

## DESCRIPTION

### SWITCHGEAR BUS CONNECTING CONSTRUCTION

#### TECHNICAL FIELD

The present invention relates to a switchgear bus connecting construction, and particularly to a bus connecting construction to be used when interconnecting power supply circuits housed inside adjacently-disposed insulating gas enclosures external to the enclosures.

#### BACKGROUND ART

In conventional bus connecting constructions, bushing conductors of bushings projecting outward from adjacent insulating gas enclosures and end portions of a connecting conductor are disposed in close proximity, a pair of linking conductors having an arc-shaped cross section are placed over the bushing conductors and the end portions of the connecting conductor from above and below, the pair of linking conductors are fastened by fastening screws, and both of the bushing conductors are connected electrically by means of the connecting conductors and the linking conductors. Electrical insulation properties at the connecting portions between the bushing conductors and the connecting conductors are ensured by mounting rubber stress cones to the connecting portions, and also fitting covers over each of the stress cones. (Japanese Patent Laid-Open No. 2002-238335 (Gazette), for example)

However, in conventional bus connecting constructions, one disadvantage has been that in order to bus-connect two insulating gas enclosures, a pair of bushings, one connecting conductor, two pairs of linking conductors, two stress cones, and two covers are required, making the number of parts large, reducing connection workability, and preventing

cost reductions.

## DISCLOSURE OF INVENTION

The present invention provides a switchgear bus connecting construction reducing component parts, improving connection workability, and achieving cost reductions.

According to the present invention, T-bushings are airtightly mounted to insulating gas enclosures such that an end portion of a branch conductor is electrically connected to a power supply circuit, and end portions of buses are disposed coaxially adjacent to each other, a connecting conductor is fitted over a pair of the adjacent end portions of the buses so as to be slidable while maintaining a state of electrical contact, and an insulating tube composed of an elastic material is fitted over an adjacent pair of electrical insulators in a radially-expanded state so as to cover the connecting conductor and the adjacent end portions of the bus and so as to short-circuit conductive films of the adjacent pair of electrical insulators electrically with each other by means of a grounding conductive layer.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a partial cross section explaining a switchgear bus connecting construction according to the present invention;

Figure 2 is a cross section showing an insulating tube used in the switchgear bus connecting construction according to the present invention;

Figure 3 is a cross section showing a connecting conductor used in the switchgear bus connecting construction according to the present invention;

Figure 4 is a partial enlarged cross section explaining the switchgear bus connecting construction according to the present invention; and

Figure 5 is a partial cross section explaining a connecting operation of the switchgear bus connecting construction according to the present invention.

#### BEST MODE FOR CARRYING OUT THE INVENTION

Preferred embodiments of the present invention will now be explained with reference to the drawings.

##### Embodiment

Figure 1 is a partial cross section explaining a switchgear bus connecting construction according to the present invention, Figure 2 is a cross section showing an insulating tube used in the switchgear bus connecting construction according to the present invention, Figure 3 is a cross section showing a connecting conductor used in the switchgear bus connecting construction according to the present invention, Figure 4 is a partial enlarged cross section explaining the switchgear bus connecting construction according to the present invention, and Figure 5 is a partial cross section explaining a connecting operation of the switchgear bus connecting construction according to the present invention.

In the figures, switchgear is constructed by arranging a plurality of insulating gas enclosures 1 charged with an insulating gas 3 such as sulfur hexafluoride ( $\text{SF}_6$ ) gas, etc., in a single column, and mutually connecting power supply circuits 2 housed inside the insulating gas enclosures 1 by means of T-bushings 4. The insulating gas enclosures 1 interconnected by means of the T-bushings 4 may also be housed inside a housing (not shown).

The T-bushings 4 are prepared so as to have a bus 5 prepared so as to have a linear shape having a circular cross section and a branch conductor 6 disposed so as to extend from a longitudinally-central portion of the bus 5 so as to be perpendicular to the longitudinal direction, the bus

5 and the branch conductor 6 being embedded in an electrical insulator 7 such as an epoxy resin, etc., for example, such that two end portions of the bus 5 and an end portion of the branch conductor 6 are exposed.

Two ends of the portion of the electrical insulator 7 embedding the bus 5 are constructed into a stepped cylindrical shape constituted by a large diameter portion 7a and a small diameter portion 7b, a step portion 7c being formed between the large diameter portion 7a and the small diameter portion 7b. A boundary portion 7d between the large diameter portion 7a and the step portion 7c and a boundary portion 7e between the step portion 7c and the small diameter portion 7b are formed so as to have curved surfaces having a radius of 2 mm. Moreover, there is no particular problem if the radius of this curved surface is within a range of 1 mm to 3 mm. Thus, the large diameter portion 7a and the step portion 7c are linked by a smooth continuous surface, and the step portion 7c and the small diameter portion 7b are linked by a smooth continuous surface.

