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(54) **Vacuum switchgear**

(57) The vacuum switchgear comprises a vacuum interrupter from which the seal is put on to both ends of insulation container where the insulation medium is enclosed airtight with the first and second metallic material, in which the vacuum interrupter has fixed electrode which penetrates through the first metallic material and clings the first metallic material, and movable electrode which penetrates the through the second metallic material, is fixed the second metallic material through bellows, and is provided to oppose to the fixed electrode; and operation mechanism which moves the movable electrode along a straight line at three positions of a close position, an open position, and an isolation position.

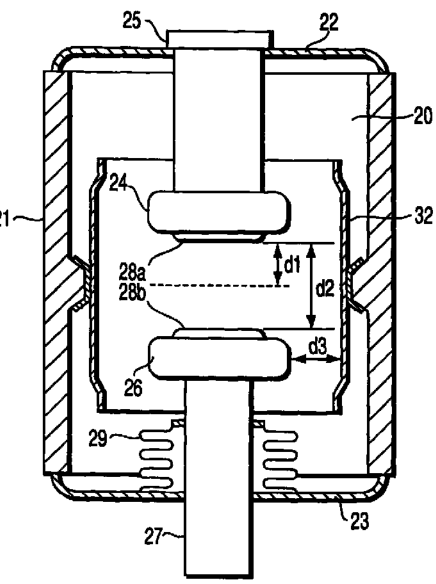

FIG. 2

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Description

[0001] The present invention relates to a vacuum switchgear which uses SF_6 gas as an insulation medium, especially, relates to a vacuum switchgear which controls use amount of the insulation medium such as SF_6 gas and harmonizes with the environment.

[0002] An example of the special high transformation of electrical energy equipment of 22/33 kV and 66/77 kV class will be explained about the conventional switchgear.

[0003] The miniaturization and sealing are requested to the switchgear of this class to solve disadvantage of the charge section stain, safety, and the noise, etc. with the sudden rise of the cost of construction and the site, and gas insulated switchgear (GIS: Gas Insulated Switchgear) and cubicle-type gas insulated switchgear (C-GIS: Cubicle-type GIS)) have been developed.

[0004] In GIS, each electric equipment is covered by a pipe-shaped metallic container, SF_6 gas of the high pressure is enclosed as an insulation medium to be miniaturized and sealed up.

[0005] On the other hand, C-GIS is switchgear developed to correspond to requests of higher reliability, safety, and simplifying maintenance than GIS, and, at the same time, capable of constructing it on a narrow site in a short term, and making the harmony with the environment with surroundings.

[0006] This C-GIS stores each electric equipment in the lump in the container of the cubicle-type in which the low-pressure insulation gas near the atmospheric pressure is used, and the inside thereof is divided into the configuration units, and has same aspect as other close switchboards.

[0007] Thus, recently, a lot of switchgears using SF_6 gas as an insulation medium have been operated.

[0008] FIG. 1 is a vertical sectional view which shows an example of the configuration of this kind of typical cubicle-type gas insulation switchgear.

[0009] In FIG. 1, SF_6 gas 2 is sealed up in box 1 whose circumference is surrounded to airtight by the mild steel plate. Box 1 is gas-divided into receipt room 1a, breaker room 1b, and generatrix room 1c.

[0010] In receipt room 1a, cable head 3 is provided to the side in box 1. Arrestor 4 and detection insulator 5 stored in receipt room 1a are connected via connection conductor 7. The power cable which penetrates through current transformer 8 is connected with cable 9.

[0011] Breaker room 1b stores breaker 11 which stores the vacuum interrupter (not shown in the figure) through insulation spacer 10a in the lower stage gas-divided from receipt room 1a. This breaker 11 is connected with insulation spacer 10b in the upper stage gas-divided from generatrix room 1c through connection conductor 7.

[0012] A high vacuum is used as insulation and arc-quenching medium for breaker 11. SF_6 gas is used as insulation and arc-quenching medium for isolation machine 6.

[0013] The solenoid mechanism, which is called a stable type comprising a permanent magnet besides an electromagnet and a movable core, has the function to hold the position by the adsorption power of a permanent magnet on the operation edge of a movable core. The solenoid mechanism of this stable type includes the mechanism which is called as a monostable type where the position is held by the part section within the range of the operation of a movable core and the mechanism which is called as a bistable type where the position is held at both ends within the range of the operation of a movable core.

[0014] Since the movable core adsorbed by the magnet is stably held to the limit of the adsorption power, a mechanism in which the solenoid mechanism is used as an operation mechanism of the vacuum breaker has been proposed.

[0015] It is preferable that the solenoid mechanism used for the operation mechanism of the vacuum breaker is a stable type in which the electromagnet can hold the position of the electrode even in the state of non-excitation. This solenoid mechanism has few number of components and easy structure, and operates along only the straight line. Therefore, since the part of generating a large stress is caused and sliding with large contact pressure is a little, it has the merit of securing reliability easily.

[0016] By the way, SF_6 gas is used as insulation and arc-quenching medium in the switchgear of such a configuration as for isolation machine 6. It is known that this SF_6 gas has about three times the arc-quenching performance and about 100 times the insulation performances compared with air. In addition, this SF_6 gas is a very stable gas of colorlessness, scentless, taste, nonflammability in a usual state of the operation, and is nontoxic.

[0017] However, when the arc electrical discharge is generated in this SF_6 gas, the decomposition products such as SOF_2, SO_2, SO_2F_2, SOF_4, HF, and SiF_4 and the decomposition gases are generated by SF_6 gas. Since the decomposition product and the decomposition gas of this SF_6 gas have strong toxicity, special processing and the management are required when the decomposing gas is collected.

[0018] There is no fear of generating the decomposition product and the decomposition gas since the insulation of the accident current etc. is performed by breaker 11. However, the generatrix switch and the line switch in the substation are performed by isolator 6.

[0019] Therefore, the insulation obligation of the loop current is requested to isolator 6. This loop current becomes a current value close to the ratings current, and in this case, the decomposition products and the decomposition gases are generated by isolator 6. It is anxious to handling though the method of the collection etc. through the adsorption material is adopted when the gas of such an isolator is collected.

[0020] SF_6 gas is a greenhouse gas which causes earth warming, and the greenhouse effect coefficient is 24000 times larger than carbon dioxide. Therefore, SF_6 gas is added as a reduction target gas, and the action of control and reduction in the exhaust is requested. It is preferable not to use SF_6 gas as insulation and the arc-quenching medium of the isolator from respect of such an environment.

[0021] Then, the vacuum isolator whose insulation medium is a vacuum can be considered. However, there is a problem that the cost of switchgear rises.

[0022] In addition, in the switchgear shown in FIG. 1, the temperature increase of connection conductor 7 by heat from the contact of breaker 11 and isolator 6 becomes a disadvantage. Since heat from the contact of such breaker 11 and isolator 6 is generated by a Joule heat by the contact resistance in this part, some measures to lower the contact resistance are needed.

[0023] On the other hand, to solve such a problem, the following vacuum switchgear is described in, for example, Japanese Application KOKAI Publication No. 9-153320. This vacuum switchgear has a fixed electrode and a ground electrode at both ends of the criss-cross vacuum interrupter, and has a conducting axis and a movable electrode, which makes an orthogonal position to this a fulcrum.

[0024] However, in this vacuum switchgear, since the configuration of the vacuum interrupter is complex, the component increases, and the cost of the vacuum interrupter rises very much. Since the configuration is complex, the build of the vacuum interrupter is not easy, then, the vacuum interrupter with high reliability can not be obtained. In addition, since a movable axis moves in the circumferential direction through the bellows, the load in an excessive bend direction is applied to the bellows, thereby it misses to intensity long-term reliability. Therefore, the vacuum leakage of the vacuum interrupter is caused. In addition, in a short time current examination to suppress the repulsion of a movable electrode by electromagnetic power, the load is applied with the spring usually, but there is a problem of hardly applying such a load with the vacuum interrupter of such a configuration.

[0025] The achievement of switchgear which does not use SF_6 gas becomes difficult from the above-mentioned reason.

[0026] From respect of the operation mechanism, the position of a movable core can be held only by the end portion within the range of the operation in the solenoid mechanism, and it is impossible to hold it stably at an intermediate position. Therefore, the electrode cannot be stably held in three positions of a close position (position where contact of movable electrode contacting with contact of fixed electrode), an open position and an isolation position, in addition, or four positions further including a ground position.

[0027] In addition, since the adsorption power with the magnet is largely influenced by the gap between a magnet and a magnetic body, the adsorption power rapidly becomes small when the gap extends. Therefore, it is difficult to achieve an enough stroke necessary to hold three positions and four positions. To make the stroke large, there is a disadvantage in which it becomes necessary to make the magnetism of an electromagnet and a permanent magnet considerably large and the enlargement of the device and the large current drive of the electromagnet are required.

[0028] An object of the present invention is to provide a vacuum switchgear which comprises the vacuum interrupter with simple configuration and high reliability and the operation mechanism with high reliability to be able to achieve three positions of the close position, the open position and the isolation position, or four positions further including the ground position, and controls use amount of the insulation medium of SF_6 gas etc.

(1) The vacuum switchgear according to the present invention is characterized by comprising: a vacuum interrupter from which the seal is put on to both ends of insulation container where the insulation medium is enclosed airtight with the first and second metallic material, in which the vacuum interrupter has fixed electrode which penetrates through the first metallic material and clings the first metallic material, and movable electrode which penetrates the through the second metallic material, is fixed the second metallic material through bellows, and is provided to oppose to the fixed electrode; and an operation mechanism which moves the movable electrode along a straight line at three positions of a close position, an open position, and an isolation position.

Since a movable electrode in the vacuum interrupter main body moves to the open position, operates as the contact of the breaker, in addition, a movable electrode further moves to the isolation position, and operates as the contact of the isolator, by penetrating through a metallic material into the sealed vacuum interrupter main body with airtight, one end thereof is arranged so that a fixed electrode is opposed to a movable electrode to movable pair of a conducting axis in an axial direction through bellows, the position where the contact of a movable electrode contacts with the contact of a fixed electrode is to be the close position, and the movable electrode continuously moves along the straight line at three positions of the close position, the open position, and the isolation position, the isolator contact can be stored in the vacuum interrupter main body for the breaker.

(2) Another vacuum switchgear of the present invention is characterized by comprising: a vacuum interrupter from which the seal is put on to both ends of insulation container where the insulation medium is enclosed airtight with the first and sec-

ond metallic material, said vacuum interrupter having a fixed electrode which penetrates through said first metallic material and clings said first metallic material, a movable electrode which penetrates through said second metallic material and clings to said second metallic material through bellows and is provided to oppose said fixed electrode, and a ground electrode provided on anti-fixed electrode side of said movable electrode; and an operation mechanism which moves said movable electrode along a straight line at four positions of a close position, an open position, an isolation position, and a ground position.

Since the ground electrode is provided at the position opposed to the conducting axis connected with a movable electrode in the above-mentioned vacuum interrupter main body, the inside diameter of the ground electrode opposed to the conducting axis is smaller than the outside diameter of a movable electrode, the ground electrode and the insulation cylinder are arranged respectively between metallic end plates at both ends, the position where a movable electrode contacts with a fixed electrode is to be the close position, and the movable electrode continuously moves along the straight line at four positions of the close position, the open position, the isolation position, and the ground position, the contact for the isolator and the contact for the ground device can be stored in the vacuum interrupter main body for the breaker.

(3) When a gap length between contacts at the open position is assumed to be d_1 and a gap length between movable electrode and the fixed electrode at the isolation position is assumed to be d_2, each of the gap lengths d_1 and d_2 is set to satisfy a relationship of: $d_2 = (1.3 \text{ to } 2.6) \cdot d_1$.

Since, when a gap length between contacts at the open position is assumed to be d_1 and a gap length between movable electrode and the fixed electrode at the isolation position is assumed to be d_2, each of the gap lengths d_1 and d_2 is set to satisfy a relationship of: $d_2 = (1.3 \text{ to } 2.6) \cdot d_1$, the dielectric breakdown probability between contacts at the isolation position lowers to become possible to cooperate about the insulation of an isolation position and the open position.

(4) An arc shield provided to surround the fixed electrode and the movable electrode is further provided, and when each of a gap length between the arc shield and the fixed electrode and a gap length between the arc shield movable electrode is assumed to be d_3 and a gap length between contacts at the isolation position is assumed to be d_2, each of the gap lengths d_2 and d_3 is set to satisfy a relationship of: $d_3 = (0.35 \text{ to } 0.8) \cdot d_2$.

Since an arc shield provided to surround the fixed electrode and the movable electrode is further provided, and when each of a gap length between the arc shield and the fixed electrode and a gap length between the arc shield movable electrode is assumed to be d_3 and a gap length between contacts at the isolation position is assumed to be d_2, each of the gap lengths d_2 and d_3 is set to satisfy a relationship of: $d_3 = (0.35 \text{ to } 0.8) \cdot d_2$, the best position of the arc shield from the insulation can be determined and the electric field intensity of the movable electrode and the fixed electrode can be decreased.

(5) A second shield surrounding the fixed electrode and a third shield surrounding the movable electrode, each of which is provided in the arc shield, and the second shield and the third shield are supported and fixed to the first and second metallic material.

Since a second shield surrounding the fixed electrode and a third shield surrounding the movable electrode, each of which is provided in the arc shield, and the second shield and the third shield are supported and fixed to the first and second metallic material, the electric field intensity of movable and fixed side contacts, and a movable electrode and a fixed electrode can be decreased.

(6) The second shield is supported and fixed to a conducting axis connected with the fixed electrode.

Since the second shield is supported and fixed to a conducting axis connected with the fixed electrode, the electric field intensity of movable and fixed side contacts, and a movable electrode and a fixed electrode can be decreased, and the electric field intensity on the upper end of the arc shield can be decreased.

(7) The second shield is supported and fixed to the fixed electrode.

Since the second shield is supported and fixed to the fixed electrode, the electric field intensity of movable and fixed side contacts, and a movable electrode and a fixed electrode can be decreased and the electric field intensity on the upper end of the arc shield can be decreased.

(8) when a gap length between the second shield and the third shield is assumed to be d_4 and a gap length between the contacts at the isolation position is assumed to be d_2, each of the gap lengths d_2 and d_4 is set to satisfy a relationship of: $d_4 = (0.6 \text{ to } 0.95) \cdot d_2$.

When a gap length between the second shield and the third shield is assumed to be d_4 and a gap length between the contacts at the isolation position is assumed to be d_2, since each of the gap lengths d_2 and d_4 is set to satisfy a relationship of: $d_4 = (0.6 \text{ to } 0.95) \cdot d_2$, the electric field intensity of movable and fixed side contacts, and a movable electrode and a fixed electrode can be decreased and the electric field intensity of these sections can be optimized.

(9) The second shield and the third shield are made

of stainless steel.

(10) The second shield and the third shield are made of tungsten.

Since the second shield and the third shield are made of tungsten, the electric field intensity of movable and fixed side contacts, and a movable electrode and a fixed electrode can be decreased and the insulation performance of the second shield and the third shield can be improved.

(11) Surfaces of the second shield and the third shield are processed by the electrochemical buffing processing.

(12) A reforming layer is provided by an irradiation of an electron beam on surfaces of the second shield and the third shield.

Since surfaces of the second shield and the third shield is processed by electrochemical buffing processing or electron beam processing, the electric field intensity of movable and fixed side contacts, and a movable electrode and a fixed electrode can be decreased and the insulation performance of the second shield and the third shield can be improved.

