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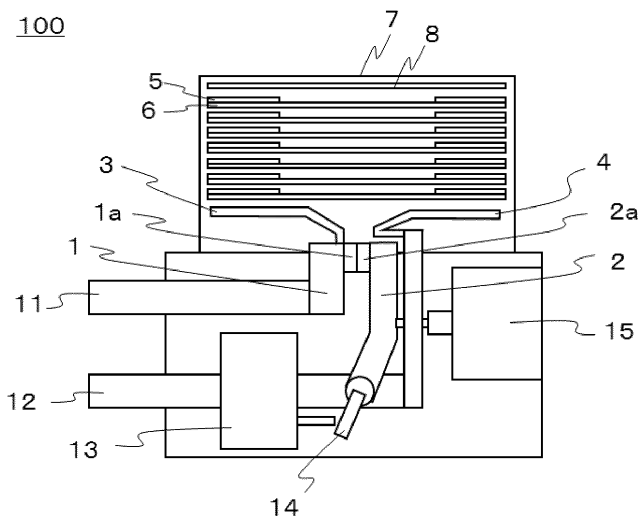
# (54) CIRCUIT BREAKER AND CIRCUIT BREAKING METHOD

(57) Provided is a circuit breaker that improves breaking performance by suppressing the return of an arc and maintaining a high arc voltage.

The circuit breaker has a fixed member having a fixed contact and a movable member having a movable contact that is connected to and disconnected from the fixed contact, and guides an arc generated between the contacts to an arc chute by an arc horn. A plurality of grids and support plates are laminated in the arc chute. The grid is formed with a notch portion, into which the arc is drawn, the notch portion being provided on each end portion on the fixed contact side and the movable contact side, and has an insulating portion which is adjacent to a peak portion of the notch portion and is extended in a width direction.

FIG. 1

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## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to a circuit breaker and a circuit breaking method, which include an arc chute arranged with grids.

### BACKGROUND ART

**[0002]** Hitherto, a circuit breaker that breaks current flowing through a circuit to protect an electric power apparatus from short circuit, ground short circuit, and the like has been used. In the circuit breaker, when contacts are separated off to break the current, an arc is generated between the contacts. When a fault current occurs, it is important to extinguish the generated arc immediately and to reduce breaking time for reducing damage of the electric power apparatus connected to the circuit. The circuit breaker generates an arc voltage higher than a power source voltage of the circuit and breaks the current by current limit by interrupting the arc by a plurality of grids arranged in an arc chute. In order to obtain high breaking performance, it is necessary to remain a state where the arc is interrupted by the grids and to maintain the elevated arc voltage. Patent document 1 discloses a circuit breaker in which a notched portion is provided at an arc approach portion of a grid to generate electromagnetic force that draws the arc into the grid by the action of biasing magnetic flux.

### RELATED ART DOCUMENT

### PATENT DOCUMENT

**[0003]** Patent Document 1: JP-A-2006-12540

### SUMMARY OF THE INVENTION

### PROBLEMS TO BE SOLVED BY THE INVENTION

**[0004]** However, a problem exists in that when it becomes a state where the arc reaches the plate surface of the plate-shaped grid and flows through in a thickness direction, the electromagnetic force by the biasing magnetic flux is not generated and thus the arc interrupted by the grids continues again and breaking performance degrades.

**[0005]** The present invention has been made to solve the aforementioned problem, and an object of the present invention is to provide a circuit breaker and a circuit breaking method, which improve breaking performance by suppressing the return of the arc to the contact sides and maintaining a high arc voltage.

### MEANS FOR SOLVING THE PROBLEMS

**[0006]** A circuit breaker according to the present invention includes: a fixed member having a fixed contact; a movable member having a movable contact that is connected to and disconnected from the fixed contact; and an arc chute arranged with a plurality of laminated grids, each of which has a notch portion into which an arc generated between the fixed contact and the movable contact is drawn and an insulating portion which is adjacent to a peak portion of the notch portion and is extended in a width direction.

**[0007]** A circuit breaking method according to the present invention is a circuit breaking method of a circuit breaker in which an arc generated between contact is interrupted by at least one grid to extinguish the arc, the circuit breaking method comprising the steps of: drawing the arc generated between the contact into a state where the arc generates arc discharge s at mutually different positions of the grid and flows through the grid; and bypassing currents flowing the grid between those generated arc discharges by an insulating portion provided between those mutually different positions of the grid to extinguish the arc.

### ADVANTAGEOUS EFFECT OF THE INVENTION

**[0008]** According to the circuit breaker of the present invention, the plurality of laminated grids, each of which has the insulating portion which is adjacent to the notch portion and is extended in the width direction, are arranged in the arc chute, whereby it becomes possible to suppress the return of the arc to the contact sides and to improve breaking performance. Furthermore, according to the circuit breaking method of the present invention, the currents flowing between the arcs in which arc discharges are generated at the mutually different positions of the grid are made to bypass by the insulating portion, whereby it becomes possible to suppress the return of the arc to the contact sides and to improve breaking performance.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]**

FIG. 1 is a schematic configuration diagram showing a circuit breaker according to Embodiment 1 of the present invention;

FIG. 2 is a schematic configuration diagram showing an example of a grid of the circuit breaker according to Embodiment 1 of the present invention;

FIG. 3 is a schematic configuration diagram showing the grid and a support plate of the circuit breaker according to Embodiment 1 of the present invention;

FIG. 4 is a typical view showing an arc of the circuit breaker according to Embodiment 1 of the present invention;

FIG. 5 is a typical view showing the action of the arc of the circuit breaker according to Embodiment 1 of the present invention;

FIG. 6 is a typical view showing the action of the arc of the circuit breaker according to Embodiment 1 of the present invention;
FIG. 7 is a typical view for explaining the action of a grid of the circuit breaker according to Embodiment 1 of the present invention;
FIG. 8 is a typical view showing flows of arc gas of the circuit breaker according to Embodiment 1 of the present invention;
FIG. 9 is a schematic configuration diagram showing other example of the grid of the circuit breaker according to Embodiment 1 of the present invention;
FIG. 10 is a schematic configuration diagram showing an example of a grid of a circuit breaker according to Embodiment 2 of the present invention;
FIG. 11 is a schematic configuration diagram showing an example of a grid of a circuit breaker according to Embodiment 3 of the present invention;
FIG. 12 is a schematic configuration diagram showing an example of a grid of a circuit breaker according to Embodiment 4 of the present invention;
FIG. 13 is a schematic configuration diagram showing an example of a grid of a circuit breaker according to Embodiment 5 of the present invention;
FIG. 14 is a schematic configuration diagram showing an example of a grid of a circuit breaker according to Embodiment 6 of the present invention;
FIG. 15 is a schematic configuration diagram showing an example of a grid of a circuit breaker according to Embodiment 7 of the present invention;
FIG. 16 is a schematic configuration diagram showing an example of a grid of a circuit breaker according to Embodiment 8 of the present invention;
FIG. 17 is a schematic configuration diagram showing a grid and a support plate of a circuit breaker according to Embodiment 9 of the present invention;
FIG. 18 is a schematic configuration diagram showing a circuit breaker according to Embodiment 10 of the present invention; and
FIG. 19 is a schematic configuration diagram showing an arc chute of the circuit breaker according to Embodiment 10 of the present invention.

## MODE FOR CARRYING OUT THE INVENTION

### Embodiment 1.

**[0010]** FIG. 1 is a schematic configuration diagram showing a circuit breaker according to Embodiment 1 of the present invention. As shown in FIG. 1, a circuit breaker 100 includes: a fixed member 1 having a fixed contact 1a; a movable member 2 having a movable contact 2a; a fixed member side arc horn 3 electrically connected to the fixed member 1; a movable member side arc horn 4 electrically connected to the movable member 2; and an arc chute 7 arranged with a plurality of grids 5 that interrupt an arc 10 and a plurality of support plates 6 that support the grids 5.

**[0011]** The circuit breaker 100 is arranged with an upper conductor 11 and a lower conductor 12 below the arc chute 7. The upper conductor 11 and the lower conductor 12 are electrically connected to the fixed member 1 and the movable member 2, respectively. The fixed contact 1a is connected to and disconnected from the movable contact 2a, thereby energizing and breaking current between the upper conductor 11 and the lower conductor 12.