A flange portion 7f is formed integrally on a portion of the electrical insulator 7 embedding the branch conductor 6 near the bus 5. An annular groove 7g is recessed into a surface of the flange portion 7f on an opposite side from the bus so as to surround the branch conductor 6. In addition, threading, for example, is applied to an end portion of the branch conductor 6 projecting out of the electrical insulator 7 to enable electrical connection with the power supply circuits 2.

In addition, a conductive coating 8 constituting a grounding layer is formed on an external surface of the electrical insulator 7 in a state of electrical isolation from the bus 5 and the branch conductor 6. This conductive coating 8 is formed, for example, by applying a process such as application of conductive paint, metallized contact spraying (a process in which a metal such as zinc, aluminum, etc., is sprayed onto a base material), etc., to the surface of the electrical insulator 7. Moreover, as

shown in Figure 4, the conductive coating 8 is formed by coating on the small diameter portion 7b in a vicinity of the step portion 7c, but the conductive coating 8 is not formed on other portions of the small diameter portion 7b.

The connecting conductor 10, as shown in Figure 3, is prepared into a cylindrical shape, an annular recessed groove 10b being formed at each of two end portions of a central aperture 10a, and an annular recessed groove 10c is formed on a longitudinally-central outer peripheral surface. Annular contacts 11 are fitted into each of the recessed grooves 10b such that a portion of each protrudes. An inside diameter of the central aperture 10a is also formed with a slightly larger diameter than a diameter of the bus 5, and an inside diameter of the contact 11 is formed with a slightly smaller diameter than the diameter of the bus 5. In addition, an outside diameter of the connecting conductor 10 generally matches an outside diameter of the small diameter portion 7b of the electrical insulator 7.

An insulating tube 12, as shown in Figure 2, is prepared so as to have a three-layer construction constituted by: a hollow cylindrical insulating body 13 made of an elastic material having electrically-insulating properties; a field-relaxing conductive layer 14 made of an elastic material having electrically-conductive properties formed integrally on an inner peripheral surface of the insulating body 13; and a grounding conductive layer 15 made of an elastic material having electrically-conductive properties formed integrally on the insulating body 13 so as to cover the external surfaces and two inner peripheral surface end portions of the electrically-insulating body 13. A protruding portion 14a is formed so as to have an annular shape on a central portion of the field-relaxing conductive layer 14 so as to project radially inward. This protruding portion 14a is shaped so as to fit together with the annular

recessed groove 10c of the connecting conductor 10. Furthermore, an inside diameter of the insulating tube 12 is formed with a slightly smaller diameter than the outside diameter of the small diameter portion 7b of the electrical insulator 7. In addition, a length of the insulating tube 12 is formed so as to be slightly shorter than a distance between the step portions 7c of the T-bushings 4 mounted on the adjacent insulating gas enclosures 1 so as to face each other, and a length of the field-relaxing conductive layer 14 is formed so as to be longer than a distance between tip ends of the small diameter portions 7b. Here, a silicone resin, or a polyethylene resin, etc., for example, can be used for the elastic material having electrically-insulating properties. Furthermore, a silicone resin, or a polyethylene resin, etc., with carbon, etc., added, for example, can be used for the elastic material having electrically-conductive properties.

Next, a method for bus-connecting the power supply circuits 2 will be explained. First, an insulating gas enclosure 1 housing a power supply circuit 2 is arranged so as to line up in a single column. Then, an end portion of the branch conductor 6 is electrically connected to the power supply circuit 2 by inserting a branch conductor end of the T-bushing 4 through an aperture 1b disposed through a mounting portion 1a of the insulating gas enclosure 1. Next, the T-bushing 4 is mounted to the insulating gas enclosure 1 by fastening the flange portion 7f to the mounting portion 1a with bolts 17. At this time, an O ring 16 functioning as a packing is fitted into the annular groove 7g of the flange portion 7f to ensure airtightness of the insulating gas enclosure 1. An insulating gas 3 such as sulfur hexafluoride ( $\text{SF}_6$ ) gas, etc., is then sealed inside the insulating gas enclosure 1.

Then, the connecting conductor 10 is fitted over an end portion of the bus 5. At this time, the connecting conductor 10 is pushed inward so as to be in close proximity to the small diameter portion 7b of the electrical insulator 7 and is placed in a state of electrical contact with the bus 5 by

means of a contact 11. Next, the insulating tube 12 with an insulating grease 18 applied to an inner peripheral surface is fitted over the electrical insulator 7 from an end near the end portion of the bus 5. At this time, the insulating tube 12 is pushed inward so as to slide onto the large diameter portion 7a of the electrical insulator 7. Thus, the insulating tube 12 expands radially outward and is mounted onto the large diameter portion 7a.