(13) When the gap length between the conducting axis to which the movable electrode clings and ground electrodes opposed to this is to be d_5 and the gap length between the open position contacts is to be d_1, each of gap lengths d_1 and d_5 is set to satisfy a relationship of: $d_5 = (1.3 \text{ to } 1.8) \cdot d_1$.

When the gap length between the conducting axis to which the movable electrode clings and ground electrodes opposed to this is to be d_5 and the gap length between the open position contacts is to be d_1, since each of gap lengths d_1 and d_5 is set to satisfy a relationship of: $d_5 = (1.3 \text{ to } 1.8) \cdot d_1$, it is possible to cooperate about the insulation between contacts at the open position of movable side contact and the insulation of the ground device, and reliability can be improved.

(14) The operation mechanism has insulation mechanism section and isolation mechanism section, each of which is arranged in series and moves in straight line between two positions, movable section of the insulation mechanism section is connected with the movable electrode and performs an open and close operation of the gap length d_1, and a frame of the insulation mechanism section is connected with a movable section of the isolation mechanism section and the isolation mechanism section performs an open and close operation from the gap length d_1 to gap length d_2.

Since the insulation mechanism section to perform the open and close operation from the close position to the open position in which a high-speed operation is required and the isolation mechanism section to perform the open and close operation from the open position to the isolation position in which a high-speed operation is not required are arranged in series, the open and close operation at three positions can surely be achieved with a cheap operation mechanism.

(15) The operation mechanism has insulation mechanism section which is arranged in series and moves between two positions in a the straight line and has isolation mechanism section which moves along the straight line with three positions including an intermediate point, a movable section of the insulation mechanism section is connected with the movable electrode and performs an open and close operation of the gap length d_1, and a frame of the insulation mechanism section is connected with a movable section of the isolation mechanism section and the isolation mechanism section performs open and close operations in two stages from the gap length d_1 to gap length d_2 and from the gap length d_2 to the gap length d_3.

Since the insulation mechanism section to perform the open and close operation from the close position to the open position in which a high-speed operation is required and the isolation mechanism section, which is arranged to the insulation mechanism section, performing the operation of two stages of the open and close operation from the open position to the isolation position and the open and close operation from the isolation position to the ground position in which a high-speed operation is not required, the open and close operation at four positions can surely be achieved with a cheap operation mechanism.

(16) The operation mechanism is arranged in series and has an insulation mechanism section, isolation mechanism section, and ground mechanism section, each of which moves between two positions along a straight line, a movable section of the insulation mechanism section is connected with the movable electrode and performs an open and close operation of the gap length d_1, a frame of the insulation mechanism section is connected with a movable section of the isolation mechanism section and the isolation mechanism section performs an open and close operation from the gap length d_1 to the gap length d_2, and a frame of the isolation mechanism section is connected with a movable section of the ground mechanism section, and the ground mechanism section performs an open and close operation from the gap length d_2 to the gap length d_3.

Since the insulation mechanism section to perform the open and close operation from the close position to the open position in which a high-speed operation is required, the isolation mechanism section to perform the open and close operation from the open position to the isolation position in which a high-speed operation is not required and the ground mechanism section performing the open and close operation from the isolation position to the ground position are arranged in series, the open and close operation at four positions can surely be achieved with a cheap operation mechanism.

(17) Each of the insulation mechanism section and the isolation mechanism section is constructed by the solenoid mechanism which comprises an electromagnetic coil, a york, a movable core, and a permanent magnet or the solenoid mechanism which further comprises the spring if necessary, a movable section of the insulation mechanism section is a movable core of the first solenoid mechanism, the frame of the insulation mechanism section is a york of the first solenoid mechanism, a movable section of the isolation mechanism section is a movable core of the second solenoid mechanism, and the frame of the isolation mechanism section is a york of the second solenoid mechanism, and each of the movable cores performs shuttling operation by magnetism of the electromagnetic coil and permanent magnet or, further by the restoration power of the spring if necessary and, in both ends within the range of the operation of a the movable core, holds the position by adsorption power of the permanent magnet or, further by the restoration power of a the spring if necessary.

Since the insulation mechanism section with a small weight in a movable part performs the open and close operation of the close position and the open position with high speed and stably holds each position, and the isolation mechanism section surely performs the open and close operation of the open position and the isolation position and stably holds each position, the open and close operation can surely be achieved with a cheap operation mechanism.

(18) The insulation mechanism section is constructed by solenoid mechanism which comprises electromagnetic coil, york, movable core, and permanent magnet, or, the solenoid mechanism which further comprises the spring if necessary, a movable section of the insulation mechanism section is a movable core of the solenoid mechanism, and the frame of the insulation mechanism section is the york, the movable core performs the shuttling operation by magnetism of the electromagnetic coil and permanent magnet, or, further by the restoration power of the spring, if necessary, and, in both ends within the range of the operation of the movable core, and the position is held by adsorption power of the permanent magnet or further by restoration power of the spring if necessary, the isolation mechanism section is an electromagnetic actuator which comprises a movable core and a permanent magnet, in which the salient is formed, to oppose to the salient of a york and the york with which an electromagnetic coil and the salient are formed, and a movable section of the isolation mechanism section is a movable core of the electromagnetic actuator, the frame of the isolation mechanism section is a york of the electromagnetic actuator, and the movable core performs the shuttling operation by the magnetism of the electromagnetic coil and a permanent magnet and holds the position by the adsorption power of the permanent magnet, and in both ends within the range of the operation of the movable core, and holds the position by the magnetism of the permanent magnet by opposing the salient of the york to the salient of the movable core at an intermediate position within the range of the operation.

Since the insulation mechanism section with a small weight in a movable part performs the open and close operation of the close position and the open position with high speed and stably holds each position, the isolation mechanism section surely performs the open and close operation of the open position and the isolation position and stably holds each position, and the ground mechanism section surely performs the open and close operation of the isolation position and the ground position and stably holds each position, the open and close operation can surely be achieved with a cheap operation mechanism.

(19) The insulation mechanism section, the isolation mechanism section, and ground mechanism section are respectively constructed by a solenoid mechanism which comprises an electromagnetic coil, a york, a movable core, and a permanent magnet, or are constructed by a solenoid mechanism which further comprises the spring if necessary, a movable section of the insulation mechanism section is a movable core of the first solenoid mechanism, the frame of the insulation mechanism section is a york of the first solenoid mechanism, a movable section of the isolation mechanism section is a movable core of the second solenoid mechanism, the frame of the isolation mechanism section is a york of the second solenoid mechanism, a movable section of the ground mechanism is a movable core of the third solenoid mechanism, and the frame of the ground mechanism section is a york of the third solenoid mechanism, and each of the movable cores performs the shuttling operation by magnetism of the electromagnetic coil and permanent magnet, and further by the restoration power of the spring, if necessary, and, in both ends within the range of the operation of the movable core, holding the position by the adsorption power of the permanent magnet or further by the restoration power of the spring if necessary.

Since the insulation mechanism section with a small weight in a movable part performs the open and close operation of the close position and the open position with high speed and stably holds each position, the isolation mechanism section surely performs the open and close operation of the open position and the isolation position and stably holds each position, the ground mechanism section surely performs the open and close operation of the isolation position and the ground position and stably holds each position, the open and close operation can surely be achieved with a cheap operation mechanism.

(20) When the movable core is moved by exciting one an electromagnetic coil of the solenoid mechanism and an electromagnetic coil of the electromagnetic actuator, other electromagnetic coil is excited to strengthen the holding power at the position of other movable cores which does not move.

When the movable core is moved by exciting either an electromagnetic coil of the solenoid mechanism or an electromagnetic coil of an electromagnetic actuator, since other electromagnetic coils are excited to strengthen the holding power at the position of other movable cores not to move, one of movable cores of the insulation mechanism section, the isolation mechanism section, or further the ground mechanism section is operated and power of holding the position is strengthened even if reaction force acts on other mechanism sections arranged in series, thereby the position can be stably held, the malfunction can be prevented and reliability can be improved.

[0029] As explained above, according to the vacuum switchgear of the present invention, a vacuum switchgear which comprises a vacuum interrupter having simple structure and high reliability and the operation mechanism with high reliability being achievable to three positions of the close position, the open position, and the isolation position or four positions further including the ground position, can control use amount of the insulation medium of SF_6 gas etc. and can harmonize with the environment.

[0030] This summary of the invention does not necessarily describe all necessary features so that the invention may also be a sub-combination of these described features.

[0031] The invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a profile which shows an example of the configuration of conventional typical cubicle-type gas insulation switchgear;

FIG. 2 is a profile which shows the first embodiment of the vacuum interrupter of the vacuum switchgear according to the present invention;

FIG. 3 is a profile which shows the second embodiment of the vacuum interrupter of the vacuum switchgear according to the present invention;

FIG. 4 is a characteristic diagram to explain the function in each of first and second embodiments, respectively;

FIG. 5 is a characteristic diagram to explain the function in each of first and second embodiments, respectively;

FIG. 6 is a profile which shows the fifth embodiment of the vacuum interrupter of the vacuum switchgear according to the present invention;

FIG. 7 is a profile which shows the sixth embodiment of the vacuum interrupter of the vacuum switchgear according to the present invention;

FIG. 8 is a profile which shows the seventh embodiment of the vacuum interrupter of the vacuum switchgear according to the present invention;

FIG. 9 is a characteristic diagram to explain the function in each of fifth, sixth and seventh embodiments, respectively;

FIG. 10 is a characteristic diagram to explain the function in each of fifth, sixth and seventh embodiments, respectively;

FIG. 11 is a characteristic diagram to explain the function in each of fifth, sixth and seventh embodiments, respectively;

FIG. 12 is a characteristic diagram to explain the function in each of fifth, sixth and seventh embodiments, respectively;

FIGS. 13A to 13C are profiles which show the twelfth embodiment of the operation mechanism of the vacuum switchgear according to the present invention;

FIG. 14 is a profile which shows the fourteenth embodiment of the operation mechanism of the vacuum switchgear according to the present invention;

FIGS. 15A to 15C are profiles which show the fifteenth embodiment of the operation mechanism of the vacuum switchgear according to the present invention;

FIGS. 16A to 16D are profiles which show the sixteenth embodiment of the operation mechanism of the vacuum switchgear according to the present invention; and

FIG. 17 is a profile which shows the seventeenth embodiment of the operation mechanism of the vacuum switchgear according to the present invention.

[0032] Hereafter, the embodiment of the present invention will be explained in detail referring to the drawings.

(First Embodiment)

[0033] FIG. 2 is a profile which shows an example of the configuration of vacuum interrupter 20 in the vacuum switchgear according to the first embodiment.

[0034] Insulation cylinder 21, which consists of ceramic or glass, constructs airtight container, and the openings of both ends thereof are sealed up, respectively, by fixed side end plate 22 and movable side end plate 23.

[0035] Fixed conducting axis 25, to which fixed electrodes 24 is connected, is supported and fixed to fixed side end plate 22. Movable electrode 26 opposed to fixed electrode 24 is fixed to movable conducting axis 27. This movable conducting axis 27 is connected with an operation mechanism described later.

[0036] Contacts 28a and 28b, which consists of various materials corresponding to the usage of vacuum interrupter 20, are set to each electrode to the side to which fixed electrode 24 and movable electrode 26 are contacted.

[0037] On the other hand, bellows 29 is allocated between movable conducting axis 27 and movable side cover plate 23, and movable electrode 26 can be moved along the straight line.

[0038] Arc shield 32 is arranged in an electrically insulated state at surroundings of fixed electrode 24 and movable electrode 26 to prevent soil of insulation cylinder 21 caused by metallic steam at the turn the current off.

[0039] The position where contacts 28a and 28b are contacted is assumed to the close position, the position where the gap length between each contact is d_1 is assumed to the open position when movable electrode 26 moves, and the position where the gap length between each contact is d_2 is assumed to the isolation position when movable electrode 26 further moves.

[0040] In vacuum interrupter 20 according to the embodiment, when there is open instruction of the breaker from the control circuit of the vacuum switchgear (not shown in the figure), movable electrode 26 moves and the gap length between contacts 28a and 28b becomes d_1 (open position).

[0041] When there is open (isolation) instruction of the isolator from the control circuit of the vacuum switchgear, movable electrode 26 further moves and the gap length between each of contacts 28a and 28b becomes d_2 (isolation position).

[0042] Thus, contact 28b provided in movable electrode 26 continuously moves along a straight line at three positions of a close position, an open position, and an isolation position.

[0043] In this case, since the contact of the isolator is stored in the vacuum chamber and SF_6 gas is not used even if a current near the ratings current such as the loop currents is intercepted, the decomposition gas and the decomposition product are not generated.

[0044] That is, as mentioned above, since a high vacuum is used without using SF_6 gas which is the greenhouse gas as insulation and an arc-quenching medium of the isolator, it is corresponding to needs of a recent market from an environmental side.

[0045] Since the contact of the breaker and the isolator becomes one contact, the contact resistance becomes small and the temperature increase of a main circuit can be lowered.

[0046] In addition, since the contact of the breaker and the isolator is contained in the same vacuum chamber and the configuration is easy, the mass production of vacuum interrupter 20 becomes possible and miniaturizaion of the vacuum switchgear and reduction of the cost can be achieved.

[0047] As described above, in this embodiment, since the breaker and the isolator are constructed by moving along the straight line continuously at three positions of the close position, the open position, and the isolation position of the contact, the operation thereabove with one operation mechanism becomes possible. It is possible to miniaturize the vacuum switchgear and lower the cost thereof from this respect.

(Second Embodiment)

[0048] FIG. 3 is profile which shows an example of configuration of vacuum interrupter 20 of vacuum switchgear according to the second embodiment. The same marks are fixed to the same parts of FIG. 2, the explanation will be omitted, and only parts different from FIG. 2 will be described here.

[0049] As shown in FIG. 3, in vacuum interrupter 20 according to this embodiment, ground electrode 35 is provided at a position opposed to movable conducting axis 27 connected with said movable electrode 26, and the inside diameter of ground electrode 35 opposed to movable conducting axis 27 is reduced smaller than the outside diameter of movable electrode 26.

[0050] Insulation cylinders 21 and 36 are arranged between ground electrode 35 and metal end plates 2 and 3 of both ends thereof, respectively. The position where contact 28b of movable electrode 26 contacts with contact 28a of fixed electrode 24 is the close position, and the position where the gap length between contacts 28a and 28b is d_6 is a ground position.

[0051] With the above-mentioned configuration, in this embodiment, the movable electrode 26 can continuously move along the straight line at four positions of a close position, an open position, an isolation position, and a ground position.

[0052] In vacuum interrupter 20 according to this embodiment, in a case of instructing of ground from the isolation state from the control circuit of the vacuum switchgear (not shown in the figure) when vacuum switchgear is checked, movable electrode 26 moves and is grounded at the position (ground position) where the gap length between contacts 28a and 28b becomes d_5.

[0053] As a result, movable electrode 26 continuously moves along the straight line at four positions of the close position, the open position, the isolation position, and the ground position.

[0054] In this case, since the ground device is stored in vacuum interrupter 20, the vacuum switchgear can be miniaturized.

[0055] Since the configuration of vacuum interrupter 20 is easy, the assembly of vacuum interrupter 20 becomes easy, and mass production becomes possible.

[0056] In addition, it is possible to lower the cost of the vacuum switchgear since the number of components decreases.

