10.

[0058] Table 2 shows the evaluation results in interruption performance of Examples 10 to 14. As a result, the arc-extinguishing members according to these examples successfully interrupted the circuit the predetermined number of times in any of the short-circuit tests and overload tests and showed satisfactory interruption performances. This is probably because the arc-exposed layer showed no deficit due to arc winds in the short-circuit tests and the backup layer resin invited less formation of a carbonized layer in the overload tests.

[0059] The arc-extinguishing member according to Example 14 had the backup layer resin exposed in part of the surface of the arc-exposed layer, and there was fear that the exposed resin might be carbonized to thereby deteriorate overload interruption performances. However, the arc-extinguishing member exhibited satisfactory results in any of overload test conditions. This is probably because the surface of arc-extinguishing member was only dotted with a carbonized layer of the exposed resin, and the creepage resistance of the arc-exposed layer resin was maintained, and an electrically continuous pass via the creepage surface of the arc-extinguishing member to the stationary contact shoe was not formed.

[0060] In these examples, the two-color molding technique was employed in bonding of the arc-exposed layer and the backup layer, from the viewpoint of mass-production, but the molding method is not specifically limited to this type, and the two layers can be bonded using, for example, an adhesive according to necessity.

Table 2

Number	Molded arc-extinguishing insulating material			Overload Interruption Performance			Short-circuit Interruption Performance		
	Arced Layer Resin	Backup Layer Resin	Laminate Structure	Interruption in Overload Test 1	Interruption in Overload Test 2	Interruption in Overload Test 3	Short-circuit Interruption/ Damage Test 1	Short-circuit Interruption/ Damage Test 2	Short-circuit Interruption/ Damage Test 3
Ex. 10	PA 66/ cyano- melamine	PA66/Br (glass fiber 25%)	simple two-layer	12	12	12	3/absent	3/absent	3/absent
Ex. 11	PA 66/ cyano- melamine	PA66/Br (talc 30%)	simple two-layer	12	12	12	3/absent	3/absent	3/absent
Ex. 12	PA 66/ cyano- melamine	PA46/Br (glass fiber 20%)	simple two-layer	12	12	12	3/absent	3/absent	3/absent
Ex. 13	PA 66/ cyano- melamine	PA46/Br (glass fiber 45%)	simple two-layer	12	12	12	3/absent	3/absent	3/absent
Ex. 14	PA 66/ cyano- melamine	PA66/Br (glass fiber 25%)	partially penetrating two-layer	12	12	12	3/absent	3/absent	3/absent

[0061] Advantages of the present invention will be described below.

1) A first embodiment of the invented circuit breaker includes a stationary contact shoe including a conductor and a stationary contact attached to the conductor; a movable contact shoe carrying a movable contact, the movable contact being separably arranged with respect to the stationary contact and being attached to the movable contact shoe; a switching mechanism for rotating the movable contact; an arc-extinguishing unit for extinguishing an arc generated upon parting of the stationary contact and the movable contact from each other; and a case for housing these components. In this circuit breaker, the arc-extinguishing unit includes an arc-extinguishing member so as to cover the entire face of the stationary contact shoe, and the arc-extinguishing member includes a molded arc-extinguishing insulating material mainly containing a non-halogenous flame-retardant resin. This circuit breaker can prevent conduction failure due to corrosion or contamination of electrode contacts or can prevent deterioration in mechanical strengths and in insulation to thereby ensure flame retardancy, and can improve interruption performances such as overload interruption or short-circuit interruption.

2) In a second embodiment of the invented circuit breaker, the molded arc-extinguishing insulating material includes an organic triazine compound as a flame retarder. This configuration can ensure flame retardancy and can further improve overload interruption performances and can miniaturize the arc-extinguishing unit, since the resulting arc-extinguishing gas does not contain phosphorus compounds being highly corrosive to metals such as contact metals, and silicon or metal oxides that cause contact failure.

3) In a third embodiment of the invented circuit breaker, the matrix resin of the molded arc-extinguishing insulating material in the circuit breaker is a polyamide. This configuration can control deterioration in insulation due to carbonization of the surface of the molded arc-extinguishing insulating material and can further improve overload interruption performances.

4) In a fourth embodiment of the invented circuit breaker, the polyamide as the matrix resin of the molded arc-extinguishing insulating material is a non-aromatic polyamide. This circuit breaker can further control deterioration in insulation due to carbonization of the surface of the molded arc-extinguishing insulating material and can further improve overload interruption performances and can miniaturize the arc-extinguishing unit.

5) In a fifth embodiment of the invented circuit breaker, the non-halogenous flame-retardant resin includes at least one filler selected from the group consisting of 10% by weight or less of organic fibers and 15% by weight or less of ceramic whiskers, each relative to the non-halogenous flame-retardant resin. This configuration can improve impact resistance of the arc-extinguishing member and can improve short-circuit interruption performances without deterioration of flame retardancy.

