

Title of the invention: Vacuum insulated switch device and vacuum insulated switchgear

Field of the invention:

5 The present invention relates to a vacuum insulated switch device and a vacuum insulated switchgear, and more particularly to a vacuum insulated switch device provided with a vacuum pressure measuring device and a vacuum insulated switchgear having the above vacuum insulated switch device.

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Background of the invention:

 Vacuum insulated switch devices are ones used for conduction and interruption of current, which are mainly used for power receiving and distribution equipments, and vacuum
15 insulated switchgears are composites each comprising the vacuum insulated switch device and an earth switch device, etc. Vacuum pressure of the vacuum insulated switch devices must be monitored because the insulating withstanding voltage depends on the vacuum pressure.

20 Patent document No. 1 discloses a technology for monitoring the vacuum pressure. In the technology disclosed by patent document No. 1, there is disclosed a vacuum container made of metal wherein a pair of fixed contact and movable contact each connected to a conductor is molded with a solid insulating
25 material having conductive terminals, which are used to detect

vacuum pressure by measuring a potential generating between the terminals.

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5 Summary of the invention:

In the above mentioned prior art, the shape of the terminals is dots, whose area is too small for forming a condenser between the terminals. As a result, the measured values may fluctuate thereby to lower a precision of the monitoring.

10 It is an object of the present invention to provide a vacuum insulated switch device with an increased reliability of vacuum pressure diagnosis and a vacuum insulated switchgear using the vacuum switch device.

In order to achieve the above object, the present invention
15 provides a vacuum switch device comprising a vacuum valve for closing and interrupting current in vacuum, a shield disposed in the vacuum valve, and a terminal for detecting vacuum pressure, which has a surface opposed to the shield with a predetermined distance.

20 According to another aspect of the present invention, the present invention provides a vacuum insulated switchgear, which comprises the vacuum insulated switch device mentioned above, an air insulated earth and disconnection portion.

According to the present invention, it is possible to
25 increase precision of diagnosis of vacuum pressure.

Brief description of drawings:

Fig. 1A shows a top plan view of a vacuum insulated switchgear of a first embodiment.

5 Fig. 1B shows a vertical cross sectional view along the line II-II of the vacuum insulated switchgear shown in Fig. 1A.

Fig. 2A shows a cross sectional view of the vacuum detecting sensor in the vacuum insulated switchgear shown in Fig. 1A.

Fig. 2B is a top plan view of the vacuum detection sensor
10 shown in Fig. 2A.

Fig. 3 shows a circuit diagram of a vacuum pressure diagnosis device according to the present invention.

Fig. 4 is a graph showing relationship (Paschen curve) between vacuum pressure and discharge start voltage.

15 Fig. 5 shows an arrangement of a vacuum insulated switch device having a vacuum pressure diagnosis device of a second embodiment.

Fig. 6 shows a vertical cross sectional view of a vacuum insulated switchgear of a third embodiment.

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Detailed description of the embodiments:

In the following the embodiments of the present invention will be explained in detail by reference to drawings. The following embodiments are examples, and a scope of the present
25 invention is not limited to the following embodiments.

(Embodiment 1)

The first embodiment will be explained by reference to Figs. 1 to 4. Fig. 1A shows a top plan view of the vacuum insulated switchgear of the present invention. Fig. 1B is a vertical cross
5 sectional view of the vacuum insulated switchgear shown in Fig. 1A.

As shown in Fig. 1B, the vacuum valve 1 (i.e. a vacuum insulated switch device) comprises a fixed side ceramic cylinder 2, a fixed side terminal plate 3 gas-tightly covering
10 the end of the fixed side ceramic cylinder 2, a fixed conductor 4 connected to the fixed side electrode 9, an intermediate shield 5 disposed around a fixed side electrode 9 and a movable side electrode 15 in the vacuum valve 1, a movable side ceramic cylinder 6, a movable side terminal plate 7 gas-tightly covering
15 the end of the movable side ceramic cylinder 6, a movable conductor 8 penetrating the movable side terminal plate 7 to be connected with the movable electrode 15 and extending outside of the vacuum valve 1, a bellows (not shown) for moving the movable conductor together with the movable electrode keeping
20 vacuum, a fixed electrode 11 disposed at the tip of the fixed conductor 4, and the movable electrode 15 opposed to the fixed electrode 11 and disposed at the tip of the movable conductor 8. The movable electrode 15 is movable in vacuum kept by the bellows and is able to contact with and separate from the fixed
25 electrode 11. The fixed conductor 4 is connected to a load

connecting conductor 9, which is connected to the load side by means of cables, etc. The load side conductor is covered with a solid insulation 13, and constitutes a load connecting bushing 17 with the insulation 13.

