



(11) **EP 4 560 673 A1**

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

(43) Date of publication:
28.05.2025 Bulletin 2025/22

(51) International Patent Classification (IPC):
H01H 9/30 ^(2006.01) **H01H 9/34** ^(2006.01)

(21) Application number: **23842141.6**

(52) Cooperative Patent Classification (CPC):
H01H 9/30; H01H 9/34

(22) Date of filing: **07.07.2023**

(86) International application number:
PCT/CN2023/106314

(87) International publication number:
WO 2024/017076 (25.01.2024 Gazette 2024/04)

(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 ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

- **GUAN, Yiqing**
Tianjin 301800 (CN)
- **KOU, Ji**
Tianjin 301800 (CN)
- **ZHOU, Bin**
Tianjin 301800 (CN)
- **LIANG, Yingjie**
Tianjin 301800 (CN)
- **NAN, Yin**
Tianjin 301800 (CN)

(30) Priority: **18.07.2022 CN 202210843205**
09.10.2022 CN 202211227931

(71) Applicant: **Tianjin Svrui Intelligent Electrical Co., Ltd.**
Tianjin 301800 (CN)

(74) Representative: **Angerhausen, Christoph**
Boehmert & Boehmert
Anwaltpartnerschaft mbB
Pettenkoferstrasse 22
80336 München (DE)

(72) Inventors:
• **NAN, Tian**
Tianjin 301800 (CN)

(54) **ARC EXTINGUISHING DEVICE FOR EXTINGUISHING ARC IN ELECTRIC SWITCH, AND ELECTRIC SWITCH**

(57) The present application discloses an arc extinguishing device for extinguishing an arc in an electric switch, and an electric switch. The arc extinguishing device at least comprises an arc extinguishing grid plate assembly, a moving contact, a static contact, and an insulating housing. An initial arc column is generated when the moving contact and the static contact are just separated. A plurality of metal arc extinguishing grid plates in the arc extinguishing grid plate assembly stacked to form at least one bending structure, and the plurality of metal arc extinguishing grid plates are ar-

ranged directly or indirectly along at least two adjacent inner sides in the insulating housing. The static contact is in the shape of at least one bending structure. A first metal arc extinguishing grid plate arranged at a first end of the arc extinguishing grid plate assembly is close to or adjacent to a bending conductor on the static contact, and is also arranged close to or adjacent to the initial arc column. The extension directions of the first metal arc extinguishing grid plate and the bending conductor are the same or form an included angle.

EP 4 560 673 A1

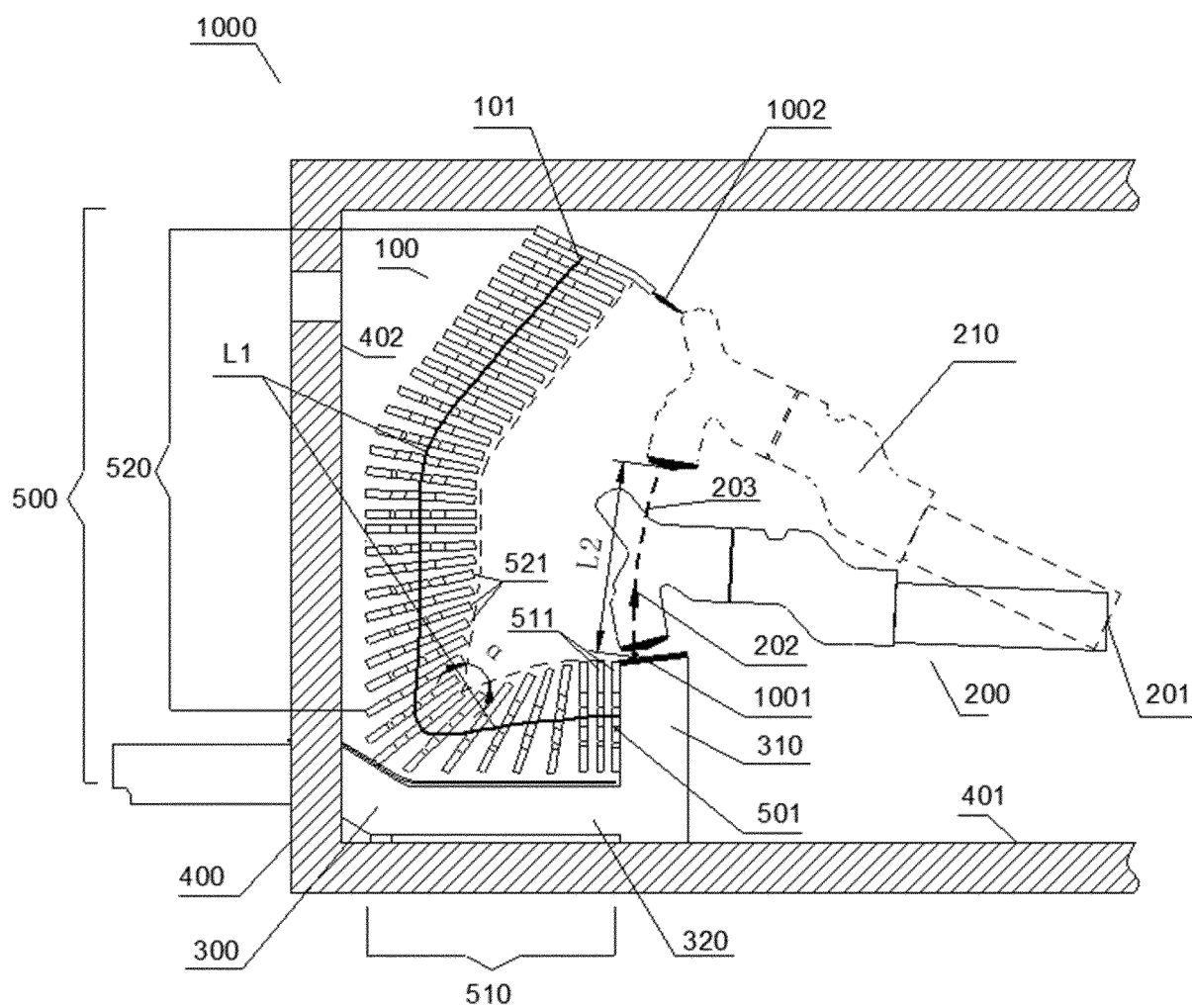


Fig. 1

Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims the benefit of priority to Chinese Patent Application No. 202210843205.0 filed on July 18, 2022, entitled "ARC-EXTINCTION APPARATUS FOR EXTINGUISHING ARC IN ELECTRIC SWITCH AND ELECTRIC SWITCH" and Chinese Patent Application No. 202211227931.6 filed on October 9, 2022, entitled "ARC-EXTINCTION APPARATUS FOR EXTINGUISHING ARC IN ELECTRIC SWITCH AND ELECTRIC SWITCH", both of which are incorporated herein by reference in their entireties.

TECHNICAL FIELD

[0002] The present application relates to the field of low-voltage appliance technology, and in particular to an arc-extinction apparatus for extinguishing an arc in an electric switch and electric switches.

BACKGROUND

[0003] As the power of new energy equipment becomes higher, the performance requirement of switches becomes higher, in particular to the voltage level, such as the voltage of some systems has reached above 1200V. One important indicator of limiting the performance of a switch is how to extinguish the arc generated by the switch interrupting high voltage, a large current, or a critical current under high voltage.

[0004] When existing single-pole switches interrupt a current of the voltage level above 500V, one thing is that an arc of high voltage with a critical current or small current has a small arc column, high temperature, and the adhesive attribute, so it is difficult to make a long arcing plate insert into an arc extinction grid plate assembly of the arc extinction apparatus by using of the Lorentz force, and an arc not inserting the arc extinction grid plate assembly will be continuously burning to cause burnout of the switch. Moreover, the number of grid plates, in the arc extinction grid plate assembly, functioning to deionize, cool, or lengthen the arc is limited by height of the switch, so that a proximal pole pressure or a proximal cathode effect is reduced, a fault large current cannot be extinguished to damage a whole electric equipment. In the related art, the above problem is solved by a multi-break concatenating method, but the multi-break concatenating method may cause problems such as a large volume of the switch, high cost, high power consumption, and poor performance.

[0005] Therefore, a new technical solution is urgently needed, thereby improving the arc-extinction performance, reducing the volume of the switch, improving service life, and reducing power consumption.

SUMMARY

[0006] Based on the above background, the present application provides an arc-extinction apparatus for extinguishing an arc in an electric switch and electric switches, and can solve at least part of large volume, high cost, high power consumption, and poor performance problem of a switch in the related art.

[0007] In a first aspect, the present application provides an arc-extinction apparatus for extinguishing an arc in an electric switch. The arc-extinction apparatus at least comprises an arc-extinction grid plate assembly, a movable contact, a stationary contact, and an insulation housing, wherein an initial arc column is generated under a condition that the movable contact and the stationary contact are initially opened and separated, and a last arc column is generated under a condition that the movable contact and the stationary contact are opened and separated by a maximal opening distance, the arc-extinction grid plate assembly at least comprises a plurality of metal arc-extinction grid plates insulated from each other by air, the plurality of the metal arc-extinction grid plates in the arc-extinction grid plate assembly are stacked to form a structure with at least one bend and are directly or indirectly arranged along at least two adjacent inner sides within the insulation housing, the stationary contact is a structure with at least one bend, the length L1 of an arc-extinction channel formed by the arc-extinction grid plate assembly is larger than a maximal opening length L2 formed under a condition that the movable contact and the stationary contact are opened and separated, a first metal arc-extinction grid plate provided at a first end of the arc-extinction grid plate assembly is disposed adjacent or close to a bent conductor of the stationary contact and is also adjacent or close to the initial arc column, and extending directions of the first metal arc-extinction grid plate and the bent conductor are identical or form an included angle.

[0008] In this manner, more arc-extinction grid plates can be arranged in the switch having same volume size; when the movable contact and the stationary contact are separated, an generated arc can be rapidly blew toward an arc chute to be spread and deionized under the action of magnetic fields of the arc and the stationary contact, so that the arc can be extinguished in an extremely short time and the arc-extinction performance of the arc-extinction apparatus is greatly improved.

[0009] In a second aspect, the present application further provides an electric switch and the electric switch includes the arc-extinction apparatus of the first aspect of the present application.

[0010] Advantageous effects of the present application are as follows:

1. The present application provides the arc-extinction grid plate assembly arranged as a long-short structure inside a switch break of the electric switch, the arc-extinction grid plate assembly at a short side

is disposed parallelly next to or adjacent to a side of the bent conductor on the stationary contact and an arcing position when the movable contact and the stationary contact are opened, the first metal arc-extinction grid plate is induced by an electromagnetic field on the stationary contact and an electromagnetic field on an arc column to obtain a magnetic field, and the arc is attracted into the metal arc-extinction grid plate and blew into the arc-extinction grid plate assembly, so that the arc of a single-break high-voltage switch having a small volume is attracted into the arc-extinction grid plate under the magnetic field effect and the arc-breaking ability is improved.

2. The metal arc-extinction grid plate is disposed at two or three sides adjacent to the insulation housing, so that the number of the metal arc-extinction grid plate is greatly increased and each break of the switch can break a rated current and a fault current of the voltage above 500V; and compared to a multi-break series connection method, in which the arc-extinction grid plate is disposed at one side of the insulation housing, in the related technical solution, the volume of the switch is relatively small and the cost of the switch is relatively low.

3. More arc-extinction grid plates are disposed in the single break, so that compared to a multi-break switch, the consumption of the switch is decreased, the energy is saved, and the benefit is increased.

4. More arc-extinction grid plates are disposed at two sides of the insulation housing, so that the number of the switch break is reduced, the situation in which the turn-on effect is influenced by a contact-point burning resulting from that a plurality of contact pairs, in each of which one movable contact is paired with one stationary contact, have different final pressures and over-travels is avoided, and service life of the switch is improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 is a general schematic view of an arc-extinction apparatus according to an embodiment of the present application;

Fig. 2 is a schematic view when an included angle of a bent structure is an acute angle β ;

Fig. 3 is an application schematic view of an alloy touch point of a movable contact and a stationary contact in Fig. 1;

Fig. 4 is a schematic view of a second structure of the stationary contact in the present application;

Fig. 5 is a schematic view of a third structure of the stationary contact in the present application;

Fig. 6 is an application schematic view of an alloy touch point of the stationary contact of a fourth structure and an alloy touch point of the movable contact in the present application;

Fig. 7 is an schematic view of a fifth structure of the stationary contact in the present application;

Fig. 8 is an A-A cross-sectional view of Fig. 7;

Fig. 9 is a schematic view of the electromagnetic principle when a current in the arc-extinction apparatus is flowed from the stationary contact to the movable contact in the present application;

Fig. 10 is a Z-direction view of Fig. 9;

Fig. 11 is a schematic view of the electromagnetic principle when a current in the arc-extinction apparatus is flowed from the movable contact to the stationary contact in the present application;

Fig. 12 is a Z-direction view of Fig. 11;

Fig. 13 is a schematic structural view in which an arc-guiding piece is disposed between first metal arc-extinction grid plates and a bent conductor in the present application;

Fig. 14 is a schematic structural view in which an arc-guiding piece of another structure is disposed between the first metal arc-extinction grid plates and the bent conductor in the present application;

Fig. 15 is a schematic structural view in which an arc-guiding piece of other structure is disposed between the first metal arc-extinction grid plates and the bent conductor in the present application;

Fig. 16 is a schematic view in which the movable contact is L-shaped in the present application;

Fig. 17 is a schematic view in which the movable contact is T-shaped in the present application;

Fig. 18 is a schematic view of a motion trajectory of the movable contact in the present application;

Figs. 19-22 are schematic views in which the movable contact is a L-shaped jaw structure in the present application;

Fig. 23 is a B-B cross-sectional view of Figs. 19-22;

Figs. 24-27 are schematic views in which the movable contact is a branch structure in the present application;

Fig. 28 is an A-direction view of Fig. 27;

Fig. 29 is an exploded schematic view of an arc chute of the arc-extinction apparatus in an embodiment of the present application;

Fig. 30 is an assembly schematic view of the arc chute in Fig. 29;

Fig. 31 is a schematic structural view of the arc chute cooperated with the movable contact in another embodiment of the present application;

Fig. 32 is a cross-sectional view along C-C in Fig. 31;

Fig. 33 is a schematic structural view of the arc chute cooperated with the movable contact in other embodiment of the present application;

Fig. 34 is a cross-sectional view along D-D in Fig. 33;

Fig. 35 is a schematic view of an arrangement of arc-extinction grid plates in the arc-extinction apparatus in an embodiment of the present application;

Fig. 36 is a schematic view of an opening structure of the arc-extinction grid plates in an embodiment of the present application;

Fig. 37 is a schematic view of an arc-attracting structure of the arc-extinction grid plates in an embodiment of the present application;

Fig. 38 and Fig. 39 are schematic views of the arc-attracting structure, in which an included angle of the arc-extinction grid plates and the stationary contact is an acute angle, in an embodiment of the present application;

Fig. 40 is a schematic view of an alternate arrangement of openings of the arc-extinction grid plates in an embodiment of the present application;

Fig. 41 is a schematic view of an arrangement of the arc-extinction grid plates as a C shape according to an embodiment of the present application;

Fig. 42 is a schematic view of an oblique arrangement of the arc-extinction grid plates according to an embodiment of the present application;

Figs. 43-46 are schematic views of various structures of a top arc-attracting piece in the arc-extinction apparatus according to an embodiment of the present application;

Figs. 47, 48, and 50 are schematic views of a magnetic field principle of a permanent magnet piece according to an embodiment of the present application;

Fig. 49 is a Y-direction view of Fig. 48; and

Fig. 51 is a Y-direction view of Fig. 50.

DETAILED DESCRIPTION

[0012] Features and exemplary embodiments of various aspects of the present application will be described in detail below. Numerous specific details are set forth in the following detailed description to provide a thorough understanding of the present application. However, it will be apparent to a person skilled in the art that the present application may be practiced without some of these specific details. The following description of the embodiments is merely intended to provide a better understanding of the present application by illustrating examples of the present application. The present application is not limited to any specific configuration and algorithms set forth below, but covers any modifications, alternatives, and improvements of elements, components, and algorithms without departing from the gist of the present application. In the drawings and the following description, well-known structures and techniques have not been shown in order to avoid unnecessarily obscuring the present application.

[0013] The function of a switch to break a current is mainly accomplished by an arc-extinction grid plate assembly disposed in the switch. A magnetic metal arc-extinction grid plate in a known arc-extinction apparatus is relatively far away from an arc-attracting area of a movable contact and an arc-attracting area of a stationary contact; an arc is attracted into the magnetic metal arc-extinction grid plate by a relatively long arc-attracting piece; an arc of high voltage has a small arc column, high

temperature, and the adhesive attribute; and when breaking a critical current, a magnetic field, inducted by the stationary contact and/or a magnetic field generated by the arc through a very long arc-attracting piece, of the magnetic metal arc-extinction grid plate is very weak, so that an arc-blowing effect cannot be generated, which results in a failure of breaking the arc.

[0014] A known solution using a multi-break concatenating method to solve the problem in which a direct current under high voltage breaks the critical current increases the volume and cost and does not meet the development requirements of small volume and large power of new energy power apparatuses.

[0015] A known solution using double breaking points or multi-pole concatenation results in increasing an internal resistance of the switch, high power consumption, and different final pressures and over-travels of a plurality of contact pairs, in each of which one movable contact is paired with one stationary contact; and therefore there is always one contact pair burning down first, which affects the connection effect of contacts and reduces the service life of the switch.

[0016] Power equipment in the area of photovoltaic power generation, such as 1000V or above direct-current ungrounded power systems, sometimes generates a ground fault. A single-pole switch needs a breaking apparatus to satisfy the requirement of full voltage and two times or less of the rated current. Because the number of the metal arc-extinction grid plates in the known low-voltage switch arc-extinction apparatus or arc chute is small, it is difficult to cut and cool the arc under such high voltage, so that a near-pole voltage drop is larger than a voltage value of a power terminal and the arc cannot be extinguished. A known solution for this problem is to concatenate a plurality of breaks, but the problems of large volume, high cost, and short service life still exist. Therefore, there is an urgent need for improving the arc-extinction performance, reducing the volume, decreasing the cost, and improving the service life.

