

Description

FIELD OF THE INVENTION:

5 **[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:

10 **[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.

15 **[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.

20 **[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.

25 **[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.

30 **[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.

35 **[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.

40 **[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.

SUMMARY OF THE INVENTION:

45 **[0009]** 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.

50 **[0010]** 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.

55 **[0011]** 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.

60 **[0012]** 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.

65 **[0013]** One aspect of the present invention provides a vacuum switchgear comprising:

a casing (1);

a vacuum switch (100), enclosed in the casing (1), comprising a metal vessel covered with a solid insulator (20), the surface of the insulator being covered with a conductive layer (21) to be earthed, a pair of movable electrode and a fixed electrode to constitute a main circuit, enclosed in the metal vessel;

a first condenser (1005) connected to the terminal (50) on the solid insulator (21),
wherein

a first connecting means (1006) connected to one end of a condenser (1005), which is connected to a terminal (50) for detecting a voltage of the metal vessel (12);

a second connecting means (1003) connected to one end of the second condenser (152) by means of a third condenser such as a coupling condenser (1001);

the first electric connection means (1006) and the second connecting means (1003) are disposed to the casing (1), the first connecting means and second connecting means being selectively acceptable to one voltage indicator (2000) that indicates statuses of vacuum pressure of the metal vessel, power application of the main circuit and soundness of the voltage indicator.

[0014] Another aspect of the present invention further provides a vacuum switchgear, wherein the voltage indicator is detachable from the first and second connecting means.

[0015] A still another aspect of the present invention still further provides a vacuum, which further comprises a second connecting means (1006) disposed to the casing (1), and a second condenser (152) one end of which is connected to a load side conductor (116), and the other is connected to a third condenser (1001), the other end of the second condenser being connected to the second connecting means to which the voltage indicator is connected.

[0016] A still another aspect of the present invention provides a vacuum switchgear, wherein the voltage indicator is connectable and detachable to and from the first connecting means and the second connecting means.

[0017] A further aspect of the present invention further provides a vacuum switchgear wherein an operating voltage (v) of the voltage indicator meets the following relation, where $V_2 = V / \sqrt{3} \times C_0 / (C_0 + C_{1005})$, C_0 is a static capacitance between a terminal (50) and the metal vessel (12), and C_{1005} is a static capacitance of the capacitor (1005),

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

[0018] A further aspect of the present invention provides a method of diagnosis of a vacuum pressure in a vacuum vessel (12) of a vacuum switchgear (100) comprising the metal vessel, covered with a solid insulator, the surface of which is covered with a conductive layer (21) to be earthed, at least a pair of movable electrode and a fixed electrode, enclosed in the metal vessel; a first condenser (1005) connected to the terminal (50) on the solid insulator and a first connecting means (1003) disposed to a casing accommodating the vacuum switchgear (100); a second condenser (152) connected to a load side conductor (116); and a second connecting means (1006) disposed to the casing (1), wherein connecting a voltage indicator (2000) to a first electric connecting means (1003) disposed to a casing (1) of the vacuum switchgear (12), the first connecting means (1003) being connected to one end of a first condenser (1005), the other being connected to a terminal (50) formed on an insulator (20) formed on the vacuum vessel (12), wherein the voltage indicator indicates a voltage status of the first connecting means that exhibits the vacuum pressure of the vacuum vessel; and

judging the soundness of the vacuum pressure of the vacuum vessel based on the indication of the voltage indicator.

[0019] Another aspect of the present invention further provides a method of diagnosis of the vacuum switchgear, wherein prior to connecting the voltage indicator (2000) to the first connecting means (1006), the voltage indicator is connected to a second connecting means (1003), which is connected to a second condenser (152) connected to a load side conductor (116) and a third condenser (1001) to be earthed, whereby the status of the main circuit of the switchgear is indicated on the voltage indicator; and if the voltage indicator shows the main circuit is ON, the voltage indicator is connected to the first electric connecting means to carry out the diagnosis of the vacuum pressure.

[0020] A still another aspect of the present invention still further provides a method of diagnosis, wherein if the voltage indicator shows that the main switch is not ON, position of the movable electrode of the vacuum switchgear is checked if it is not ON, the movable electrode is operated to be closed, and if the voltage indicator shows the main circuit is ON, the voltage indicator is connected to the first connecting means.

