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# SWITCHGEAR

## BACKGROUND OF THE INVENTION

This invention relates to a switchgear having a circuit making and breaking section in a vacuum vessel maintained in a high vacuum for making and breaking a circuit between a power supply and a load machine and in particular to a switchgear for preventing degradation of withstand voltage performance.

A switchgear for making and breaking a circuit between a power supply and a load machine has a circuit making and breaking section in a vacuum vessel maintained in a high vacuum and uses a high dielectric strength in a high vacuum and an excellent arc-extinguishing capability to stably shut off a current.

FIG. 5 is an elevational sectional view to show a switchgear in a related art. In the figure, numeral 1 denotes a vacuum vessel, which is a vessel for holding the inside in a high vacuum by hermetically sealing both ends of a cylindrical insulating pipe 2 forming flanks by a lower lid 3 and an upper lid 4.

At the center of the lower lid 3, a cylindrical fixed conductor rod 5 is fixed in a state in which it penetrates the vacuum vessel 1. A disc-like fixed contactor 6 formed in a diameter to the same degree as that of the fixed conductor rod 5 is brazed via a metal jointing material 7 to the top face of the fixed conductor rod 5 in the vacuum vessel 1, and the margin of the top face of the fixed contactor 6 is chaffered so as to become a curved surface to prevent an electric field

from concentrating.

A cylindrical moving conductor rod 8 penetrating the vacuum vessel 1 through the center of the upper lid 4 is supported movably in an axial direction via an extendable bellows 9 attached in the vacuum vessel 1. A disc-like moving contactor 10 opposed on the bottom face to the top face of the fixed contactor 6 and formed in a diameter to the same degree as that of the moving conductor rod 8 is fixedly secured to the bottom end of the moving conductor rod 8 in the vacuum vessel 1 in an insertion state, and the margin of the bottom face of the moving contactor 10 is chaffered so as to become a curved surface to prevent an electric field from concentrating.

The bellows 9 is hermetically sealed at the top end part to the upper lid 4 of the vacuum vessel 1, covers the moving conductor rod 8, is hermetically sealed at the lower end part at a position to such an extent to expose the lower part of the moving conductor rod 8 to a proper length, and expands and contracts as the moving conductor rod 8 makes a move axially, so that the hermeticity of the vacuum vessel 1 can be held.

The bellows 9 is shaped like a closed-end cylinder and is covered with the bottom face and flanks of a bellows cover 13 formed of a low-conductivity material such as stainless steel, so that it is protected from metal vapor caused by arc occurring between the fixed contactor 6 and the moving contactor 10. The bottom face of the bellows cover 13 is in contact with the bottom end of the bellows 9 and is supported by the moving conductor rod 8 penetrating the center of the bottom face. The flank of the bellows cover 13 has a length

to such an extent it does not come in contact with the upper lid 4 when the moving conductor rod 8 moves upward.

In the described switchgear in the related art, the top face of the fixed contactor 6 and the bottom face of the moving contractor 10 are opposed to each other and when the moving conductor rod 8 moves downward, the moving contractor 10 comes in contact with the fixed contactor 6, placing the switchgear in a make state. When the moving conductor rod 8 is caused to make a move upward for shutting off a current to make the make-to-break state transition of the switchgear, an arc occurs between the fixed contactor 6 and the moving contactor 10 and is extinguished, then the switchgear enters a break state.

However, in the switchgear in the related art, when the current is shut off, the contact surfaces of the fixed contactor 6 and the moving contactor 10 are worn because of the arc occurring between the fixed contactor 6 and the moving contactor 10 and become rough, forming points.

To place the switchgear in a make state for energization in a state in which the contact surfaces of the fixed contactor 6 and the moving contactor 10 are rough, the resistance values of the contact parts of the fixed contactor 6 and the moving contactor 10 are increased because of the presence of the points and thus high heat is generated, fusing the contact parts. Then, when the switchgear is placed in a break state, the contact surfaces are furthermore made rough, forming points.

An electric field concentrates on the thus formed points projecting from the fixed contactor 6 and the moving contactor

10, thus a problem of degrading the withstand voltage performance occurs.

Since the feet of arcs easily stop because of concentration of the electric field, a vicious cycle of causing a local wear to occur and making furthermore the contact surfaces rough is repeated.

## SUMMARY OF THE INVETION

It is therefore an object of the invention to provide a switchgear comprising electric field easing members each projecting from a fixed contactor or a moving contactor in the surroundings of the fixed contactor and the moving contactor, thereby preventing degradation of withstand voltage performance.