[0057] As described above, in this embodiment, movable electrode 26 continuously moves along the straight line at four positions of the close position, the open position, the isolation position and the ground position for the contact, the operation thereabove with one operation mechanism becomes possible. It is possible to miniaturize the vacuum switchgear and lower the cost thereof from this respect.

(Third Embodiment)

[0058] According to vacuum interrupter 20 of the third embodiment, when the gap length between contacts 28a and 28b of open position is assumed to be d_1 and the gap length between contacts 28a and 28b of isolation position is assumed to be d_2, the relationship of each gap length d_1 and d_2 is set to $d_2 = (1.3 \text{ to } 2.6) \bullet d_1$ in above-mentioned vacuum interrupter 20 shown in FIG. 2

[0059] In vacuum interrupter 20 according to the embodiment, since the relationship of each gap lengths d_1 and d_2 is assumed to be $d_2 = (1.3 \text{ to } 2.6) \bullet d_1$, the dielectric breakdown probability between contacts at the isolation position lowers, and it becomes possible to cooperate about the insulation of an isolation position and an open position.

[0060] In general, relationship to breakdown voltage Vb between electrodes in the vacuum and gap length d is shown by $Vb = a \bullet d_n$. It is known to be about n = 0.6, though the value of this n is different according to the electrode material.

[0061] The probability distribution of the dielectric breakdown in the vacuum becomes a normal distribution, and this standard deviation σ shows the dispersion of the breakdown voltage.

[0062] Here, the allowance of the insulation performance, when contact 28b provided to movable electrode 26 shown in FIG. 2 is at the open position, is assumed to be 2σ for V_{50} when 50% breakdown voltage is assumed to be V_{50}. On the other hand, since the allowance of the insulation performance at the isolation position should consider reliability and the safety side, the allowance of 3σ will be given for V_{50}, where 3σ is the destruction probability of about 0.1%.

[0063] The breakdown voltage dispersion σ between contacts 28a and 28b is large different depending on the contact material, the surface state, and the insulation current, etc., and is considered to 10 to 23%.

[0064] FIG. 4 is characteristic diagram which shows an example of relationship to ratio of gap length (that is, ratio of d_2 and d_1) which gives 3σ and gap length which gives 2σ and dispersion (standard deviation) σ of breakdown voltage from the relationship of the above-mentioned breakdown voltage and the gap length.

[0065] When the standard deviation is assumed to be 10%, ratio d_2/d_1 of the gap length becomes about 1.3, and when the standard deviation is assumed to be 23%, ratio d_2/d_1 of the gap length becomes about 2.6.

[0066] As mentioned above, since the gap length has ratio of $d_2/d_1 = 1.3 \text{ to } 2.6$, the vacuum switchgear with low-cost and high insulation reliability can be obtained.

(Fourth Embodiment)

[0067] According to vacuum interrupter 20 of this fourth embodiment, in vacuum interrupter 20 shown in above-mentioned FIG. 2, when the gap length between arc shield 32 which surrounds fixed electrode 24 and movable electrode 26, and fixed electrode 24 and movable electrode 26 is assumed to be d_3, and the gap length between contacts 28a and 28b of the isolation position is assumed to be d_2, the relationship of d_3 and d_2 is set to be $d_3 = (0.35 \text{ to } 0.8) \bullet d_2$.

[0068] In vacuum interrupter 20 according to the embodiment, since the relationship of each of gap lengths d_2 and d_3 is set at $d_3 = (0.35 \text{ to } 0.8) \bullet d_2$, the best position of the arc shield from the insulation side is determined, and the electric field intensity of a movable electrode and a fixed electrode can be reduced.

[0069] FIG. 5 is a characteristic diagram which shows an example of relationship of electric field intensity E1 of the end portion of fixed electrodes 24 and ratio of above-mentioned d_3 and d_2.

[0070] In FIG. 5, electric field intensity Ec of the vertical axis is destruction electric field intensity in which the material of fixed electrode 24 is to be copper.

[0071] When ratio d_3/d_2 of the gap length becomes 0.5 or less, since the electric field intensity at the electrode end portion is determined by the gap length between fixed electrode 24 and arc shield 32, the electric field intensity at the electrode end portion becomes large with decreasing ratio d_3/d_2 of the gap length.

[0072] When ratio d_3/d_2 of the gap length is 0.35, the electric field intensity at the end portion of fixed electrode 24 reaches the destruction electric field intensity.

[0073] When ratio d_3/d_2 of the gap length becomes 0.8 or more, since the electric field intensity at the end portion of fixed electrode 24 is determined between electrodes, the electric field intensity does not lower too much.

[0074] When ratio d_3/d_2 of the gap length becomes large, since the diameter of vacuum interrupter 20 becomes large, it is desired that ratio d_3/d_2 of the gap length as small as possible from the cost.

[0075] Therefore, since the ratio of d_3 and d_2 of the gap length is set at 0.35 to 0.8, the outside diameter of vacuum interrupter 20 is suppressed, and vacuum interrupter 20 with an excellent insulation characteristic can be obtained.

(Fifth Embodiment)

[0076] FIG. 6 is profile which shows an example of configuration of vacuum interrupter 20 of vacuum switchgear according to the embodiment. In FIG. 6, the same marks are fixed to the same to part of FIG. 2, the explanation will be omitted, and only a different part will be described here.

[0077] Vacuum interrupter 20 according to the fifth embodiment has second shield 33 which surrounds the fixed electrode 24 and third shield 34 which surrounds said movable electrode 26, as shown in FIG. 6. This second shield 33 and third shield 34 are supported and fixed with metallic end plates at both ends.

[0078] In vacuum interrupter 20 according to the embodiment, second shield 33 which surrounds fixed electrode 24, and third shield 34 which surrounds movable electrode 26, are provided and second shield 33 and third shield 34 are supported and fixed with metallic end plate at both ends, the electric field intensity of movable side contact 28b and fixed side contact 28a, movable electrode 26 and fixed electrode 24 can be decreased.

[0079] That is, in FIG. 6, the insulation performance between each of contacts 28a and 28b is controlled by the micro surface state of the contact as described above. Therefore, the insulation performance largely lowers according to the insulation condition of the current. Even if the contact is opened and closed without load, since a part of the opposed contact is ablated by the cool seizing, it becomes a projection of the surface, and is departed in the form of the particle, it is known that the insulation performance lowers.

[0080] Then, since second shield 33 which surrounds fixed electrode 24 and third shield 34 which surrounds movable electrode 26 are provided, the electric field intensity on the surface of each of contacts 28a and 28b lowers and the insulation performance is not influenced by the insulation condition of the current and no load switching.

[0081] As described above, since second shield 33 and third shield 34 are provided, the vacuum switchgear with excellent insulation performance can be obtained.

(Sixth Embodiment)

[0082] FIG. 7 is profile which shows an example of configuration of vacuum interrupter 20 of vacuum switchgear according to the embodiment. In FIG. 7, the same marks are fixed to the same to FIG. 6 part, the explanation will be omitted, and only a different part will be described here.

[0083] In vacuum interrupter 20 according to the embodiment, as shown in FIG. 7, second shield 33, which surrounds said fixed electrode 24, is supported and fixed with fixed conducting axis 25.

[0084] In vacuum interrupter 20 according to the embodiment, since second shield 33 is supported and fixed with conducting axis 25 connected with fixed electrode 24, the electric field intensity of movable side contact 28b, fixed side contact 28a, movable electrode 26 and fixed electrode 24 can be reduced and the electric field intensity of the upper end of the arc shield can be reduced.

[0085] That is, in vacuum interrupter 20 of FIG. 6, to which second shield 33 is provided, the electric field intensity of the upper end of the arc shield becomes large.

[0086] Then, by supporting second shield 33 with fixed conducting axis 25, the electric field intensity of the upper end of the arc shield is reduce and the insulation performance between arc shield and second shield 33 improves. A similar function and effect as a case of the fifth above-mentioned embodiment can be achieved about the insulation performance between each of contacts 28a and 28b.

(Seventh Embodiment)

[0087] FIG. 8 is profile which shows an example of configuration of vacuum interrupter 20 of vacuum switchgear according to the embodiment. In FIG. 8, the same marks are fixed to the same parts of FIGS. 6 and 7 and the explanation will be omitted. Only a different part will be described here.

[0088] In vacuum interrupter 20 according to the embodiment, as shown in FIG. 8, second shield 33 which surrounds the fixed electrode 24 is supported and fixed with fixed electrode 24.

[0089] In vacuum interrupter 20 according to the embodiment, since second shield 33, which surrounds fixed electrode 24, is supported and fixed with fixed electrode 24, similar function and advantage as a case of the above-mentioned sixth embodiment can be achieved, and the vacuum switchgear with excellent insulation performance can be obtained.

(Eighth Embodiment)

[0090] In vacuum interrupter 20 according to the embodiment, in vacuum interrupter 20 shown in above-mentioned FIGS. 6, 7, and 8, the relationship of each gap length d_2 and d_4 is set at $d_4 = (0.6 \text{ to } 0.95) \cdot d_2$, when the gap length between second shield 33 and third shield 34 is assumed to be d_4 and the gap length between each of contacts 28a and 28b isolation position is assumed to be d_2.

[0091] In vacuum interrupter 20 according to the embodiment, since the relationship of each gap length d_2 and d_4 is set at $d_4 = (0.6 \text{ to } 0.95) \cdot d_2$, the electric field intensity of movable side contact 28b, fixed side contact 28a, movable electrode 26 and fixed electrode 24 can be decreased, and each section of the electric field intensity thereof can be optimized.

[0092] FIG. 9 is a characteristic diagram which shows an example of peripheral electric field intensity of second shield 33 and third shield 34 by the presence thereof.

[0093] Here, straight line E0 with chain line shown in the upper end shows the electric field intensity on the surface of contact 28a or 28b when there are neither second shield 33 nor third shield 34, curve E1 shows the electric field intensity in the point of second shield 33 or third shield 34, and curve E2 shows the electric field intensity on the surface of contact 28a or 28b at the isolation position.

[0094] Curve E1 is inversely proportional to ratio d_4/d_2 of the gap length, and curve E2 is proportional to ratio d_4/d_2 of the gap length.

[0095] Breakdown electric field intensity Ea is a value when the material of second shield 33 and third shield 34 is stainless steel, and breakdown electric field intensity Eb is a value when the material of contacts 28a and 28b is a copper chrome alloy.

[0096] The reason why breakdown electric field intensity Eb of the contact is lower than that of Ea is considered that not only the material is different, but also it is lowered by various open and close operation of the current insulation etc. as mentioned above.

[0097] Then, as shown in FIG. 9, since the relationship of each gap length d_2 and d_4 is set to $d_4 = (0.6 \text{ to } 0.95) \bullet d_2$, the electric field intensity of each of contacts 28a and 28b can be decreased, and the small vacuum switchgear with excellent insulation performance can be obtained.

(Ninth Embodiment)

[0098] In vacuum interrupter 20 according to the embodiment, in vacuum interrupter 20 shown in above-mentioned FIGS. 6, 7, and 8, the material of second shield 33 and third shield 34 is made of stainless steel or tungsten.

[0099] In vacuum interrupter 20 according to the embodiment, since the material of second shield 33 and third shield 34 is made of stainless steel or tungsten, the electric field intensity of movable side contact 28b, fixed side contact 28a, movable electrode 26 and fixed electrode 24 can be decreased, and the insulation performance of second shield 33 and third shield 34 can be improved.

[0100] FIG. 10 is a characteristic diagram which shows an example of comparing the thunder impulse breakdown voltage performances by the difference of the material of second shield 33 and third shield 34 performed by the invention inventor etc.

[0101] The material is copper (no oxygen copper), stainless steel (SUS 304), and tungsten. The electrode shape used for the examination is a plate electrode of 34 mm in the diameter, and the gap length is 1.5 mm.

[0102] In FIG. 10, a breakdown voltage is 1.7 times in stainless steel and 1.9 times in tungsten compared with the copper material.

[0103] However, since a similar advantage is obtained even if tungsten is coated on the surface of the copper material by the technique of the vacuum evaporation etc. Stainless steel or tungsten may be used as the surface material of the shield.

[0104] As described above, since the material of second shield 33 and third shield 34 is made of stainless steel or tungsten, the vacuum switchgear can be miniaturized in addition to the advantage of the above-mentioned electric field relaxation.

(Tenth Embodiment)

[0105] In vacuum interrupter 20 according to the embodiment, in vacuum interrupter 20 shown in above-mentioned FIGS. 6, 7, and 8, the electrochemical buffing processing or the electron beam processing (reforming layer by the irradiation of the electron beam) is performed on the surfaces of second shield 33 and third shield 34.

[0106] In vacuum interrupter 20 according to the embodiment, since the surfaces of second shield 33 and third shield 34 are processed by the electrochemical buffing processing or the electron beam processing, the electric field intensity of movable side contact 28b, fixed side contact 28a, movable electrode 26 and fixed electrode 24 can be decreased, and the insulation performance of second shield 33 and third shield 34 can be improved.

[0107] FIG. 11 is a characteristic diagram, which shows an example of comparing the thunder impulse breakdown voltages by the difference of the surfaces of second shield 33 and third shield 34.

[0108] The thunder impulse breakdown voltage characteristic between the electrode finished up in the surface rough about 1 μm level and the electrode in which electrode thereof is processed by the electrochemical buffing processing. The electrolysis liquid is a mixture liquid of phosphoric acid and sulfuric acid.

[0109] In general, the breakdown voltage of the dielectric breakdown in the vacuum rises every time the dielectric breakdown is repeated as understood from FIG. 11. This is called as conditioning effect, and the conditioning processing, in which this is used, is performed in the final step of manufacturing the vacuum interrupter.

[0110] As is apparent from FIG. 11, by performing the electrochemical buffing processing, a high insulation performance is shown by a little destruction frequency, and, in addition, the final breakdown voltage rises by about 20 kV.

[0111] As described above, by performing the electrochemical buffing processing, the advantage which is capable of shortening the time required for conditioning processing can be obtained.

[0112] Even when this electrochemical buffing processing is performed to arc shield 32 shown in FIGS. 2, 3, 6, 7, and 8, the effect of the improvement of a similar breakdown voltage performance can be achieved.

[0113] FIG. 12 is characteristic diagram which shows an example of comparing a voltage characteristics of the electron beam processing with that of the electrochemical buffing processing for second shield 33 and third shield 34.

[0114] As is apparent from FIG. 12, by performing the electron beam processing, a high insulation performance is shown by a little destruction frequency, and, in addition, the final breakdown voltage rises by about 20 kV.

[0115] As described above, by performing the electron beam processing, the advantage which is capable of shortening the time required for conditioning processing can be obtained.

(Eleventh Embodiment)

[0116] In vacuum interrupter 20 according to the embodiment, in vacuum interrupter 20 shown in abovementioned FIG. 3, when the gap length between contacts 28a and 28b of the open position is assumed to be d_1, and the gap length between movable conducting axis 27 and ground electrode 35 provided in movable electrode 26 is assumed to be d_5, the relationship of each gap length d_5 and d_1 is set to $d_5 = (1.3 \text{ to } 1.8) \cdot d_1$.

[0117] In vacuum interrupter 20 according to the embodiment, since the relationship of each gap length d_1 and d_5 is set to $d_5 = (1.3 \text{ to } 1.8) \cdot d_1$, it is possible to cooperate about the insulation between contacts at the open position of movable side contact 28b and the insulation of the ground device, and reliability can be improved.