Next, a T-bushings 4 is mounted to an adjacent insulating gas enclosure 1. Thus, as shown in Figure 5, end portions of the buses 5 of the T-bushings 4 are disposed coaxially in close proximity to each other.

Then, while expanding the free end of the insulating tube 12 radially outward, the insulating tube 12 is moved in the direction indicated by the arrows in Figure 5 to a position at which the protruding portion 14a and the recessed groove 10c fit together. Thus, when the expansion of the insulating tube 12 is released, the insulating tube 12 contracts radially inward, and the protruding portion 14a engages the recessed groove 10c. Thereafter, the insulating tube 12 moves in the direction indicated by the arrows in Figure 5 until positioned over the small diameter portion 7b of the electrical insulator 7. With the movement of the insulating tube 12, the connecting conductor 10 slides and moves over the bus 5, and eventually one end of the connecting conductor 10 is fitted over the opposite bus 5, electrically connecting the buses 5 by means of the connecting conductor 10 and the contact 11. In other words, the power supply circuits 2 inside the two insulating gas enclosures 1 are electrically connected. At this time, the insulating tube 12, as shown in Figure 1, covers the end portions of the connecting conductor 10 and the adjacent buses 5, and is fitted over the small diameter portions 7b of the adjacent electrical insulators 7 in a radially-expanded state. Furthermore, the conductive films 8 of the adjacent electrical insulators 7 are electrically

connected by means of the grounding conductive layer 15. In addition, as shown in Figure 4, gaps between the insulating tube 12 and the small diameter portion 7b of the electrical insulators 7 are filled by the insulating grease 18.

This operation is performed repeatedly to electrically connect power supply circuits 2 housed inside the insulating gas enclosures 1 arranged in the single column to each other.

Next, when electrically disconnecting the power supply circuits 2, a central portion of the insulating tube 12 is held and moved toward a first bus 5. Thus, the connecting conductor 10 slides over the buses 5 and moves onto the first bus 5, disconnecting the power supply circuits 2 electrically. Then, if the insulating tube 12 is moved additionally toward the first bus 5, the connecting conductor 10 is placed in contact with the end portion of the small diameter portion 7b, preventing further movement. Thus, the engagement between the protruding portion 14a and the recessed groove 10c is released and only the insulating tube 12 moves, expanding in a radial direction while riding up onto the large diameter portion 7a, and assuming the state shown in Figure 5.

In addition, the connecting conductor 10 can be exposed by moving only the insulating tube 12 toward the first bus 5, enabling the main circuit resistance to be measured.

Using this bus connecting construction, because two power supply circuits 2 are constructed so as to be connected by a pair of T-bushings 4, a single connecting conductor 10, and a single insulating tube 12, the number of parts is reduced, connection workability is improved, and costs can be reduced. Because connection and disconnection between the buses 5 can be performed by the movement of the insulating tube 12 in an axial direction of the buses 5, workability is improved. Furthermore, interface insulation portions between the electrical insulators 7 are reduced,

improving the reliability of the bus connecting portion. In addition, because the insulating tube 12 is made of an elastic material and has an inside diameter less than the outside diameter of the small diameter portion 7b, when the insulating tube 12 is fitted over the small diameter portion 7b, a radially-inward shrinkage force arises, reliably ensuring the engagement of the insulating tube 12 on the small diameter portion 7b.

Because two end portions of the portion of the electrical insulator 7 embedding the bus are constructed so as to have a stepped cylindrical shape constituted by a large diameter portion 7a and a small diameter portion 7b formed by means of a step portion 7c from the large diameter portion 7a, movement of the insulating tube 12 resulting from vibrations is regulated by the small diameter portion 7b, also avoiding situations such as the connecting conductor 10 being exposed accidentally.

Because the boundary portion 7d between the large diameter portion 7a and the step portion 7c is formed so as to have a curved surface shape, damage generated in the insulating tube 12 during movement of the insulating tube 12 can be suppressed.

Because the boundary portion 7e between the step portion 7c and the small diameter portion 7b is formed with a curved surface shape, the movement operation from the small diameter portion 7b to the large diameter portion 7a and the movement operation from the large diameter portion 7a to the small diameter portion 7b of the insulating tube 12 can be performed smoothly.

Because the insulating grease 18 is charged between the insulating tube 12 and the small diameter portion 7b, reductions in withstand voltage performance and partial discharge performance resulting from air gaps can be prevented, and movement of the insulating tube 12 is smooth.

Because the protruding portion 14a is formed so as to have an annular shape projecting from a central portion of the field-relaxing

conductive layer 14, and the annular recessed groove 10c is formed on a longitudinally-central outer peripheral surface of the connecting conductor 10, when the insulating tube 12 is mounted, the recessed groove 10c fits together with the protruding portion 14a, maintaining the engagement of the connecting conductor 10 relative to the adjacent buses 5. Thus, incidents such as the power supply circuits 2 being disconnected from each other electrically by movement of the connecting conductor 10 can be prevented, enabling bus connection reliability to be increased.

