



(11)

EP 3 979 292 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
06.04.2022 Bulletin 2022/14

(51) International Patent Classification (IPC):
H01H 73/18 (2006.01) **H01H 33/08** (2006.01)

(21) Application number: **20813702.6**

(52) Cooperative Patent Classification (CPC):
H01H 33/08; H01H 73/18

(22) Date of filing: **20.05.2020**

(86) International application number:
PCT/JP2020/019864

(87) International publication number:
WO 2020/241397 (03.12.2020 Gazette 2020/49)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(72) Inventors:
• **MATSUMURA, Kohei**
Tokyo 100-8310 (JP)
• **TOYA, Nobumoto**
Tokyo 100-8310 (JP)

(74) Representative: **Witte, Weller & Partner**
Patentanwälte mbB
Postfach 10 54 62
70047 Stuttgart (DE)

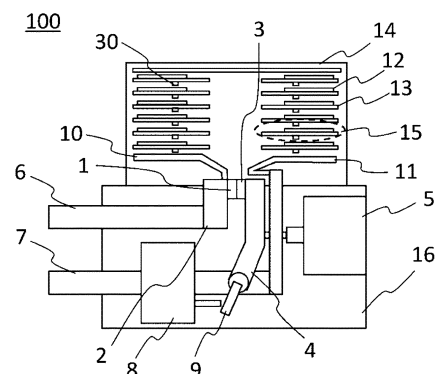
(30) Priority: **28.05.2019 JP 2019099017**

(71) Applicant: **MITSUBISHI ELECTRIC CORPORATION**
Chiyoda-ku
Tokyo 100-8310 (JP)

(54) **DIRECT-CURRENT CIRCUIT BREAKER**

(57) The DC circuit breaker includes: an interruption mechanism portion (16) configured to perform opening between a fixed contact (1) and a movable contact (3), to interrupt DC current; and an arc extinguishing chamber (14) in which a plurality of arc extinguishing plates (15) each obtained by superposing an insulating plate (13) and a grid (12) which has electrical conductivity and has a plate shape, are accommodated in a stacked state at fixed intervals. An interrupting portion having a projecting shape is disposed on either surface of each arc extinguishing plate (15) so as to originate from an edge of the arc extinguishing plate. Thus, the DC circuit breaker has so high interruption performance that no arc leaks from a location on the grid (12) to the surroundings.

FIG.1



EP 3 979 292 A1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a DC circuit breaker having an interrupting portion on an arc extinguishing plate thereof.

BACKGROUND ART

[0002] A DC circuit breaker includes: a fixed element having a fixed contact; and a movable element having a movable contact that is separable from the fixed contact. The DC circuit breaker performs opening between the contacts, to interrupt current. An arc generated in association with the opening is transferred from the contacts onto arc runners disposed in the vicinity of the contacts and is guided into an arc extinguishing chamber.

[0003] A plurality of arc extinguishing plates each formed by retaining a grid on an insulating plate are parallelly disposed at fixed intervals in the arc extinguishing chamber. The arc having arrived in the arc extinguishing chamber is divided by the arc extinguishing plates, and an arc voltage equal to or higher than a power supply voltage of a DC circuit is generated, whereby fault current is limited and interrupted.

CITATION LIST

PATENT DOCUMENT

[0004]

Patent Document 1: Japanese Laid-Open Patent Publication No. 61-190828

Patent Document 2: Japanese Laid-Open Patent Publication No. 62-82616

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] In the conventional DC circuit breaker, an arc having arrived on an arc extinguishing plate in the arc extinguishing chamber may flow back in directions toward the contacts during the limitation and the interruption, to cause restrike of an arc. This results in elongation of the time taken to complete interruption and sometimes also leads to failure of interruption.

[0006] Considering this drawback, in Patent Document 1 and Patent Document 2, an interrupting portion is provided between contacts and arc extinguishing plates in an arc extinguishing chamber. Consequently, hot gases generated by an arc having arrived in the arc extinguishing chamber are prevented from flowing back in directions toward the contacts. Thus, restrike of an arc in the vicinity of the contacts is inhibited. However, Patent Document 1 and Patent Document 2 have the following prob-

lem. That is, control of the flowing direction of an arc which has arrived on, and divided by, an arc extinguishing plate, is not sufficient, and thus backflow of the arc sometimes occurs, to cause failure of interruption.

[0007] The present disclosure has been made to solve the above problem, and an object of the present disclosure is to obtain a DC circuit breaker in which an interrupting portion for controlling the flow of an arc is provided on each of arc extinguishing plates in an arc extinguishing chamber, and which has so high interruption performance that no arc flows back from a location on a grid.

SOLUTION TO THE PROBLEMS

[0008] A DC circuit breaker according to the present disclosure is a DC circuit breaker including: an interruption mechanism portion configured to perform opening between a fixed contact and a movable contact, to interrupt DC current; an arc extinguishing plate obtained by superposing an insulating plate and a grid which has electrical conductivity and has a plate shape; and an arc extinguishing chamber in which a plurality of the arc extinguishing plates are accommodated in a stacked state at fixed intervals such that edges of the arc extinguishing plates are located above the fixed contact and the movable contact, wherein an interrupting portion having a projecting shape is disposed on either surface of each arc extinguishing plate so as to originate from an edge of the arc extinguishing plate.

EFFECT OF THE INVENTION

[0009] In the DC circuit breaker according to the present disclosure, the interrupting portion is provided on each of the arc extinguishing plates. Thus, it is possible to obtain so high interruption performance that no arc flows back from a location on any of the arc extinguishing plates.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

[FIG. 1] FIG. 1 is a schematic cross-sectional view showing the structure of a DC circuit breaker according to embodiment 1.

[FIG. 2] FIG. 2 is a schematic cross-sectional view showing the structure of the DC circuit breaker according to embodiment 1.

[FIG. 3] FIG. 3 is a perspective view of arc extinguishing plates on each of which interrupting portions according to embodiment 1 are formed.

[FIG. 4] FIG. 4 is a perspective view showing the back surface structure of the arc extinguishing plates on each of which the interrupting portions according to embodiment 1 are formed.

[FIG. 5] FIG. 5 is a partial perspective view showing a modification of the arc extinguishing plate on which

the interrupting portions according to embodiment 1 are formed.

[FIG. 6] FIG. 6 is a perspective view showing the internal structure of an arc extinguishing chamber according to embodiment 1.

[FIG. 7] FIG. 7 is a conceptual view showing an effect of the interrupting portions according to embodiment 1.

[FIG. 8] FIG. 8 is a schematic cross-sectional view showing the structure of a DC circuit breaker according to embodiment 1.

[FIG. 9] FIG. 9 is a conceptual view showing an effect of interrupting portions according to embodiment 1.

[FIG. 10] FIG. 10 is a perspective view of arc runners on which interrupting portions according to embodiment 2 are formed.

DESCRIPTION OF EMBODIMENTS

[0011] The same or corresponding portions in descriptions of embodiments and the drawings are denoted by the same reference characters.

