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(54) **Vacuum switchgear and a method of diagnosing vacuum pressure thereof**

Vakuumschaltgetriebe und Verfahren zur Diagnose des Vakuumdrucks darin

Appareil de commutation sous vide et procédé de diagnostic de pression sous vide

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Description

FIELD OF THE INVENTION:

[0001] The present invention relates to a vacuum switchgear having a diagnosis function and a method of diagnosing a vacuum pressure of a switch section.

RELATED ART:

[0002] In general, a vacuum-switchgear performs opening and closing of electrodes in a vacuum vessel, and the pressure in the vacuum vessel (vacuum pressure) may affect on a voltage withstanding performance and interruption characteristics of the switchgear. Fig. 4 shows a Paschen curve representing a discharge characteristic in vacuum, i.e. a relationship between a pressure and a discharge start voltage, wherein a vacuum isolation gap length is set to 5mm.

[0003] As shown in the figure, the discharge start voltage depends on the vacuum pressure, which means the voltage withstanding performance and interruption characteristics depend on the vacuum pressure. Accordingly, the vacuum switchgear must be periodically diagnosed about normality or soundness of the vacuum pressure so as to guarantee the performance thereof.

[0004] The diagnosis of the soundness of the vacuum pressure of the vacuum switchgear has been conducted by applying a predetermined high voltage between the electrodes thereby to detect a flashover. In this case the switchgear must be power-cut at the time of diagnosis, and a high voltage power source for applying the high voltage is necessary. Thus, a cost and load for diagnosis increases.

[0005] In order to avoid the cost increase for diagnosis it is desired to conduct the diagnosis in service of the switchgear, i.e. without power cutting of the switchgear. A switchgear that is capable of conducting the in-service diagnosis is known in patent document No. 1 (Japanese patent laid-open 2007-80549), for example.

[0006] In the patent document No. 1, a switchgear is disclosed
wherein a measurement terminal for vacuum pressure diagnosis is disposed in opposed relation with respect to a metal vessel of a floating potential, in which the measurement terminal is molded together with the metal vessel in an insulator, and the measurement terminal is connected to a condenser one end of which is earthed. A voltage between the ends of the condenser is compared by means of a comparator with a predetermined threshold voltage, and a warning lamp, which is ON/OFF by a relay contact in response to an output of the comparator to thereby diagnose soundness of the vacuum pressure.

[0007] In the above-described switchgear, an operator who is in charge of the diagnosis recognizes and confirms ON/OFF of the warning lamp at the time of periodic diagnosis to thereby diagnose the soundness of the vacuum pressure.

[0008] In secondary power stations close to consumers, which are installed on road shoulders, vacuum switchgears are covered with an outer case, chances of observing warning lamps is once in several years. Accordingly, if vacuum pressure degrades to light the warning lamps for a long time, soundness of the warning lamps should be diagnosed. Since the warning lamps may be damaged or out of order, degradation of vacuum pressure might be over-looked.

[0009] EP 1 763 049 A1 describes a vacuum switchgear in line with the preamble of present claim 1.

SUMMARY OF THE INVENTION:

[0010] The vacuum switchgear having a vacuum pressure diagnosis function disclosed in the patent document No. 1 has a vacuum pressure diagnosis apparatus (51) is always connected to a terminal (50). Therefore, the diagnosis apparatus must be equipped to each of the vacuum switchgears.

[0011] It is necessary to diagnose soundness of the diagnosis apparatus itself. If the diagnosis is out of order, reliability of the diagnosis is lost. Further, it is necessary to diagnose whether main circuits of the switchgears are on or off. If the main circuits are not in close position, and if such the status is not taken into consideration, the result of the diagnosis should be wrong. Therefore, the diagnosis of the power application status of the main circuits should be done before the diagnosis of the vacuum pressure.

[0012] Accordingly, from the viewpoint of fail-safe, it was necessary to dispose a reversible circuit in the technology disclosed in the patent document No. 1, which makes the circuit ON when the signal potential is sound or OFF when the signal potential is not sound, or to dispose another circuit/tool for diagnosing the warning lamp. As a result, the structure thereof became complicated and its cost increased.

[0013] The present invention aims at providing a switchgear that is capable of performing easily diagnosis of soundness of a diagnosing apparatus for vacuum pressure and main circuits of the switchgear as well as soundness of vacuum pressure of a metal vessel. The present invention also aims at providing a method of diagnosing vacuum pressure that is capable of easily performing diagnosis of vacuum pressure of the vacuum switchgear with increased reliability.

[0014] The present invention provides a vacuum switchgear as defined in claim 1 and a diagnosis method as defined

in claim 5. The subclaims relate to preferred embodiments.

[0015] According to the embodiments of the present invention, the diagnosis of the vacuum pressure can be carried out easily because the diagnosis is done by observing the voltage indicators having lamps such as LEDs or buzzers, which are on the market. The voltage indicators are electrically connected to an connecting means such as connecting plugs disposed to the casing of the switchgear. That is, the diagnosis of the present invention does not need specific circuits or devices that are used in the patent document No. 1.

[0016] Further, the diagnosis of the present invention can be conducted with a high reliability because the diagnosis can be carried out after confirmation of the ON state of the main circuit of the switchgear or after diagnosis of the ON state of the main circuit using an inner diagnosis circuit the diagnosis of the vacuum pressure is done by the voltage indicator, i.e. by a two step method.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0017]

Fig. 1 shows a side cross sectional view of a switchgear of an embodiment of the present invention.
Fig. 2 is a detailed cross sectional view of a switch section of the switchgear shown in Fig. 1.
Fig. 3 is a flow chart showing a method of diagnosis of vacuum pressure of the present invention.
Fig. 4 shows Paschen curve showing relationship between vacuum pressure and a discharge start voltage.

[0018] In the drawings the reference numerals are:

1; vacuum switchgear, 2; casing, 3; operation mechanism, 4; bus bar, 5; cable, 12; metal vessel, 20; solid insulator, 50; terminal, 100; switch section, 101, 102, vacuum bulbs, 110, 114; fixed electrodes, 111, 115, 143; fixed conductor, 112;bus bar side conductor, 116; load side conductor, 117; bushing, 118, 140; ceramic cylinders, 119; arc shield, 120, 121, 146; movable electrodes, 122, 123, 144; movable electrode conductors, 124, 149; electric connecting conductor, 125; ceramic rod, 126; operating rod, 127, 151; insulating rods, 130,148; bellows, 141,142; terminal plates, 150; metal connector, 152; voltage detection condenser (second condenser), 1001; voltage detection coupling condenser (third condenser), 1002; front panel of the casing, 1003, 1006; electric connecting plugs, 1004, 1007; coaxial cables, 1005; vacuum pressure diagnosis condenser, 2000; voltage indicator.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS:

[0019] In the following embodiment of the present invention will be explained by reference to Figs. 1 to 4.

