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

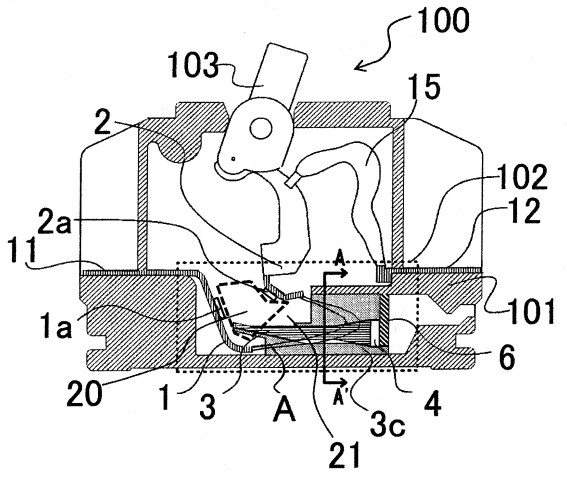
(72) Inventors:
- **WATANABE Shinya**
  Tokyo 100-8310 (JP)
- **KOKURA Kentaro**
  Tokyo 100-8310 (JP)
- **SAGARA Yuta**
  Tokyo 100-8310 (JP)
- **MIYOSHI Nobuo**
  Tokyo 100-8310 (JP)
- **KOHI Yuta**
  Tokyo 100-8310 (JP)

(74) Representative: **Sajda, Wolf E.**
Meissner Bolte Patentanwälte
Rechtsanwälte Partnerschaft mbB
Postfach 86 06 24
81633 München (DE)

(54) SWITCHING DEVICE

(57) A switching device that can secure reliability of interruption is obtained. A switching device (100) includes: a magnet (4) that generates a magnetic field for extending an arc generated between a fixed contact (1) and a movable contact (2) when a fixed contact point (1a) and a movable contact point (2a) are opened; a magnetic body (3), one end of which is arranged in the vicinity of an arc generation region (20) between the fixed contact (1) and the movable contact (2), and the other end of which is arranged in a manner to contact one magnetic pole surface of the magnet (4); and an insulation cover (3c) that protects the magnet (4) and the magnetic body (3) and that partitions arc extension spaces (21) where energizing directions of the arc differ. The magnet (4) is arranged in a region other than the arc generation region (20).

FIG.1



EP 3 185 270 A1

Description

Technical Field

[0001] The present invention relates to a switching device such as a switch for interrupting a current, a breaker, an electromagnetic contactor, and a relay.

Background Art

[0002] A switching device extends an arc that is generated between contact points to increase arc resistance, boosts an arc voltage to a high voltage, and interrupts a current. In particular, in a DC switching device, it is necessary to increase the arc voltage to be higher than a power supply voltage, produce current zero, and thereby interrupt the current. Thus, a technique of extending the arc is essential.

[0003] Conventionally, in order to extend the arc, magnetic lines of a permanent magnet are normally interlinked with the arc, so as to apply a Lorentz force to the arc. In this way, the arc length is increased (see, for example, PTL 1).

List of Citations

Patent Literature

[0004]

PTL 1 JP 2009-087 918 A

Disclosure of the Invention

Technical Problem

[0005] However, a conventional switching device as disclosed in PTL 1 has such a problem that, when an energizing direction is reversed in the switching device in which a magnet is mounted in an arc-extinguishing chamber for extinguishing the arc, a drive direction of the arc is reversed, and reliability of interruption is thereby degraded.

[0006] Alternatively, in order to allow interruption of the current even when the arc is driven in the reverse direction, means for increasing an arc-extinguishing space is available. However, this means has a problem of enlarging the device.

[0007] In addition, not only a magnetic drive action is less likely to be exerted on the arc that is driven and extended to the outside of a surface opposing a magnetic pole surface of the magnet, but also the magnetic lines generated from the magnet generate an electromagnetic force in an unexpected direction. Thus, the reliability of the interruption is degraded.

[0008] In such a switching device, in order to apply the desired Lorentz force to the arc, the magnetic lines in a uniform direction have to be applied to a surface of application of this Lorentz force.

[0009] In order to interlink the magnetic lines in the uniform direction with the arc, the magnetic pole surface of the permanent magnet has to become larger than the surface of application of this Lorentz force, which results in a high-cost configuration and difficulty in securing an arrangement space.

[0010] In addition, the magnetic lines generated from the permanent magnet exert a Lorentz force in an unexpected direction on the arc located at a position that does not oppose the magnetic pole surface of the permanent magnet. Accordingly, the reliability of the interruption is degraded, and, in the worst case, failure in interruption occurs.

[0011] In a conventional switching device in which the permanent magnet is mounted, the arc is most likely to be extended to the outside of the surface opposing the permanent magnet. The reliability of the interruption is low in such a switching device.

[0012] Furthermore, there is a case where a magnetic yoke is used to generate the magnetic lines from the permanent magnet on the outside of the surface opposing the permanent magnet. However, a Lorentz force, which is generated by the magnetic lines from the permanent magnet, is applied in the reverse direction when a direction of the current is changed.

[0013] Thus, when reverse connection is made in this case, the interruption becomes difficult, and the failure occurs. In order to avoid this failure, an arc extension space and the magnetic yoke, which allow the arc to be extended sufficiently even when the direction of the current is reversed and the arc moves in the reverse direction, have to be mounted, which results in a problem of enlarging the switching device.

[0014] The invention has been made to solve the problems as described above and therefore has a purpose of obtaining a switching device that can secure sufficient reliability of interruption regardless of a direction of a current even when a small magnet is used.