Embodiment 1

[0012] The present embodiment will be described mainly with reference to FIG. 1 to FIG. 7. FIG. 1 and FIG. 2 are each a schematic cross-sectional view showing the schematic structure of a DC circuit breaker 100 of the present embodiment. FIG. 1 shows a closed state between contacts, and FIG. 2 shows an opened state between the contacts. FIG. 3 is a perspective view showing several ones taken out from among arc extinguishing plates 15 disposed in an arc extinguishing chamber 14 of the DC circuit breaker 100. FIG. 3 shows a state where interrupting portions 30 are formed on the arc extinguishing plates 15 which are each formed by an insulating plate 13 and grids 12. FIG. 4 shows the back surface structure in FIG. 3. FIG. 5 shows a modification of the arrangement of a grid 12.

[0013] FIG. 6 shows the internal structure of the arc extinguishing chamber 14. FIG. 6 shows a structure in which the arc extinguishing plates 15 which are each formed by the insulating plate 13 and the grids 12 and on which the interrupting portions 30 are formed, are stacked. FIG. 7 shows the flows, of hot gases, that are controlled by the interrupting portions 30.

[0014] FIG. 1 and FIG. 2 are each a cross-sectional view of the DC circuit breaker 100 of the present embodiment and each show a schematic structure of the device. Of the DC circuit breaker 100 shown in each of FIG. 1 and FIG. 2, the lower portion indicates an interruption mechanism portion 16 and the upper portion indicates the arc extinguishing chamber 14.

[0015] FIG. 1 shows the interruption mechanism portion 16 in a closed state between the contacts. In this state, a movable element 4 is pressed by a closing actuator 5 in the leftward direction in FIG. 1, and a movable

contact 3 attached to the movable element 4 is in contact with a fixed contact 1 attached to a fixed element 2. This enables electric conduction between an upper conductor 6 and a lower conductor 7.

[0016] In the arc extinguishing chamber 14 at the upper portion in FIG. 1, a space is present above the fixed contact 1 and the movable contact 3, and a fixed-side arc runner 10 and a movable-side arc runner 11 are disposed on the left and right sides. Integrated products are disposed so as to be stacked over the fixed-side arc runner 10 and the movable-side arc runner 11. Each integrated product is composed of: grids 12 which have electrical conductivity and have flat plate shapes; an insulating plate 13 on which the grids 12 are disposed and retained; and interrupting portions 30 which are each made of resin and each formed in a projecting shape in the form of a line to prevent backflow of hot gases.

[0017] In the present embodiment, each member disposed in the arc extinguishing chamber 14 and composed of the grids 12 and the insulating plate 13 is referred to as an arc extinguishing plate 15. Meanwhile, each portion disposed on the arc extinguishing plate 15 and having a projecting shape in the form of a line is referred to as an interrupting portion 30.

[0018] In FIG. 1, the portion enclosed by the broken line in the arc extinguishing chamber 14 represents the arc extinguishing plate 15. In the arc extinguishing plate 15, the grids 12 are attached to the upper surface of the insulating plate 13, and each interrupting portion 30 is further formed on the insulating plate 13 so as to originate from an edge of the arc extinguishing plate 15.

[0019] The interrupting portion 30 on the insulating plate 13 can be formed integrally with the insulating plate 13. Alternatively, the interrupting portion 30 can be formed as a separate member and attached on the insulating plate 13.

[0020] The order of stacking of the interrupting portion 30, and the insulating plate 13 and the grids 12 which compose the arc extinguishing plate 15, is merely an example, and it is also possible to change the order of the insulating plate 13 and the grids 12 as described later. In addition, although the interrupting portions 30 are formed on the insulating plate 13 in the present embodiment, the interrupting portions 30 can be formed on the grids 12.

[0021] It is noted that FIG. 1 shows a closed state, and thus, in this state, electric conduction is present between the fixed contact 1 and the movable contact 3 and no arc has occurred. A flow at the time of generation of an arc will be described with reference to FIG. 2 and the like.

[0022] FIG. 2 shows the interruption mechanism portion 16 in an opened state.

[0023] When fault current flows through the interruption mechanism portion 16, a detector 8 disposed on the lower conductor 7 detects the fault current, and a latch 9 retaining the movable element 4 is released by the closing actuator 5. Consequently, the movable element 4 retaining the movable contact 3 is moved. Thus, opening

occurs between the fixed contact 1 and the movable contact 3 in a state where current is being applied. At the time of the opening, an arc 20 is generated between the fixed contact 1 and the movable contact 3. It is noted that the stage in which the arc 20 is generated in the opened state is referred to as emergence and is, in some cases, distinguished from other stages of the arc 20.

[0024] The arc 20 having emerged between the contacts moves between the fixed-side arc runner 10 and the movable-side arc runner 11. This stage is referred to as transference of an arc 21. Then, the arc 21 moves into the arc extinguishing chamber 14 owing to influences of: electromagnetic forces generated by currents flowing through the fixed-side arc runner 10 and the movable-side arc runner 11; and the flows of electrically conductive hot gases. This stage is referred to as travel of an arc 22.

[0025] The arc 22 having travelled into the arc extinguishing chamber 14 arrives at intervals between the arc extinguishing plates 15. The stage in which the arc is divided between the plurality of arc extinguishing plates 15 may be referred to as division of an arc 23. If the divided state is maintained, an arc voltage increases to become equal to or higher than a power supply voltage of a circuit. Consequently, limitation and interruption are performed.

[0026] In the present embodiment, the interrupting portions 30 are, as shown in FIG. 2, formed on surfaces of the insulating plates 13 of the arc extinguishing plates 15 so as to originate from edges of the arc extinguishing plates 15 in order to prevent the arc 23 from flowing back from the intervals between the arc extinguishing plates 15 and prevent restrike of an arc due to hot gases.

[0027] Hereinafter, the arrangement, the structures, functions, and the like of the interrupting portions 30 will be described with reference to FIG. 3 to FIG. 7.

[0028] FIG. 3 illustrates the arrangement and the structures of the interrupting portions 30 formed on the insulating plates 13 of the arc extinguishing plates 15. Some of the plurality of arc extinguishing plates 15 disposed in the arc extinguishing chamber 14 have been taken out and shown.

[0029] FIG. 4 shows the back surface structure in FIG. 3. FIG. 5 shows a modification of the structure of the arc extinguishing plate 15, in which the arrangement of a grid 12 is changed.

[0030] FIG. 6 shows a schematic structure of the arc extinguishing plates 15 disposed in the arc extinguishing chamber 14 and partially shows, together with the schematic structure, the fixed-side arc runner 10, the movable-side arc runner 11, and the like.

[0031] As shown in FIG. 6, the interrupting portions 30 are formed on the insulating plates 13 of the arc extinguishing plates 15 in the present embodiment. When each arc extinguishing plate 15 is disposed in the arc extinguishing chamber 14, the arc extinguishing plate 15 is disposed such that the surface on which the interrupting portions 30 are formed faces downward as shown in FIG. 4.

