

Description

Background of the Invention

1. Field of the Invention

The present invention generally relates to coverings for splice connections in electrical cables, and more particularly to a transition joint for use when splicing or terminating a cable having an oil-impregnated layer.

2. Description of the Prior Art

Electrical cables, such as those used for telephone lines, high voltage lines, cable television, etc., can develop faults or breaks in the line due to manufacturing defects or environmental factors. Faults occur both in underground and aerial cables. Rather than replacing an entire section of such a cable, it is expedient to expose a portion of cable, repair the fault, and place an enclosure about the connection. Splicing of electrical wires is similarly useful in the connection of successive cable sections, and in the termination of such cables.

One of the earliest constructions for these cables, particularly for underground telephone and power cables, consists of a lead jacket surrounding one or more conductors, with a layer of insulative, oil-impregnated paper placed between the lead jacket and the conductors. Although modern underground cables now have extruded dielectric (plastic) jackets, with no fluid inside, there are still substantial amounts of the paper-insulated lead cables ("PILC") in use. A problem thus arises when a PILC cable needs to be repaired or terminated, due to the deleterious effects caused by the egress of the oil or other dielectric fluid.

Several prior art patents are directed to splicing of PILC cables, including U.S. Patent Nos. 4,110,550 issued to Di Pietro; 4,354,050 issued to Gregory; 4,375,577 issued to Silver et al.; 4,383,131 issued to Clabburn; 4,638,112 issued to Giorgio et al.; and 4,695,676 issued to Lawrence et al. Each of these patents, however, suffer from certain drawbacks. For example, in the transition splice disclosed in Clabburn (see Figure 4), four separate layers of polymeric materials are used in addition to an internal void filling material and an outer metallic braid. Clearly, this construction is unduly complicated and requires an excessive amount of time to assemble. Those skilled in the art will further appreciate that the Clabburn construction, while disclosing the use of elastomeric tubing, requires that an oil-impervious layer be interposed between any such elastomeric tubing and the oil-impregnated paper. Such an oil-impervious layer has been required in prior art splice assemblies due to the fact that, if the oil comes into direct contact with the elastomeric layer, the oil will be absorbed into the

elastomer, causing it to swell and eventually degrade; this promotes the creation of voids at the interface between the elastomer and the cable, leading to high-voltage failures. Finally, Clabburn relies on a heat shrinkable material which is in contact with the cable; this construction is undesirable since, as the material is heated, oil within the cable can easily vaporize and leave a harmful void between the cable surface and the oil-impervious (heat shrinkable) layer.

Patent document FR-A-2557390 discloses a transition joint for a coaxial cable having a central conductor, a layer of oil-impregnated paper surrounding the conductor and an electrically conductive jacket. A portion of the jacket is removed thereby partially exposing the paper layer, and a portion of the paper layer is in turn cut away thereby exposing the conductor. To form the joint an electrically insulative elastomeric tube made from a material resistant to oil is placed in tight conformity around the entire portion of the paper layer. This arrangement is thus likely to suffer from the same problems as the Clabburn construction referred to above. As regards the other prior art arrangements, the Di Pietro, Gregory, Silver et al. and Giorgio et al. assemblies each require several metallic parts, such as bars, ferrules, collars, clamps and the like, which are also difficult to apply and are more expensive than the materials used in Clabburn. The construction of Lawrence et al. is somewhat simpler, but still requires placement of a mass of encapsulating particulate material. Furthermore, the splice shown in Lawrence et al. (as well as that shown in Clabburn) is not suitable for termination joints, i.e., a joint which effectively seals the end of the fluid-filled cable and allows a wide variety of cable accessories to then be attached thereto. It would, therefore, be desirable and advantageous to devise a transition joint for a fluid-filled cable which is simpler (and less expensive) to assemble than the foregoing splice assemblies, and which has wider application for connecting two of such cables together, for splicing one such cable to a plastic dielectric cable, for terminating the fluid-filled cable, or for receiving various other cable accessories.

Summary of the Invention

The present invention provides a transition joint and a method of producing a transition joint as set out in the appended claims. In this arrangement the heat recoverable sleeve mechanically restricts the elastomeric tube, preventing the elastomeric tube from swelling which, in turn, precludes absorption of the degradative oil. A complete oil seal is thus achieved with only two layers in the joint, and without the need for oil-resistant mastics, epoxy sealing resins, or metal clamps.

