

POWER CABLE TERMINATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is entitled to and claims the benefit of Japanese Patent Application
5 No.2013-188281, filed on September 11, 2013, the disclosure of which including the specification, drawing and abstract is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

10 [0002] The present invention relates to a power cable termination in which a terminal part of the power cable is housed in an epoxy porcelain bushing, and in particular, to a non-penetration type termination (closed type).

2. Description of Related Art

15 [0003] Conventionally, as a power cable termination of a power cable such as an OF cable (oil-filled cable), a “penetration type” termination is known (Non-PTL 1: Yukio YAMASHITA et al., “Completion of the 400 kV Polypropylene Laminated Paper Insulated Oil-filled Cable Project in Singapore,” Mitsubishi Cable Industries review, July, 2002 No. 99, pp. 61-68). In a penetration type termination, a conductor connection terminal connected to a cable conductor is
20 inserted into an opening part of a fore end of an epoxy porcelain bushing and pulled out. Therefore, the opening part of the fore end of the epoxy porcelain bushing is sealed with an sealing member such as an O-ring to prevent insulating oil from leaking out through the opening part of the fore end of the epoxy porcelain bushing (the penetration part of the conductor connection terminal), and to prevent gas (such as SF₆ gas, for example) in the device from
25 entering the epoxy porcelain bushing. To be more specific, a sealing member is provided on the outer periphery of the conductor connection terminal that passes through the opening part of the fore end of the epoxy porcelain bushing, so as to seal the opening part between the inner periphery of the opening part and the outer periphery of the conductor connection terminal.

[0004] In the above-described penetration type termination, aging degradation of the sealing
30 member is unavoidable. In particular, at the termination of an OF cable, leakage of insulating oil due to degradation of the sealing member is concerned. Under such circumstances, in recent years, a “non-penetration type (closed type)” termination in which a conductor connection terminal is connected to an inner conductor that is embedded in the fore end of an epoxy porcelain bushing and whose fore end side is sealed is desired. A conventional non-penetration
35 type termination has, as a termination of a CV cable, a configuration in which a conductor connection terminal and an inner conductor are connected by a tulip type contact (so-called “tulip contact”), for example (PTL 1: Japanese Patent No. 4667472).

SUMMARY OF THE INVENTION

[0005] An object of the present invention is to provide a highly reliable non-penetration type (closed type) termination that is easy to assemble and can surely prevent removal of a power cable.

[0006] To achieve the abovementioned object, a power cable termination reflecting one aspect of the present invention includes: a terminal part of a power cable including a cable conductor exposed by step-stripping; a conductor connection terminal connected to a fore end of the cable conductor; an epoxy porcelain bushing including an epoxy resin insulator and an inner conductor that are integrally formed, the epoxy resin insulator being configured to house the terminal part of the power cable, the inner conductor connected to the conductor connection terminal; a contact interposed between the conductor connection terminal and the inner conductor, the contact being configured to electrically connect the conductor connection terminal and the inner conductor together; a cable detention part symmetrically protruding from the conductor connection terminal in a radial direction; a fixing member disposed in the epoxy porcelain bushing and including a through hole, the through hole being configured to allow insertion of the conductor connection terminal and the cable detention part and to make the conductor connection terminal and the cable detention part irremovable toward rear end side when the conductor connection terminal and the cable detention part are axially rotated after the insertion; and an anti-rotation part disposed near the through hole, the anti-rotation part being configured to non-rotatably hold the conductor connection terminal and the cable detention part.

BRIEF DESCRIPTION OF DRAWINGS

[0007] The present invention will become more fully understood from the detailed description given hereinbelow and the appended drawings which are given by way of illustration only, and thus are not intended as a definition of the limits of the present invention, and wherein:

FIG. 1 illustrates a general configuration of a power cable termination according to an embodiment of the present invention;

FIG. 2 is an enlarged view of a fore end portion (a fixing portion of the power cable) of the power cable termination;

FIG. 3 is an exploded view of the power cable and an epoxy porcelain bushing in a non-assembled state;

FIG. 4 is a plan view of a fixing part as viewed from the fore end side;

FIG. 5 is a sectional view of a state where the power cable terminal part is inserted into the epoxy porcelain bushing;

FIG. 6 illustrates a positional relationship between a conductor connecting part and a fixing metal part at the time when the terminal part of the power cable is inserted into the epoxy porcelain bushing; and

FIG. 7 illustrates a positional relationship between the conductor connecting part and the fixing metal part after the terminal part of the power cable has been inserted into the epoxy porcelain bushing.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0008] In the following, an embodiment of the present invention will be described in detail with reference to the accompanying drawings.