[0021] A still further aspect of the present invention provides a method of diagnosis, wherein if the movable electrode is in a closed position and if the voltage indicator shows the main circuit is not ON, it is judged that the voltage indicator is in out of order.

[0022] Another aspect of the present invention further provides a method of diagnosis, wherein an operating voltage (v) of the voltage indicator meets the following relation, where $V_2 = V / \sqrt{3} \times C_0 / (C_0 + C_{1005})$, C_0 is a static capacitance

between a terminal(50) and the metal vessel (12), and C_{1005} is a static capacitance of the capacitor (1005),

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

[0023] 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.

[0024] 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:

[0025]

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.

[0026] 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:

[0027] In the following embodiment of the present invention will be explained by reference to Figs. 1 to 4.

[0028] 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.

[0029] 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.

[0030] The switch section 100 is encased in the casing 1 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 an connecting means 1003 or 1006 disposed to the front panel 1002 of the casing, as shown in Fig. 1.

[0031] 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.

[0032] 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.

[0033] 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.

[0034] 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.

[0035] 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.

[0036] 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.

[0037] 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.

[0038] 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.

[0039] 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.

[0040] 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.

[0041] 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.

[0042] 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.

[0043] 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.

[0044] 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.

[0045] 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.

[0046] 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.

[0047] 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.

$$V_1 = V / \sqrt{3} \times C_{152} / (C_{152} + C_{1001})$$

[0048] In the above equation, the partial potential V1 is a product of a rate of a static capacitance C₁₅₂ of the second condenser 152 to the total capacitance of the capacitance C₁₅₂ of the condenser 152 and a capacitance C₁₀₀₁ of the third condenser 1001 and the earth voltage V/√3. Accordingly, if a voltage proportional to V₁ 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).

[0049] 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.

[0050] 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.

[0051] Next, the voltage indicator 2000 is connected to the connecting plug 1006 (step 205).

[0052] A static capacitance C_g between the metal vessel 12 in a float potential and the earthed conductive coating 21 sufficiently large, compared with static capacitance C_m between the main circuit in the vacuum bulb 101 and the metal vessel 12 (C_g » C_m). Accordingly, the potential of the metal vessel 12 becomes almost the same as the earth voltage when the vacuum pressure is sound.

[0053] 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/√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 V₂, which is represented by the following equation.

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

[0054] In the above equation, C₀ is a capacitance between the terminal 50 and the metal vessel 12 and C₁₀₀₅ is a static capacitance of the vacuum pressure diagnosis condenser 1005.

[0055] 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.

[0056] 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.

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

[0057] In the above formula, if a driving voltage of the voltage indicator 2000 is v , $v \leq V1$.

[0058] 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 $V/\sqrt{3}$ and the driving voltage v of the voltage indicator 2000 to the driving voltage v , the vacuum bulb 101 can be detected.

[0059] The relationship between the static capacitance C_0 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, $v \leq V2$.

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

[0060] 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 $v/\sqrt{3}$ 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.

[0061] 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.

[0062] 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 of 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.

[0063] 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.

[0064] 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.

[0065] 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.

[0066] 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.

[0067] 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.

[0068] 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.

[0069] The diagnosis of the vacuum pressure of the switch section is conducted without increasing a 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.

[0070] 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.

[0071] 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 comprising:

a casing (1);

a vacuum switch (100), enclosed in the casing (1), comprising a metal vessel covered with a solid insulator (20), the surface of the insulator being covered with a conductive layer (21) to be earthed, a pair of movable electrode and a fixed electrode to constitute a main circuit, enclosed in the metal vessel;

a first condenser (1005) connected to a terminal (50) on the solid insulator (20),

characterized in that

a first electric connection means (1006) is disposed to the casing (1), the first connecting means being connected to a first condenser (1005) connected to a terminal (50) for detecting voltage of the metal vessel (12)

a second connecting means (1003) is disposed to the casing, the second connecting means being connected to a second condenser (152), connected to a coupling condenser (1001); and

a voltage indicator (2000) that indicates a status of vacuum of the metal vessel and a status of power application to the main circuit of the switch section (101), the voltage indicator being connected to either one of the first and second connecting means.

2. The vacuum switchgear according to claim 1, wherein the voltage indicator is connectable to and detachable from the first and second connecting means.