6) In a sixth embodiment of the invented circuit breaker, the arc-extinguishing member is composed of a laminate including an arc-exposed layer to be exposed to arc, and a backup layer supporting the arc-exposed layer, and the arc-exposed layer is composed of a molded arc-extinguishing insulating material mainly containing a non-halogenous flame-retardant resin, and the backup layer is composed of a flame-retardant resin containing at least one selected from among glass fibers, inorganic minerals, and ceramic fibers. This configuration can ensure flame retardancy and can improve impact resistance of the arc-extinguishing member to further improve short-circuit interruption performances.

7) A seventh embodiment of the invented circuit breaker, in which part of the backup layer penetrates the arc-exposed layer at plural points, can strengthen bonding between the arc-exposed layer and backup layer of the arc-extinguishing member to thereby further improve short-circuit interruption performances.

[0062] Other embodiments and variations will be obvious to those skilled in the art, and this invention is not to be limited to the specific matters stated above.

Claims

1. A circuit breaker comprising:

a stationary contact shoe including a conductor and a stationary contact attached to said conductor;
 a movable contact shoe carrying a movable contact, said movable contact being separably arranged with respect to said stationary contact and being attached to said movable contact shoe;
 a switching mechanism for rotating said movable contact;
 an arc-extinguishing unit for extinguishing an arc generated upon parting of said stationary contact and said movable contact from each other; and
 a case for housing these components, wherein
 said arc-extinguishing unit comprises an arc-extinguishing member so as to cover the entire face of said stationary contact shoe, and said arc-extinguishing member includes a molded arc-extinguishing insulating material mainly containing a non-halogenous flame-retardant resin.

2. A circuit breaker according to claim 1, wherein said molded arc-extinguishing insulating material comprises an organic triazine compound as a flame retarder.
3. A circuit breaker according to claim 1, wherein the matrix resin of said molded arc-extinguishing insulating material is a polyamide.
4. A circuit breaker according to claim 3, wherein said polyamide as the matrix resin of said molded arc-extinguishing insulating material is a non-aromatic polyamide.
5. A circuit breaker according to claim 1, wherein said non-halogenous flame-retardant resin comprises at least one filler selected from the group consisting of 10% by weight or less of organic fibers relative to said non-halogenous flame-retardant resin, and 15% by weight or less of ceramic whiskers relative to said non-halogenous flame-retardant resin.
6. A circuit breaker according to claim 1, wherein said arc-extinguishing member is composed of a laminate including an arc-exposed layer to be exposed to arc, and a backup layer supporting said arc-exposed layer, said arc-exposed layer is composed of a molded arc-extinguishing insulating material mainly containing a non-halogenous flame-retardant resin, and said backup layer is composed of a flame-retardant resin containing at least one selected from the group consisting of glass fibers, inorganic minerals, and ceramic fibers.
7. A circuit breaker according to claim 6, wherein part of said backup layer penetrates said arc-exposed layer at plural points.