This construction offers greater simplicity in design and application, affording both cost and time

savings. The novel transition joint assembly essentially converts the end of the PILC cable into a plastic (extruded dielectric) cable, which can then be connected to another cable (PILC or extruded dielectric), or fitted with a termination. Pre-molded or extruded cable accessories, which are designed for use with extruded dielectric cables and normally not usable with PILC cables, may be used to effect these connections.

Brief Description of the Drawings

The novel features and scope of the invention are set forth in the appended claims. The invention itself, however, will best be understood by reference to the accompanying drawings, wherein:

Figure 1 is a side elevational view of the terminal end of a paper-insulated, lead-jacketed, coaxial cable, with portions of the various layers removed, exposing the central conductor;
 Figure 2 is an elevational view similar to Figure 1 wherein electrical stress-relief tape has been applied to the end of the lead jacket and the intermediate semiconducting layer, and the paper insulation has been taped to prevent unravelling, in accordance with the present invention;
 Figure 3 is another elevational view similar to the previous figures, but further illustrating application of the elastomeric tube which forms part of a transition joint constructed in accordance with the kit and method of the present invention;
 Figure 4 is yet another elevational view further depicting the elastomeric tube in tight conformity with the PILC cable;
 Figure 5 is still another elevational view showing application of the heat recoverable sleeve which forms a part of the transition joint of the present invention;
 Figure 6 is a longitudinal cross-section showing the transition joint on a PILC cable, and further illustrating a connection of the PILC cable to a second cable; and
 Figure 7 is a top plan view of the transition joint of the present invention depicting a connection of the PILC cable to a "Tee" module.

Description of the Preferred Embodiment

With reference now to the figures, and in particular with reference to Figure 1, there is depicted an exemplary coaxial cable 10 which contains a dielectric fluid therein. Such a cable is typically constructed of an outer lead jacket 12, an intermediate semiconducting layer 14 formed of carbon-loaded paper, an insulative layer 16 formed of oil-impregnated paper, and a central conductor or group of conductors 18. The present invention is primarily designed for making a transition from such an oil-filled cable. It should

also be understood, however, that the invention will work with cables having other fluids therein, including those filled with a dielectric jelly. Some PILC cables also have a plastic sheath which surrounds the lead jacket.

As shown in Figure 1, the PILC cable is prepared for splicing by first cutting off a large section (e.g., 28 cm) of lead jacket 12, thereby exposing semiconducting layer 14. Sharp corners at the edge of lead jacket 12 should be peened. A slightly smaller section (e.g., 22 cm) of semiconducting layer 14 is similarly removed, exposing insulative layer 16. Finally, an even smaller section (e.g., 11 cm) of insulative layer 16 is removed, exposing central conductor 18.

As shown in Figure 2, insulative layer 16 may be held in place by a strip of (insulative) adhesive tape 20, which keeps the paper insulation from unravelling. Tape 20 should be applied with the adhesive side out to allow tensioning on the second wrap thereof. An appropriate tape for this purpose is sold by Minnesota Mining & Manufacturing Co. (3M), assignee of the present invention, under product number 33+ vinyl electrical tape. A second strip of tape 22 may be placed on lead jacket 12 near its edge (e.g., 1-2 cm); tape 22 is used to mark the location of the edge of lead jacket 12 as explained below. The same type of tape may be used for tape 22 as was used for tape 20.

As further preparation for the installation of the transition joint of the present invention, cable 10 should preferably be provided with some form of, dielectric stress relief. This may easily be accomplished by winding a high-dielectric constant tape 24 around the terminal portion of lead jacket 12 and semiconducting layer 14. Stress control tape 24 should completely cover semiconducting layer 24 and slightly overlap (e.g., 1 cm) insulative layer 16; it is preferably wrapped in two half-lapped layers. An appropriate tape for this purpose is available from 3M under product number 2220 stress control tape.

With reference now to Figure 3, the first element of the transition joint kit and method of the present invention is an elastomeric tube 26. Elastomeric tube 26 is typically fabricated by extrusion and, in its relaxed state, is generally cylindrical. It may be formed of any elastomeric material, such as natural rubber, synthetic (silicone) rubber, styrene-butadiene rubber, polychloroprene, or urethane rubber (this list is not exhaustive). The preferred material for elastomeric tube 26 is ethylene-propylene non-conjugated diene terpolymer (EPDM), which is electrically insulative. It is understood that the terms "tube" and "tubular" are not limited to objects having a circular cross-section, but rather denotes a hollow, elongated member of any cross-section.