3. The vacuum switchgear according to claim 1, which further comprises the second connecting means (1003) disposed to the casing (1), and the second condenser (152) one end of which is connected to a load side conductor (116), and the other is connected to the third condenser (1001), the other end of the second condenser being connected to the second electric connecting means to which the voltage indicator is connected.

4. The vacuum switchgear according to any one of claims 1 to 3, wherein an operating voltage (v) of the voltage indicator meets the following relation, where $V_2 = V/\sqrt{3} \times C_0/(C_0 + C_{1005})$, C_0 is a static capacitance between a terminal (50) and the metal vessel (12), and C_{1005} is a static capacitance of the capacitor (1005),

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

5. A method of diagnosis of a vacuum pressure in a vacuum vessel (12) of a vacuum switchgear (100) comprising the metal vessel, covered with a solid insulator, the surface of which is covered with a conductive layer (20) to be earthed, at least a pair of movable electrode and a fixed electrode, enclosed in the metal vessel; a first condenser (1005) connected to the terminal (50) on the solid insulator (20), and a first connecting means (1003) disposed to a casing accommodating the vacuum switchgear (100); a second condenser (152) connected to a load side conductor (116); and

a second connecting means (1006) disposed to the casing (1),

characterized by

connecting a voltage indicator (2000) to a first electric connecting means (1003) disposed to a casing (1) of the vacuum switchgear (12), the first connecting means (1003) being connected to one end of a first condenser (1005) and a terminal (50) formed on the solid insulator (20), which is formed on the vacuum vessel (12), wherein the voltage indicator indicates a voltage status of the first connecting means that exhibits the vacuum pressure of the vacuum vessel; and

diagnosing the soundness of the vacuum pressure of the vacuum vessel based on the indication of the voltage indicator.

6. The method of diagnosis of the vacuum switchgear according to claim 5, wherein prior to connecting the voltage indicator (2000) to the first connecting means (1006), the voltage indicator is connected to a second electric connecting means (1003), which is connected to a second condenser (152) connected to a load side conductor (116) and a third condenser (1001) to be earthed, whereby the voltage status of the main circuit of the switchgear is indicated on the voltage indicator; and
if the voltage indicator shows the main circuit is ON, the voltage indicator is connected to the first electric connecting means to carry out the diagnosis of the vacuum pressure.
7. The method of diagnosis according to claim 6, wherein if the voltage indicator shows that the main switch is not ON, position of the movable electrode of the vacuum switchgear is checked if it is not ON, the movable electrode is operated to be closed, and if the voltage indicator shows the main circuit is ON, the voltage indicator is connected to the first electric connecting means.
8. The method of diagnosis according to claim 7, wherein if the movable electrode is in a closed position and if the voltage indicator shows the main circuit is not ON, it is judged that the voltage indicator is in out of order.
9. The method of diagnosis according to any one of claims 5 to 8, wherein an operating voltage (v) of the voltage indicator meets the following relation, where $V_2 = V/\sqrt{3} \times C_0/(C_0 + C_{1005})$, C_0 is a static capacitance between a terminal (50) and the metal vessel (12), and C_{1005} is a static capacitance of the first condenser (1005),