[0118] That is, when is 50% breakdown voltage is assumed to be V_{50} as well as the isolation position, the allowance of 3σ is required for V_{50} as the allowance of the insulation performance at the ground position. The standard of the allowance of the insulation performance at the open position is 2σ for V_{50} as described above. Since ground electrode 35 has no obligation of the current insulation, the damage of the surface of the electrode is comparatively small.

[0119] When the examination for obtaining the dispersion of the breakdown voltage of ground electrode 35 and movable conducting axis 27 is performed, the dispersion is 10 to 18% when the dispersion is shown by the standard deviation.

[0120] From relationship to the ratio of the gap length which gives 3σ shown in FIG. 4 and the gap length which gives 2σ (That is, d_5/d_1) and the dispersion (standard deviation) of breakdown voltages, ratio d_5/d_1 of the gap length becomes 1.3 to 1.8.

[0121] As a result, the insulation of ground electrode 35 and movable conducting axis 27 can be cooperated with the insulation at the isolation position, and the vacuum switchgear with low cost and high reliability can be obtained.

(Twelfth Embodiment)

[0122] FIGS. 13A to 13C are profiles which show examples of configuration of operation mechanism in vacuum switchgear according to the embodiment, the configurations show at the close position, the open position, and the isolation position, respectively.

[0123] In FIGS. 13A to 13C, operation mechanism 50 is constructed by arranging two mechanism sections 60 and 70 in series.

[0124] Here, from a near side of vacuum interrupter 20, it is assumed that insulation mechanism section 60 and isolation mechanism section 70 are arranged.

[0125] That is, movable axis 61 of insulation mechanism section 60 is connected with movable conducting axis 27 of vacuum interrupter 20 through insulation stick 36, and movable conducting axis 71 of isolation mechanism section 90 is connected with frame 62 of insulation mechanism section 60 and screw section 91a.

[0126] Insulation mechanism section 60 is a mechanism for the insulation operation (open and close operation from the close position to the open position) to which the high-speed open and close operation is requested. Isolation mechanism section 90 is a mechanism for the open and close operation from the open position to the isolation position.

[0127] Here, for example, the solenoid operation mechanism, which has been known, can be used as insulation mechanism section 60, and has permanent magnet 63 fixed to surroundings in frame 62, movable core 64 and electromagnetic coil 65 fixed to movable axis 61, and coil spring 66 connected with a movable axis.

[0128] Isolation mechanism section 90 stores rotation axis 91 and motor 93, which is constructed as one body thereto, in frame 92.

[0129] Screw section 91a of rotation axis 91 is connected with frame 62 of insulation mechanism section 60, and connection length S shown in FIG. 13B becomes $(d_2 - d_1)$ or more.

[0130] In addition, though it is not shown in the figure, frame 62 can relatively move only in an axial direction for frame 92, but can not relatively rotate.

[0131] Function of operation mechanism in vacuum switchgear according to the embodiment will be explained.

[0132] First, the operation of insulation mechanism section 60 will be described.

[0133] At the close position shown in FIG. 13A, the close position is held by exceeding the suck power with the flange part of movable core 64 and permanent magnet 63 than the compression power of coil spring 66.

[0134] Now, in such a state, when the current flows in a positive direction from the external power supply (not shown in the figure) to electromagnetic coil 65, the suck power between flanges of permanent magnet 63 and movable core 64 lowers, the repulsion power of coil spring 66 exceeds the suck power and movable axis 61 is driven in the direction of the open position.

[0135] At the open position of FIG. 13B, movable core 64 is apart from permanent magnet 63, thereby, the suck power therebetween is small and the repulsion power of coil spring 66 is superior to the suck power and the open position is held.

[0136] The insulation operation is completed by the above-mentioned operation.

[0137] Next, when a reverse-current flows to electromagnetic coil 65, electromagnetic power between electromagnetic coil 65 and permanent magnet 63 is superior to the repulsion power of coil spring 66, movable axis 61 is driven in the direction of the close position while compressing coil spring 66 and is held at the close position shown in FIG. 13A by the suck power of permanent magnet 63, and the turning on operation is completed.

[0138] Next, the operation of isolation mechanism section 90 will be described.

[0139] When rotation axis 91 is rotated by motor 93, frame 62 of the insulation mechanism section, with which the screw is connected, and movable conducting axis 27 of vacuum interrupter 20 are opened from the open position of FIG. 13B to the isolation position of FIG. 13C.

[0140] Next, when rotating motor 73 reversely, insulation mechanism section 60 and movable conducting axis 27 of vacuum interrupter 20 move from the isolation position of FIG. 13C to the open position of FIG. 13B, and the close operation is completed.

[0141] As described above, according to the embodiment, the operation mechanism of the vacuum switchgear in the first above-mentioned embodiment can be achieved with an easy configuration.

[0142] That is, since a suitable mechanism for high-speed open and close operation is used for the operation part as the breaker, and a suitable mechanism for low-speed open and close operation is used for the operation part as the isolator, an operation mechanism with low-cost can be obtained as a whole.

[0143] Since independent operations of two the mechanism sections 60 and 90 are combined, holding the close position, the open position, and the isolation position is certain and the operation mechanism with high reliability can be obtained.

(Modification of Twelfth Embodiment)

[0144] In this embodiment, though the case that the vacuum interrupter, the insulation mechanism section, and the isolation mechanism section connected directly in series is explained, the present invention is not limited to this. It is also possible to connect the vacuum interrupter and the insulation mechanism section or the insulation mechanism section and the isolation mechanism section in series through the lever and the link.

(Thirteenth Embodiment)

[0145] In the operation mechanism of the vacuum switchgear according to the embodiment, connection length S of screw section 91a of the isolation mechanism section and frame 62 of the insulation mechanism section becomes (d_3 - d_1) or more in the operation mechanism of the vacuum switchgear shown in above-mentioned FIGS. 13A to 13C.

[0146] In the operation mechanism of the vacuum switchgear according to the embodiment, insulation mechanism section 60, as explained by the above-mentioned twelfth embodiment, performs insulation and the turning on operation from the close position to the open position, and isolation mechanism section 90, as explained by the above-mentioned twelfth embodiment, performs the open operation from the open position to the isolation position, and, by further rotating motor 93, insulation mechanism section 60 and movable conducting axis 27 of vacuum interrupter 20 are driven from the isolation position to the ground position.

[0147] As described above, in this embodiment, the operation mechanism of the vacuum switchgear in the above-mentioned second embodiment can be achieved by an easy configuration.

[0148] That is, since a suitable mechanism for high-speed open and close operation is used for the operation part as the breaker, and a suitable mechanism for low-speed open and close operation is used for the operation part as the isolator and the ground device, an operation mechanism with low-cost can be obtained as a whole.

[0149] Since independent operations of two the mechanism sections 60 and 90 is combined, holding the close position, the open position, and the isolation position is certain and the operation mechanism with high reliability can be obtained.

(Fourteenth Embodiment)

[0150] FIG. 14 is profile which shows an example of configuration of operation mechanism in vacuum switchgear according to the embodiment, and the configuration at the close position is shown in FIG. 14.

[0151] In FIG. 14, operation mechanism 50 is constructed by arranging three mechanism sections 60, 70 and 80 in series.

[0152] Here, from a near side of vacuum interrupter 20, it is assumed that insulation mechanism section 60, isolation mechanism section 70 and ground mechanism section 80 are arranged.

[0153] In this embodiment, all of insulation mechanism section 60, isolation mechanism section 70, and ground mechanism section 80 are constructed by using the solenoid operation mechanism explained by FIGS. 13A to 13C.

[0154] That is, movable axis 61 of insulation mechanism section 60 is connected with movable conducting axis 27 of vacuum interrupter 20 through insulation stick 36, movable axis 71 of isolation mechanism section 70 is connected with frame 62 of insulation mechanism section 60, and movable axis 81 of ground mechanism section 80 is connected with frame 72 of isolation mechanism section 70.

[0155] In the operation mechanism of the vacuum switchgear according to the embodiment, according to the current from the external power supply (not shown in the figure), the solenoid operation mechanism of insulation mechanism section 60 performs insulation and the turning on operation from the close position to the open position.

[0156] In the same way, by driving the solenoid operation mechanism of isolation mechanism section 70, movable conducting axis 27 of vacuum interrupter 20 and insulation mechanism section 60 perform the open and close operation from the open position to the isolation position.

[0157] In addition, by driving the solenoid operation mechanism of ground mechanism section 80, movable conducting axis 27, insulation mechanism section 60, and isolation mechanism section 70 of vacuum interrupter 20 perform the open and close operation from the isolation position to the ground position.

[0158] As described above, in this embodiment, the operation mechanism of the vacuum switchgear in the above-mentioned second embodiment can be achieved by an easy configuration.

[0159] Since there is the combination of independent operations of three mechanism sections 60, 70, and 80, holding the close position, the open position, the isolation position, and the ground position is certain and the operation mechanism with high reliability can be obtained.

(Modification of Fourteenth Embodiment)

[0160] In this embodiment, though the operation mechanism is explained in the case of arranging three solenoid operation mechanisms in series, the present invention is not limited to this, a suitable solenoid operation mechanism for high-speed open and close operation may be used for the operation part as the breaker and suitable other operation mechanisms may be used for low-speed open and close operation as the isolator and the ground device, in this case, an operation mechanism with low cost can be obtained as a whole.

(Fifteenth Embodiment)

[0161] FIGS. 15A to 15C are profiles which show an example of configuration of operation mechanism in vacuum switchgear according to the embodiment, and show the configurations at the close position, the open position, and the isolation position, respectively.

[0162] The same marks are fixed to the same parts in above-mentioned embodiments in FIGS. 15A to 15C.

[0163] In FIG. 15A, in operation mechanism 150, insulation mechanism section 160 which is near vacuum interrupter 20 and isolation mechanism section 170 which is far from the vacuum interrupter 20 are arranged in series, and each mechanism section is constructed with the solenoid operation mechanism of the bistable type.

[0164] That is, movable axis 161a, which consists of non-magnetic body of stainless etc, is assembled to movable core 161 of insulation mechanism section 160, movable axis 161a is supported to a free sliding to guide material 166a which consists of non-magnetic body, and is assembled to movable conducting axis 27 through insulation stick 36.

[0165] Electromagnetic coils 165a and 165b are arranged in surrounding of movable core 161, and york 162 is arranged outside of electromagnetic coils 165a and 165b.

[0166] In addition, permanent magnet 163 is assembled to york 162 between electromagnetic coil 165a and 165b, and, for example, permanent magnet 163 is magnetized in the direction of the inside and outside such that the outside becomes S-pole and the inside becomes N-pole.

[0167] In addition, york 167 for the guide is assembled in permanent magnet 163.

[0168] On the other hand, isolation mechanism section 170 is constructed as well as above-mentioned insulation mechanism section 160, movable axis 171a, which consists of non-magnetic body, is assembled to movable core 171, movable axis 171a clings to york 162 of insulation mechanism section 160, and a point guides movable axis 161b of insulation mechanism section 160 with a free sliding.

[0169] Electromagnetic coils 175a and 175b and permanent magnet 173 magnetized in the direction of the inside and outside are arranged surrounding of movable core 171, york 172 is assembled around electromagnetic coil 175a and 175b, and york 172 is fixed to the base of operation mechanism 150 (not shown in the figure).

[0170] In the operation mechanism of the vacuum switchgear according to the embodiment, each electromagnetic coil is not excited at the close position shown in FIG. 15A, the upper end of movable core 161 of insulation mechanism section 160 is adsorbed by the upper part of york 162 by the magnetism of permanent magnet 163, and a magnetic path, which is shut in the direction indicated by an arrow shown in FIG. 15A, is formed.

[0171] Similarly, in isolation mechanism section 170, movable core 171 is adsorbed by york 172.

[0172] Next, in such a state, when electromagnetic coil 165b and 175a are excited to cause magnetic flux in the direction of the arrow shown in FIG. 15B, movable core 161 moves with high-speed and the bottom section thereof is adsorbed by york 162, and movable electrode 26 reaches open position d_1.

[0173] In this case, though the impact when movable core 161 and york 162 collide is transferred to movable axis 171b of isolation mechanism section 170, since the holding power at the position of movable core 172 of isolation mechanism section 170 is strengthened by exciting electromagnetic coil 175a, movable core 171 is surely held. Then, when excitation of an electromagnetic coil is quitted after the electrode is driven, the position is also held by the action of permanent magnet 163 and permanent magnet 173.

[0174] To perform the close operation, if magnetic flux is generated in the direction of the arrow shown in FIG. 15A by exciting electromagnetic coil 165a and electromagnetic coil 175b at the same time, the close operation can be performed with high-speed with surely holding isolation mechanism section 170.

[0175] In addition, as well as the isolation operation, when electromagnetic coil 175b of isolation mechanism section 170 and electromagnetic coil 165b of insulation mechanism section 160 are excited at the same time to generate magnetic flux in the direction of the arrow shown in FIG. 15C, it is possible to reach the position of movable electrode 27 to isolation position d_2 with surely holding the position of movable core 161 of insulation mechanism section 160.

[0176] In addition, in the same way, the operation returned from such a state to open position d_1 can be performed surely.

[0177] As described above, in this embodiment, since the operation between the open position and the close position is achieved by the high-speed reciprocation operation only of one movable electrode, the operation of insulation and turning on can surely be performed. Since the solenoid operation mechanism of the bistable type is arranged in series, three positions of the close position, the open position, and the isolation position can surely be held by the adsorption power of a permanent magnet. In addition, since the holding power at the position of the other movable core is strengthened when one movable core is driven, even if the impact power etc. act, the position can surely be held. Therefore, the vacuum switchgear, which comprises the operation mechanism having simple structure and high reliability, can be achieved.

(Modification of the Fifteenth Embodiment)

[0178] In this embodiment, though a case that an electromagnetic coil is excited to strengthen the holding power of a movable core which is not driven is explained, the present invention is not limited to this, a case of capable of being held enough only by the adsorption power of a permanent magnet is not necessary to be excited.

[0179] Though a case that movable electrode, insulation mechanism section 160, and isolation mechanism section 170 are arranged in series is explained, the present invention is not limited to this, if the series even if arrangement is not a series transferring power, as a configuration for which free swing lever and link are used, similar function and advantage can be achieved as mentioned-above.

[0180] In addition, the configuration having the wipe spring mechanism, which generates the power to press the closed electrode in the direction of further closed position, may be provided between a movable axis and movable electrode of insulation mechanism section 160.

[0181] In addition, though a case of the configuration to assemble a permanent magnet to the york is explained, the present invention is not limited to this, permanent magnet may be assembled to a movable core, and a solenoid operation mechanism of the bistable type where the position is held by the adsorption power of a permanent magnet at both ends within the range of the operation of a movable core may be adapted.

(Sixteenth Embodiment)

[0182] FIGS. 16A to 16D are profiles which show an example of configuration of operation mechanism in vacuum switchgear according to the embodiment, and show the configurations at the close position, the open position, the isolation position, and the ground position, respectively.

[0183] In FIG. 16A, operation mechanism 350 is constructed by arranging insulation mechanism section 360 which consists of the solenoid operation mechanism of the bistable type has already been explained in FIGS. 15A to 15C and isolation mechanism section 370 which is constructed by an electromagnetic actuator which can hold three positions in series.

[0184] That is, movable core 361 of insulation mechanism section 360 is assembled to movable conducting axis 27 through insulation stick 36, electromagnetic coils 365a and 365b are assembled around movable core 361, and york 362 is assembled around electromagnetic coils 365a and 365b.

[0185] Permanent magnet 363 is assembled inside york 362 as well as the state explained in FIGS. 15A to 15C.