Solution to Problem

[0015] A switching device according to the invention is characterized by comprising:

- a fixed contact that has a fixed contact point;
- a movable contact that is installed in a manner to oppose the fixed contact and has a movable contact point;
- a switching mechanism section that performs a switching operation of the fixed contact point and the movable contact point;
- a magnet that generates a magnetic field for extending an arc generated between the fixed contact and the movable contact when the fixed contact point and the movable contact point are opened;
- a magnetic body, one end of which is arranged in the vicinity of an arc generation region between the

fixed contact and the movable contact, and the other end of which is arranged in a manner to contact one magnetic pole surface of the magnet; and

- an insulation cover that protects the magnet and the magnetic body and partitions arc extension spaces where energizing directions of the arc differ, in that the magnet is arranged in a region other than the arc generation region.

Advantageous Effects of the Invention

[0016] According to the switching device of the invention, regardless of a direction of a current, the arc generated between the contacts can be driven in a direction toward the magnet along a lateral surface of an attraction rod as the magnetic body.

[0017] At this time, the arc travels and is extended in the direction toward the magnet while being driven along the lateral surface of the attraction rod as the magnetic body. Thus, the arc is rapidly cooled. In this way, a small low-cost switching device, which maintains high reliability of interruption even when a current of reverse polarity flows, can be obtained.

Brief Description of Drawings

[0018]

FIG. 1 is a lateral cross-sectional view of an open pole state of a switching device in a first embodiment of the invention.

FIG. 2 is a cross-sectional view taken along line A-A' in FIG. 1.

FIG. 3 includes explanatory views for explaining an arc-extinguishing operation by the switching device in the first embodiment of the invention.

FIG. 4 is a lateral cross-sectional view of an open pole state of a switching device in a second embodiment of the invention.

FIG. 5 is a lateral cross-sectional view of an open pole state of a switching device in a third embodiment of the invention.

FIG. 6 is a cross-sectional view taken along line A-A' in FIG. 5.

FIG. 7 is a lateral cross-sectional view of an open pole state of a switching device in a fourth embodiment of the invention.

FIG. 8 is a cross-sectional view taken along line A-A' in FIG. 7.

Description of Embodiments

First Embodiment

[0019] A description will hereinafter be made on a first embodiment of the invention on the basis of the drawings. Noted that the same reference sign indicates the same or corresponding portions in each of the drawings.

[0020] FIG. 1 is a lateral cross-sectional view that schematically depicts an open pole state of a switching device in a first embodiment of the invention. In addition, FIG. 2 is a cross-sectional view taken along line A-A' in FIG. 1. As depicted in FIG. 1, a switching device 100 in the first embodiment of the invention includes: a fixed contact 1 that has a fixed contact point 1a; a movable contact 2 that has a movable contact point 2a; and a switching mechanism section 103 that performs a switching operation of the fixed contact point 1 a and the movable contact point 2a.

[0021] The switching device 100 also includes a magnet 4 that generates a magnetic field for extending an arc A generated between the fixed contact 1 and the movable contact 2 when the fixed contact point 1 a and the movable contact point 2a are opened.

[0022] The switching device 100 further includes an attraction rod 3, one end of which is arranged in the vicinity of an arc generation region 20 between the fixed contact 1 and the movable contact 2, the other end of which is arranged in a manner to contact one magnetic pole surface of the magnet 4, and which is formed of a long magnetic body. The magnet 4 is arranged in a region other than the arc generation region 20.

[0023] Moreover, the switching device 100 includes an insulation cover 3c that protects the magnet 4 and the attraction rod 3, which is formed of the long magnetic body. The insulation cover 3c is formed of a resin material such as nylon, for example. Here, the arc generation region 20 represents a space that is between the fixed contact 1 and the movable contact 2 and is surrounded by a dotted line in FIG. 1.

[0024] The switching device 100 in the first embodiment of the invention is provided with a fixed-side terminal 11 and a movable-side terminal 12, each of which is connected to an external power circuit, at both ends of a housing that is constructed of a case 101 formed of an insulator, and is provided with an extinguishing chamber 102 for extinguishing the arc in a lower portion.

[0025] The fixed contact 1, the movable contact 2, the attraction rod 3, and the magnet 4 are arranged in this extinguishing chamber 102, the fixed contact 1 being integrally formed with the fixed-side terminal 11 and provided with the fixed contact point 1a at a specified portion, the movable contact 2 having the movable contact point 2a that contacts and separates from the fixed contact point 1 a and being provided to turn, the attraction rod 3 having the one end arranged in the vicinity of the arc generation region 20 so as to be opposed to a space interposed between the fixed contact 1 and the movable contact 2 and being formed of the long magnetic body, and the magnet 4 being arranged in contact with this attraction rod 3 and generating the magnetic field for extending the arc A, which is generated between the fixed contact 1 and the movable contact 2.

[0026] As it has been described so far, the switching device 100 in the first embodiment of the invention has a basic configuration including the magnet 4, which con-

trols and extends the arc A generated between both of the contacts when both of the contact points are opened, and the attraction rod 3, the one end of which is arranged in the vicinity of the arc generation region 20, the other end of which is arranged in contact with the one magnetic pole surface of the magnet 4, and which is formed of the long magnetic body.

[0027] Due to this structure, the arc A is extended along a longitudinal lateral surface of the attraction rod 3, which is formed of the long magnetic body, by the magnetic field generated by the magnet 4. Here, a space between the lateral surface of the attraction rod 3 that is located on a right side of the arc generation region 20 in FIG. 1 and a magnetic reinforcing plate 6 is set as an arc extension space 21.