[0020] As shown in Figs. 1 and 2, a vacuum switchgear 1 comprises a switch section 100, an operating mechanism 3 for operating electrodes of the switch section 100. The operating mechanism 3 is disposed above the switch section 100, a bus bar 4 connected to the vacuum switch for supplying electric power to the switch section 100, a cable 5 for supplying electric power to a load side from the vacuum switch 100, and a casing 2 encasing the above components.

[0021] The switch section 100 comprises a vacuum bulb 101 for a circuit breaker and a disconnector, a vacuum bulb 102 for an earth switch, a conductor 112 for connecting the vacuum bulb 101 and a bus bar 4, a bushing 113 for connecting the conductor 112 and the bus bar 4, a conductor 116 for connecting the vacuum bulb 101 and the cable 5, a second condenser 152 for detecting voltage, a coupling condenser 1001 for detecting voltage, and a condenser 1005 for diagnosing vacuum pressure of the vacuum bulb 101.

[0022] The switch section 100 is encased in the casing 2 together with a condenser 1005 for diagnosing vacuum pressure of the vacuum vessel 12 and a condenser second for diagnosing a status of a main circuit of the switch section 100. The condensers 1005 and 152 are connected to a connecting means 1003 or 1006 disposed to the front panel 1002 of the casing, as shown in Fig. 1.

[0023] A voltage indicator 2000 is connected to the first connecting means 1006 or second connecting means 1003. The voltage indicator is available on the market as VOISOR+ (manufactured by Kries-Energietechnik GmbH & Co.), for example. The voltage indicator may indicate the state of the main circuit and/or vacuum pressure of the metal vessel by light (lamps) or sound, etc.

[0024] The first condenser is connected to the second connecting means 1003 when the diagnosis of the main circuit of the vacuum switch is conducted. Normally, the diagnosis of the main circuit is done prior to the diagnosis of the vacuum pressure.

[0025] The vacuum bulb 101 disposed in the switch section 100 and having interruption and disconnection characteristics comprises a metal vessel 12 in float potential, two pairs of fixed electrodes 110, 114 and movable electrodes 120, 121 disposed in the metal vessel 12 and in opposite relation. The fixed electrode 110 is supported by one end of the fixed conductor 111. The movable electrode 120 is supported by one end of the movable conductor 122, and the

other end of the movable conductor 122 is connected to a connecting conductor 124. The fixed electrode 114 is supported by one end of the fixed conductor 115 and the other end of the fixed conductor 115 is connected to the conductor 116.

[0026] An arc shield 119 is arranged around the fixed electrode 110 and the movable electrode 120 to prevent metal particles emitted from the electrodes at the time of interruption from adhesion on the inner face of the ceramic cylinders, the arc shield 119 being sandwiched between ceramic cylinders 118 surrounding the electrodes. The connecting conductor 124 is connected to an operating rod 126 by means of a ceramic rod 125. A bellows 130 is disposed between the operating rod 126 and the metal vessel 12 so as to operate the operating mechanism 3, keeping a vacuum condition of the switch section 100. The operating rod 126 extrudes from the metal vessel 12 of the switch section 101, and an end of the operating rod 126 located at the opposite position with respect to the ceramic rod 125 is supported by the insulating rod 127 and connected to the operating mechanism 3.

[0027] As shown in Fig. 2, the terminal 50 for diagnosis of the vacuum pressure is molded in integral with the solid insulator 20 on the metal vessel 12 to thereby electrically insulate the metal vessel 12 of the vacuum bulb 101 from the terminal 50. The terminal 50 is disposed outside of the metal vessel 12 and opposed to the metal vessel 12. The solid insulator 20 has a conductive coating 21 on its surface, and the coating is in an earth potential by earthing. The terminal 50 and the conductive coating 21 are electrically insulated from each other.

[0028] On the other hand, the vacuum bulb 102 for an earth switch comprises an insulating ceramic cylinder 140 surrounding the fixed electrode 145 and the movable electrode 146, bellows 148, and terminal plates 141, 142 located at both ends of the ceramic cylinder. The movable electrode 146 opposed to the fixed electrode 145. The fixed electrode 145 is supported by one end of the fixed conductor 143, one end of which is connected to a conductor 116. The movable electrode 146 is supported by one end of the movable conductor 144, which is supported by the terminal plate 141 by means of the bellows 148. Part of the movable conductor 144 extrudes outwardly in the axial direction from the ceramic cylinder 140 and the terminal plates 141, 142.

[0029] The bellows 148 follows the movement of the movable conductor 144, and the bellows 148 can air-tightly seal the space between the movable conductor 144 and the terminal plate 141. The end of the movable conductor 144, which is opposite to the end supported by the movable electrode 146 is connected to a connecting conductor 149, which is earthed, and the connecting conductor 149 is connected to an insulating rod 151 by means of a metal tool 150. The insulating rod 151 is connected to an operating mechanism 3 at its upper part. A high temperature solder bonds the components in the vacuum bulb 102 are bonded in a vacuum furnace.

[0030] One end of the voltage detecting condenser 152, which is opposite to the end connected to the conductor 116, is connected to one end of a voltage detecting coupling condenser 1001, and the other end of the coupling condenser 1001 is earthed.

[0031] Connecting plugs 1003 and 1006 to which a voltage indicator 2000 is electrically connected are disposed in the front panel 1002 of the casing 2. The voltage indicator 2000, which is a plug in type, indicates the status of voltage application of the U, V, W switches of the switchgear 1. If all of the U, V, W switches are ON, the voltage indicator 2000 indicates the three switches are ON. If one or more of the switches are not ON, the indicator indicates one or more of the switches are OFF. According to this indication, the status of the power application of the switches is recognized. The voltage indicator 2000 may be equipped with LEDs, etc, which indicate information on the status. The voltage indicator 2000 can be detached from the connecting plugs 1003, 1006.

[0032] The connecting plug 1003 is connected to both ends of the coupling condenser 1001 by means of a co-axial cable 1004 to apply the voltage of the coupling condenser 1001 to the connecting plug 1003.

[0033] The connecting plug 1006 is used for connecting the voltage indicator 2000 to detect and indicate a status of vacuum pressure in the metal vessel 12 of the U, V, W switches. If vacuum of one of the metal vessels of the switches leaks to higher a vacuum pressure in the metal vessel, discharge may take place in the switch section 100 because of the presence of air therein so that a voltage of the metal vessel increases. The voltage indicator 2000 indicates the status of the vacuum in the metal vessels based on the voltage of the metal vessel. Accordingly, the vacuum status can be diagnosed by the indication on the indicator 2000. In this specification, the voltage indicator 2000 was used as a vacuum diagnosis means.

[0034] A terminal 50 for diagnosis of vacuum pressure is molded in the solid insulator 20 such as epoxy resin is located outside of the metal vessel 12. The solid insulator 20 electrically separates terminal 50 from the metal vessel 12. The terminal 50 is connected to a vacuum diagnosis condenser 1005 one end of which is earthed. The both ends of the condenser 1005 are connected to the connecting plug 1003 by means of a co-axial cable 1007. The potential of the first condenser 1005 is applied to the connecting plug 1003.