[0186] In addition, salient 371a, 371b, 371c, and 371d are formed to movable core 371 of isolation mechanism section 370 to which york 362 of insulation mechanism section 360 is connected, electromagnetic coils 375a and 375b are assembled the outside thereof, and york 372 is assembled around electromagnetic coils 375a and 375b.

[0187] On the other hand, permanent magnets 363a, 363b, 363c, and 363d are assembled to the position opposed to each above-mentioned salient 371a of movable cores 371, 371b, 371c, and 371d inside of york 372, permanent magnets 373a and 373b are magnetized to so that the inside may become S-pole and the outside may become N-pole, and permanent magnets 373c and 373d are magnetized so that the inside may become S-pole and the outside may become N-pole.

[0188] York 372 is fixed to the base (not show in the figure) of operation mechanism 350.

[0189] In the operation mechanism of the vacuum switchgear according to the embodiment, at the close position shown in FIG. 16A, movable core 361 and movable core 371 are adsorbed by york 362 and york 372 by the magnetism of permanent magnet 363, permanent magnets 373a, and 373b, respectively.

[0190] Next, in such a state, when electromagnetic coil 365b of movable core 361 is excited to generate magnetic flux in the direction indicated by the arrow shown in FIG. 16B and electromagnetic coil 375a of isolation mechanism section 370 is excited, the open operation is performed by moving only movable core 361 with high-speed to the lower side of the figure, the position of movable core 371 is surely held, and a certain open operation can be achieved.

[0191] In addition, in such a state, when electromagnetic coil 375a of isolation mechanism section 370 is excited to generate the magnetic flux in the direction opposite to the arrow shown in FIG. 16B, and electromagnetic coil b is excited to strengthen the holding power at the position of movable core 361 of insulation mechanism section 360, movable core 371 moves to lower middle side of the figure and reaches in the state shown in FIG. 16C and the isolation operation is achieved.

[0192] In the state shown in FIG. 16C, the closed magnetic circuit indicated by the arrow shown in FIG. 16C is formed by opposing permanent magnets 373a, 373b, 373c, and 373d to salient 371a, 371b, 371c, and 371d of a movable core, the position is stably held.

[0193] In addition, in such a state, when electromagnetic coils 375a and 375b of isolation mechanism section 370 are excited to generate the magnetic flux in the direction shown in FIG. 16D respectively and electromagnetic coil 375b is excited to strengthen the holding power at the position of movable core 361 of electromagnetic coil 375b and insulation mechanism section 360, movable core 371 further moves downward and reaches in the state shown in FIG. 16D and the ground operation is achieved.

[0194] In the state shown in FIG. 16D, since movable core 371 is adsorbed by york 372 by the magnetism of permanent magnets 373c and 373d, the position is stably held.

[0195] As described above, in this embodiment, the operation between the open position and the close position can surely be performed by the high-speed reciprocation operation only of one movable electrode. Since it constructs it by arranging electromagnetic actuator which stably holds three positions in series, four positions of the close position, the open position, the isolation position, and the ground position can surely be held by the adsorption power of the permanent magnet. In addition, since the holding power at the position of the other movable core is strengthened when the one movable core is driven, even if the impact power etc. act, the position can surely be held. Therefore, the vacuum switchgear having the operation mechanism with simple structure and high reliability can be achieved.

(Modification of Sixteenth Embodiment)

[0196] In this embodiment, though a case that a movable core is chiefly driven is explained, the present invention is not limited to this, the sensor which detects the position of a movable core may be provided, thereby reliability can be further improved.

(seventeenth Embodiment)

[0197] FIG. 17 is a profile which shows an example of configuration of operation mechanism of vacuum switchgear according to the embodiment, and FIG. 17 shows the configuration at the close position.

[0198] In FIG. 17, operation mechanism 250 is constructed by insulation mechanism section 260, isolation mechanism section 270, and ground mechanism section 280 from a near side of vacuum interrupter 20, and each mechanism section is constructed by the solenoid operation mechanism of the bistable type explained in FIG. 15A to FIG. 15C.

[0199] That is, movable cores 261 of insulation mechanism section 260 is connected with movable conducting axis 27 of vacuum interrupter 20 through insulation stick 36, movable cores 271 of isolation mechanism section 270 is connected with york 262 of insulation mechanism section 260, and movable cores 281 of ground mechanism section 280 is connected with york 272 of isolation mechanism section 270.

[0200] Electromagnetic coils 265a, 265b, 275a, 275b, 285a, 285b, and permanent magnets 263, 273, 283 are assembled to the three above-mentioned mechanism sections, respectively.

[0201] York 282 of ground mechanism section 280 is fixed to the base of operation mechanism 250 (not shown in the figure).

[0202] In the operation mechanism of the vacuum switchgear according to the embodiment, the function is almost similar to the action explained in FIGS. 15A to 15C.

[0203] That is, the open and close operation of the close position and the open position is performed by the operation of insulation mechanism section 260, the open and close operation of the open position and the isolation position is performed by the operation of isolation mechanism section 270, and the open and close operation of the isolation position and the ground position is performed by the operation of ground mechanism section 280.

[0204] When the movable core of one of mechanism sections is driven, each electromagnetic coil is excited to strengthen the holding power at the position of the other two movable cores.

[0205] As described above, in this embodiment, since three solenoid mechanisms of the bistable type is arranged in series, four positions of the close position, the open position, the isolation position, and the ground position can surely be held by the adsorption power of a permanent magnet. In addition, since the holding power is strengthened at the position of other movable cores when one movable core is driven even if the impact power etc. act, the position can surely be held. Therefore, the vacuum switchgear having the operation mechanism with simple structure and high reliability can be achieved.

Claims

1. A vacuum switchgear characterized by comprising:

   a vacuum interrupter (20) from which the seal is put on to both ends of insulation container (21) where the insulation medium is enclosed airtight with the first and second metallic material (22, 23), in which said vacuum interrupter (20) has fixed electrode (24) which penetrates through said first metallic material (22) and clings said first metallic material (22), and movable electrode (26) which penetrates said through said second metallic material (23), is fixed said second metallic material (23) through bellows (29), and is provided to oppose to said fixed electrode (24); and
   an operation mechanism (60, 90) which moves said movable electrode (26) along a straight line at three positions of a close position, an open position, and an isolation position.

2. The vacuum switchgear characterized by comprising:

   a vacuum interrupter (20) from which the seal is put on to both ends of insulation container (21) where the insulation medium is enclosed airtight with the first and second metallic material (22, 23), said vacuum interrupter (20) having a fixed electrode (24) which penetrates through said first metallic material (22) and clings said first metallic material (22), a movable electrode (26) which penetrates through said second metallic material (23) and clings to said second metallic material (23) through bellows (29) and is provided to oppose said fixed electrode (24), and a ground electrode (35) provided on anti-fixed electrode side (24) of said movable electrode (26); and
   an operation mechanism (60, 70, 80) which moves said movable electrode (26) along a straight line at four positions of a close position, an open position, an isolation position, and a ground position.

3. The vacuum switchgear according to claim 1 or claim 2, characterized in that

   when a gap length between contacts at said open position is assumed to be d_1 and a gap length between movable electrode (26) and said fixed electrode (24) at said isolation position is assumed to be d_2, each of said gap lengths d_1 and d_2 is set to satisfy a relationship of:

$$d_2 = (1.3 \text{ to } 2.6) \cdot d_1.$$

4. The vacuum switchgear according to any one of claim 1 to claim 3, characterized by further comprising

   an arc shield (32) provided to surround said fixed electrode (24) and said movable electrode (26), wherein
   when each of a gap length between said arc shield (32) and said fixed electrode (24) and a gap length between said arc shield (32) movable electrode (26) is assumed to be d_3 and a gap length between contacts at said isolation position is assumed to be d_2, each of said gap lengths d_2 and d_3 is set to satisfy a relationship of:

$$d_3 = (0.35 \text{ to } 0.8) \cdot d_2.$$

5. The vacuum switchgear according to any one of claim 1 to claim 4, characterized by further comprising:

   a second shield (33) surrounding said fixed electrode (24) and a third shield (34) surrounding said movable electrode (26), each of which is provided in said arc shield (32), wherein
   said second shield (33) and said third shield (34) are supported and fixed to said first and second metallic material (22, 23).

6. The vacuum switchgear according to claim 5, characterized in that said second shield (33) is supported and fixed to a conducting axis (25) connected with said fixed electrode (24).

7. The vacuum switchgear according to claim 5, characterized in that said second shield (33) is supported and fixed to said fixed electrode (24).

8. The vacuum switchgear according to any one of claim 2, and claim 5 to claim 7, characterized in that

   when a gap length between said second shield (33) and said third shield (34) is assumed to be d_4 and a gap length between said contacts at said isolation position is assumed to be d_2, each of said gap lengths d_2 and d_4 is set to satisfy a relationship of:

$$d_4 = (0.6 \text{ to } 0.95) \cdot d_2.$$

9. The vacuum switchgear according to any one of claim 5 to claim 8, characterized in that said second shield (33) and said third shield (34) are made of stainless steel.

10. The vacuum switchgear according to any one of claim 5 to claim 8, characterized in that said second shield (33) and said third shield (34) are made of tungsten.

11. The vacuum switchgear according to any one of claim 5 to claim 9, characterized in that surfaces of said second shield (33) and said third shield (34) are processed by the electrochemical buffing processing.

12. The vacuum switchgear according to any one of claim 5 to claim 9, characterized in that a reforming layer is provided by an irradiation of an electron beam on surfaces of said second shield (33) and said third shield (34).

13. The vacuum switchgear according to claim 2, characterized in that

when the gap length between the conducting axis to which said movable electrode (26) clings and ground electrodes (35) opposed to this is to be d_5 and the gap length between said open position contacts is to be d_1, each of gap lengths d_1 and d_5 is set to satisfy a relationship of:

$$d_5 = (1.3 \text{ to } 1.8) \cdot d_1.$$

14. The vacuum switchgear according to any one of claim 1, and claim 3 to claim 13, characterized in that

said operation mechanism has insulation mechanism section (60) and isolation mechanism section (90), each of which is arranged in series and moves in straight line between two positions,
movable section of said insulation mechanism section (60) is connected with said movable electrode (26) and performs an open and close operation of said gap length d_1, and
a frame of said insulation mechanism section (60) is connected with a movable section of said isolation mechanism section (90) and said isolation mechanism section (90) performs an open and close operation from said gap length d_1 to gap length d_2.

15. The vacuum switchgear according to any one of claim 2, and claim 3 to claim 13, characterized in that

said operation mechanism has insulation mechanism section (60) which is arranged in series and moves between two positions in a the straight line and has isolation mechanism section (90) which moves along the straight line with three positions including an intermediate point,
a movable section of said insulation mechanism section (60) is connected with said movable electrode (26) and performs an open and close operation of said gap length d_1, and
a frame of said insulation mechanism section (60) is connected with a movable section of said isolation mechanism section (90) and said isolation mechanism section (90) performs open and close operations in two stages from said gap length d_1 to gap length d_2 and from said gap length d_2 to said gap length d_3.

I

16. The vacuum switchgear according to any one of claim 2, and claim 3 to claim 13, characterized in that

said operation mechanism is arranged in series and has an insulation mechanism section (60), isolation mechanism section (70), and ground mechanism section (80), each of which moves between two positions along a straight line,
a movable section of said insulation mechanism section (60) is connected with said movable electrode (26) and performs an open and close operation of said gap length d_1,
a frame of said insulation mechanism section (60) is connected with a movable section of said isolation mechanism section (70) and said isolation mechanism section (70) performs an open and close operation from said gap length d_1 to said gap length d_2, and
a frame of said isolation mechanism section (70) is connected with a movable section of said ground mechanism section (80), and said ground mechanism section (80) performs an open and close operation from said gap length d_2 to said gap length d_3.

17. The vacuum switchgear according to claim 14, characterized in that

each of said insulation mechanism section

(160) and said isolation mechanism section (170) is constructed by the solenoid mechanism which comprises an electromagnetic coil, a york, a movable core, and a permanent magnet or the solenoid mechanism which further comprises the spring if necessary,

a movable section of said insulation mechanism section (160) is a movable core of the first solenoid mechanism, the frame of said insulation mechanism section (160) is a york of the first solenoid mechanism, a movable section of said isolation mechanism section (170) is a movable core of the second solenoid mechanism, and the frame of said isolation mechanism section (170) is a york of the second solenoid mechanism, and
each of said movable cores performs shuttling operation by magnetism of said electromagnetic coil and permanent magnet or, further by the restoration power of said spring if necessary and, in both ends within the range of the operation of a said movable core, holds the position by adsorption power of said permanent magnet or, further by the restoration power of a said spring if necessary.

18. The vacuum switchgear according to claim 15, characterized in that

said insulation mechanism section (360) is constructed by solenoid mechanism which comprises electromagnetic coil, york, movable core, and permanent magnet, or, the solenoid mechanism which further comprises the spring if necessary,
a movable section of said insulation mechanism section (360) is a movable core of said solenoid mechanism, and the frame of said insulation mechanism section (360) is said york,
said movable core performs the shuttling operation by magnetism of said electromagnetic coil and permanent magnet, or, further by the restoration power of the spring, if necessary, and, in both ends within the range of the operation of said movable core, and the position is held by adsorption power of said permanent magnet or further by restoration power of the spring if necessary,
said isolation mechanism section (370) is an electromagnetic actuator which comprises a movable core and a permanent magnet, in which the salient is formed, to oppose to the salient of a york and said york with which an electromagnetic coil and the salient are formed, and a movable section of said isolation mechanism section (370) is a movable core of said electromagnetic actuator,
the frame of said isolation mechanism section (370) is a york of said electromagnetic actuator, and

said movable core performs the shuttling operation by the magnetism of said electromagnetic coil and a permanent magnet and holds the position by the adsorption power of said permanent magnet, and in both ends within the range of the operation of said movable core, and holds the position by the magnetism of said permanent magnet by opposing the salient of said york to the salient of said movable core at an intermediate position within the range of said operation.

19. The vacuum switchgear according to claim 16, characterized in that

said insulation mechanism section (260), said isolation mechanism section (270), and ground mechanism section (280) are respectively constructed by a solenoid mechanism which comprises an electromagnetic coil, a york, a movable core, and a permanent magnet, or are constructed by a solenoid mechanism which further comprises the spring if necessary,
a movable section of said insulation mechanism section (260) is a movable core of the first solenoid mechanism, the frame of said insulation mechanism section (260) is a york of the first solenoid mechanism, a movable section of said isolation mechanism section (270) is a movable core of the second solenoid mechanism, the frame of said isolation mechanism section (270) is a york of the second solenoid mechanism, a movable section of said ground mechanism is a movable core of the third solenoid mechanism, and the frame of said ground mechanism section (280) is a york of the third solenoid mechanism, and
each of said movable cores performs the shuttling operation by magnetism of said electromagnetic coil and permanent magnet, and further by the restoration power of said spring, if necessary, and, in both ends within the range of the operation of said movable core, holding the position by the adsorption power of said permanent magnet or further by the restoration power of said spring if necessary.

20. The vacuum switchgear according to any one of claim 17 to claim 19, characterized in that

when the movable core is moved by exciting one an electromagnetic coil of said solenoid mechanism and an electromagnetic coil of said electromagnetic actuator, other electromagnetic coil is excited to strengthen the holding power at the position of other movable cores which does not move.