Because the flange portions 7g formed on the portions of the electrical insulators 7 embedding the branch conductors 6 are fastened to the mounting portions 1a of the insulating gas enclosures 1 with O rings 16 interposed between the flange portions 7g and the mounting portions 1a, airtightness of the insulating gas enclosures 1 is ensured.

Moreover, in the above embodiments, the contacts 11 are explained as being mounted to the connecting conductor 10, but the contacts 11 may also be mounted to the buses 5.

#### INDUSTRIAL APPLICABILITY

As explained above, a switchgear bus connecting construction according to the present invention is useful for externally interconnecting power supply circuits housed inside adjacently-disposed insulating gas enclosures constituting switchgear.

## CLAIMS

1. A switchgear bus connecting construction in which a plurality of insulating gas enclosures housing a power supply circuit are disposed adjacently, said switchgear bus connecting construction comprising:

    T-bushings having:

        a bus prepared so as to have a linear shape having a circular cross section;

        a branch conductor disposed so as to extend perpendicular to a longitudinal direction from a longitudinally-central portion of said bus;

        an electrical insulator embedding said bus and said branch conductor such that first and second end portions of said bus and an end portion of said branch conductor are exposed; and

        a conductive film formed on an external surface of said electrical insulator in a state of electrical isolation from said bus and said branch conductor;

a hollow cylindrical connecting conductor; and

an insulating tube having:

        a hollow cylindrical insulating body made of an elastic material having electrically-insulating properties;

        a field-relaxing conductive layer composed of an elastic material having electrically-conductive properties formed integrally on an inner peripheral surface of said insulating body; and

        a grounding conductive layer composed of an elastic material having electrically-conductive properties formed integrally on said insulating body so as to cover an external surface and first and second end portions of an inner peripheral surface of said insulating body,

wherein:

said T-bushings are airtightly mounted to each of said insulating gas enclosures such that said end portion of said branch conductor is electrically connected to said power supply circuit, and said end portions of said buses are disposed coaxially adjacent to each other;

said connecting conductor is fitted over a pair of said adjacent end portions of said buses so as to be slidable while maintaining a state of electrical contact; and

said insulating tube is fitted over an adjacent pair of said electrical insulators in a radially-expanded state so as to cover said connecting conductor and said adjacent end portions of said bus and so as to short-circuit said conductive films of said adjacent pair of electrical insulators electrically with each other by means of said grounding conductive layer.

2. The switchgear bus connecting construction according to Claim 1, wherein:

first and second end portions of a portion of said electrical insulator embedding said bus are constructed so as to have a stepped cylindrical shape constituted by:

a large diameter portion; and

a small diameter portion over which said insulating tube is fitted, formed by means of a step portion from said large diameter portion; and

a boundary portion between said large diameter portion and said step portion and a boundary portion between said step portion and said small diameter portion are formed so as to have curved surfaces.

3. The switchgear bus connecting construction according to Claim 2,

wherein:

an insulating grease is charged between said insulating tube and said small diameter portion.

4. The switchgear bus connecting construction according to Claim 1, wherein:

a protruding portion is formed so as to project in an annular shape from a central portion of an inner periphery of said field-relaxing conductive layer of said insulating tube; and

an annular recessed groove fitting together with said protruding portion is formed on a longitudinally-central outer peripheral surface of said connecting conductor.

5. The switchgear bus connecting construction according to Claim 1, wherein:

a flange portion is formed on a portion of said electrical insulator embedding said branch conductor; and

said T-bushings are mounted by interposing a packing between said flange portion and said insulating gas enclosure, and fastening said flange portion to said insulating gas enclosure.

## SWITCHGEAR BUS CONNECTING CONSTRUCTION

## ABSTRACT

An object of the present invention is to provide a switchgear bus connecting construction reducing component parts, improving connection workability, and achieving cost reductions.

In this construction, T-bushings are airtightly mounted to insulating gas enclosures such that an end portion of a branch conductor is electrically connected to a power supply circuit, and end portions of buses are disposed coaxially adjacent to each other, a connecting conductor is fitted over a pair of the adjacent end portions of the buses so as to be slidable while maintaining a state of electrical contact, and an insulating tube composed of an elastic material is fitted over an adjacent pair of electrical insulators in a radially-expanded state so as to cover the connecting conductor and the adjacent end portions of the bus and so as to short-circuit conductive films of the adjacent pair of electrical insulators electrically with each other by means of a grounding conductive layer.

Thus, the number of parts is reduced, connection workability is improved, and cost reductions are enabled.

FIGURE 1