[0032] It is noted that FIG. 3 shows that the insulating plate 13 side on which the interrupting portions 30 are formed faces upward for facilitating explanations.

[0033] Although each arc extinguishing plate 15 is composed of the grids 12 and the insulating plate 13 and has a structure in which the interrupting portions 30 are formed, no grids 12 can be viewed in FIG. 6 owing to the view angle.

[0034] In FIG. 3, a quadrangular opening in which the traveling arc 22 flows is formed at the center of each insulating plate 13. The grids 12 are stacked so as to protrude into the opening. As shown in FIG. 1 and FIG. 2, the opening is located directly above the fixed contact 1 and the movable contact 3. That is, as shown in FIG. 2, the arc 20 generated owing to an opening operation between the fixed contact 1 and the movable contact 3 flows into the opening owing to the flows of hot gases and electromagnetic forces of the fixed-side arc runner 10 and the movable-side arc runner 11. Then, the arc arrives at the intervals between the arc extinguishing plate 15, whereby the arc is divided by the grids 12 disposed on the arc extinguishing plates 15.

[0035] As shown in FIG. 3, each interrupting portion 30 is disposed in the form of a line and has a projecting shape. The interrupting portion 30 is attached to the insulating plate 13 by bringing side surfaces of the projecting-shape portion into close contact with the insulating plate 13. Further, the interrupting portion 30 is disposed substantially in a radial pattern so as to originate from an edge of the quadrangular opening formed at the center of the insulating plate 13 of each arc extinguishing plate 15 and so as to face the outer side of the insulating plate 13 and extend to an edge on the outer peripheral side of the arc extinguishing plate 15.

[0036] Regarding the locations at which the interrupting portions 30 are to be formed, the interrupting portions 30 are preferably formed in regions in which the grids 12 are disposed on the arc extinguishing plate 15. Specifically, the interrupting portions 30 are preferably formed on the surfaces of the grids 12 stacked on the arc extinguishing plate 15 or at locations that: are present on a surface, of the arc extinguishing plate 15, that is opposite to the surface on which the grids 12 are formed; and correspond to the locations at which the grids 12 are formed.

[0037] Further, if the interrupting portions 30 are disposed so as to originate from regions in which the grids 12 protrude into the quadrangular opening in the arc extinguishing plate 15 shown in FIG. 3, an effect of controlling arcs can be improved.

[0038] The thickness of each interrupting portion 30 takes the same value as the thickness of each of the grids 12 and the insulating plate 13 so as not to inflict any great influence on the stacking structure when the arc extinguishing plates 15 are disposed in the arc extinguishing chamber 14 in a mutually stacked manner.

[0039] Detailed effects of each interrupting portion 30 exhibited when the divided arc 23 flows into the intervals

between the arc extinguishing plates 15, will be described later. Since the interrupting portion 30 is disposed in a radial pattern so as to face the outer side of the insulating plate 13, the interrupting portion 30 is advantageous in diffusing hot gases. In addition, the interrupting portions 30 are each bent at an obtuse angle and have bent portions disposed so as to face each other. Thus, projecting portions at the bent portions make it possible to prevent backflow of hot gases. Therefore, re-emergence of an arc can be prevented.

[0040] FIG. 4 shows the back surface structure of the arc extinguishing plates 15 shown in FIG. 3. In the structure, projecting portions are formed at center portions in the longitudinal direction of the arc extinguishing plates 15 at which no grids 12 are disposed. The effect of controlling the arc 23 is small in the case of using only these projecting portions. However, if the projecting portions are used in combination with the interrupting portions 30 shown in FIG. 3, a favorable effect of controlling the arc can be expected.

[0041] FIG. 5 is a modification in which a grid 12 is disposed between the insulating plate 13 and interrupting portions 30. This arrangement also makes it possible to obtain the favorable effect of controlling the arc.

[0042] FIG. 7 shows the flows of hot gases and the arc 22 having travelled to the intervals between the arc extinguishing plates 15. An effect of each interrupting portion 30 on the arc 23 divided by the arc extinguishing plates 15, will be described with reference to FIG. 7. Similarly to FIG. 3, FIG. 7 also shows, for explanations, the state in which the surface of the insulating plate 13 of each arc extinguishing plate 15 on which the interrupting portions 30 are formed faces upward. It is noted that the divided arc 23 spreads in all directions such that, since the shape of the insulating plate 13 of the arc extinguishing plate 15 is symmetric about the quadrangular opening at the center, the diffusion of the arc 23 also has symmetry. Considering this, description will be given with the direction being limited to one direction, for facilitating explanations.

[0043] The arc 20 having emerged upon the opening between the fixed contact 1 and the movable contact 3 moves and travels into the quadrangular opening portion at the center in FIG. 7. The arc 22 having travelled past the fixed-side arc runner 10 and the movable-side arc runner 11 is influenced by the flows of hot gases and the electromagnetic forces of the grids 12 of the arc extinguishing plate 15 and moves along the white arrow 32 which indicates the travel of the arc 22 in FIG. 7. Consequently, the arc 22 turns into a divided arc 23.

[0044] Further, hot gases generated by the arc 23 and having high electrical conductivity move along the surface of the arc extinguishing plate 15 and are diffused in a radial pattern, as indicated by the black arrows 31 which indicate the flows of the hot gases.

[0045] If no interrupting portion 30 is disposed on the insulating plate 13, parts of the diffused hot gases may pass around from sides and may move again in directions

toward the center of the arc extinguishing plate 15. In this case, a situation in which restriking of an arc or the like occurs is also conceivable. However, as shown in FIG. 7, the interrupting portions 30 which have projecting shapes in the forms of lines bent at obtuse angles and which have the bent portions facing each other are formed on the insulating plate 13 of the arc extinguishing plate 15 so as to originate from edges of the opening at the center and so as to extend to edges on the outer peripheral side of the arc extinguishing plate 15. Thus, hot gases are diffused as indicated by the black arrows 31, and a hot gas passing around from a side is received by one of the bent portions, whereby the hot gas can be diffused in a radial pattern to the outer side of the arc extinguishing plate 15.

[0046] By the above features, backflow of the hot gases generated owing to the divided arc 23 can be prevented, and the hot gases can be diffused to the outer side of the arc extinguishing plate 15. Therefore, the hot gases can be ejected to the vicinity of a housing of the arc extinguishing chamber 14. Consequently, restriking of an arc can be prevented, and an interruption characteristic of the DC circuit breaker 100 can be improved.

[0047] In the present embodiment 1, each interrupting portion 30 having a bent shape is formed on the lower surface of the insulating plate 13 with use of the same resin material as that of the insulating plate 13. However, the present disclosure is not limited thereto. The same advantageous effects can be obtained also by making an interrupting portion 30 having a linear or bent projecting shape with use of a different insulating material and attaching the interrupting portion 30 to the insulating plate 13 by pasting or screwing.