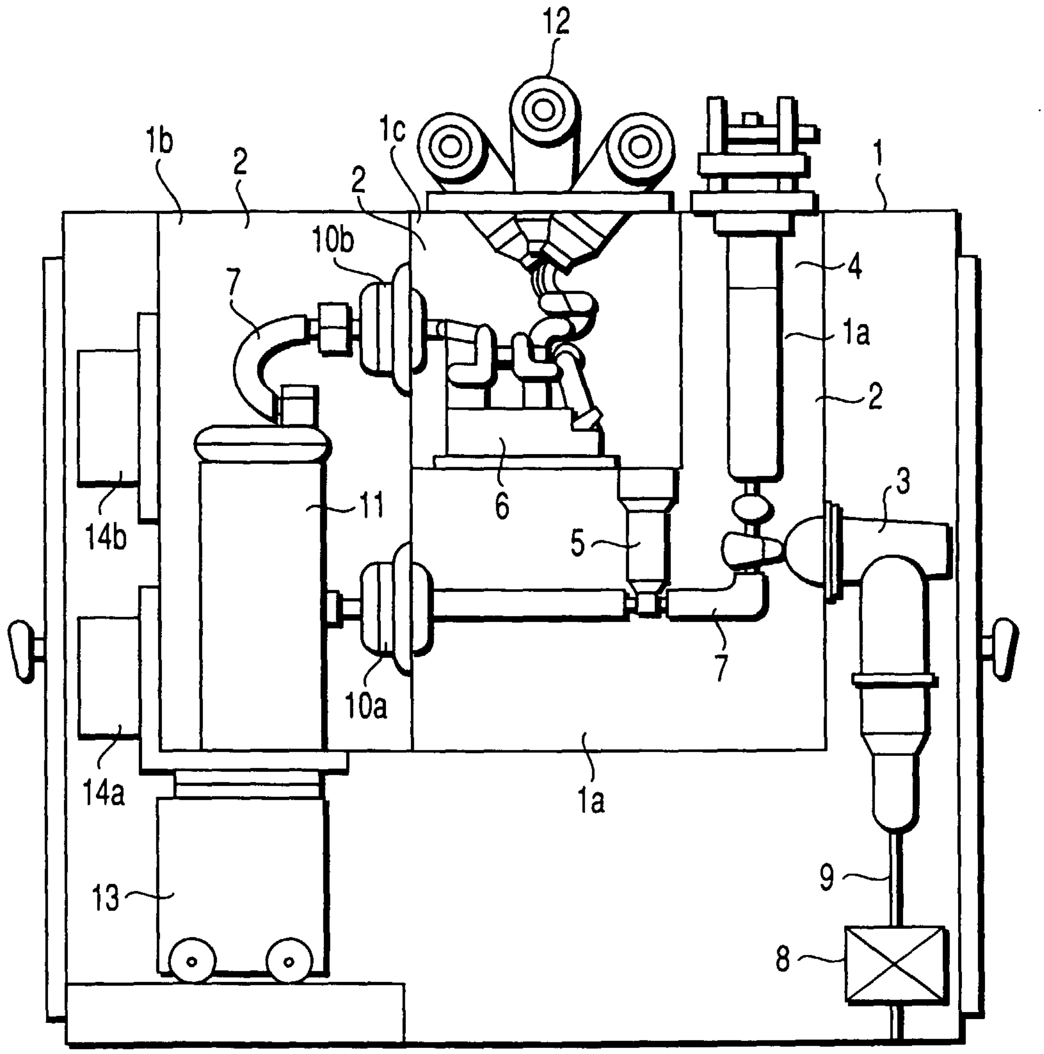


FIG. 1

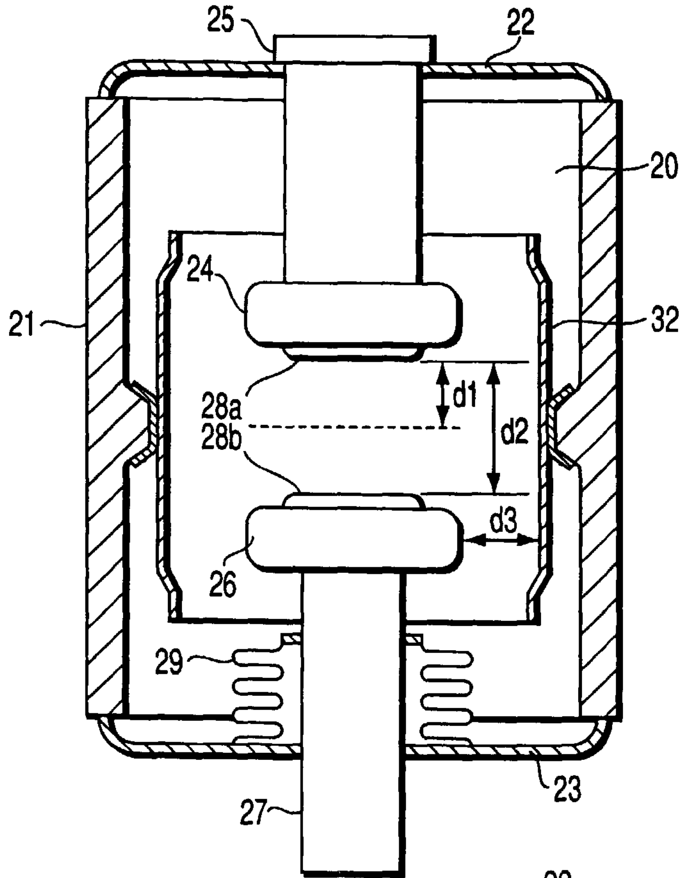

25
22
20
24
21
32
d1
28a
d2
28b
d3
26
29
23
27

FIG. 2

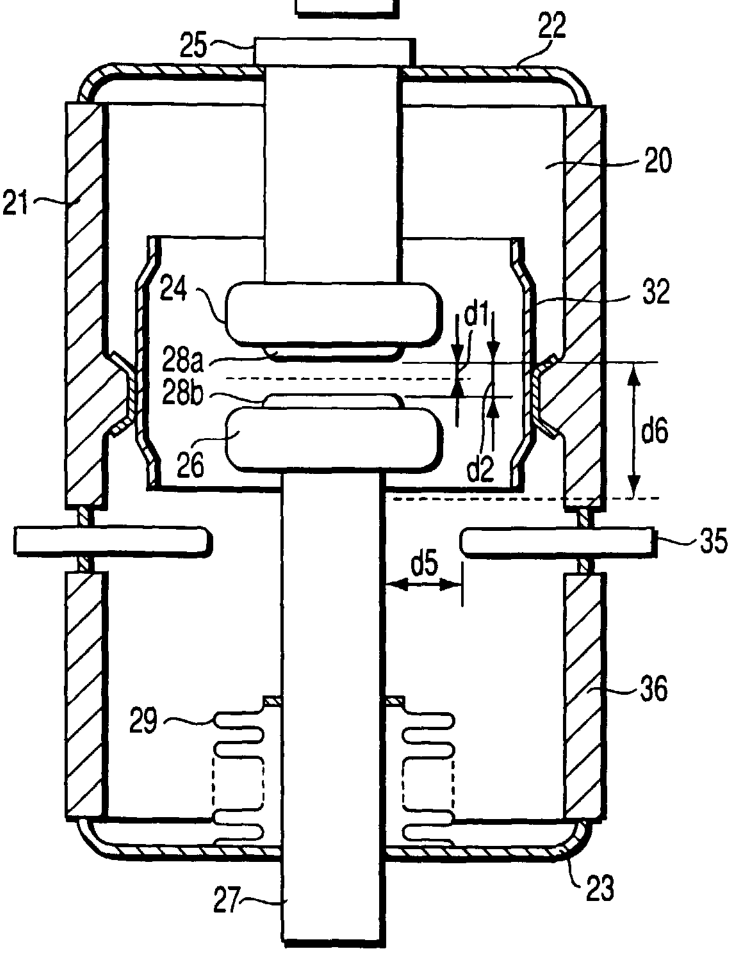

25
22
20
21
24
32
d1
28a
28b
d6
26
d2
35
d5
36
29
23
27

FIG. 3

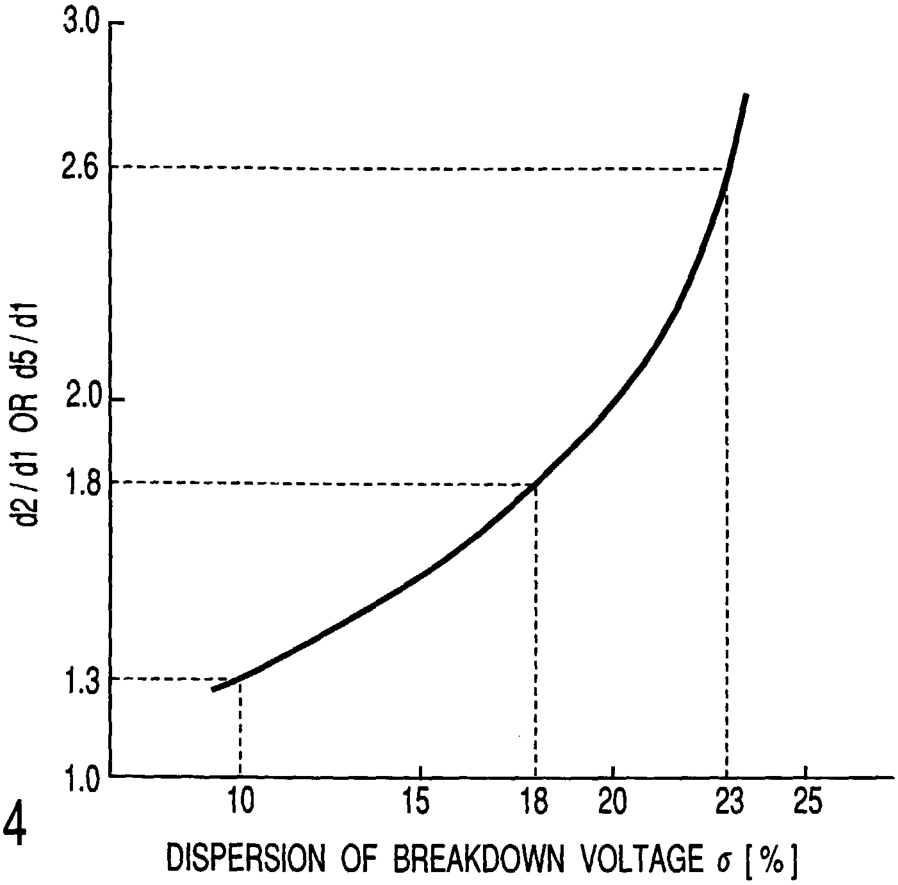

3.0
2.6
2.0
1.8
1.3
1.0
d2 / d1 OR d5 / d1
10
15
18
20
23
25
DISPERSION OF BREAKDOWN VOLTAGE σ [%]

