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(71) Applicant: **Mitsubishi Electric Corporation**
Chiyoda-ku
Tokyo 100-8310 (JP)

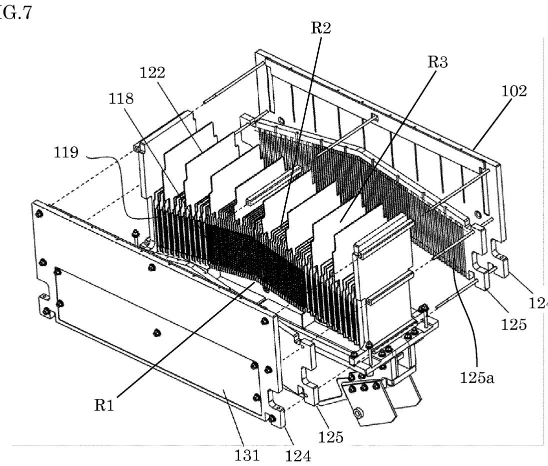
(72) Inventors:
- **NAKATA Tomohiro**
Tokyo 100-8310 (JP)
- **TOHYA Nobumoto**
Tokyo 100-8310 (JP)

(74) Representative: **Moore, Graeme Patrick et al**
Mewburn Ellis LLP
City Tower
40 Basinghall Street
London EC2V 5DE (GB)

(54) DC HIGH-SPEED CIRCUIT BREAKER

(57) The present invention is to provide a DC high-speed circuit breaker in which a high interruption performance can be obtained even from a large current to a small current. The arc chute includes: first insulation side plates which are arranged so as to sandwich the fixed main contact and the movable main contact from both sides, and form a first arc gas flow passage through which arc gas generated at the fixed main contact and the movable main contact is led to the outside of the arc chute; a plurality of grids which are arranged on the upper side of the fixed main contact and the movable main contact , and form a second arc gas flow passage, the second arc gas flow passage being configured to be a larger width than the space between the first insulation side plates, being communicated to the first arc gas flow passage, and having a larger sectional area than the sectional area of the first arc gas flow passage; and second insulation side plates which are arranged so as to sandwich the grids from both sides, and forms a third arc gas flow passage on the upper side of the grids, the third arc gas flow passage being communicated to the second arc gas flow passage and having a larger sectional area than the sectional area of the second arc gas flow passage.

FIG.7



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Description

TECHNICAL FIELD

[0001] The present invention relates to DC high-speed circuit breakers for use as, for example, protection circuit breakers and the like for railway substations and, more particularly, relates to an arc chute structure.

BACKGROUND ART

[0002] There has been a direct current (DC) high-speed circuit breaker as a protection circuit breaker for a railway substation. In the DC high-speed circuit breaker, an arc generated between arc contacts during current interruption is made to commutate to an arc runner arranged at an upper portion of the arc contacts; the arc is led and remained to iron plates referred to as grids arranged at an upper portion of an arc chute in a short time by making the arc travel on the arc runner; and a higher arc voltage than a power source voltage is generated by an electrode drop due to an increase in arc resistance by arc extension and due to dividing by the grids and a fault current is limited; whereby interruption needs to be performed by forcibly creating a current zero point.

[0003] On the other hand, an extremely high temperature arc melts the peripheral arc contacts and the arc runner and generates a highly conductive arc gas. The arc has a property that is easily short-circuited at a highly conductive place; and accordingly, if the arc gas is remained or flows in between main contacts, the arc led to the grids causes a reignition of arc which regenerate s an arc between the main contacts. If the reignition of arc occurs, the arc voltage increased to equal to or higher than the power source voltage is rapidly dropped to near 100 V; and accordingly, the current-limiting is interrupted and interruption performance is deteriorated. Furthermore, at worst, the arc is continuously short-circuited between the contacts and an interruption failure is likely to be made. Thus, in order to lead the arc to the grids in a short time and to reliably interrupt, the arc gas is made to move smoothly from the contact to the grids to discharge efficiently from an opening portion at the upper portion of the arc chute, and the arc needs to be remained by the grids.

[0004] In addition, the DC high-speed circuit breaker needs to have performance that can interrupt a small current. However, since electromagnetic force that is for driving and elongating the arc is weak in a small current region and the arc does not travel to the end of an arcing horn, the interruption cannot be made unless the electromagnetic force is enhanced or the arc voltage has to be raised within a limited travel region. Thus, the DC high-speed circuit breaker needs to have performance that can interrupt a wide current region from a large current to the small current.

[0005] For example, there is a structure disclosed in Patent Document 1 (JP-U H6 (1994)-060944) as the conventional DC high-speed circuit breaker. As shown in FIGS. 22A, 22B, in order to control arc gas and to improve interruption performance, for example, in an arc chute AS which is installed so as to enter an arcing horn AH in a lower portion of the arc chute AS, a passing through groove 17 is provided at a position of each side plate 131, 132, the position being lower than the arcing horn AH; a barrier insulation plate 18 is attachably/detachably provided through the passing through groove 17; an arc is prevented from being blown-out downward to prevent the arc from causing a ground fault to lower devices of the arc chute AS; and pressure between the arcing horn AH and the insulation plate 18 is enhanced to improve the interruption performance.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0006] Patent Document 1: JP-U H6(1994)-060944

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0007] In order to reliably interrupt a fault current, the aforementioned conventional DC high-speed circuit breaker needs to make the arc gas smoothly move from the contact to the grids and efficiently discharge from an opening portion of an upper portion of the arc chute. In order to make the arc gas flow efficiently and easily to the upper direction of the arc chute from the contact to the grids, the sectional area of the opening portion through which the arc gas is carried needs to be gradually enlarged as the arc gas moves to the upper portion of the arc chute.

[0008] Furthermore, since the amount of generated arc gas also increases if the current increases, it is necessary to increase the sectional area of the opening portion and to improve the amount of gas discharge from the opening portion of the upper portion of the arc chute in order to also prevent the arc gas from entering into a contact portion from a grid portion in a large current region.

[0009] However, the conventional arc chute is constant in thickness from the lower portion to the upper portion and the sectional area of the opening portion is decreased if the grids are arranged; and accordingly, the arc gas is difficult to flow to the upper portion of the arc chute. Furthermore, since the opening area of the upper portion of the arc chute is also small, a problem exists in that the arc gas is reversely entered from the grid portion to the contact portion to cause a reignition of arc in the large current region.

[0010] Besides, in order to obtain a high interruption performance in the DC high-speed circuit breaker, an arc voltage when the arc gas reaches the grid portion has to be maintained constant until the interruption is completed. The number of plates of the grid and the length of the arc serve as elements for deciding the arc voltage and the arc voltage can be adjusted by the number of plates of the grid.

[0011] However, if the number of plates of the grid is reduced, the space between the adjacent grids is elongated. As for ease of starting an arc discharge, it becomes easy to discharge as a distance to an object to be discharged is shorter, and it becomes difficult to discharge as the distance is longer. Accordingly, if the grid space is elongated, it becomes difficult to discharge between the grids, a reignition of arc occurs at the contact portion whose insulation distance is short; or since there exists a highly conductive arc gas discharged from the arc chute in the upper portion of the arc chute, a bridging phenomenon, in which the arc is short-circuited at the upper portion of the arc chute via this arc gas, is likely to be caused. If the bridging phenomenon occurs, not only the arc voltage cannot be maintained constant, but also the arc voltage necessary for interruption cannot be secured and an interruption failure occurs. Thus, in order to remain the arc in a portion where the grids are arranged, it is important to create a state where the arc discharge occurs most easily between the grids.

[0012] On the other hand, if the space between the grids is shortened, the number of plates of the grid is increased and the arc voltage becomes higher than a standard value; and accordingly, a problem exists in that it becomes difficult to achieve two conditions of an optional arc voltage and a stable keeping.

[0013] As described above, in the case of a method in which the arc is made to travel on the arcing horn and the arc is made to be divided by the grids to enhance the arc voltage and the fault current is current-limited and interrupted, Lorentz force that makes the arc travel is large in the large current region; and therefore, the arc is made to travel on the end of the arcing horn and the arc can be divided by all the arranged grids. However, since electromagnetic force that is for making the arc travel is small in the case of the small current, a problem exist in that the arc cannot be traveled to the end of the arcing horn and the arc cannot be divided by all the grids.

[0014] In addition, since the electromagnetic force to be exerted on the arc is small in the small current, the arc cannot be traveled to the end of the arcing horn and it is difficult to enlarge and prolong the arc to raise the arc voltage to the power source voltage; and accordingly, the interruption failure may be occurred. Thus, in order to improve the electromagnetic force, a pole plate needs to be arranged on the lateral surface of the arc chute to improve performance of small current interruption.

[0015] However, if the magnetic pole plate is arranged on the lateral surface of the arc chute, a part of the arc gas is blown out in the direction of the outside of the arc chute during large current interruption, and there is a case where the arc is short-circuited at the magnetic pole plate via the arc gas and the interruption failure occurs.

[0016] The present invention has been made to solve the above described problem, and an object of the present invention is to provide a DC high-speed circuit breaker in which an arc voltage is maintained constant by preventing a reignition of arc between contacts and a bridging at an upper portion of an arc chute and a high interruption performance can be obtained even from a large current to a small current.

MEANS FOR SOLVING THE PROBLEMS

[0017] According to the present invention, there is provided a DC high-speed circuit breaker including: an arc chute in which an arc extinguishing space is formed; a fixed main contact arranged on the lower side of the arc chute; and a movable main contact which is arranged on the lower side of the arc chute and is connected/disconnected to/from the fixed main contact. In the DC high-speed circuit breaker, the arc chute includes: first insulation side plates which are arranged so as to sandwich the fixed main contact and the movable main contact from both sides, and form a first arc gas flow passage through which arc gas generated at the fixed main contact and the movable main contact is led to the outside of the arc chute; a plurality of grids which are arranged on the upper side of the fixed main contact and the movable main contact , and form a second arc gas flow passage, the second arc gas flow passage being configured to be a larger width than the space between the first insulation side plates, being communicated to the first arc gas flow passage, and having a larger sectional area than the sectional area of the first arc gas flow passage; and second insulation side plates which are arranged so as to sandwich the grids from both sides, and forms a third arc gas flow passage on the upper side of the grids, the third arc gas flow passage being communicated to the second arc gas flow passage and having a larger sectional area than the sectional area of the second arc gas flow passage.