**[0012]** An tripping device 13 connected to the lower conductor 12 detects overcurrent in breaking current and a latch 14 that holds the movable member 2 in energizing is released, whereby the movable member 2 is rotated in a direction away from the fixed member 1 to open the fixed contact 1a and the movable contact 2a. Furthermore, when the opened state is brought to the energizing state shown in FIG. 1, an actuator 15 coupled to the movable member 2 drives the movable member 2 to a position where the movable contact 2a comes in contact with the fixed contact 1a.

**[0013]** The fixed member side arc horn 3 is provided on an upper portion of the fixed member 1; and the movable member side arc horn 4 is provided on an upper portion of the movable member 2, the fixed member side arc horn 3 and the movable member side arc horn 4 being for guiding the arc 10 generated between the fixed contact 1a and the movable contact 2a (hereinafter, referred to as both contact 1a, 2a) to the arc chute 7. Each one end of the fixed member side arc horn 3 and the movable member side arc horn 4 is arranged adjacent to both contact la, 2a, respectively; and each other end thereof is provided in an extended manner so as to separate from each other.

**[0014]** The arc chute 7 has the grid 5 formed of conductive plate-shaped metal and the insulating support plate 6 that supports the grid 5. The plurality of laminated grids 5 and support plates 6 are arranged with a predetermined distance on an upper portion of the fixed member side arc horn 3 and the movable member side arc horn 4. The support plate 6 is arranged on the bottom surface of the grid 5 to support the grid 5 and to prevent the arc 10 from jumping out to both contact 1a, 2a sides and from causing bridging. A top surface plate 8 is arranged on the uppermost tier of the grids 5. The top surface plate 8 prevents arc gas 20 generated by the heat of the arc 10 from leaking above the arc chute 7. An exhaust port 16 (not shown in the drawing) which is for discharging the arc gas 20 to the outside of the circuit breaker 100 is provided on both sides of the arc chute 7.

**[0015]** FIG. 2 is a schematic configuration diagram showing an example of the grid of the circuit breaker according to Embodiment 1 of the present invention. As shown in FIG. 2, the grid 5 has a notch portion 51 formed on one end portion and an insulating portion 52 which is adjacent to a peak portion 51a of the notch portion 51 and is extended in a width direction. Here, a direction toward the notch portion 51 and a direction toward a top portion 53 opposite to the notch portion 51 are referred

to as a length direction and a direction perpendicular to the length direction is referred to as a width direction. The insulating portion 52 is, for example, a slit-shaped through hole. Here,
the shape of the notch portion 51 is a V-shape, a U-shape, a rectangular shape, or the like.

**[0016]** FIG. 3 is a schematic configuration diagram showing the grid and the support plate of the circuit breaker according to Embodiment 1 of the present invention. As shown in FIG. 3, two grids 5 are arranged on the support plate 6 so that the notch portions 51 face to each other. The support plate 6 is formed with an opening portion 61 in the center thereof and the insulating portion 52 of the grid 5 is arranged so as to overlap on the opening portion 61 of the support plate 6. The support plate 6 is provided so that the center of the opening portion 61 is located at both contact 1a, 2a when seen from the upper side of FIG. 1. That is, the grids 5 are arranged so that the notch portions 51 are directed toward both contacts 1a, 2a.

**[0017]** The support plate 6 and the top surface plate 8 are formed of thermosetting resin such as unsaturated polyester resin and melamine resin and may be formed of ceramics such as alumina and zirconia as other material.

**[0018]** Next, operation in breaking current of the circuit breaker 100 according to the present invention will be described. FIG. 4 is a typical view showing an arc of the circuit breaker according to Embodiment 1 of the present invention.

**[0019]** The circuit breaker 100 is opened the contacts by separating the movable member 2 from the fixed member 1 to generate the arc 10 between the fixed contact 1a and the movable contact 2a. The generated arc 10 is commutated to the fixed member side arc horn 3 or the movable member side arc horn 4 arranged on the upper portion of both contact 1a, 2a. The commutated arc 10 is guided to the arc chute 7 by electromagnetic force that is exerted by magnetic flux produced by current flowing through the fixed member side arc horn 3 or the movable member side arc horn 4 (hereinafter, referred to as both arc horns 3, 4).

**[0020]** FIG. 5 is a typical view showing the action of the arc in the arc chute of the circuit breaker according to Embodiment 1 of the present invention. FIG. 5(a) is a top view of the grid; and FIG. 5(b) is a perspective view of the grid. As shown in FIG. 5, electromagnetic force F exerts on the arc 10 by biasing magnetic flux $\phi$ that passes through the grid 5 and the arc 10 is drawn into the notch portion 51 of the grid 5 in the arc chute 7. The arc 10 is driven toward the notch portion 51 of the grid 5 to come in contact with the grid 5. Then, the arc 10 flows through in the thickness direction of the grid 5 and is interrupted by the plurality of grids 5 arranged in lamination.

**[0021]** FIG. 6 is a typical view showing the action of the arc in the grid of the circuit breaker according to Embodiment 1 of the present invention. FIG. 6(a) is a perspective view of the grid; and FIG. 6(b) is a sectional view taken along the line A-A' of the grid. The arc 10 flowing through in the thickness direction of the grid 5 generates arc discharges at different positions of the plate surface of the grid 5 due to differences of time from generation between both contacts 1a, 2a to arrival at the plate surface of the grid 5, generation places of arc discharge on the grid 5, and the like. As shown in FIG. 6(a), an arc 10a on the notch portion 51 side and an arc 10b on the top portion 53 side, the arc 10a and the arc 10b being generated sandwiching the insulating portion 52 of the grid 5, form an arc 10c that is current flowing along the plate surface of the grid 5. The arc 10c traces a current path that flows from the arc 10b on the top portion 53 side to the arc 10a on the notch portion 51 side, bypassing the insulating portion 52.

**[0022]** Next, the action of the present invention will be described by comparing with a grid 5 that has not an insulating portion 52. FIG. 7 is a typical view for explaining the action of a grid according to Embodiment 1 of the present invention. FIG. 7(a) is a perspective view of the grid; and FIG. 7(b) is a sectional view taken along the line B-B' of the grid. As shown in FIG. 7, in the case of the grid 5 that has not the insulating portion 52, electromagnetic repulsive force P exerts between the arc 10c flowing straight from the top portion 53 side toward the notch portion 51 side along the plate surface of the grid 5 and the arcs 10a, 10b flowing through in the thickness direction of the grid 5. The arc 10a on the notch portion 51 side is drawn back to both contact 1a, 2a sides by the electromagnetic repulsive force P.

**[0023]** On the other hand, in the case of the grid 5 having the insulating portion 52 extended in the width direction according to the present invention shown in FIG. 6, current flows bypassing the insulating portion 52 without going straight in the length direction and therefore the electromagnetic repulsive force P that exerts on the arc 10a on the notch portion 51 side can be suppressed. This can reduce current that flows straight in the length direction of the grid 5 and can suppress the return of the arc 10a toward both contact 1a, 2a sides.

**[0024]** FIG. 8 is a typical view showing a flow of arc gas according to Embodiment 1 of the present invention. The arc gas 20 generated at both contacts 1a, 2a flows from the opening portion 61 of the support plate 6 to a mutual gap 5d between the grids 5 arranged in lamination and is discharged from the exhaust port 16 arranged on both sides of the arc chute 7 to the outside of the circuit breaker 100. Furthermore, when the insulating portion 52 of the grid 5 is the through hole, the arc gas 20 generated at both arc horns 3, 4 flows passing through in the thickness direction of the grid 5 via the insulating portion 52. Then, the arc gas 20 flows from the insulating portion 52 to the gap 5d between the grids 5 and is discharged from the exhaust port 16 to the outside of the circuit breaker 100. The arc 10 interrupted by the grids 5 is driven to the top portion 53 side in the opposite direction to both contact 1a, 2a sides by the gas flow of the arc gas 20.

**[0025]** In such a manner, the insulating portion 52 of the grid 5 is the through hole, whereby in addition to the arc gas 20 generated between both contact 1a, 2a, the arc gas 20 generated at both arc horns 3, 4 can be efficiently sent to the gap 5d between the grids 5. This can drive the arc 10 to the top portion 53 side in the opposite direction to both contact 1a, 2a sides and can improve breaking performance.