5 In the following, the embodiment of the present invention is described referring to the drawings.

FIG. 1 illustrates a general configuration of power cable termination 1 according to an embodiment of the present invention. FIG. 2 is an enlarged view of a fore end portion (a fixing portion of the power cable 10) of power cable termination 1. FIG. 3 is an exploded view of power cable 10 and epoxy porcelain bushing 20 in a non-assembled state. In FIG. 1 to FIG. 3, the lower side in the drawings is referred to as the rear end side or the rear end direction, and the upper side in the drawings is referred to as the fore end side or the end direction.

[0009] As illustrated in FIG. 1 to FIG. 3, power cable termination 1 includes a terminal part of power cable 10, epoxy porcelain bushing 20, conductor connecting part 30, fixing part 40, and the like. Power cable termination 1 is a non-penetration type (closed type) termination for use in connecting power cable 10 to electric power devices (not illustrated) such as switchgear units and transformer units. In the present embodiment, an exemplary case of a gas immersed termination in which an OF cable is applied as power cable 10 will be described.

[0010] In the case where power cable 10 is an OF cable, power cable 10 includes, in order from the center, an oil passage (not illustrated), cable conductor 11, cable insulation layer 12, metal sheath 13, a corrosion-proof layer (not illustrated) and the like, and insulating oil is filled in power cable 10.

The oil passage (not illustrated) is a passage of the insulating oil filled in power cable 10. A reinforcing steel pipe (not illustrated) is inserted to the fore end of the oil passage so as not to collapse the oil passage when conductor connection terminal 31 is compressively connected to the terminal part of power cable 10. Cable conductor 11 is composed of a copper strand or an aluminum strand, for example. Insulation layer 12 is oil impregnated paper that is wound around the peripheral surface of cable conductor 11, and is composed of kraft paper and semisynthetic paper, for example. Metal sheath 13 is composed of lead or aluminum, for example. The corrosion-proof layer (not illustrated) is composed of PVC (polyvinyl chloride), PE (polyethylene), or nylon, for example.

[0011] The terminal part of power cable 10 is step-stripped, and cable conductor 11 and insulation layer 12 are exposed. On the outer peripheral surface of insulation layer 12, electric field stress-control part 14 that is used for electric field stress-control and is composed of reinforce insulation paper 142 and epoxy bell-mouth 141 is formed. In the case of the OF cable, electric field stress-control part 14 is formed before the terminal part of power cable 10 is inserted into epoxy porcelain bushing 20. In addition, conductor connection terminal 31 is compressively connected to the fore end of the terminal part of power cable 10 (fore end of cable conductor 11).

[0012] Conductor connecting part 30 includes conductor connection terminal 31, cable detention rod 32, and the like.

Conductor connection terminal 31 is a metal member configured to be connected to the fore end of cable conductor 11. Conductor connection terminal 31 includes small diameter part 311 provided on the fore end side, large diameter part 312 continuously provided on the rear end side of small diameter part 311, and compression connecting part 313 continuously provided on the rear end side of large diameter part 312.

[0013] Small diameter part 311 includes a horizontal detention rod through hole (not illustrated) for insertion of cable detention rod 32. In addition, in small diameter part 311, a smaller-sized pin through hole (not illustrated) perpendicular to the detention rod through hole is provided in a horizontal direction. The smaller-sized pin through hole is used for insertion of a pin (not illustrated) that fixes cable detention rod 32 to conductor connection terminal 31 (small diameter part 311). Resin protection cap 35 is disposed at the fore end of small diameter part 311. Protection cap 35 is formed in a cylindrical form. The outer diameter of protection cap 35 is substantially the same as the outer diameter of small diameter part 311.

