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(54) GAS-INSULATION SWITCH DEVICE

(57) A gas-insulated switchgear which efficiently removes a remaining thermal gas to improve an insulation performance, and which is capable of easily accomplishing a current breaking duty required for a switchgear for a high voltage is provided. Inside a movable shield 23, with a piston 25a of an operation rod 25 being a partition wall, a compression chamber 30 and a suction chamber 31 are formed at a movable-contact-base-22 side and a movable-contact-21 side, respectively. The compression chamber 30 compresses an insulating gas in the compression chamber 30 by a movement of the piston 25a at the time of circuit opening operation, and sprays the insulating gas to an arc 40 produced between the fixed arcing contact 11 and the movable contact 21 via a communication hole 25c, a hollow portion 25b, and a ventilation hole 21a. The suction chamber 31 reduces the internal pressure by expanding an internal space by a movement of the piston 25a to suction a high-temperature gas due to the arc 40 through a clearance 31a between the movable contact 21 and the movable shield 23.

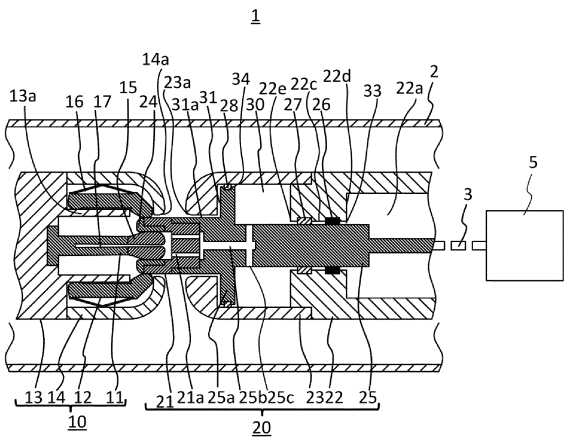

FIG. 1

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Description

FIELD

[0001] Embodiments of the present disclosure relate to a gas-insulated switchgear that has improved insulation characteristics.

BACKGROUND

[0002] A switchgear for a high voltage that has a duty of breaking an accident current in a power system is required to surely break currents from a small current to a large current. In particular, as for a large-current breaking, the following two current breaking duties must be satisfied. One is a duty of breaking a short-distance line fault (SLF) current, and the other is a duty of breaking a breaker terminal short-circuit fault (BTF) current. The SLF current is a current having a voltage in a triangular waveform which has a low absolute value but has a keen change rate at the initial stage of rising of a transient recovery voltage produced immediately after a current zero point. The BTF current is a current to which a voltage having a gentle rise at the initial stage of the transient recovery voltage but has a high absolute value at the final stage.

[0003] Conventionally, a switchgear that accomplishes the above-described two current breaking duties by a single contact unit has been broadly adopted. However, when it is attempted to accomplish the two current breaking duties by a single contact unit, the weight of a movable member in the contact unit becomes heavy, and a load on an operation mechanism that actuates a movable member increases. Hence, a scheme of accomplishment by a single contact unit may be inadequate for an application where a quite-short current breaking time is required.

[0004] In recent years, a reduction of a current breaking time is desired, and there is a request to reduce the weight of the movable member of the contact unit and reduce a load on the operation mechanism. Accordingly, a multipoint current breaking switchgear that includes a plurality of contact units specialized for respective current breaking duties to separately accomplish the above-described two current breaking duties is proposed. In the multipoint current breaking scheme, different types of contact units are electrically connected in series, enabling accomplishment of multiple kinds of current breaking duties. An example known contact unit specialized for a current breaking duty is a vacuum current breaking unit, a gas contact unit, etc.

[0005] A vacuum current breaking unit is a contact unit with excellent current breaking characteristics for a keen voltage change, and breaks an accident current. The gas contact unit is a contact unit with high insulation characteristics, and executes insulation after a current breaking. In multipoint current breaking switchgear that has such two contact units, since the respective contact units share different current breaking duties, the weight of the movable member per each contact unit can be reduced. Hence, a load on the operation mechanism can be reduced, and the current breaking time can be efficiently reduced. Accordingly, the multipoint current breaking switchgear is suitable for an application where a quite-short current breaking time is required.

CITATION LIST

PATENT LITERATURES

[0006]

Patent Document 1: JP 2015-43656 A
Patent Document 2: WO 2015/185095 A1
Patent Document 3: JP S55-053824 A
Patent Document 4: JP H8-321233 A
Patent Document 5: JP 2002-075148 A
Patent Document 6: JP 2008-112633 A
Patent Document 7: JP S61-14444 A
Patent Document 8: JP 2014-72032 A
Patent Document 9: JP 2015-79635 A
Patent Document 10: JP 2015-185381 A
Patent Document 11: JP 2015-185467 A
Patent Document 12: US Patent No. 5,258,590
Patent Document 13: US Patent NO. 5,258,590

SUMMARY

[0007] According to the multipoint current breaking switchgear, when a vacuum current breaking unit that breaks an accident current, and a gas contact unit that executes insulation after the current breaking are provided as the contact units that share the current breaking duties, there are the following technical problems. That is, when the vacuum current breaking unit extinguishes the accident current, an arc is produced in the vacuum current breaking unit until the accident current is fully dissipated, and not only that, an arc is also produced in the gas contact unit.

[0008] Hence, an insulating gas in the gas contact unit becomes a thermal gas with a high temperature because of the production of arc. This thermal gas remains in the gas contact unit for a long time, even after the arc is extinguished. Consequently, there is a possibility that an insulation performance of the gas contact unit decreases. In particular, when the amount of remaining thermal gas is large, ignition of an arc may occur again in the gas contact unit, which may result in a failure of the current breaking itself.

[0009] Embodiments has been proposed in order to address the above-described technical problems, and an objective is to provide a gas-insulated switchgear which efficiently removes a remaining thermal gas to improve an insulation performance, and which can easily accomplish a current breaking duty required in a switchgear for a high voltage.

[0010] In order to accomplish the above objective, an embodiment of the present disclosure provides a gas-insulated switchgear that includes a pressure chamber in which an insulating gas is gas-tightly filled, a fixed contact base and a movable contact base placed in the pressure chamber so as to face with each other, a fixed arcing contact fixed to the fixed contact base, a fixed shield fixed to the fixed contact base so as to surround the fixed arcing contact, a fixed conductive contact placed at the fixed shield, a movable contact placed so as to face the fixed conductive contact and to be freely movable, a movable shield fixed to the movable contact base so as to surround the movable contact, an operation rod which is connected to the movable contact and to which a piston is fixed, and an operation mechanism that reciprocates the operation rod so as to move the movable contact to be apart or in contact relative to the fixed arcing contact and the fixed conductive contact, in which the following features (1) to (6) are included.

[0011]

(1) Inside the movable shield, with the piston of the operation rod acting as a partition wall, a compression chamber and a suction chamber are formed at a movable-contact-base side and at the movable-contact side, respectively.

(2) The operation rod is provided with a hollow portion, and a communication hole that communicates the hollow portion and the compression chamber.

(3) The movable contact is provided with a ventilation hole that passes completely through from an end surface of the movable contact to the hollow portion of the operation rod.

(4) The compression chamber compresses the insulating gas therein by a movement of the piston associated with a movement of the operation rod at a time of circuit opening operation, and sprays the insulating gas to an arc produced between the fixed arcing contact and the movable contact via the communication hole, the hollow portion, and the ventilation hole.

(5) A clearance is provided between an outer circumference of the movable contact and an inner circumference of the movable shield.

(6) The suction chamber reduces an internal pressure by expanding an internal space by a movement of the piston associated with a movement of the operation rod at a time of circuit opening operation, and sucks the high-temperature insulating gas heated by the arc into the internal space through the clearance.

BRIEF DESCRIPTION OF DRAWINGS

[0012]

FIG. 1 is a cross-sectional view illustrating a close-circuit state of a gas-insulated switchgear according to a first embodiment;

FIG. 2 is a cross-sectional view illustrating an open-circuit state of the gas-insulated switchgear according to the first embodiment;

FIG. 3 is a cross-sectional view illustrating a close-circuit state of a gas-insulated switchgear according to a second embodiment;

FIG. 4 is a cross-sectional view illustrating an open-circuit state of the gas-insulated switchgear according to the second embodiment;

FIG. 5 is a cross-sectional view illustrating a close-circuit state of a gas-insulated switchgear according to a third embodiment;

FIG. 6 is a cross-sectional view illustrating an open-circuit state of the gas-insulated switchgear according to the third embodiment;

FIG. 7 is a cross-sectional view illustrating a close-circuit state of a gas-insulated switchgear according to a fourth embodiment; and

FIG. 8 is a cross-sectional view illustrating an open-circuit state of the gas-insulated switchgear according to the fourth embodiment.

DETAILED DESCRIPTION

[0013] Embodiments of a gas-insulated switchgear according to the present disclosure will be described below with reference to the drawings. Gas-insulated switchgears to be described in below embodiments all have a plurality of contactors which can share a current breaking duty and which are electrically connected in series, and are applied to a gas contact unit that is a contact unit.