[0017] Embodiments of the present application provide an arc-extinction apparatus for extinguishing an arc in an electric switch. In some disclosed embodiments, different shape configurations of contact pairs in different switches generate a Lorenz force and/or Holm force when the current passes; and in some disclosed embodiments, the arc-extinction grid plate assembly drives various plasma to make full use of the Lorenz force and/or Holm force, so that the speed of deionizing the arc is increased and the arc-extinction effect is improved. In some disclosed embodiments, a plurality of metal arc-extinction grid plates that are magnetically conductive and insulated from each other by air are stacked to form the arc-extinction grid plate assembly as a bent structure. First metal arc-extinction grid plates at a first end (i.e., an initial end) of the arc-extinction grid plate assembly are disposed adjacent to or close to an initial arc column and as well the stationary contact. The term "adjacent" indicates that a distance between the first metal arc-ex-

tion grid plates and a bent conductor of the stationary contact is very small. The term "close" indicates that the first metal arc-extinction grid plates are in contact with the bent conductor of the stationary contact. The initial arc column is generated when the movable contact and the stationary contact are separated. At this time, the initial arc column, the bent conductor of the stationary contact and the first metal arc-extinction grid plates are substantially parallel, the initial arc column and the stationary contact each generate an electromagnetic field, the first metal arc-extinction grid plates are magnetized under the magnetic field, and the metal arc-extinction grid plates release the magnetic field. In turn, the arc column is subjected to an acting force of the magnetic field and moved to the metal arc-extinction grid plates under an effect of the Lorentz force and/or Holm force. The metal arc-extinction grid plates behind the first metal arc-extinction grid plates successively deliver the magnetic field, so that the whole arc-extinction apparatus generates the arc-blowing effect. The metal arc-extinction grid plates at a tip of the arc-extinction apparatus are adjacent to or close to a last arc column. The arc, arc plasma, and thermal plasma that are on the metal arc-extinction grid plate are moved toward an arc-attracting corner under the effect of the magnetic field, so that a deionization loop among the stationary contact, arc-extinction apparatus, and movable contact is formed, the near-pole voltage drop effect or near negative-pole effect is substantially improved, and the arc is rapidly extinguished. The arc-extinction grid plate assembly of the bent structure and the motion trajectory of the movable contact are structured as an area with a narrow top and a wide bottom. An arc-cooling area and arc-spreading area are structured in the wide bottom of the area, so that the arc is rapidly spread at the bent position, the arc column is lengthened and widened under the bent position, an arc root of the arc falls behind, and the arc structure of the arc is enlarged and thickened. Because the exchange between the low-temperature air and the high-temperature air is sped up, the temperature of the arc is decreased, so that the viscosity of the arc is lowered and the arc is more smoothly moved into the arc-extinction grid plates.

[0018] The arc-extinction apparatus according to embodiments of the present application will be described in detail with reference to Figs. 1-38. The arc-extinction apparatus comprising an exemplary structure is used as an example in following embodiments for describing the gist and principle of the present application and the scope of the present application can further comprise an arc-extinction apparatus having other structures.

[0019] The arc-extinction apparatus 1000 of an embodiment disclosed in the present application is firstly described with reference to Fig. 1 which shows a general schematic view of an arc-extinction apparatus according to an embodiment of the present application. In some embodiments, as shown in Fig. 1, the arc-extinction apparatus 1000 comprises an arc-extinction grid plate assembly 100, a movable contact 200, a stationary con-

tact 300, and an insulation housing 400; the arc-extinction grid plate assembly 100 and the movable contact are disposed inside the insulation housing 400; the stationary contact 300 is partially disposed inside the insulation housing 400 and partially extended from the insulation housing 400 to be electrically connected to an external conductor; the movable contact 200 has a rotation center 201 and a conductive body end 210 of an elongated structure extending toward one end from the rotation center 201; the stationary contact 300 is shaped as a bent structure, and the bent-shaped stationary contact 300 includes a bent conductor 310 that extends toward one end from the bend and a long side 320 that extends toward another end from the bend; the long side 320 is disposed at one internal side of the insulation housing 400, the bent conductor 310 extends in a direction toward the movable contact 200, and the movable contact 200 is rotatable around the rotation center 201 to cooperatively contact or separate from the bent conductor 310 of the stationary contact 300; the initial arc column 1001 is generated when the movable contact 200 and the stationary contact 300 are initially opened and separated; the last arc column 1002 is generated when the movable contact 200 and the stationary contact 300 are opened and separated by a maximal opening distance; the arc-extinction grid plate assembly 100 extends toward two ends from the bend separately, in which one extension is arranged along a first direction, and the other extension is arranged along a second direction; the length L1 of the arc-extinction channel 101 formed by the arc-extinction grid plate assembly 100 is larger than the maximal opening length L2 formed when the movable contact 200 and the stationary contact 300 are opened and separated; a first arc-extinction grid plate assembly 510 arranged along the first direction is disposed at a first internal side 401 of the insulation housing 400, a second arc-extinction grid plate assembly 520 arranged along the second direction is disposed at a second internal side 402 of the insulation housing 400, an arc-entering end 521 of the metal arc-extinction grid plates of the second arc-extinction grid plate assembly 520 is toward a motion trajectory 203 of the movable contact 200, and an arc-entering end 511 of the metal arc-extinction grid plates of the first arc-extinction grid plate assembly 510 is toward a motion trajectory 202 of the movable contact 200; the first arc-extinction grid plate assembly 510 is disposed parallel to a side surface of the bent conductor 310 of the stationary contact 300, the extending directions of a first metal arc-extinction grid plate 501 and the bent conductor 310 are basically identical, and the first metal arc-extinction grid plate 501 of the first arc-extinction grid plate assembly 510 is disposed adjacent to or close to the initial arc column 1001; metal arc-extinction grid plates of a top portion of the second arc-extinction grid plate assembly 520 are part of metal arc-extinction grid plates in the second arc-extinction grid plate assembly 520 away from the first arc-extinction grid plate assembly 510 and are tilted to the adjacent movable contact 200 in the direction

where the movable contact 200 is opened by the maximal opening distance; and the last arc column 1002 is generated between the top portion of the second arc-extinction grid plate assembly 520 and the movable contact 200.

[0020] In such manner, a magnetic blow acting on the first metal arc-extinction grid plates 501 is generated by the electromagnetic field of the initial arc column 1001 and the stationary contact 300 and the arc is rapidly transferred to the arc-extinction grid plates; the electromagnetic field generated by the last arc column 1002 and the intensity of the electric field of the movable contact 200 drive the motion of the plasma, so that the arc is propelled toward the movable contact 200; an arc spread cooling area is formed between the bent structure of the arc-extinction grid plate assembly and the motion trajectory of the movable contact 200, the arc column is enlarged, thickened, and in advance of the arc root, and the arc temperature is rapidly reduced to significantly lower the viscosity, so that a heat dissipation condition of the arc is good, a deionization process of the arc column is strong, a potential gradient of the arc column is high, the near-pole voltage drop or near negative-pole effect is strong, which facilitates to extinguish the critical current of 500V or higher and break a large fault current, and the arc-extinction performance can be largely improved.

[0021] Additionally, still referring to Fig. 1, an arrangement direction of the metal arc-extinction grid plates in the first arc-extinction grid plate assembly 510 is the first direction, an arrangement direction of the metal arc-extinction grid plates in the second arc-extinction grid plate assembly 520 is the second direction, and the first direction and the second direction are disposed as an acute angle. In this embodiment, the length of the second arc-extinction grid plate assembly 520 in the second direction is larger than the length of the first arc-extinction grid plate assembly 510 in the first direction, and part of metal arc-extinction grid plates in the second arc-extinction grid plate assembly 520 away from the first arc-extinction grid plate assembly 510 is arranged obliquely toward the direction where the movable contact 200 is located.

[0022] The first direction and the second direction are disposed as a right angle or an obtuse angle, different angles correspond to different shapes formed by the arc-extinction grid plate assembly, and it can be reasonably disposed according to a specific structure configuration of the movable contact 200 and the stationary contact 300.

[0023] The first arc-extinction grid plate assembly 510 is successively arranged from the first metal arc-extinction grid plates 501 adjacent to or close to the bent conductor 310 to the direction away from the bent conductor 310, two adjacent metal arc-extinction grid plates in the first arc-extinction grid plate assembly 510 adjacent to the bent conductor 310 are disposed partially parallel to each other, two adjacent metal arc-extinction grid plates in the first arc-extinction grid plate assembly 510 adjacent to the second arc-extinction grid plate assembly

520 are disposed at an included angle and are connected to the second arc-extinction grid plate assembly 520 to form the arc-extinction grid plate assembly as a bent-shaped arc structure, so that extending surfaces of each metal arc-extinction grid plate are intersected with each other in the direction where the movable contact 200 is located, which facilitates to move more quickly into the arc chute.

[0024] Any two adjacent metal arc-extinction grid plates in some metal arc-extinction grid plates, adjacent to the first arc-extinction grid plate assembly 510, of the second arc-extinction grid plate assembly 520 are disposed at an included angle, thereby implementing a transitional connection with the first arc-extinction grid plate assembly 510 to cooperatively form a bend. The arc-extinction grid plates in the part, past the bend, of the second arc-extinction grid plate assembly 520 are arranged in a composite manner of disposing at an included angle and parallel. Some metal arc-extinction grid plates away from the first arc-extinction grid plate assembly 510, i.e., part of the metal arc-extinction grid plates in the top portion of the second arc-extinction grid plate assembly 520, are successively disposed to be gradually close to the movable contact 200 opened by the maximal opening distance, so that when the movable contact 200 is opened by the maximal opening distance, the arc on the movable contact 200 can be rapidly transferred to the metal arc-extinction grid plates in the top portion of the second arc-extinction grid plate assembly 520, the transfer speed of the arc is accelerated, the arc is elongated, and the arc-extinction performance of the arc-extinction apparatus 1000.

[0025] In other embodiments, the metal arc-extinction grid plates in the top portion of the second arc-extinction grid plate assembly 520 can further be arranged at an angle to form an arc structure, thereby being brought together with the movable contact 200 opened by the maximal opening distance to implement the same technical effect.

[0026] In an embodiment shown in Fig. 1, the arc-extinction grid plate assembly is disposed at an acute angle and the acute angle is a sharp corner. An optional range, obtained by experiments, of the sharp corner angle α is $30^\circ < \alpha \leq 75^\circ$. Compared to the included angle β as shown in Fig. 2, in which an optional range is $75^\circ < \beta \leq 90^\circ$, when the angle α is a sharp corner, the sharp corner shape allows to arrange more metal arc-extinction grid plates under a same condition, elongate the arc to a greater extent, increase the motion distance of the arc, and increase the field strength at the position of the acute angle, so that the arc is further easily moved into the arc-extinction grid plate to be deionized under the effect of high field strength; the sharp corner shape further enlarges an area in front of the acute angle, the number of the air plasma is increased, and the thermal ionization speed of thermal plasma is accelerated to enhance the effect of the arc deionization.

[0027] In embodiments shown in Fig. 1, the bent con-

ductor 310 of the stationary contact 300 is substantially disposed perpendicular to the long side 320, the bent conductor 310 is substantially perpendicular to the first internal side 401 of the insulation housing 400, and the long side 320 is arranged along the first internal side 401.

[0028] As shown in Fig. 3, the stationary contact 300 and the movable contact 200 are provided with a stationary-contact alloy contact point 312 and a movable-contact alloy contact point 214, respectively, at the positions where the stationary contact 300 and the movable contact 200 are contacted with each other. The alloy contact points provided on the stationary contact 300 and the movable contact 200 can reduce the resistivity of the stationary contact 300 and the movable contact 200 and improve the conductive property between the stationary contact 300 and the movable contact 200. Meanwhile, the alloy contact point has advantages of high-temperature, abrasion resistance, and anti-oxidation for resisting the arc burning of cutting off a large current.

[0029] In other embodiments, the stationary contact can be provided as other structures. Fig. 4 shows a second structure of the stationary contact, in which the bent conductor 310 of the stationary contact 300 and the long side 320 are disposed at a 45-degree angle and the bent conductor 310 is tilted to the direction close to the rotation center of the movable contact 200; Fig. 5 shows a third structure of the stationary contact 300, in which the bent conductor 310 of the stationary contact 300 and the long side 320 are disposed at a 45-degree angle and the bent conductor 310 is tilted to a direction away from the rotation center of the movable contact 200; and Fig. 6 shows a fourth structure of the stationary contact 300, in which the bent conductor 310 of the stationary contact 300 and the long side 320 are disposed parallel to each other, and the stationary contact 300 and the movable contact 200 in this structure are provided with the stationary-contact alloy contact point 312 and the movable-contact alloy contact point 214 respectively, which have the advantages are identical to the alloy contact points described above. The bent structure of the stationary contact 300 can change a flow direction of a current in the stationary contact 300, so that the electromotive force acted on the arc can increase, which facilitates the transfer of the arc. Fig. 7 shows a fifth structure of the stationary contact and Fig. 8 is an A-A cross-sectional view of Fig. 7. In this structure, the stationary contact 300 is jaw-shaped and the movable contact 200 is connected to or disconnected from the stationary contact 300 by inserting in or drawing out a jaw of the stationary contact 300. The jaw-shaped structure facilitates the movable contact 200 not to be pushed away by the Lorentz force when the movable contact 200 withstands a large current.

[0030] How the first metal arc-extinction grid plates 501 attract the arc to the metal arc-extinction grid plates is further described below with reference to Figs. 9-12, so that the arc can be rapidly attracted into the arc-extinction

apparatus 1000.

[0031] As shown in Fig. 9 and Fig. 10, when a current I goes through the switch and flows from the stationary contact 300 to the movable contact 200, it may be known according to the right-hand rule that the magnetic field direction above the stationary contact 300 is inside-out and the metal arc-extinction grid plates above the stationary contact 300 are subject to the action of a magnetic field FF . It may be known according to Fig. 10 that the metal arc-extinction grid plates are passed through and magnetized by the magnetic field FF , the inside magnetic field $FF1$ of the arc-extinction grid plate and the magnetic field FF have a same magnetic direction, and a magnetic field GG is generated at an opening of the arc-extinction grid plate under the action of the magnetic field $FF1$ and has a magnetic direction that is opposite to the magnetic direction of the magnetic field $FF1$. The initial arc column 1001 is generated when the movable contact 200 and the stationary contact 300 are separated. Under the action of the magnetic field GG at an opening of the first metal arc-extinction grid plate 501 close to the initial arc column 1001, it may be known according to the left-hand rule that the initial arc column 1001 moves toward the first metal arc-extinction grid plate 501 under the action of the Lorentz force F .

[0032] As shown in Fig. 11 and Fig. 12, when a current I goes through the switch and flows from the movable contact 200 to the stationary contact 300, it may be known according to the right-hand rule that the magnetic field direction above the stationary contact 300 is outside-in and the metal arc-extinction grid plates above the stationary contact 300 are subject to the action of the magnetic field FF . It may be known according to Fig. 12 that the metal arc-extinction grid plates are passed through and magnetized by the magnetic field FF , the inside magnetic field $FF1$ of the arc-extinction grid plate and the magnetic field FF have a same magnetic direction, and a magnetic field GG is generated at the opening of the arc-extinction grid plate under the action of the magnetic field $FF1$ and has the magnetic direction that is opposite to the magnetic direction of the magnetic field $FF1$. The initial arc column 1001 is generated when the movable contact 200 and the stationary contact 300 are separated. Under the action of the magnetic field GG at the opening of the first metal arc-extinction grid plate 501 close to the initial arc column 1001, it may be known according to the left-hand rule that the initial arc column 1001 moves toward the first metal arc-extinction grid plate 501 under the action of the Lorentz force F .

[0033] It may be known according to the above analysis that when the switch is conductive, the metal arc-extinction grid plates above the stationary contact 300 generate a force acted on the arc to move toward the metal arc-extinction grid plates under the action of the electromagnetic field, so that the arc can be more rapidly moved into the arc-extinction system, thereby being quickly extinguished.

[0034] In some embodiments, as shown in Figs. 13-15,

an arc-guiding piece 540 that is relatively short and have a different structure is disposed between the alloy contact point of the stationary contact 300 and the first metal arc-extinction grid plates 501 and a length X1 of the arc-guiding piece 540 in the first direction is no longer than 50% of a length of the first arc-extinction grid plate assembly 510 in the first direction. When the first metal arc-extinction grid plates 501 and the bent conductor 310 are disposed adjacent to each other and not contacted to each other, the arc can be quickly transferred by the arc-guiding piece 540. The arc cannot be directly entered the arc-extinction grid plate in some structures, the arc-guiding piece 540 disposed as different shapes guides the arc to move toward the arc-extinction grid plates, so that the arc can be rapidly moved into the arc chute.

[0035] In some other embodiments, the movable contact 200 can further be provided with other structures.

[0036] As the movable contact 200 provided in Fig. 16, the movable contact 200 is extended from the rotation center 201 toward one end, a protrusion 213 contacted to the stationary contact 300 and a protrusion arc-guiding portion are formed on an end portion of the movable contact 200, the protrusion 213 and the protrusion arc-guiding portion have different extending directions, and the movable contact 200 is substantially L-shaped. The protrusion 213 can be substituted for the movable contact point on the movable contact 200 to a certain extent, thereby being helpful to reduce the cost.

[0037] As shown in Fig. 17 and Fig. 18, a protrusion electrical contact portion 211 contacted to the stationary contact 300 and a protrusion arc-guiding portion 212 disposed in a reverse direction of the protrusion electrical contact portion 211 are formed on one end portion of the movable contact 200, the protrusion electrical contact portion 211 and the protrusion arc-guiding portion 212 are extended toward two sides respectively, so that the movable contact 200 is T-shaped. A T-type shape is easy to be processed and beneficial for controlling the cost.