ADVANTAGEOUS EFFECT OF THE INVENTION

[0018] According to the DC high-speed circuit breaker according to the present invention, the arc chute includes: the first insulation side plates and first magnetic pole plates, which form the first arc gas flow passage through which the arc gas generated at the fixed main contact and the movable main contact is led to the outside of the arc chute; the plurality of grids which are arranged on the upper side of the fixed main contact and the movable main contact , and form the second arc gas flow passage, the second arc gas flow passage being configured to be the larger width than the space between the first insulation side plates, being communicated to the first arc gas flow passage, and having the larger sectional area than the sectional area of the first arc gas flow passage; and second insulation side plates which are arranged so as to sandwich the grids from both sides, and forms the third arc gas flow passage on the upper side of the grids, the third arc gas flow passage being communicated to the second arc gas flow passage and having the larger sectional area than the sectional area of the second arc gas flow passage, whereby the arc gas is made to easily flow to an upper portion of the arc chute, air discharge performance of the arc gas is improved to be able to suppress a reignition of arc between the contacts, and a high interruption performance can be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a side sectional view showing a contact closure state in a DC high-speed circuit breaker according to Embodiment 1 of the present invention;
FIG. 2 is a side sectional view showing that contacts are in a state during separation operation, in the DC high-speed circuit breaker according to Embodiment 1 of the present invention;
FIG. 3 is a perspective view showing an arc chute in the DC high-speed circuit breaker according to Embodiment 1 of the present invention;
FIG. 4 is a perspective view showing a flat plate grid and a U-shaped grid in the DC high-speed circuit breaker according to Embodiment 1 of the present invention;
FIG. 5 is a perspective view showing insulation plates in the DC high-speed circuit breaker according to Embodiment 1 of the present invention;
FIG. 6A is a front view and FIG. 6B is a side view, which show the insulation plate, the flat plate grid, and the U-shaped grid in the DC high-speed circuit breaker according to Embodiment 1 of the present invention;
FIG. 7 is a perspective exploded view showing an upper portion of the arc chute in the DC high-speed circuit breaker according to Embodiment 1 of the present invention;
FIG. 8 is a perspective exploded view showing a lower portion of the arc chute in the DC high-speed circuit breaker according to Embodiment 1 of the present invention;
FIG. 9A is a front exploded view and FIG. 9B is a side exploded view, which show the lower portion of the arc chute in the DC high-speed circuit breaker according to Embodiment 1 of the present invention;
FIG. 10A is a front sectional view of the arc chute and FIG. 10B is a sectional view taken along the line A-A, which show the relationship between a flow of arc gas and an opening portion of the arc chute in the DC high-speed circuit breaker according to Embodiment 1 of the present invention;
FIG. 11 is a characteristic view showing the relationship between the opening sectional area of the opening portion and a position of the arc chute, which is ease of the arc gas flow in the arc chute, in the DC high-speed circuit breaker according to Embodiment 1 of the present invention;
FIG. 12 is relevant part front views each showing the relationship between an arc discharge and an arc voltage in a grid arrangement portion of an arc chute in a DC high-speed circuit breaker according to Embodiment 2 of the present invention;
FIG. 13 is a front view showing ease of remaining an arc in an arc chute in a DC high-speed circuit breaker according to Embodiment 3 of the present invention;
FIG. 14 is a front view showing the arrangement of an arc during a small current, flat plate grids, and U-shaped grids in an arc chute in a DC high-speed circuit breaker according to Embodiment 4 of the present invention;
FIG. 15 is a characteristic view showing electromagnetic force in which an arc in the arc chute receives from an arcing horn serving as a current conduction conductor, in the DC high-speed circuit breaker according to Embodiment 4 of the present invention;
FIG. 16 is a characteristic view showing electromagnetic force to be exerted on the arc in the arc chute in the DC high-speed circuit breaker according to Embodiment 4 of the present invention;
FIG. 17A is a front view and FIG. 17B is a side view, which show effects of a magnetic pole plate in a DC high-speed circuit breaker according to Embodiment 5 of the present invention;
FIG. 18A is a front view and FIG. 18B is a side view, which show U-shaped grids in a DC high-speed circuit breaker according to Embodiment 6 of the present invention;
FIG. 19A is a front view and FIG. 19B is a side view, which show magnetic pole plates in a DC high-speed circuit breaker according to Embodiment 7 of the present invention;
FIG. 20 is a perspective view showing a conventional DC high-speed circuit breaker;
FIG. 21A is a front view and FIG. 21B is a sectional view taken along the line B-B, which show the conventional DC high-speed circuit breaker; and
FIG. 22A is a front view and FIG. 22B is a sectional view, which show other conventional DC high-speed circuit breaker.

MODE FOR CARRYING OUT THE INVENTION

Embodiment 1.

[0020] Hereinafter, Embodiment 1 of the present invention will be described with reference to FIG. 1 to FIG. 11. Then, in each of the drawings, identical or equivalent members and portions will be described with the same reference numerals (and letters) assigned thereto. FIG. 1 is a side sectional view showing a contact closure state in a DC high-speed circuit breaker according to Embodiment 1 of the present invention. FIG. 2 is a side sectional view showing that contacts are in a state during separation operation, in the DC high-speed circuit breaker according to Embodiment 1 of the present invention.

[0021] First, the configuration of the DC high-speed circuit breaker will be described by FIG. 1. In a DC high-speed circuit breaker 101, when a current is conducted, a fixed main contact 105, which is arranged on a lower portion of an arc chute 102 formed with an arc extinguishing space and is connected to an upper conductor 103, comes in contact with a movable main contact 107, which is connected to a movable element 106 connected to a lower conductor 104 arranged on the lower side of upper conductor 103; and the movable element 106 is made to conduct a current via the upper conductor 103 and the lower conductor 104.

[0022] When a current is interrupted, and if a fault current flows, an overcurrent detector 108 arranged on the lower conductor 104 detects an overcurrent and is operated; and when the current is conducted, the movable element 106 is rotated in a clockwise direction centering on a rotating shaft 110 to perform an opening operation by releasing a latch 109 that holds the movable element 106. The fixed main contact 105 and the movable main contact 107 are stored in the inside of the arc chute 102. Then, an arc contact, at which an arc K is generated during interruption, is arranged on an upper portion of the fixed main contact 105 and the movable main contact 107; and the arc contact is composed of a fixed side arc contact 111 and a movable side arc contact 112.

[0023] The fixed side arc contact 111 and the movable side arc contact 112 are separated after separation of the fixed main contact 105 and the movable main contact 107 in an opening operation, thereby preventing the arc K from being generated at the fixed main contact 105 and the movable main contact 107 and preventing these main contacts from being melted, whereby the fixed main contact 105 and the movable main contact are protected.

[0024] An arcing horn by which the generated arc K is commutated and is led to the upper portion of the arc chute 102 is arranged on an upper portion of the fixed side arc contact 111 and the movable side arc contact 112. The arcing horn is composed of a fixed side arcing horn 113 and a movable side arcing horn 114.

[0025] A plurality of grids 115a, which are made of a thin sheet-shaped magnetic body having magnetic properties and are for current-limiting and interrupting by enhancing an arc voltage by an electrode drop voltage and extension of the length of the arc, are arranged on the upper side of the arc chute 102. An air discharge opening 116 which is for discharging the arc gas to the outside of the arc chute 102 is provided on the upper portion side of a grid assembly 115 of the grids 115a.

[0026] Next, the configuration of the arc chute in the DC high-speed circuit breaker according to Embodiment 1 of the present invention will be described with reference to FIG. 3 to FIGS. 9A, 9B. FIG. 3 is a perspective view showing the arc chute in the DC high-speed circuit breaker according to Embodiment 1 of the present invention. FIG. 4 is a perspective view showing a flat plate grid and a U-shaped grid in the DC high-speed circuit breaker according to Embodiment 1 of the present invention. FIG. 5 is a perspective view showing insulation plates in the DC high-speed circuit breaker according to Embodiment 1 of the present invention. FIG. 6A is a front view and FIG. 6B is a side view, which show the insulation plate, the flat plate grid, and the U-shaped grid in the DC high-speed circuit breaker according to Embodiment 1 of the present invention. FIG. 7 is a perspective exploded view showing the upper portion of the arc chute in the DC high-speed circuit breaker according to Embodiment 1 of the present invention. FIG. 8 is a perspective exploded view showing the lower portion of the arc chute in the DC high-speed circuit breaker according to Embodiment 1 of the present invention. FIG. 9A is a front exploded view and FIG. 9B is a side exploded view, which show the lower portion of the arc chute in the DC high-speed circuit breaker according to Embodiment 1 of the present invention.

[0027] The arc chute 102 is composed of three constituent elements. As shown in FIG. 3, FIG. 8, and FIGS. 9A, 9B, a first element is a pair of first insulation side plates 123 which are arranged so as to sandwich the fixed main contact 105, the movable main contact 107, the fixed side arc contact 111, and the movable side arc contact 112 from both sides, and form a first arc gas flow passage R1 through which the arc gas generated at the fixed main contact 105 and the movable main contact 107 is led to the outside of the arc chute 102. As shown in FIG. 4, FIG. 7, FIGS. 9A, 9B, and FIGA. 10A, 10B, a second element is a plurality of grids composed of flat plate grids 118 and U-shaped grids 119, which are arranged on the upper side of the fixed main contact 105, the movable main contact 107, the fixed side arc contact 111, and the movable side arc contact 112, and form a second arc gas flow passage R2, the second arc gas flow passage R2 being configured to be a larger width than the space between the first insulation side plates 123, being communicated to the first arc gas flow passage R1, and having a larger sectional area than the sectional area of the first arc gas flow passage R1. As shown in FIG. 7 and FIGS. 10A, 10B, a third element is a pair of second insulation side plates 124, which are arranged so as to sandwich the flat plate grids 118 and the U-shaped grids 119 which constitute the grids from both sides, and form a third arc gas flow passage R3, the third arc gas flow passage R3 being communicated to the second arc gas flow passage R2 on the upper side of the flat plate grids 118 and the U-shaped grids 119 which constitute the grids, having a larger sectional area than the sectional area of the second arc gas flow passage R2, and being arranged to be a larger width than the width between the first insulation side plates 123. Then, the arc chute 102 is composed of these three constituent elements.

Incidentally, the width between the second insulation side plates 124 is configured to be larger width than the width between the first insulation side plates 123; and, for example, there is shown a case where the former width is about three times as much as the latter width as shown in FIGS. 10A, 10B.

[0028] As shown in FIG. 4 to FIG. 7, the flat plate grids 118 and the U-shaped grids 119, each of which is formed with a V-shaped notch 117 toward the fixed side arc contact 111 and the movable side arc contact 112 side, are arranged in the inside of the arc chute 102. The grids are constituted by the flat plate grids 118 and the U-shaped grids 119.

[0029] Furthermore, as shown in FIG. 5 and FIGS. 6A, 6B, an insulation plate 120 is arranged on the lateral surface of the thickness direction of the flat plate grid 118 in order to prevent the arc K from flying out from the flat plate grid 118; and the insulation plate 120 and an insulation plate 121 are arranged on the lateral surface of the U-shaped grid 119 in order to prevent the arc K from flying out from the U-shaped grid 119.

[0030] Further as shown in FIG. 5 to FIG. 7, a space insulation plate 122, which is arranged each time a plurality of groups of the grids composed of the flat plate grids 118 and the U-shaped grids 119 are arranged in a state extended to the upper side of the flat plate grids 118 and the U-shaped grids 119.

[0031] Then, as shown in FIG. 3, FIG. 7, FIG. 8, and FIGS. 9A, 9B, the second insulation side plates 124 are arranged so as to sandwich the flat plate grids 118, the U-shaped grids 119, the insulation plates 120, the insulation plates 121, and the space insulation plates 122 from both sides; elongated grooves 125a are formed on an insulation plate 125 arranged on the inner side of the second insulation side plate 124; and the flat plate grids 118, the U-shaped grids 119, the insulation plates 120, the insulation plates 121, and the space insulation plates 122 are fitted and fixed to these grooves 125a.