FIG. 4

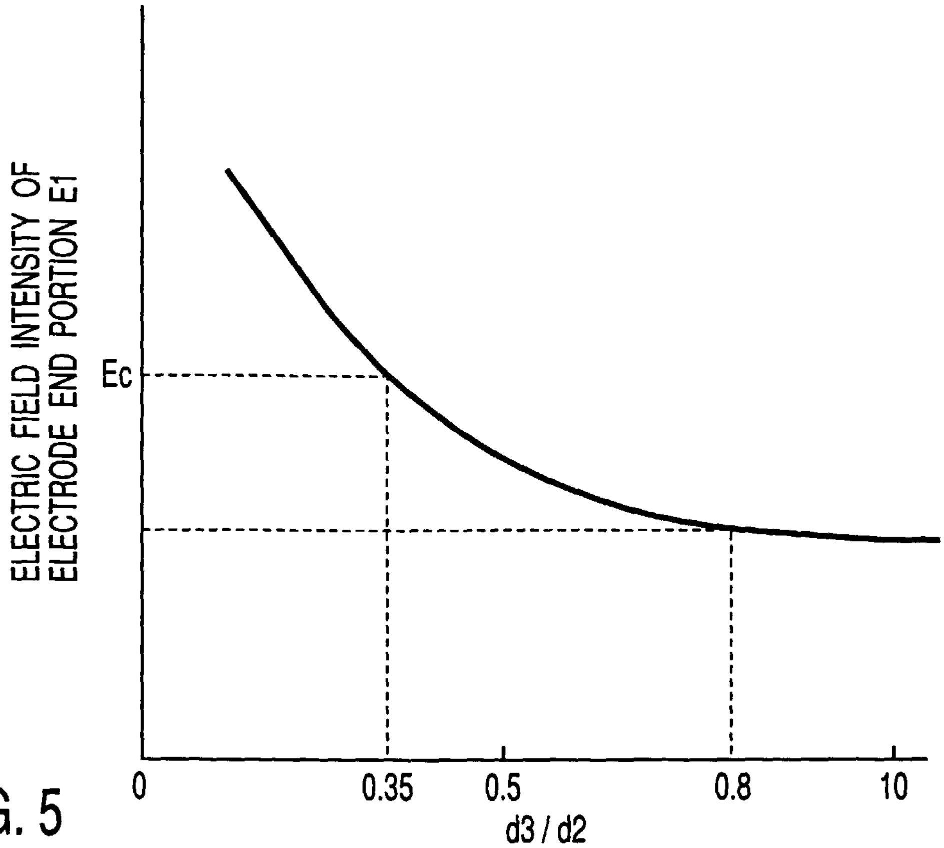

ELECTRIC FIELD INTENSITY OF ELECTRODE END PORTION E1
Ec
0
0.35
0.5
0.8
10
d3 / d2

FIG. 5

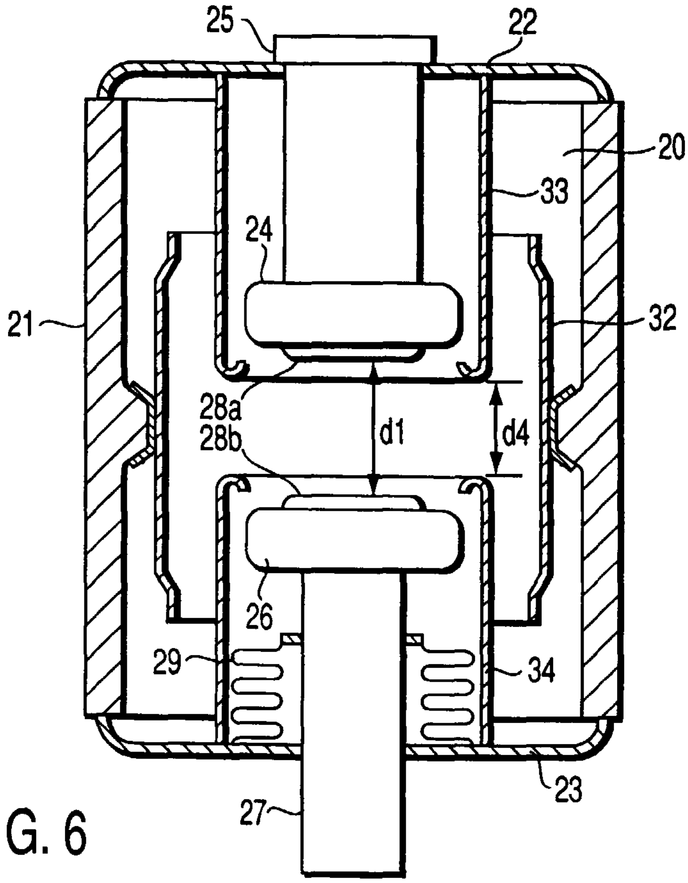

25
22
20
33
24
21
32
28a
28b
d1
d4
26
29
34
23
27

FIG. 6

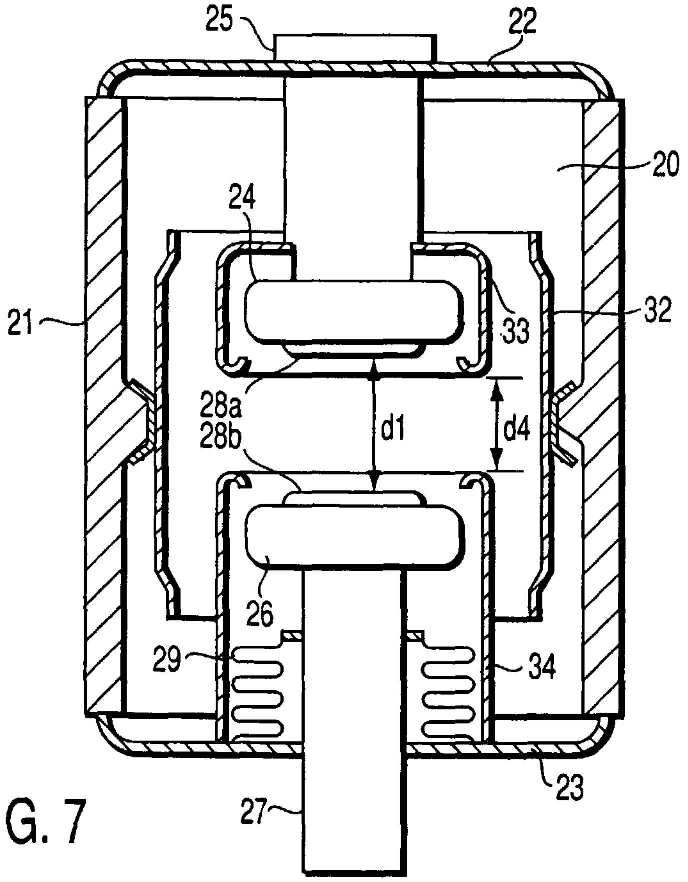

25
22
20
24
21
33
32
28a
28b
d1
d4
26
29
34
23
27

FIG. 7

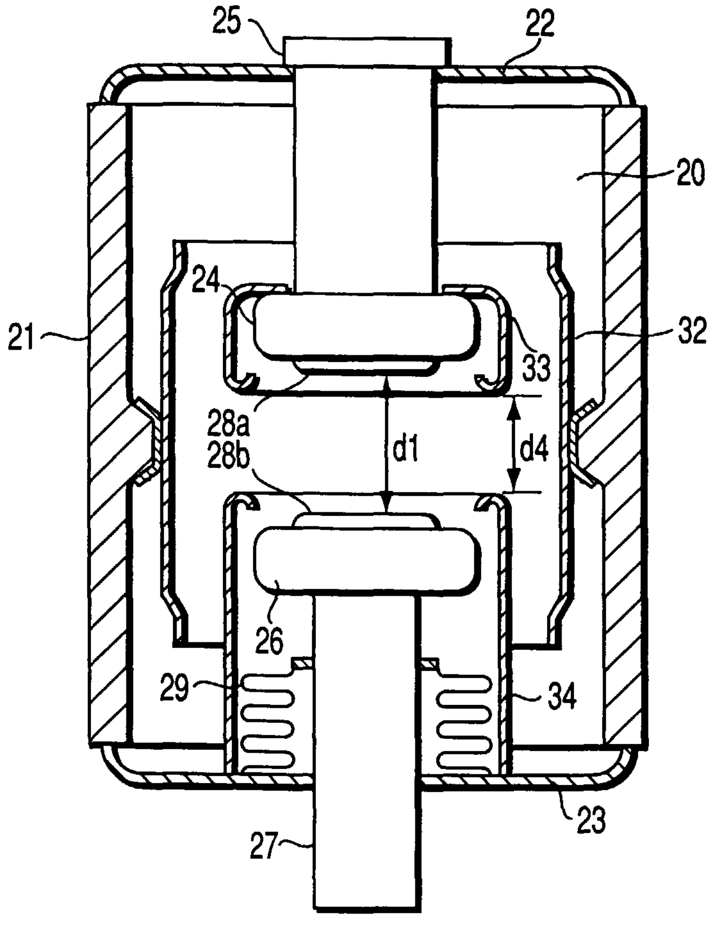


FIG. 8

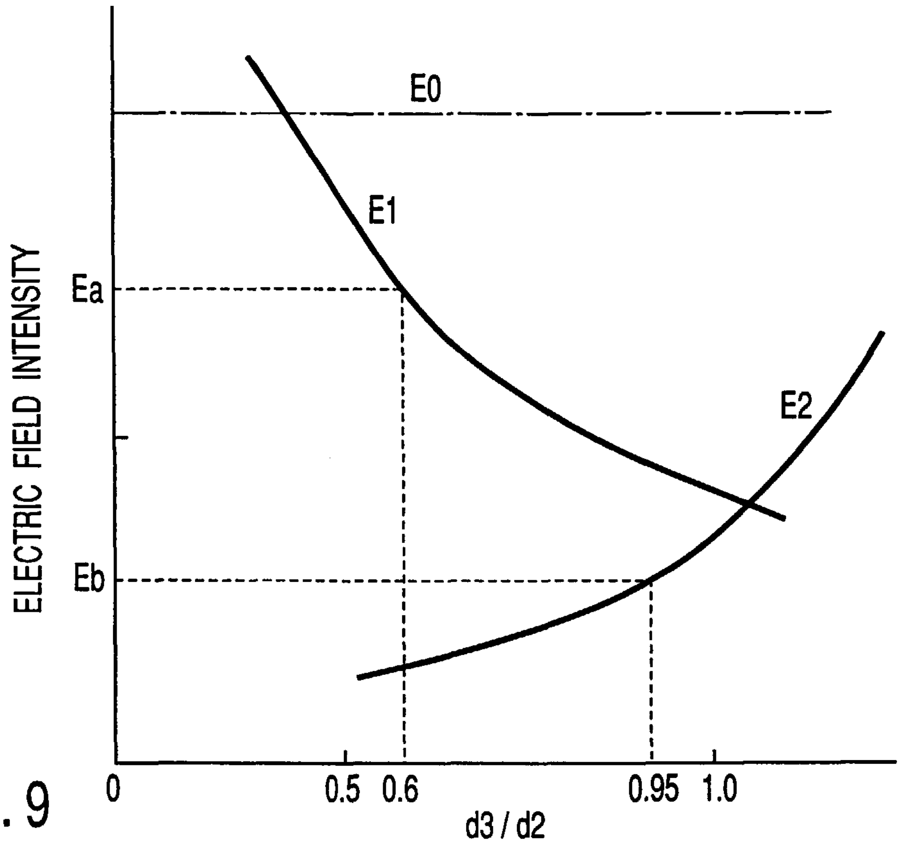

E0
E1
E2
Ea
Eb
ELECTRIC FIELD INTENSITY
0
0.5
0.6
0.95
1.0
d3 / d2

FIG. 9

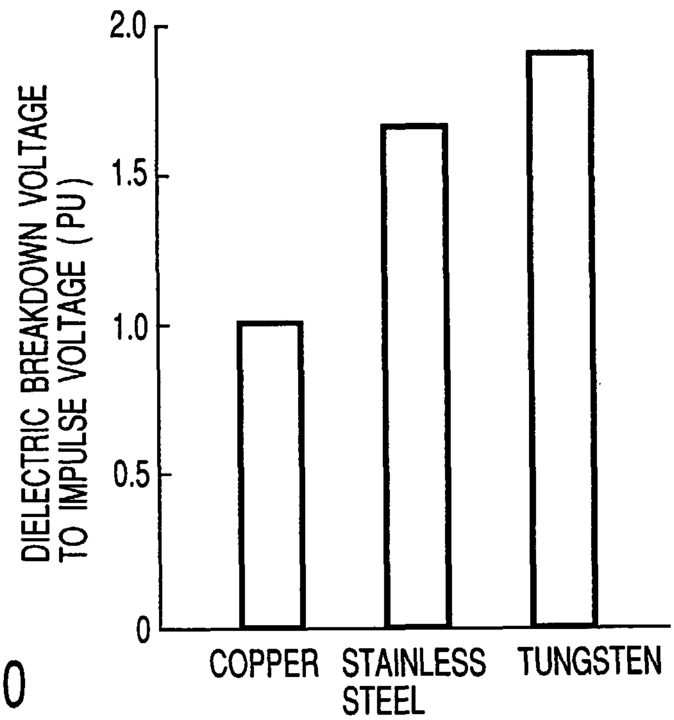

2.0
1.5
1.0
0.5
0
DIELECTRIC BREAKDOWN VOLTAGE TO IMPULSE VOLTAGE (PU)
COPPER
STAINLESS STEEL
TUNGSTEN

FIG. 10

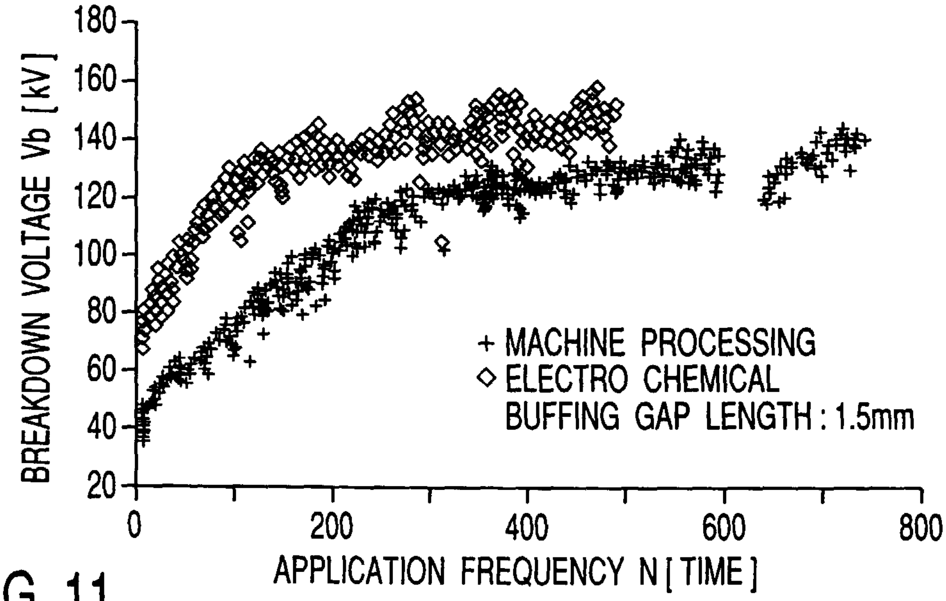

180
160
140
120
100
80
60
40
20
BREAKDOWN VOLTAGE Vb [kV]
0
200
400
600
800
APPLICATION FREQUENCY N [TIME]
+ MACHINE PROCESSING
◇ ELECTRO CHEMICAL
BUFFING GAP LENGTH : 1.5mm

FIG. 11

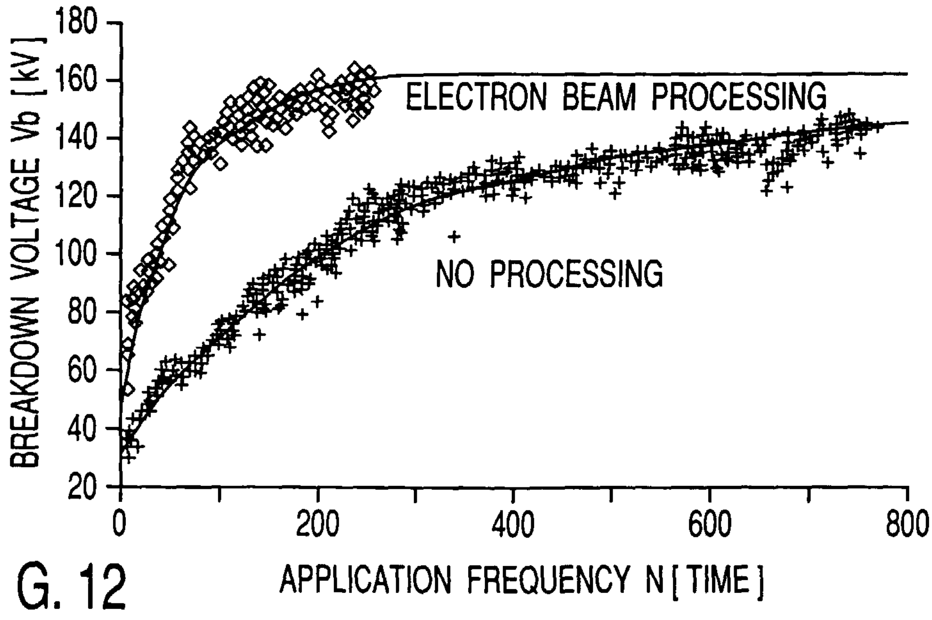
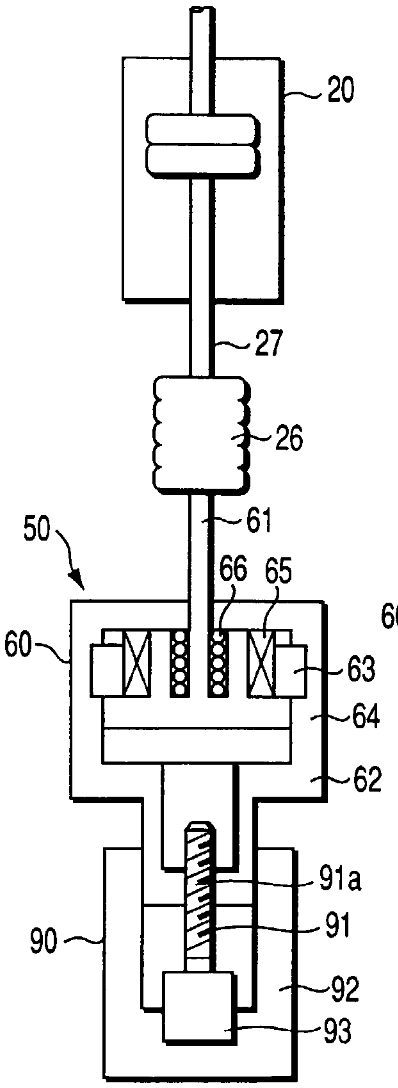
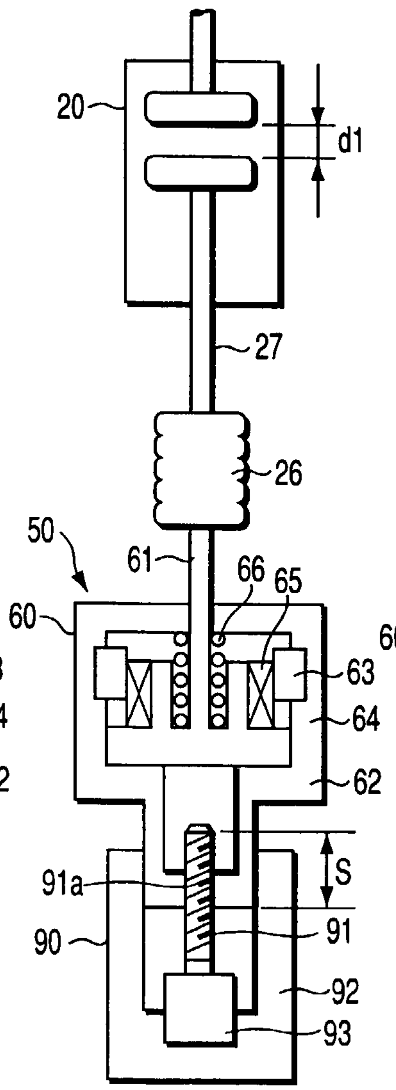