[0028] Noted that a similar effect is obtained even when a mode, such as a round rod or a cuboid, cylindrical, or polygonal rod, is used for the attraction rod 3, which is formed of the long magnetic body. In addition, as will be described below, the attraction rod 3, which is formed of the long magnetic body, is protected by the insulation cover 3c for the magnetic body, the insulation cover 3c being provided to be opposed to a generation region of the arc A whose energizing direction is a forward direction of the sheet. The magnetic reinforcing plate 6, which will be described below, is attached to the magnet 4.

[0029] FIG. 3 includes explanatory views for explaining an arc-extinguishing operation of the switching device in the first embodiment of the invention. By using a model of FIG. 3 in which the attraction rod 3, which is protected by the insulation cover 3c for the magnetic body and is formed of the long magnetic body, is arranged and in which an end surface of the attraction rod 3 on an opposite side of an arc generation position is arranged in a manner to contact a magnetic pole surface of a permanent magnet 41 having an N pole, principle of extinguishing the arc will be described by dividing a progressive stage to extinction of the arc into five stages depicted in stages 3A to 3E.

[0030] Initially, in stage 3A of FIG. 3 at the progressive stage of the extinction of the arc, magnetic lines M that are generated from the permanent magnet 41 are guided by the attraction rod 3, and an interlinkage magnetic field with the arc is generated from a tip of the attraction rod 3 toward the arc.

[0031] With the interlinkage magnetic field, a Lorentz force is applied to the arc, and the arc is driven in a downward direction in stage 3A. In stage 3A, the reference sign 8 denotes the arc and a direction of a current thereof, and the reference sign 9 denotes an application direction of a Lorentz force.

[0032] Next, in stage 3B at the progressive stage of the extinction, the magnet lines M, which are formed in a manner to move round to an S-pole side of the permanent magnet 41 from the tip of the attraction rod 3, are interlinked with the arc, which has been driven at the stage 3A. Due to this interlinkage magnetic field, the arc is drawn into the arc extension space 21 that expands in a longitudinal lateral surface portion of the attraction rod 3. In stage 3B, the reference sign 10 denotes an arc in a case where the direction of the current is reversed.

[0033] Next, in stage 3C at the progressive stage of the extinction, the arc, which has been drawn into the arc extension space 21, is further drawn thereinto by the magnetic lines M generated on normal lines from the lateral surface of the attraction rod 3.

[0034] As the arc is drawn deep inside, magnetic field intensity that is generated from the lateral surface of the attraction rod 3 is increased, which makes it difficult for the arc to separate from the attraction rod 3. Accordingly, the arc can stably be extended deep inside (to a right side of) the attraction rod 3.

[0035] Many of the magnet lines that are interlinked with the arc drawn deep inside are the magnet lines that move round to the S-pole side of the permanent magnet 41, and the interlinkage magnetic field by the magnet lines in this direction (a right direction in the drawing) generate a force of attracting the arc to the inside of the attraction rod 3.

[0036] Next, in stage 3D at the progressive stage of the extinction, the Lorentz force that presses the arc to the inside of the attraction rod 3 with a further greater force is applied to the arc that has approached the insulation cover 3c for the magnetic body for protecting the attraction rod 3. In this way, the arc is compressed against the insulation cover 3c for the magnetic body, and resistance on the inside of the arc is rapidly increased.

[0037] Then, ablated gas that is generated from an arc-exposed surface of the insulation cover 3c for the magnetic body by arc heat is sprayed on the arc. In this way, the arc is cooled, and the resistance on the inside of the arc is further increased.

[0038] Finally, in stage 3E at the progressive stage of the extinction, in the case where a recessed narrow gap 3e as depicted in FIG. 3 is provided in a portion of the insulation cover 3c for the magnetic body, the arc is drawn into the narrow gap 3e by the Lorentz force, which presses the arc to the inside of the attraction rod 3, and the arc is thereby compressed to be narrow.

[0039] The ablated gas by the insulation cover 3c for the magnetic body is sprayed on the further compressed arc from a periphery thereof. In this way, the resistance of the arc is increased to such an extent that a conductive property on the inside thereof can no longer be maintained, and thus the arc is extinguished.

[0040] Noted that, according to the above structure, the similar effect can be obtained even when an energizing direction is reversed, and the arc is extended in a manner to be symmetrical about an axis of the attraction rod 3 at each of the progressive stages of the extinction as depicted in FIG. 3.

The similar effect can also be obtained even when the magnetic pole surface of the permanent magnet 41 (or the magnet 4) faces opposite, and the arc is extended in a manner to be symmetrical about the axis of the attraction rod 3 at each of the progressive stages of the extinc-

tion.

[0041] As described above, the arc can be driven and extended in the same direction by using the attraction rod 3 and the permanent magnet 41 (or the magnet 4). Therefore, reliability of interruption can be increased without enlarging the switching device 100.

[0042] In addition, this first embodiment further obtains an effect by adding the following components to the above basic configuration.

[0043] Initially, the switching device 100 includes the arc extension space 21, and the permanent magnet 41 (or the magnet 4) is arranged in the arc extension space 21. In this way, extension length of the arc can be increased, and thus arc resistance can further be increased.

[0044] In addition, the magnetic reinforcing plate 6 formed of a magnetic body is provided on a magnetic pole surface on an opposite side (an attraction rod opposite side) of the permanent magnet 41 (or the magnet 4) that is not adjacent to (not arranged in contact with) the attraction rod 3. In this way, magnetic resistance of a magnetic circuit, which is formed by the magnetic lines circling around the permanent magnet 41 (or the magnet 4) via the attraction rod 3, is lowered. Thus, the intensity of the magnetic field, which is generated from the surface of the attraction rod 3, is increased, and extinguishing performance can further be increased.