[0035] Next, Open-closing mechanism of the earth switch vacuum bulb 101 disposed in the switch section 100 will be explained. Upon the up and down movement of the insulating rod 151 operated by the operating mechanism 3, the movable electrodes moves up and down so as to make open-closing operation with the fixed electrode 145. One end of the fixed conductor 143 connects to the conductor 116. Since the connecting conductor 149 is earthed, a load is earthed upon closing of the vacuum bulb 101.

[0036] Current flow in the switch section 100 and operation mechanism 3 will be explained in the following. Electric

power from the bus bar 4 is supplied to bushing 113 - conductor 112 - fixed conductor 111 - fixed electrode 110 - movable electrode 120 - movable conductor 122 - connecting conductor 124 - movable conductor 123 - movable electrode 121 - fixed electrode 114 - fixed conductor 115 - conductor 116 - bushing 117, and the electric power is supplied to the load side by means of cable 5.

[0037] The operating mechanism 3 drives the insulating rod 127 up and down, the movable electrodes 120, 121 moves to three positions to form close position Y0, open position Y1 and disconnection position Y2 with the fixed electrodes 110, 114. The movement from the close position Y0 to open position Y1 performs an interruption function and the movement from the open position to the disconnection position Y2 performs a disconnection function.

[0038] In the following the diagnosis of vacuum pressure of the metal vessel 12 will be explained by reference to Fig. 3, as well as Figs. 1 and 2.

[0039] At first, diagnosis of the power application on the main circuit of the switches is conducted. The voltage indicator 2000 is connected to the connecting plug 1003 (step 200). When the conductor 116 is ON, a potential between the voltage detecting condenser 152 and the voltage detecting coupling condenser 1001 is equal to a partial voltage V1, which is represented as follows.

$$V1 = V/\sqrt{3} \times C_{152}/(C_{152}+C_{1001})$$

[0040] In the above equation, the partial potential V1 is a product of a rate of a static capacitance C_{152} of the second condenser 152 to the total capacitance of the capacitance C_{152} of the condenser 152 and a capacitance C_{1001} of the third condenser 1001 and the earth voltage $V/\sqrt{3}$. Accordingly, if a voltage proportional to V_1 is applied to the connecting plug 1003, the voltage indicator 2000 indicates that the main circuit is ON, and as a result, the voltage indicator 2000 is judged as sound (step 204).

[0041] On the other hand, when the voltage indicator 2000 does not turn on, positions of the movable electrodes 120, 121 are checked if they are in the close positions. If they are not in the close position, they are moved to close positions by means of the operating mechanism 3. If the voltage indicator 200 turns on, the voltage indicator 200 is judged as sound (step 204). If the voltage indicator 200 does not turn on upon closing the switches, the voltage indicator 200 is judged as out of order (step 203). The voltage indicator 2000 is repaired or substituted with another voltage indicator.

[0042] Therefore, it is possible to diagnose soundness of the vacuum switch 1 and the voltage indicator 2000 by judging turn-on of the voltage indicator 2000.

[0043] Next, the voltage indicator 2000 is connected to the connecting plug 1006 (step 205).

[0044] A static capacitance Cg between the metal vessel 12 in a float potential and the earthed conductive coating 21 sufficiently large, compared with static capacitance Cm between the main circuit in the vacuum bulb 101 and the metal vessel 12 (Cg»Cm). Accordingly, the potential of the metal vessel 12 becomes almost the same as the earth voltage when the vacuum pressure is sound.

[0045] On the other hand, if the vacuum pressure becomes worse, and discharge between the main circuit in the vacuum bulb 101 and the metal vessel 12 takes place. As a result, the potential of the metal vessel 12 increases to the earth voltage $V/\sqrt{3}$ of the line voltage V. That is, a potential between the metal vessel 12 and the terminal 50 and the potential between the terminal 50 and the vacuum pressure diagnosis condenser 1005 is almost the same as the earth potential when the vacuum pressure is sound. However, when the vacuum pressure becomes worse to generate discharge between the main circuit and metal vessel, the terminal voltage becomes equal to the potential V_2, which is represented by the following equation.

$$V_2 = V/\sqrt{3} \times C_0/(C_0+C_{1005})$$

[0046] In the above equation, C_0 is a capacitance between the terminal 50 and the metal vessel 12 and C_{1005} is a static capacitance of the vacuum pressure diagnosis condenser 1005.

[0047] Accordingly, a voltage proportional to the partial potential V2 is applied between the first condenser and the connecting plug 1003, which is connected to the condenser 1005 by means of the co-axial cable 1007. If the voltage indicator 2000 turns on, the vacuum pressure is judged as sound (step 206), but if it turns on, the vacuum pressure in the metal vessel 12 is judged as not sound (step 207). If the vacuum pressure is judged as not sound, the vacuum bulb 101 or switch section 100 is repaired or exchanged with another one.

[0048] The relationship between static capacitance C_{152} of the second condenser 152 and the static capacitance C_{1001} of the third condenser 1001 is as follows.

$$(C_{1001}/C_{152}) \leqq \{(V/\sqrt{3})-v\}/v$$

[0049] In the above formula, if a driving voltage of the voltage indicator 2000 is v, v≦V1.

[0050] Therefore, if a ratio of the capacitance C_{1001} of the condenser 1001 to capacitance C_{152} of the second condenser 152 is equal or smaller than a ratio of a difference between V/ √3 and the driving voltage v of the voltage indicator 2000 to the driving voltage v, the vacuum bulb 101 can be detected.

[0051] The relationship between the static capacitance Co between the terminal 50 and the metal vessel 12 and the capacitance C_{1005} of the first condenser 1005 is as follows. The driving voltage v of the voltage indicator 2000 should be equal to or smaller than V2. That is, v«V2.

$$(C_{1005}/C_o) \leqq \{(V/\sqrt{3})-v\}/v$$

[0052] Therefore, if a ratio of the capacitance C_{1005} of the condenser 1005 to the capacitance C_0 of the static capacitance C_0 is equal to or smaller than a ratio of a difference between v/√3 and the driving voltage of. the voltage indicator 2000 to the driving voltage v, soundness of the voltage pressure of then vacuum bulb 101 can be diagnosed.

[0053] In this embodiment, the diagnosis of the power application of the main circuit and the vacuum pressure was conducted, but it is possible to conduct only the diagnosis of the vacuum pressure.

[0054] In this embodiment the terminal 50 is disposed in opposite relation to the metal vessel 12, one end of the vacuum pressure diagnosis condenser 1005 is connected to the terminal 50 and the other end thereof is earthed. The voltage indicator 2000 is connected to the first condenser by means of the co-axial cable 1007 and is connected to the connecting plug 1006. The voltage indicator is detachable from the connecting plug. The vacuum pressure is diagnosed by the voltage indicator 2000 upon demand. The portable voltage indicator 2000 is detachable, and can be used for diagnosis of the vacuum pressure of the switches on different sites. Therefore, the diagnosis is conducted economically.