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

FIG. 1

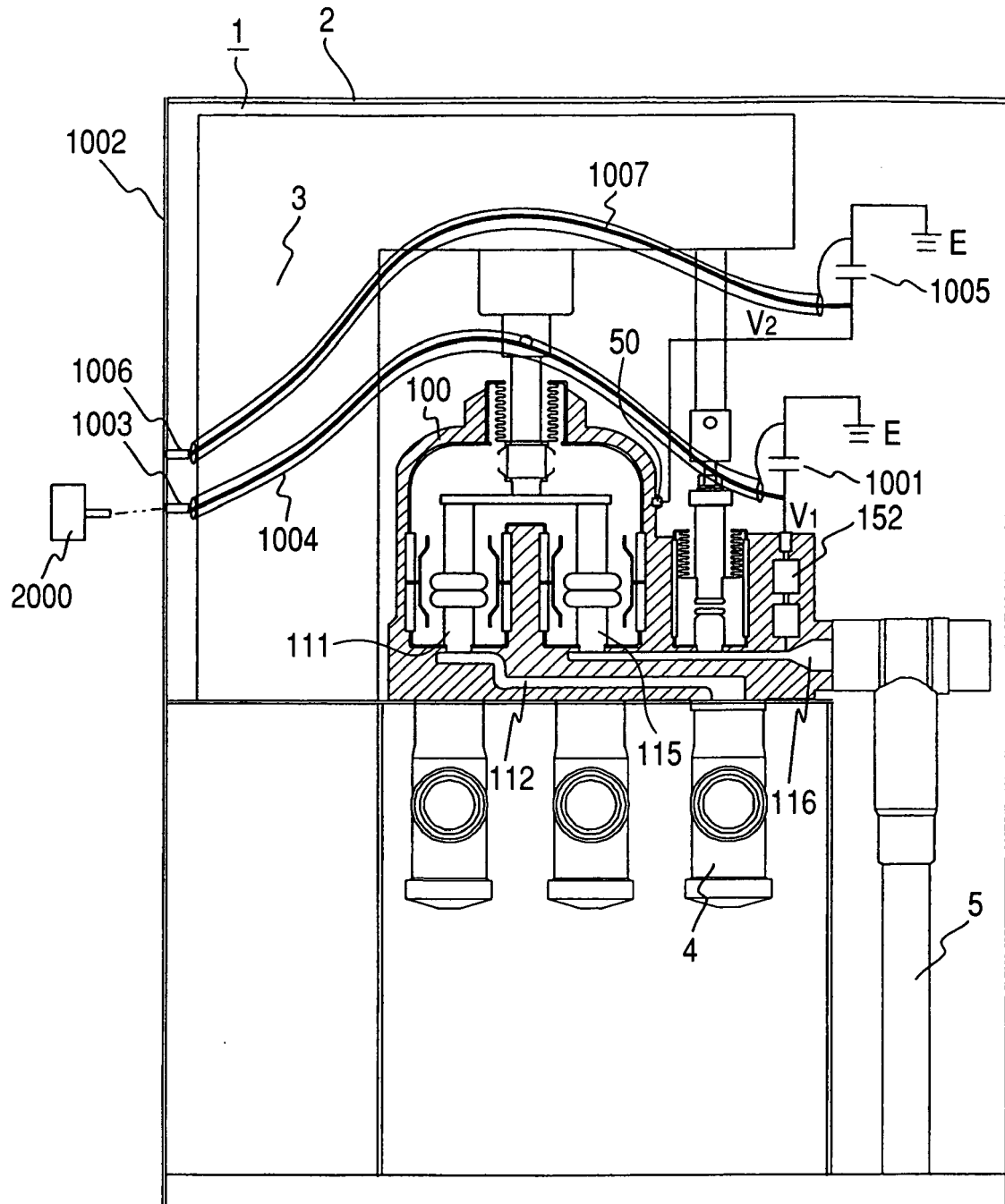


FIG. 2