**[0026]** As described above, the circuit breaker 100 according to the present embodiment includes the arc chute 7 arranged with the plurality of laminated grids 5, each of which has the insulating portion 52 extended in the width direction, whereby the electromagnetic repulsive force, which is directed toward both contact 1a, 2a sides and exerts on the arc 10 generated sandwiching the insulating portion 52, can be suppressed. This interrupts the arc 10 by the grids 5, can maintain a state where an arc voltage is elevated, and can improve breaking performance. Furthermore, the insulating portion 52 is the through hole, whereby the arc gas 20 is efficiently sent to the gap 5d between the grids 5, the arc 10 can be driven to the top portion 53 side in the opposite direction to both contact 1a, 2a sides, and the breaking performance can be improved.

**[0027]** Incidentally, the shape and the position of the insulating portion 52 of the grid 5 can be suitably changed. FIG. 9 is other example of the grid of the circuit breaker according to Embodiment 1 of the present invention. The width W52 of the insulating portion 52 is preferable to be brought close to the width W5 of the grid 5. This can lengthen distance in which current flowing along the plate surface of the grid 5 bypasses the insulating portion 52 without going straight in the length direction of the grid 5.

**[0028]** Furthermore, the length of the side L52 of the insulating portion 52 in the length direction of the grid 5 is preferable to be lengthened in a range where the arc 10 flowing through in the thickness direction of the grid 5 can be driven to the top portion 53 side, sandwiching the insulating portion 52. When the insulating portion 52 of the grid 5 is the through hole, the length of the side L52 of the insulating portion 52 is lengthened and the area of the surface of the grid 5 of the insulating portion 52 is increased, whereby the inflow area of the arc gas 20 can be increased and driving in the opposite direction to both contact 1a, 2a sides of the arc 10 can be expedited utilizing the gas flow.

**[0029]** Furthermore, the position of the insulating portion 52 of the grid 5 is preferable to be provided adjacent to the peak portion 51a of the notch portion 51. For example, the insulating portion 52 is provided to the notch portion 51 side than a midpoint of a line segment connecting the peak portion 51a of the notch portion 51 and the top portion 53 opposite to the peak portion 51a. This can further suppress the return of the arc 10 remained in the vicinity of the peak portion 51a of the notch portion 51.

Embodiment 2.

**[0030]** FIG. 10 is a schematic configuration diagram showing an example of a grid of a circuit breaker according to Embodiment 2 of the present invention. Two insulating portions 52 of a grid 5 are formed with a predetermined distance spaced in a length direction. The number of insulating portions 52 of the grid 5 may be further increased to three or four. The number of the insulating portions 52 is increased, whereby electromagnetic repulsive force, which is directed toward both contact 1a, 2a sides and exerts on an arc 10 generated sandwiching the insulating portion 52, can be suppressed; and when the insulating portion 52 is a through hole, the inflow area of arc gas 20 can be increased and driving in the opposite direction to both contact 1a, 2a sides of the arc 10 can be expedited utilizing a gas flow.

Embodiment 3.

**[0031]** FIG. 11 is a schematic configuration diagram showing an example of a grid of a circuit breaker according to Embodiment 3 of the present invention. An insulating portion 52 of a grid 5 is formed so as to be connected with a notch portion 51. The insulating portion 52 is a through hole and a slit 51b is provided between the notch portion 51 and the insulating portion 52, whereby the notch portion 51 and the insulating portion 52 can be communicated with each other. This can suppress electromagnetic repulsive force, which is directed toward both contact 1a, 2a sides and exerts on an arc 10 generated sandwiching the insulating portion 52, and processing of the insulating portion 52 of the grid 5 becomes easy.

Embodiment 4.

**[0032]** FIG. 12 is a schematic configuration diagram showing an example of a grid of a circuit breaker according to Embodiment 4 of the present invention. A grid 5 is segmented in a length direction to be electrically connected. For example, the grid 5 is segmented into a divided grid 5a on the top portion 53 side and a divided grid 5b on the notch portion 51 side; and the divided grids 5a, 5b are electrically connected with a predetermined distance spaced from each other using connection portions 5c. The connection portion 5c is, for example, a electric wire, a connecting pin, a rivet, or the like. Furthermore, the divided grids 5a, 5b may be connected by welding. The distance between the divided grid 5a and the divided grid 5b functions as an insulating portion 52; and similarly, electromagnetic repulsive force, which is directed toward both contact 1a, 2a sides and exerts on an arc 10, can be suppressed. Further, the width W52 and the length L52 of the insulating portion 52 can be suitably adjusted and therefore the distance between the divided grids 5a, 5b and the connection position can be easily changed according to an arc discharge generation

point of arc discharge.

Embodiment 5.

**[0033]** FIG. 13 is a schematic configuration diagram showing an example of a grid of a circuit breaker according to Embodiment 5 of the present invention. An insulating portion 52 of a grid 5 is formed in a T-shape. The insulating portion 52 is formed by a portion extended in a width direction and a portion extended from the center position thereof toward a top portion 53. The insulating portion 52 is formed in the T-shape, whereby a distance in which current flowing along the plate surface of the grid 5 bypasses the insulating portion 52 without going straight in a length direction can be lengthened and electromagnetic repulsive force directed toward both contact 1a, 2a sides can be suppressed.

Embodiment 6.

**[0034]** FIG. 14 is a schematic configuration diagram showing an example of a grid of a circuit breaker according to Embodiment 6 of the present invention. FIG. 14(a) is a perspective view of the grid; and FIG. 14(b) is a side view in which a plurality of the grids are laminated. A grid 5 has a shape folded back in a U-shape in a length direction. As shown in FIG. 14 (a), the grid 5 folded back in the U-shape is provided with a notch portion 51 in a folded end portion and is provided with an insulating portion 52 that is made adjacent to a peak portion 51a of the notch portion 51. Furthermore, as shown in FIG. 14(b), an arc 10 flowing through the grid 5 in a thickness direction forms an arc 10c that flows along the plate surface of the grid 5. The arc 10c traces a current path that flows from an arc discharge generation point of the arc 10 to the top portion 53 side via the folded end portion. The arc 10c forms magnetic flux $\phi$ in a direction orthogonal with respect to the thickness direction of the grid 5. Electromagnetic force F, which is driven by the magnetic flux $\phi$ to the top portion 53 side in the opposite direction to both contact 1a, 2a sides, exerts on the arc 10 flowing in the thickness direction in the direction orthogonal with respect to the thickness direction of the grid 5.

**[0035]** As described above, in the present embodiment, the grid 5 folded back in the U-shape is provided with the insulating portion 52 extended in the width direction, whereby electromagnetic repulsive force, which is directed toward both contact 1a, 2a sides and exerts on the arc 10 generated sandwiching the insulating portion 52, can be suppressed, and driving of the arc 10 in the opposite direction to both contact 1a, 2a sides can be expedited by the electromagnetic force F.

Embodiment 7.

**[0036]** FIG. 15 is a schematic configuration diagram showing a grid of a circuit breaker according to Embodiment 7 of the present invention. An insulating portion 52 of a grid 5 is formed in a V-shape along a notch portion 51. The grid 5 has a peak portion 52a of the insulating portion 52 adjacent to a peak portion 51a of the notch portion 51; and the insulating portion 52 has leg portions 521, 522 each extending from the peak portion 52a toward each side formed by the notch portion 51 and a top portion 53, the leg portions 521, 522 being coupled to form the V-shape. In the grid 5, an arc 10c flowing along the plate surface of the grid 5 is generated by arcs 10a, 10b flowing through in a thickness direction. The arc 10c flows from the top portion 53 side to the notch portion 51 side and flows bypassing from the notch portion 51 side to the top portion 53 side along the V-shape of the insulating portion 52. Electromagnetic repulsive force Q exerts between the arc 10c directed toward the top portion 53 side from the notch portion 51 side of the grid 5 and the arc 10a on the notch portion 51 side sandwiching the insulating portion 52. The arc 10a on the notch portion 51 side is exerted by the electromagnetic repulsive force Q and is driven to the top portion 53 in the opposite direction to both contact 1a, 2a sides.

**[0037]** As described above, in the present embodiment, the insulating portion 52 extended in the width direction of the grid 5 is provided, whereby the electromagnetic repulsive force, which is directed toward both contact 1a, 2a sides and exerts on the arc 10 generated sandwiching the insulating portion 5, can be suppressed; the insulating portion 52 is the V-shape, whereby the electromagnetic repulsive force Q directed toward the top portion 53 in the opposite direction to both contact 1a, 2a sides can exert on the arc 10a in which the arc 10 generates on the notch portion 51 side sandwiching the insulating portion 52; and therefore, breaking performance can be further improved.

Embodiment 8.