[0038] Figs. 19-22 show an L-shaped jaw structure of the movable contact, and Fig. 23 is a B-B cross-sectional view of Figs. 19-22. A head direction of the L-shaped jaw structure in Fig. 19 and Fig. 20 is opposite to a head direction of the L-shaped jaw structure in Fig. 21 and Fig. 22. The position where the movable contact 200 and the stationary contact 300 contact each other is jaw-shaped; the movable contact 200 is inserted on both sides of the stationary contact 300 to achieve the conductivity between the movable contact 200 and the stationary contact 300; the movable contact 200 is pulled from the stationary contact 300 to achieve the separation of the movable contact 200 from the stationary contact 300. The jaw-shaped structure facilitates that the movable contact 200 is not pushed away by the Lorentz force when the movable contact 200 withstands a large current.

[0039] Fig. 17, Fig. 19, and Fig. 21 are schematic views of the motion trajectory of the movable contact. A rotation radius R1 of the protrusion arc-attracting portion 212 is larger than or equal to a rotation radius R2 of the protrusion

electrical contact portion 211, and a distance between the protrusion arc-attracting portion 212 and the arc-extinction grid plates is gradually reduced in a motion process of the movable contact 200. The arc is attracted to transfer toward the protrusion arc-attracting portion 212 and is guided to move into the arc-extinction grid plate assembly.

[0040] Fig. 18, Fig. 20, and Fig. 22 are schematic views of the motion trajectory of the movable contact. The rotation radius R1 of the protrusion arc-attracting portion 212 is smaller than the rotation radius R2 of the protrusion electrical contact portion 211. In the motion process of the movable contact, the distance between the protrusion arc-attracting portion 212 and the arc-extinction grid plates firstly changes from greater to less, and the arc is attracted to transfer toward the protrusion arc-attracting portion 212; when the movable contact 200 moves to a maximal opening distance position, the distance D1 between the protrusion arc-attracting portion 212 and the arc-extinction grid plates is larger than the distance D2 between the protrusion electrical contact portion 211 and the arc-extinction grid plates.

[0041] This application may produce different arc-extinction effects when an arc energy is relatively low. When the protrusion electrical contact portion 211 at the maximal opening distance position is located far away from a front end of the arc-extinction grid plates, the arc is more easily attracted by an adjacent metal arc-extinction grid plate when the energy of the arc is relatively low and moved toward the adjacent metal arc-extinction grid plate, and a path is formed between the arc and the protrusion arc-attracting portion 212 of the movable contact 200 at last. In this case, the arc is elongated and divided between the metal arc-extinction grid plates into short arcs connected each other, so that the utilization rate of the arc chute is improved, an approximate dough-shaped arc formed near the end portion is avoided, and the front portions of the metal arc-extinction grid plates are shorted. A short in the metal arc-extinction grid plate is not beneficial to dividing the arc into more short arcs, the near-pole pressure drop or near-cathode effect is improved, and the dough-shaped arc can enable the arc energy to be gathered and is not easy to extinguish.

[0042] Fig. 24 and Fig. 25 are schematic views of the motion trajectory of the movable contact, the movable contact 200 is extended from the rotation center 201 to one end, a protrusion electrical contact portion 211 contacted to the stationary contact 300 and a protrusion arc-guiding portion 212 disposed in a reverse direction of the protrusion electrical contact portion 211 are formed on one end portion of the movable contact 200, the protrusion electrical contact portion 211 and the protrusion arc-guiding portion 212 are formed as a fork-like shape, and the rotation radius R1 of the protrusion arc-attracting portion 212 is larger than or equal to the rotation radius R2 of the protrusion electrical contact portion 211.

[0043] As shown in Fig. 24, in the motion process of the movable contact 200, the distance between the protrusion

sion arc-attracting portion 212 and the metal arc-extinction grid plates is gradually reduced, the arc is attracted to be transferred toward the protrusion arc-attracting portion 212, and the arc is guided to move toward the arc-extinction grid plate assembly.

[0044] As shown in Fig. 25, in the motion process of the movable contact 200, the distance between the protrusion arc-attracting portion 212 and the metal arc-extinction grid plates 524 firstly changes from greater to less and the arc is guided to be transferred toward the protrusion arc-attracting portion 212; when the movable contact 200 is moved at the maximal opening distance position, the distance D3 between the protrusion arc-attracting portion 212 and the metal arc-extinction grid plates 524 is larger than the distance D4 between the protrusion electrical contact portion 211 and the metal arc-extinction grid plates 524; and this embodiment is applicable to the situation in which the arc energy is relatively low.

[0045] Fig. 26 and Fig. 27 are schematic views of the motion trajectory of the movable contact. The movable contact 200 extends from the rotation center 201 to one end, a protrusion electrical contact portion 211 to contact the stationary contact 300 and a protrusion arc-guiding portion 212 disposed in a direction away from the protrusion electrical contact portion 211 are formed on one end portion of the movable contact 200 as a fork-like shape, and the rotation radius R1 of the protrusion arc-attracting portion 212 is less than the rotation radius R2 of the protrusion electrical contact portion 211.

[0046] As shown in Fig. 26, in the motion process of the movable contact, the distance between the protrusion electrical contact portion 211 and the metal arc-extinction grid plates 524 changes from larger to less, the arc is guided to be transferred toward the protrusion arc-guiding portion 212; when the movable contact 200 is moved at the maximal opening distance position, the distance D1 between the protrusion arc-attracting portion 212 and the metal arc-extinction grid plates 524 is larger than the distance D2 between the protrusion electrical contact portion 211 and the metal arc-extinction grid plates 524; and this embodiment is applicable to the situation in which the arc energy is relatively low.

[0047] Fig. 27 illustrates another example of the distance between the protrusion arc-attracting portion and the front ends of the metal arc-extinction grid plates, and Fig. 28 is an A-direction view of Fig. 27. An arc-blocking piece 900 is disposed near the maximal opening distance position of the movable contact 200 and at leg portions of the metal arc-extinction grid plates 524. Through the shielding of the arc-blocking piece 900, the arc needs to crawl a longer distance at the end portion to be connected to the front ends of the metal arc-extinction grid plates 524 at the protrusion arc-attracting portion 212. This arrangement is beneficial for achieving a compact space structure or the same effect as in Fig. 25 under a situation of a complex space.

[0048] The arc-blocking piece 900 may also be dis-

posed on the protrusion arc-attracting portion 212 to achieve the same effect, and this embodiment only shows a typical application therein, and does not represent all embodiments, and on this basis, embodiments that can be designed by those skilled in the art are all within the scope of the present application.

[0049] As shown in Fig. 25, when the radius R1 of the motion trajectory of the protrusion arc-attracting portion 212 is larger than the radius R2 of the motion trajectory of the protrusion electrical contact portion 211, through the manners such as moving the position of the metal arc-extinction grid plates 524 and changing the size of the metal arc-extinction grid plates 524, the distance D3 between the protrusion arc-attracting portion 212 and the metal arc-extinction grid plates 524 near the maximal opening distance position of the movable contact 200 is larger than the distance D4 between the protrusion electrical contact portion 211 and the front end of the metal arc-extinction grid plates 524 near the protrusion electrical contact portion 211.

[0050] In the motion process in which the movable contact 200 and the stationary contact 300 are separated, when an electrical gap between the protrusion arc-attracting portion 212 and the arc-extinction grid plates is minimal, the arc is transferred toward the protrusion arc-attracting portion 212. Meanwhile, one path is formed between the protrusion arc-attracting portion 212 and the stationary contact point on the stationary contact 212. Therefore, a protrusion-shaped structure of the protrusion arc-attracting portion 212 allow to arrange more metal arc-extinction grid plates 524, the arc can be transferred toward more arc-extinction grid plates and be divided into more short arcs, thereby improving the near-pole pressure drop or near-cathode effect and allowing an area with a narrow top and a wide bottom to be formed between the arc-extinction apparatus 1000 and the motion trajectory of the movable contact 200, so that the arc column is quickly developed, the arc root of the arc falls behind the arc column to quickly spread and cool the arc, and the arc-extinction performance of the arc can be significantly improved.

[0051] The magnetic arc-extinction grid plate assembly 100 is further described below with reference to Figs. 29-30. As shown in Fig. 29, the arc-extinction grid plate assembly 100 comprises insulation pieces 610, insulation arc-isolation pieces 700, and metal arc-extinction grid plates 500. The insulation pieces 610 further comprise two insulation plates coupled to two sides of the metal arc-extinction grid plates 500, respectively, to fix the metal arc-extinction grid plates 500 stacked and insulated from each other by air. The insulation pieces 610 in this embodiment comprise a first insulation plate 611 and a third insulation plate 613 that are disposed at one side of the metal arc-extinction grid plates 500 and a second insulation plate 612 and a fourth insulation plate 614 that are disposed at the other side of the metal arc-extinction grid plates 500. The metal arc-extinction grid plates 500 are fixed to the first insulation plate 611 and the

third insulation plate 613 on one side and are fixed to the second insulation plate 612 and the fourth insulation plate 614 on another side. The insulation arc-isolation pieces 700 comprise a first insulation arc-isolation piece 701 and a third insulation arc-isolation piece 703 wrapping one leg portion of the metal arc-extinction grid plates 500 and a second insulation arc-isolation piece 702 and a fourth insulation arc-isolation piece 704 wrapping another leg portion of the metal arc-extinction grid plates 500. A gas-producing insulation material can be selected to manufacture the insulation pieces 610 and insulation arc-isolation pieces 700, and the insulation arc-isolation pieces 700 are located on the inner side of the insulation pieces 610.

[0052] Additionally, an assembly aperture and a slot feature 620 are disposed on the insulation plate, a protrusion feature 501 is disposed on the metal arc-extinction grid plates 500 and mated with the slot feature 620, and the insulation piece 610 and the metal arc-extinction grid plates 500 are assembled and fixed to each other through a mating manner of a protrusion and a slot aperture or a mating manner of riveting.

[0053] In other embodiments, the metal arc-extinction grid plates 500 can be directly assembled on the insulation housing 400. At this time, the insulation housing 400 is the insulation piece 610. When the space inside the insulation housing 400 is limited and the size of the metal arc-extinction grid plates 500 cannot be reduced. The metal arc-extinction grid plates 500 are assembled on the insulation housing 400, which can increase the utilization rate of the effective space.

[0054] The metal arc-extinction grid plates 500 and the insulation plates are assembled through the above manner, which is beneficial to improving a product assembly efficiency. Undesirable phenomena, such as assembling fewer metal arc-extinction grid plates 500 and mistakenly assembling the metal arc-extinction grid plates 500, can be avoided.

[0055] As shown in Fig. 30, the insulation arc-isolation pieces 700 are disposed inside the arc-extinction grid plate assembly 100. An air gap height H1 between the insulation arc-isolation pieces 700 wrapping two leg portions of the metal arc-extinction grid plates 500 is smaller than an air gap height H2 between the insulation pieces 610 on the two sides. By setting the air gap height H1 between the two insulation arc-isolation pieces 700 to be less than the air gap height H2 between the two insulation pieces 610, the path in which the arc is passes through is narrowed to form an air pressure difference between the front portion and the rear portion of the arc-extinction grid plate assembly. It is beneficial to accelerating the movement of the arc toward the interior of the metal arc-extinction grid plates 500 and the arc extinction.

[0056] The insulation arc-isolation pieces 700 may also be divided into one insulation arc-isolation piece or a plurality of insulation arc-isolation pieces at each of the left side and right side, and it should be arranged according to actual conditions.

[0057] In other embodiments, as shown in Fig. 31 and Fig. 32, two insulation arc-isolation pieces 700 each are disposed between the end portion of the arc-extinction grid plate assembly 100 and the motion area of the movable contact 200, and an air gap height H1 between the two insulation arc-isolation pieces is smaller than an air gap height H2 between the two insulation pieces. In this embodiment, two insulation arc-isolation pieces 700 can be fixedly disposed on two insulation pieces or the insulation housing 400. As shown in Fig. 33 and Fig. 34, an extending length from the end portion of the arc-extinction grid plate assembly 100 to the motion area of the movable contact 200 between two insulation arc-isolation pieces 700 is larger than a distance between the end portion of the arc-extinction grid plate assembly 100 to the motion area of the movable contact 200. That is to say, the end portion of the movable contact 200 is extended into the space gap area formed by the two insulation arc-isolation pieces 700, and the air gap height H1 between the two insulation arc-isolation pieces 700 is less than the air gap height H2 between the two insulation pieces 610. The arrangement of the insulation arc-isolation pieces 700 is merely exemplary and can be arranged according to a specific structure. It is only necessary to meet the requirement that a space gap height between the two insulation arc-isolation pieces 700 is smaller than a space gap height of at least one side thereof. Therefore, when the arc is moved toward the arc-extinction grid plates 500, because the air gap height H1 between the two insulation arc-isolation pieces 700 is less than the air gap height H2 between the two insulation pieces 610, the path in which the arc is passed through is narrowed, an arc voltage is increased, so that the arc can be more quickly moved toward the rear portion of the arc-extinction grid plates 500, and the arc is elongated to reduce the arc energy.

[0058] The shape of the insulation arc-isolation piece 700 can be selected from any one of a columnar shape, a wall shape, a sheet shape, a triangular shape, a partial ring shape, a polyhedron shape, or any combination thereof. The insulation arc-isolation pieces 700 provided with a different structure can better guide the arc into the arc-extinction grid plate assembly.

[0059] The insulation arc-isolation pieces 700 are made of a gas-producing material and an optional gas-producing material is nylon or polyacetal. The insulation arc-isolation pieces 700 can produce gas when the arc is burned, the arc is spread and moved toward the rear end of the metal arc-extinction grid plates 500 under the effect of the airflow, and it is beneficial to extinguishing the arc more quickly.

[0060] An angle at which two arc-extinction grid plates are disposed can be between 0 and 45 degrees. In the arc-extinction grid plate assembly 100 arranged as the bent structure, when the arc-extinction grid plates in a bent transition area are arranged, the greater an angle between adjacent arc-extinction grid plates, the less the number of the arc-extinction grid plates arranged and the

smaller a space of the bent transition area required. In contrast, the smaller an angle between adjacent arc-extinction grid plates, the more the number of the arc-extinction grid plates arranged and the greater a space of the bent transition area required. The angle value obtained and verified by multiple tests can be 5 to 15 degrees, such as, the arc-extinction grid plate assembly 100 shown in Fig. 1.

[0061] Fig. 35 illustrates the arrangement of the metal arc-extinction grid plates in the arc-extinction grid plate assembly 100. The metal arc-extinction grid plates 500 are spaced and insulated from each other by the air; the metal arc-extinction grid plates 500 are disposed parallel to each other or at an included angle; when disposed at the included angle, an open end distance h1 of the metal arc-extinction grid plates 500 is not larger than a bottom portion distance h2 of the metal arc-extinction grid plates 500; and the metal arc-extinction grid plates 500 are arranged substantially as an arc-shaped structure.

[0062] This arrangement can gradually enlarge the arc distance when the arc is moved toward the bottom portion of the metal arc-extinction grid plates 500, expand the air insulation gap, elongate the arc, and lower the arc energy, thereby being beneficial to quickly extinguishing the arc.

[0063] Fig. 36 shows different structures of the metal arc-extinction grid plates. The metal arc-extinction grid plate 500 is provided with a magnetic-field concentrating opening 552 located toward the arc-entering end, and a shape of the magnetic-field concentrating opening 552 is any one of a slit shape, an inclination shape, a horizontal shape, a trapezoidal-structure shape, a mouth shape, a circular shape, and an arc shape.

[0064] Fig. 37 shows a schematic view of an arc-attracting structure of the metal arc-extinction grid plate. The metal arc-extinction grid plate 500 is provided with the arc-attracting structure located toward the arc-entering end. Leg portion structures on two sides of the magnetic-field concentrating opening 552 of the metal arc-extinction grid plate 500 are different. A shape of a first end surface 551 of one leg portion is different from a shape of a second end surface 553 of the other leg portion, i.e., the leg portions on the two sides are set asymmetric, and this structure is beneficial to more quickly attracting the arc into the arc-extinction grid plates in some applications.

[0065] The metal arc-extinction grid plates 500 shown in Fig. 37 can be modified further, and the leg portion feature can be lengthened to form a combination shape of the arc-attracting piece and the arc-extinction grid plate. For example, the metal arc-extinction grid plates 500 shown in Fig. 38 and Fig. 39 and the stationary contact 300 are disposed at an acute angle θ . This structure simplifies the structure of components and is beneficial to reducing the cost.

[0066] Fig. 40 illustrates a schematic structural view of the staggered arrangement of the arc-extinction grid plates. The metal arc-extinction grid plates 500, having

different leg portion structures, as shown in Fig. 36 are arranged in a staggered manner, and the arc-extinction channel 101 of the arc become discontinuous or uneven, so that the movement path of the arc is lengthened when the arc moves, the arc energy is lowered, and the arc is quickly cut the metal arc-extinction grid plates 500 to effectively extinguish the arc.

[0067] When the metal arc-extinction grid plates 500 are spaced apart from each other by air insulation slits, under the action of the magnetic-field electromotive force of the structure in which the arc is located, the arc is lengthened and entered into the slit of the arc-extinction apparatus 1000, thereby being moved in a grid plate slit. The arc is cooled to enhance the effect of the deionization; moreover, the arc is lengthened, an arc radius is shrunk, and an arc resistance is enlarged, so that the arc is extinguished.