[0045] As depicted in FIG. 2, a wall for partitioning the two arc extension spaces 21 (spaces on both sides of the attraction rod 3) is provided by the insulation cover 3c in the first embodiment. Because the wall for partitioning the arc extension spaces 21 at two positions at which the energizing directions of the arc differ is formed by the insulation cover 3c, the arc can be prevented from moving round from the one arc extension space 21 to the other arc extension space 21. Thus, the arc can stably be extended.

[0046] Furthermore, in the first embodiment of the invention, because the magnet 4 is constructed of the permanent magnet 41, constant magnetic flux is applied to the arc. Thus, the stable interruption can be realized even in a current region where the magnetic flux generated from an energizing conductor is low (for example, lower than 1 kA).

[0047] Moreover, the permanent magnet 41 is used as the magnet to be used in the above description of the principle of extinguishing the arc. However, even in the cases where a coil-shaped conductor that is electrically connected to one of the contacts or an external power supply is wound around a portion of a periphery of the attraction rod 3 and the portion of the attraction rod 3 is thereby configured as an electromagnet (not depicted), the arc can be extinguished by a similar phenomenon as described above.

[0048] A current range in which the effect can be exerted the most differs between the case where the permanent magnet 41 is used as the magnet 4 and the case where the electromagnet (not depicted) is used as the magnet 4. In the case where the permanent magnet 41 is used, the effect is exerted in a relatively low current range (for example, of lower than 1 kA). In the case where the electromagnet (not depicted) is used, the effect is exerted in a relatively high current range (for example, of 1 kA and higher) in which the magnetic flux generated from the current flowing through the conductor is increased.

[0049] As it has been described so far, by adopting the basic configuration of the invention, the generated arc A can be drawn into deep inside the attraction rod 3 regardless of the energizing direction, and the arc can thereafter be extended, cooled, and extinguished. In other words, the arc can be extended and cooled in a direction in which the permanent magnet is arranged regardless of the direction of the current. Thus, even when the current is reversed, the reliability of the interruption can be secured, and the switching device 100 can be downsized. In addition, because the partitioning wall, which is formed by the insulation cover 3c, prevents the arc from moving round to the other arc extension space 21, interruption performance can be stabilized.

Second Embodiment

[0050] FIG. 4 is a lateral cross-sectional view of an open pole state of a switching device in a second embodiment of the invention. In the first embodiment, the attraction rod 3 is formed of the long magnetic body. Meanwhile, as depicted in FIG. 4, in the second embodiment, the attraction rod 3 is arranged such that the shape thereof is enlarged so as to partition the spaces where the arc extends and which are located at two different positions at which the energizing directions differ.

[0051] In this way, magnetic saturation near the surface of the attraction rod 3 that contacts the magnet 4 can be suppressed, and the arc generated between the contact points can efficiently be drawn into the arc extension spaces 21. Furthermore, in conjunction with enlargement of the attraction rod 3, a region where the magnetic intensity is increased in the arc extension space 21 is expanded. Thus, the above extended state of the arc can easily be maintained, and the reliability of the interruption is improved.

Third Embodiment

[0052] FIG. 5 is a lateral cross-sectional view of an open pole state of a switching device in a third embodiment of the invention. In addition, FIG. 6 is a cross-sectional view taken along line A-A' in FIG. 5. As depicted in FIG. 5, in the third embodiment, in addition to that the wall for partitioning the arc extension spaces 21 at the two positions at which the energizing directions of the arc differ is formed by the insulation cover 3c, the insulation cover 3c is arranged in a manner to surround the arc during the extension.

[0053] In general, a material that is less likely to be

ablated is selected for the case 101 of the switching device 100, so as to prevent wear even when the case 101 is exposed to the generated arc heat. Thus, spraying efficiency of the ablated gas on the arc is low.

[0054] According to the third embodiment of the invention, the insulation cover 3c can be molded by a material that is likely to be ablated. Accordingly, the spraying efficiency of the ablated gas on the arc can be improved by arranging the insulation cover 3c in the manner to surround the arc during the extension. Therefore, the reliability of the interruption can be increased. Noted that, the shape of the attraction rod 3 in the second embodiment may be combined with that in the third embodiment and the reliability of the interruption is further improved by the combination.

Fourth Embodiment

[0055] FIG. 7 is a lateral cross-sectional view of an open pole state of a switching device in a fourth embodiment of the invention. In addition, FIG. 8 is a cross-sectional view taken along line A-A' in FIG. 7. As depicted in FIG. 7 and FIG. 8, in the fourth embodiment, in addition to that the wall for partitioning the arc extension spaces 21 at the two positions at which the energizing directions of the arc differ is formed by the insulation cover 3c, a projecting section 7 is provided in a central portion of the arc (central portions of the arc extension spaces 21) such that the arc during the extension can collide or be compressed against the projecting section 7. The projecting section 7 is formed of the same material as that of the insulation cover 3c and has a projecting shape to a lateral surface of the case 101.

[0056] According to the fourth embodiment of the invention, the arc collides or is compressed against the projecting section 7, and the arc is extended around the projecting section 7. Therefore, cooling efficiency of the arc can further be improved.

[0057] Note that, in the invention, the embodiments can freely be combined within the scope of the invention and each of the embodiments can appropriately be modified or features can be omitted.