[0055] In this embodiment, though the terminal 50 is opposed to the metal vessel 12, another member such as conductive film may be used instead of the terminal 50.

[0056] According to the embodiment, since the connecting plugs 1003 and 1006 are identical in the structure, one voltage indicator can be connected to them. As a result, the vacuum pressure of the metal vessel and the power application to the main circuit can be diagnosed with a single voltage indicator by changing the connecting plugs. In addition, the diagnosis of the voltage indicator 2000 itself can be done. Therefore, other circuit such as reversible circuits or elements for conducting diagnosis of the vacuum pressure, etc are not necessary, and hence the diagnosis of the present invention is economical and simple.

[0057] In this embodiment, the switch section 100 is covered with the solid insulator 20 such as epoxy resin together with the terminal 50, and the conductive coating 21 to be earthed is formed thereon. When the conductive coating is earthed, operator or other stuffs are safe even if they touch the coating 21 or the solid insulator 20.

[0058] The second condenser 152, third condenser (coupling condenser) 1001 and first condenser 1005 are disposed in the casing, but they may be arranged outside of the casing.

[0059] The connecting means is connecting plugs 1003, 1006, but the voltage indicator 2000 can be electrically connected to the ends of the condensers 1001, 152 with various means such as screws, etc.

[0060] In this embodiment, the status of power application of the main circuit and the soundness of the voltage indicator are diagnosed prior to the diagnosis of the vacuum pressure. Therefore, the diagnosis is carried out safely and with high reliability.

[0061] The diagnosis of the vacuum pressure of the switch section is conducted without increasing cost and making the structure complicated. In addition, if the voltage indicator 2000 is equipped with several terminals for connecting to the connecting plugs 1003, 1006, the diagnosis of the switch section and the vacuum pressure can be conducted simultaneously.

[0062] The connecting plugs 1003, 1006 are disposed on the front panel 1002 of the casing 2 so that operability and safety are increased. However, the connecting plugs can be disposed on other panels as long as operators or inspectors can observe the indication of the voltage indicator easily. In this sense, the voltage indicator can be such that the status of the soundness of vacuum pressure or main switch or voltage indicator itself is output as sound, buzzer, etc.

[0063] The first condenser 1005 and the connecting plug 1003 are connected to coupling condenser 1001 by means of the co-axial cables 1007, 1004. As a result, the wiring distance between the voltage indicator 200 and the third condenser 1001 or second condenser 152 is the same at any positions. Therefore, The capacitance generating on the wirings are the same at any positions so that it is possible to adjust voltages applied to the connecting plugs by means of the static capacitance of the first condenser 1005 and/or coupling condenser 1001.

Claims

1. A vacuum switchgear (1) comprising:

   a casing (2);
   a vacuum switch (100), enclosed in the casing (2), comprising a metal vessel (12) covered with a solid insulator (20), the surface of the insulator (20) being covered with a conductive layer (21) to be earthed, and a pair of a movable electrode (122, 123) and a fixed electrode (111, 115) to constitute a main circuit of a switch section (101), enclosed in the metal vessel (12);
   a first condenser (1005) connected to a terminal (50) on the solid insulator (20);
   a first electric connecting means (1006) disposed to the casing (2) and connected to the first condenser (1005) for detecting a voltage of the metal vessel (12); and
   a voltage indicator (2000) that is adapted to indicate a status of vacuum in the metal vessel (12) based on the detected voltage, when the voltage indicator (2000) is connected to the first connecting means (1006),
   characterized in that
   the vacuum switchgear (1) further comprises a second connecting means (1003) disposed to the casing (2) and connected to a second condenser (152), which is connected to a coupling condenser (1001), and
   the voltage indicator (2000) is adapted to indicate a status of power application to the main circuit based on a voltage applied to the second connecting means (1003), when the voltage indicator (2000) is connected to the second connecting means (1003).

2. The vacuum switchgear (1) of claim 1, wherein the voltage indicator (2000) is connectable to and detachable from the first and second connecting means (1006, 1003).

3. The vacuum switchgear (1) of claim 1, wherein one end of the second condenser (152) is connected to a load side conductor (116), and the other is connected to the coupling condenser (1001), the other end of the second condenser (152) being connected to the second electric connecting means (1003).

4. The vacuum switchgear (1) of any of claims 1 to 3, wherein a driving voltage v of the voltage indicator (2000) meets the relation

$$(C_{1005}/C_0) \leq \{(V/\sqrt{3})\text{-}v\}/v,$$

   where V is the line voltage, C_0 is a static capacitance between the terminal (50) and the metal vessel (12), and C_{1005} is a static capacitance of the first condenser (1005).

5. A method of diagnosis of a vacuum pressure in a metal vessel (12) of a vacuum switchgear (1) comprising: the metal vessel (12), covered with a solid insulator (20) the surface of which is covered with a conductive layer (21) to be earthed; at least a pair of a movable electrode (122, 123) and a fixed electrode (111, 115), enclosed in the metal vessel (12); a first condenser (1005) connected to a terminal (50) on the solid insulator (20); a first electric connecting means (1006) disposed to a casing (2) accommodating the vacuum switchgear (1), the first electric connecting means (1006) being connected to one end of the first condenser (1005) and the terminal (50); and a second electric connecting means (1003) disposed to the casing (2) and connected to a second condenser (152) which is connected to a coupling condenser (1001), the method comprising the steps of:

   connecting a voltage indicator (2000) to the second connecting means (1003), whereby a status of power application to a main circuit of the switchgear (1) is indicated on the voltage indicator (2000) to be ON or OFF based on a voltage applied to the second connecting means (1003);
   if the voltage indicator (2000) shows the main circuit is ON, connecting the voltage indicator (2000) to the first electric connecting means (1006), so that the voltage indicator (2000) indicates a status of vacuum in the metal vessel (12) based on a detected voltage of the metal vessel (12); and
   diagnosing the soundness of the vacuum pressure in the metal vessel (12) based on the indication of the voltage indicator (2000).

6. The method of claim 5, wherein if the voltage indicator (2000) shows that the main circuit is OFF, the position of the movable electrode (122, 123) of the vacuum switchgear (1) is checked and if it is not ON, the movable electrode

(122, 123) is operated to be closed.

7. The method of claim 6, wherein if the movable electrode (122, 123) is in a closed position and if the voltage indicator (2000) shows the main circuit is OFF, it is judged that the voltage indicator (2000) is out of order.