[0014] The total length of cable detention rod 32 is greater than the outer diameter of small diameter part 311 of conductor connection terminal 31, and smaller than the inner diameter of end housing part 222 of inner conductor 22 described later. Cable detention rod 32 is made of metal, formed in a cylindrical form, and provided with a pin through hole (not illustrated) having the same diameter as that of the pin through hole provided in small diameter part 311, at the center in the longitudinal direction. Cable detention rod 32 is inserted into the detention rod through hole (not illustrated) provided in small diameter part 311, and is fixed to conductor connection terminal 31 (small diameter part 311) by inserting a pin through the pin through hole in a state where the positions of the pin through hole provided in cable detention rod 32 and the pin through hole provided in small diameter part 311 of conductor connection terminal 31 are matched. Cable detention rod 32 symmetrically protrudes in the radial direction (horizontal direction) from conductor connection terminal 31.

[0015] The outer diameter of large diameter part 312 is greater than the outer diameter of small diameter part 311, and slightly smaller than the inner diameter of inner conductor 22 (intermediate housing part 223 described later). Resin protective cover 34 is disposed at the fore end of large diameter part 312. Protective cover 34 is formed in a cylindrical form so as to allow small diameter part 311 to pass therethrough. The outer diameter of protective cover 34 is substantially the same as that of large diameter part 312.

[0016] An annular recessed groove for fitting contact 33 is formed in the peripheral surface of large diameter part 312, and contact 33 for electrically connecting conductor connection terminal 31 and inner conductor 22 together is disposed in the recessed groove. Preferably, contact 33 is a spring-like contact (for example, the Multilam Contact Band having a plurality of v-shaped contact segments as disclosed in PTL 1) that includes a plurality of radially extendable v-shaped contact segments joined in parallel with one another along the circumferential direction of

conductor connection terminal 31. Thus, an energization part having a good flexibility can be formed.

[0017] Compression connecting part 313 includes conductor housing part 313a that houses cable conductor 11. Compression connecting part 313 is compressed with cable conductor 11 inserted in conductor housing part 313a, and is electrically connected to cable conductor 11, while irremovably holding cable conductor 11.

[0018] Epoxy porcelain bushing 20 has a configuration in which epoxy resin insulator 21 and inner conductor 22 are integrally formed by molding. Since insulator 21 and inner conductor 22 are integrally formed, it is not necessary to dispose a sealing member such as an O-ring at the boundary portion.

[0019] Insulator 21 is a hanging-bell-shaped member having opening 211 at the rear end thereof. The inner space of insulator 21 serves as cable terminal housing part 212 for housing the terminal part of power cable 10. Insulator 21 is provided with flange part 213 for attaching epoxy porcelain bushing 20 to device case 60 of an electric power device, at the rear end portion thereof. Flange part 213 is air-tightly attached to device case 60 such that the fore end side of epoxy porcelain bushing 20 with respect to flange part 213 is located in device case 60.

[0020] Inner conductor 22 is a capped cylindrical metal member which has opening 221 at the rear end thereof, and whose fore end is closed. The rear end side of inner conductor 22 is embedded in the fore end portion of insulator 21 with the inner periphery thereof exposed.

[0021] The inner space of inner conductor 22 is divided into end housing part 222, intermediate housing part 223, and rear end housing part 224.

Large diameter part 312 of conductor connection terminal 31 is located at intermediate housing part 223, and inner conductor 22 and conductor connection terminal 31 are electrically connected together through contact 33.

The rear end portion of conductor connecting part 30 (conductor connection terminal 31) is located at the rear end housing part 224. To moderate concentration of electric field, the rear end of inner conductor 22 has a bulging form having an arc-like form as viewed in cross-section.

Fixing part 40 for fixing conductor connecting part 30 is disposed at the rear end portion of end housing part 222. Screw part 222a for mounting fixing part 40 is formed on the inner periphery surface of the rear end portion of end housing part 222.

[0022] Fixing part 40 includes fixing metal part 41 and check pins 42. FIG. 4 is a plan view of fixing part 40 as viewed from the fore end side.

Fixing metal part 41 is a cylindrical metal member having an outer diameter same as the inner diameter of the rear end portion of end housing part 222 of inner conductor 22. Screw part (male screw) 41a that is threadedly engaged with screw part (female screw) 222a of end housing part 222 is formed on the outer peripheral surface of fixing metal part 41.