[First Embodiment]

(Structure)

[0014] With reference to FIGS. 1 and 2, a structure according to a first embodiment will be described. FIG. 1 is a cross-sectional view illustrating a close-circuit state according to the first embodiment, and FIG. 2 is a cross-sectional views illustrating an open-circuit state according to the first embodiment. As illustrated in FIGS. 1 and 2, a gas-insulated switchgear 1 is provided with a pressure chamber 2 in which an insulating gas is gas-tightly filled. A fixed contact unit 10 and a movable contact unit 20 are placed in the pressure chamber 2 so as to face with each other.

[0015] The movable contact unit 20 includes a movable shaft 3 that extends out to the exterior of the pressure chamber 2, and the movable shaft 3 is connected to an operation mechanism 5. The operation mechanism 5 is attached to the pressure chamber 2. The operation mechanism 5 linearly reciprocates the movable contact unit 20 via the movable shaft 3, and moves the movable contact unit 20 to be apart or in contact relative to the fixed contact unit 10.

[0016] In the following description, end portions of the fixed contact unit 10 and the movable contact unit 20 that relatively come close to each other are defined as respective tip end portions of the contactor units 10 and 20, and the opposite sides thereto are defined as respective basal end portions. In FIGS. 1 and 2, in the movable contact unit 20, the right side in FIG. 1 is a basal-end portion side, and the opposite side is a tip-end portion side. In contrast, in the fixed contact unit 10, the right side in FIG. 1 is a tip-end portion side, and the opposite side is a basal-end portion side. Note that when the tip end portion is an end surface, this will be also referred to as a tip end surface.

(Fixed contact Unit)

[0017] The fixed contact unit 10 includes a fixed arcing contact 11, a fixed conductive contacts 12, a fixed contact base 13, and a fixed shield 14, all arranged concentrically to one another. A spring 16 is placed inside the fixed shield 14.

[0018] The fixed contact base 13 is fixed to the pressure chamber 2. The fixed arcing contact 11 in a bar shape is attached to the center part of the fixed contact base 13. A cylindrical portion 13a that is thinner than the outer diameter of the base 13 protrudes and is formed on the tip end surface of the fixed contact base 13, and the fixed conductive contact 12 is placed so as to surround the cylindrical portion 13a.

[0019] The plurality of fixed conductive contacts 12 is placed in the circumferential direction, and the tip end portions are bent toward the internal side. The fixed conductive contacts 12 are pushed by the spring 16 in the internal direction, and at the same time abuts the outer circumference of the cylindrical portion 13a of the fixed contact base 13, and thus the movement toward the internal side by the spring 16 is restricted.

[0020] The fixed shield 14 is fixed to the outer circumference of the fixed contact base 13 so as to surround the fixed conductive contact 12. The tip end portion of the fixed shield 14 is bent toward the internal side so as to cover the tip end portion of the fixed conductive contact 12. A circular opening 14a is formed in the tip end portion of the fixed shield 14.

[0021] An arc-resistant metal 15 that has arc-resistant characteristics is firmly attached to the tip end portion of the fixed arcing contact 11. The arc-resistant metal 15 is formed in a spindle shape that expands outwardly. The fixed arcing contact 11 is provided with slit 17 that has tip end portion sides split in the lengthwise direction. The plurality of slits 17 is provided in parallel with each other. By these slits 17, the fixed arcing contact 11 has spring characteristics that deforms the tip end portion in the radial direction.

(Movable contact Unit)

[0022] The movable contact unit 20 includes a movable contact 21, a movable contact base 22, a movable shield 23, and an operation rod 25, all arranged concentrically to one another. Among these components, the operation rod 25 has the tip end portion connected to the movable contact 21, and the basal end portion connected to the movable shaft 3. The operation rod 25 moves the movable contact 21 to be apart or in contact relative to the fixed arcing contact 11 and the fixed conductive contact 12 due to the movable shaft 3 performing reciprocation movement by the operation mechanism 5.

[0023] Apiston 25a in a disk shape is fixed to the operation rod 25. Moreover, a hollow portion 25b that extends in the lengthwise direction is provided in the center part of the operation rod 25. Furthermore, a communication hole 25c which is orthogonal to the hollow portion 25b and which reaches the outer circumference of the actuation rod 25 from the hollow portion 25b is provided in the operation rod 25. The communication hole 25c is a hole that communicates the hollow portion 25b and a compression chamber 30 to be described later.

[0024] The movable contact 21 is attached to the tip end portion of the operation rod 25, and is placed so as to be freely movable and face the fixed current-carrying contactor 12 in the lengthwise direction. The outer diameter of the movable contact 21 is formed so as to be smaller than the internal diameter of the opening 14a of the fixed shield 14, so that the movable contact 21 can be inserted in the opening 14a of the fixed shield 14. When the movable contact 21 is inserted in the opening 14a of the fixed shield 14, the movable contact 21 is provided so that the outer circumference is in contact with the inner circumference of the fixed conductive contact 12.

[0025] An arc-resistant metal 24 that has arc-resistant characteristics is firmly attached to the tip end portion of the movable contact 21. The arc-resistant metal 24 is formed in a ring shape so that the arc-resistant metal 15 of the fixed arcing contact 11 is in contact or moves apart relative to the inner circumference. That is, in the movable contact unit 20, the operation rod 25 and movable contact 21 are members that move in an circuit opening operation and circuit closing operation. In contrast, the movable contact base 22 is a component that is fixed to the pressure chamber 2, and the movable shield 23 is a component that is fixed to the movable contact base 22 even in the movable contact unit 20.

[0026] In the movable contact 21, at the basal end portion side when viewed from a portion where the arc-resistant metal 15 is inserted, a plurality of ventilation holes 21a each extending in the lengthwise direction of the movable contact 21 is provided. The ventilation hole 21a is a hole that passes completely through from the end surface of the movable contact 21 to the hollow portion 25b of the operation rod 25. An opening of the ventilation hole 21a at the tip end portion side is arranged so as to face the end portion of the arc-resistant metal 15 of the fixed arcing contact 11.

[0027] The movable contact base 22 is fixed to the pressure chamber 2. The movable contact base 22 is a hollow cylindrical component, and the interior is in communication with an internal space 22a of the pressure chamber 2. A thick flange 22d is formed at the tip end portion of the movable contact base 22. In the end surface of the flange 22d of the movable contact base 22, a corner portion that faces the communication hole 25c of the operation rod 25 at the end of the circuit opening operation is defined as a gas flow volume limiting portion 22e. The gas flow volume limiting portion 22e is provided so as to cover at least a part of the communication hole 25c with a predetermined clearance at the end of the circuit opening operation.

[0028] A holder hole 22c is opened at the center of the flange 22d of the movable contact base 22. The operation rod 25 is inserted in the holder hole 22c. A clearance 33 is formed between the inner circumference of the holder hole 22c of the movable contact base 22 and the outer circumference of the operation rod 25. This clearance 33 becomes a gap when the gas flow volume limiting portion 22e of the movable contact base 22 covers the communication hole 25c.

[0029] Placed in the clearance 33 are a collecting contactor 26 and a slide packing 27 so as to contact the inner circumference of the movable contact base 22 and the outer circumference of the operation rod 25. In the flange 22d of the movable contact base 22, the collecting contactor 26 is attached to the basal end portion side, and the slide packing 27 is attached to tip end portion side, respectively. Since the slide packing 27 is installed in the clearance 33, the insulating gas compressed in the compression chamber 30 does not flow toward the internal space 22a of the movable contact base 22 through the clearance 33. Moreover, the slide packing 27 is configured to block a part of the communication hole 25c of the operation rod 25 at the end of a circuit opening operation.

[0030] The movable shield 23 is fixed to the outer circumference of the flange 22d of the movable contact base 22, and a circular opening 23a is formed in the tip end surface so as to surround the outer circumference of the movable contact 21. The outer diameter of the movable contact 21 is formed to be smaller than the internal diameter of the opening 23a. Hence, a clearance 31a is formed between the outer circumference of the movable contact 21 and the inner circumference of the opening 23a of the movable shield 23.

[0031] Two spaces are formed in the internal space of the movable shield 23 with the piston 25a of the operation rod 25 being a partition wall. One is the compression chamber 30 formed in the movable contact base 22 side, and the other is a suction chamber 31 formed in the movable contact 21 side. The internal diameter of the compression chamber 30 is designed to be larger than the internal diameter of the suction chamber 31. A clearance 34 is formed between the inner circumference of the movable shield 23 and the outer circumference of the piston 25a. A slide packing 28 is placed in the clearance 34 so as to contact the inner circumference of the movable shield 23 and the outer circumference of the piston 25a.

[0032] The compression chamber 30 is a space surrounded by the piston 25a of the operation rod 25, the outer circumference of the operation rod 25, the flange 22d of the movable contact base 22, and the inner circumference of the movable shield 23. The compression chamber 30 compresses the insulating gas therein by a movement of the piston 25a associated with the movement of the operation rod 25 at the time of the circuit opening operation. Moreover, the compression chamber 30 sprays the compressed insulating gas to an arc 40 (illustrated in FIG. 2) produced between the arc-resistant metal 15 of the fixed arcing contact 11 side and the arc-resistant metal 24 of the movable contact 21 side through the communication hole 25c, the hollow portion 25b, and the plurality of ventilation holes 21a. Note that since the insulating gas in the compression chamber 30 has a low temperature in comparison with a thermal gas, the insulating gas in the compression chamber 30 will be referred to as a low-temperature gas.