8. The method of any of claims 5 to 7, wherein a driving voltage v of the voltage indicator (2000) meets the relation

$$(C_{1005}/C_0) \leq \{(V/\sqrt{3})-v\}/v,$$

where V is the line voltage, C_0 is a static capacitance between the terminal (50) and the metal vessel (12), and C_{1005} is a static capacitance of the first condenser (1005).

Patentansprüche

1. Vakuumschaltanlage (1) umfassend:

ein Gehäuse (2);
einen Vakuumschalter (100), eingefasst im Gehäuse (2), umfassend ein mit einem festen Isolator (20) bedecktes Metallgefäß (12), wobei die Oberfläche des Isolators (20) mit einer zu erdenden leitfähigen Schicht (21) bedeckt ist, und ein Paar einer beweglichen Elektrode (122, 123) und einer festen Elektrode (111, 115), eingefasst im Metallgefäß (12), zum Bilden einer Hauptschaltung eines Schaltabschnitts (101);
einen ersten Kondensator (1005), der mit einem Anschluss (50) auf dem festen Isolator (20) verbunden ist;
eine erste elektrische Verbindungseinrichtung (1006), die am Gehäuse (2) angeordnet ist und mit dem ersten Kondensator (1005) zum Detektieren einer Spannung des Metallgefäßes (12) verbunden ist; und
eine Spannungsanzeigeeinrichtung (2000), die dazu ausgelegt ist, einen Vakuumzustand im Metallgefäß auf der Grundlage der detektierten Spannung anzuzeigen, wenn die Spannungsanzeigeeinrichtung (2000) mit der ersten Verbindungseinrichtung (1006) verbunden ist,
gekennzeichnet dadurch, dass
die Vakuumschaltanlage (1) ferner eine zweite Verbindungseinrichtung (1003) umfasst, die am Gehäuse (2) angeordnet ist und mit einem zweiten Kondensator (152), der mit einem Kopplungskondensator (1001) verbunden ist, verbunden ist, und
die Spannungsanzeigeeinrichtung (2000) dazu ausgelegt ist, einen Zustand der Stromzuführung zur Hauptschaltung auf der Grundlage einer an die zweite Verbindungseinrichtung (1003) angelegten Spannung anzuzeigen, wenn die Spannungsanzeigeeinrichtung (2000) mit der zweiten Verbindungseinrichtung (1003) verbunden ist.

2. Vakuumschaltanlage (1) nach Anspruch 1, wobei die Spannungsanzeigeeinrichtung (2000) mit der ersten und zweiten Verbindungseinrichtung (1006, 1003) verbunden und von diesen getrennt werden kann.

3. Vakuumschaltanlage (1) nach Anspruch 1, wobei ein Ende des zweiten Kondensators (152) mit einer lastseitigen Leitung (116) verbunden ist und das andere mit dem Kopplungskondensator (1001) verbunden ist, wobei das andere Ende des zweiten Kondensators (152) mit der zweiten elektrischen Verbindungseinrichtung (1003) verbunden ist.

4. Vakuumschaltanlage (1) nach einem der Ansprüche 1 bis 3, wobei eine Betriebsspannung v der Spannungsanzeigeeinrichtung (2000) folgende Bedingung erfüllt

$$(C_{1005}/C_0) \leq \{(V/\sqrt{3})-v\}/v,$$

wobei V die Leitungsspannung ist, C_0 eine statische Kapazität zwischen dem Anschluss (50) und dem Metallgefäß (12) ist und C_{1005} eine statische Kapazität des ersten Kondensators (1005) ist.

5. Diagnoseverfahren für einen Vakuumdruck in einem Metallgefäß (12) einer Vakuumschaltanlage (1), die umfasst: das Metallgefäß (12), bedeckt mit einem festen Isolator (20), dessen Oberfläche mit einer zu erdenden leitfähigen

Schicht (21) bedeckt ist; mindestens ein Paar einer beweglichen Elektrode (122, 123) und einer festen Elektrode (111, 115), eingefasst im Metallgefäß (12); einen mit einem Anschluss (50) auf dem festen Isolator (20) verbundenen ersten Kondensator (1005), eine erste elektrische Verbindungseinrichtung (1006), die an einem die Vakuumschaltanlage (1) aufnehmenden Gehäuse (2) angeordnet ist, wobei die erste elektrische Verbindungseinrichtung (1006) mit einem Ende des ersten Kondensators (1005) und dem Anschluss (50) verbunden ist; und eine zweite elektrische Verbindungseinrichtung (1003), die am Gehäuse (2) angeordnet ist und mit einem zweiten Kondensator (152), der mit einem Kopplungskondensator (1001) verbunden ist, verbunden ist, wobei das Verfahren die folgenden Schritte umfasst:

Verbinden einer Spannungsanzeigeeinrichtung (2000) mit der zweiten Verbindungseinrichtung (1003), wodurch ein Zustand der Stromzuführung zu einer Hauptschaltung der Schaltanlage (1) auf der Spannungsanzeigeeinrichtung (2000) als AN oder AUS auf der Grundlage einer an die zweite Verbindungseinrichtung (1003) angelegten Spannung angezeigt wird;
falls die Spannungsanzeigeeinrichtung (2000) zeigt, dass die Hauptschaltung AN ist, Verbinden der Spannungsanzeigeeinrichtung (2000) mit der ersten elektrischen Verbindungseinrichtung (1006), sodass die Spannungsanzeigeeinrichtung (2000) einen Vakuumzustand im Metallgefäß (12) auf der Grundlage einer detektierten Spannung des Metallgefäßes (12) anzeigt; und
Diagnostizieren der Stimmigkeit des Vakuumdrucks im Metallgefäß (12) auf der Grundlage der Anzeige der Spannungsanzeigeeinrichtung (2000).

6. Verfahren nach Anspruch 5, wobei die Position der beweglichen Elektrode (122, 123) der Vakuumschaltanlage (1), falls die Spannungsanzeigeeinrichtung (2000) zeigt, dass die Hauptschaltung AUS ist, überprüft wird und falls sie nicht AN ist, das Schließen der beweglichen Elektrode (122, 123) bewirkt wird.

7. Verfahren nach Anspruch 6, wobei bestimmt wird, dass die Spannungsanzeigeeinrichtung (2000) außer Betrieb ist, falls die bewegliche Elektrode (122, 123) sich in einer geschlossenen Position befindet und falls die Spannungsanzeigeeinrichtung (2000) zeigt, dass die Hauptschaltung AUS ist.

8. Verfahren nach einem der Ansprüche 5 bis 7, wobei eine Betriebsspannung v der Spannungsanzeigeeinrichtung (2000) die folgende Bedingung erfüllt:

$$(C_{1005}/C_0) \leq \{(V/\sqrt{3})-v\}/v,$$

wobei V die Leitungsspannung ist, C_0 eine statische Kapazität zwischen dem Anschluss (50) und dem Metallgefäß (12) ist und C_{1005} eine statische Kapazität des ersten Kondensators (1005) ist.