FIG. 1

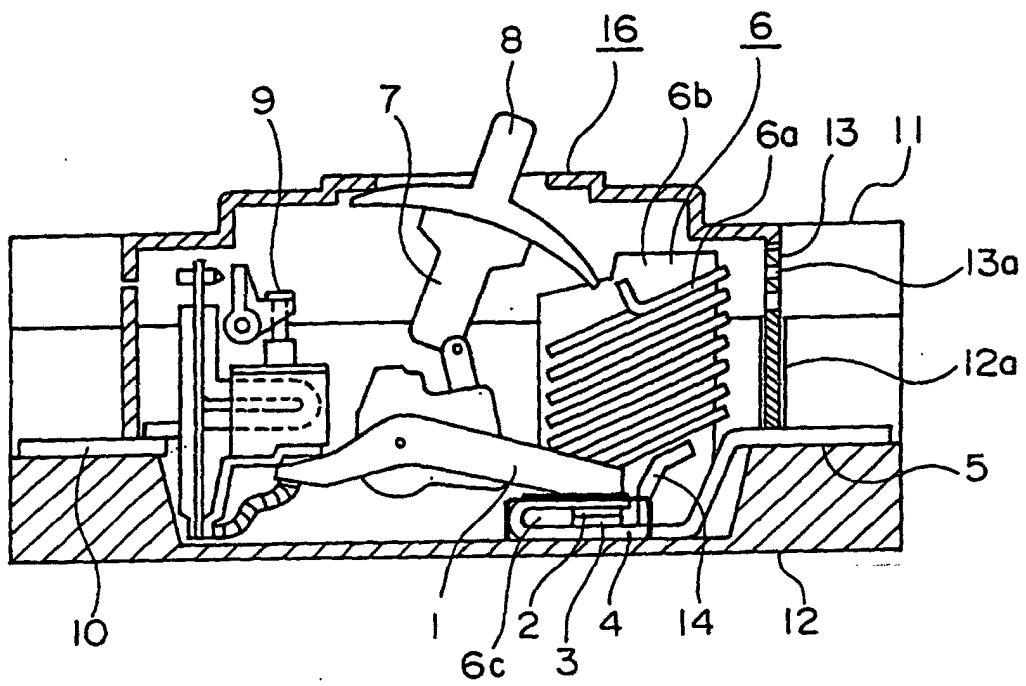


FIG. 2

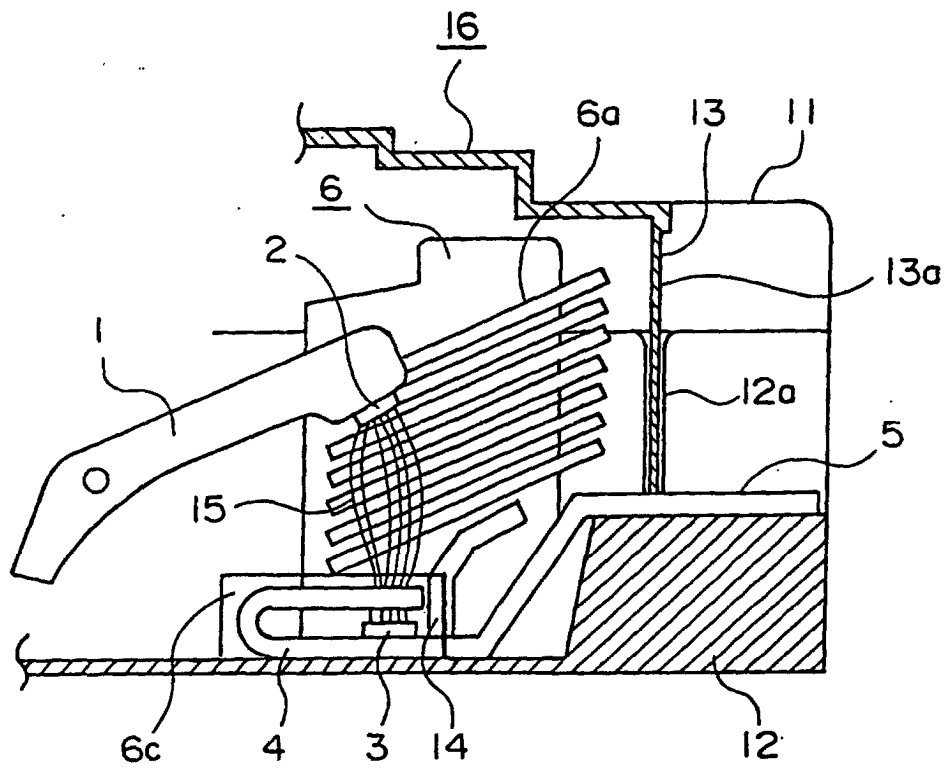


FIG. 3

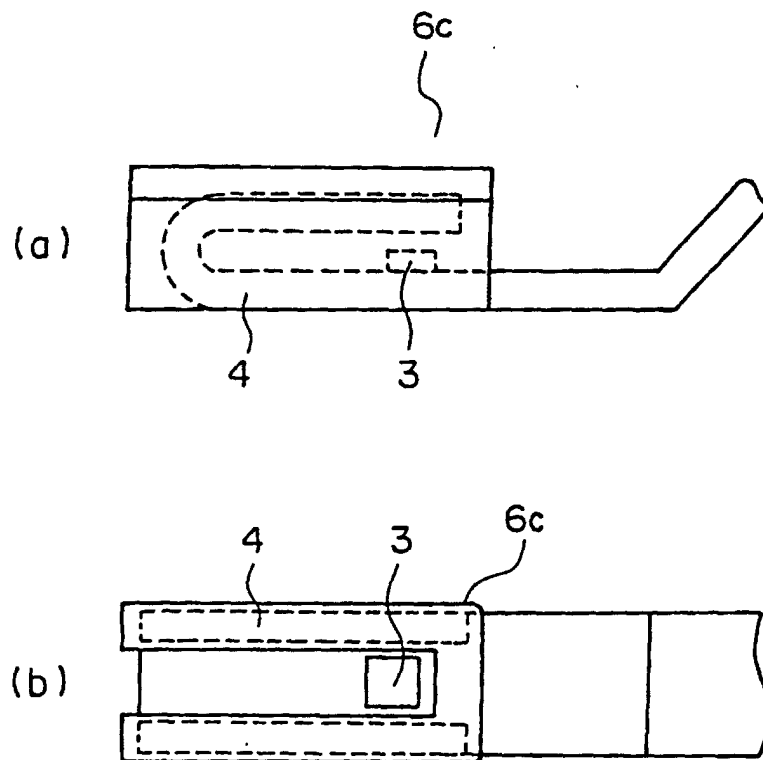


FIG. 4

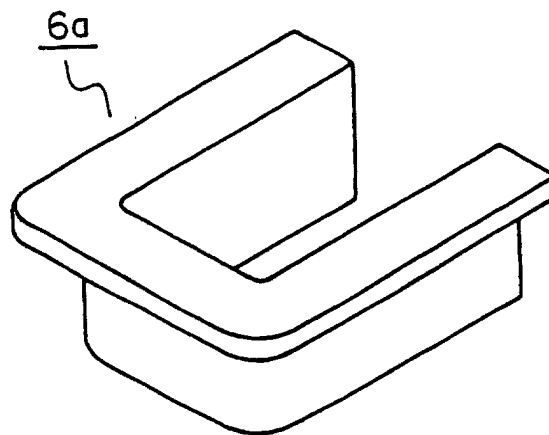
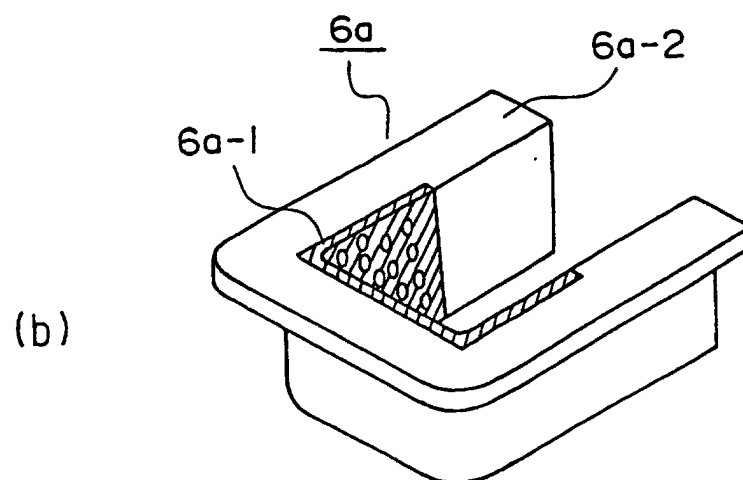
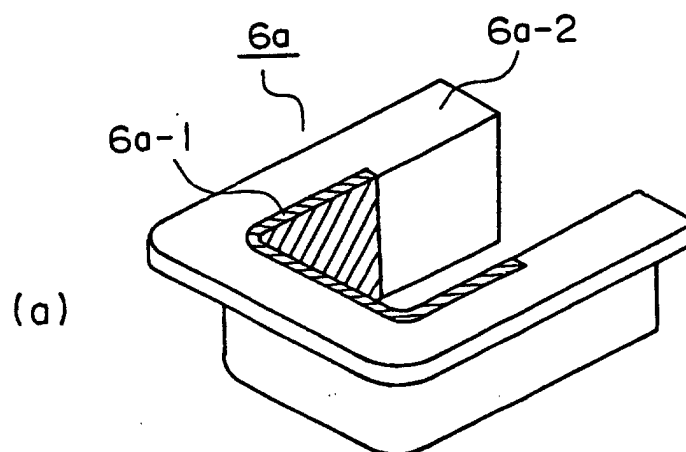


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP01/02486

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl. ⁷ H01H71/18		
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 H01H71/00-83/22		
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 1996-2001 Kokai Jitsuyo Shinan Koho 1971-2001 Toroku Jitsuyo Shinan Koho 1994-2001		
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, 7-302535, A (Mitsubishi Electric Corporation),	1, 3-6
Y	14 November, 1995 (14.11.95),	2
A	column 1, line 1 to column 4, line 49; column 21, lines 25 to 29; column 24, lines 5 to 14; column 24, line 43 to column 26, line 30; Figs. 1 to 14 & EP, 671754, A2 & EP, 694940, A1 & EP, 703590, A1 & CN, 1124402, A & KR, 115699, Y & US, 5841088, A & KR, 190216, B & US, 5990440, A & DE, 69512167, T & CN, 1287370, A & CN, 1287371, A & CN, 1287372, A	7
Y	JP, 2000-119494, A (Kanegafuchi Chem. Ind. Co., Ltd.), 25 April, 2000 (25.04.00), column 1, line 23 to column 2, line 45; column 4, line 39 to column 5, line 10; column 10, lines 31 to 37 (Family: none)	1-2
Y	JP, 11-335534, A (Toray Industries, Inc.), 07 December, 1999 (07.12.99), column 2, line 12 to column 3, line 7; column 3, lines 9 to 44 (Family: none)	1-2
☐ 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 12 June, 2001 (12.06.01)		Date of mailing of the international search report 26 June, 2001 (26.06.01)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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