[0032] Furthermore, as shown in FIG. 8 and FIGS. 9A, 9B, an arc extinguishing material 126 that improves arc extinguishing performance by cooling the arc K during interruption is arranged on the inside of the first insulation side plates 123; and a first magnetic pole plate 127, which is arranged for improving electromagnetic force to be exerted on the arc K, is arranged in the inside of the first insulation side plate 123 that is placed on the outside of the arc extinguishing material 126, and is arranged so as to be covered by insulation plates 128, 129 which prevent the arc K from being short-circuited. In addition, a second magnetic pole plate 130, which is arranged for improving the electromagnetic force to be exerted on the arc K, is arranged in the inside of the second insulation side plate 124, and is arranged so as to be covered by an insulation plate 131 that prevents the arc K from being short-circuited.

[0033] Next, the relationship between a flow of the arc gas and an opening portion of the arc chute in the DC high-speed circuit breaker according to Embodiment 1 of the present invention will be described with reference to FIGS. 10A, 10B. The first arc gas flow passage R1 through which the arc gas generated at the fixed main contact 105 and the movable main contact 107 is led to the outside of the arc chute 102 is formed between the first insulation side plates 123; and as shown by an arrow K1, the arc gas is circulated in the first arc gas flow passage R1.

[0034] The arc gas circulated in the first arc gas flow passage R1 as shown by the arrow K1 is circulated in the second arc gas flow passage R2 between the flat plate grids 118 and between the U-shaped grids 119 as shown by an arrow K2, the second arc gas flow passage R2 having a larger sectional area than the sectional area of the first arc gas flow passage R1. Further, the arc gas circulated in the second arc gas flow passage R2 is circulated in the third arc gas flow passage R3 on the upper side of the flat plate grids 118 and the U-shaped grids 119 as shown by an arrow K3, the third arc gas flow passage R3 having a larger sectional area than the sectional area of the second arc gas flow passage R2. Then, the arc gas circulated in the third arc gas flow passage R3 is led out from the air discharge opening 116 that is an opening portion between the first insulation side plates 123 to the outside of the arc chute 102 as shown by an arrow K4.

[0035] As described above, in Embodiment 1, a position A, a position I, and a position U in the arc chute 102 are configured in the relationship of (the position A>the position I>the position U); whereas, in the conventional DC high-speed circuit breaker, as shown in FIG. 20 and FIGS. 21A, 21B, the width between insulation plates 32 provided with magnetic pole plates 33 on the outside of the lateral surfaces is the same width from the fixed main contact and the movable main contact to the grid end portion and their relationship is (a position A=a position I=a position U). In characteristics by both relationships, as shown in FIG. 11, the sectional areas of the arc gas flow passages become larger toward the upper portion of the arc chute 102 from the lower portion of the arc chute 102 as shown in the relationship of (the position A>the position I>the position U) in Embodiment 1; whereby, as compared to the conventional one, the arc gas can be easily flown, air discharge performance of the arc gas is improved, a reignition of arc between the contacts is suppressed, and a high interruption performance can be obtained.

[0036] Furthermore, the first magnetic pole plate 127 for improving the electromagnetic force to be exerted on the arc K is arranged in the inside of the first insulation side plate 123 and the second magnetic pole plate 130 for improving the electromagnetic force to be exerted on the arc K is arranged in the inside of the second insulation side plate 124; whereby the arc is prevented from being short-circuited via the first magnetic pole plate 127 and the second magnetic pole plate 130 in a large current, an interruption failure can be prevented, and the interruption can be reliably performed from a small current to the large current.

[0037] Embodiment 2. Embodiment 2 of the present invention will be described with reference to FIG. 12. FIG. 12 is relevant part front views each showing the relationship between an arc discharge and an arc voltage in a grid arrangement portion of an arc chute in a DC high-speed circuit breaker according to Embodiment 2 of the present invention.

[0038] Since a U-shaped grid 119 is such that one magnetic plate is bent in a U-shape, an intermediate portion becomes a space 132. The structure thereof is made such that a V-shaped notch 117 is formed at a central position of a bottom portion of the U-shaped grid 119 to pass through the space 132 of the intermediate portion and arc gas can be blown therethrough.

[0039] The difference between the arc discharge when flat plate grids 118 are arranged and the arc discharge when the U-shaped grids 119 are arranged will be described. In the case of arranging only the flat plate grids 118, an arc discharge H is generated between the adjacent flat plate grids 118. In the case of arranging the U-shaped grids 119, both ends of the bottom portion of the U-shaped grid 119 are communicated; and thus, the arc discharge is not generated in the space 132 of the intermediate portion, but the arc discharge H is generated between the U-shaped grids 119.

[0040] Thus, each space between the flat plate grids 118 and between the U-shaped grids 119, that is, an arc length 133, in which the arc discharge is generated; and the number of plates of the flat plate grid 118 and the U-shaped grid 119, at which an electrode drop is generated, can be adjusted by changing the number of plates of the flat plate grid 118, or the length (width) and/or the number of plates of the bottom portion of the U-shaped grid 119. Therefore, an optional arc voltage can be generated.

[0041] According to Embodiment 2, the flat plate grid 118 and the U-shaped grid 119 are combined and used as the grid, whereby the optional arc voltage can be generated.

Embodiment 3.

[0042] Embodiment 3 of the present invention will be described with reference to FIG. 13. FIG. 13 is a front view showing ease of remaining an arc in an arc chute in a DC high-speed circuit breaker according to Embodiment 3 of the present invention.

[0043] As shown in FIG. 13, regions in which the arc remains easily in an arc chute 102 can be divided into: the vicinity of a contact portion 136 such as a fixed main contact 105, a movable main contact 107, a fixed side arc contact 111, and a movable side arc contact 112; a grid arrangement portion 137 such as flat plate grids 118 and U-shaped grids 119; and an arc chute upper portion 138 on the upper side of the flat plate grids 118 and the U-shaped grids 119. Of these three portions, in the case where the arc remains most easily at the vicinity of the contact portion 136, a reignition of arc is caused; in the case where the arc remains most easily at the arc chute upper portion 138, a bridging in which the arc flies out to the arc chute upper portion is caused; and both cases are causes of deterioration of interruption performance or an interruption failure.

[0044] Thus, in order to maintain a stable arc voltage necessary for interruption, it is necessary to create a state where an arc discharge occurs most easily at the grid arrangement portion 137, until the interruption is completed. Also in the U-shaped grid 119, arc gas that is one of factors of ease of discharge passes through a space 132 of an intermediate portion via a V-shaped notch 117 and is discharged from an air discharge opening 116 of the upper portion of the arc chute 102; and therefore, air discharge performance is the same as the case where the flat plate grid 118 is arranged.

[0045] Furthermore, a grid space that is easy to discharge the arc can be provided by adjusting the width of a bottom portion and/or the ratio of the number of plates of the U-shaped grid 119. Therefore, by using the U-shaped grids 119, ease of remaining the arc at the grid arrangement portion 137 can be improved while being the same ease of discharge of the arc gas at the vicinity of the contact portion 136.

[0046] Consequently, the arc is stably maintained at the grid arrangement portion 137 and a stable and constant arc voltage which is higher than a power source voltage necessary for interruption can be maintained by creating the state where the arc discharge occurs most easily at the grid arrangement portion 137.

[0047] As described above, the grid space and the length of the arc are shortened, the state where the arc is remained most easily is created at the grid arrangement portion 137, and the stable arc voltage can be maintained until the interruption is completed.

Embodiment 4.

[0048] Embodiment 4 of the present invention will be described with reference to FIG. 14 to FIG. 16. Then, in each of the drawings, identical or equivalent members and portions will be described with the same reference numerals (and letters) assigned thereto. FIG. 14 is a front view showing the arrangement of an arc during a small current, flat plate grids, and U-shaped grids in an arc chute in a DC high-speed circuit breaker according to Embodiment 4 of the present invention. FIG. 15 is a characteristic view showing electromagnetic force in which an arc in the arc chute receives from an arcing horn serving as a current conduction conductor, in the DC high-speed circuit breaker according to Embodiment 4 of the present invention. FIG. 16 is a characteristic view showing electromagnetic force to be exerted on the arc in the arc chute in the DC high-speed circuit breaker according to Embodiment 4 of the present invention.

[0049] A flat plate grid 118 and a U-shaped grid 119 of an arc chute 102 in Embodiment 4 of the present invention are configured such that, as shown in FIG. 14, the flat plate grids 118 are arranged on the central side 139 and the U-shaped grids 119 are arranged on both sides 140.

[0050] The electromagnetic force in which the arc receives includes: electromagnetic force 142 generated according to the Fleming's left hand rule by receiving magnetic flux G from a fixed side arcing horn 113 and a movable side arcing horn 114, which are arcing horns each serving as a current conduction conductor through which a current I flows, as shown in FIG. 15; and electromagnetic force 144 that is generated when balance of pinch force 143 to be exerted in the center direction of the arc is lost by a magnetic body to become magnetic flux 145 having a region with weak magnetic flux G1 and a region with strong magnetic flux G2, as shown in FIG. 16. Since the electromagnetic force 142 in which the arc receives from the current conduction conductor is small in the small current, the arc cannot travel to an end portion 141a of the fixed side arcing horn 113 and to an end portion 141b of the movable side arcing horn 114, the arcing horns 113, 114 being the arcing horns. Accordingly, it cannot be available only for the limited range, that is, the central side grids. However, in order to interrupt a DC current, a higher arc voltage than a power source voltage needs to be generated.

[0051] So, the flat plate grids 118 are arranged on the central side 139 as shown in FIG. 14, whereby, even the case during the small current, the arc passes through a large number of the flat plate grids 118 at the limited range of the central side 139, an arc voltage rise effect by an electrode drop voltage can be effectively obtained, and a high interruption performance can be obtained even in the case of small current interruption.

[0052] By the above, according to Embodiment 4, the flat plate grids 118 are arranged on the central side 139 and the U-shaped grids 119 are arranged on both sides 140, whereby, the arc voltage can be raised by a large number of electrode drops even within a limited arc travel range of the small current and a high small current interruption performance can be obtained.

[0053] As described above, the arc voltage rise by the electrode drop by a large number of the grids can be effectively utilized in the limited range even during small current interruption in which the electromagnetic force for making the arc travel and elongate is low; and a high interruption performance can be obtained even in the small current interruption.

Embodiment 5.

[0054] Embodiment 5 of the present invention will be described with reference to FIGS. 17A, 17B. FIG. 17A is a front view and FIG. 17B is a side view, which show effects of magnetic pole plates in a DC high-speed circuit breaker according to Embodiment 5 of the present invention.

[0055] As shown in FIGS. 17A, 17B, for example, if a first magnetic pole plate 127 is arranged on a first insulation side plate 123 of an arc chute 102, magnetic flux 145 generated by an arc passes through the first magnetic pole plate 127. On the other hand, when the first magnetic pole plate 127 is not arranged, the magnetic flux 145 passes through the air. When the magnetic flux 145 passes through the first magnetic pole plate 127, magnetic resistance of a magnetic body of the first magnetic pole plate 127 is smaller than the air; and thus, loss of the magnetic flux 145 becomes small and electromagnetic force 144 becomes large. Therefore, the first magnetic pole plates 127 have an effect to improve the electromagnetic force 144 that is generated by the arc itself and is particularly effective for small current interruption in which electromagnetic force 142 is small.