Revendications

1. Appareil de commutation à vide (1) comportant :

un boîtier (2),
un commutateur à vide (100), enfermé dans le boîtier (2), comprenant un récipient métallique (12) recouvert d'un isolateur solide (20), la surface de l'isolateur étant recouverte d'une couche conductrice (21) à mettre à la terre, et une paire d'une électrode mobile (122, 123) et d'une électrode fixe (111, 115) pour constituer un circuit principal d'une section de commutation (101), enfermée dans le récipient métallique,
un premier condensateur (1005) relié à une borne (50) sur l'isolateur solide (20),
un premier moyen de connexion électrique (1006) disposé dans le boîtier (2) et relié à un premier condensateur (1005) pour détecter une tension du récipient métallique (12), et
un indicateur de tension (2000) qui est adapté pour indiquer un état de vide du récipient métallique (12) sur la base de la tension détectée, lorsque l'indicateur de tension (2000) est relié au premier moyen de connexion (1006),
caractérisé en ce que
l'appareil de commutation à vide (1) comporte en outre un second moyen de connexion (1003) disposé dans le boîtier (2) et relié à un second condensateur (152), lequel est relié à un condensateur de couplage (1001), et l'indicateur de tension (2000) est adapté pour indiquer un état d'application de puissance au circuit principal

sur la base d'une tension appliquée au second moyen de connexion (1003), lorsque l'indicateur de tension (2000) est relié au second moyen de connexion (1003).

2. Appareil de commutation à vide (1), dans lequel l'indicateur de tension (2000) est connectable à et déconnectable des premier et second moyens de connexion (1006, 1003).

3. Appareil de commutation à vide (1) selon la revendication 1, dans lequel une extrémité du second condensateur (152) est reliée à un conducteur de côté de charge (116), et l'autre est reliée au condensateur de couplage (1001), l'autre extrémité du second condensateur (152) étant reliée au second moyen de connexion électrique (1003).

4. Appareil de commutation à vide selon l'une quelconque des 1 à 3, dans lequel une tension de fonctionnement (V) de l'indicateur de tension (2000) satisfait à la relation

$$(C_{1005}/C_0) \leq \{(V/\sqrt{3})-v\}/v,$$

où V est la tension de ligne, C_0 est une capacité statique entre la borne (50) et le récipient métallique (12), et c_{1005} est une capacité statique du premier condensateur (1005).

5. Procédé de diagnostic d'une pression de vide dans un récipient métallique (12) d'un appareil de commutation à vide (1) comportant : le récipient métallique (12), recouvert d'un isolateur solide (20) dont la surface est recouverte d'une couche conductrice (21) à mettre à la terre, au moins une paire d'une électrode mobile (122, 123) et d'une électrode fixe (111, 115), enfermées dans le récipient métallique (12) ; un premier condensateur (1005) relié à une borne (50) sur l'isolateur solide (20), un premier moyen de connexion électrique (1006) disposé dans un boîtier (2) contenant l'appareil de commutation à vide (1), le premier moyen de connexion électrique (1006) étant relié à une extrémité du premier condensateur (1005) et à la borne (50), et un second moyen de connexion électrique (1003) disposé dans le boîtier (2) et relié à un second condensateur (152) lequel est relié à un condensateur de couplage (1001), le procédé comportant les étapes consistant à :

relier un indicateur de tension (2000) au second moyen de connexion (1003), un état d'application de puissance à un circuit principal de l'appareil de commutation (1) est indiqué sur l'indicateur de tension (2000) comme étant sous tension ou hors tension sur la base d'une tension appliquée au second moyen de connexion (1003) ;
si l'indicateur de tension (2000) montre que le circuit principal est sous tension, relier l'indicateur de tension (2000) au premier moyen de connexion électrique (1006), de sorte que l'indicateur de tension (2000) indique un état de vide dans le récipient métallique (12) sur la base d'une tension détectée du récipient métallique (12) ; et
diagnostiquer la stabilité de la pression de vide dans le récipient métallique (12) sur la base de l'indication de l'indicateur de tension (2000).

6. Procédé selon la revendication 5, dans lequel si l'indicateur de tension (2000) montre que le circuit principal est hors tension, la position de l'électrode mobile (122, 123) de l'appareil de commutation à vide (1) est vérifiée et, si elle n'est pas sous tension, l'électrode mobile (122, 123) est actionnée pour être fermée.

7. Procédé selon la revendication 6, dans lequel si l'électrode mobile (122, 123) est dans une position fermée et si l'indicateur de tension (2000) montre que le circuit principal est fermé, il est déterminé que l'indicateur de tension (2000) est hors service.

8. Procédé selon l'une quelconque des revendications 5 à 7, dans lequel une tension de fonctionnement v de l'indicateur de tension (2000) satisfait à la relation

$$(C_{1005}/C_0) \leq \{(V/\sqrt{3})-v\}/v,$$

où V est la tension de ligne, C_0 est une capacité statique entre la borne (50) et le récipient métallique (12), et c_{1005} est une capacité statique du premier condensateur (1005).