[0048] In addition, although a configuration in which the interrupting portions 30 are attached to the lower surface of the insulating plate 13 of each arc extinguishing plate 15 has been described in the present embodiment, the same advantageous effects can be obtained even when an interrupting portion 30 having a linear or bent projecting shape is formed on the upper surface of the insulating plate 13.

[0049] In addition, although each interrupting portion 30 is formed on the insulating plate 13 with use of an insulating material in the present embodiment 1, it is also possible to: form an interrupting portion 30 having a linear or bent projecting shape on each grid 12 of the arc extinguishing plate 15 with use of a metal material; and bring side surfaces of the interrupting portion 30 into close contact with the grid by welding to fix the interrupting portion 30. Alternatively, the interrupting portion 30 can be formed also by half-blanking the grid 12 through press working.

[0050] Further, although the arc extinguishing chamber 14 in which each arc extinguishing plate 15 composed of the insulating plate 13 and the grids 12 is disposed horizontally has been used in the present embodiment 1, the same advantageous effects can be obtained by forming the interrupting portions 30 on the insulating plate

13 or the grids 12 in the same manner, also in an arc extinguishing chamber 14 in which each arc extinguishing plate 15 composed of the insulating plate 13 and the grids 12 is disposed in the vertical direction as in a DC circuit breaker 101 shown in a cross-sectional view in FIG. 8.

[0051] FIG. 9 shows the flows of hot gases and an arc 22 having travelled to the intervals between the arc extinguishing plates 15 disposed in the vertical direction.

[0052] An arc 20 having emerged upon opening between the fixed contact 1 and the movable contact 3 moves and travels into the opening portion at the center in FIG. 9. The arc 22 is influenced by the flows of hot gases and the electromagnetic forces of the grids 12 of each arc extinguishing plate 15 and moves along the white arrow 32 which indicates the travel of the arc 22 in FIG. 9. Consequently, the arc 22 turns into a divided arc 23.

[0053] Further, hot gases generated by the arc 23 and having high electrical conductivity can be moved along the surface of the arc extinguishing plate 15 and diffused in a radial pattern, as indicated by the black arrows 31 which indicate the flows of the hot gases.

[0054] In the present embodiment 1, the interrupting portions 30 having the bent portions disposed so as to face each other have been used. In addition, an example has been shown in which four interrupting portions 30 originating from edges of the opening at the center and extending to edges on the outer peripheral side are used on one arc extinguishing plate 15. However, since the important point about the interrupting portions 30 formed on the arc extinguishing plate 15 is to move hot gases to the outer side, the shape of each interrupting portion 30 is not limited to a bent shape and a projecting shape in the form of a line. Specifically, a cylindrical shape, a prismatic shape, or the like having proportions that greatly differ in the longitudinal direction and the lateral direction may be employed, and the interrupting portion 30 does not necessarily have to be so long as to extend to an edge on an outer peripheral side. Furthermore, the number of the interrupting portions 30 is also not limited to four and only has to be one or more.

Embodiment 2

[0055] In embodiment 1, an example has been shown in which: the plurality of arc extinguishing plates 15 each obtained by superposing the insulating plate 13 and the grids 12 are disposed in the arc extinguishing chamber 14; and the interrupting portions 30 are formed on a surface of the insulating plate 13 or each grid 12.

[0056] The present embodiment is basically the same as embodiment 1 in that each interrupting portion 30 is formed so as to originate from an edge of the opening at the center. Meanwhile, the present embodiment is characterized in that interrupting portions 33 are formed so as to be in contact with side surfaces of the fixed-side arc runner 10 and the movable-side arc runner 11.

[0057] FIG. 10 is a perspective view of an arc extinguishing plate 15 at a lowermost stage connected to the fixed-side arc runner 10 and the movable-side arc runner 11. FIG. 10 shows a state where the movable contact 3, the movable element 4, and the upper conductor 6 are disposed beneath the arc runners.

[0058] The fixed-side arc runner 10 and the movable-side arc runner 11 are fixed to a surface of the arc extinguishing plate 15 such that a part of each arc runner protrudes to the said surface. The interrupting portions 33 having bent shapes are disposed in a radial pattern on the surface of the insulating plate 13 such that end portions of the interrupting portions 33 are connected to the protruding portions of the arc runners.

[0059] An arc 20 having emerged upon opening between the movable contact 3 and the fixed contact (not shown) is transferred between the arc runners, and an arc 22 having travelled to a location on the arc extinguishing plate 15 at the lowermost stage shown in FIG. 10 moves in a direction toward the outer periphery owing to the flows of hot gases and electromagnetic force of each grid 12 in the same manner as in FIG. 7. Consequently, the arc 22 turns into a divided arc 23. Further, the arc 23 generates hot gas having high electrical conductivity which is prevented by the interrupting portion 33 from flowing back, to be diffused in a radial pattern in the direction toward the periphery of the insulating plate 13 of the arc extinguishing plate 15.

[0060] By the above features, backflow of the hot gases generated owing to the divided arc 23 can be prevented, and the hot gases can be diffused to the outer side of the insulating plate 13 of the arc extinguishing plate 15. Therefore, the hot gases can be ejected to the vicinity of the housing of the arc extinguishing chamber 14. Further, in the present embodiment, a region in the vicinity of each arc runner is a region in which the arc 22 travels at high speed, and thus the effect of preventing the backflow can also be notably obtained. Consequently, restrike of an arc can be prevented, and the interruption characteristic of the DC circuit breaker 100 can be improved.

[0061] In the present embodiment, an example has been shown in which the interrupting portions 33 are formed on the insulating plate 13, at the lowermost stage in the arc extinguishing chamber 14, which is connected to the arc runners. However, the present disclosure is not limited thereto, and the same advantageous effects can be obtained also by forming the interrupting portions 33 on the grids 12.

[0062] In addition, the disposition locations for the interrupting portions 33 are not limited to such locations that the interrupting portions 33 are in contact with side surfaces of the arc runners, and only has to be locations near the arc runners. Thus, the same advantageous effects are exhibited also by forming the interrupting portions 33 on the inner wall of the arc extinguishing chamber 14 retaining the fixed element 2 and the movable element 4 or on a frame portion forming a circuit breaker body.

[0063] In addition, if the interrupting portions 30 formed

on the arc extinguishing plate 15 disposed in the arc extinguishing chamber 14 described in embodiment 1 and the interrupting portions 33 disposed on the arc extinguishing plate 15 at the lowermost stage described in the present embodiment so as to be in contact with the side surfaces of the arc runners are used together, restrike of an arc can be further prevented, and the interruption characteristic of the DC circuit breaker 100 can be improved.

[0064] Although the disclosure is described above in terms of various exemplary embodiments and implementations, it should be understood that the various features, aspects, and functionality described in one or more of the individual embodiments are not limited in their applicability to the particular embodiment with which they are described, but instead can be applied, alone or in various combinations to one or more of the embodiments of the disclosure.