[0056] However, as shown in FIG. 20 and FIGS. 21A, 21B, in a conventional arc chute 31, a magnetic pole plate 33 is arranged as it is in the exposed state on the outside of an insulation plate 32 of the arc chute 31; and accordingly, the magnetic pole plate 33 cannot be covered by the insulation plate 32, the arc is short-circuited via the magnetic pole plate 33, and an interruption failure may occur.

[0057] So, as shown in FIG. 8, Embodiment 5 is configured such that the first magnetic pole plate 127 is arranged in the inside of the first insulation side plate 123 of the arc chute 102, a second magnetic pole plate 130 is arranged in the inside of a second insulation side plate 124 of the arc chute 102 and is covered and fixed by an insulator, whereby the arc does not directly come into contact with the first magnetic pole plate 127 and the second magnetic pole plate 130 and electrical connection cannot be made.

[0058] Furthermore, since a width dimension of a lower portion of the first insulation side plate 123 side is different from that of an upper portion of the second insulation side plate 124 side, the arc chute 102 is configured such that the magnetic pole plates are arranged by being divided into the first magnetic pole plate 127 and the second magnetic pole plate 130, the first magnetic pole plate 127 is arranged in the inside of the first insulation side plates 123 and the second magnetic pole plate 130 is arranged in the inside of the second insulation side plates 124; and, for example, the first magnetic pole plate 127 is covered by an insulation plate 128 and the second magnetic pole plate 130 is covered by an insulation plate 131. Therefore, the arc does not directly come into contact with the first magnetic pole plate 127 and the second magnetic pole plate 130.

[0059] According to Embodiment 5, the arc or the arc gas also does not directly come into contact with the first magnetic pole plate 127 and the second magnetic pole plate 130 without damaging effects of the magnetic pole plates that improve the electromagnetic force to be exerted on the arc, the arc gas is prevented from being short-circuited via the first magnetic pole plate 127 and the second magnetic pole plate 130 and an interruption failure can be prevented, and the interruption can be reliably performed from a small current to a large current.

Embodiment 6.

[0060] Embodiment 6 of the present invention will be described with reference to FIGS. 18A, 18B. FIG. 18A is a front view and FIG. 18B is a side view, which show U-shaped grids in a DC high-speed circuit breaker according to Embodiment 6 of the present invention.

[0061] As shown in FIGS. 18A, 18B, if two facing flat plate grids 118 can be electrically connected and a current can be conducted, the function of a U-shaped grid 119 can be satisfied. Therefore, the connection can be made by using a bolt 146, a nut 147, or a rivet; and alternatively, the connection can be made by welding 148.

Embodiment 7.

[0062] Embodiment 7 of the present invention will be described with reference to FIGS. 19A, 19B. FIG. 19A is a front view and FIG. 19B is a side view, which show magnetic pole plates in a DC high-speed circuit breaker according to Embodiment 7 of the present invention.

[0063] As shown in FIGS. 19A, 19B, each of a first magnetic pole plate 127 and a second magnetic pole plate 130 is not made of one sheet of plate, but even when thin magnetic pole plates 149a, 149b are laminated with adhering closely into an assembly 150a, 150b, respectively, the function of the first magnetic pole plate 127 and the second magnetic pole plate 130 can be satisfied.

[0064] Incidentally, the present invention can freely combine the respective embodiments and appropriately modify and/or omit the respective embodiments, within the scope of the present invention.

INDUSTRIAL APPLICABILITY

[0065] The present invention is suitable for achieving a DC high-speed circuit breaker in which arc gas is made to easily flow to an upper portion of an arc chute, air discharge performance of the arc gas is improved, a reignition of arc between contacts can be suppressed, and a high interruption performance can be obtained.

DESCRIPTION OF REFERENCE NUMERALS

[0066] 101 DC high-speed circuit breaker, 102 Arc chute, 105 Fixed main contact , 107 Movable main contact , 111 Fixed side arc contact, 112 Movable side arc contact, 118 Flat plate grid, 119 U-shaped grid, 123 First insulation side plate, 124 Second insulation side plate, 127 First magnetic pole plate, 130 Second magnetic pole plate, 139 Central side, 140 Both sides, R1 First arc gas flow passage, R2 Second arc gas flow passage, and R3 Third arc gas flow passage.

Claims

1. A DC high-speed circuit breaker comprising:

    an arc chute in which an arc extinguishing space is formed;
    a fixed main contact arranged on the lower side of said arc chute; and
    a movable main contact which is arranged on the lower side of said arc chute and is connected/disconnected to/from said fixed main contact ,
    wherein said arc chute includes:

        first insulation side plates which are arranged so as to sandwich said fixed main contact and said movable main contact from both sides, and form a first arc gas flow passage through which arc gas generated at the fixed main contact and the movable main contact is led to the outside of said arc chute;
        a plurality of grids which are arranged on the upper side of said fixed main contact and said movable main contact , and form a second arc gas flow passage, said second arc gas flow passage being configured to be a larger width than the space between said first insulation side plates, being communicated to said first arc gas flow passage, and having a larger sectional area than said sectional area of the first arc gas flow passage; and
        and second insulation side plates which are arranged so as to sandwich said grids from both sides, and forms a third arc gas flow passage on the upper side of said grids, said third arc gas flow passage being communicated to said second arc gas flow passage and having a larger sectional area than the sectional area of said second arc gas flow passage.

2. The DC high-speed circuit breaker according to claim 1,
wherein said grids are configured by combining a flat plate grid and a U-shaped grid.

3. The DC high-speed circuit breaker according to claim 2,
wherein said grids are arranged by adjusting the ratio of the number of plates of said flat plate grid and the width of said U-shaped grid.

4. The DC high-speed circuit breaker according to claim 2 or claim 3,
wherein said flat plate grids are arranged on the central side; and,
said U-shaped grids are arranged on both sides.

5. The DC high-speed circuit breaker according to any one of claim 1 to claim 4,
further comprising: a first magnetic pole plate that is

arranged in said first insulation side plate; and a second magnetic pole plate that is arranged in said second insulation side plate.

6. The DC high-speed circuit breaker according to claim 5, wherein said first magnetic pole plate is covered by said first insulation side plate; and said second magnetic pole plate is covered by said second insulation side plate.

FIG.1

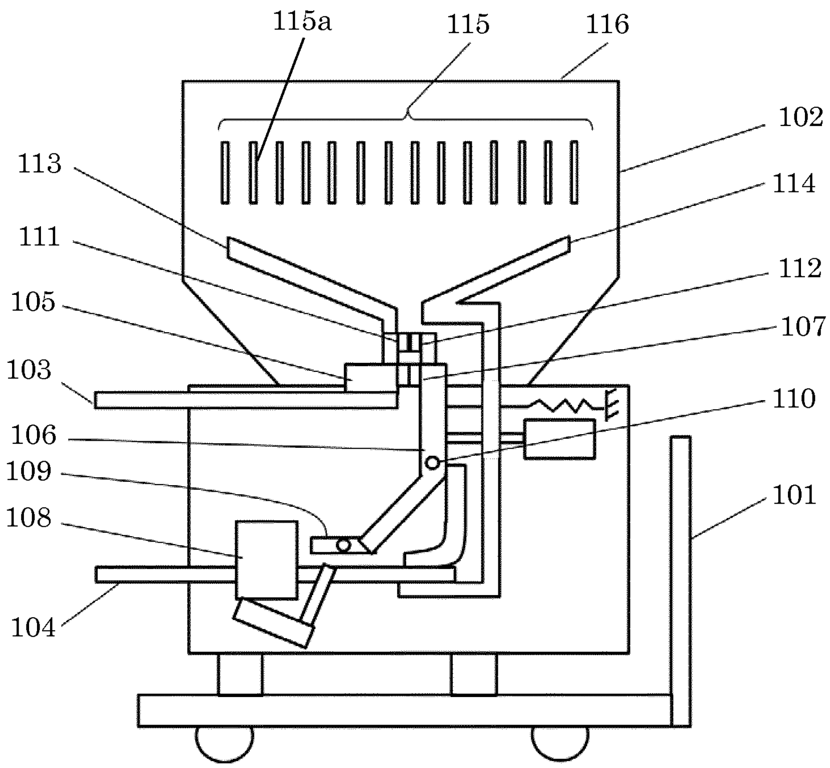

115a
115
116
102
113
114
111
112
105
107
103
110
106
109
101
108
104

FIG.2

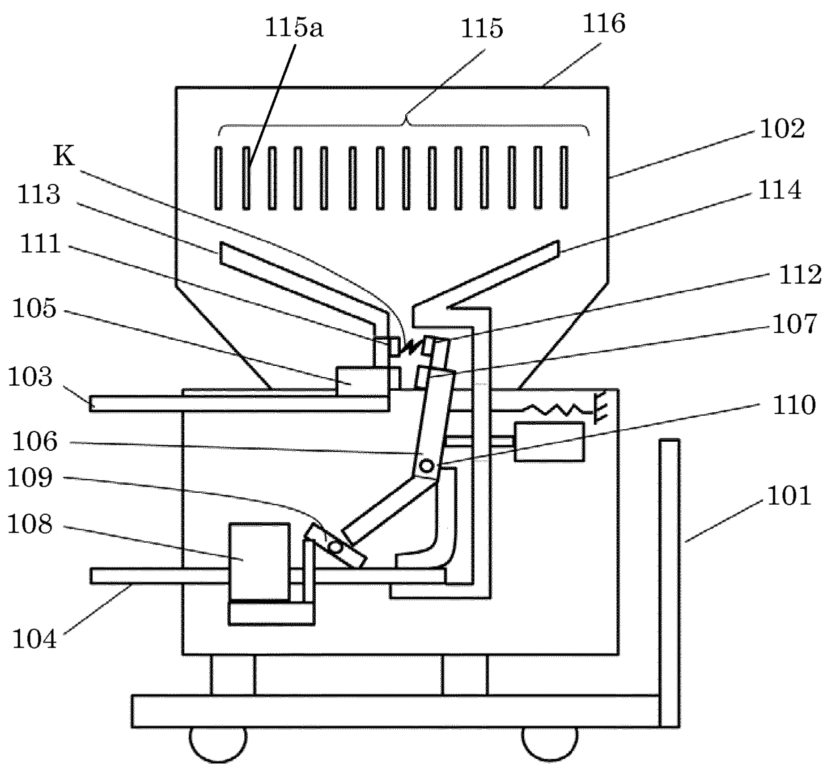
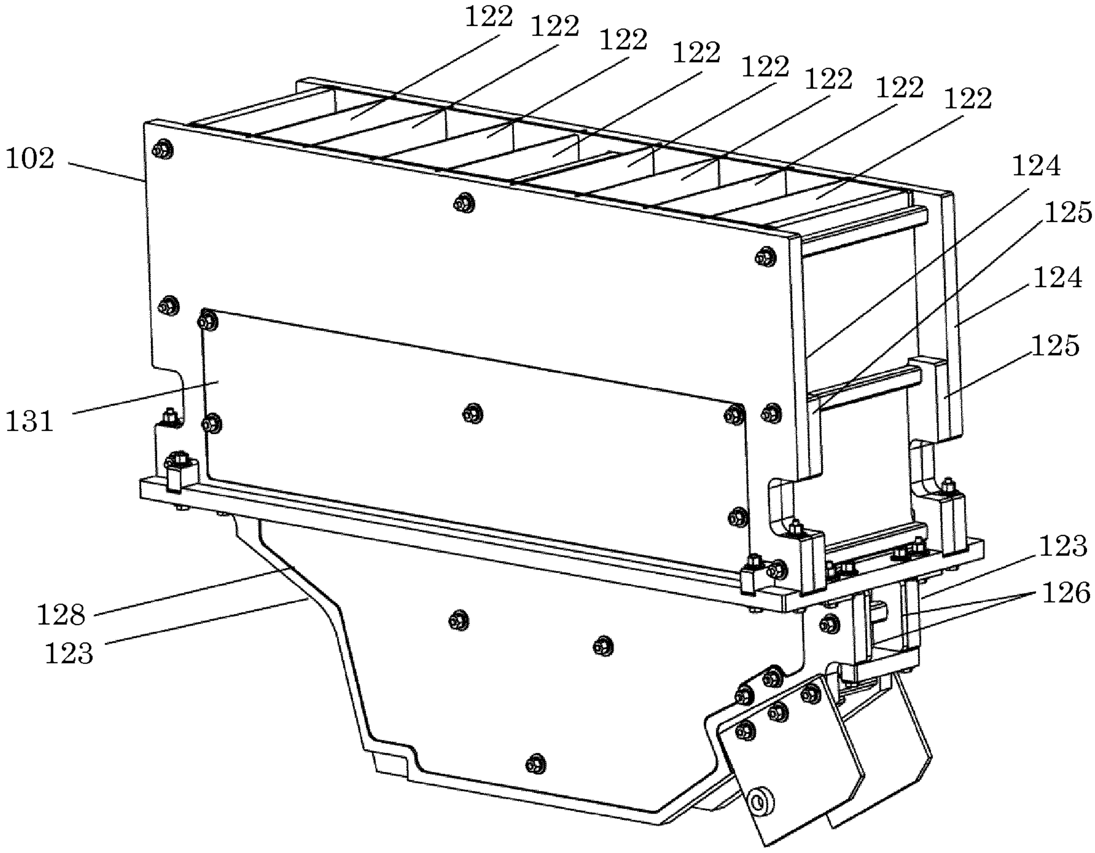