[0023] Fixing metal part 41 has through hole 411 through which the fore end portion of conductor connecting part 30, that is, small diameter part 311 and cable detention rod 32 of

conductor connection terminal 31 can be inserted. That is, through hole 411 has a form same as the planar form of small diameter part 311 and cable detention rod 32 of conductor connection terminal 31 as viewed from the fore end side. Through hole 411 has such a size that large diameter part 312 of conductor connection terminal 31 cannot be inserted therethrough.

Through hole 411 is divided into first portion 411a (circular portion) through which conductor connection terminal 31 is inserted, and second portions 411b (portions which radially outwardly protrude from first portion 411a) through which cable detention rod 32 is inserted.

[0024] Check pins 42 are cylindrical metal members, and the tip of each check pin 42 has an arc-like form in cross-section in FIG. 4 (that is, the tip of each check pin 42 has a hemispherical form in the case of FIG. 4). Check pins 42 are uprightly provided on the upper end surface of fixing metal part 41. In the case of FIG. 4, on the upper end surface of fixing metal part 41, screw holes for threadedly engaging check pins 42 are provided at four places. Check pins 42A to 42D are threadedly engaged in respective screw holes, and fixed with an adhesive agent and the like so as not to be loosened. In FIG. 4, check pins 42A and 42B are disposed at two positions facing each other with one of second portions 411b of through hole 411 therebetween, and check pins 42C and 42D are disposed at two positions facing each other with the other of second portions 411b of through hole 411 therebetween. With this configuration, it is possible to surely prevent a situation where the terminal part of power cable 10 rotates and drops off from fixing metal part 41 after the terminal part of power cable 10 is inserted into epoxy porcelain bushing 20 and assembled.

It is to be noted that each check pin 42 only has to have such a height as not to allow cable detention rod 32 to easily pass over check pin 42 when an axial torque is caused at the terminal part of power cable 10.

[0025] When assembling power cable termination 1, first, fixing metal part 41 provided with upright check pins 42 is attached to the rear end portion of the end housing part 222 of epoxy porcelain bushing 20. Screw part 222a is provided at the rear end portion of end housing part 222, and a step is provided on the fore end side of screw part 222a. Until the fore end face of fixing metal part 41 abuts the step, fixing metal part 41 is screwed. The position where fixing metal part 41 is attached is set at a position where cable detention rod 32 is located upwardly of check pin 42 when the terminal part of power cable 10 is inserted into epoxy porcelain bushing 20 and the fore end of conductor connecting part 30 abuts the inner fore end surface of inner conductor 22 (see FIG. 5).

[0026] In the present embodiment, the position where fixing metal part 41 is attached is located on the fore end side with respect to the fore end portion of insulator 21, and located at a position far from opening 211 of insulator 21. Besides, in the case of an OF cable, epoxy bell-mouth 141 is mounted to cable insulation layer 12. Therefore, it is nearly impossible to, after power cable 10 is inserted into epoxy porcelain bushing 20 with fixing metal part 41 put in advance on the terminal part of power cable 10, insert and attach fixing metal part 41 to a predetermined part beyond epoxy bell-mouth 141. For this reason, in the present embodiment, it is necessary that

fixing metal part 41 is attached to epoxy porcelain bushing 20 (inner conductor 22) before the terminal part of power cable 10 is inserted into epoxy porcelain bushing 20.

[0027] On the other hand, at the terminal part of power cable 10, electric field stress-control part 14 is formed on the peripheral surface of cable insulation layer 12. In addition, conductor connecting part 30 is attached to cable conductor 11. Further, the terminal part of power cable 10 is vertically supported with a support stand (not illustrated).

[0028] Next, with the terminal part of power cable 10 and epoxy porcelain bushing 20 aligned, epoxy porcelain bushing 20 is lowered to insert the fore end portion of conductor connecting part 30 to through hole 411 of fixing metal part 41 such that cable detention rod 32 is inserted into through hole 411 of fixing metal part 41 (see FIGS. 5 and 6). At this time, epoxy porcelain bushing 20 is lowered until the fore end of conductor connecting part 30 abuts the inner fore end surface of inner conductor 22. That is, the inserting position is confirmed by bringing the fore end portion of conductor connecting part 30 into abutment with inner conductor 22. As illustrated in FIG. 5, cable detention rod 32 is located on the fore end side with respect to check pin 42.