**[0038]** FIG. 16 is a schematic configuration diagram showing an example of a grid of a circuit breaker according to Embodiment 8 of the present invention. An insulating portion 52 of a grid 5 is formed of solid insulation material. As the insulation material, for example, thermosetting resin such as unsaturated polyester resin and melamine resin can be used. The insulating portion 52 may be formed of ceramics such as alumina and zirconia, as other material. Then insulating portion 52 of the grid 5 is formed of the insulation material, whereby electromagnetic repulsive force, which is directed toward both contact 1a, 2a sides and exerts on an arc 10 generated sandwiching the insulating portion 52, and the arc 10 can be prevented from passing through the insulating portion 52 and causing bridging.

Embodiment 9.

**[0039]** FIG. 17 is a top view showing the schematic configuration of a grid and a support plate of a circuit breaker according to Embodiment 9 of the present inven-

tion. In a circuit breaker 100 according to the present embodiment, the width W52 of an insulating portion 52 of a grid 5 is formed so as to be equal to or longer than the width W61 of an opening portion 61 of a support plate 6.

**[0040]** The width W52 of the insulating portion 52 of the grid 5 is formed so as to be equal to or longer than the width W61 of the opening portion 61 of the support plate 6, whereby a current path, in which an arc 10c flowing along the plate surface of the grid 5 bypasses the insulating portion 52, is blocked. That is, the current path, which flows on the plate surface of the grid 5 from the top portion 53 side to the notch portion 51 side or from the notch portion 51 side to the top portion 53 side, is blocked and electromagnetic repulsive force, which is directed toward both contact la, 2a sides and exerts on an arc 10, is not generated. This suppresses the return of the arc 10 to both contact 1a, 2a sides from a state where the arc 10 is interrupted by the grids 5 and breaking performance can be improved.

Embodiment 10.

**[0041]** FIG. 18 is a schematic configuration diagram of a circuit breaker according to Embodiment 10 of the present invention. FIG. 19 is a perspective view showing the schematic configuration of an arc chute of the circuit breaker according to Embodiment 10 of the present invention. In Embodiment 1, the grids 5 are arranged in lamination from the lower side to the upper side of the arc chute 7; whereas, in this embodiment, grids 5 are arranged in parallel along the movable direction of a movable member 2.

**[0042]** The grid 5 has a notch portion 51 formed on one end portion and an insulating portion 52 extended in a width direction. In the grid 5, the notch portion 51 is arranged on both contact la, 2a sides of a fixed contact 1a and a movable contact 2a and a top portion 53 opposite to the notch portion 51 is arranged so as to face the upper side of the arc chute 7. A support plate 6 is provided on the plate surface of each grid 5 and an opening portion 61 is arranged so as to face both contact 1a, 2a sides. An exhaust port 16 which is for discharging arc gas 20 is provided on the upper side of the arc chute 7.

**[0043]** In such a manner, the arc chute 7, in which the grids 5 each having the insulating portion 52 extended in the width direction are arranged in parallel along the movable direction of the movable member 2, is provided, whereby electromagnetic repulsive force, which is directed toward both contact 1a, 2a sides and exerts on an arc 10 generated sandwiching the insulating portion 52, can be suppressed. This interrupts the arc 10 by the grids 5, can maintain a state where an arc voltage is elevated, and can improve breaking performance. Furthermore, the grid 5 is arranged so that the notch portion 51 faces the both contact 1a, 2a sides and the top portion 53 opposite to the notch portion 51 faces the upper side of the arc chute 7 provided with the exhaust port 16, whereby the arc gas 20 generated between both contact 1a, 2a can be efficiently sent to a gap 5d between the grids 5.

**[0044]** Incidentally, the present invention may suitably combine a plurality of constituent elements disclosed in Embodiment 1 to 10 without departing from the spirit or scope of the present invention.

DESCRIPTION OF REFERENCE NUMERALS

**[0045]**

| | |
|---|---|
| 1 | Fixed member |
| 2 | Movable member |
| 3 | Fixed member side arc horn |
| 4 | Movable member side arc horn |
| 5 | Grid |
| 51 | Notch portion |
| 52 | Insulating portion |
| 6 | Support plate |
| 61 | Opening portion |
| 7 | Arc chute |
| 8 | Top surface plate |
| 10 | Arc |
| 11 | Upper conductor |
| 12 | Lower conductor |
| 13 | Tripping device |
| 14 | Latch |
| 15 | Actuator |
| 16 | Exhaust port |
| 100 | Circuit breaker |

**Claims**

**1.** A circuit breaker comprising:

a fixed member having a fixed contact;
a movable member having a movable contact that is connected to and disconnected from the fixed contact; and
an arc chute arranged with a plurality of laminated grids, each of which has a notch portion into which an arc generated between the fixed contact and the movable contact is drawn and an insulating portion which is adjacent to a peak portion of the notch portion and is extended in a width direction.

**2.** The circuit breaker according to claim 1, wherein the insulating portion of the grid is provided so that current directed toward the top portion side opposite to the notch portion from the notch portion side and current directed toward the notch portion side from the top portion side are made to bypass in the width direction of the grid.

**3.** The circuit breaker according to claim 1 or 2, wherein the insulating portion is a through hole provided in

the grid.

**4.** The circuit breaker according to claim 3, wherein the notch portion and the insulating portion of the grid are communicated with each other.

**5.** The circuit breaker according to claim 1 or 2, wherein the insulating portion is formed of solid insulation material.

**6.** The circuit breaker according to claim 1 or 2, wherein the grid is segmented into the notch portion side and the top portion side to be mutually electrically connected with a distance spaced therebetween; and the distance is the insulating portion.

**7.** The circuit breaker according to claim 1 or 2, wherein the grid is folded back in a U-shape in a length direction; and the folded end portion is provided with the notch portion.

**8.** The circuit breaker according to any one of claim 1 to 5, wherein the insulating portion has leg portions each extending in a width direction, the leg portions being coupled to form a V-shape.

**9.** The circuit breaker according to any one of claim 1 to 8, wherein the grid is supported by a support plate having an opening portion in the center thereof; and the insulating portion of the grid is arranged so as to overlap with the opening portion of the support plate.

**10.** The circuit breaker according to claim 9, wherein the width of the insulating portion of the grid is equal to or larger than the width of the opening portion of the support plate.

**11.** A circuit breaker in which an arc generated between contact is interrupted by at least one grid to extinguish the arc, wherein the grid has an insulating portion;
the arc generated between the contact is drawn into the grid, generates arc discharges at mutually different positions of the grid, and flows through the grid; and
the insulating portion is provided between those mutually different positions of the grid and makes current flowing through the grid between those generated arc discharges bypass.

**12.** A circuit breaker comprising:

a first and a second contact; and
an arc chute arranged with a grid which has a notch portion into which an arc generated between the first and the second contact is drawn and a through hole, wherein
arc gas flows passing through the through hole in the thickness direction of the grid.

**13.** A circuit breaking method of a circuit breaker in which an arc generated between contact is interrupted by at least one grid to extinguish the arc, the circuit breaking method comprising the steps of:

drawing the arc generated between the contact into a state where the arc generates arc discharges at mutually different positions of the grid and flows through the grid; and
bypassing currents flowing the grid between those generated arc discharges by an insulating portion provided between those mutually different positions of the grid to extinguish the arc.