[0068] Fig. 41 shows a schematic view of a C-shaped arrangement of the arc-extinction grid plate assembly. The arc-extinction grid plate assembly 100 comprises a first arc-extinction grid plate assembly 510, a second arc-extinction grid plate assembly 520, and a third arc-extinction grid plate assembly 570. The first arc-extinction grid plate assembly 510 is arranged in the first direction and disposed at the first internal side 401 of the insulation housing 400, the second arc-extinction grid plate assembly 520 is arranged in the second direction and disposed at the second internal side 402 of the insulation housing 400, and the third arc-extinction grid plate assembly 570 is arranged in the first direction and disposed at the third internal side 403 of the insulation housing 400. The length of the first arc-extinction grid plate assembly 510 and the third arc-extinction grid plate assembly 570 each in the first direction is less than the length of the second arc-extinction grid plate assembly 520 in the second direction. The first arc-extinction grid plate assembly 510, the second arc-extinction grid plate assembly 520, and the third arc-extinction grid plate assembly 570 are together form a C-shaped arc-extinction grid plate assembly having two bent portions. When a volume condition of the switch allow, a number of the metal arc-extinction grid plates 500 disposed at three internal sides of the insulation housing 400 is more than a number of the metal arc-extinction grid plates 500 disposed at two internal sides of the insulation housing 400, so that the arc-extinction performance is better.

[0069] In some embodiments, as shown in Fig. 42, partial metal arc-extinction grid plates 525 in the top portion of the second arc-extinction grid plate assembly 520 are arranged as an arc-shaped structure or obliquely arranged toward the direction where the movable contact 200 is located. This arrangement is beneficial to guiding the direction of the arc and enlarging a cooling space between the arc-extinction grid plates and the movable contact 200.

[0070] Figs. 43-46 show schematic views of various structures of an arc-attracting piece provided at the top portion of the arc-extinction grid plate assembly 100. The

arc-extinction grid plate assembly 100 have only one bent structure, and one arc-attracting piece 530 is disposed at the top portion of the second arc-extinction grid plate assembly 520 to attract the arc toward the protrusion arc-attracting portion 212. The arc-attracting piece 530 can have different shapes, which aims to generate a larger cooling and spread space when the distance between the movable contact 200 and the stationary contact 300 is very large, so that the arc-extinction performance is improved.

[0071] In some embodiments, multiple poles of the insulation housing 400 of the switch carrying the phase or pole power supply are arranged adjacent at the left and right sides, the movable contact 200 is moved vertically up and down, the structure is suitable for a switch with large working current, the arc chute is arranged as a C-shaped arc-extinction grid plate assembly with three faces or an L-shaped arc-extinction grid plate assembly with two faces, and higher voltage and larger current are broken.

[0072] In some embodiments, one or more permanent magnet steel pieces 800 are disposed on or outside the arc-extinction apparatus 1000, which facilitates the arc extinction. Specifically, the permanent magnet steel piece 800 is disposed at one side of the arc-extinction apparatus 1000, can be adjacent to or close to the insulation piece 610, or can be disposed between the insulation 610 and the insulation arc-isolation piece 700.

[0073] As shown in Fig. 47, the permanent magnet steel piece 800 is disposed at one side of the insulation piece 610, the north pole of the permanent magnet steel pieces 800 is directed to right, and the direction of the magnetic field passes through the metal arc-extinction grid plates 500 from left to right as shown by the arrow. When the arc is moved upwards in the illustrated direction, an acting force F of the magnetic field acts on the arc. It can be known according to the left-hand rule that the direction of the acting force F is perpendicular to the paper, and under the action of the acting force F , the arc is rapidly moved towards the rear end of the metal arc-extinction grid plates 500, so that the motion trajectory of the arc becomes longer, the arc energy is lowered, the cooling effect is enhanced, and it is beneficial to rapidly extinguishing the arc.

[0074] In other embodiments, as shown in Figs. 48-51, the permanent magnet steel pieces 800 is disposed behind the arc-extinction apparatus, disposed on the insulation housing 400, or insulated between the metal arc-extinction grid plates 500.

[0075] Still referring to Fig. 48 and Fig. 49, the north pole of the permanent magnet steel piece 800 faces towards the X positive direction illustrated in figures, and the magnetic field direction passes through the metal arc-extinction grid plates 500 from left to right as shown by the arrow. When the arc is moved towards the Y positive direction illustrated in figures, it can be seen according to the left-hand rule that the direction of the acting force F is perpendicular to the paper inwardly (the

Z positive direction illustrated in figures). Specifically, it can be seen from Fig. 49 that the arc is moved towards the right end of the metal arc-extinction grid plates 500 under the action of the magnetic field force F .

[0076] Still referring to Fig. 50 and Fig. 51, the north pole of the permanent magnet steel piece 800 faces towards the X positive direction illustrated in figures, and the magnetic field direction passes through the metal arc-extinction grid plates 500 from left to right as shown by the arrow. When the arc is moved towards the Y negative direction illustrated in figures, it can be seen according to the left-hand rule that the direction of the acting force F is perpendicular to the paper outwardly (the Z negative direction illustrated in figures). Specifically, it can be seen from Fig. 51 that the arc is moved towards the left end of the metal arc-extinction grid plates 500 under the action of the magnetic field force F .

[0077] As mentioned above, when the permanent magnet steel pieces 800 is disposed behind the arc-extinction apparatus, a partial arc is moved toward the left and right sides of the opening of the arc-extinction grid plate, so that the arc can be lengthened, the length of the arc is longer, and it is beneficial to extinguishing the arc.

[0078] The position and number of the permanent magnet steel pieces 800 should be determined according to actual requirements and structures, and this figure is merely a representation of the principle of the magnetic field, and may also be other situations.

[0079] Embodiments of the present application are described above, the above description is exemplary and merely optional embodiments of the present application rather than exhaustive, and it is not intended to limit the present application. Although the claims is formulated in the present application for a particular combination of features, it should be understood that the scope of the present application further includes any novel feature or any novel combination of features explicitly or implicitly or in any summary thereof disclosed herein, regardless of whether it refers to the same scheme in any claims presently claimed or not. Applicants hereby inform that new claims may be formulated as these features and/or combinations of these features in any further application, either during the prosecution of the present application or derived therefrom.

[0080] To those skilled in the art, the present application can have various modifications and variations. Any modification, equivalent replacement and improvement made within the gist and principle of the present application shall be included in the protection scope of the present application.

Claims

1. An arc-extinction apparatus for extinguishing an arc in an electric switch, the arc-extinction apparatus at least comprising an arc-extinction grid plate assembly, a movable contact, a stationary contact, and an

insulation housing, wherein

an initial arc column is generated under a condition that the movable contact and the stationary contact are initially opened and separated, and a last arc column is generated under a condition that the movable contact and the stationary contact are opened and separated by a maximal opening distance, the arc-extinction grid plate assembly at least comprises a plurality of metal arc-extinction grid plates insulated from each other by air, the plurality of the metal arc-extinction grid plates in the arc-extinction grid plate assembly are stacked to form a structure with at least one bend and are directly or indirectly arranged along at least two adjacent inner sides within the insulation housing, the stationary contact is a structure with at least one bend, and a length of an arc-extinction channel formed by the arc-extinction grid plate assembly is larger than a maximal opening length formed under a condition that the movable contact and the stationary contact are opened and separated, a bent conductor is disposed on the stationary contact, a first metal arc-extinction grid plate provided at a first end of the arc-extinction grid plate assembly is disposed adjacent or close to the bent conductor of the stationary contact and also adjacent or close to the initial arc column, and extending directions of the first metal arc-extinction grid plate and the bent conductor are identical or form an included angle.

2. The arc-extinction apparatus according to claim 1, wherein the arc-extinction grid plate assembly comprises a first arc-extinction grid plate assembly and a second arc-extinction grid plate assembly, the first arc-extinction grid plate assembly is arranged along a first direction, located in front of the initial arc column, and disposed at a first inner side of the insulation housing, and the second arc-extinction grid plate assembly is arranged along a second direction, located from the initial arc column to front of the last arc column, and disposed on a second inner side of the insulation housing; the first direction is not parallel with the second direction, and the first direction is disposed perpendicular to, at an acute angle or at an obtuse angle with respect to an extending direction of the movable contact.
3. The arc-extinction apparatus according to claim 2, wherein an extending direction of the first arc-extinction grid plate assembly is at an acute angle with respect to an extending direction of the second arc-extinction grid plate assembly, and the acute angle at

which the arc-extinction grid plate assembly is disposed is a sharp corner.

4. The arc-extinction apparatus according to claim 2, wherein a length of the first arc-extinction grid plate assembly in the first direction is smaller than a length of the second arc-extinction grid plate assembly in the second direction.
5. The arc-extinction apparatus according to claim 2, wherein a number of arc-extinction grid plates, disposed along the first direction, of the first arc-extinction grid plate assembly is at least two.
6. The arc-extinction apparatus according to claim 2, wherein part of arc-extinction grid plates of the second arc-extinction grid plate assembly away from the first arc-extinction grid plate assembly are arranged as an arc-shaped structure or obliquely toward a direction of the movable contact.
7. The arc-extinction apparatus according to claim 2, wherein an arc-attracting piece extended toward a direction of the movable contact is disposed on a top of the second arc-extinction grid plate assembly.
8. The arc-extinction apparatus according to claim 1, wherein an arc-guiding piece is or is not disposed between the initial arc column and the first metal arc-extinction grid plates.
9. The arc-extinction apparatus according to claim 1, wherein an arc-guiding piece is disposed between the initial arc column and the first metal arc-extinction grid plate, and a length of the arc-guiding piece is not more than 50% of a length of the first arc-extinction grid plate assembly in the first direction.
10. The arc-extinction apparatus according to claim 1, wherein the arc-extinction grid plate assembly comprises an insulation piece for fixing the plurality of metal arc-extinction grid plates, and the insulation piece is a portion of the insulation housing having a cavity inside and/or at least two sheet-shaped insulation plates.
11. The arc-extinction apparatus according to claim 1, wherein the first arc-extinction grid plate assembly is disposed at a left side and/or right side of the bent conductor.
12. The arc-extinction apparatus according to claim 1, wherein two adjacent of the metal arc-extinction grid plates are disposed in parallel or at an included angle.
13. The arc-extinction apparatus according to claim 1, wherein an end face of the metal arc-extinction grid

plate is or is not provided with an opening with a geometrical structure under the end face.

14. The arc-extinction apparatus according to claim 13, wherein the geometrical structure of the opening is any one of an inclined shape, horizontal shape, trapezoidal shape, mouth shape, circular shape, arc shape, or any combination thereof. 5
15. The arc-extinction apparatus according to claim 10, wherein an assembly manner of the metal arc-extinction grid plates and the insulation piece is a concave-convex mating and/or an aperture mating. 10
16. The arc-extinction apparatus according to claim 11, wherein an insulation arc-isolation piece is or is not disposed inside the arc-extinction grid plate assembly. 15
17. The arc-extinction apparatus according to claim 16, wherein the arc-extinction apparatus further comprises at least two insulation arc-isolation pieces; and two of the insulation arc-isolation pieces are disposed between the arc-extinction grid plate assembly and the movable contact or disposed inside the arc-extinction grid plate assembly. 20 25
18. The arc-extinction apparatus according to claim 17, wherein the two insulation arc-isolation pieces are disposed at two leg portions of the metal arc-extinction grid plates respectively and an air gap height H1 between the two insulation arc-isolation pieces is smaller than an air gap height H2 between two insulation pieces. 30 35
19. The arc-extinction apparatus according to claim 17, wherein the two insulation arc-isolation pieces are disposed separately between an end portion of the arc-extinction grid plate assembly and a movement region of the movable contact; or an extending length, from an end portion of the arc-extinction grid plate assembly to a movement region of the movable contact, of the insulation arc-isolation piece is larger than a distance between the end portion of the arc-extinction grid plate assembly and the movement region of the movable contact, and an air gap height between the two insulation arc-isolation pieces is smaller than an air gap height between two insulation pieces. 40 45 50
20. The arc-extinction apparatus according to claim 1, wherein the movable contact is provided with a rotation center from which the movable contact extends toward at least one end, at least one end portion of the movable contact is formed with a protrusion electrical contact portion and a protrusion arc-attracting portion, the protrusion electrical contact portion is to contact the stationary contact, the protrusion arc-attracting portion is disposed in an opposite direction to the protrusion electrical contact portion, the protrusion electrical contact portion and the protrusion arc-attracting portion are formed as a fork-like shape, and a rotation radius R1 of the protrusion arc-attracting portion is equal to, larger than, or smaller than a rotation radius R2 of the protrusion electrical contact portion. 55

sion arc-attracting portion is disposed in an opposite direction to the protrusion electrical contact portion, the protrusion electrical contact portion and the protrusion arc-attracting portion are formed as a fork-like shape, and a rotation radius R1 of the protrusion arc-attracting portion is equal to, larger than, or smaller than a rotation radius R2 of the protrusion electrical contact portion.

21. The arc-extinction apparatus according to claim 1, wherein the movable contact is provided with a rotation center from which the movable contact extends toward at least one end, at least one end portion of the movable contact is formed with a protrusion electrical contact portion and a protrusion arc-attracting portion, the protrusion electrical contact portion is to contact the stationary contact, the protrusion arc-attracting portion is disposed in an opposite direction to the protrusion electrical contact portion, the protrusion electrical contact portion and protrusion arc-attracting portion are formed as a T or L-shape, and a rotation radius R1 of the protrusion arc-attracting portion is equal to, larger than, or smaller than a rotation radius R2 of the protrusion electrical contact portion.
22. An electric switch, comprising the arc-extinction apparatus according to any one of claims 1 to 21.