It is another object of the invention to provide a switchgear comprising an electric field easing member shaped like a disc having a larger diameter than a fixed contactor has and sandwiched between the fixed contactor and a fixed conductor rod on the fixed contactor side and an electric field easing member shaped like a cylinder having a larger diameter than a moving contactor or a moving conductor rod has and placed in the surroundings of the moving contactor or the moving conductor rod on the moving contactor side, whereby the electric field easing member can also serve as a bellows cover, for example, for preventing degradation of withstand voltage performance without increasing the number of parts as compared with a switch gear in a related art.

(Aspect 1)

According to a first aspect of the invention, there is provided a switchgear comprising:

a fixed contactor,

a moving contactor coming into and out of contact with the fixed contactor,

a first electric field easing member projecting from the fixed contactor side to the moving contactor side, and

a second electric field easing member projecting from the moving contactor side to the fixed contactor side.

(Aspect 2)

According to a second aspect of the invention, there is provided

the switchgear according to aspect 1, wherein

the first electric field easing member is placed in the surrounding of the fixed contactor, and projecting from the fixed contactor to the moving contactor side, and

the second electric field easing member is placed in the surrounding of the moving contactor, and projecting from the moving contactor to the fixed contactor side, when the moving contact is at a position out of contact with the fixed contactor.

Each of the switchgears of the first and second aspects of the invention comprises the electric field easing members each projecting from the fixed contactor or the moving contactor in the surroundings of the fixed contactor and the moving contactor, whereby if either or both of the contact surfaces of the fixed contactor and the moving contactor are made rough and points are formed, concentration of an electric

field on each point is eased and degradation of withstand voltage performance can be prevented.

(Aspect 3)

According to a third aspect of the invention, there is provided the switchgear according to aspect 1, wherein

the fixed contactor is shaped like a disc,

the first electric field easing member is shaped like a disc or a ring having a larger diameter than the fixed contractor has, and fixedly secured to the fixed contactor,

a portion of the first electric field easing member in the surrounding of the fixed contactor projects from the fixed contactor to the moving contactor side,

the second electric field easing member is shaped like a cylinder having a larger diameter than the moving contactor has, and placed in the surrounding of the moving contactor, and has a portion projecting from the moving contactor to the fixed contactor side, when the moving contact is at a position out of contact with the fixed contactor.

(Aspect 4)

According to a fourth aspect of the invention, there is provided the switchgear according to aspect 1, further comprising:

a vessel for housing the fixed contactor, the moving contactor, the first electric field easing member, and the second electric field easing member.

The switchgear of the third aspect of the invention comprises the electric field easing member shaped like a disc having a larger diameter than the fixed contactor has and

sandwiched between the fixed contactor and the fixed conductor rod on the fixed contactor side and the electric field easing member shaped like a cylinder having a larger diameter than the moving contactor or the moving conductor rod has and placed in the surroundings of the moving contactor or the moving conductor rod on the moving contactor side, whereby the part of the switchgear in the related art, for example, a bellows cover is deformed or replaced, so that the number of parts is not increased and if the surface of either or both of the fixed contactor and the moving contactor is made rough and points are formed, concentration of an electric field on each point is eased, thus degradation of withstand voltage performance can be prevented.

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Besides, it is preferable that the moving contactor moves linearly.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is an elevational sectional view to show the break state of a switchgear in a first embodiment of the invention;

FIG. 2 is an elevational sectional view to show the make state of the switchgear in the first embodiment of the invention;

FIG. 3 is a graph to show the simulation results of the switch gear of the invention and that in a related art;

FIG. 4 is an elevational sectional view to show the break state of a switchgear in a second embodiment of the invention;

and

FIG. 5 is an elevational sectional view to show a switchgear in the related art.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the accompanying drawings, there are shown preferred embodiments of the invention.

(First embodiment)

FIGS. 1 and 2 are elevational sectional views to show a switchgear in a first embodiment of the invention; FIG. 1 shows a break state and FIG. 2 shows a make state. In the figure, numeral 1 denotes a vacuum vessel, which is a vessel for holding the inside in a high vacuum by hermetically sealing both ends of a cylindrical insulating pipe 2 forming flanks by a lower lid 3 and an upper lid 4.

At the center of the lower lid 3, a cylindrical fixed conductor rod 5 is fixed in a state in which it penetrates the vacuum vessel 1. The upper diameter of the fixed conductor rod 5 in the vacuum vessel 1 is formed larger than that of any other portion.