115a
115
116
102
K
113
114
111
112
105
107
103
110
106
109
101
108
104

FIG.3


122
122
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122
122
122
122
122
102
124
125
124
125
131
123
126
128
123

FIG.4

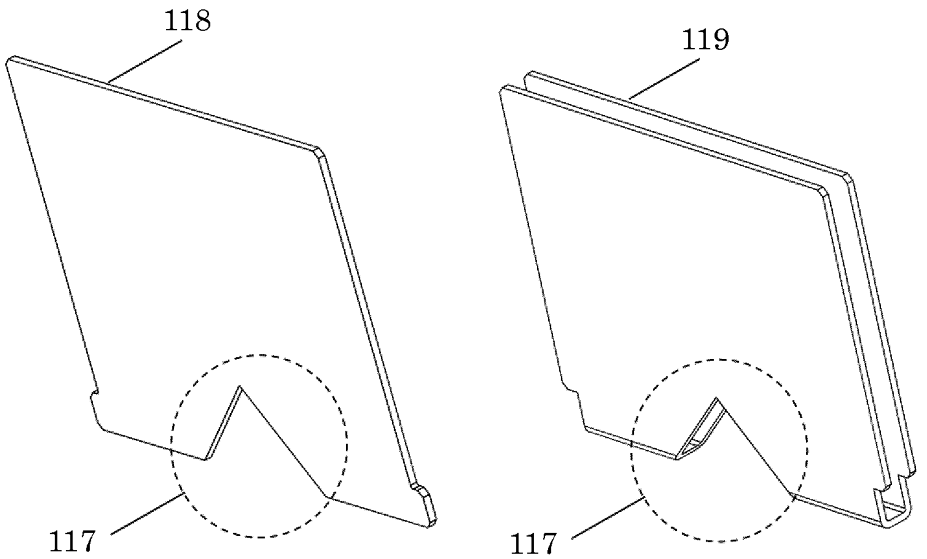

118
119
117
117

FIG.5

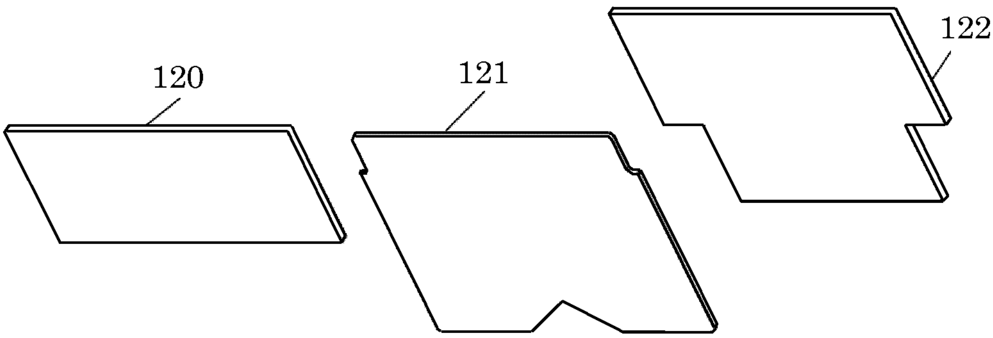


FIG.6

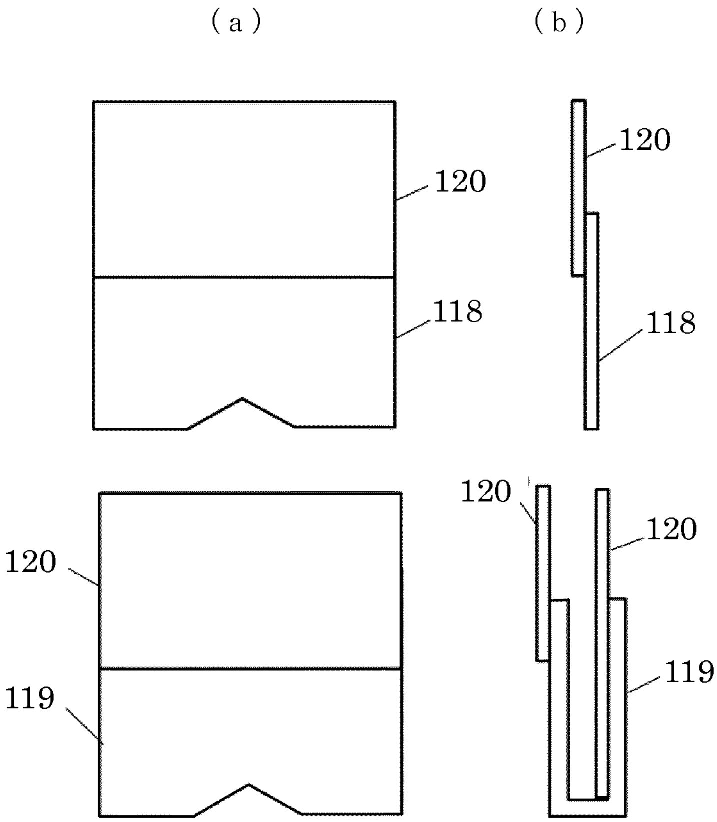


FIG.7

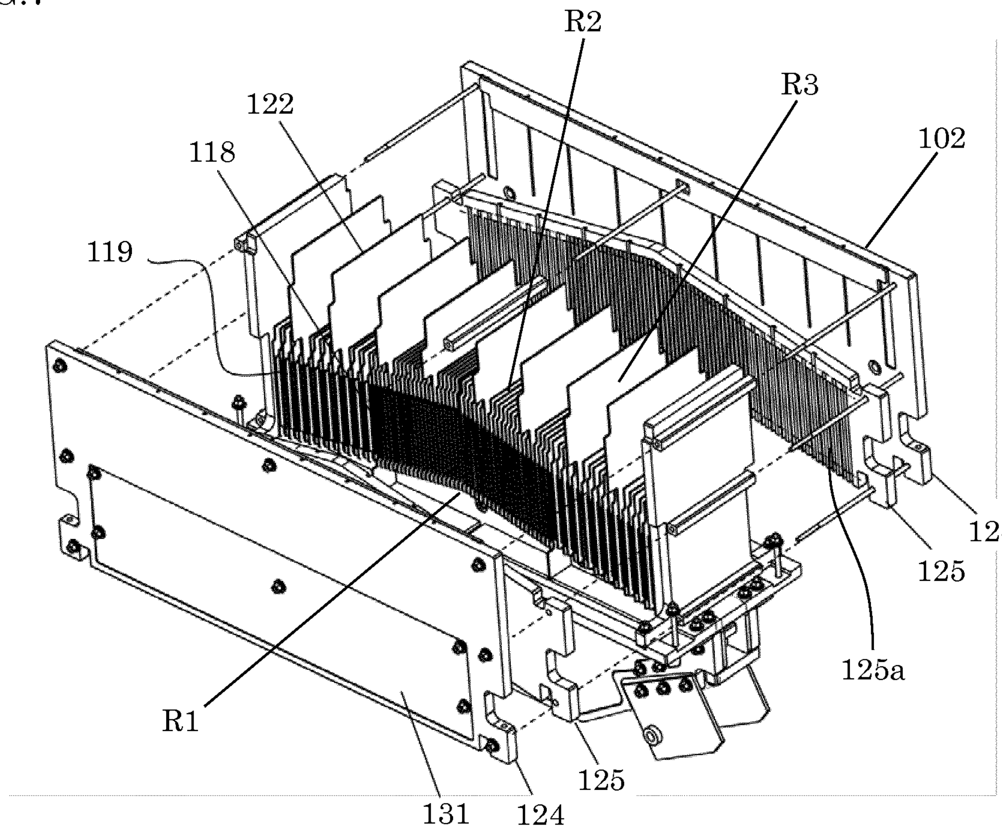
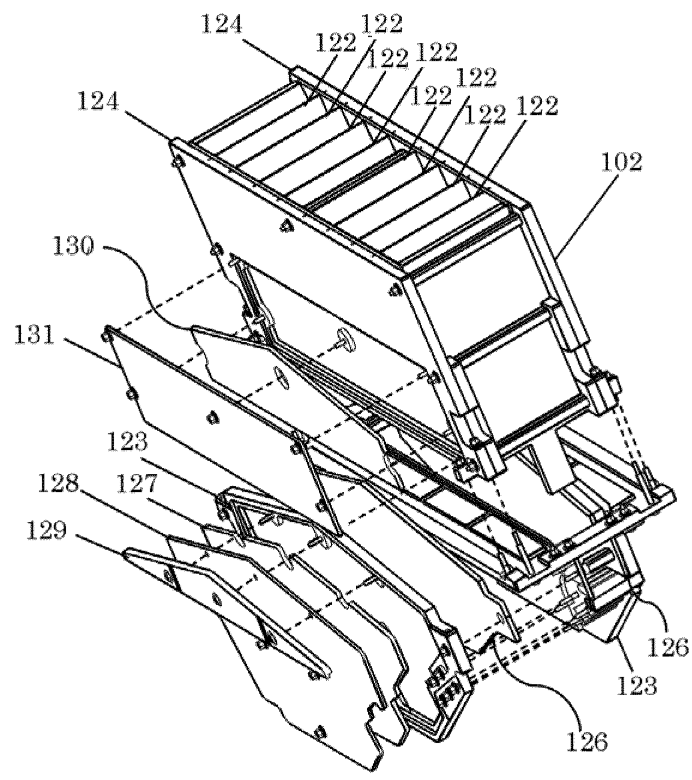