[0033] The suction chamber 31 is a space surrounded by the piston 25a of the operation rod 25, the outer circumference of the operation rod 25, the outer circumference of the movable contact 21, and the inner circumference of the movable shield 23. The suction chamber 31 decreases the pressure in the chamber by an expansion of the internal space due to the movement of the piston 25a associated with the movement of the operation rod 25 at the time of the circuit opening operation, and suctions a high-temperature insulating gas (will be referred to as a thermal gas below) heated by the arc 40 in the chamber through the clearance 31a, .

(Circuit Opening Operation)

[0034] The circuit opening operation according to the first embodiment that employs the above-described structure will be described through a transition from a close-circuit state illustrated in FIG. 1 to an open-circuit state illustrated in FIG. 2. First, in the close-circuit state illustrated in FIG. 1, the movable contact 21 is in contact with the fixed arcing contact 11 and with the fixed conductive contact 12, and is in a conduction state.

[0035] In the close-circuit state, the fixed conductive contact 12 is pushed against the outer circumference of the movable contact 21 by the elastic force of the spring 16. Moreover, in the close-circuit state, since the fixed arcing contact 11 deforms to shrink in the radial direction by the plurality of slits 17, the arc-resistant metal 15 firmly attached to the tip end portion of the fixed arcing contact 11 is pushed in the outer circumference direction, and is pressed against the inner circumference of the movable contact 21.

[0036] With the above-described close-circuit state being an initial state, when the operation mechanism 5 is activated by a circuit opening command transmitted from the exterior and the movable shaft 3 is driven to the right side in FIG. 1, the operation rod 25 and the movable contact 21 are also driven to the right side. Hence, the movable contact 21 becomes apart first from the fixed conductive contact 12. At this time, since the fixed arcing contact 11 is in contact with the movable contact 21, no arc 40 is produced between the movable contact 21 and the fixed conductive contact 12.

[0037] Subsequently, when circuit opening operation advances and the movable contact 21 becomes apart from the fixed arcing contact 11, the arc 40 (illustrated in FIG. 2) is produced between the arc-resistant metal 24 of the movable contact 21 side and the arc-resistant metal 15 of the fixed arcing contact 11 side. Since the arc 40 is in extremely high temperature, the insulating gas therearound becomes the high-temperature thermal gas, and remains between the fixed arcing contact 11 and the movable contact 21.

[0038] When the circuit opening operation further advances, an accident current is broken by the other switchgear (unillustrated) that is connected in series with the gas-insulated switchgear 1. Hence, the arc 40 produced between the fixed arcing contact 11 and the movable contact 21 extinguishes. However, even when the arc 40 is extinguished, the thermal gas due to the arc 40 still remains between the fixed arcing contact 11 and the movable contact 21. Hence, it is in a state in which the insulation performance relative to the transient recovery voltage after the current breaking is decreased.

[0039] Hence, according to the first embodiment, in order to suppress the reduction of the insulation performance, the following operation is executed. That is, in the circuit opening operation, the piston 25a that is driven to the right side associated with the movement of the operation rod 25 compresses the low-temperature gas in the compression chamber 30. The low-temperature gas compressed in the compression chamber 30 passes through the communication hole 25c, the hollow portion 25b, and the plurality of ventilation holes 21a in sequence, and is sprayed between the fixed arcing contact 11 and the movable contact 21.

[0040] Moreover, in the circuit opening operation, the internal space of the suction chamber 31 expands because the piston 25a has moved to the right side, and the pressure of the insulating gas in the chamber becomes lower than the surroundings. At this time, the internal space of the suction chamber 31 and the space where the arc 40 is produced are in communication with each other by the clearance 31a provided between the outer circumference of the movable contact 21 and the inner circumference of the opening 23a of the movable shield 23. Hence, the thermal gas present around the arc-resistant metal 24 and the movable contact 21 can be taken into the suction chamber 31 via the clearance 31a.

[0041] At the end of the circuit opening operation, the gas flow volume limiting portion 22e provided in the end surface of the flange 22d of the movable contact base 22 covers at least a part of the communication hole 25c of the operation rod 25, and the slide packing 27 blocks a part of the communication hole 25c (a state illustrated in FIG. 2). The circuit opening operation ends when the state transitions to the state in FIG. 2 from the state in FIG. 1. At the end of the circuit opening operation, the movable contact 21 is completely retained in the movable shield 23.

(Circuit Closing Operation)

[0042] Next, a circuit closing operation of the gas-insulated switchgear 1 illustrated in FIG. 2 where a transition to the close-circuit state illustrated in FIG. 1 from the open-circuit state occurs will be described. First, in the open-circuit state illustrated in FIG. 2, the movable contact 21 moves apart from the fixed arcing contact 11 and the fixed conductive contact 12, and is in non-conductive state.

[0043] With the above-described open-circuit state being an initial state, when the operation mechanism 5 is activated by a circuit closing command transmitted from the exterior and the movable shaft 3 is driven to the left side in FIG. 2, the operation rod 25 and the movable contact 21 are driven to the left side, and the movable contact 21 is closed and in contact with the fixed arcing contact 11, and then is closed and in contact with the fixed conductive contact 12fixed arcing contact.

[0044] Since the piston 25a is driven to the left side in FIG. 2 as the circuit closing operation advances, the internal space of the compression chamber 30 expands, and the pressure of the insulating gas becomes lower than the surroundings. Hence, the insulating gas around the fixed arcing contact 11 is taken into the compression chamber 30 through the communication hole 25c, the hollow portion 25b, and the ventilation hole 21a.

[0045] Moreover, by driving the piston 25a to the left side in FIG. 2, the insulating gas in the suction chamber 31 is compressed, and the insulating gas is sprayed toward the arc-resistant metal 24 side of the movable contact 21 via the clearance 31a. The circuit closing operation ends when the state transitions to the state in FIG. 1 from the state in FIG. 2, and the movable contact 21 is closed and in contact with the fixed arcing contact 11 and the fixed conductive contact 12, and is in the conductive state.

(Action an Effect)

[0046]

(1) According to the first embodiment, in the compression chamber 30, the insulating gas in the chamber is compressed by the movement of the piston 25a assocaited with the movement of the operation rod 25 at the time of the circuit opening operation, and the low-temperature gas is sprayed to the arc 40 via the communication hole 25c, the hollow portion 25b, and the plurality of ventilation holes 21a. At this time, the plurality of ventilation holes 21a faces a portion where the arc-resistant metal 15 of the fixed arcing contact 11 is inserted.

Hence, the ventilation hole 21a can intensively spray a large amount of low-temperature gas from the compression chamber 30 to the thermal gas due to the arc 40. Accordingly, the thermal gas due to the arc 40 can be cooled efficiently, and the remaining thermal gas can be diffused all around from the space where the arc 40 is produced, and can be blown away from between the fixed arcing contact 11 and the movable contact 21.

In addition, according to the first embodiment, since the piston 25a that starts moving compresses the insulating gas in the compression chamber 30, the low-temperature gas can be sprayed toward the space where the arc 40 is produced from the initial stage of the circuit opening operation. Therefore, the thermal gas can be promptly diffused, contributing to an improvement in insulation performance.

According to the first embodiment, simultaneously with the above-described diffusion of the thermal gas, the thermal gas due to the arc 40 can be suctioned by the suction chamber 31. Hence, the thermal gas can be efficiently removed from between the fixed arcing contact 11 and the movable contact 21. At this time, the clearance 31a that becomes a flow channel for the thermal gas to the suction chamber 31 is located at the outer circumference of the movable contact 21.

Accordingly, the thermal gas diffused along the outer circumference of the movable contact 21 by the sprayed low-temperature gas can smoothly flow toward the clearance 31a. Moreover, according to the first embodiment, since the pressure in the suction chamber 31 decreases by the piston 25a that starts moving, the suction chamber 31 can quickly suction the thermal gas through the clearance 31a from the initial stage of the circuit opening operation.

As described above, according to the gas-insulated switchgear 1 of the first embodiment, since the thermal gas is removed from between the fixed arcing contact 11 and the movable contact 21, re-ignition of the fixed arcing contact 11 and the movable contact 21 hardly occurs. Accordingly, an excellent insulation performance relative to the transient recovery voltage after the current breaking can be obtained. Hence, the gas-insulated switchgear 1 can easily achieve the current breaking duty required for a switchgear for a high voltage, and reduces a load on the operation mechanism 5, contributing to a reduction of a current breaking time.

(2) According to the first embodiment, since the gas flow volume limiting portion 22e of the flange 22d of the movable contact base 22 covers at least a part of the communication hole 25c of the operation rod 25 at the end of the circuit opening operation, the cross-sectional area of the communication hole 25c in communication with the compression chamber 30 decreases. Accordingly, immediately before the end of the circuit opening operation, the flow volume of the low-temperature gas that flows toward the ventilation hole 21a from the compression chamber 30 can be reduced, and the internal pressure of the compression chamber 30 increases.

Consequently, puffer reaction force that acts in the direction opposite to the driving direction in the circuit opening operation, that is, the leftward direction in FIG. 2 to the piston 25a increases, and the operation rod 25 and to the movable contact 21 can be braked immediately before the end of the circuit opening operation. This can ease a shock produced when the circuit opening operation ends, and the operational reliability can be improved.