FIG. 1

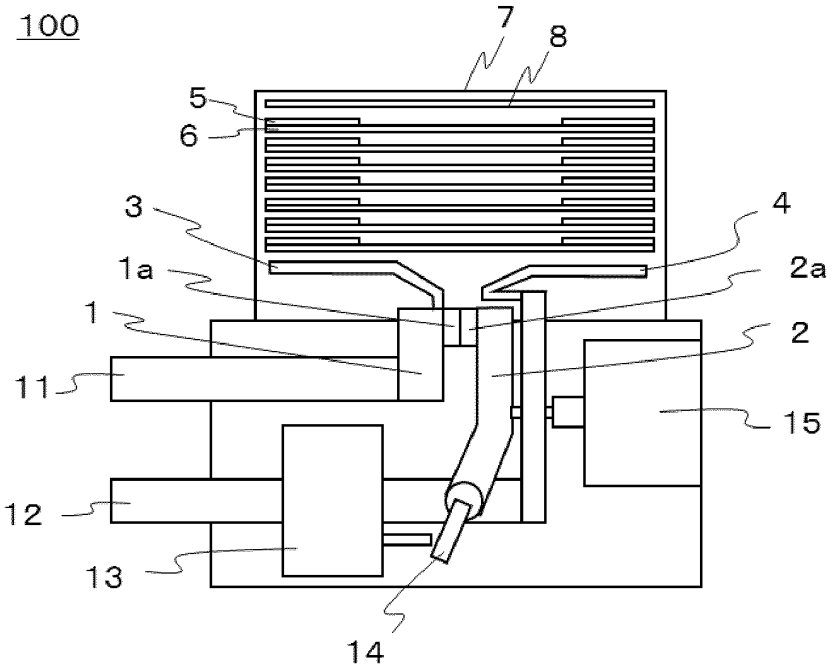



FIG. 2

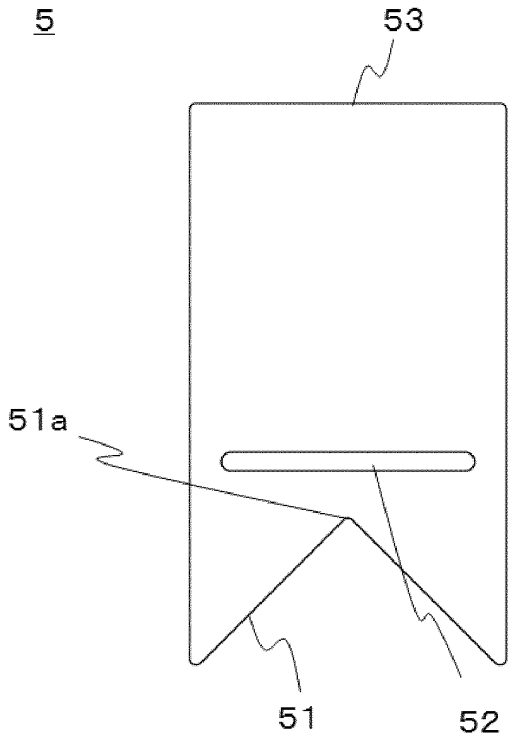


FIG. 3

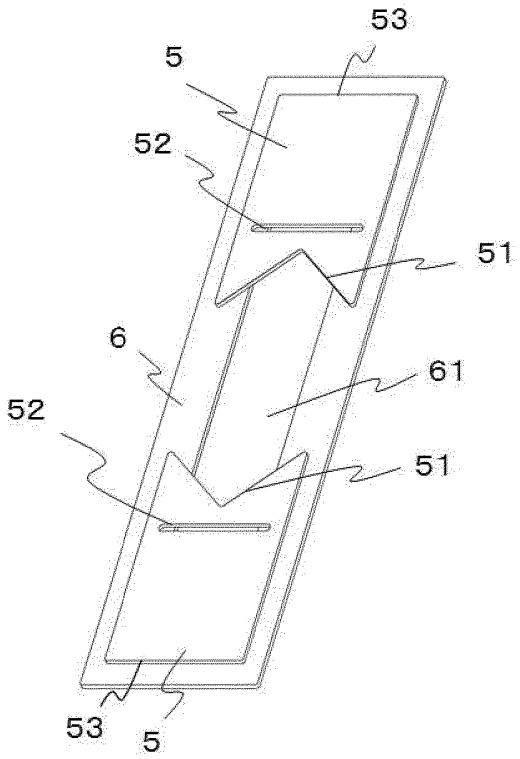



FIG. 4

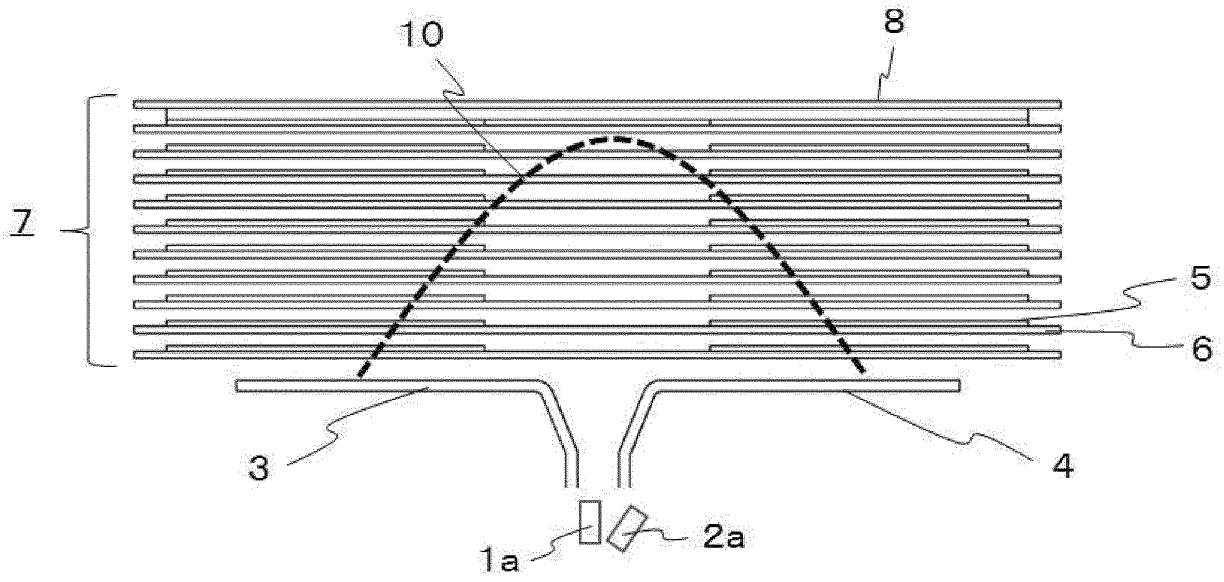
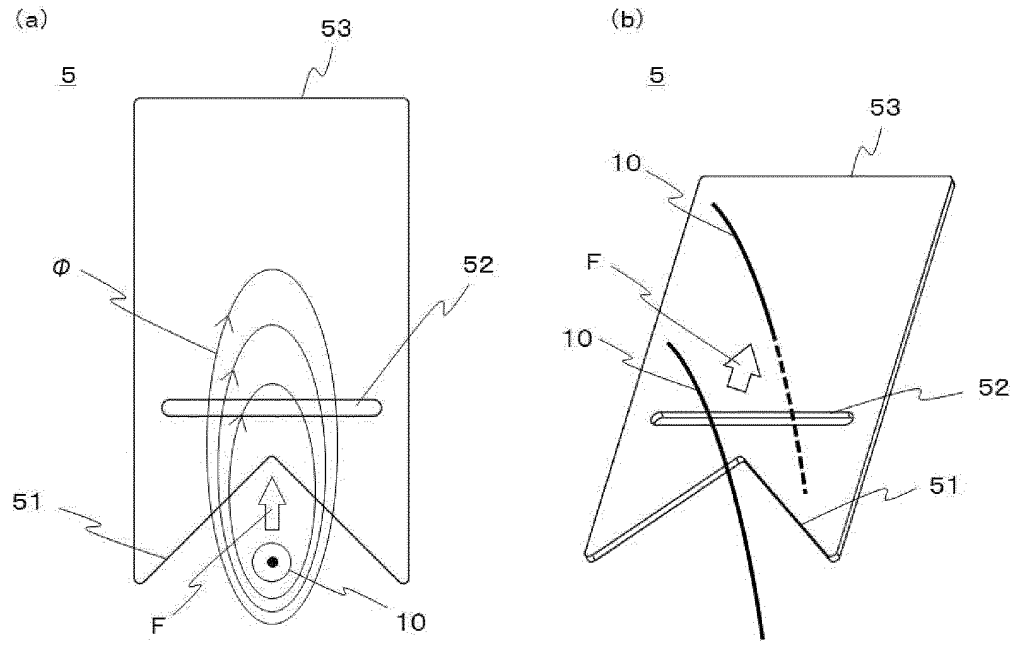