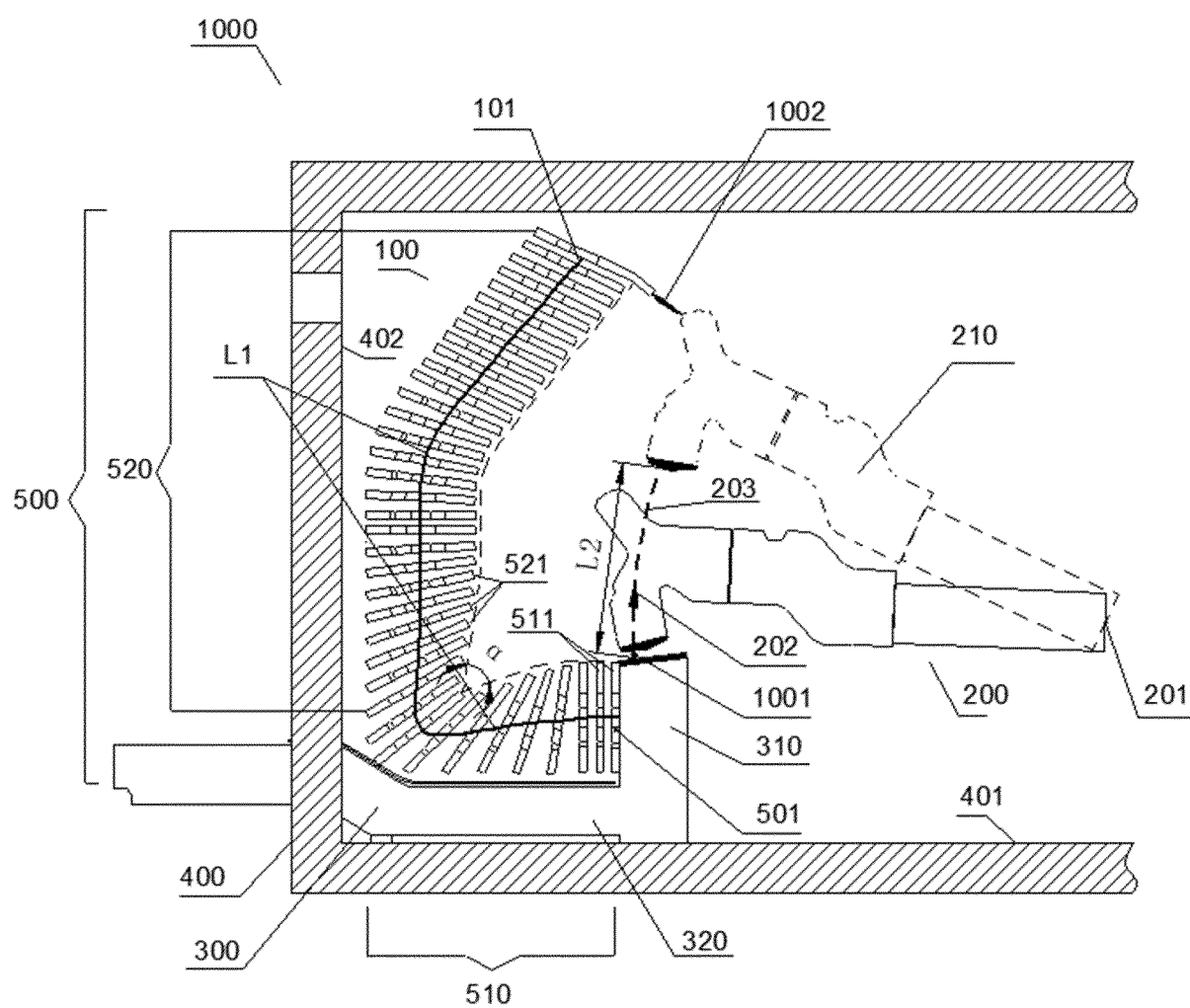


Fig. 1

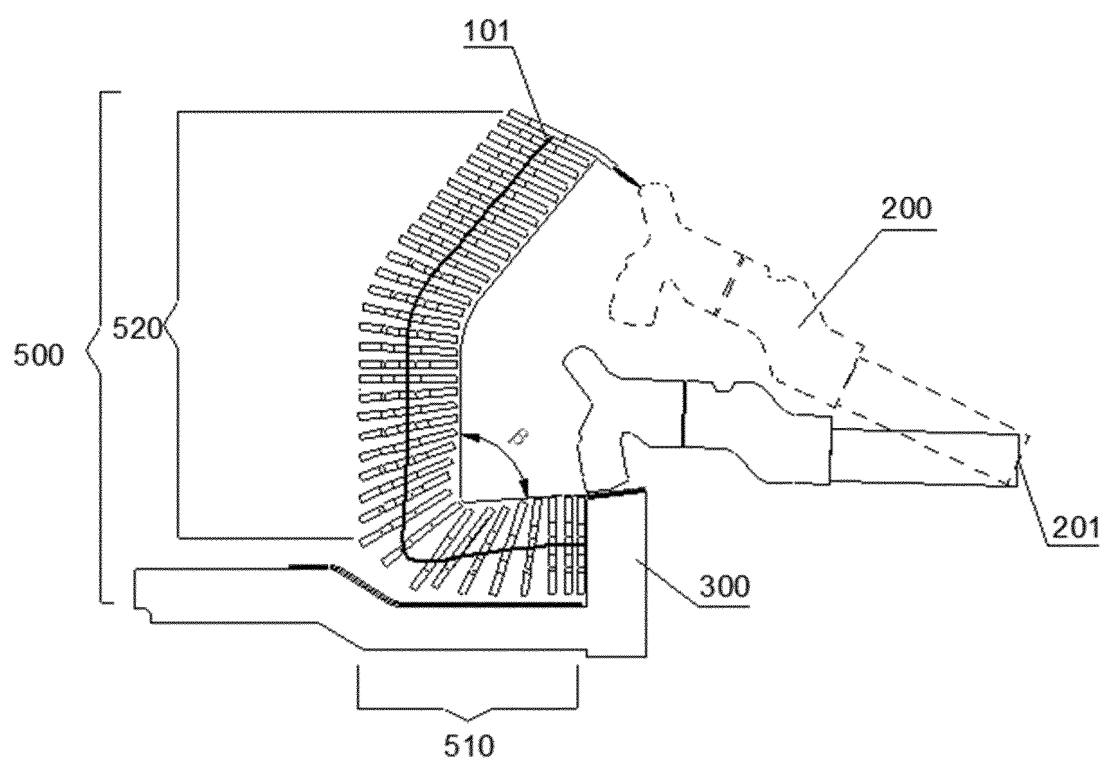


Fig. 2

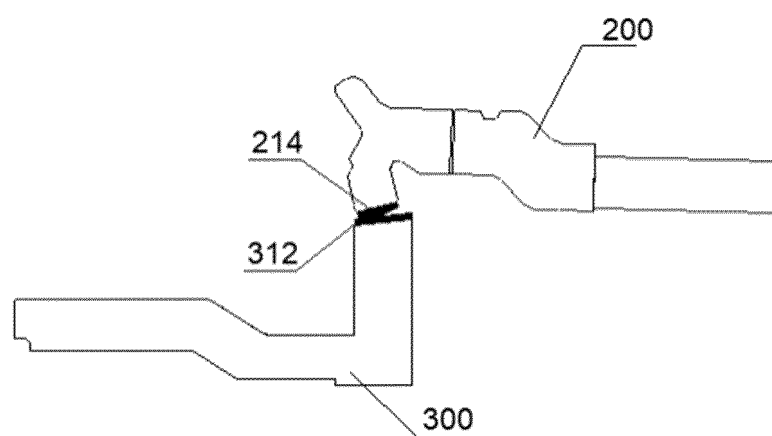


Fig. 3

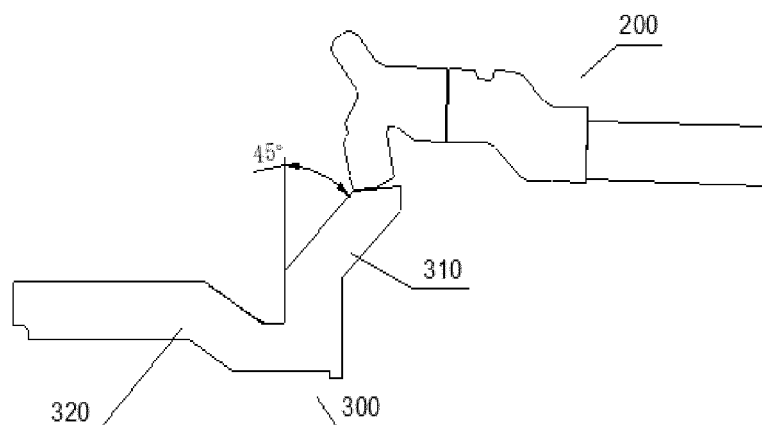


Fig. 4

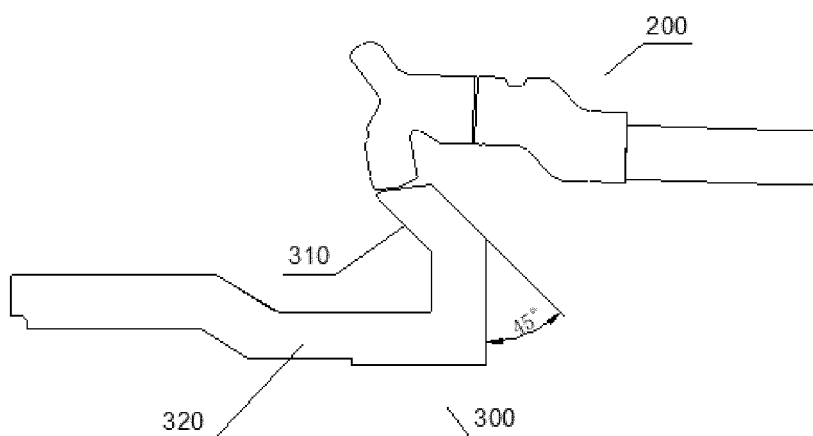


Fig. 5

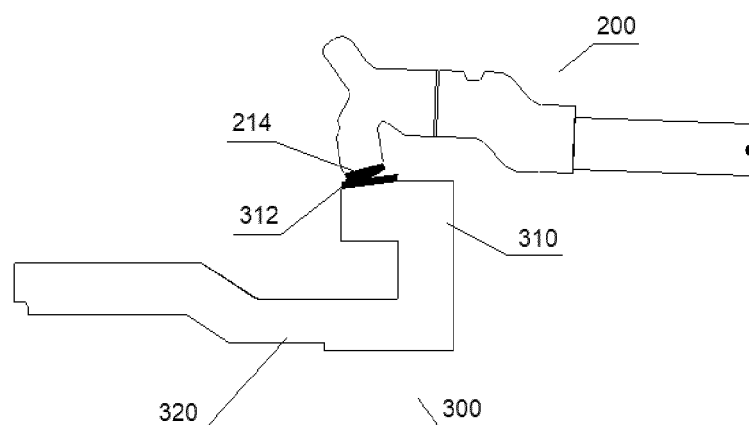


Fig. 6

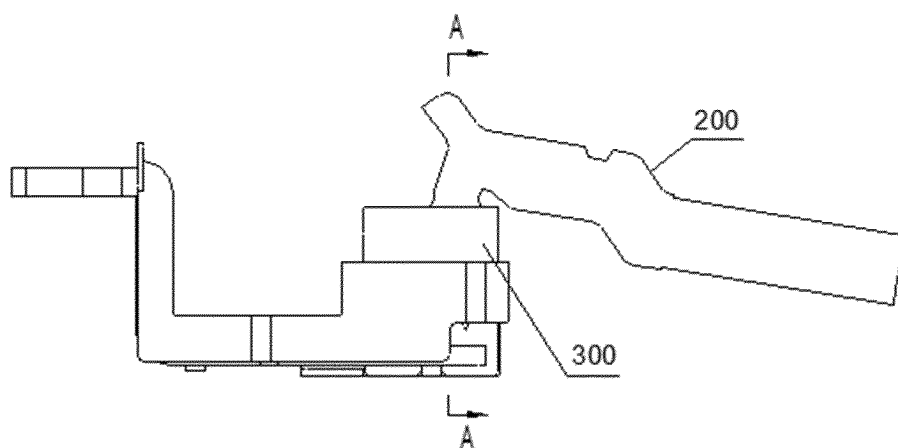


Fig. 7

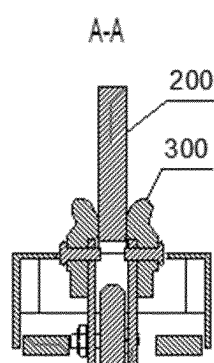


Fig. 8

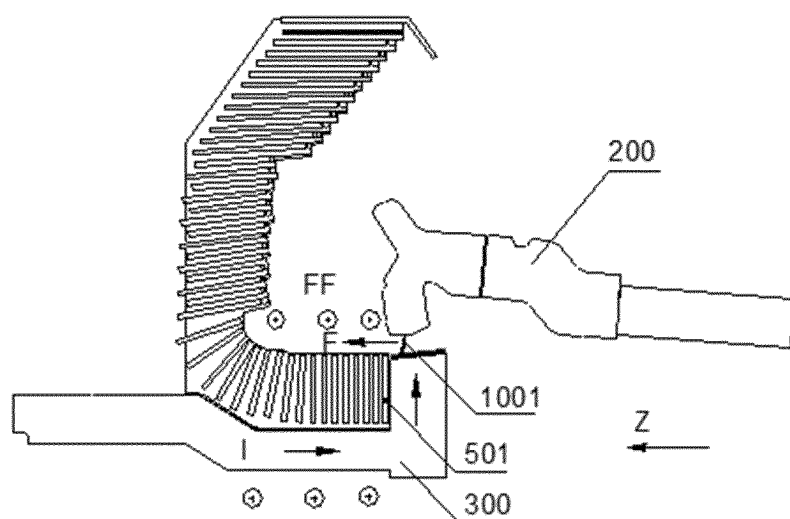


Fig. 9

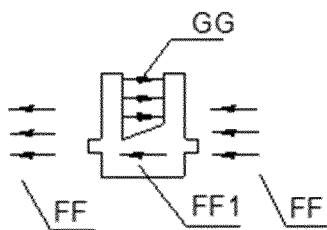


Fig. 10

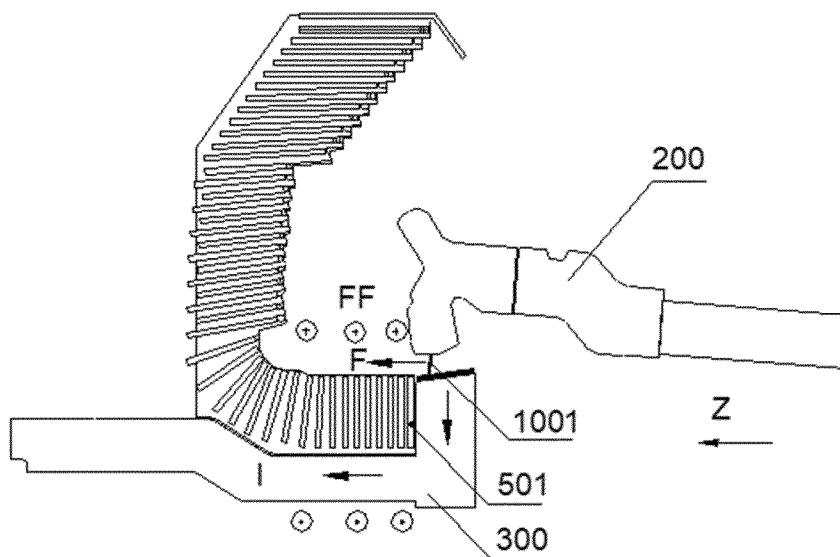


Fig. 11

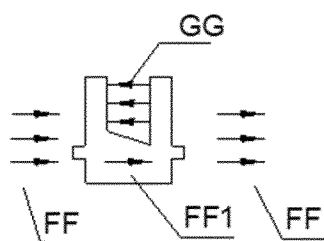


Fig. 12

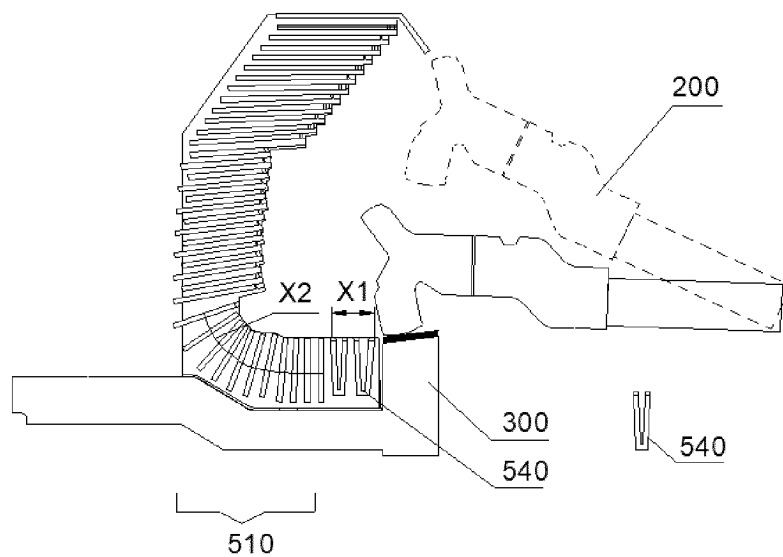


Fig. 13

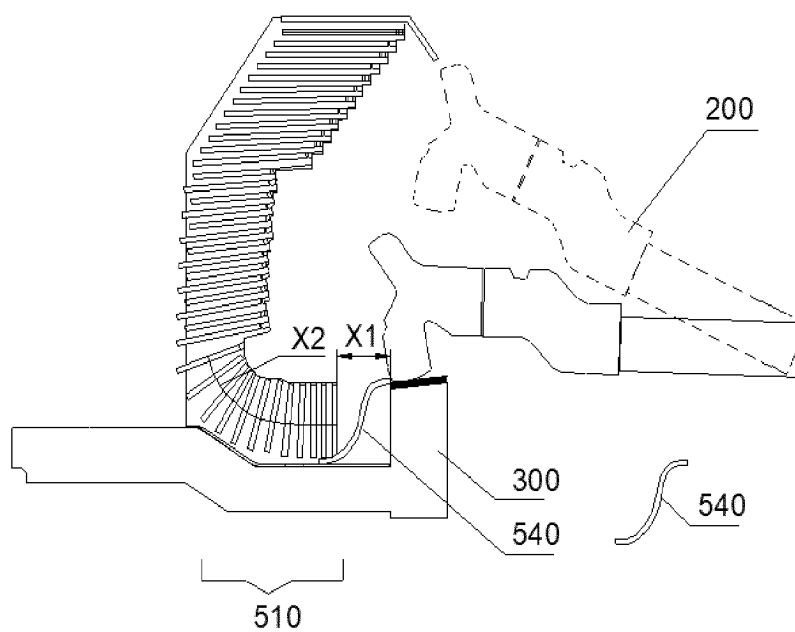


Fig. 14

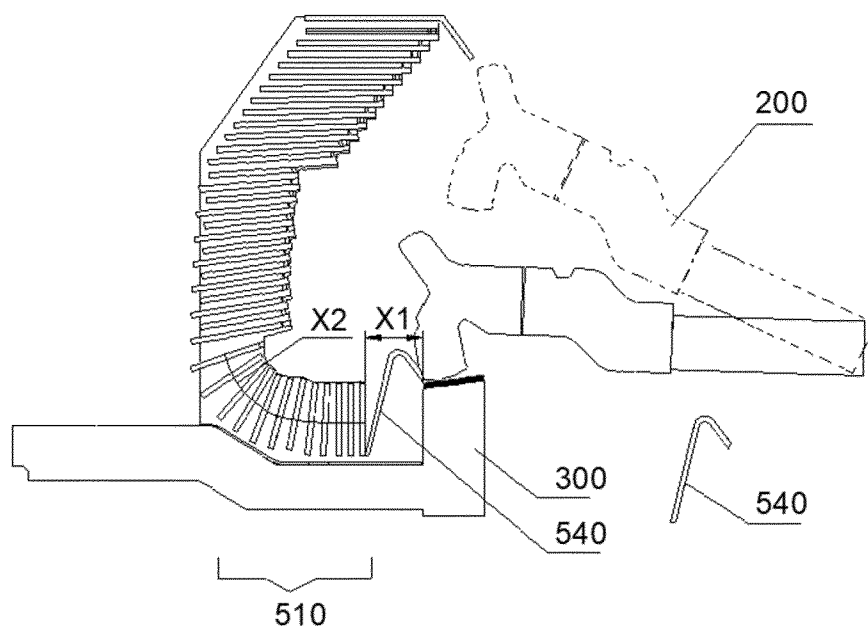


Fig. 15

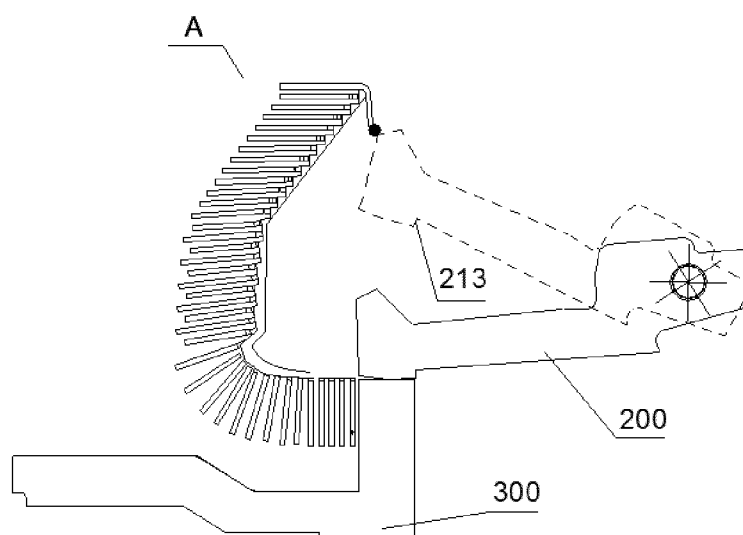


Fig. 16

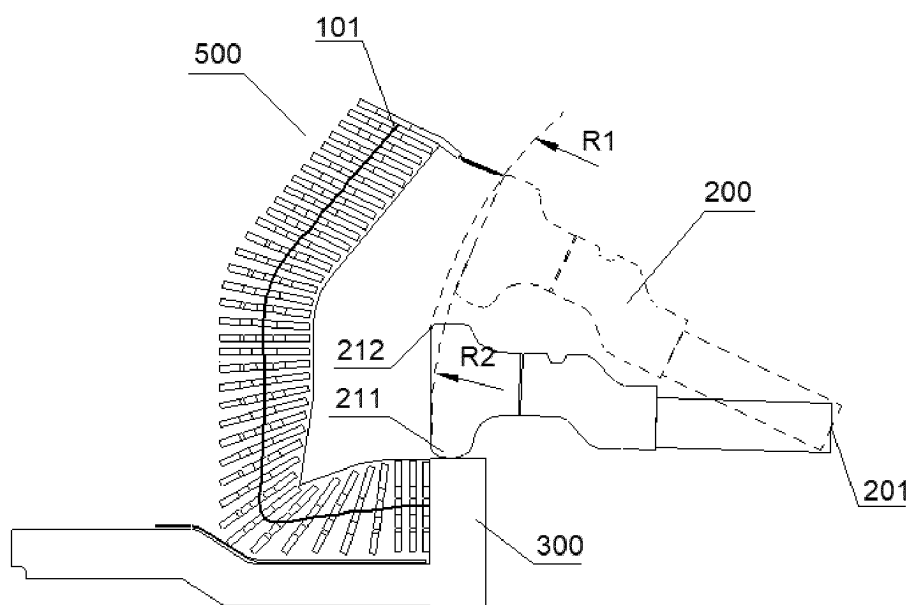


Fig. 17

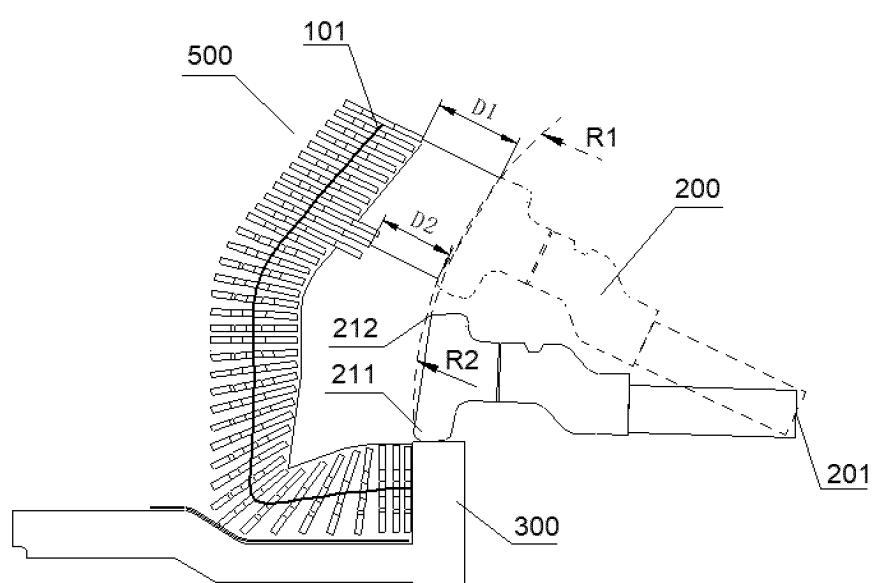


Fig. 18

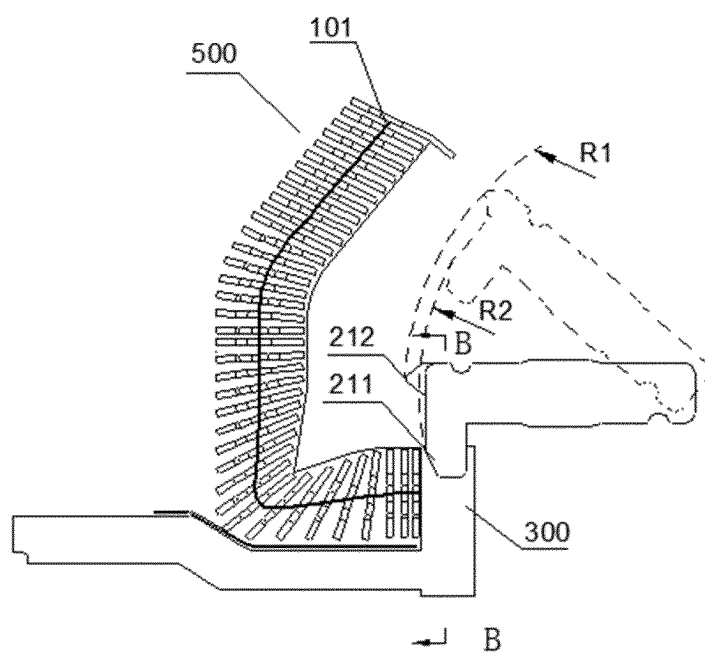


Fig. 19

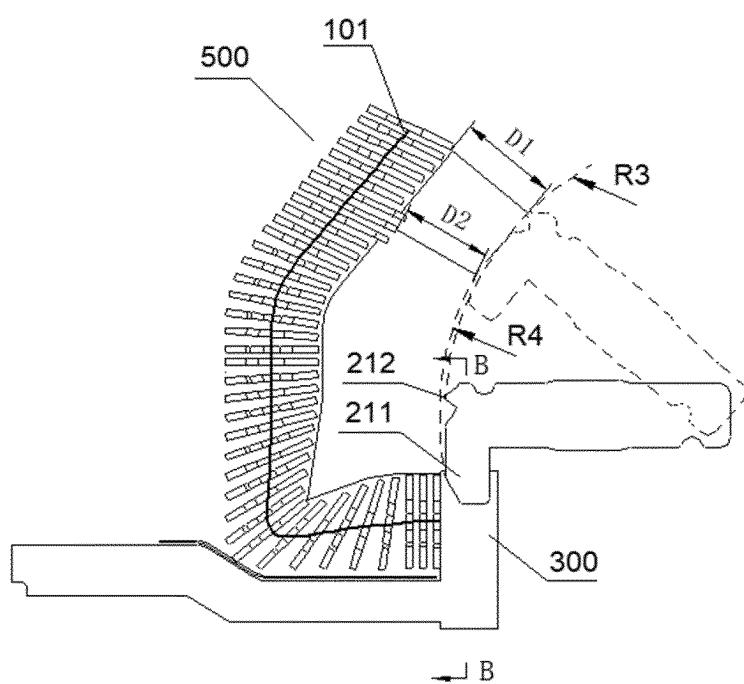


Fig. 20

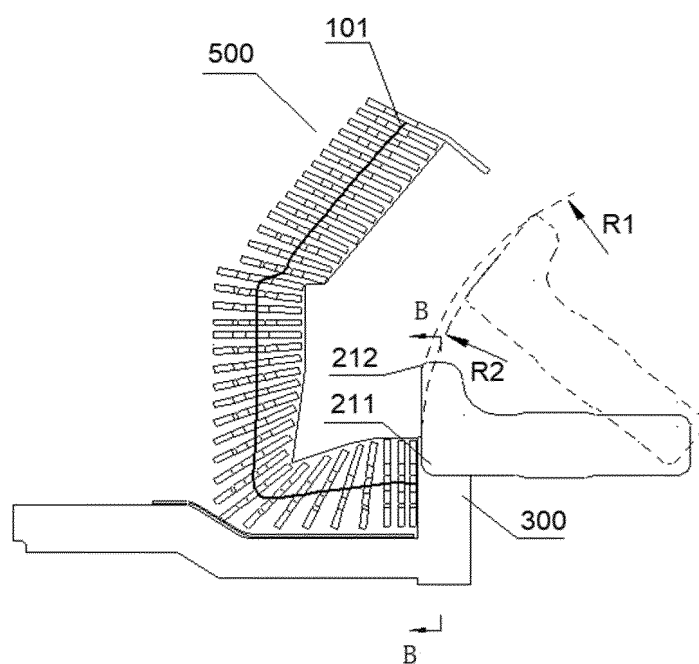


Fig. 21

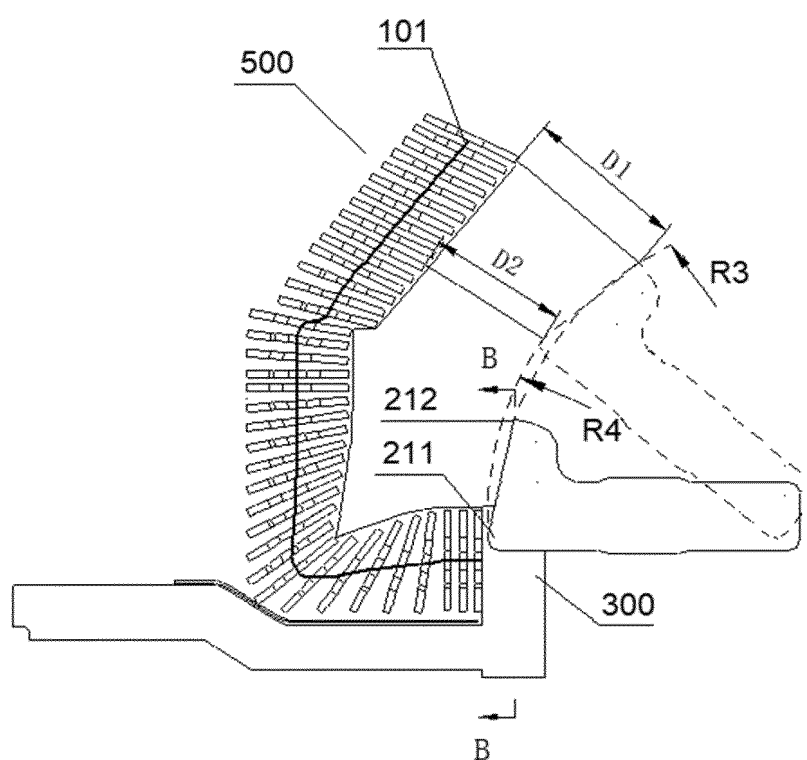


Fig. 22

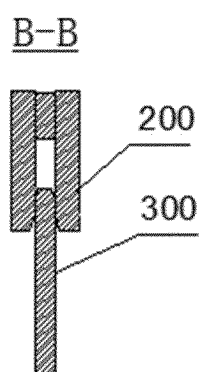


Fig. 23

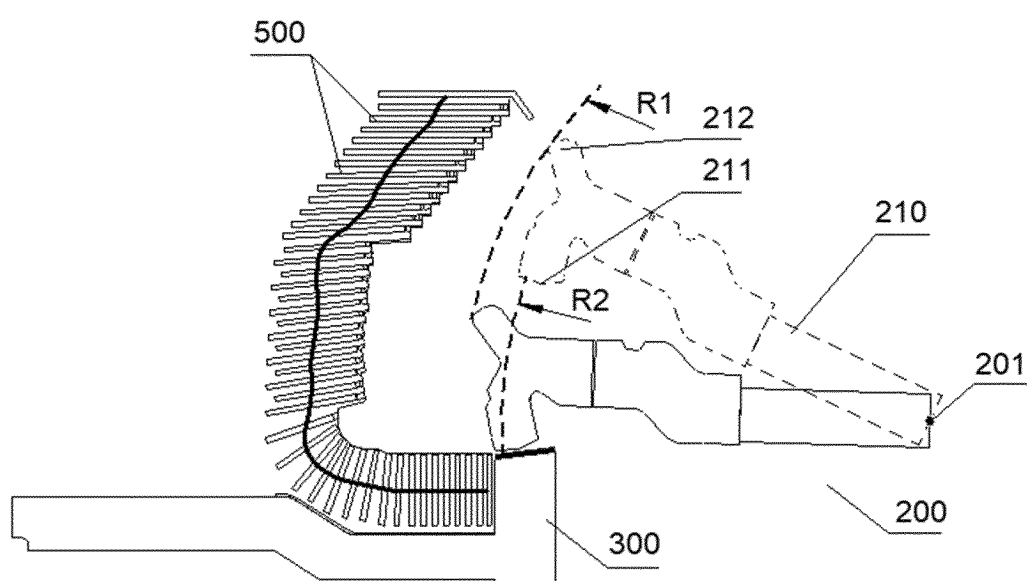


Fig. 24

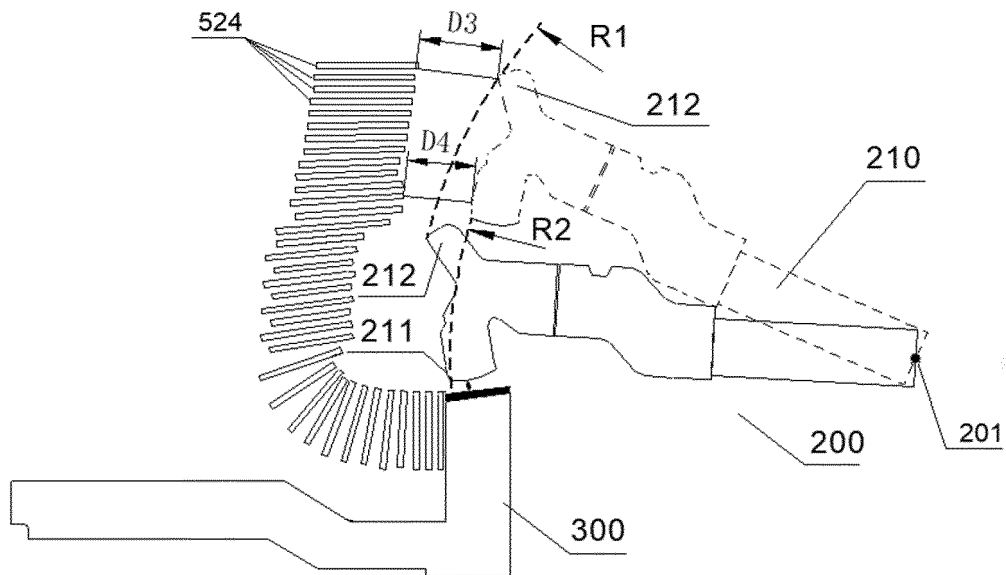


Fig. 25

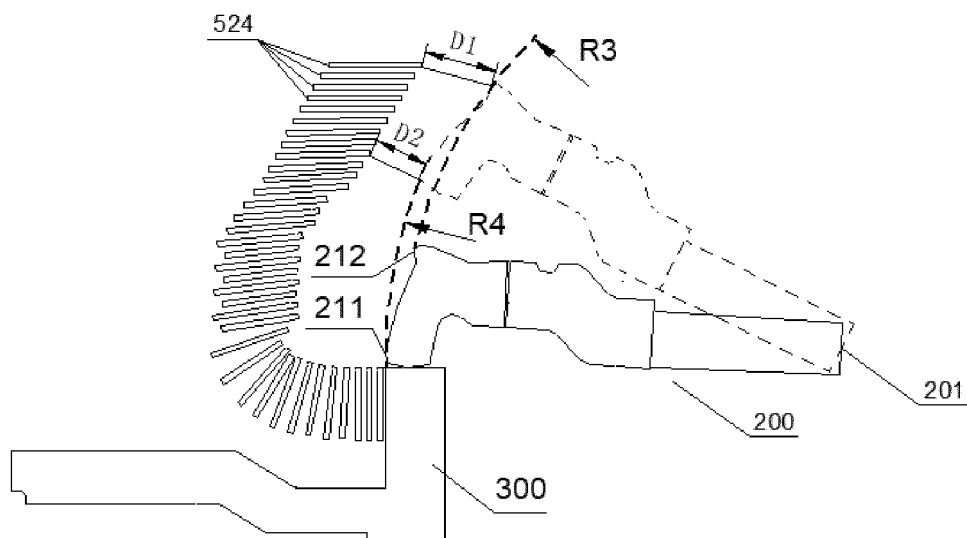