(3) According to the first embodiment, at the end of the circuit opening operation, the slide packing 27 blocks only a part of the communication hole 25c of the operation rod 25. That is, the communication hole 25c is not completely blocked by the slide packing 27. Accordingly, as described in the previous paragraph, although the flow volume of the low-temperature gas from the compression chamber 30 is reduced immediately before the end of the circuit opening operation, the flow volume does not become completely zero, and the low-temperature gas is degassed from the compression chamber 30 to the ventilation hole 21a through the communication hole 25c.

Consequently, immediately before the end of the circuit opening operation, even if the internal pressure of the compression chamber 30 increases by the reduction of the flow volume of the low-temperature gas, the pressure in the compression chamber 30 does not excessively increase. Hence, at the end of the circuit opening operation, the piston 25a is prevented from moving in the opposite side to the left side in FIG. 2 because of the puffer reaction force.

(4) According to the first embodiment, immediately before the end of the circuit closing operation, the internal space of the compression chamber 30 expands and the pressure of the insulating gas becomes lower than the surroundings. Conversely, in the suction chamber 31, the pressure becomes higher than the surroundings, and the puffer reaction force that is in the direction opposite to the driving direction in the circuit closing operation, that is, the rightward direction in FIG. 1 acts on the piston 25a. Accordingly, the braking force can be surely applied to the operation rod 25 and the movable contact 21 can be surely braked immediately before the end of the circuit closing operation, and a shock produced when the circuit closing operation ends can be eased.

(5) According to the first embodiment, the spring 16 pushes the fixed conductive contact 12 against the outer circumference of the movable contact 21. Hence, an electrical resistance decreases, and heat generation by conduction can be suppressed. Moreover, the fixed arcing contact 11 deforms so as to

shrink in the radial direction by the plurality of slits 17 to have elastic force in the outer circumference direction, and thus the fixed arcing contact 11 is pushed against the inner circumference of the movable contact 21. Hence, like the fixed conductive contact 12, the electrical resistance decreases, and there is an advantage that heat generation by conduction is suppressed.

[Second Embodiment]

(Structure)

[0047] A structure according to a second embodiment will be described with reference to FIGS. 3 and 4. FIG. 3 is a cross-sectional view illustrating a close-circuit state according to the second embodiment, and FIG. 4 is a cross-sectional view illustrating an open-circuit state according to the second embodiment. Note that the same or similar component as that of the first embodiment will be denoted by the same reference numeral, and the duplicated description will be omitted.

[0048] According to the second embodiment, a plurality of first suction holes 22b is formed in the flange 22d of the movable contact base 22. The first suction hole 22b is a hole that communicates the internal space 22a of the movable contact base 22 and the compression chamber 30, and suctions the insulating gas in the internal space 22a into the compression chamber 30 at the time of the circuit closing operation.

[0049] A valve 32 in a ring-plate shape is placed inside the compression chamber 30. The valve 32 is fitted in a groove 32a formed in the inner circumference of the movable shield 23, has the restricted movable range by abutting the end portion of the groove 32a. The groove 32a is a positioning portion for the valve 32 at the end of the circuit closing operation. The valve 32 has a structure to block the first suction holes 22b by pressure difference when the pressure in the compression chamber 30 becomes higher than the pressure in the internal space 22a.

(Circuit Opening Operation)

[0050] A circuit opening operation according to the second embodiment that employs the above structure will be described through a transition from a close-circuit state illustrated in FIG. 3 to the open-circuit state illustrated in FIG. 4. However, as for the same feature as that of the circuit opening operation in the first embodiment, the detailed description will be omitted.

[0051] At the time of the circuit opening operation, the pressure in the compression chamber 30 becomes higher than the pressure in the internal space 22a because the piston 25a is driven to the right side in FIG. 3, and the valve 32 blocks the first suction hole 22b (a state in FIG. 4). Accordingly, no insulating gas flows in the compression chamber 30 from the internal space 22a through the first suction holes 22b.

[0052] Accordingly, the low-temperature gas in the compression chamber 30 can be efficiently compressed by the driven piston 25a, and the low-temperature gas in the compression chamber 30 can be intensively sprayed toward the fixed arcing contact 11 side via the communication hole 25c, the hollow portion 25b, and the ventilation hole 21a. Moreover, according to the second embodiment, like the first embodiment, since the internal space of the suction chamber 31 expands and the pressure of the insulating gas becomes lower than the surroundings, the insulting gas around the arc-resistant metal 24 is taken in the interior of the suction chamber 31 through the clearance 31a.

(Circuit Closing Operation)

[0053] A circuit closing operation according to the second embodiment will be described through a transition from the open-circuit state illustrated in FIG. 4 to the close-circuit state illustrated in FIG. 3. However, as for the same feature as that of the circuit closing operation according to the first embodiment, the detailed description will be omitted.

[0054] In the circuit closing operation, the pressure in the compression chamber 30 becomes lower than the pressure in the internal space 22a because the piston 25a is driven to the left side in FIG. 4, and the valve 32 opens the first suction holes 22b. Hence, the insulating gas in the internal space 22a flows into the compression chamber 30 via the first suction hole 22b, and a pressure reduction by the expansion of the internal space of the compression chamber 30 is suppressed. Accordingly, the piston 25a does not become a condition that is difficult to move in the circuit opening direction (the leftward direction in FIG. 4) associated with the pressure reduction of the compression chamber 30. The valve 32 abuts the end portion of the groove 32a at the end of the circuit closing operation, and the valve 32 is positioned.

(Action and Effect)

[0055] According to the second embodiment, the action and effect similar to the first embodiment can be achieved, and there are the following further unique action and effect. That is, at the time of circuit closing operation, since the valve 32 opens the first suction holes 22b, the insulating gas flows into the compression chamber 30 from the internal space 22a of the movable contact base 22 via the first suction holes 22b. Accordingly, suppression force to the circuit closing operation produced relative to the piston 25a decreases without a pressure reduction of the compression chamber 30.

[0056] In addition, according to the second embodiment, since the internal space 22a of the movable contact base 22 is adopted as a space for supplying the insulating gas into the compression chamber 30, it is easy to ensure the flow volume of the insulating gas into the compression chamber 30. Moreover, adjustment of the flow volume of the insulating gas is facilitated by changing the size of the first suction holes 22b. Consequently, the circuit closing operation can be executed with the minimum energy, a further reduction of a load on the operation mechanism 5 is advanced, and the current breaking time is further reduced.

[Third Embodiment]

(Structure)

[0057] A structure according to a third embodiment will be described with reference to FIGS. 5 and 6. FIG. 5 is a cross-sectional view illustrating a close-circuit state according to the third embodiment, and FIG. 6 is a cross-sectional view illustrating an open-circuit state according to the third embodiment. Note that the same or similar component as that of the first embodiment will be denoted by the same reference numeral, and the duplicated description will be omitted.

[0058] According to the third embodiment, a plurality of second suction holes 25d is formed in the piston 25a. The second suction holes 25d communicates the compression chamber 30 and the suction chamber 31, and suctions the insulating gas into the compression chamber 30 at the time of circuit closing operation like the first suction holes 22b.

[0059] The valve 32 in a ring-plate shape is placed inside the compression chamber 30. The valve 32 has the movable range restricted by a retainer ring 32b that is fixed to the outer circumference of the operation rod 25. The retainer ring 32b is a positioning portion of the valve 32 at the end of the circuit closing operation. Furthermore, the valve 32 has a structure that blocks the second suction holes 25d by pressure difference when the pressure in the compression chamber 30 becomes higher than the pressure in the suction chamber 31.

(Circuit Opening Operation)

[0060] A circuit opening operation according to the third embodiment that employs the above structure will be described through a transition from the close-circuit state illustrated in FIG. 5 to the open-circuit state illustrated in FIG. 6. However, as for the same feature as that of the circuit opening operation in the first embodiment, the detailed description will be omitted.

[0061] At the time of the circuit opening operation, the pressure in the compression chamber 30 becomes higher than the pressure in the suction chamber 31 because the piston 25a is driven to the right side in FIG. 5, and the valve 32 blocks the second suction holes 25d. Accordingly, no insulating gas flows into the compression chamber 30 from the suction chamber 31 through the second suction holes 25d, and the insulating gas can be efficiently compressed in the compression chamber 30.

[0062] Accordingly, the low-temperature gas in the compression chamber 30 can be intensively sprayed toward the fixed arcing contact 11 from the compression chamber 30 via the communication hole 25c, the hollow portion 25b, and the ventilation hole 21a. Furthermore, according to the third embodiment, like the first and second embodiments, the internal space of the suction chamber 31 expands, the pressure of the insulating gas becomes lower than the surroundings, and the insulating gas around the arc-resistant metal 24 is taken in the interior of the suction chamber 31 through the clearance 31a.

(Circuit Closing Operation)

[0063] A circuit closing operation according to the third embodiment will be described through a transition from the open-circuit state illustrated in FIG. 6 to the close-circuit state illustrated in FIG. 5. However, as for the same feature as that of the circuit closing operation according to the first embodiment, the detailed description will be omitted.