List of Reference Signs

[0058]

1	Fixed contact
1a	Fixed contact point
2	Movable contact
2a	Movable contact point
3	Attraction rod
3c	Insulation cover
4	Magnet
6	Magnetic reinforcing plate
7	Projecting section
11	Fixed-side terminal
12	Movable-side terminal
15	Flexible conductor
20	Arc generation region
21	Arc extension space
41	Permanent magnet
100	Switching device
101	Case
102	Extinguishing chamber
103	Switching mechanism section

Claims

1. A switching device **characterized by** comprising:

- a fixed contact that has a fixed contact point;
- a movable contact that is installed in a manner to be opposed to the fixed contact and has a movable contact point;
- a switching mechanism section that performs a switching operation of the fixed contact point and the movable contact point;
- a magnet that generates a magnetic field for extending an arc generated between the fixed contact and the movable contact when the fixed contact point and the movable contact point are opened;
- a magnetic body, one end of which is arranged in the vicinity of an arc generation region between the fixed contact and the movable contact, and the other end of which is arranged in a manner to contact one magnetic pole surface of the magnet; and
- an insulation cover that protects the magnet and the magnetic body and partitions arc extension spaces where energizing directions of the arc differ, in that

the magnet is arranged in a region other than the arc generation region.

2. The switching device according to claim 1, **characterized in that** the other end of the magnetic body is enlarged so as to partition the arc extension spaces where the energizing directions of the arc differ.

3. The switching device according to claim 1 or claim 2, **characterized in that** the insulation cover is arranged in a manner to surround the arc during extension.

4. The switching device according to any one of claim 1 to claim 3, **characterized in that** the insulation cover is provided with a projecting section in a central portion of the arc such that the arc during the extension can collide or be compressed against the projecting section.

5. The switching device according to any one of claims 1 to 4,
characterized in that the insulation cover is formed of a resin material.