Fig. 26

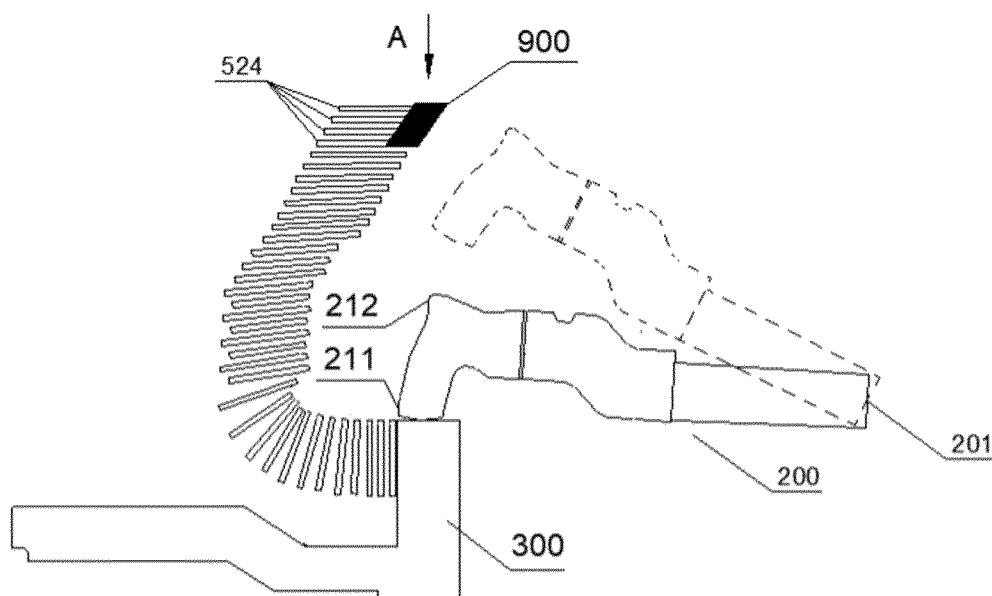


Fig. 27

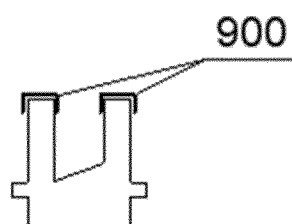


Fig. 28

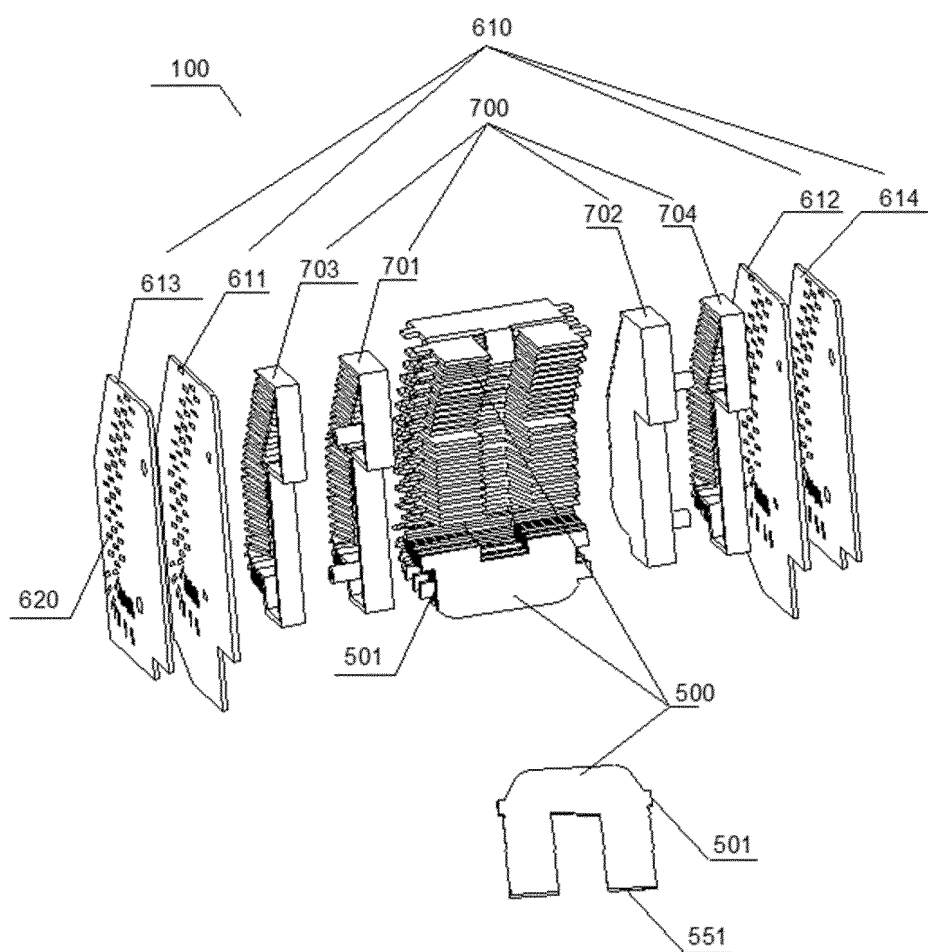


Fig. 29

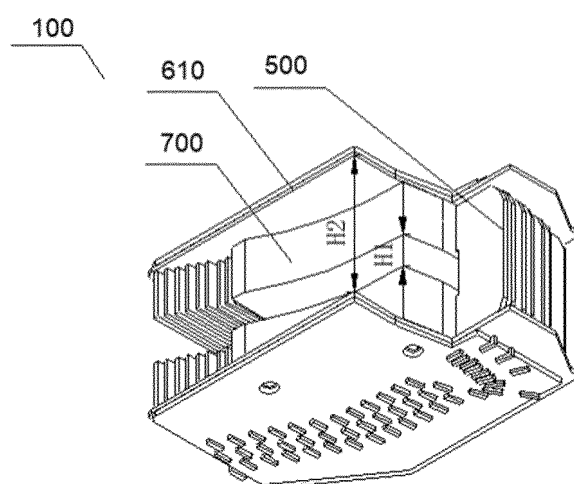


Fig. 30

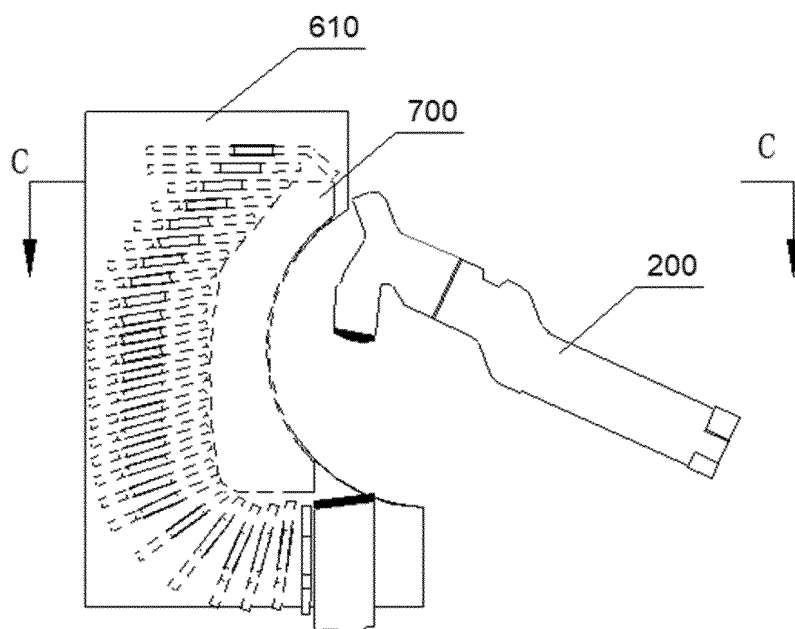


Fig. 31

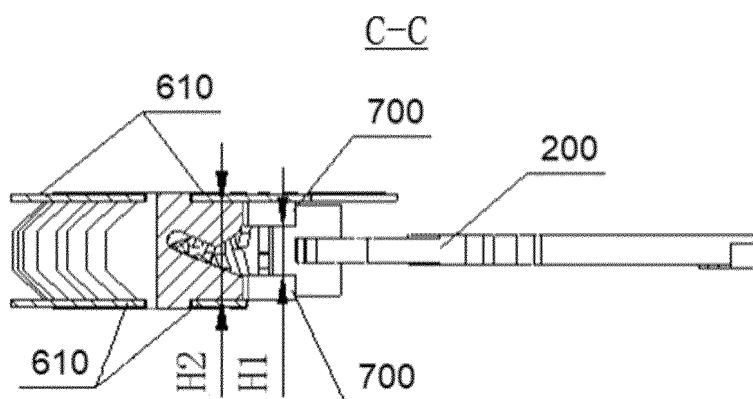


Fig. 32

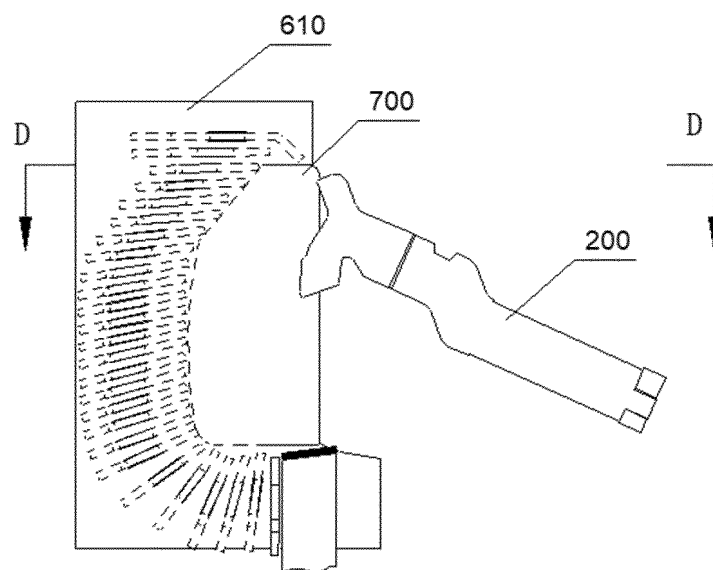


Fig. 33

D-D

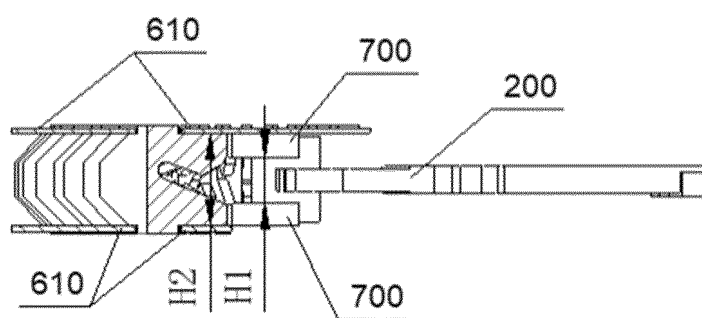


Fig. 34

500

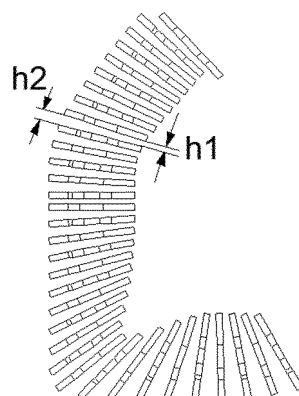


Fig. 35

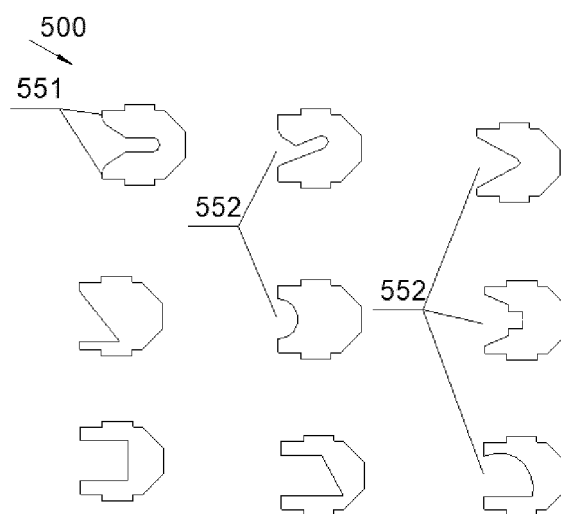


Fig. 36

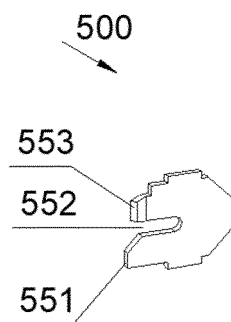


Fig. 37

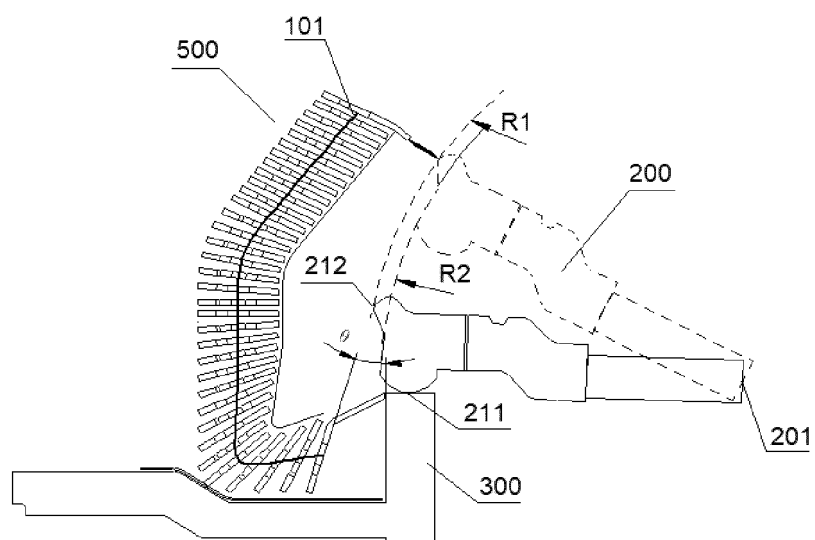


Fig. 38

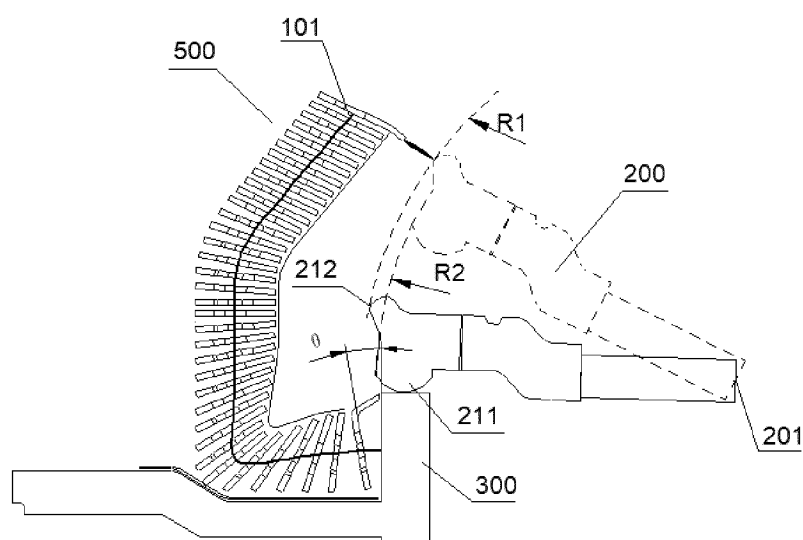


Fig. 39

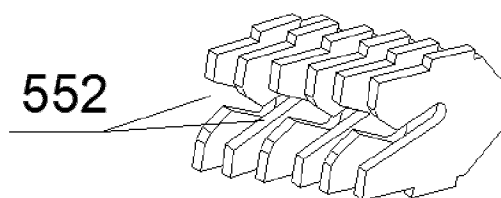


Fig. 40

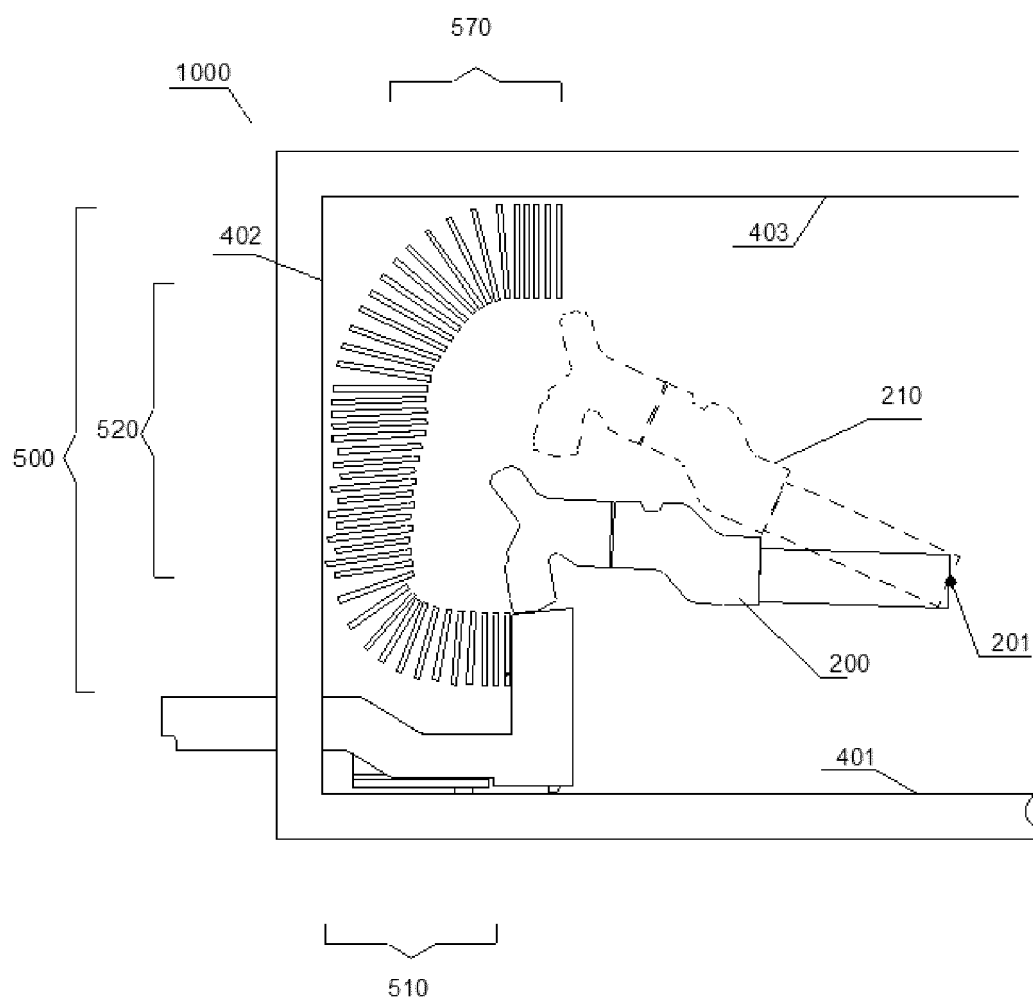


Fig. 41

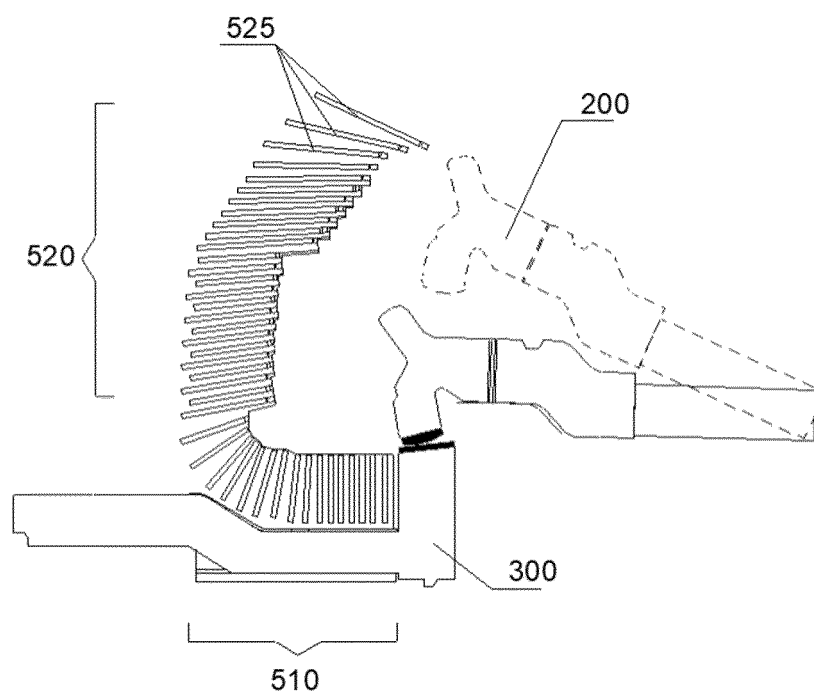


Fig. 42

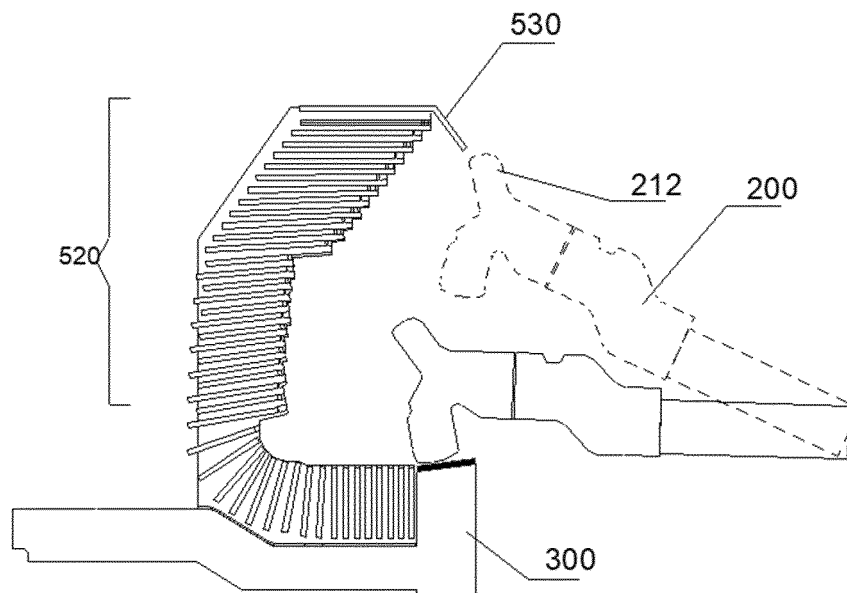


Fig. 43

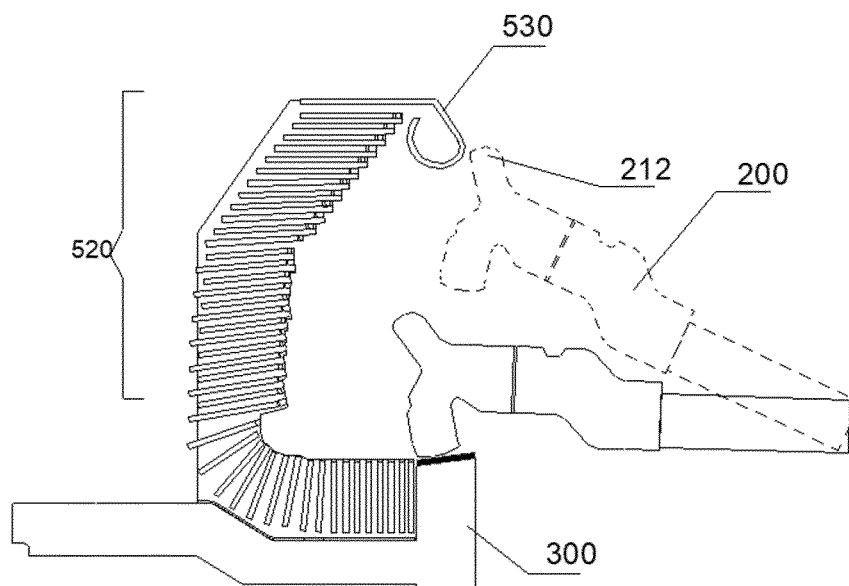


Fig. 44

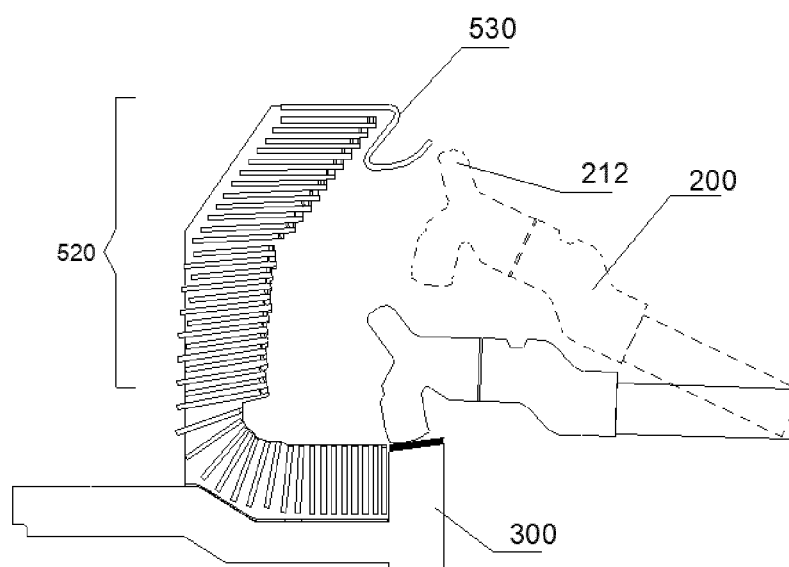


Fig. 45

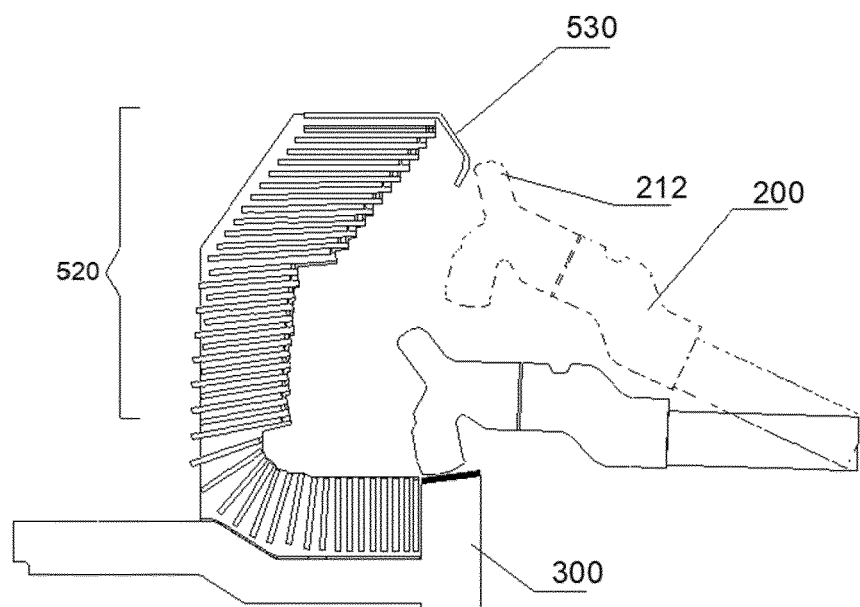


Fig. 46

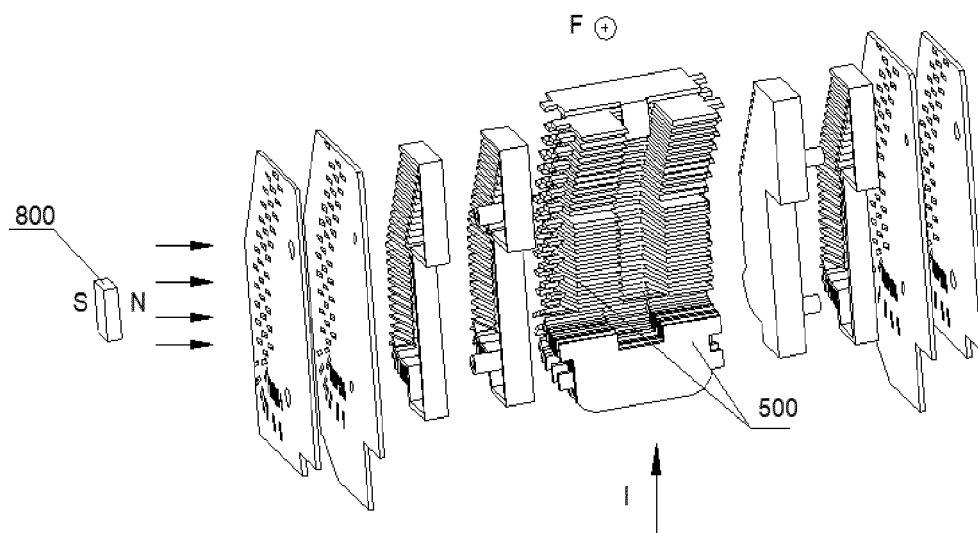


Fig. 47

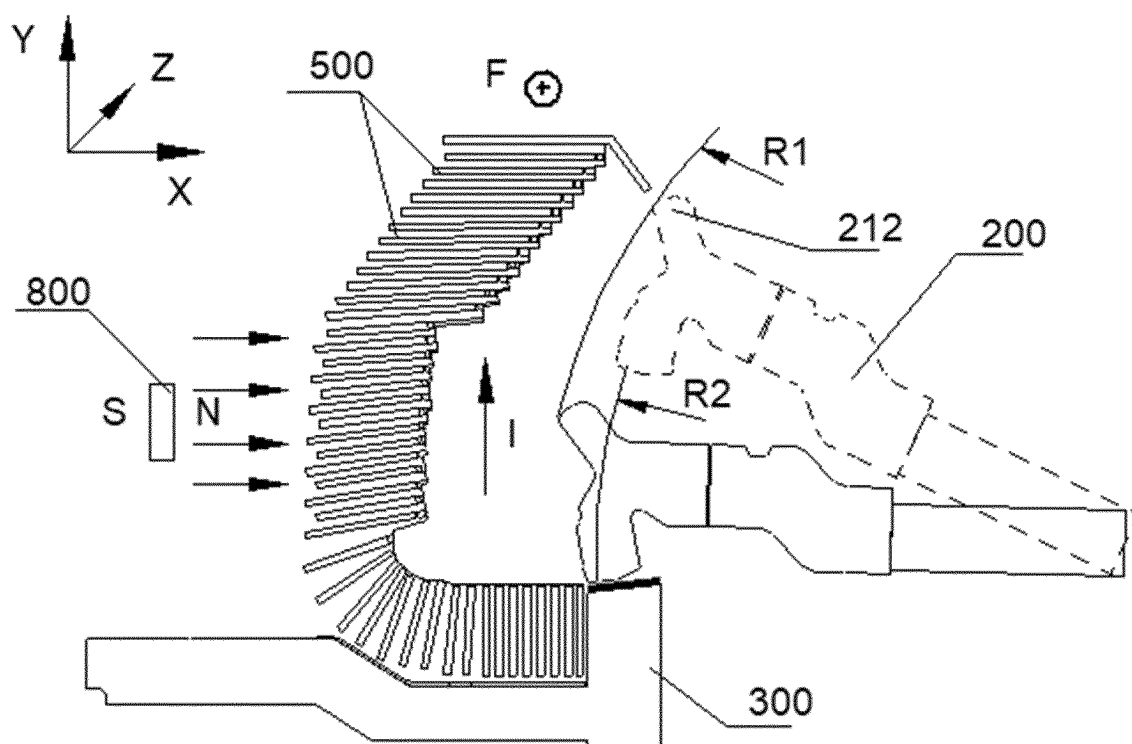


Fig. 48

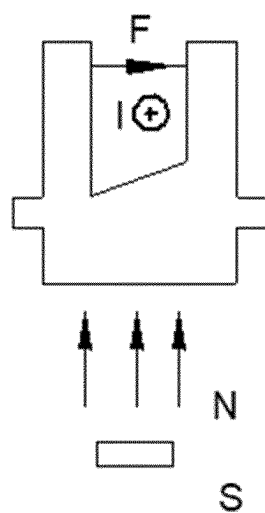


Fig. 49

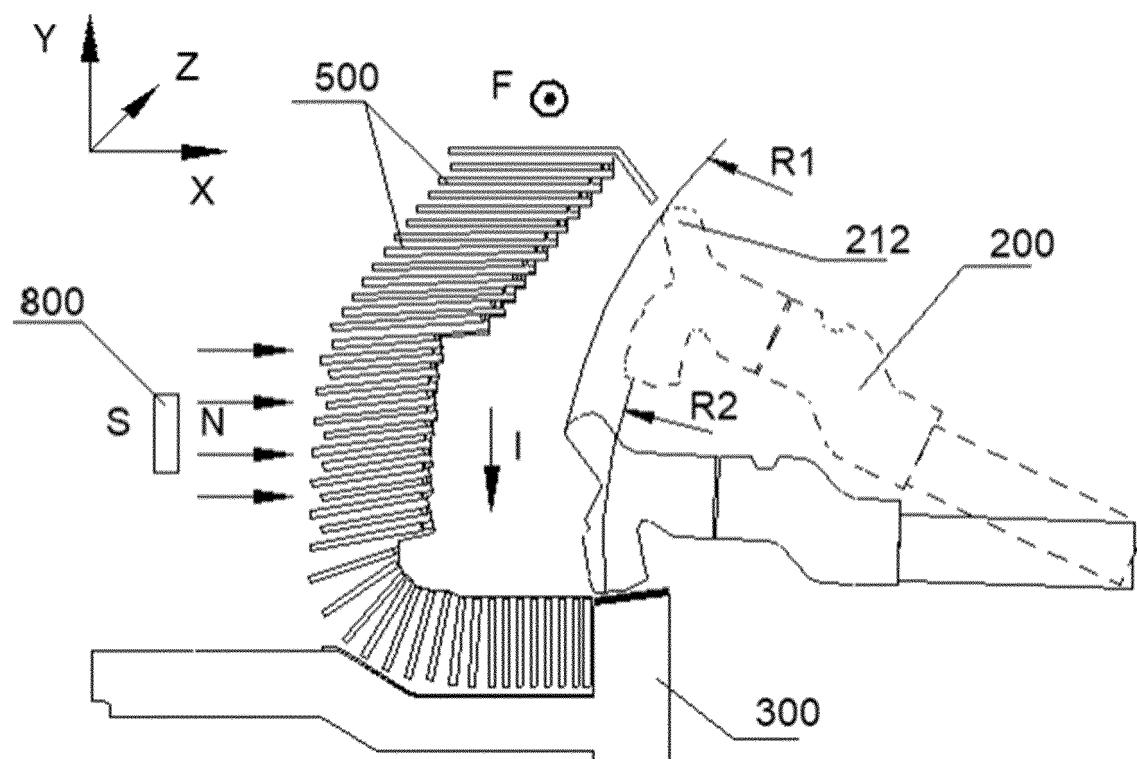


Fig. 50

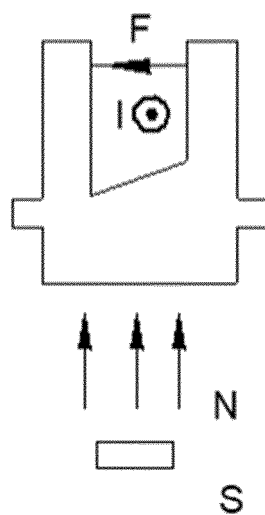


Fig. 51