5 An air insulated earth-disconnection portion 25 comprises a bushing side fixed electrode 31, which is integrally formed with a bus-bar side conductor 10 connected to a bus-bar side, an intermediate air-insulated contact 30, which slides and contacts with the bushing side fixed electrode 31, an air
10 insulated movable conductor 33, which is provided with the intermediate air-insulated contact 30 and driven by an operator (not shown) in a direction of up-and downward in Fig. 1B, an earthing air-insulated contact 29 disposed to the air-insulated movable conductor 33, an intermediate fixed electrode 34
15 electrically connected to the movable electrode of the vacuum valve by means of a flexible conductor 22, an earth side fixed electrode 32, which is fixed to the metal casing 28 in an earth potential and covers the insulation 13, and an
20 earth-disconnection insulating rod 24 for transmitting a driving force to the air insulated movable conductor 33 from the operator, which is connected to the air insulated movable conductor 33 at the operator side. The earth side fixed electrode 32 is on the same axis as the bushing side fixed electrode 31 and the intermediate fixed electrode 34.

25 The air insulated contact 30 slides with the bushing side

fixed electrode 31 and the intermediate fixed electrode 34, and the earth air insulated contact 29 slides with the earth side fixed electrode 32 and the intermediate fixed electrode 34, the intermediate air insulated contact 30 and the earth

5 air-insulated contact 29 being able to be contact each other. The bus-bar connecting conductor 10 is surrounded with an insulator 13 so that a bus-bar connecting bushing 16 is constituted by the bus-bar connecting conductor 16 and the insulator 13.

10 Closing and opening of the vacuum valve 1 is carried out by moving the vacuum valve insulating rod 23 and the opening and closing of the air insulated earth disconnection portion 25 is carried out by the earth disconnection insulating rod 24. The air insulated earth-disconnection portion 25 is capable of
15 being taking three positions, i.e. close, disconnection and earth positions.

In this embodiment, as shown in Fig. 1B and Figs. 2A, 2B, the vacuum valve is provided with a vacuum detection terminal 12 for vacuum pressure diagnosis, wherein the vacuum detection
20 terminal 12 is provided with a potential detection terminal 18, which is connected to a diagnosis circuit shown in Fig. 3 for detecting a potential of the vacuum container. As shown in Fig. 1A, the vacuum detection terminal 12 and the detection terminal detector 18 are molded with an insulating resin 13. The vacuum
25 detection terminal 12 and the conductive coating 14 are

electrically isolated to avoid a direct contact.

As shown in Fig. 3, the pressure diagnosis circuit 19 is connected with the detection terminal potential detector 18 at its one end, and the other is an earth potential. The diagnosis
 5 circuit comprises a condenser 26 having a static capacitance of C_0 , a voltmeter 20 for measuring a potential V_{out} between the both terminals of the condenser, a judging circuit 21 for judging if the vacuum pressure in the vacuum container is within a normal range or not.

10 The vacuum detection terminal 12 is connected to the condenser 26, which is grounded at one terminal, and the voltmeter 20 detects a potential V_{out} generating at both terminals of the condenser 26. The judging circuit 21 compares the detected potential V_{out} with a predetermined value. If the
 15 detected potential exceeds the predetermined value, the vacuum pressure is judged as being abnormal, and if the potential V_{out} does not exceeds the predetermined value, the vacuum pressure is judged as being normal.

A condenser is formed between the vacuum detection terminal
 20 12 and the intermediate shield 5 having a static capacity of C_1 . In order to secure an area for generating the static capacity C_1 between the vacuum detection terminal 12 and the intermediate shield 5, the vacuum detection terminal 12 has such a shape that it has almost the same center of the circle of the intermediate
 25 shield 5 and it covers at least a part of the outer periphery

of the intermediate shield 5 thereby to secure a sufficient area so that static capacity between the terminal 12 and the intermediate shield 5. The vacuum detection terminal 12 has almost the same center of the circle, and at least a part of the outer periphery of the intermediate shield 5 is covered with the measuring terminal 12 so that a distance between the intermediate shield 5 and the measuring terminal becomes almost constant. Since the distance between the intermediate shield 5 and the vacuum detection terminal 12 can be the minimum, a homogeneous electric field can be formed between the intermediate shield 5 and the terminal 12.