It is to be noted that protection cap 35 disposed at the fore end is omitted in FIG. 6 for convenience of the description. The same applies to FIG. 7.

[0029] Protection cap 35 is disposed at the fore end of small diameter part 311 of conductor connection terminal 31, and protective cover 34 is disposed at the fore end of large diameter part 312, whereby epoxy porcelain bushing 20 and conductor connecting part 30 are not damaged even when the fore end of conductor connecting part 30 abuts epoxy porcelain bushing 20 (inner conductor 22). That is, it is possible to prevent a situation where the metal members make contact with each other in epoxy porcelain bushing 20 to generate metal powder.

[0030] Next, after epoxy porcelain bushing 20 is axially rotated by approximately 90 degrees such that one end of cable detention rod 32 is located between check pins 42A and 42C and the other end of cable detention rod 32 is located between check pins 42B and 42D, epoxy porcelain bushing 20 is raised. The length from second portions 411b on one side of through hole 411 to second portions 411b on the other side of through hole 411 in fixing metal part 41 is slightly greater than the total length of cable detention rod 32. In addition, the inner diameter of first portion 411a (circular portion) of through hole 411 of fixing metal part 41 is smaller than the total length of cable detention rod 32. Thus, cable detention rod 32 is caught at the peripheral portion of through hole 411 of fixing metal part 41, and the terminal part of power cable 10 becomes irremovable toward rear end side (see FIG. 7). It is also possible to rotate power cable 10 with epoxy porcelain bushing 20 fixed to device case 60 (see FIG. 1); however, rotating epoxy porcelain bushing 20 offers better workability, and therefore is preferable.

In addition, large diameter part 312 of conductor connection terminal 31 is set at a position of intermediate housing part 223 of inner conductor 22, and conductor connection terminal 31 and inner conductor 22 are favorably electrically connected by contact 33.

[0031] It is to be noted that lower metal member 51 is air-tightly attached to the rear end of

epoxy porcelain bushing 20. In addition, melted solder is applied at the boundary between lower metal member 51 and metal sheath 13 to thereby form solder part 52, and thus lower metal member 51 and metal sheath 13 are connected to each other. Reinforcement layer 53 made of epoxy resin and the like is formed around solder part 52. Further, waterproof treatment 54 such as a self-fusing rubber tape and an adhesive PVC tape is provided around reinforcement layer 53. Insulating oil from power cable 10 is supplied in epoxy porcelain bushing 20.

[0032] Power cable termination 1 according to the present embodiment includes: a terminal part of power cable 10 having cable conductor 11 exposed by step-stripping; conductor connection terminal 31 connected to a fore end of cable conductor 11; epoxy porcelain bushing 20 including epoxy resin insulator 21 that houses the terminal part of power cable 10 and an inner conductor 22 that is connected to conductor connection terminal 31, epoxy resin insulator 21 and inner conductor 22 being integrally formed; contact 33 interposed between conductor connection terminal 31 and inner conductor 22, contact 33 being configured to electrically connect conductor connection terminal 31 and inner conductor 22 together; cable detention rod 32 (cable detention part) symmetrically protruding from conductor connection terminal 31 in a radial direction; fixing metal member 41 (fixing member) disposed in epoxy porcelain bushing 20 and including through hole 411, through hole 411 being configured to allow insertion of conductor connection terminal 31 and cable detention rod 32 and to make conductor connection terminal 31 and cable detention rod 32 irremovable toward rear end side when conductor connection terminal 31 and cable detention rod 32 are axially rotated after the insertion; and check pin 42 (anti-rotation part) disposed near through hole 411, check pin 42 being configured to non-rotatably hold conductor connection terminal 31 and cable detention rod 32.

[0033] According to power cable termination 1, by only rotating after the terminal part of power cable 10 is inserted into epoxy porcelain bushing 20, cable detention rod 32 is held by fixing metal part 41 and check pin 42. To be more specific, cable detention rod 32 is disposed at a position shifted from second portions 411b of through hole 411 of fixing metal part 41 (a position at approximately 90 degrees with respect to the insertion position), and besides, the both end portions of cable detention rod 32 are each disposed between two check pins 42. Thus, removal of power cable 10 can be surely prevented.