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/106314

A. CLASSIFICATION OF SUBJECT MATTER

H01H9/30(2006.01)i; H01H9/34(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)

H01H

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

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

CNTXT; ENTXT; ENTXTC; WPABS; CJFD: 电开关, 灭弧, 电弧, 栅片, 动触头, 静触头, 弯折, 排列引弧, 导弧, electric switch, breaker, static contact, movable contact, arc, shell

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 206401213 U (CHANGSHU SWITCHGEAR MANUFACTURING CO., LTD. (FORMERLY CHANGSHU SWITCHGEAR PLANT)) 11 August 2017 (2017-08-11) description, paragraphs 18-25, and figures 1-8	1, 22
Y	CN 206401213 U (CHANGSHU SWITCHGEAR MANUFACTURING CO., LTD. (FORMERLY CHANGSHU SWITCHGEAR PLANT)) 11 August 2017 (2017-08-11) description, paragraphs 18-25, and figures 1-8	2-21
Y	CN 215183824 U (ZHEJIANG BENYI ELECTRICAL CO., LTD.) 14 December 2021 (2021-12-14) description, paragraphs 21-34, and figures 1-6	2-21
PX	CN 219105960 U (TIANJIN SHOURUI INTELLIGENT ELECTRIC CO., LTD.) 30 May 2023 (2023-05-30) claims 1-22	1-22
A	CN 110033967 A (TIANJIN JINGREN ELECTRICAL APPLIANCE CO., LTD.) 19 July 2019 (2019-07-19) entire document	1-22

☒ 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

“D” document cited by the applicant in the international application

“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

13 October 2023

Date of mailing of the international search report

18 October 2023

Name and mailing address of the ISA/CN

China National Intellectual Property Administration (ISA/
CN)China No. 6, Xitucheng Road, Jimenqiao, Haidian District,
Beijing 100088

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/106314

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2017098521 A1 (BEIJING PEOPLE'S ELECTRIC PLANT CO., LTD.) 06 April 2017 (2017-04-06) entire document	1-22

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2023/106314

5

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report			Publication date (day/month/year)		Patent family member(s)			Publication date (day/month/year)	
CN	206401213	U	11 August 2017		None				
CN	215183824	U	14 December 2021		None				
CN	219105960	U	30 May 2023		None				
CN	110033967	A	19 July 2019		CN	209658042	U	19 November 2019	
US	2017098521	A1	06 April 2017		WO	2015172605	A1	19 November 2015	
					JP	2017515279	A	08 June 2017	
					JP	6496326	B2	03 April 2019	
					US	10026578	B2	17 July 2018	
					BR	112016026315	A2	15 August 2017	
					BR	112016026315	B1	05 April 2022	

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

- CN 202210843205 [0001]
- CN 202211227931 [0001]