The vacuum detection terminal 12 and the voltage detection terminal 18 should be made of metals with good workability such as brass or aluminum for shaping a metal mold.

The vacuum detection terminal 12 and the voltage detector 18 for the terminal are electrically connected. In this embodiment, they are unitedly formed with a metal material. Although the vacuum detection terminal 12 is molded with insulator 13, the voltage detector 18 of the terminal is exposed and connected with an outside pressure diagnosis device shown in Fig. 3. In molding the vacuum detection terminal 12, it is fixed to a mold in advance, and after molding the terminal 12 and molding are separated from the mold to thereby realize a molding thereof at a precise location. Though the detection terminal 18 for the measuring terminal 12 is exposed, exposure

is not essential for detecting the voltage. That is, the detection terminal may be molded not to be exposed, wherein the terminal should be electrically connected with the pressure diagnosis circuit 19. The molding of the measuring terminal 12
 5 in the insulator is not essential for the present invention.

Next, diagnosis of the vacuum pressure will be explained. Since the vacuum detection terminal 12 and the intermediate shield 5 constitute the condenser having a static capacity of C_1 , which is connected in series with the condenser 26 of the
 10 diagnosis circuit 19, the potential V_{out} between the both ends of the condenser 26 depends on a potential applied to the condenser C_1 . Discharge characteristics is expressed by the Paschen curve shown in Fig. 4, which shows a relationship between pressure and discharge start voltage. If a distance
 15 between a main conduct disposed within the intermediate shield 5 and the detection terminal 12 is constant, discharge occurs between the main circuit and intermediate shield 5 if a pressure in the vacuum container reaches a certain value to generate a voltage V_1 at the intermediate shield 5. If C_1 and C_0 are
 20 previously detected, it is possible to calculate the potential V_1 of the intermediate shield 5 from the potential V_{out} between the both ends of the condenser 26. As a result, it is possible to diagnose if the vacuum pressure is normal or not from the calculated potential or a variants dependent on the potential
 25 such as V_{out} .

The static capacity C_1 between the vacuum detection terminal 12 and the intermediate shield 5 can be determined if shapes of the measuring terminal 12 and the intermediate shield 5 and the distance between the measuring terminal 12 and the intermediate shield 5 are set in advance. Thus the static capacity C_1 between the vacuum detection terminal 12 and the intermediate shield 5 is important for diagnose the vacuum pressure, Therefore, the value of C_1 does not deviates from the present value range.

The output voltage V_{out} is determined is proportional to a ratio of the static capacity C_1 between the vacuum detection terminal 12 and the intermediate shield 5 to a total of C_1 plus capacitor C_0 of the condenser 26, and the output voltage is expressed as follows.

$$V_{out} = V_1 \times C_1 / (C_1 + C_0)$$

The values of C_1 and C_0 are set in advance so that the V_{out} should fall within a detection range of the pressure diagnosis device.

That is, since the C_0 and C_1 are constants, the voltage V_1 of the intermediate shield 4 can be calculated by measuring the V_{out} . Since the voltage V_1 varies depending on the pressure in the vacuum valve 1, and since the pressure increases when something abnormal happens in the vacuum pressure, it is possible to diagnose soundness of the vacuum pressure of the vacuum switch device based on the V_1 or V_{out} values because an

abnormal vacuum pressure increases when discharge takes place.

In this embodiment, the center of the vacuum detection terminal 12 and the intermediate shield 5 are almost the same, and at least a part of the outer periphery of the intermediate shield 5 is covered concentrically with the measuring terminal 12 so that a portion with a minimum distance between the measuring terminal 12 and the intermediate shield 5 can be formed, and the static capacity C_1 hardly varies. Further, since a value of the static capacity can be changed freely by changing an area of the vacuum detection terminal 12 opposed to the intermediate shield 5. As a result, the precision of the vacuum pressure diagnosis increases. It is possible to freely design the static capacity value so that the V_{out} value falls within a detection range of the pressure diagnosis device.