A disc-like fixed contactor 6 formed in a diameter smaller than the upper diameter of the fixed conductor rod 5 is brazed via a metal jointing material 7 formed in a diameter to the same degree as the upper diameter of the fixed conductor rod 5 to the center of the top face of the fixed conductor rod 5, and the margin of the top face of the fixed contactor 6 is chaffered so as to become a curved surface to prevent an electric field from concentrating.

The surrounding of the fixed contactor 6, namely, the margin of the metal jointing material 7 is molded so as to project above the fixed contactor 6 and the fixed contactor 6 is buried in the recess center of the metal jointing material 7. The upward projecting margin of the metal jointing material 7 is also chaffered so as to become a curved surface to prevent an electric field from concentrating.

Since the metal jointing material 7 is thus concave in cross section, concentration of an electric field on the vicinity of the buried fixed contactor 6 is eased.

A cylindrical moving conductor rod 8 penetrating the vacuum vessel 1 through the center of the upper lid 4 is supported movably in an axial direction via an extendable bellows 9 attached in the vacuum vessel 1. A disc-like moving contactor 10 formed in a diameter to the same degree as that of the moving conductor rod 8 is fixedly secured to the bottom end of the moving conductor rod 8 in the vacuum vessel 1 in an insertion state, and the margin of the bottom face of the moving contactor 10 is chaffered so as to become a curved surface to prevent an electric field from concentrating.

The bellows 9 is hermetically sealed at the top end part to the upper lid 4 of the vacuum vessel 1, covers the moving conductor rod 8, is hermetically sealed at the lower end part at a position to such an extent to expose the lower part of the moving conductor rod 8 to a proper length, and expands and contracts as the moving conductor rod 8 makes a move axially, so that the hermeticity of the vacuum vessel 1 can be held.

In the surrounding of the bellows 9, a cylindrical

electric field easing shield 11 having a diameter to such an extent that it does not come in contact with the bellows 9 is fixedly secured at the top end to the upper lid 4, and the bottom end of the electric field easing shield 11 is bent inward like an inward flange. Thus, the bottom end of the electric field easing shield 11 is shaped like a plane having an opening at the center, the diameter of the opening is formed a little larger than that of the moving conductor rod 8 or the moving contactor 10, and the tip of the opening is bent upward to prevent an electric field from concentrating.

The side wall of the electric field easing shield 11 is formed to a length to such an extent that it projects to the fixed contactor 6 side from the moving contactor 10 if the moving conductor rod 8 is in the upper limit of the move area.

The electric field easing shield 11 is formed of a low-conductivity material such as stainless steel so that the bend part becomes a curved surface by a working method of drawing and press, etc., to prevent an electric field from concentrating.

Since the electric field easing shield 11 also has a function of protecting the bellows 9 from metal vapor caused by an arc like the bellows cover 13 of the switchgear in the related art, it eliminates the need for the bellows cover 13, thus the number of parts does not increase.

In the described switchgear of the invention, the top face of the fixed contactor 6 and the bottom face of the moving contractor 10 are opposed to each other. Thus, when the moving conductor rod 8 moves downward, the moving contractor 10 comes

in contact with the fixed contactor 6, placing the switchgear in a make state. When the moving conductor rod 8 is caused to make a move upward for shutting off a current to make the make-to-break state transition of the switchgear, an arc occurs between the fixed contactor 6 and the moving contactor 10 and is extinguished, then the switchgear enters a break state.

If the moving conductor rod 8 is in the upper limit of the move area, a contact-to-contact distance d1 between the fixed contactor 6 and the moving contractor 10 becomes longer than a distance d2 between the top end of the metal jointing material 7 and the bottom end of the electric field easing shield 11. If the contact surfaces are made rough and points are formed due to an arc occurring between the fixed contactor 6 and the moving contractor 10 when an electric current is shut off and fusion of the contact parts of the fixed contactor 6 and the moving contractor 10 by heat generated upon energization, the distance between the points of the fixed contactor 6 and the moving contractor 10 does not become shorter than the distance d2 between the projection end of the metal jointing material 7 and an opposite end of the electric field easing shield 11. Thus, concentration of an electric field on each point is eased and an electric field distribution between the contactors is made uniform.

Next, the simulation results will be discussed. FIG. 3 is a graph to show the simulation results of the switch gear of the invention and that in the related art. The calculated electric field at the voltage application time is plotted on

the vertical axis with the calculated electric field in the vicinity of the end part in the contactor of the switchgear in the related art with a rough contact surface as 100%.

In the figure, the △ mark indicates the calculated electric field in the vicinity of the end part in the contactor with the rough contact surface and the calculated electric field of the switchgear of the invention comprising the electric field easing shield is about 50% of the calculated electric field of the switchgear in the related art comprising no electric field easing shield.