[0064] At the time of the circuit closing operation, the pressure in the compression chamber 30 becomes lower than the pressure in the suction chamber 31 because the piston 25a is driven to the left side in FIG. 6, and the valve 32 opens the second suction holes 25d. Hence, the insulating gas in the suction chamber 31 flows in the compression chamber 30 via the second suction holes 25d, and the insulating gas in the suction chamber 31 decreases and the insulating gas in the compression chamber 30 increases.

[0065] Accordingly, the pressure in the compression chamber 30 and in the suction chamber 31 can be equalized, and a pressure reduction of the compression chamber 30 and a pressure increase of the suction chamber 31 can be simultaneously suppressed. Consequently, the piston 25a does not become a condition that is difficult to move in the circuit closing operation direction (the leftward direction in FIG. 6). The valve 32 abuts the retainer ring 32b at the end of the circuit closing operation, and the valve 32 is positioned.

(Action and Effect)

[0066] According to the third embodiment, the action and effect similar to those of the first and second embodiments can be achieved, and furthermore, not only the pressure reduction of the compression chamber 30 but also the pressure increase of the suction chamber 31 can be suppressed at the time of circuit closing operation. Hence, in the circuit closing operation, the suppression force to the circuit closing operation produced at the piston 25a can be surely reduced, and the circuit closing operation can be executed by a further smaller energy. Accordingly, a reduction of load on the operation mechanism 5 can be further advanced, and the current breaking time can be efficiently reduced.

[Fourth Embodiment]

(Structure)

[0067] A structure according to a fourth embodiment will be described with reference to FIGS. 7 and 8. FIG. 7 is a cross-sectional view illustrating a close-circuit state according to the fourth embodiment, and FIG. 8 is a cross-sectional view illustrating an open-circuit state according to the fourth embodiment. Note that the same or similar component as that of the first embodiment will be denoted by the same reference numeral, and the duplicated description will be omitted.

[0068] The fourth embodiment is a modified example relating to the ventilation hole 21a of the movable contact 21 illustrated in FIGS. 1 and 2. A ventilation hole 21b is formed to increase the flow-channel cross-sectional area for the insulating gas from a portion connected to the hollow portion 25b of the actuation rod 25 toward the end surface of the movable contact 21. That is, the ventilation hole 21b increases the flow-channel cross-sectional area from the portion in communication with the hollow portion 25b toward the portion where the low-temperature gas is sprayed. In to the fourth embodiment, the number of ventilation holes 21b is one.

(Action and Effect)

[0069] According to the above fourth embodiment, in addition to the action and effect similar to those of the first embodiment, the following unique action and effect are achieved. That is, also in the fourth embodiment, the low-temperature gas compressed in the compression chamber 30 at the time of circuit opening operation is sprayed from the ventilation hole 21a via the communication hole 25c and the hollow portion 25b.

[0070] At this time, the ventilation hole 21b has the flow-channel cross-sectional area that increases from the portion in communication with the hollow portion 25b toward the spray portion to the fixed arcing contact 11. Hence, the low-temperature gas that passes through the ventilation hole 21b increases the flow velocity when sprayed to the thermal gas. Accordingly, the thermal gas can be more efficiently cooled, and diffused. Consequently, a further better insulation performance relative to the transient recovery voltage after current breaking can be obtained.

[Other Embodiments]

[0071] Several embodiments of the present disclosure have been described, but those embodiments are merely presented as examples, and are not intended to limit the scope of the present disclosure. Those embodiments can be carried out in other various forms, and various omissions, replacements, and modifications can be made without departing from the scope of the present disclosure. Such embodiments and modified forms thereof are within the scope of the present disclosure, and also within the scope of the invention as recited in appended claims and equivalent range thereto.

[0072] For example, the shape and dimension of the clearance 31a that is formed along the outer circumference of the movable contact 21, the shape and dimension of the movable contact 21, the number, shape, and dimension of the ventilation hole 21a formed in the movable contact 21, and the number, shape, and dimension of the hollow portion 25b and the communication hole 25c formed in the operation rod 25, etc., can be selected as appropriate, and by simply adjusting the flow volume of the low-temperature gas to be sprayed toward the space where the arc 40 is produced, diffusion and cooling of the thermal gas due to the arc 40 can be efficiently executed. Moreover, in the end surface of the movable contact base 22 and the slide packing 27, the size of the area that covers the communication hole 25c at the end of the circuit opening operation can be changed as appropriate as long as braking of the operation rod 25 and the movable contact 21 is achievable.

REFERENCE SIGNS LIST

[0073]

1	Gas-insulated switchgear
2	Pressure chamber
3	Movable shaft
5	Operation mechanism
10	Fixed contact unit
11	Fixed arcing contact
12	Fixed conductive contact
13	Fixed contact base
13a	Cylindrical portion
14	Fixed shield
14a, 23a	Opening
15, 24	Arc-resistant metal
17	Slit
20	Movable contact unit
21	Movable contact
21a, 21b	Ventilation hole
22	Movable contact base
22a	Internal space
22b	First suction hole
22c	Holder hole
22d	Flange
22e	Gas flow volume limiting portion
23	Movable shield
25	operation rod
25a	Piston
25b	Hollow portion
25c	Communication hole
25d	Second suction hole
26	Collecting contactor
27, 28	Slide packing
30	Compression chamber
31	Suction chamber

31a, 33, 34	Clearance
32	Valve
32a	Groove
32b	Retainer ring
40	Arc

Claims

1. A gas-insulated switchgear comprising:

   a pressure chamber in which an insulating gas is gas-tightly filled;
   a fixed contact base and a movable contact base placed in the pressure chamber so as to face with each other;
   a fixed arcing contact fixed to the fixed contact base;
   a fixed shield fixed to the fixed contact base so as to surround the fixed arcing contact;
   a fixed conductive contact placed at the fixed shield;
   a movable contact placed so as to face the fixed conductive contact and to be freely movable;
   a movable shield fixed to the movable contact base so as to surround the movable contact;
   an operation rod which is connected to the movable contact and to which a piston is fixed; and
   an operation mechanism that reciprocates the operation rod so as to move the movable contact to be apart or in contact relative to the fixed arcing contact and the fixed conductive contact, wherein:

   inside the movable shield, with the piston of the operation rod being a partition wall, a compression chamber and a suction chamber are formed at a movable-contact-base side and at the movable-contact side, respectively;
   the operation rod is provided with a hollow portion, and a communication hole that communicates the hollow portion and the compression chamber;
   the movable contact is provided with a ventilation hole that passes completely through from an end surface of the movable contact to the hollow portion of the operation rod;
   the compression chamber compresses the insulating gas therein by a movement of the piston associated with a movement of the operation rod at a time of circuit opening operation, and sprays the insulating gas to an arc produced between the fixed arcing contact and the movable contact via the communication hole, the hollow portion, and the ventilation hole;
   a clearance is provided between an outer circumference of the movable contact and an inner circumference of the movable shield; and
   the suction chamber reduces an internal pressure by expanding an internal space by a movement of the piston associated with a movement of the operation rod at a time of circuit opening operation, and suctions the high-temperature insulating gas heated by the arc into the internal space through the clearance.

2. The gas-insulated switchgear according to claim 1, wherein:

   a first suction hole to suction the insulating gas into the compression chamber at the time of circuit closing operation is formed in an end surface of the movable contact base facing with the compression chamber; and
   a valve which blocks the first suction hole at the time of circuit opening operation and which opens the first suction hole at the time of circuit closing operation is attached to the first suction hole.

3. The gas-insulated switchgear according to claim 1 or 2, wherein:

   a second suction hole which communicates the suction chamber and the compression chamber, and which is to suction the insulating gas in the suction chamber into the compression chamber at the time of circuit closing operation is formed in the piston; and
   a valve which block the second suction hole at the time of circuit opening operation and which opens the second suction hole at the time of circuit closing operation is attached to the second suction hole.

4. The gas-insulated switchgear according to claim 2 or 3, wherein the valve is placed in the compression chamber.

5. The gas-insulated switchgear according to any one of claims 2 to 4, further comprising a valve positioning portion that positions the valve at an end of the circuit closing operation.

6. The gas-insulated switchgear according to any one of claims 1 to 5, wherein the ventilation hole is formed so as to increase a flow-channel cross-sectional area for the insulating gas from a portion connected to the hollow portion of the operation rod toward an end surface of the movable contact.

7. The gas-insulated switchgear according to any one

of claims 1 to 6, wherein a plurality of the ventilation holes is formed.

8. The gas-insulated switchgear according to any one of claims 1 to 7, wherein at least either the fixed arcing contact or the fixed conductor contactor is pushed toward the movable contact.

9. The gas-insulated switchgear according to any one of claims 1 to 7, wherein a gas flow volume limiting portion which covers at least a part of the communication hole at an end of the circuit opening operation is provided at an end surface of the movable contact base.

10. The gas-insulated switchgear according to any one of claims 1 to 9, further comprising a slide packing placed so as to contact an inner circumference of the movable contact base and an outer circumference of the operation rod,
wherein the slide packing is configured to block a part of the communication hole of the operation rod at an end of the circuit opening operation.