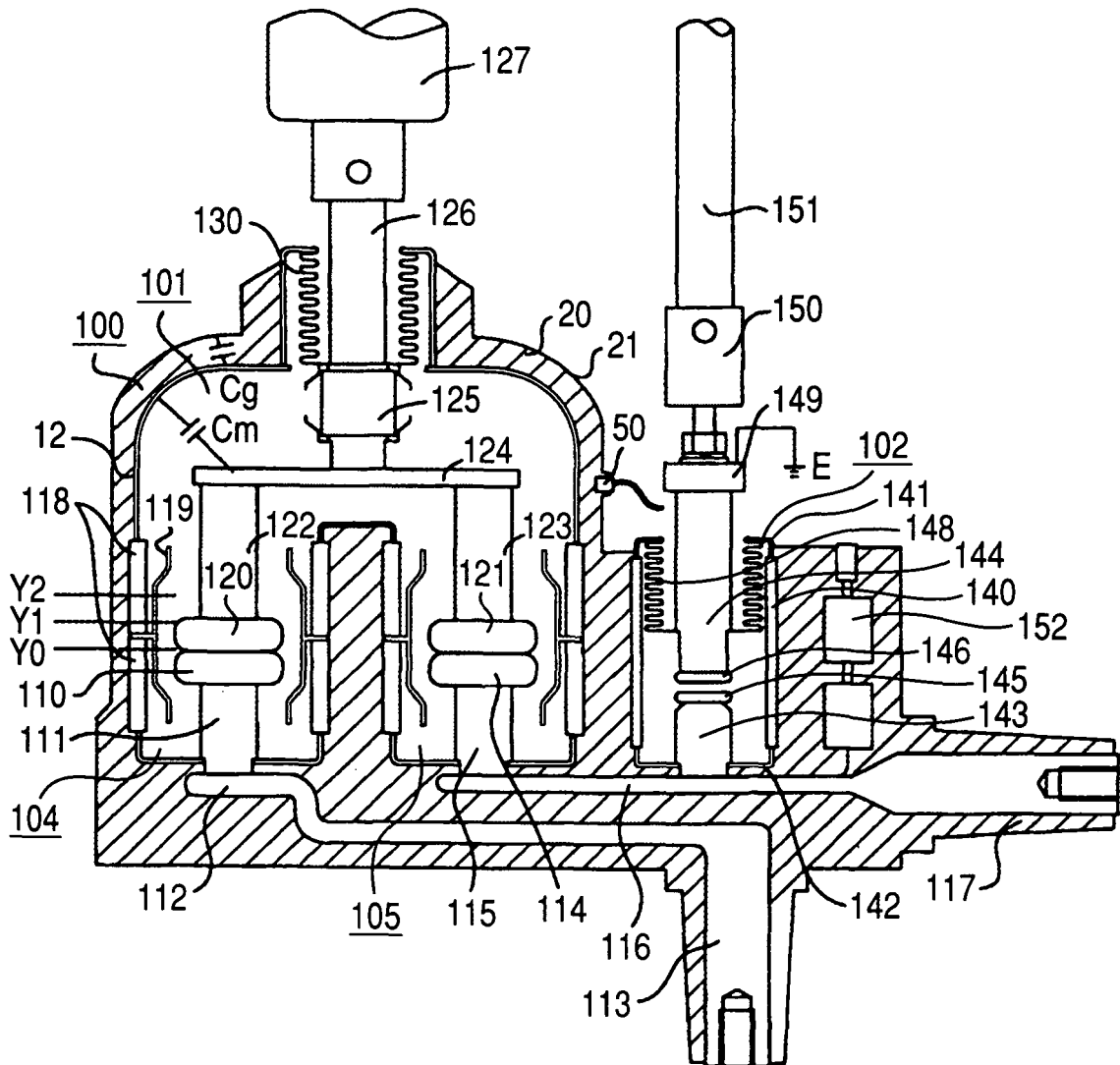


FIG. 3

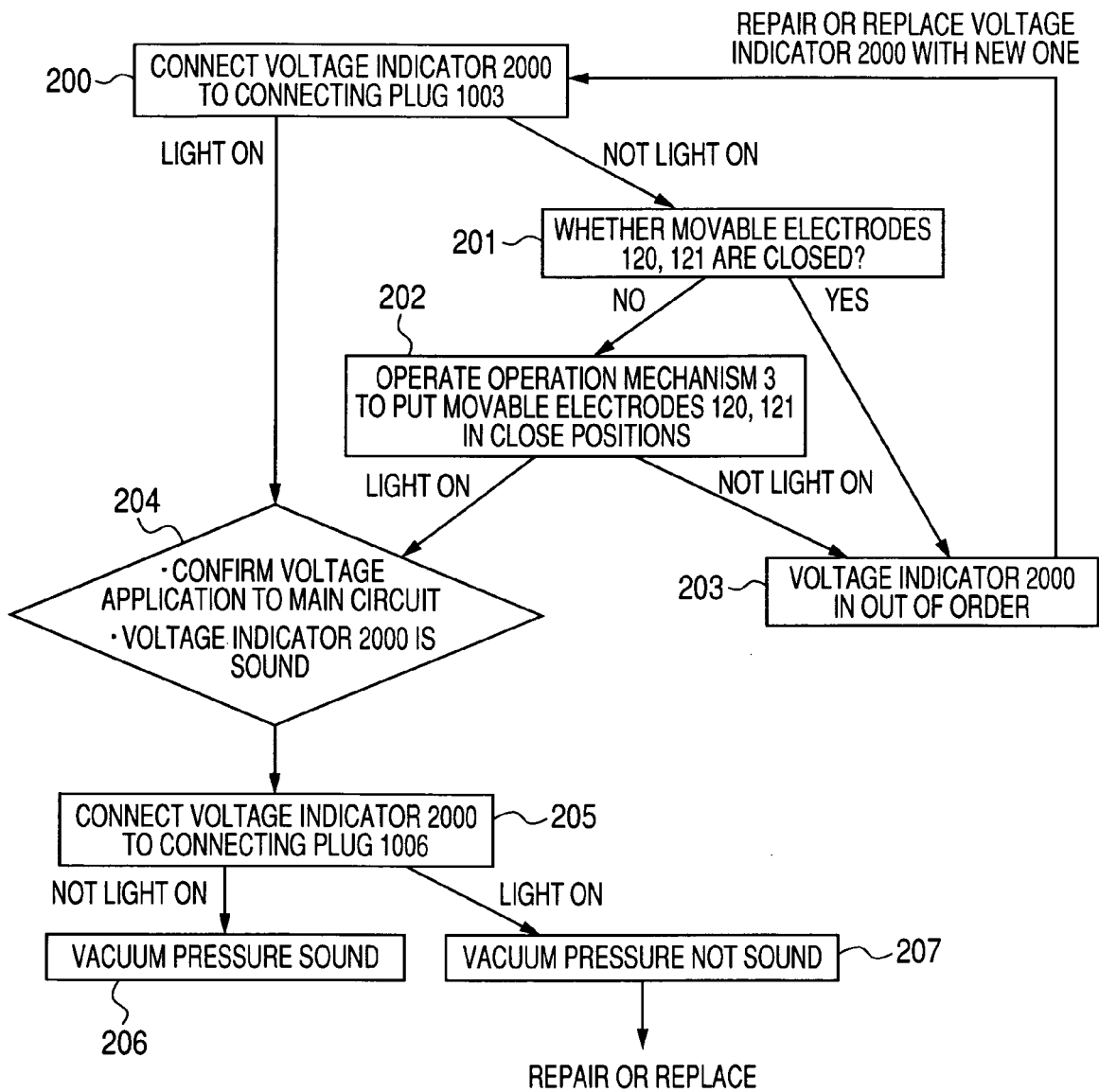
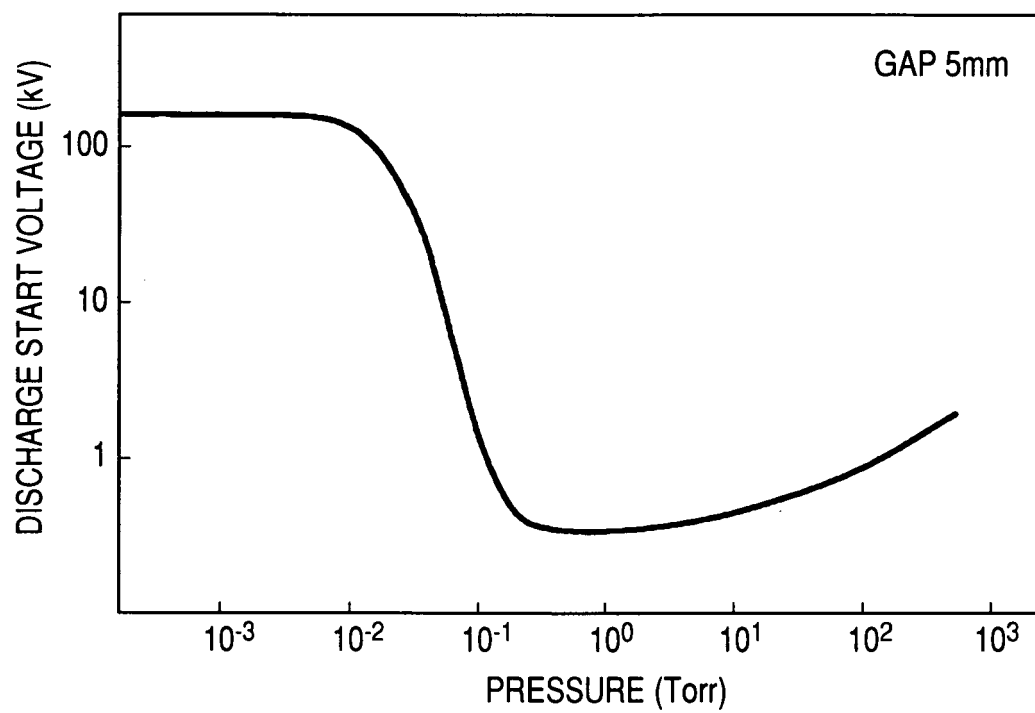


FIG. 4



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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