FIG. 1

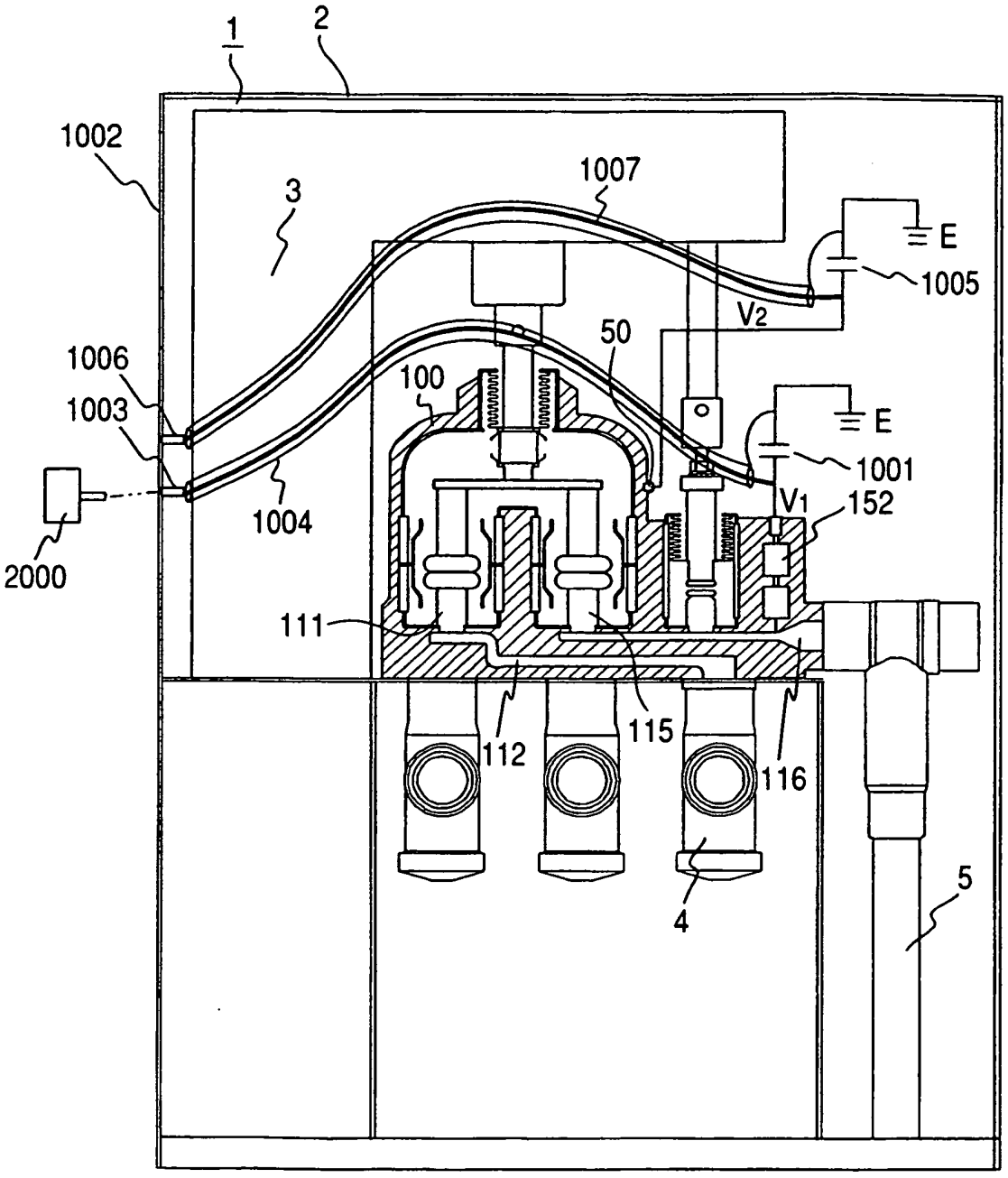

1
2
1002
3
1007
E
1005
V2
50
1006
100
1003
E
1001
V1
152
1004
2000
111
112
115
116
4
5

FIG. 2

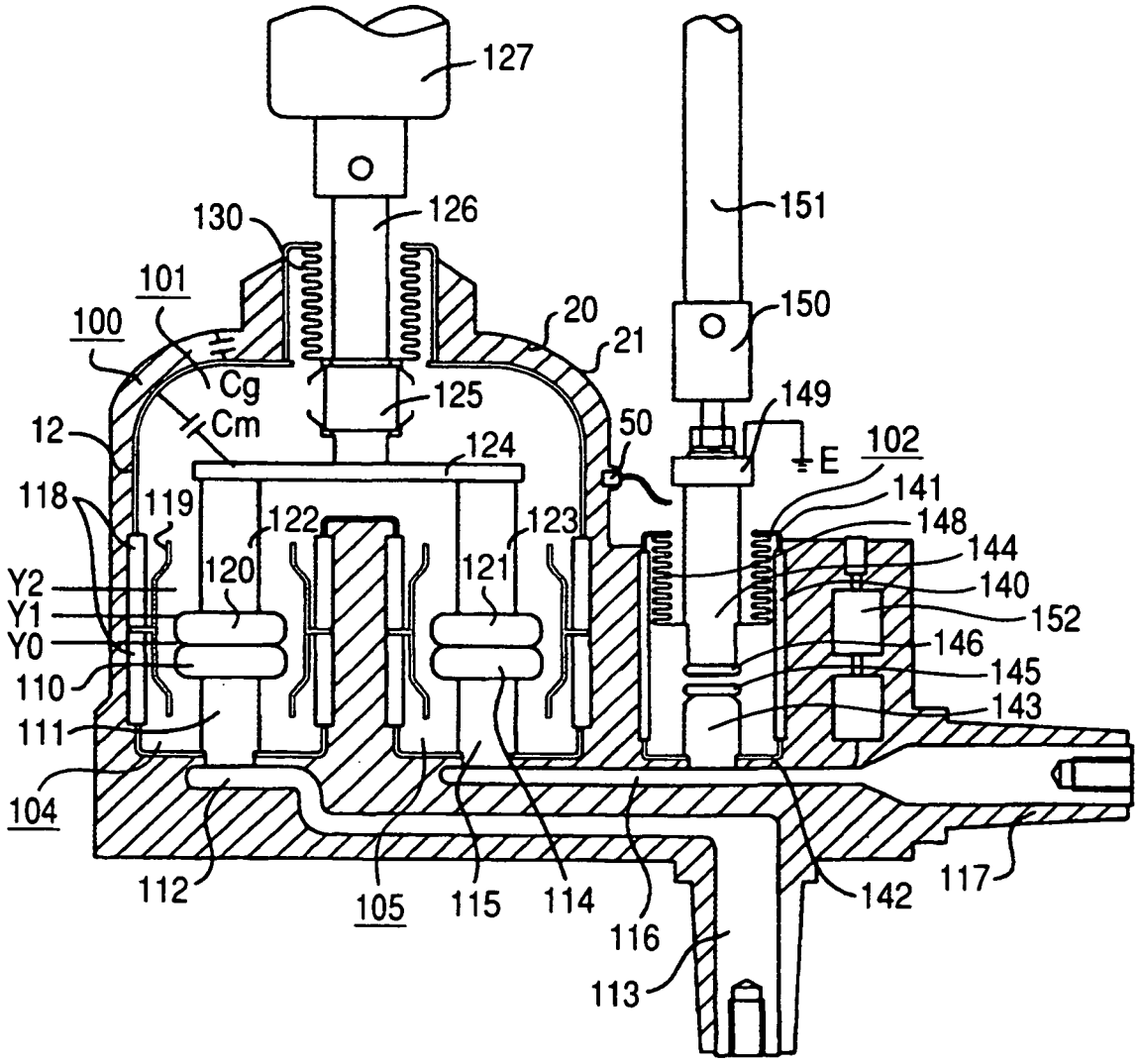

127
130
126
151
101
100
20
21
150
Cg
Cm
125
149
12
50
124
102
E
118
119
122
123
141
148
144
120
121
140
Y2
Y1
Y0
152
146
110
145
111
143
104
112
105
115
114
116
142
117
113