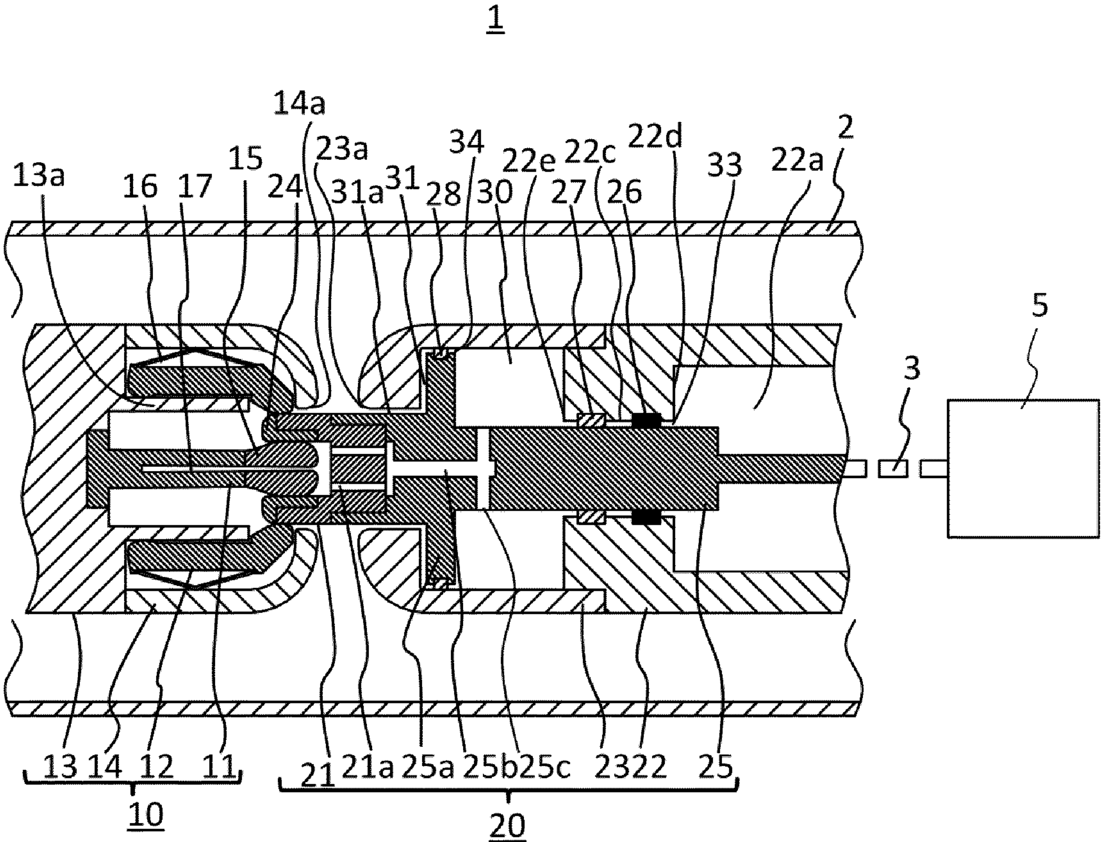
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FIG. 1

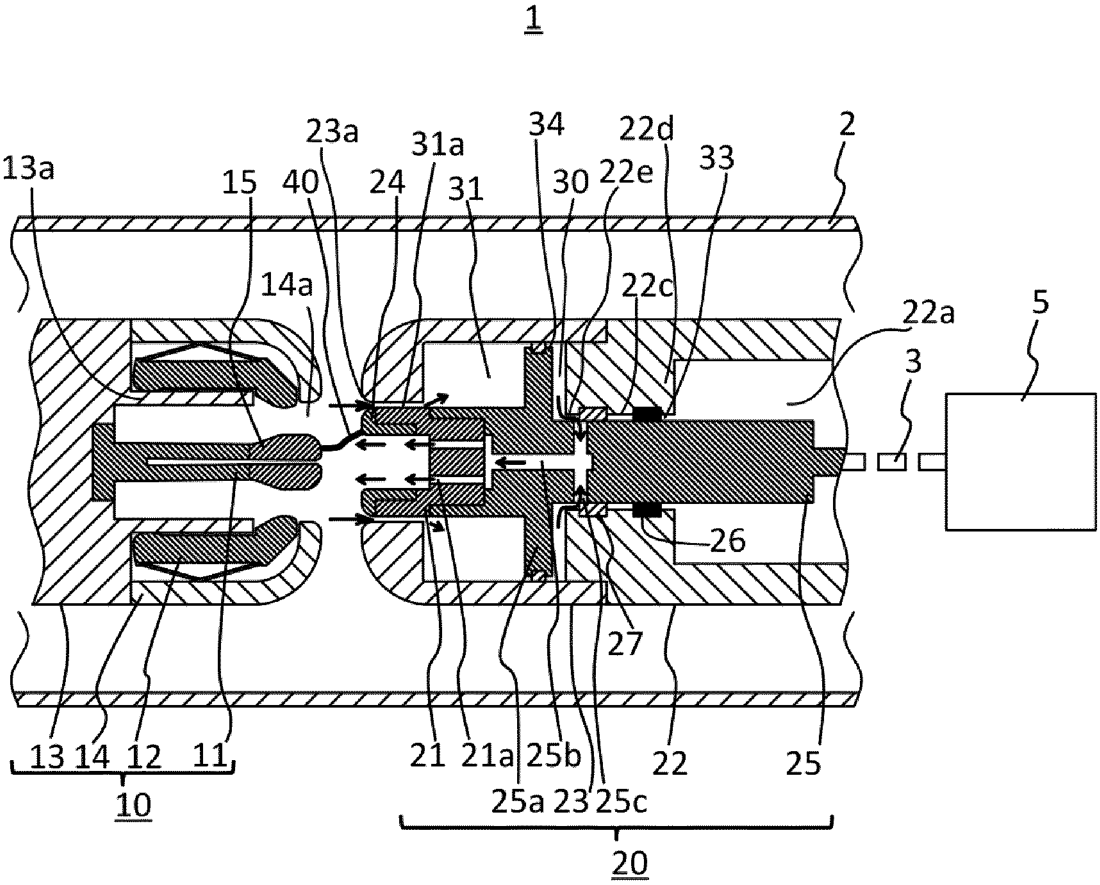
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FIG. 2

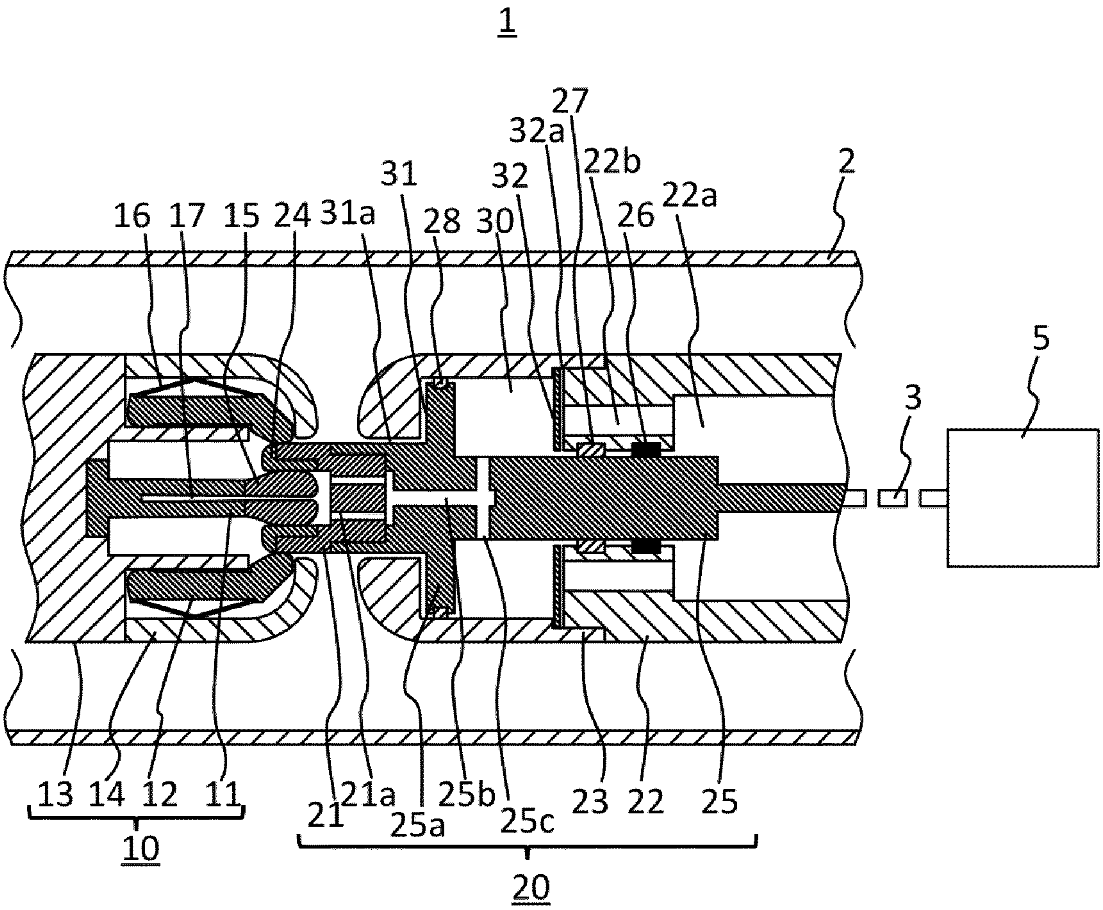
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FIG. 3