In addition, contact 33 such as the Multilam Contact Band is interposed between conductor connection terminal 31 and inner conductor 22, whereby a large current can be passed.

Further, in comparison with the case where a tulip contact is used, power cable termination 1 is significantly easy to assemble.

As described, power cable termination 1 is easy to assemble, and can surely prevent removal of power cable 10 after the assembly, thus providing high-reliability.

[0034] While the invention made by the present inventor has been specifically described based on the preferred embodiments, it is not intended to limit the present invention to the above-mentioned preferred embodiments but the present invention may be further modified within the scope and spirit of the invention defined by the appended claims.

For example, while the cable detention part can be easily obtained by providing the cable detention part separately from conductor connection terminal 31 as cable detention rod 32 of the embodiment and by integrating with conductor connection terminal 31 at the time of assembling power cable termination 1, the cable detention part may be integrally formed with conductor connection terminal 31 in advance.

In addition, check pins 42 disposed in fixing metal part 41 only have to prevent the terminal part of power cable 10 from rotating to a position where the terminal part of power cable 10 can be removed from fixing metal part 41, and the disposing manner and the number of check pins 42 are not limited.

In addition, the present invention can be applied not only to a termination for an OF cable, but also to a termination of a CV cable (crosslinked polyethylene insulated PVC sheathed cable).

In addition, while the present invention is applied to a gas immersed termination in the embodiment, the present invention may be applied to an oil immersed termination.

In addition, while flange part 213 is fixed on the outside of the device as illustrated in FIG. 1 in the embodiment, flange part 213 may be fixed on the inside of the device as illustrated in FIG. 7 of Non-PTL 1.

[0035] The embodiment disclosed herein is merely an exemplification and should not be considered as limitative. The scope of the present invention is specified by the following claims, not by the above-mentioned description. It should be understood that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors in so far as they are within the scope of the appended claims or the equivalents thereof.

What is claimed is:

1. A power cable termination comprising:

a terminal part of a power cable including a cable conductor exposed by step-stripping;

a conductor connection terminal connected to a fore end of the cable conductor;

an epoxy porcelain bushing including an epoxy resin insulator and an inner conductor that are integrally formed, the epoxy resin insulator being configured to house the terminal part of the power cable, the inner conductor connected to the conductor connection terminal;

a contact interposed between the conductor connection terminal and the inner conductor, the contact being configured to electrically connect the conductor connection terminal and the inner conductor together;

a cable detention part symmetrically protruding from the conductor connection terminal in a radial direction;

a fixing member disposed in the epoxy porcelain bushing and including a through hole, the through hole being configured to allow insertion of the conductor connection terminal and the cable detention part and to make the conductor connection terminal and the cable detention part irremovable toward rear end side when the conductor connection terminal and the cable detention part are axially rotated after the insertion; and

an anti-rotation part disposed near the through hole, the anti-rotation part being configured to non-rotatably hold the conductor connection terminal and the cable detention part.

2. The power cable termination according to claim 1, wherein

the through hole is divided into a first portion through which the conductor connection terminal is inserted, and second portions through which the cable detention part is inserted, the second portions protruding from the first portion toward both sides in a radial direction, and

a plurality of the anti-rotation parts are disposed at positions facing each other with one of the second portions therebetween.

3. The power cable termination according to claim 1 or 2, wherein

the conductor connection terminal includes a small diameter part that is insertable into the through hole, and a large diameter part that is not insertable into the through hole, and

a resin protection member is disposed at each of a fore end of the small diameter part and a fore end of the large diameter part.

4. The power cable termination according to any one of claims 1 to 3, wherein

the contact is a spring-like contact including a plurality of radially extendable v-shaped contact segments, the v-shaped contact segments being joined in parallel with one another along a circumferential direction of the conductor connection terminal.

5. The power cable termination according to any one of claims 1 to 4, wherein

the power cable is composed of an OF cable including, in order from a center, at least an oil passage, a cable conductor, and a cable insulation layer, and

an electric field stress-control part including an epoxy bell-mouth is mounted on a
5 peripheral surface of the cable insulation layer.