[0065] It is therefore understood that numerous modifications which have not been exemplified can be devised without departing from the technical scope of the specification of the present disclosure. For example, at least one of the constituent parts may be modified, added, or eliminated. At least one of the constituent parts mentioned in at least one of the preferred embodiments may be selected and combined with the constituent parts mentioned in another preferred embodiment.

DESCRIPTION OF THE REFERENCE CHARACTERS

[0066]

1	fixed contact
2	fixed element
3	movable contact
4	movable element
5	closing actuator
6	upper conductor
7	lower conductor
8	detector
9	latch
10	fixed-side arc runner
11	movable-side arc runner
12	grid
13	insulating plate
14	arc extinguishing chamber
15	arc extinguishing plate
16	interruption mechanism portion
20 to 23	arc
30	interrupting portion
33	interrupting portion
100, 101	DC circuit breaker

Claims

1. A DC circuit breaker comprising:

an interruption mechanism portion configured to

perform opening between a fixed contact and a movable contact, to interrupt DC current;
an arc extinguishing plate obtained by superposing an insulating plate and a grid which has electrical conductivity and has a plate shape; and

an arc extinguishing chamber in which a plurality of the arc extinguishing plates are accommodated in a stacked state at fixed intervals such that edges of the arc extinguishing plates are located above the fixed contact and the movable contact, wherein

an interrupting portion having a projecting shape is disposed on either surface of each arc extinguishing plate so as to originate from an edge of the arc extinguishing plate.

2. The DC circuit breaker according to claim 1, wherein a plurality of the interrupting portions are disposed mutually in a radial pattern.
3. The DC circuit breaker according to claim 2, wherein the plurality of the interrupting portions are disposed on a surface of the grid formed on each arc extinguishing plate or an opposite surface, of the arc extinguishing plate, that corresponds to a region in which the grid is formed.
4. The DC circuit breaker according to claim 3, wherein

a projecting portion is disposed in addition to the interrupting portions, and
the projecting portion is disposed in a region, on the arc extinguishing plate, in which the grid is not formed.
5. The DC circuit breaker according to claim 2, wherein each arc extinguishing plate is accommodated in the arc extinguishing chamber such that a surface of the arc extinguishing plate is oriented in a horizontal direction.
6. The DC circuit breaker according to claim 5, wherein

the arc extinguishing plate has an opening at a center portion thereof,
an edge, of the arc extinguishing plate, that delimits the opening is located above the fixed contact and the movable contact, and
the plurality of the interrupting portions are disposed mutually in a radial pattern so as to originate from the edges.
7. The DC circuit breaker according to claim 6, wherein the plurality of the interrupting portions have shapes of bent lines and are disposed such that bent portions thereof face each other.

8. The DC circuit breaker according to claim 2, wherein each arc extinguishing plate is accommodated in the arc extinguishing chamber such that a surface of the arc extinguishing plate is oriented in a vertical direction. 5
9. A DC circuit breaker comprising:
an interruption mechanism portion configured to perform opening between a fixed contact and a movable contact, to interrupt DC current; 10
an arc extinguishing plate obtained by superposing an insulating plate and a grid which has electrical conductivity and has a plate shape, the arc extinguishing plate having a surface oriented in a horizontal direction; and 15
an arc extinguishing chamber in which the arc extinguishing plate has an opening at a center portion thereof, and a plurality of the arc extinguishing plates are accommodated in a stacked state at fixed intervals such that edges that delimit the openings are located above the fixed contact and the movable contact, wherein 20
a fixed-side arc runner and a movable-side arc runner which are fixed and protrude from the opening of the arc extinguishing plate at a lowermost stage, have side surfaces on which an interrupting portion having a projecting-shape side surface brought into close contact with a surface of the arc extinguishing plate is disposed such that ends of the interrupting portion are in contact with the side surfaces of the fixed-side arc runner and the movable-side arc runner. 25 30
10. The DC circuit breaker according to any one of claims 1 to 9, wherein the interrupting portion is made of a same resin as a resin of the insulating plate. 35
11. The DC circuit breaker according to any one of claims 1 to 9, wherein the interrupting portion is made through a step of half-blanking a grid made of metal. 40
12. The DC circuit breaker according to any one of claims 1 to 9, wherein 45
the interrupting portion is made of metal and attached to either surface of each arc extinguishing plate by welding.
13. The DC circuit breaker according to any one of claims 1 to 9, wherein the interrupting portion is attached to either surface of each arc extinguishing plate by screwing. 50