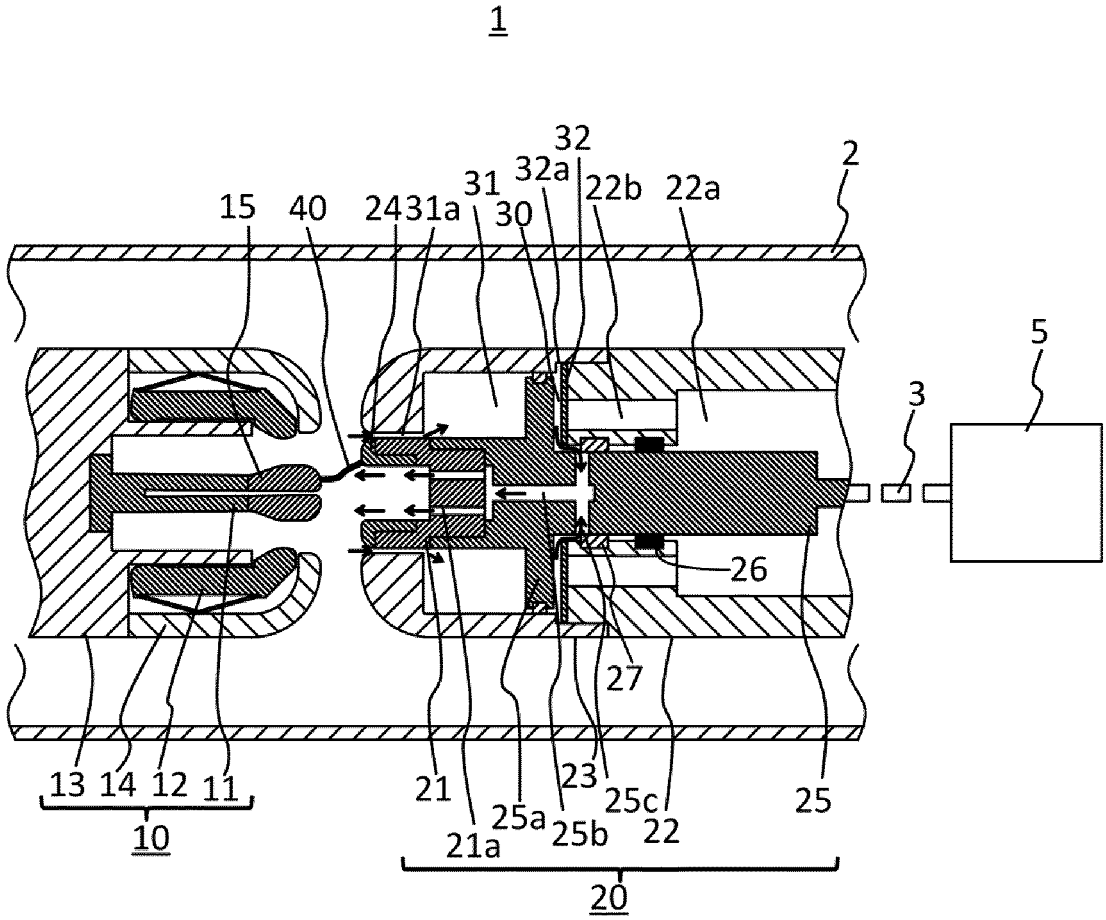
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FIG. 4

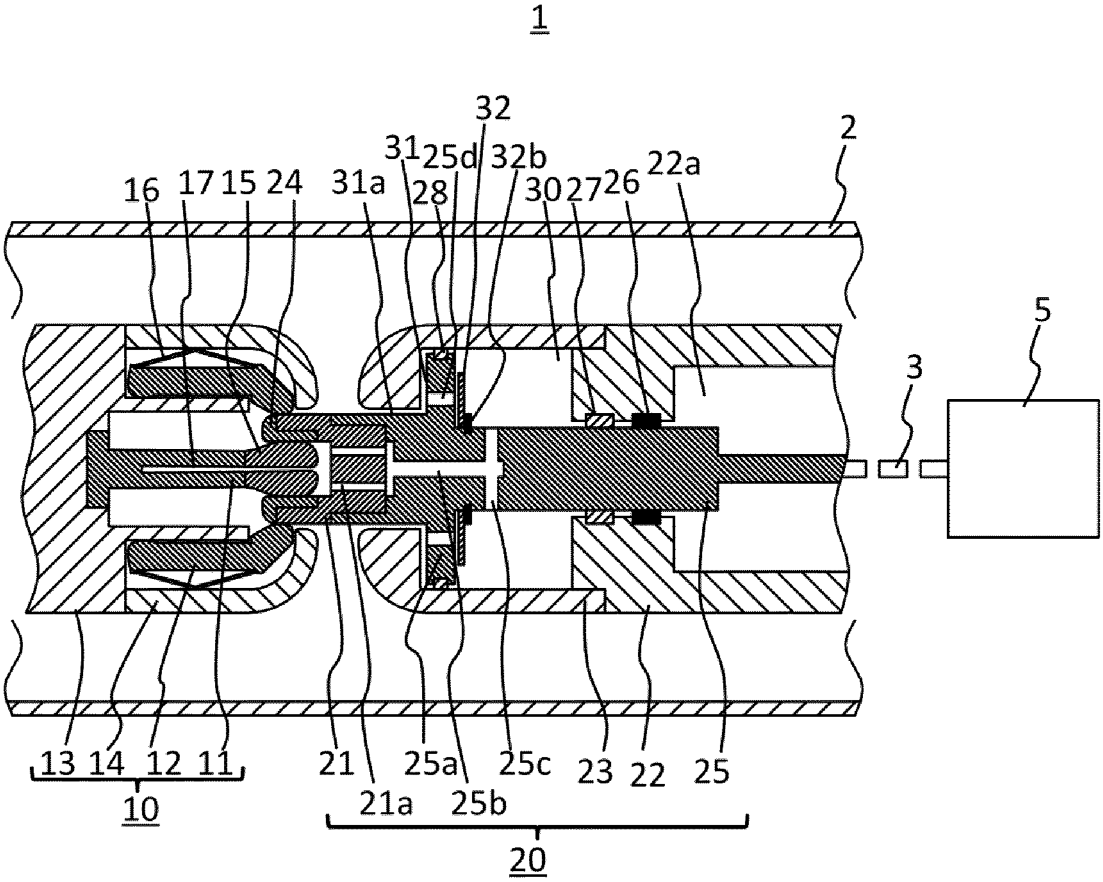
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FIG. 5

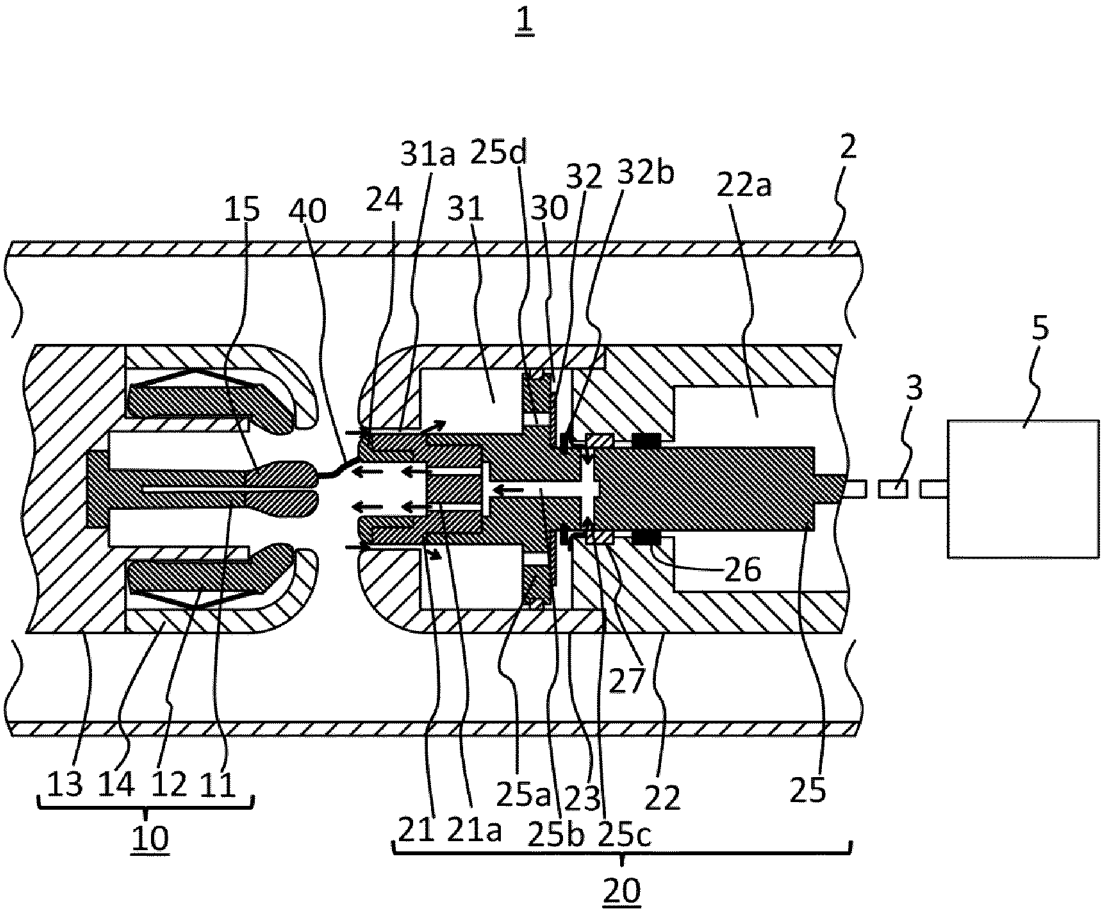
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FIG. 6