In the figure, the ○ mark indicates the calculated electric field at the center in the contactor with the rough contact surface and the calculated electric field of the switchgear of the invention comprising the electric field easing shield is about 70% of the calculated electric field of the switchgear in the related art comprising no electric field easing shield.

It is indicated that the smaller the calculated electric field value, the higher the withstand voltage performance. The simulation results of the rough contact surface state indicate that the switchgear of the invention has higher withstand voltage performance than the switchgear in the related art.

(Second embodiment)

FIG. 4 is an elevational sectional view to show the break state of a switchgear in a second embodiment of the invention. In the second embodiment, the diameter of a fixed conductor rod 5 is made constant and in place of a metal jointing material

7 for burying a fixed contactor 6, a disc-like fixed conductor rod side electric field easing shield 12 having a larger diameter than the fixed contactor 6 has is provided.

The fixed conductor rod side electric field easing shield 12 is sandwiched concentrically between the top face of the fixed conductor rod 5 and the bottom face of the fixed contactor 6 and the surrounding of the fixed contactor 6, namely, the margin of the fixed conductor rod side electric field easing shield 12 is molded so as to project to the side of a moving contactor 8 from the fixed contactor 6, so that the fixed contactor 6 is buried in the recess part at the center of the fixed conductor rod side electric field easing shield 12.

The fixed conductor rod side electric field easing shield 12 is formed of a low-conductivity material such as stainless steel so that the bend part and the outermost margin become curved surfaces by a working method of drawing and press, etc., to prevent an electric field from concentrating.

In the second embodiment of the invention described, the fixed conductor rod side electric field easing shield 12 that can be manufactured comparatively easily is provided, whereby the fixed conductor rod 5 can be shaped to a form having a constant diameter easily molded.

The parts identical with or similar to those previously described with reference to FIGS. 1 and 2 are denoted by the same reference numerals in FIG. 4 and will not be discussed again.

As described in detail, the switchgear according to the invention comprises the electric field easing members each

projecting from the fixed contactor or the moving contactor in the surroundings of the fixed contactor and the moving contactor, whereby if either or both of the contact surfaces of the fixed contactor and the moving contactor are made rough and points are formed, concentration of an electric field on each point is eased and degradation of withstand voltage performance can be prevented.

Further, the switchgear according to the invention comprises the electric field easing member shaped like a disc having a larger diameter than the fixed contactor has and sandwiched between the fixed contactor and the fixed conductor rod on the fixed contactor side and the electric field easing member shaped like a cylinder having a larger diameter than the moving contactor or the moving conductor rod has and placed in the surroundings of the moving contactor or the moving conductor rod on the moving contactor side, whereby the part of the switchgear in the related art is deformed or replaced, so that the number of parts is not increased and if the surface of either or both of the fixed contactor and the moving contactor is made rough and points are formed, concentration of an electric field on each point is eased, thus degradation of withstand voltage performance can be prevented.




WHAT IS CLAIMED IS:

1. A switchgear comprising:

a fixed contactor,

a moving contactor coming into and out of contact with said fixed contactor,

a first electric field easing member projecting from the fixed contactor side to the moving contactor side, and

a second electric field easing member projecting from the moving contactor side to the fixed contactor side.

2. The switchgear according to claim 1, wherein

said first electric field easing member is placed in the surrounding of said fixed contactor, and projecting from said fixed contactor to the moving contactor side, and

said second electric field easing member is placed in the surrounding of said moving contactor, and projecting from said moving contactor to the fixed contactor side, when said moving contact is at a position out of contact with said fixed contactor.

3. The switchgear according to claim 1, wherein

said fixed contactor is shaped like a disc,

said first electric field easing member is shaped like a disc or a ring having a larger diameter than said fixed contractor has, and fixedly secured to said fixed contactor,

a portion of said first electric field easing member in the surrounding of said fixed contactor projects from said fixed contactor to the moving contactor side,

said second electric field easing member is shaped like a cylinder having a larger diameter than said moving contactor has, and placed in the surrounding of said moving contactor, and has a portion projecting from said moving contactor to the fixed contactor side, when said moving contact is at a position out of contact with said fixed contactor.

4. The switchgear according to claim 1, further comprising:

a vessel for housing said fixed contactor, said moving contactor, said first electric field easing member, and said second electric field easing member.

5. The switchgear according to claim 1, further comprising:

a closed-end cylinder for covering said moving contactor.

6. The switchgear according to claim 5, wherein

said closed-end cylinder is formed of a low-conductivity material.

7. The switchgear according to claim 6, wherein

said closed-end cylinder is formed of stainless steel.