FIG. 5


(a)
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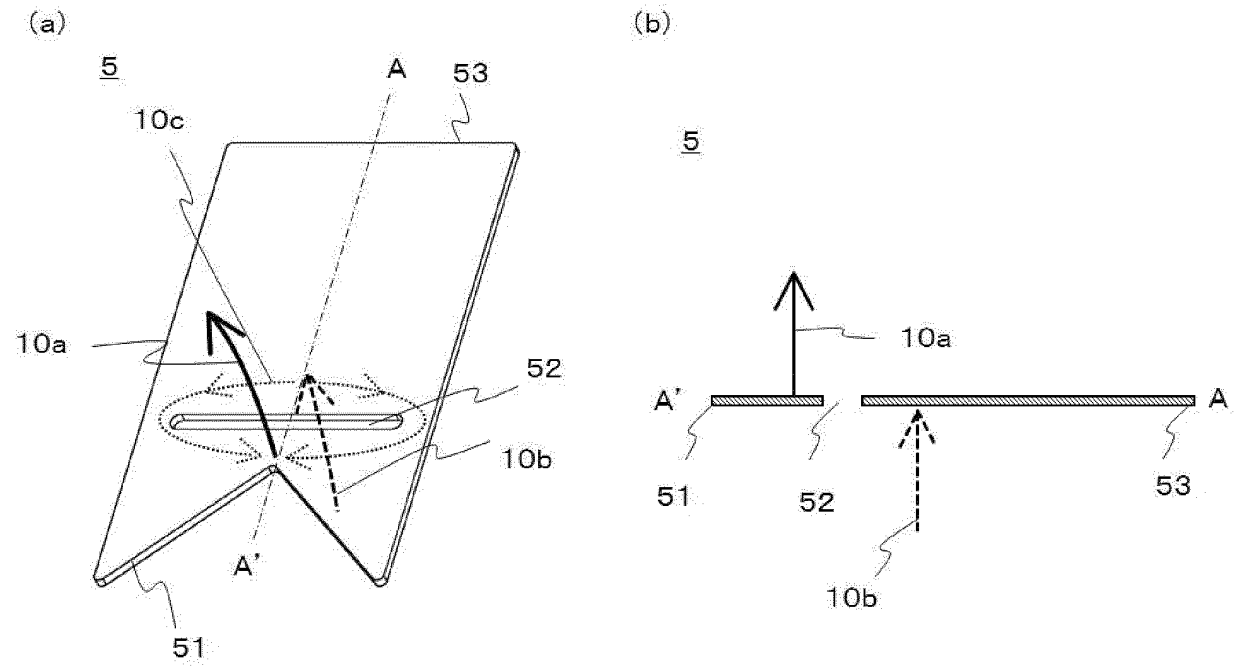
53
Φ
52
51
F
10
(b)
5
53
10
F
10
52
51

FIG. 6


(a)
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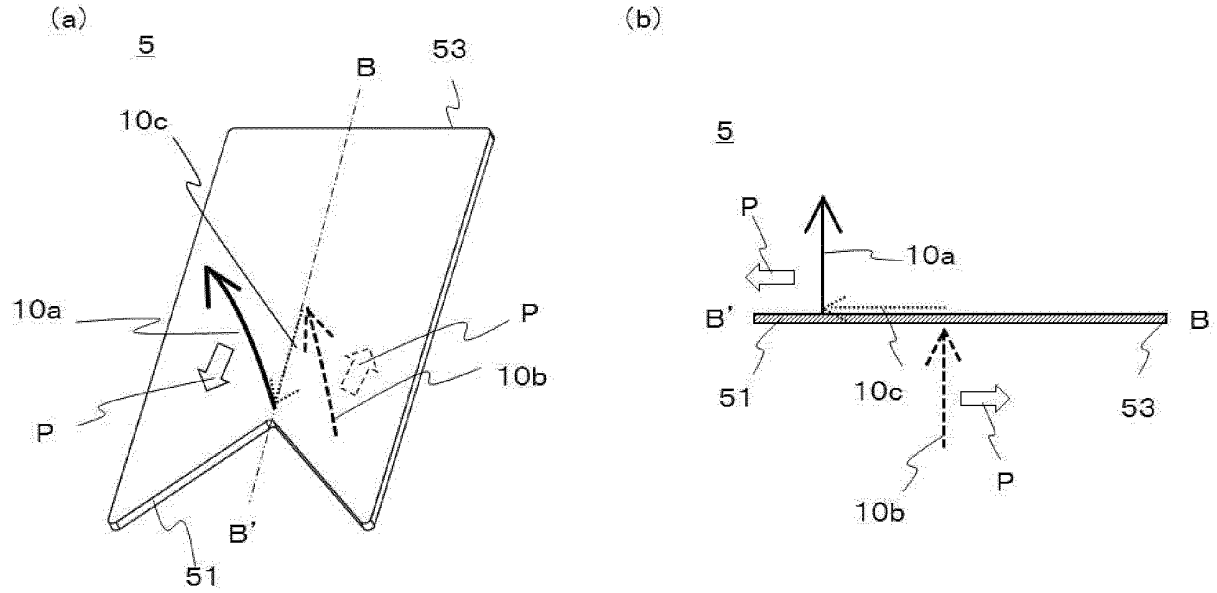
A
53
10c
10a
52
10b
A'
51
(b)
5
10a
A'
A
51
52
53
10b

FIG. 7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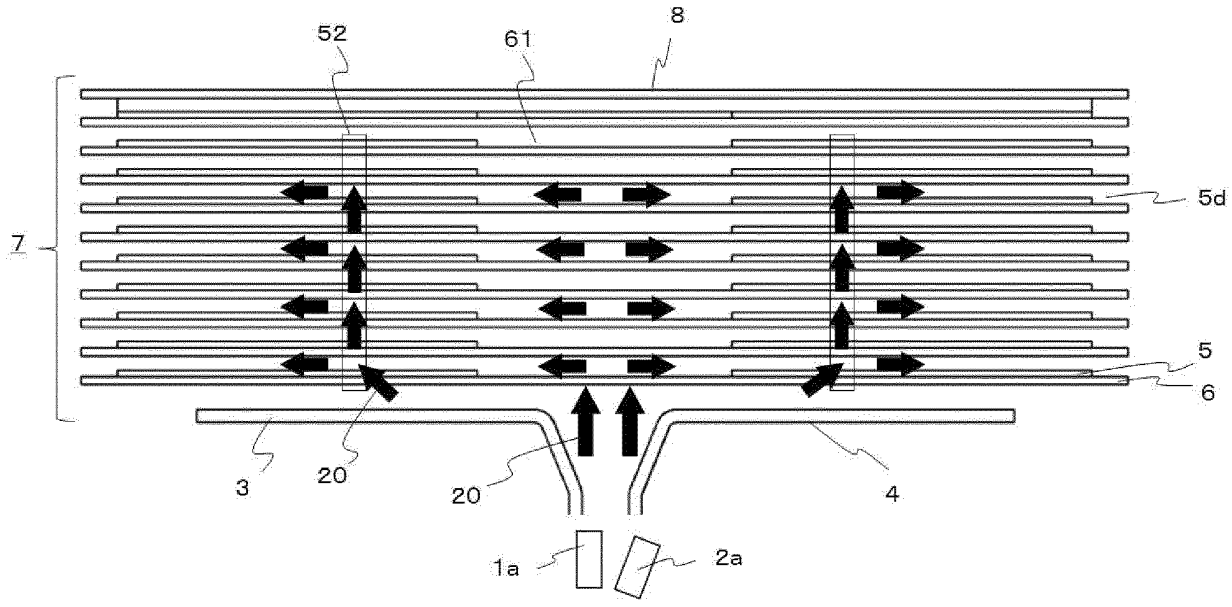
10c
10a
P
10b
P
B'
51
(b)
5
P
10a
B'
B
51
10c
53
P
10b

FIG. 8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8
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5d
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6
3
20
20
4
1a
2a