R2
R3
122
118
102
119
124
125
125a
R1
125
131
124

FIG.8


124
122
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102
130
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128
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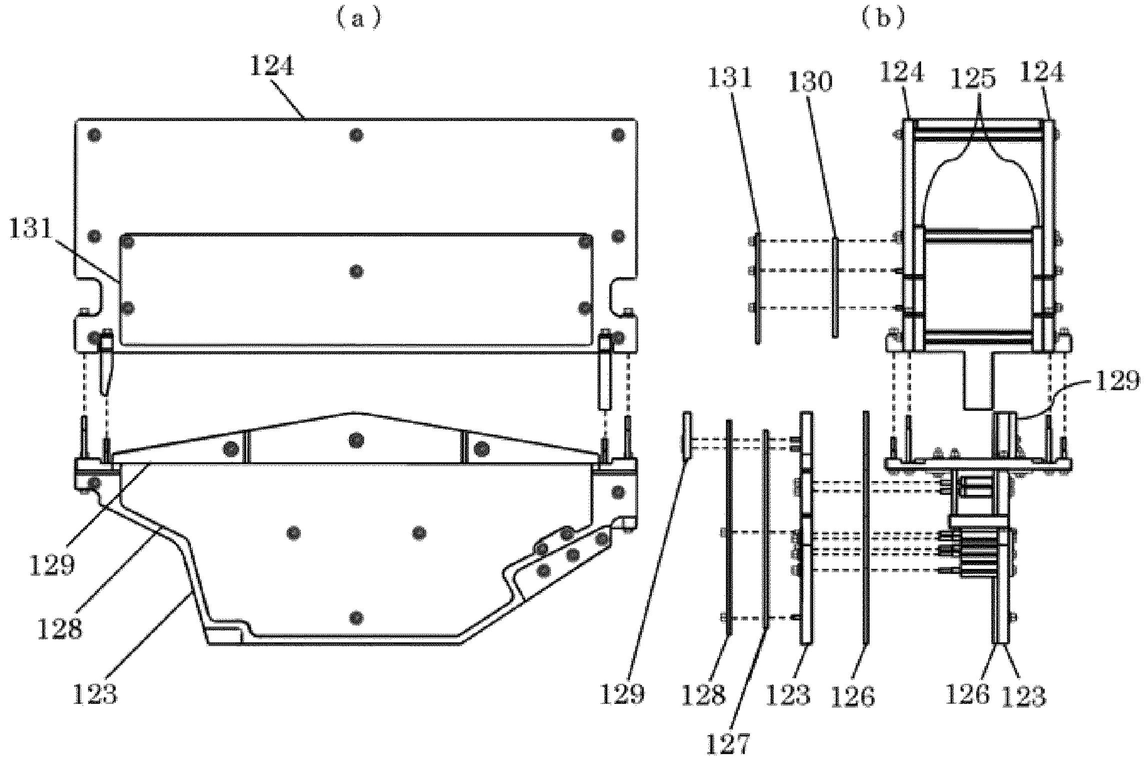
129
126
123
126

FIG.9


(a)
(b)
124
131
129
128
123
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124
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124
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128
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127
126
123

FIG.10

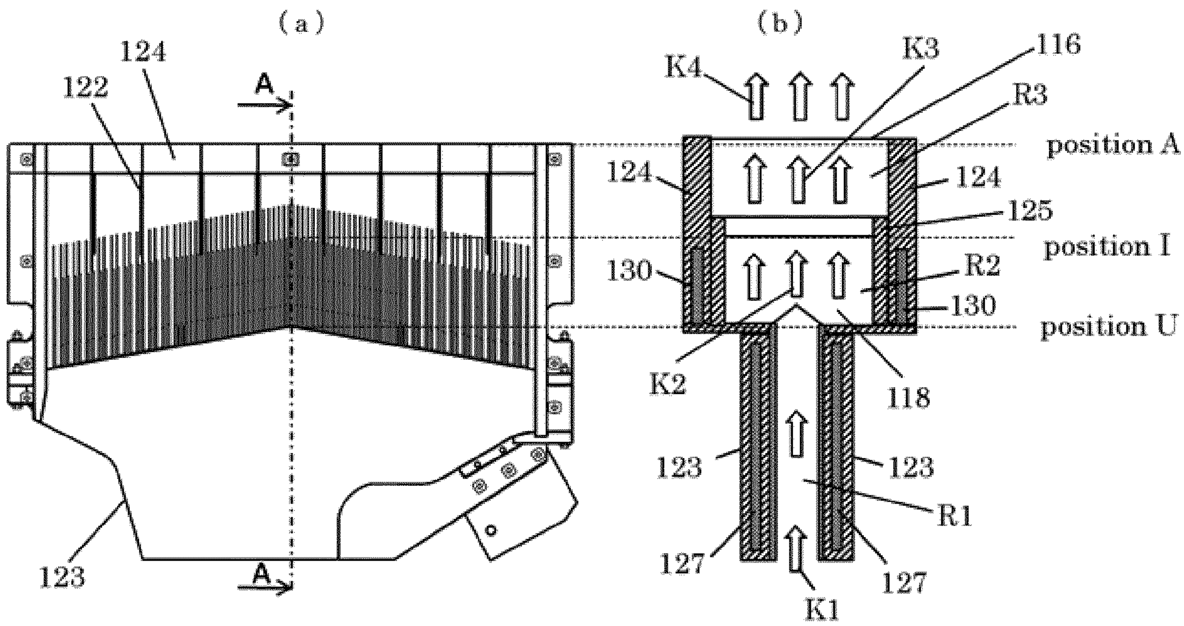

(a)
(b)
124
122
A
A
123
K4
K3
116
R3
position A
124
124
125
position I
130
R2
130
position U
K2
118
123
123
R1
127
127
K1

FIG.11

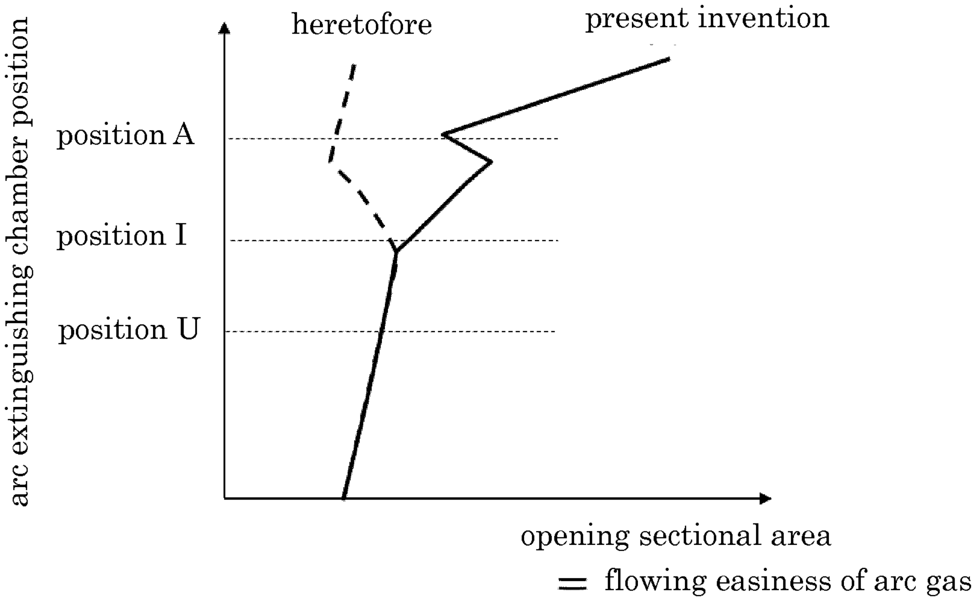

heretofore
present invention
arc extinguishing chamber position
position A
position I
position U
opening sectional area
= flowing easiness of arc gas

FIG.12

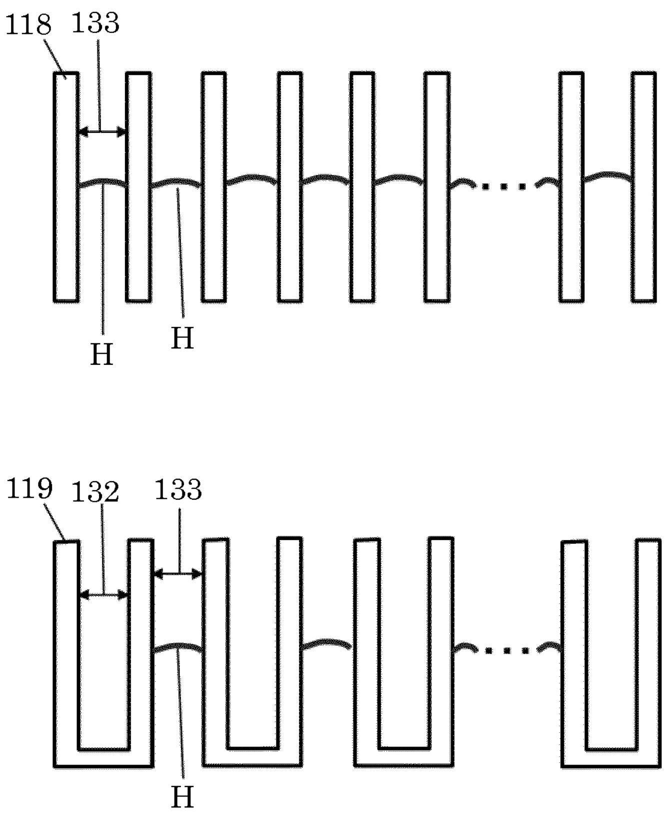
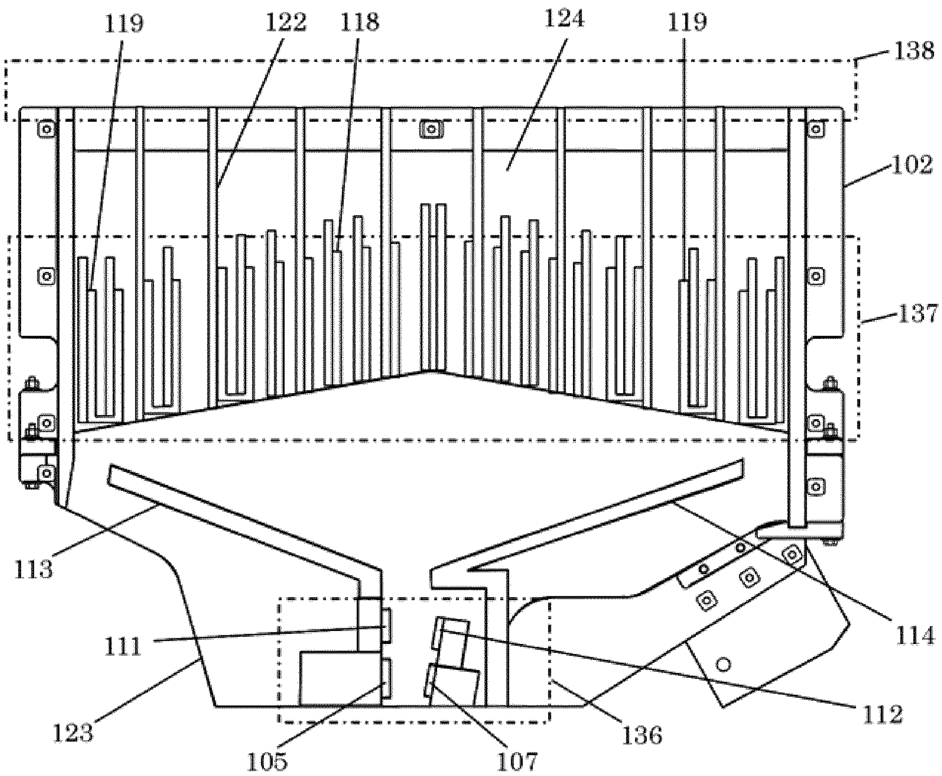