FIG.1

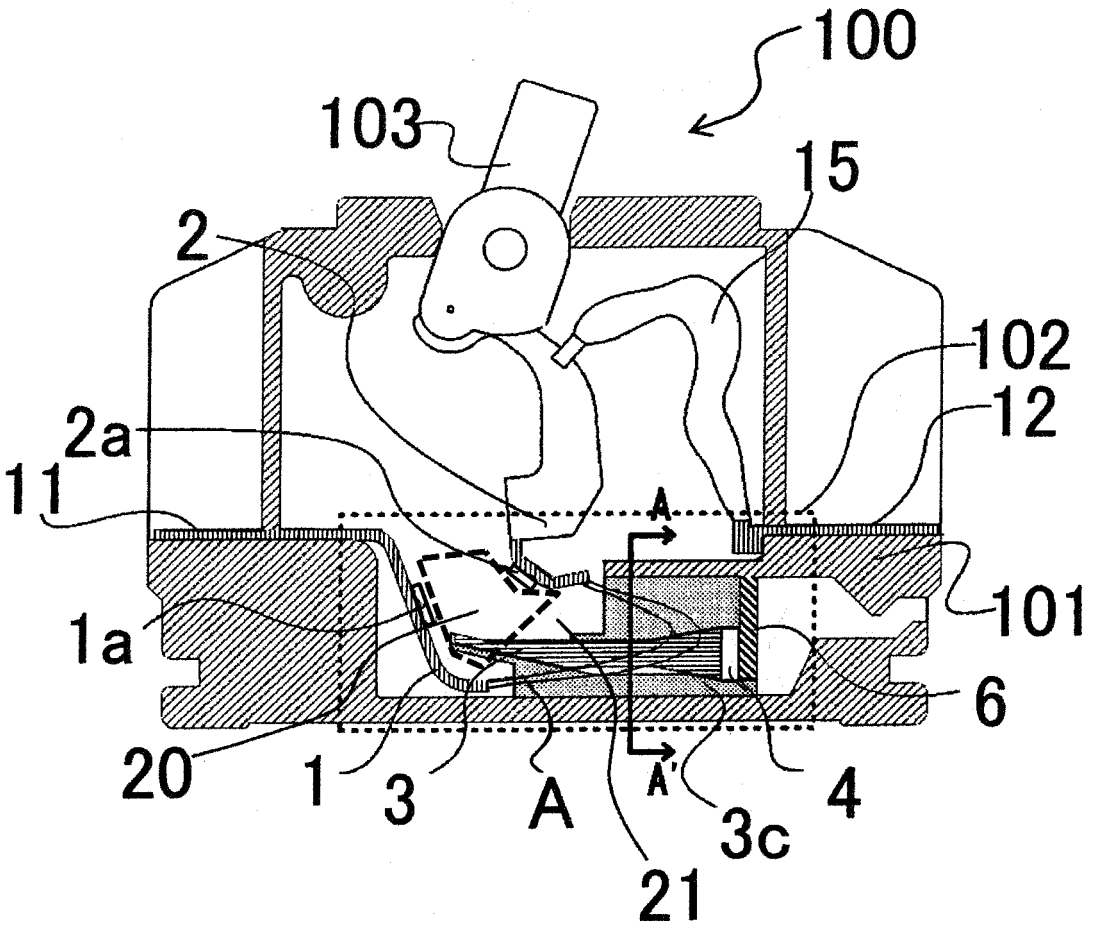


FIG.2

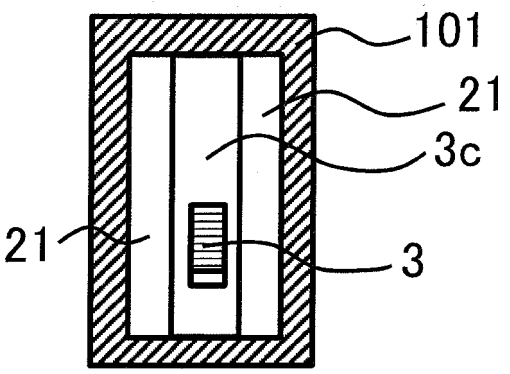


FIG.3

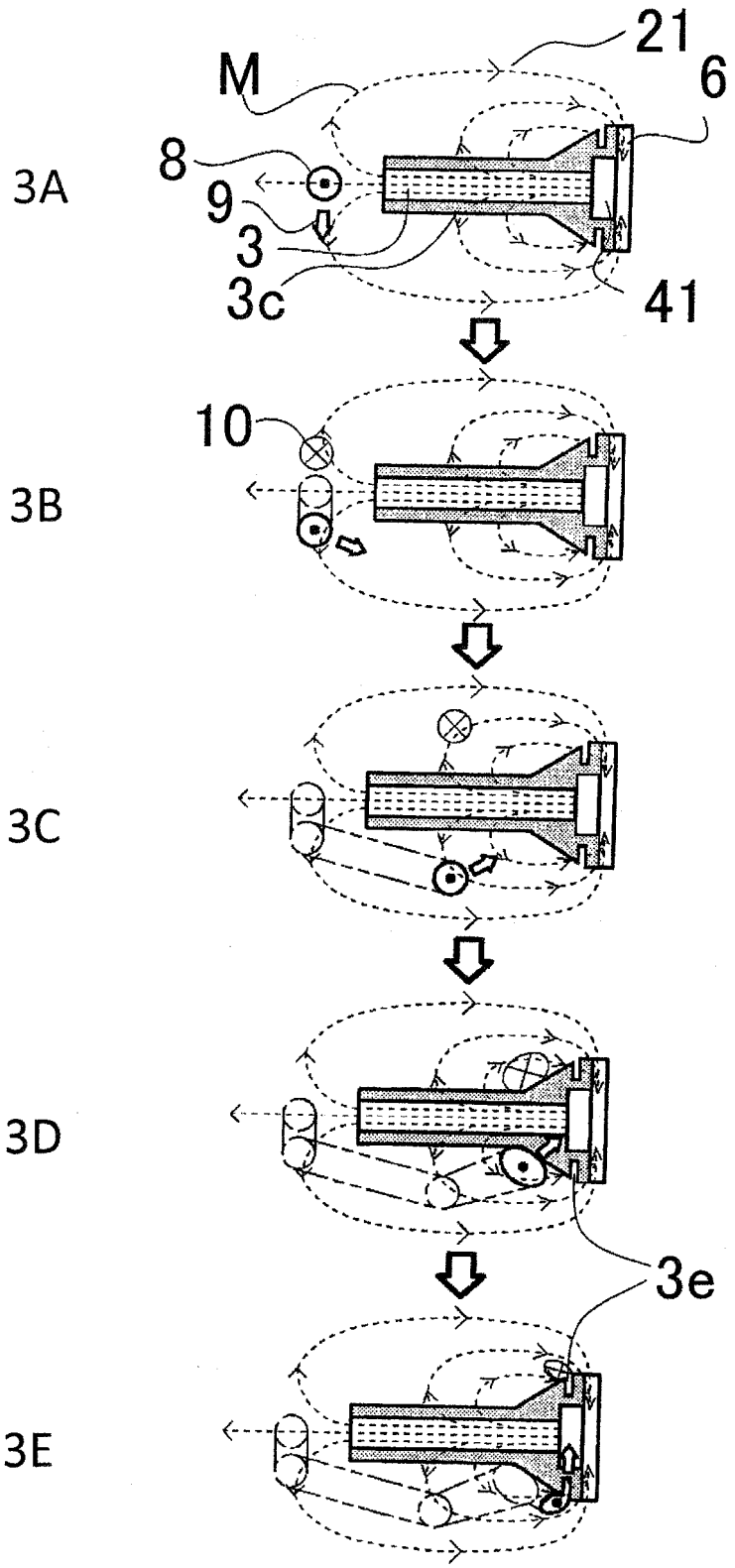


FIG.4

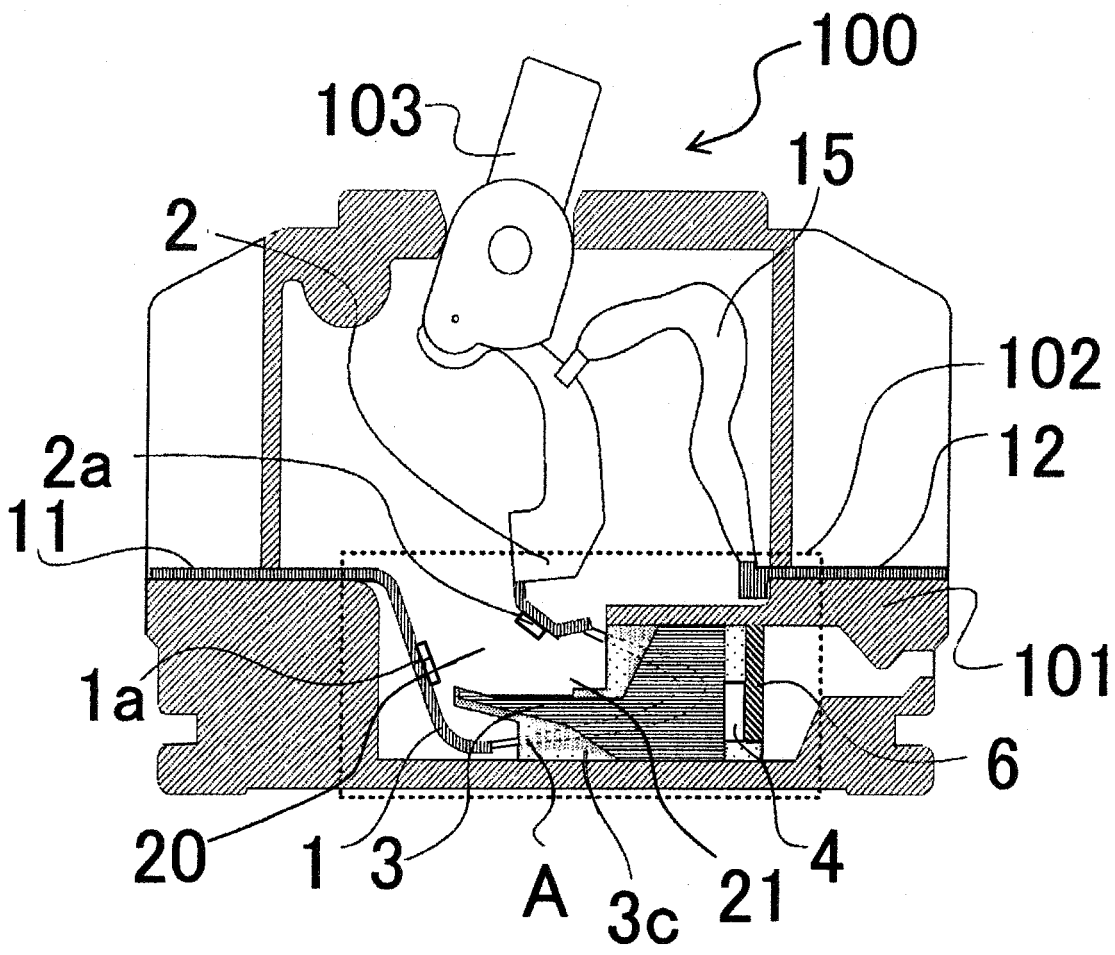


FIG.5

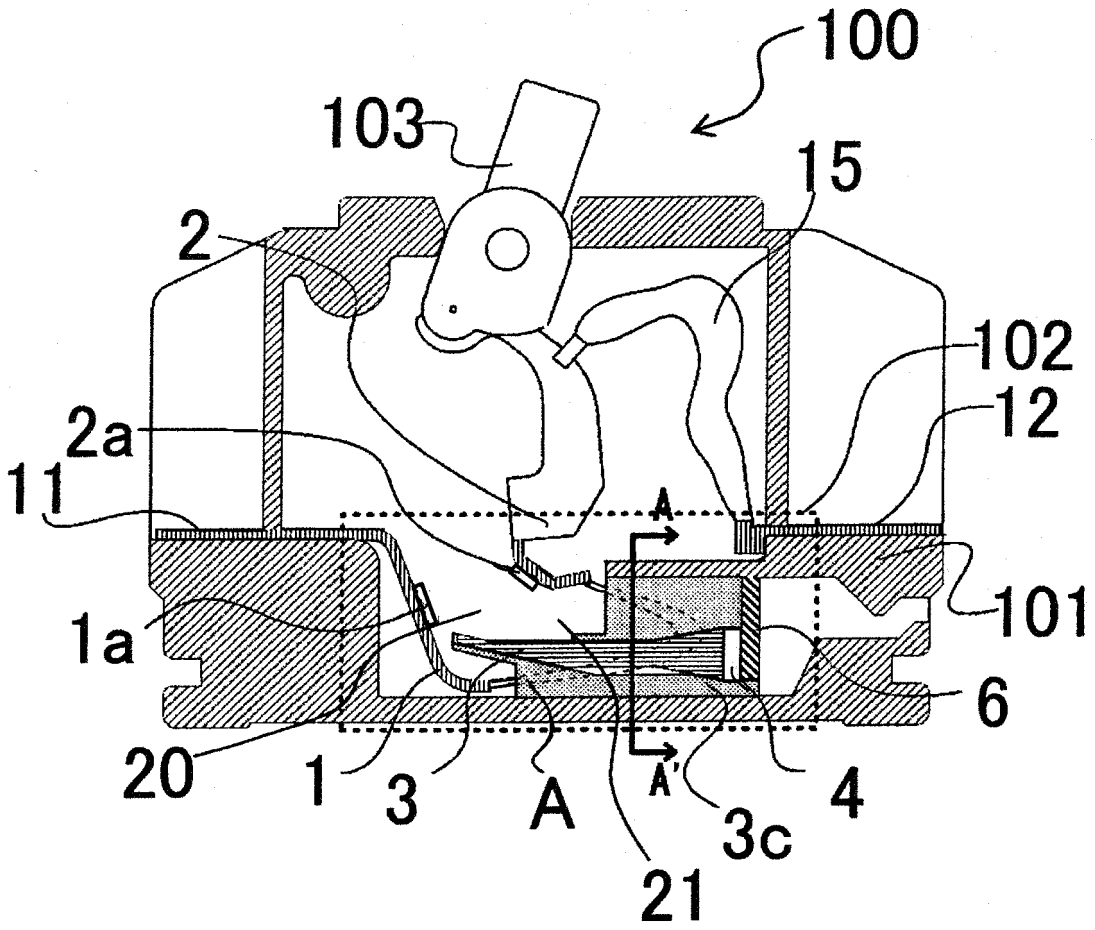


FIG.6

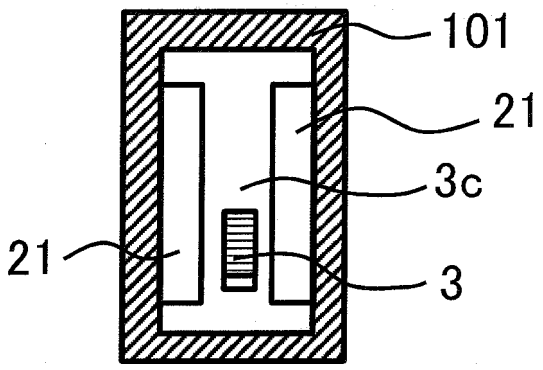


FIG.7

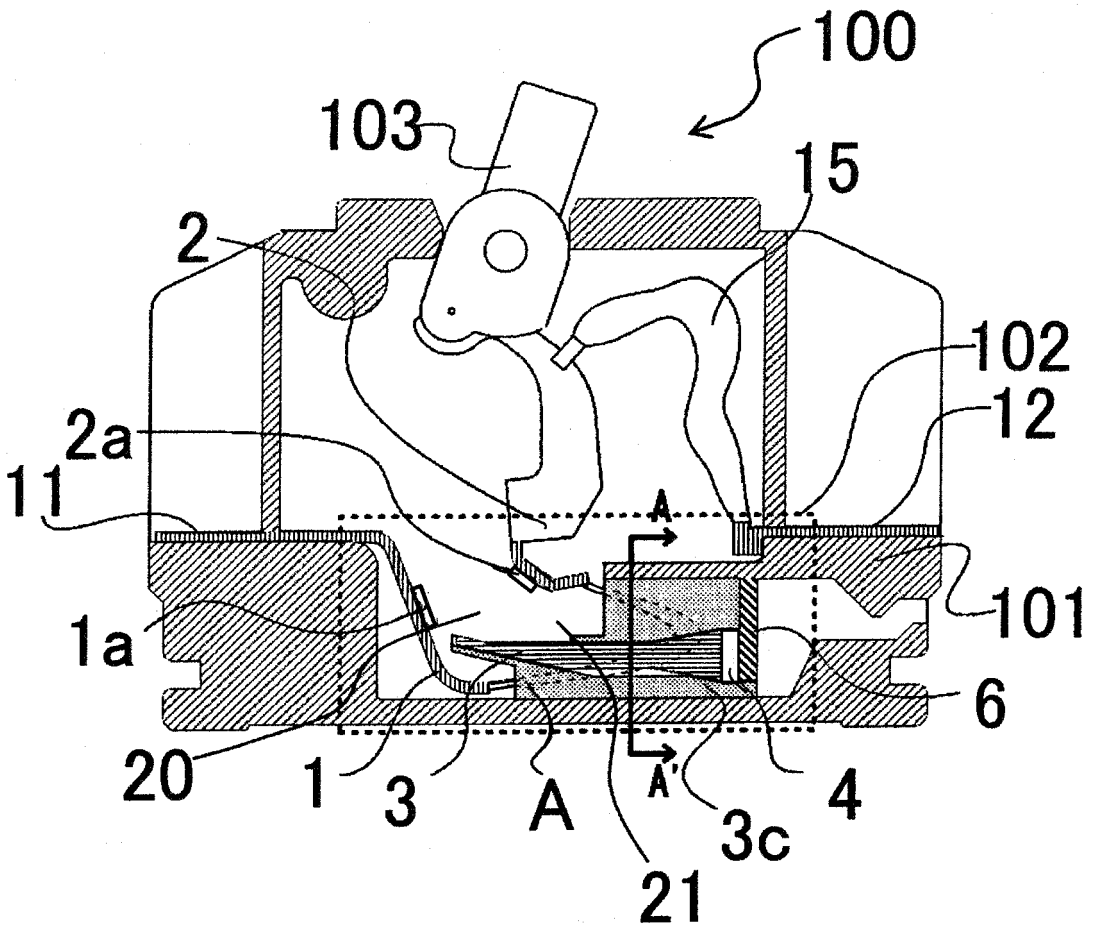
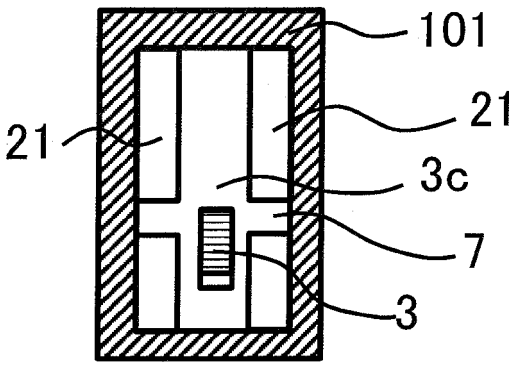


FIG.8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/060812

A. CLASSIFICATION OF SUBJECT MATTER
H01H9/44(2006.01)i, *H01H73/18*(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)
H01H9/44, H01H73/18

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 39-028834 B1 (Siemens-Schuckertwerke AG.), 12 December 1964 (12.12.1964), entire text; fig. 2 (Family: none)	1,3-5 2
Y	JP 62-287533 A (Mitsubishi Electric Corp.), 14 December 1987 (14.12.1987), entire text; fig. 1 to 2 (Family: none)	1,3-5
Y	WO 2010/150390 A1 (Mitsubishi Electric Corp.), 29 December 2010 (29.12.2010), paragraph [0038]; all drawings & EP 2447975 A1 & CN 102804313 A	1,3-5

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
11 June 2015 (11.06.15)	23 June 2015 (23.06.15)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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Patent documents cited in the description

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