180
160
140
120
100
80
60
40
20
BREAKDOWN VOLTAGE Vb [kV]
0
200
400
600
800
APPLICATION FREQUENCY N [TIME]
ELECTRON BEAM PROCESSING
NO PROCESSING

FIG. 12



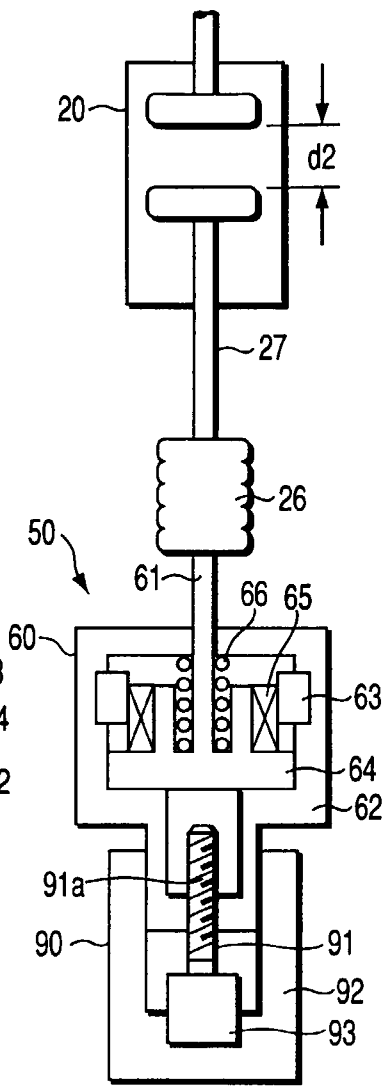
CLOSE POSITION

F I G. 13A



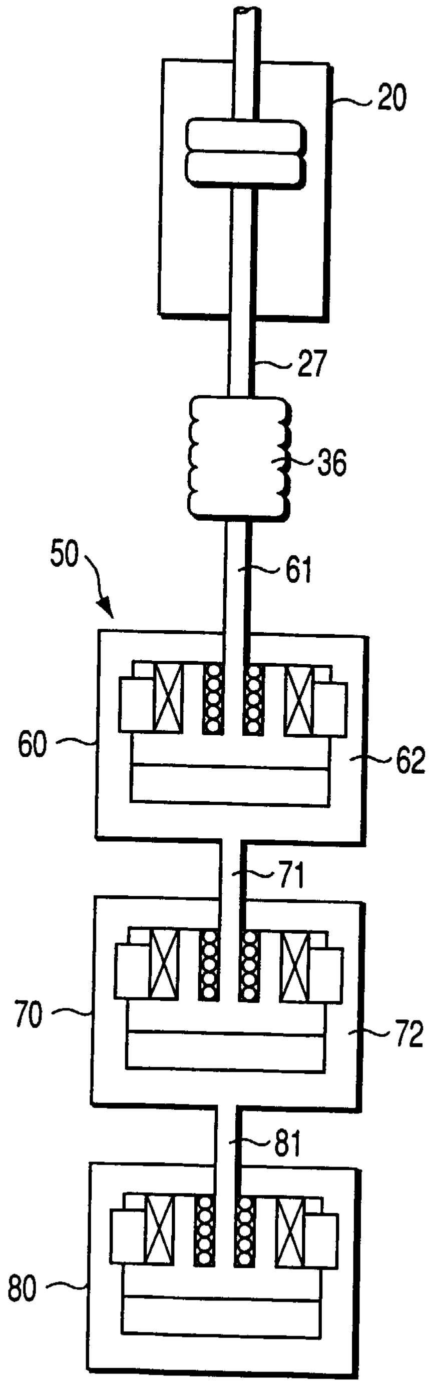
OPEN POSITION

F I G. 13B

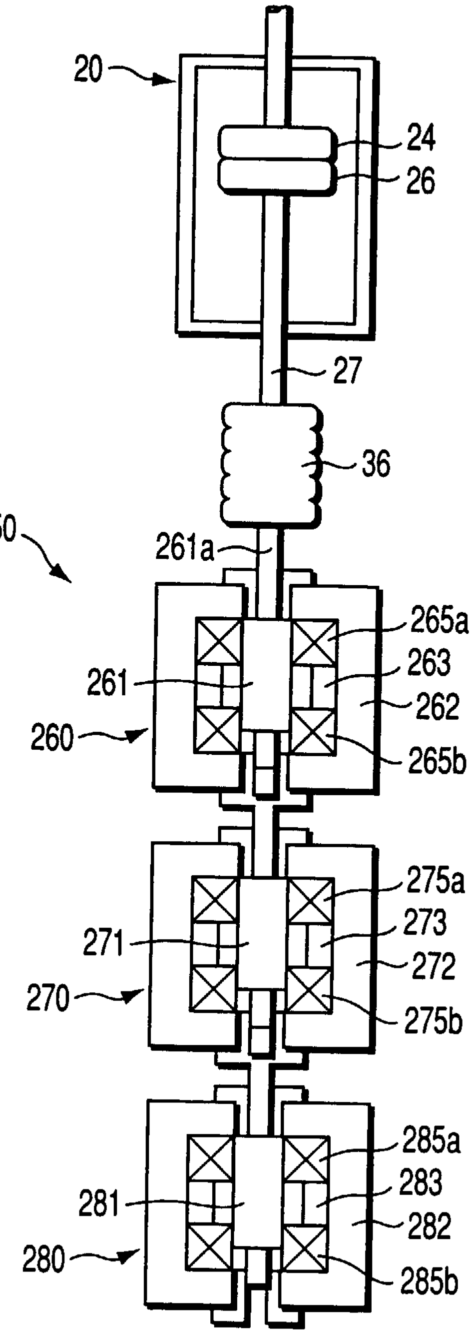


ISOLATION POSITION

F I G. 13C


20
27
36
50
61
60
62
71
70
72
81
80

F I G. 14


20
24
26
27
36
250
261a
265a
261
263
262
260
265b
275a
273
271
272
270
275b
285a
283
281
282
280
285b

F I G. 17

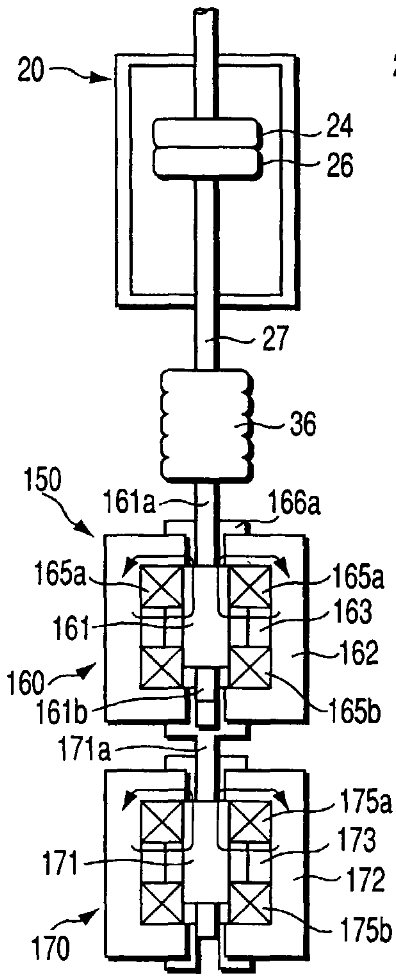


FIG. 15A

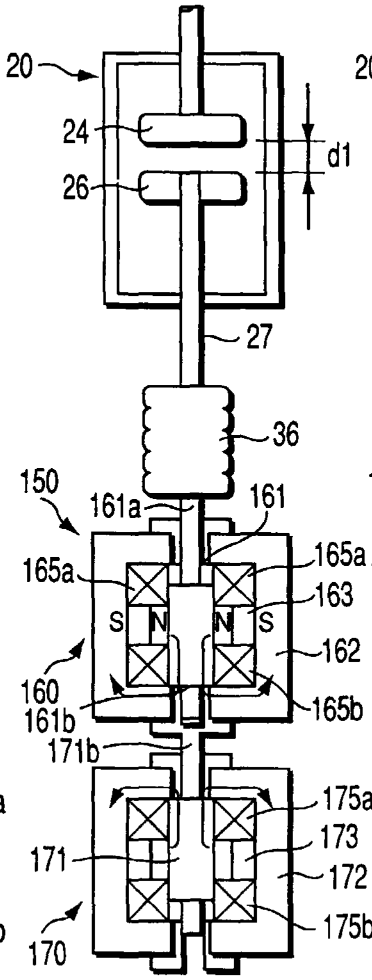


FIG. 15B

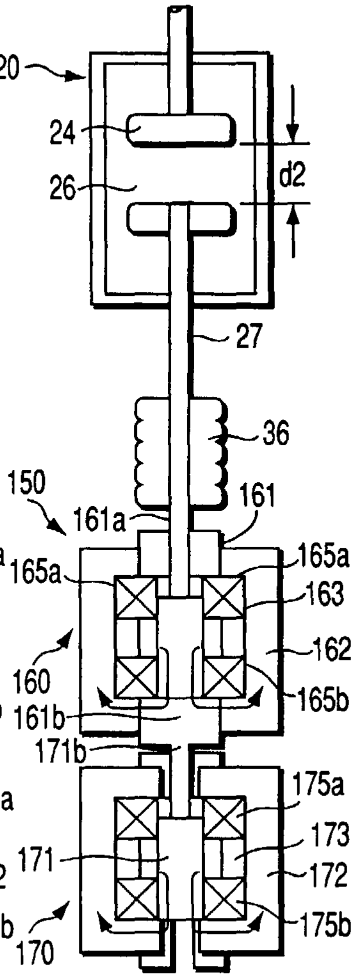


FIG. 15C

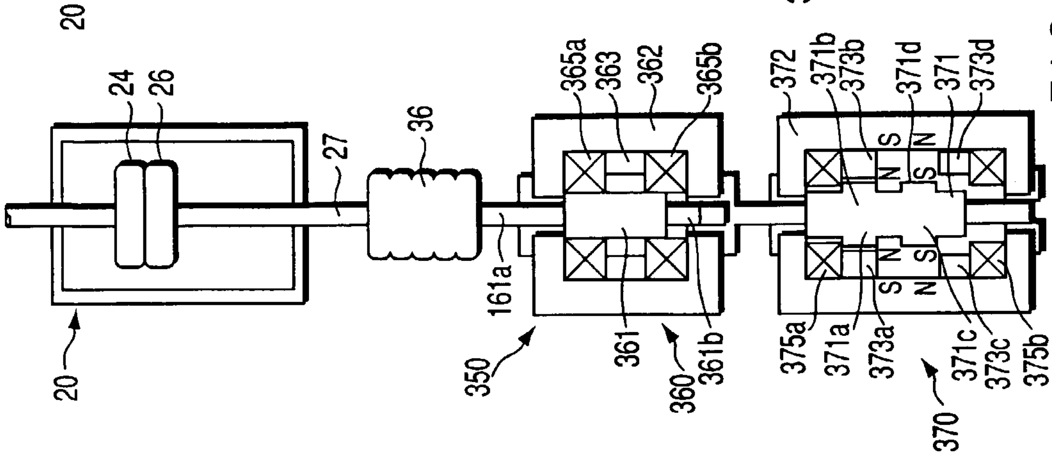


FIG. 16A

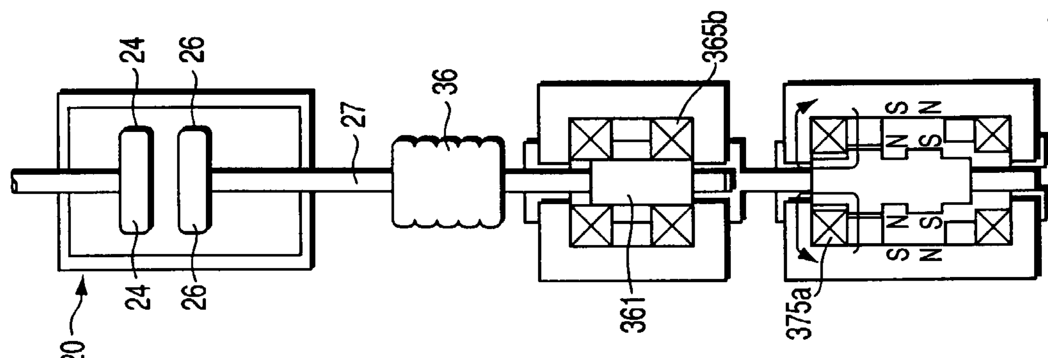


FIG. 16B

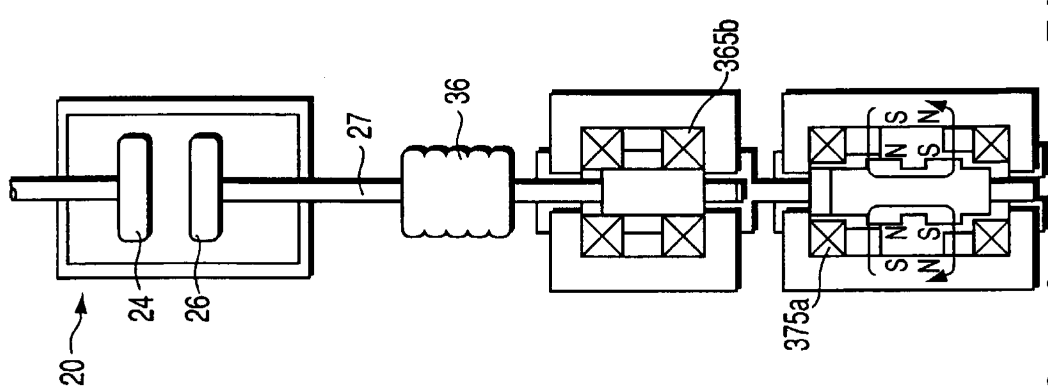


FIG. 16C

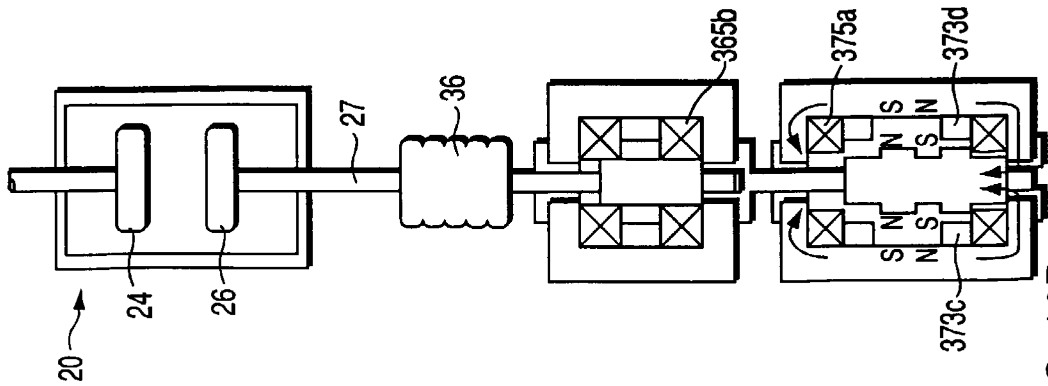


FIG. 16D