55

FIG.1

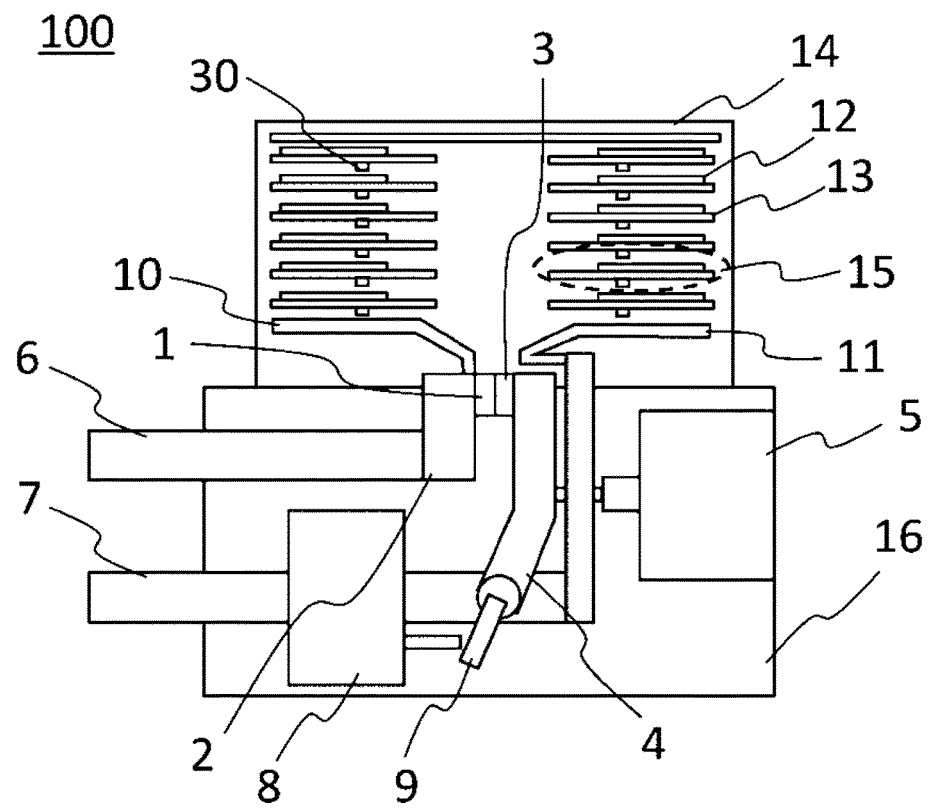


FIG.2

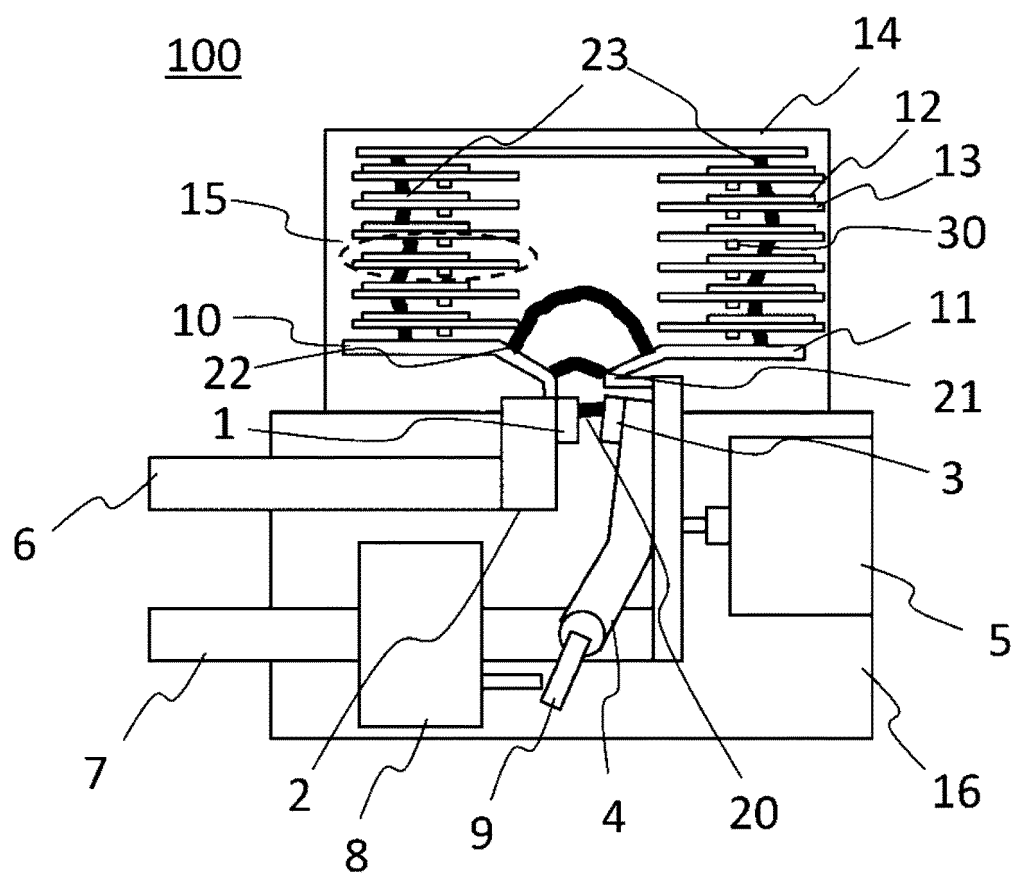


FIG.3

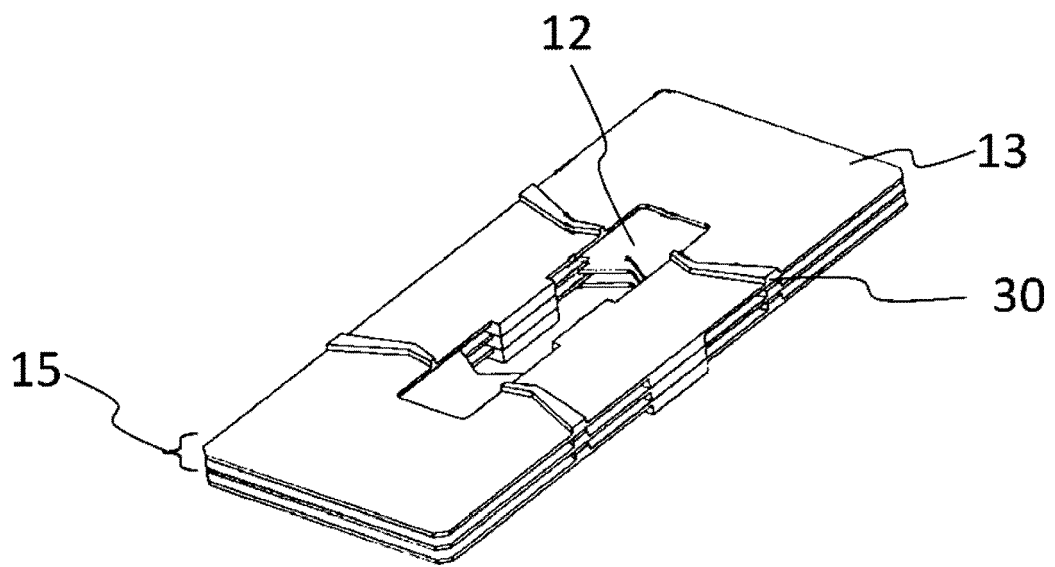


FIG.4

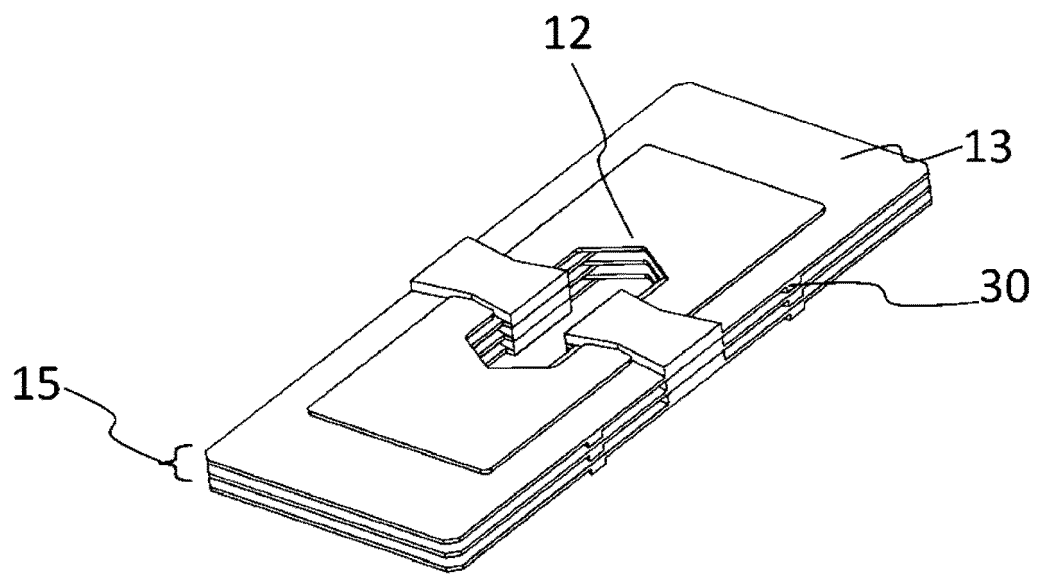


FIG.5

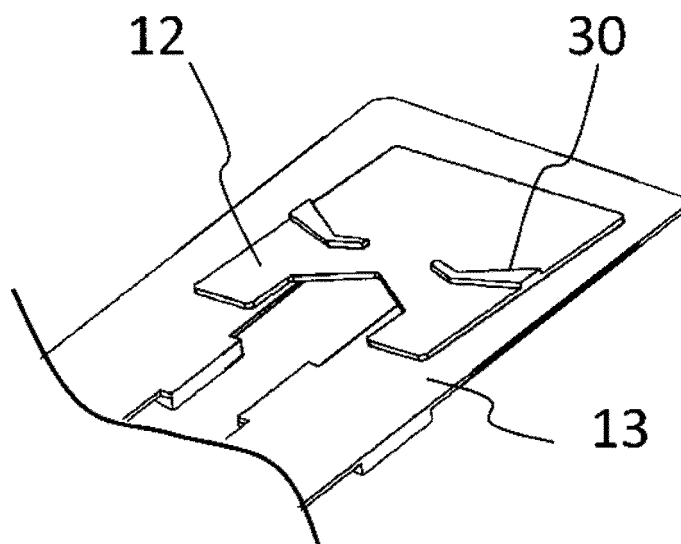


FIG.6

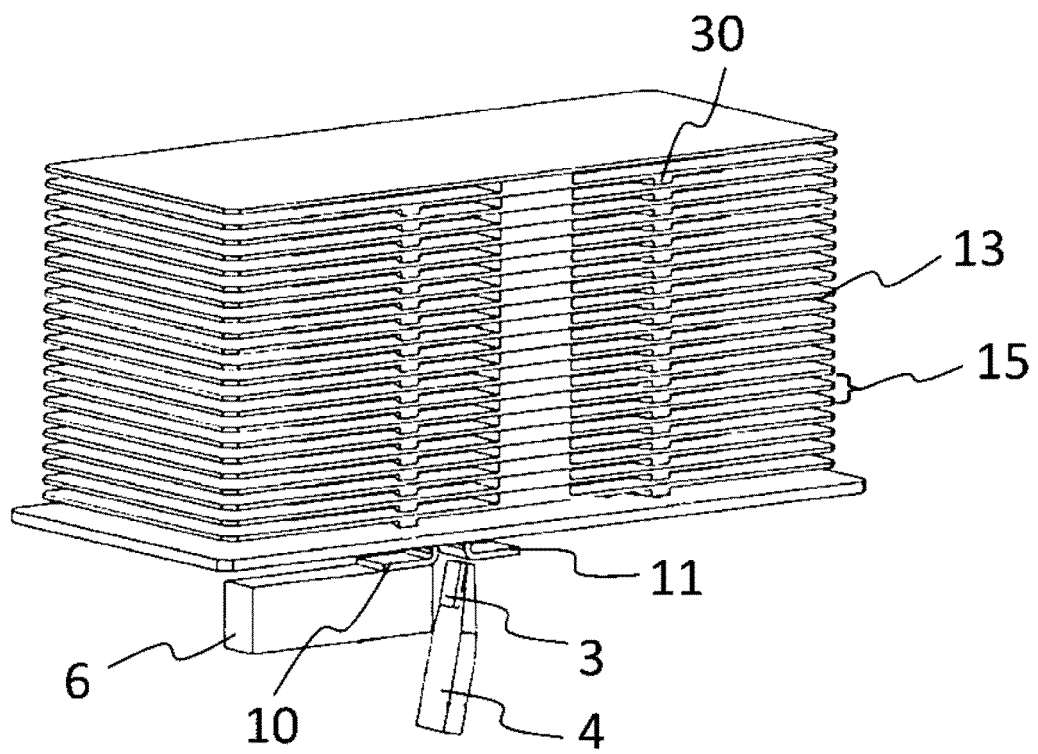


FIG.7

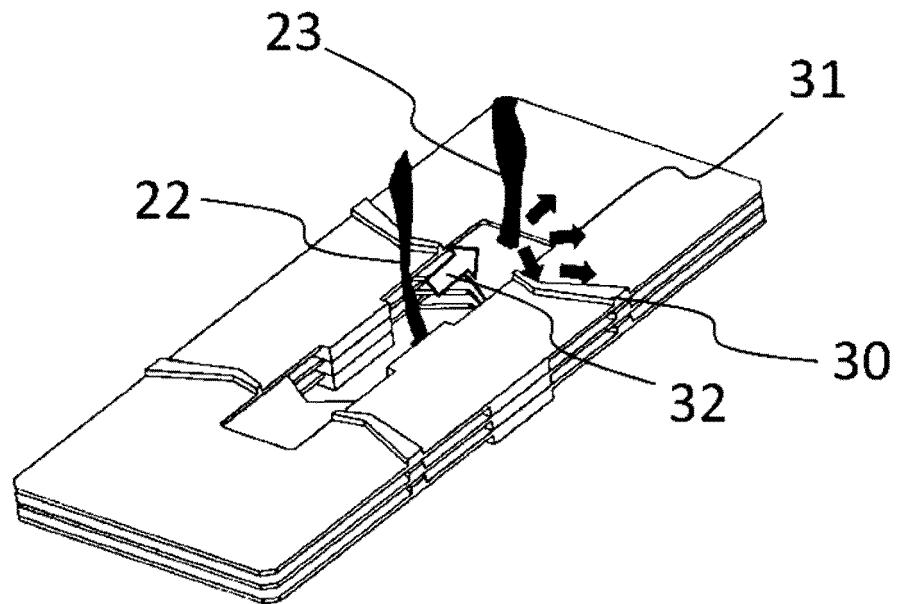


FIG.8

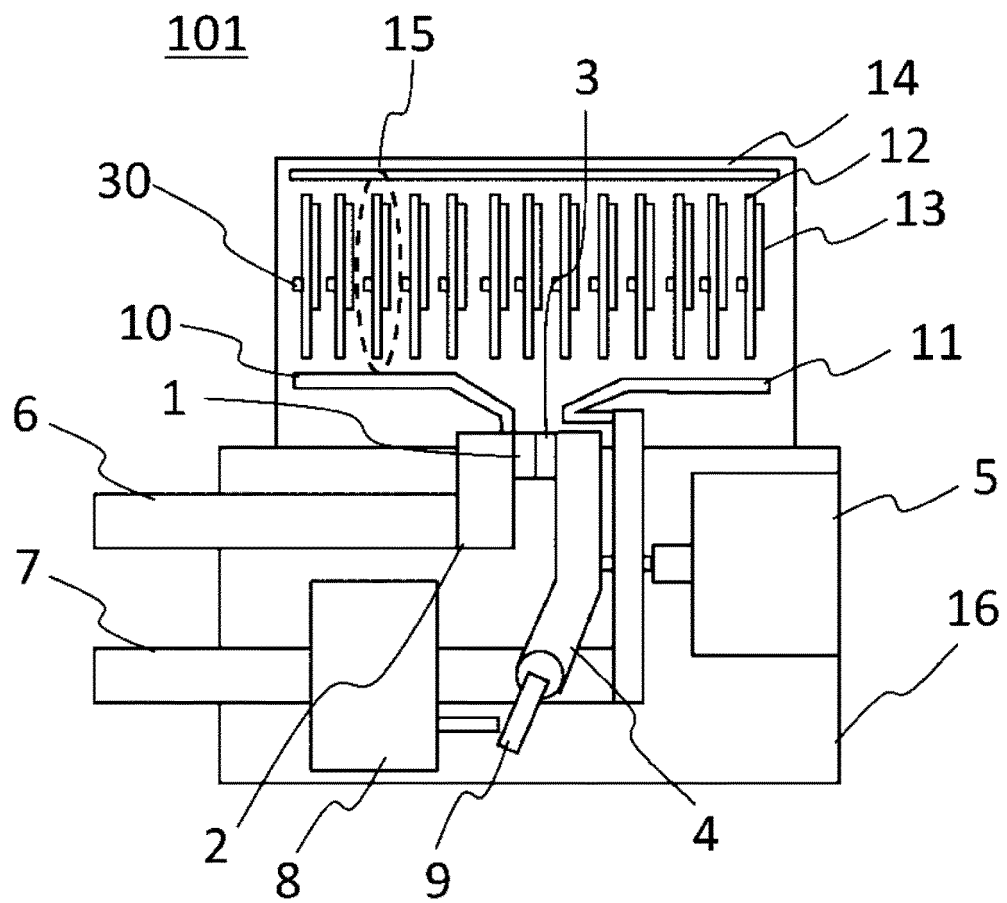


FIG.9

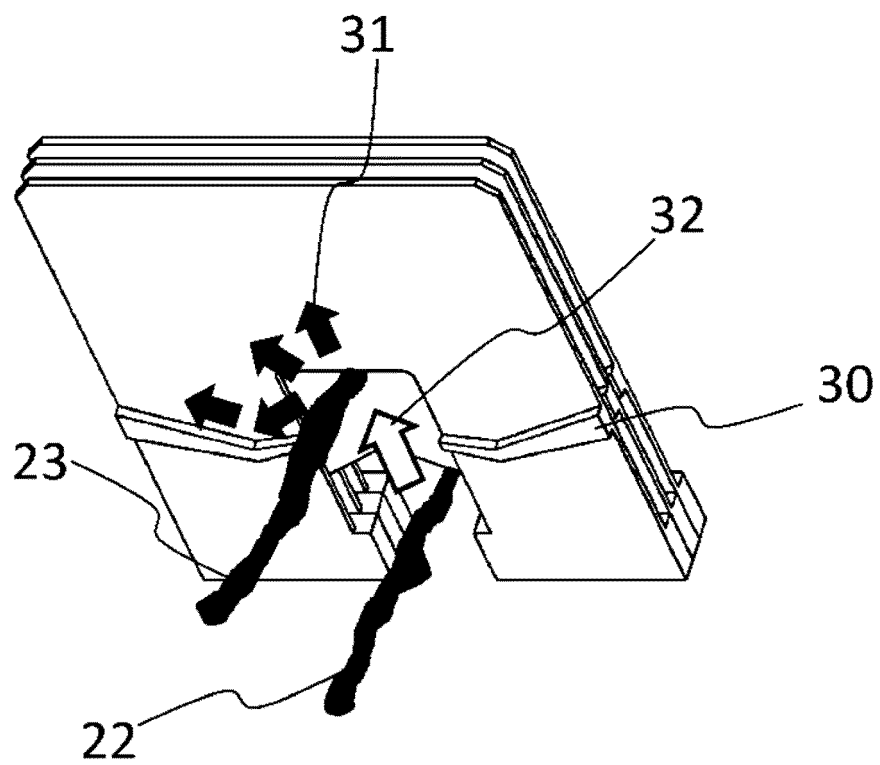
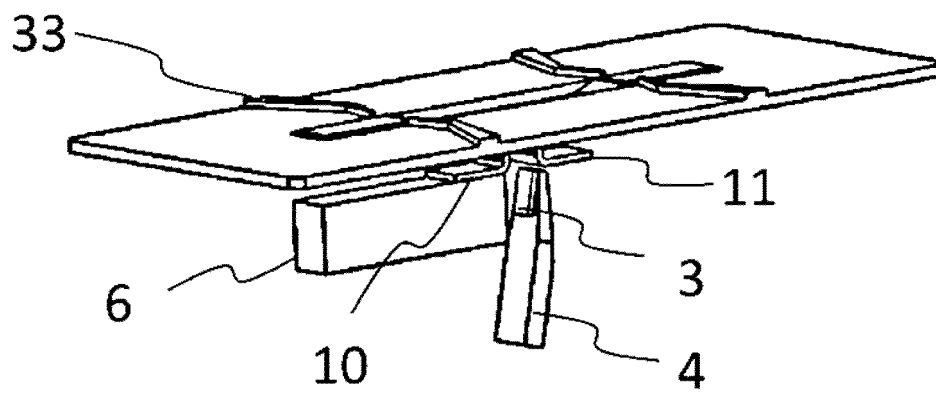


FIG.10



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/019864

A. CLASSIFICATION OF SUBJECT MATTER

H01H 73/18 (2006.01) i; H01H 33/08 (2006.01) i
FI: H01H33/08; H01H73/18 B

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)
H01H73/18; H01H33/08