FIG. 9

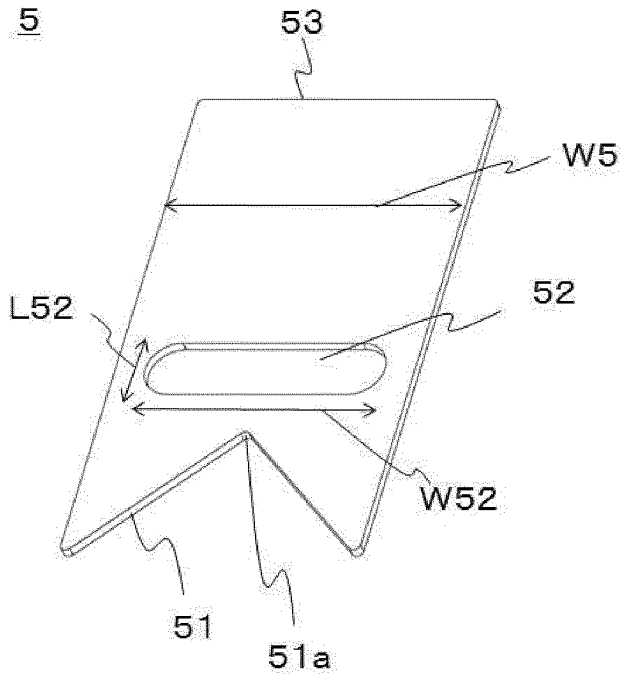



FIG. 10

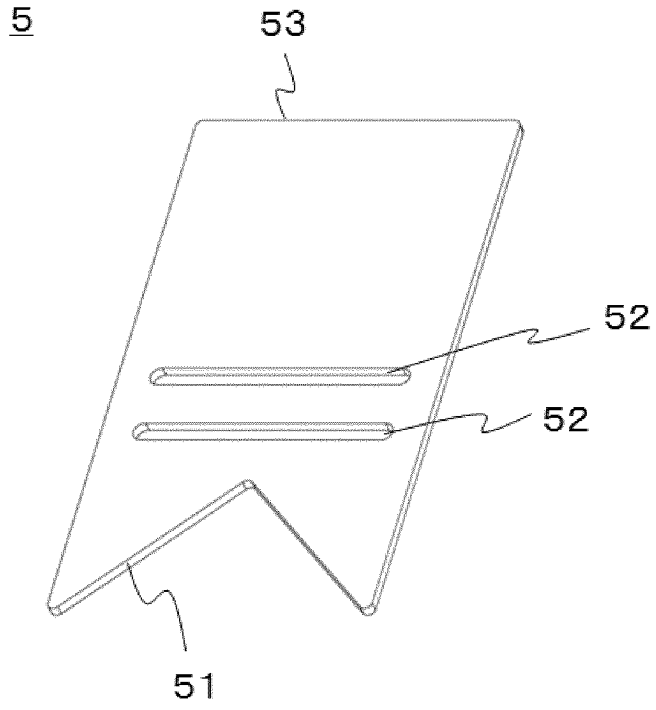


FIG. 11

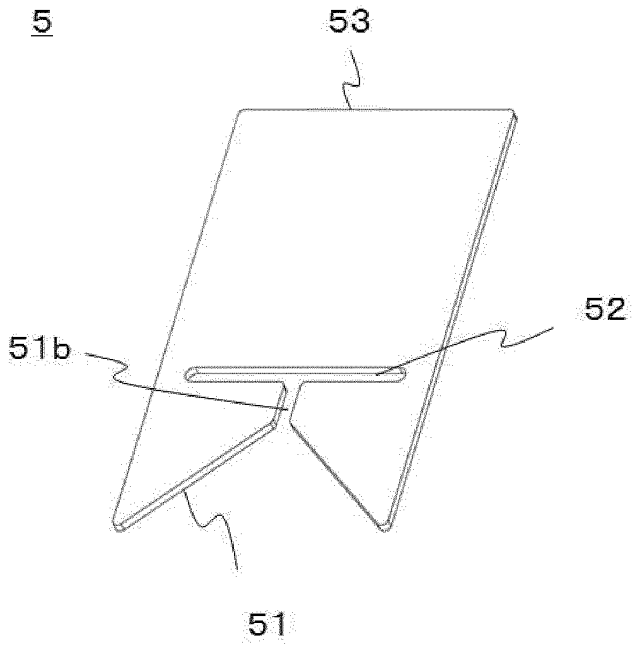



FIG. 12

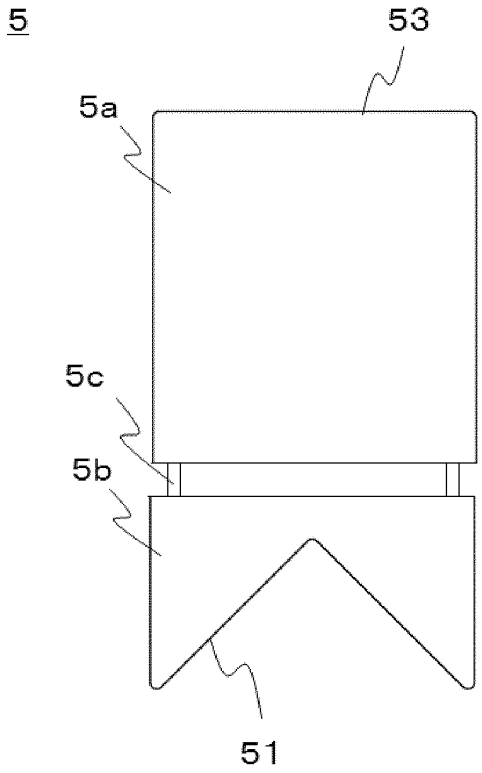


FIG. 13

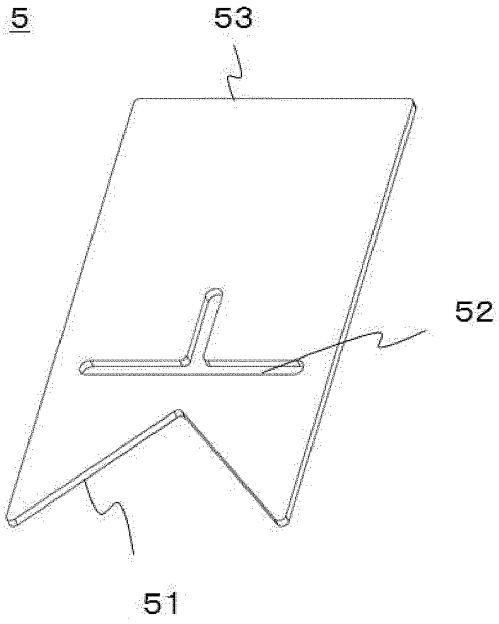



FIG. 14

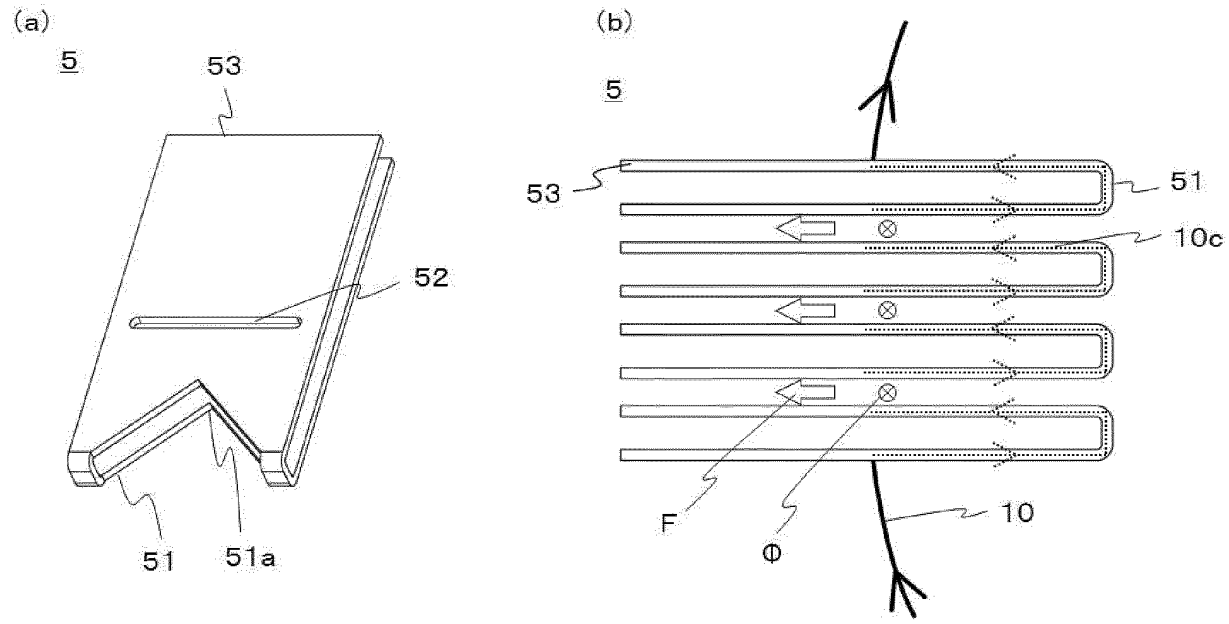


FIG. 15

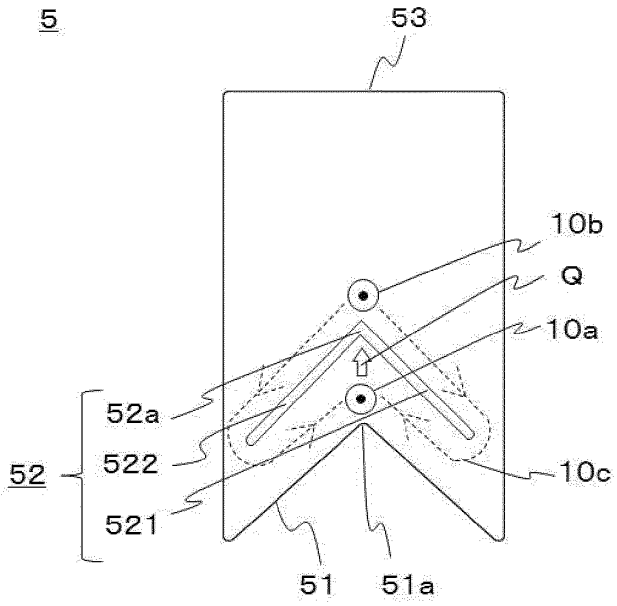



FIG. 16

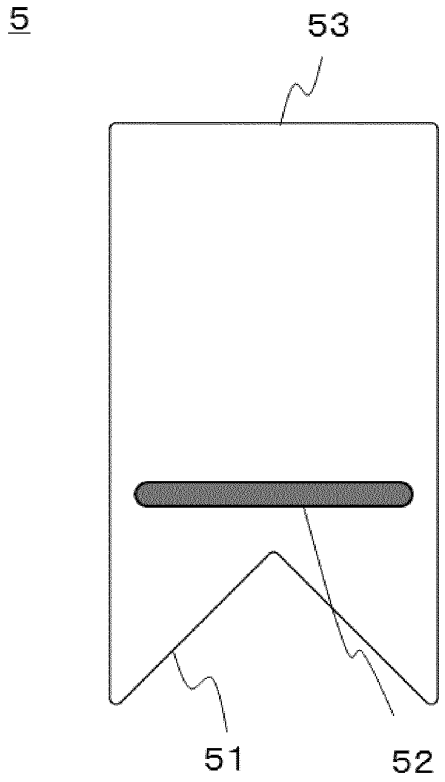


FIG. 17

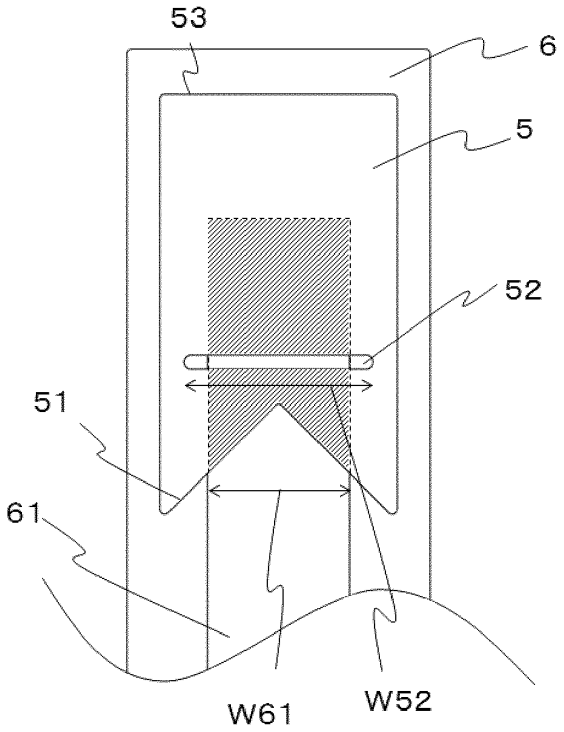



FIG. 18

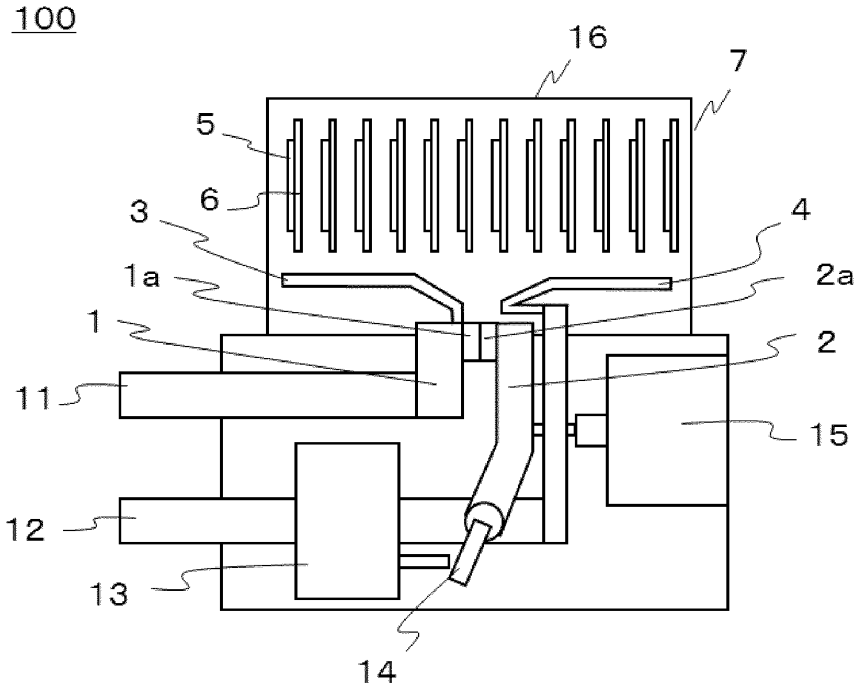
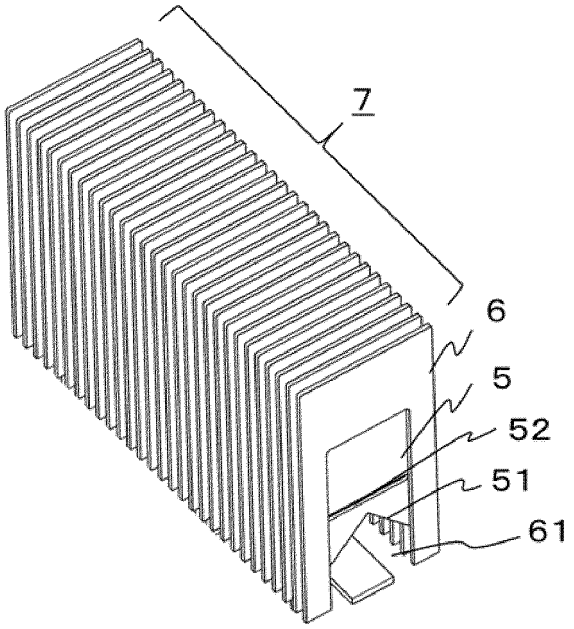


FIG. 19



**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2018/029414

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. H01H73/18(2006.01)i, H01H9/36(2006.01)i, H01H33/10(2006.01)i

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. H01H73/18, H01H9/36, H01H33/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2018
Registered utility model specifications of Japan 1996-2018
Published registered utility model applications of Japan 1994-2018

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<br>A | JP 54-089278 A (MITSUBISHI ELECTRIC CORP.) 16 July 1979, page 1, lower right column to page 3, upper left column, fig. 3-6 (Family: none) | 12<br>1-11, 13 |
| X<br>A | Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 007708/1983 (Laid-open No. 113946/1984) (MITSUBISHI ELECTRIC CORP.) 01 August 1984, description, pages 1-7, fig. 1-7 (Family: none) | 12<br>1-11, 13 |

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 15.10.2018 | 23.10.2018 |
| Name and mailing address of the ISA/<br>Japan Patent Office<br>3-4-3, Kasumigaseki, Chiyoda-ku,<br>Tokyo 100-8915, Japan | Authorized officer<br><br>Telephone No. |

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**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2018/029414

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | JP 2016-538692 A (EATON CORPORATION) 08 December 2016, paragraphs [0002]-[0028], fig. 1-7 & US 2015/0136740 A1, paragraphs [0002]-[0056], fig. 1-7 & WO 2015/073136 A1 & EP 3069363 A1 & CN 105917430 A | 1-13 |
| A | JP 2004-152703 A (ENERGY SUPPORT CORP.) 27 May 2004, paragraphs [0001]-[0142], fig. 1-24 & CN 1499552 A & KR 10-2004-0038886 A | 1-13 |

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## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- JP 2006012540 A **[0003]**