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Further, in this embodiment, since the intermediate shield 5 has a cylindrical form in coincide with the vacuum valve 1, the vacuum detection terminal 12 has a cylindrical form. If a portion having a face where the opposing minimum distance between the intermediate shield and the vacuum detection terminal is approximately constant is formed, a condenser is formed between the opposing faces. The capacity C_1 hardly changes and the static capacity values can be freely changed by altering the opposing face areas.

When the intermediate shield and the vacuum detection

terminal have an analogous form at least part thereof so that the opposing distance is constant, and that the static capacitor C_1 hardly changes. In this case, the static capacitance of the condenser formed between the opposing faces is more stable than
5 the case where the intermediate shield and the vacuum detection terminal are no SOUJIKEI, which have a constant distance therebetween.

Among the cases where at least parts of the intermediate shield and the vacuum detection terminal are analogous and the
10 minimum opposing distance is constant, the intermediate shield 5 is a cylindrical and the vacuum detection terminal has the same center of a circle, corners are removed to alleviate an electric field concentration.

Although the intermediate shield 5 in this embodiment is
15 an arc shield for preventing arc from being in contact with the insulating cylinder, other types of shields may be employed. (Embodiment 2)

Embodiment 2 will be explained by reference to Fig. 5. In this embodiment, three of the vacuum switch devices shown in
20 Figs. 1A and 1B are assembled for three phases. Since each of the vacuum switch devices is already explained, detailed description will be omitted for simplification.

In this embodiment, each of the switch device is provided with a vacuum detection terminal 12 surrounding an intermediate
25 shield 12 and three of voltage detection terminals 18 to which

potentials of the terminals 12 are synthesized at the connection point 27, a synthesized voltage of which is connected to a side of the voltage diagnosis device 19 opposite to an earthing side thereof. Accordingly, a detected voltage V_{out} is a voltage
5 proportional to the synthesized voltage generated at the measuring terminals for three phases.

According to explanation about the embodiment 1 shown in Figs. 1A and 1B, soundness of vacuum pressure of each of the vacuum switches is diagnosed, but a potential induced to the
10 intermediate shield is as high as about 40% the voltage of the main circuit, which is higher than that of conventional value. In addition, since voltages varies in accordance with status of contacts (on or off), the potential tends to vary to thereby lower an S/N ratio.

15 It is possible to monitor a vacuum leak of the vacuum container by issuing signals when a vacuum degree is normal, signal is zero, and when abnormality occurs in any of the three phases and imbalance among the three phases occurs, the signal is issued indicating the abnormality. Regarding the potentials
20 in the abnormal state and normal state, each of the static capacities should be adjusted, and it is not always set to be the normality being zero and abnormality being deviate from zero.

In this embodiment, the signals for three phases are
25 synthesized and input into the diagnosis device 19. However,

the connection points may be two or more to synthesize potentials stepwise. It is not restrict to synthesize all of the three potentials.

In order to inspect if the vacuum detection terminal 12 works normally, an AC withstanding potential test, which is a routine test before shipment is utilized. In this test, the vacuum detection terminal 12 generates a signal when the synthesized voltage of the three phases becomes imbalance, and accordingly it is possible to see if the terminal 12 works normally when the AC voltage application test of each phase is conducted. Although the inspection of the vacuum pressure terminal 12 and the AC voltage withstanding test have been conducted separately, the above mentioned method can conduct the inspection of the vacuum detection terminal 12 and the AC voltage withstanding test simultaneously to thereby reduce the number of test items and shorten the testing time before shipment of the switchgear.

(Embodiment 3)

Embodiment 3 will be explained by reference to Fig. 6. In Fig. 6, disconnection state of the vacuum switch device will be explained. Explanations of other points are omitted for simplification because they are the same as those of other embodiments.

In this embodiment, the disconnection distance between the intermediate air insulated contact 30 of the air insulated earth

disconnection portion 25 and the bushing fixed electrode 31 is made larger than that between the air insulated earth contact 29 of the air insulated earth disconnection portion 25 and the earth side fixed electrode 3. The contact at the vacuum valve 5 1 side is positioned at disconnection thereby to enhance the disconnection state. The earth side fixed electrode 32 is connected to the metal casing 28, which is in the ground potential, as explained in embodiment 1.