FIG. 3

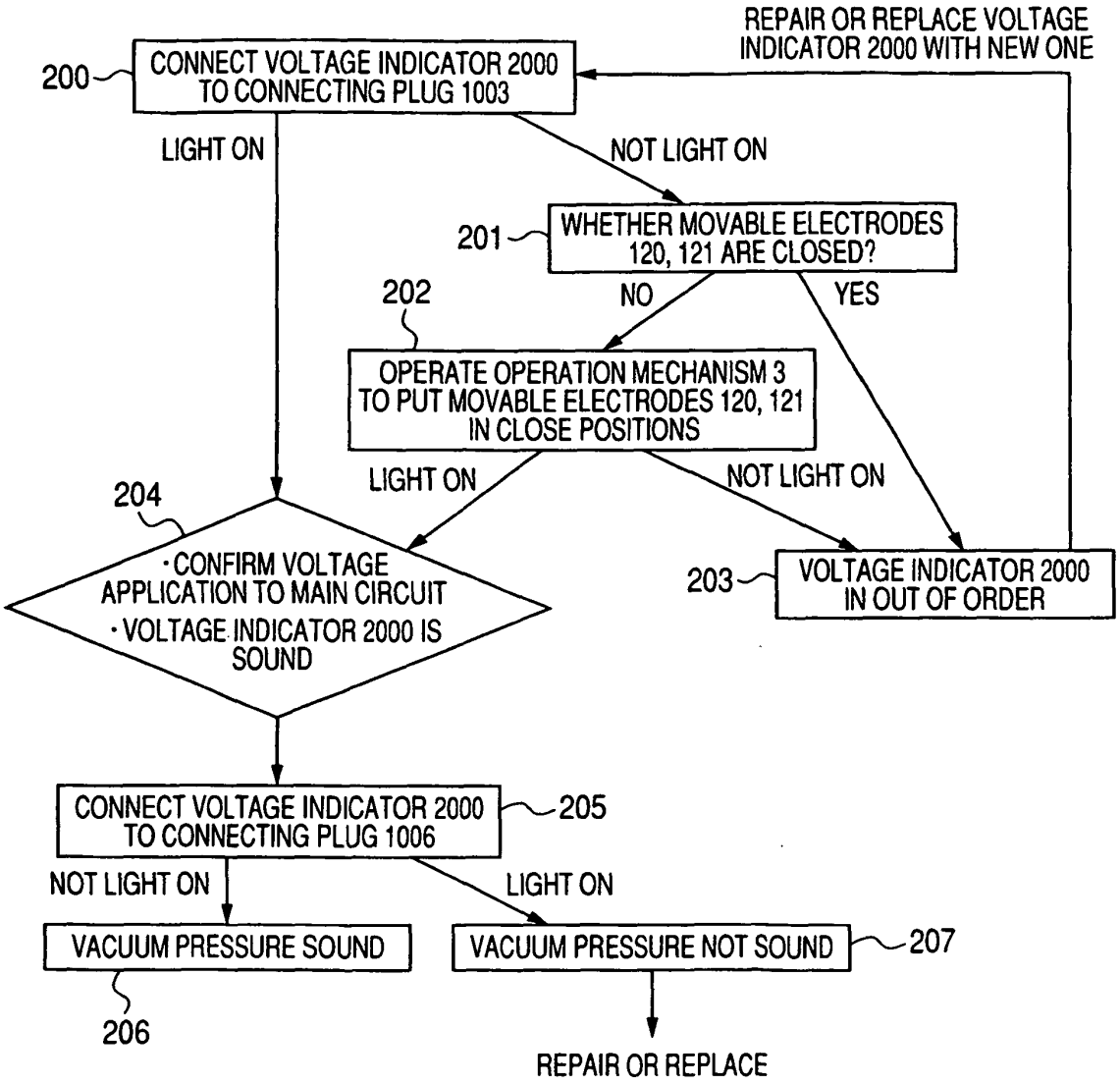
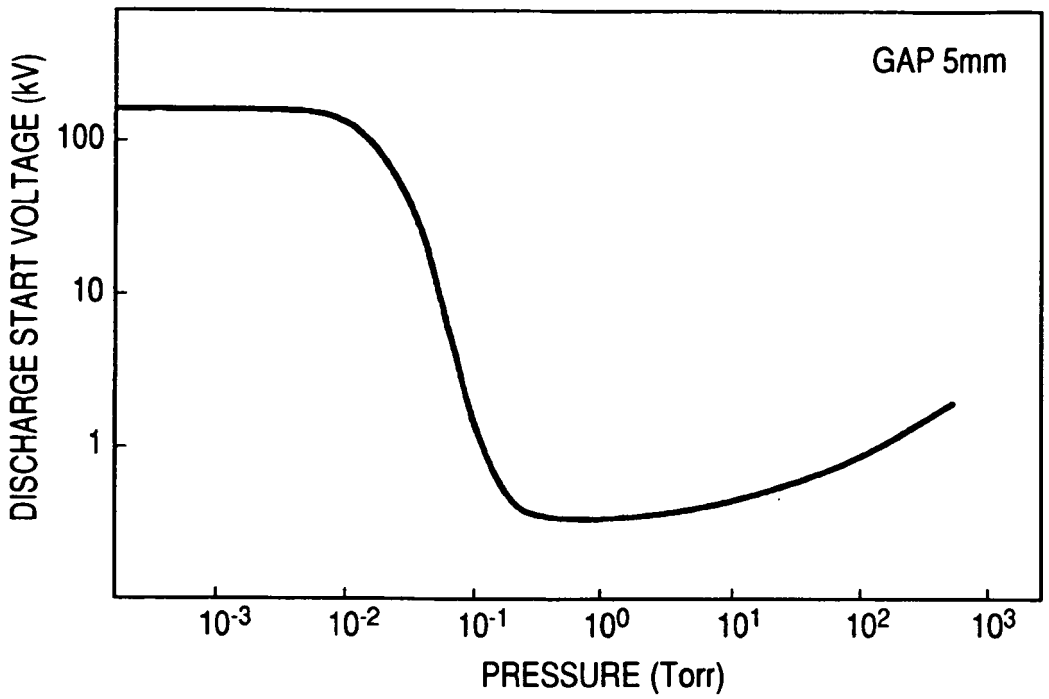

REPAIR OR REPLACE VOLTAGE INDICATOR 2000 WITH NEW ONE
200
CONNECT VOLTAGE INDICATOR 2000 TO CONNECTING PLUG 1003
LIGHT ON
NOT LIGHT ON
201
WHETHER MOVABLE ELECTRODES 120, 121 ARE CLOSED?
202
NO
YES
OPERATE OPERATION MECHANISM 3 TO PUT MOVABLE ELECTRODES 120, 121 IN CLOSE POSITIONS
LIGHT ON
NOT LIGHT ON
204
· CONFIRM VOLTAGE APPLICATION TO MAIN CIRCUIT
· VOLTAGE INDICATOR 2000 IS SOUND
203
VOLTAGE INDICATOR 2000 IN OUT OF ORDER
CONNECT VOLTAGE INDICATOR 2000 TO CONNECTING PLUG 1006
205
NOT LIGHT ON
LIGHT ON
VACUUM PRESSURE SOUND
VACUUM PRESSURE NOT SOUND
207
206
REPAIR OR REPLACE

FIG. 4


GAP 5mm
DISCHARGE START VOLTAGE (kV)
100
10
1
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
PRESSURE (Torr)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007080549 A **[0005]**
- EP 1763049 A1 **[0009]**