118
133
H
H
119
132
133
H

FIG.13


119
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124
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138
102
137
113
111
123
105
107
136
112
114

FIG.14

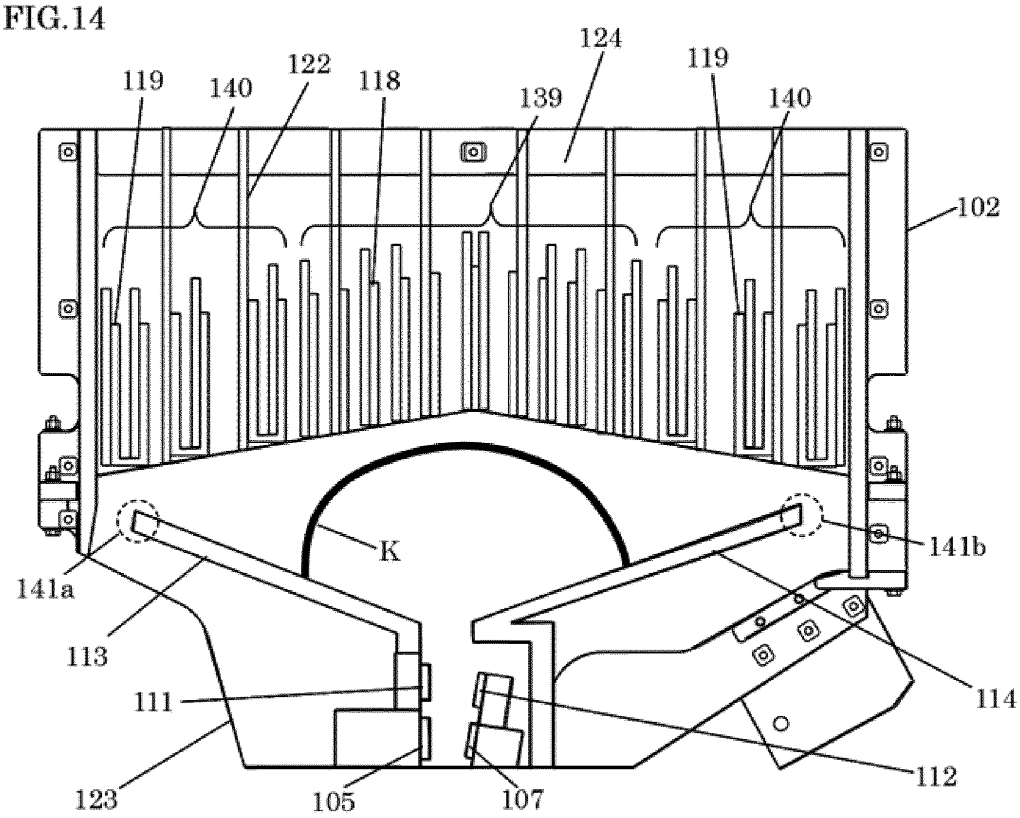

119
140
122
118
139
124
119
140
102
141a
113
K
141b
114
111
123
105
107
112

FIG.15

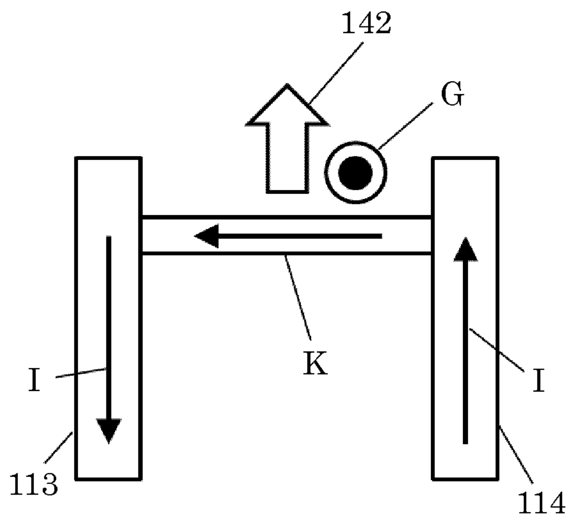


FIG.16

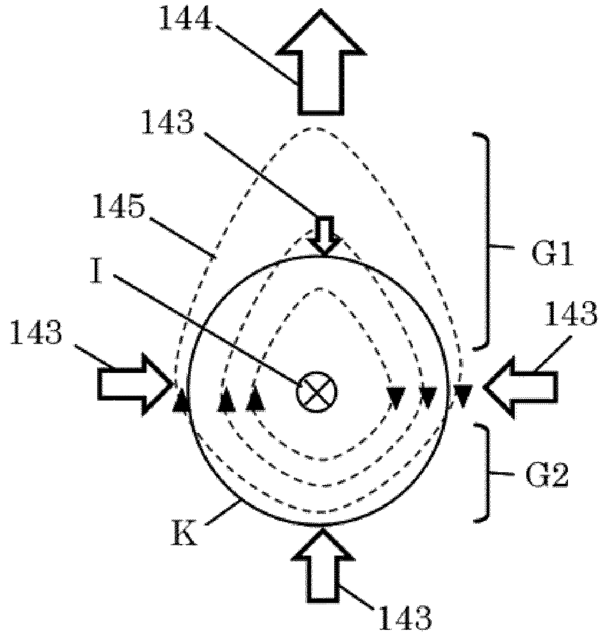


FIG.17

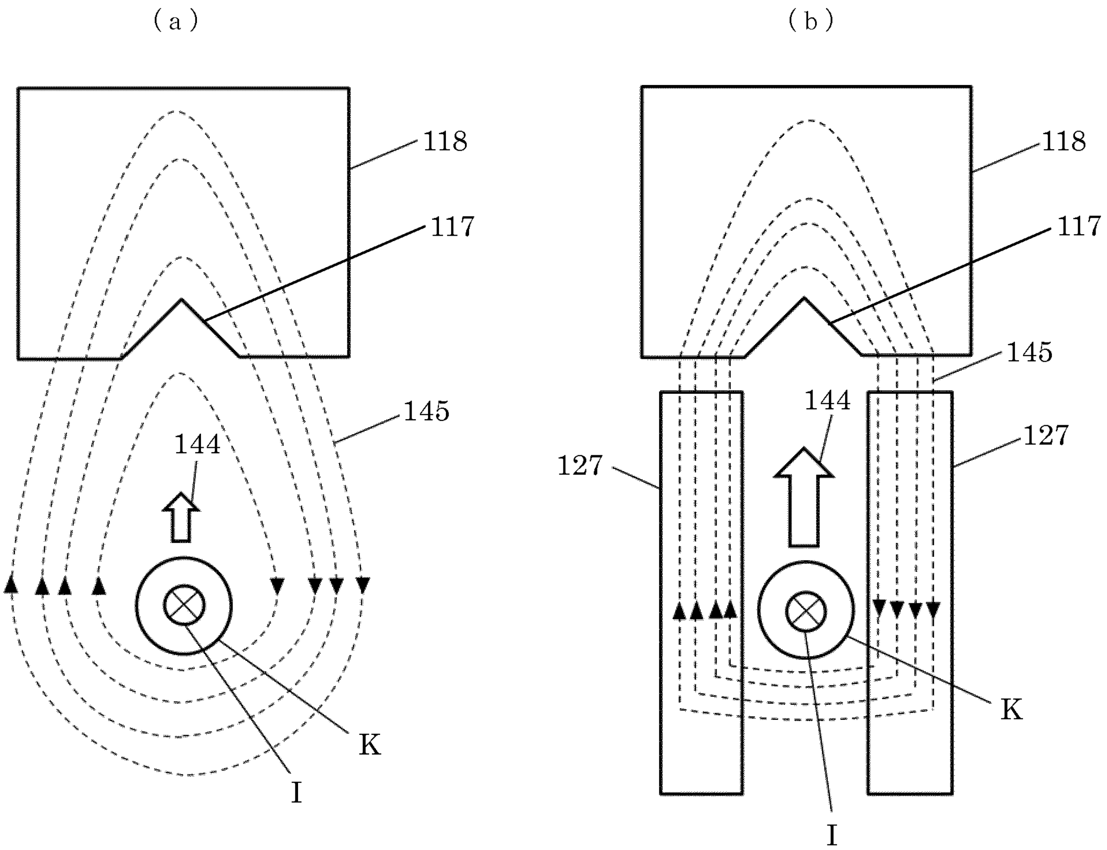


FIG.18

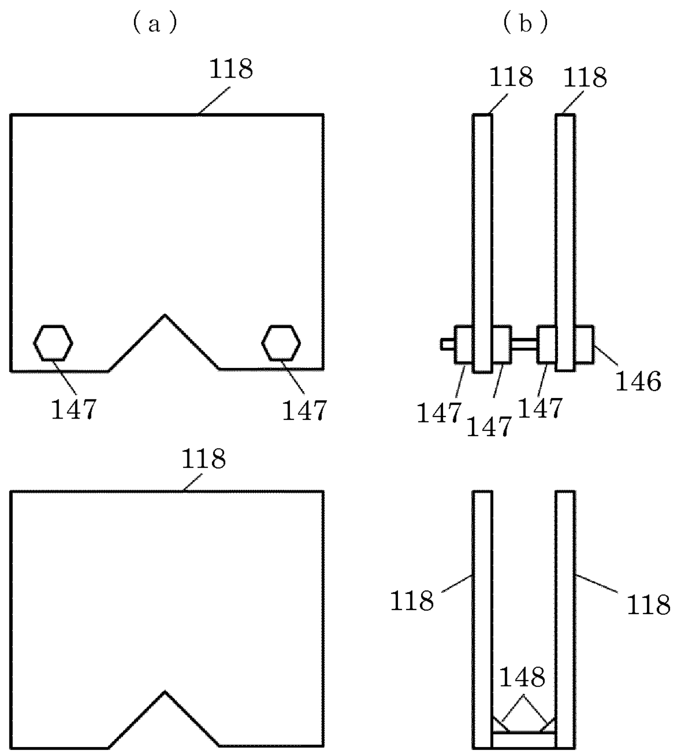


FIG.19

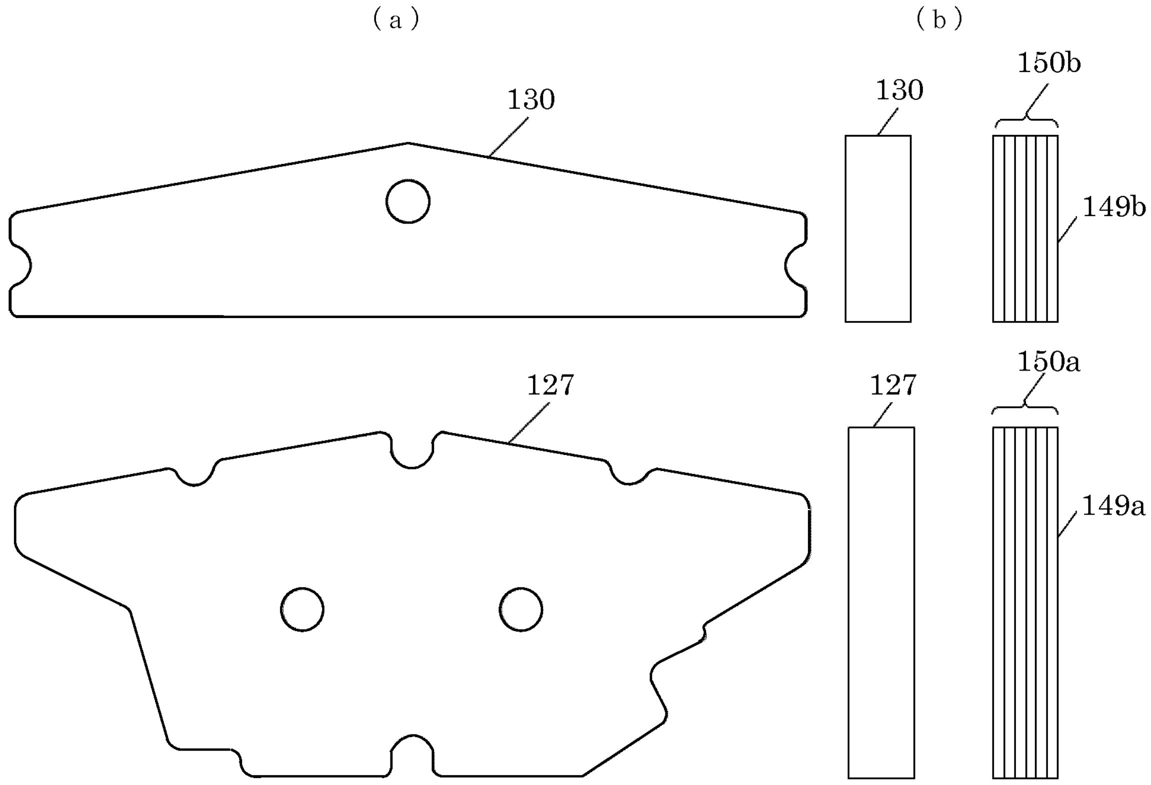


FIG.20

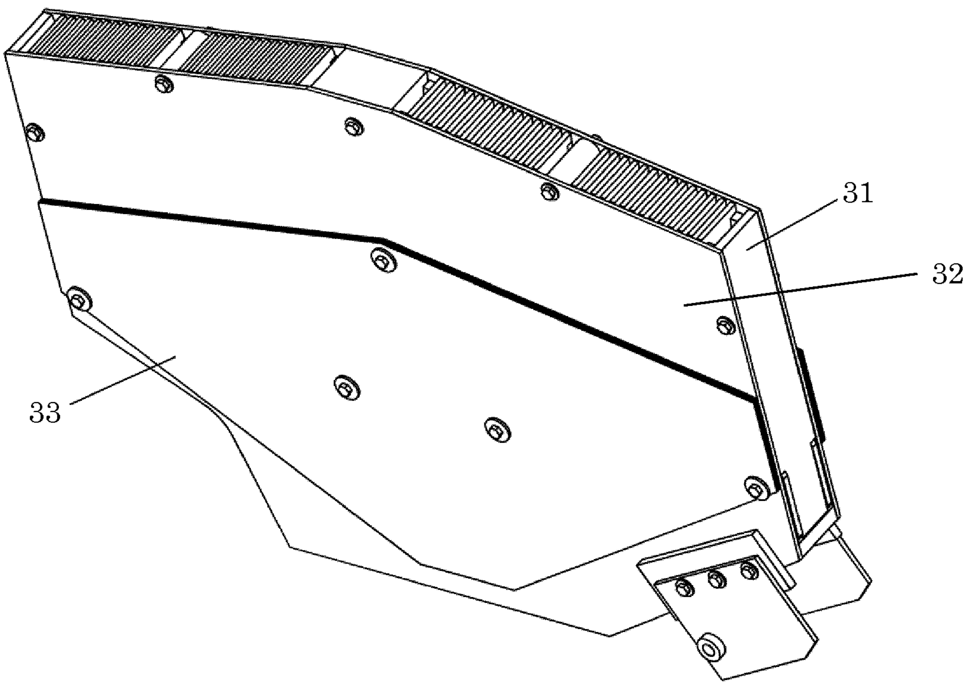


FIG.21

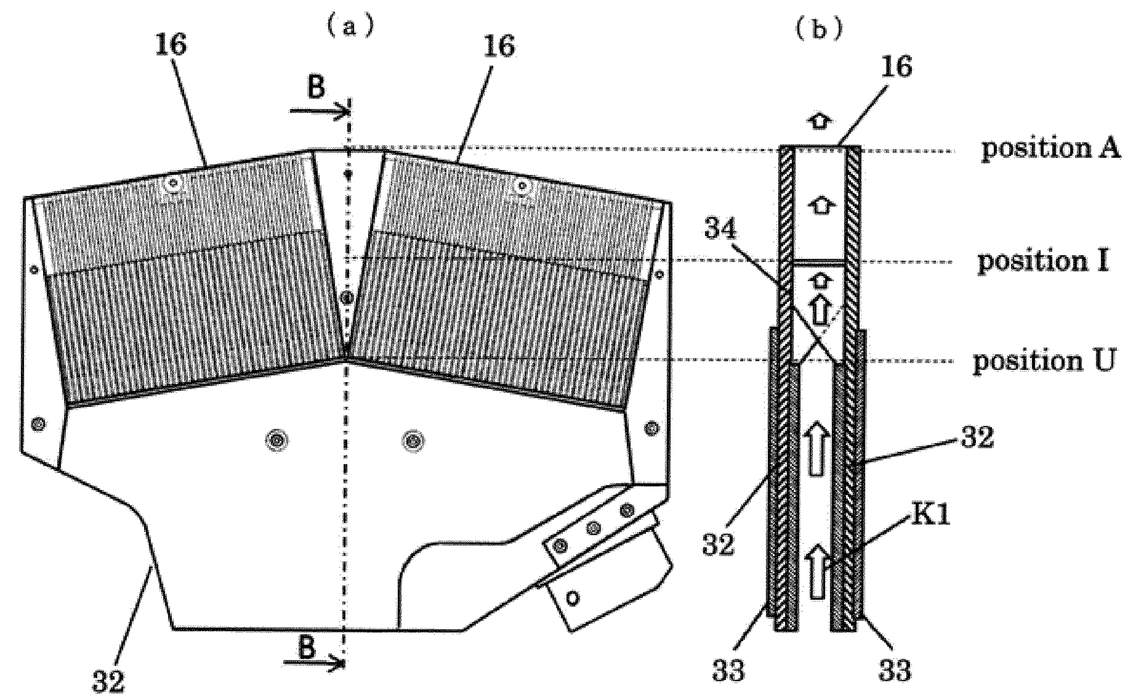
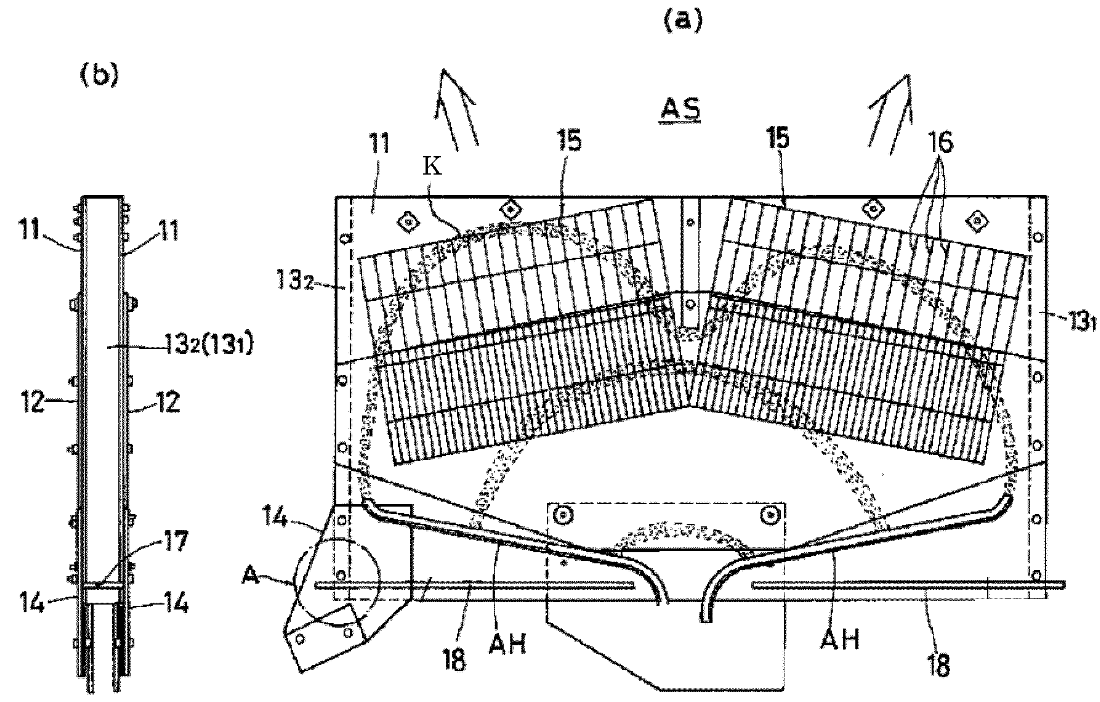

(a)
16
16
B
B
32
(b)
16
position A
34
position I
position U
32
32
K1
33
33

FIG.22


(a)
(b)
AS
11
K
15
15
16
11
11
13_2
13_1
$13_2(13_1)$
12
12
14
17
14
14
A
18
AH
AH
18

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/082521

A. CLASSIFICATION OF SUBJECT MATTER
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)
H01H33/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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.
A	JP 5-290682 A (Meidensha Corp.), 05 November 1993 (05.11.1993), entire text; all drawings (Family: none)	1-6
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 20809/1987(Laid-open No. 129932/1988) (Toshiba Corp.), 25 August 1988 (25.08.1988), entire text; all drawings (Family: none)	1-6

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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"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	Date of mailing of the international search report
22 January 2016 (22.01.16)	02 February 2016 (02.02.16)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2015/082521

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 1-319217 A (Fuji Electric Co., Ltd.), 25 December 1989 (25.12.1989), entire text; all drawings (Family: none)	1-6

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H61994060944 U **[0005] [0006]**