According to the above mentioned structures, even if 10 abnormal state such as thunderbolt happens at the load side, the abnormality does not propagate to the bus-bar side to increase reliability because the vacuum valve 1 is positioned at the disconnection.

Even if a vacuum leak takes place and if the disconnection 15 state of the vacuum valve is broken so that the contacts are conducted thereby an abnormal potential of the load side is applied to the air insulated movable conductor 33, the intermediate air insulated contact 30 of the air insulated movable conductor 33 and bushing side fixed electrode 31 do not 20 become conductive because the distance between the intermediate air insulated contact 30 of the air insulated earth disconnection portion 25 and the bushing side fixed electrode 31 is larger than that between the earth air insulated contact 29 of the air insulated earth disconnection portion 25 and the 25 bushing side fixed electrode 31. As a result, the air insulated

earth contact 29 of the air insulated movable conductor 33 and earth side fixed electrode 32 become conductive, without the intermediate air insulated contact 30 of the air insulated movable conductor 33 and the bushing side fixed electrode 31 becoming conductive. Accordingly, it is possible to make preferentially earthing without propagating abnormality to the bus-bar side.

Since propagation of the abnormality to the bus-bar side may further propagate to other circuits, abnormality of one of the circuit at the load side may propagate. Therefore, the reliability of the electric power system is increased by forming preferential earthing structure without propagating the abnormality to the bus-bar side.

The above embodiment is not limited to the vacuum devices provided with a vacuum diagnosis means, but may be utilized for switches or switchgears, which do not diagnose vacuum pressure.

Reference numerals

1; vacuum valve, 2; fixed side ceramic cylinder, 3; fixed side terminal plate, 4; fixed conductor, 5; intermediate shield, 6; movable side ceramic cylinder, 7; movable side terminal plate, 8; movable conductor, 9; load connection conductor, 10; bus-bar connecting conductor, 11; fixed electrode, 12; vacuum detection terminal, 13; insulator, 14; electro-conductive coating, 16; bus-bar connecting bushing, 17; load connecting bushing, 18;

potential detection portion of the vacuum detection terminal,
19; vacuum pressure diagnosis device, 20; voltmeter, 21;
judging circuit, 22; flexible conductor, 23; vacuum valve
insulating rod, 24; earth disconnection insulating rod, 25;
5 air-insulated earth disconnector, 26; condenser, 27;
connecting point, 28; metal casing, 29; air-insulated earth
contact, 30; intermediate air insulated contact, 31; bushing
side fixed electrode, 32; earth side fixed electrode, 33; air
insulated movable conductor, 34; intermediate fixed electrode

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Claims:

1. A vacuum switch device comprising a vacuum valve having a movable conductor and a fixed conductor for closing and interrupting current in vacuum; a shield, which surrounds the movable conductor and the fixed conductor for closing and interrupting current, disposed in the vacuum valve; and a vacuum detection terminal having a face opposed to the face of the shield with a constant distance there between, the face of the terminal extending along the face of the shield, the face of the terminal and the face of the shield having analogous portions where the terminal and the shield being opposed, to detect a voltage generating between a condenser formed between the shield and the terminal so that a vacuum pressure in the vacuum valve is diagnosed.
2. The vacuum switch device according to claim 1, wherein the shield and the vacuum detection terminal have an analogous portion at least a part thereof, and a distance between the shield and the vacuum detection terminal is constant at the analogous portion.
3. The vacuum switch device according to claim 2, the shield is cylindrical, and the vacuum detection terminal has approximately the same center as the shield, where the vacuum detection terminal has a shape surrounding at least a part of the shield.
4. The vacuum switch device according to any one of claims 1 to 3, wherein a potential applied to the vacuum detection terminal is a synthesized potential of potentials of different phases.
5. The vacuum switch device according to claim 4, wherein the

potential applied to the vacuum detection terminal is a synthesized potential of three phases.

6. A vacuum switchgear comprising the vacuum switch device according to any one of claims 1 to 5, and an air insulation-earth disconnection part.

7. The vacuum switchgear according to claim 6, wherein the air insulation earth disconnection portion comprises a movable conductor, an intermediate air contact and air insulated earth contact each being disposed to the movable conductor, a bushing side fixed electrode connected to the bus-bar bushing, and an earth side fixed electrode that contacts with and separates from the air insulated earth contact.