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	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2003-168349 A (ENERGY SUPPORT CO., LTD.) 13.06.2003 (2003-06-13) paragraphs [0011]-[0048], fig. 1-7	1-6, 8, 10-11 7, 9, 12-13
Y	JP 63-257138 A (MITSUBISHI ELECTRIC CORP.) 25.10.1988 (1988-10-25) page 2, upper right column, line 5 to page 2, lower left column, line 9, page 3, upper right column, line 1 to page 3, lower right column, line 17, page 4, upper right column, line 11 to page 4, lower left column, line 8, fig. 1, 8-9	1-6, 8, 10-11
Y	JP 63-108623 A (MITSUBISHI ELECTRIC CORP.) 13.05.1988 (1988-05-13) page 3, upper left column, line 3 to page 3, upper right column, line 2, page 4, lower left column, line 5 to lower left column, line 11, fig. 1-2, 9	11
A	JP 6516078 B1 (MITSUBISHI ELECTRIC CORP.) 22.05.2019 (2019-05-22)	1-13



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 application or patent 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
05 August 2020 (05.08.2020)

Date of mailing of the international search report
25 August 2020 (25.08.2020)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2020/019864

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 2003-168349 A	13 Jun. 2003	(Family: none)	
JP 63-257138 A	25 Oct. 1988	(Family: none)	
JP 63-108623 A	13 May 1988	US 5003137 A	
		column 21, line 7 to	
		column 21, line 30,	
		fig. 55-56	
		EP 269750 A1	
		KR 10-1988-7001451 A	
JP 6516078 B1	22 May 2019	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 61190828 A [0004]
- JP 62082616 A [0004]