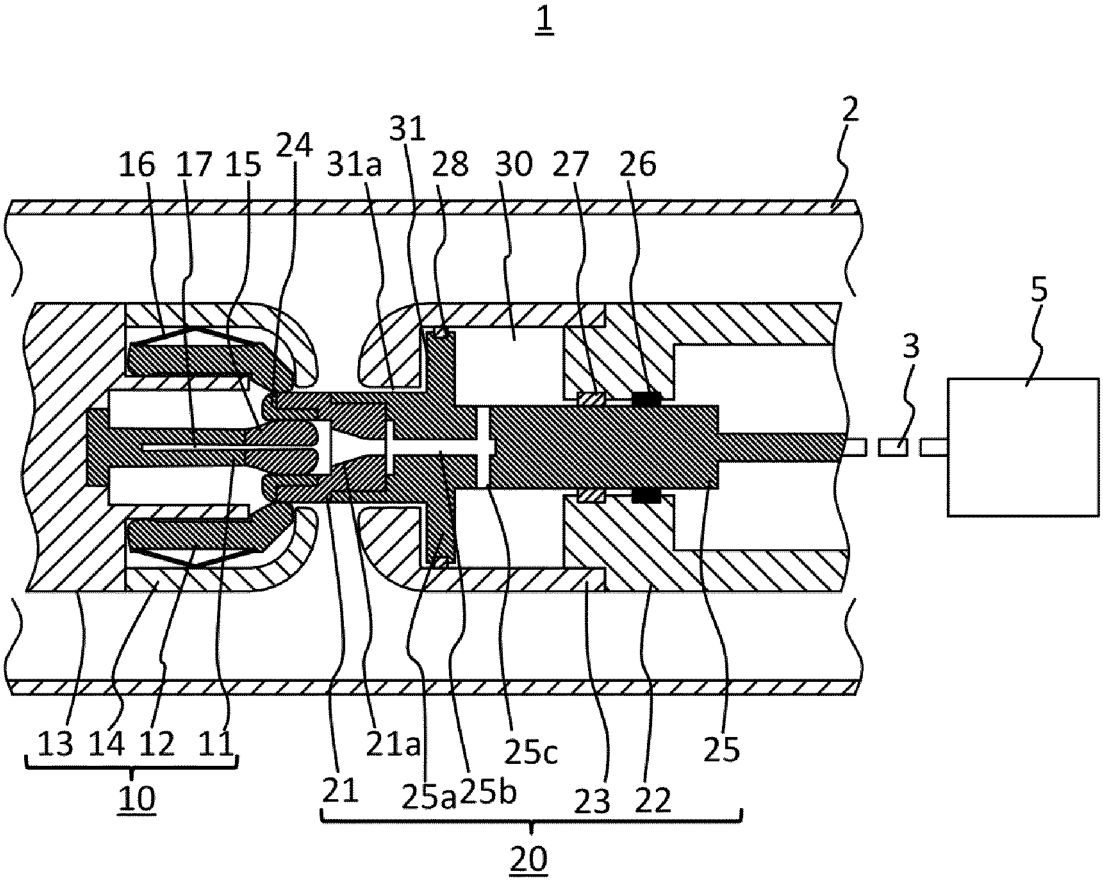
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FIG. 7

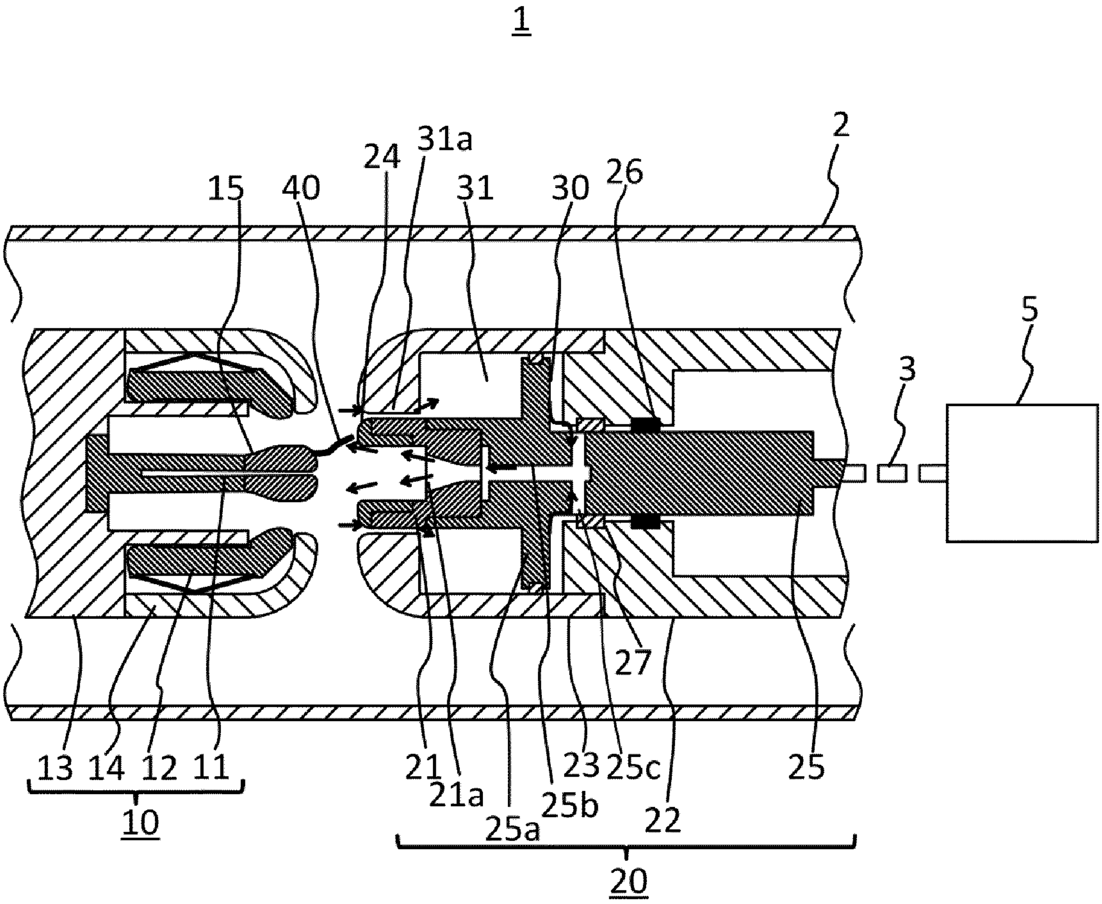
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FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/087587

A. CLASSIFICATION OF SUBJECT MATTER
H01H33/04(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01H33/04, H01H33/06, H01H33/91, H01H33/915

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	1996-2017
Kokai Jitsuyo Shinan Koho	1971-2017	Toroku Jitsuyo Shinan Koho	1994-2017

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 58-100326 A (Tokyo Shibaura Electric Co., Ltd.), 15 June 1983 (15.06.1983), page 1, lower right column to page 5, upper right column; fig. 1 to 10 (Family: none)	1,7,8 2-6,9,10
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 094129/1988(Laid-open No. 014741/1990) (Nissin Electric Co., Ltd.), 30 January 1990 (30.01.1990), pages 1 to 10; fig. 1 to 2 (Family: none)	1,7,8

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

* Special categories of cited documents:
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"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
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 March 2017 (27.03.17)	04 April 2017 (04.04.17)

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

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

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2016/087587

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 106158/1991(Laid-open No. 053094/1993) (Toshiba Corp.), 13 July 1993 (13.07.1993), paragraphs [0001] to [0027]; fig. 1 to 6 (Family: none)	1,7,8
Y	WO 2012/093507 A1 (Mitsubishi Electric Corp.), 12 July 2012 (12.07.2012), paragraphs [0056] to [0063]; fig. 19 to 20 & JP 5389279 B2 & US 2013/0270228 A1 paragraphs [0074] to [0081]; fig. 19 to 20 & EP 2662877 A1 & CN 103201809 A	1,7,8
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 156589/1988(Laid-open No. 077830/1990) (Takaoka Electric Mfg. Co., Ltd.), 14 June 1990 (14.06.1990), pages 1 to 8; fig. 1 to 2 (Family: none)	1-10
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 025103/1990(Laid-open No. 116638/1991) (Takaoka Electric Mfg. Co., Ltd.), 03 December 1991 (03.12.1991), pages 1 to 7; fig. 1 to 3 (Family: none)	1-10

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

REFERENCES CITED IN THE DESCRIPTION

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