The size of elastomeric tube 26 may vary considerably, depending upon the size of the cable to be spliced. The length of elastomeric tube 26 should be greater than the combined length of the exposed por-

tions of semiconducting layer 14 and insulative layer 16; based on the exemplary dimensions previously given, elastomeric tube 26 should be about 20 cm long. The diameter of elastomeric tube 26 (in its relaxed state), should be smaller than the diameter of central conductor 18, typically in the range of one to five centimeters. Due to the elastic properties of elastomeric tube 26, a single diameter tube may conveniently be used on cables of varying diameter. Of course, in the expanded state shown in Figure 3, the diameter of elastomeric tube 26 is greater than the diameter of cable 10. The thickness of elastomeric tube 26 (in its relaxed state) may vary.

Although elastomeric tube 26 may be applied without prior expansion, e.g., by sliding it over cable 10 with the use of a lubricant, or by everting the tube and rolling it onto cable 10, it is greatly preferable to pre-load elastomeric tube 26 onto a removable core 28, as described in U.S. Patent No. 3,515,798 issued to Sievert. Removable core 28 maintains elastomeric tube 26 in a radially expanded state, and is also generally cylindrical and slightly longer than elastomeric tube 26. The diameter of removable core 28 may vary widely, the only practical requirement being that it is larger than the outer diameter of cable 10, and providing sufficient clearance for the core to be unwound. Removable core 28 is constructed of any durable, flexible material, such as cellulose acetate butyrate, polypropylene, polyethylene or polyvinyl chloride, and has a helical groove formed by a continuous strip, adjacent coils being interconnected. A similar core may be fabricated by helically perforating a hollow cylinder. The wall of core 28 typically has a thickness in the range of one millimeter to five millimeters. Core 28 is collapsed by firmly pulling and unwinding the end 30 of the strip.

As shown in Figure 3, one end of elastomeric tube 26 is held adjacent marking tape 22. As end 30 of removable core 28 is pulled, elastomeric tube 26 slowly shrinks in place around cable 10, until it is in tight conformity with cable 10 as shown in Figure 4. It should be noted that elastomeric tube 26 is in direct contact with insulative layer 16 (oil-impregnated paper). The second element of the transition joint of the present invention may now be installed, namely, the heat recoverable sleeve 32 illustrated in Figure 5.

Referring now to Figure 5, heat recoverable sleeve 32 is placed over cable 10, completely covering elastomeric tube 26 (marker tape 22 is preferably removed before installation of sleeve 32). A heat source is then applied, such as from a torch 34, causing heat recoverable sleeve 32 to shrink in close conformity about elastomeric tube 26. The heat source should be applied evenly, starting at the center of heat recoverable sleeve 32. Sleeve 32 should be heated until wrinkle free and in constricting contact with lead jacket 12 at one end, and with central conductor 18 at the other end. Those skilled in the art will appreci-

ate that elastomeric tube 26 acts as a thermal barrier such that, as heat is applied to sleeve 32, the oil within cable 10 is not overly heated, and thus does not vaporize and cause the harmful voids which are often created in prior art transition splices.

Heat recoverable sleeve 32 may also be formed from a wide variety of materials, particularly polymeric resins such as polytetrafluoroethylene, polychloroprene, fluoroelastomers or cross-linked polyolefins (this list is not exhaustive). The preferred material is polyvinylidene fluoride, which meets the primary requisites of being heat recoverable and electrically insulative, and having a crystalline melting point higher than that generated in emergency overload conditions of cable 10. Such material is sold by 3M under the brand name Kynar. Other heat recoverable materials may be used if their melting point is greater than 125° C, and preferably about 175° C. The term "heat recoverable" as used herein refers to any thermoelastic material, i.e., any material which, upon the application of heat, either returns to its original (smaller) shape, or shrinks without having been previously deformed.

As with elastomeric tube 26, the size of heat recoverable sleeve 32 may vary considerably, depending upon the size of the cable to be spliced. The length of sleeve 32, in its contracted state, should be greater than the length of elastomeric tube 26, and preferably overlaps lead jacket 12 by about two cm and overlaps central conductor 18 by about one cm. The length of sleeve 32 in its contracted state may easily be determined since most of the above-listed thermoelastic materials have fairly exact shrinkage ratios. Excess sleeve length may be trimmed after shrinkage; this is best accomplished while sleeve 32 is still warm to the touch. Of course, the diameter of sleeve 32 in its expanded state must be large enough to accommodate cable 10; the diameter in its contracted state should be smaller than the diameter of central conductor 18.

Once heat recoverable sleeve 32 is in place, the transition joint of the present invention is complete. This assembly creates a reliable seal and prevents the egress of any oil exuding from insulative layer 16, in spite of the fact that the oil-permeable elastomeric tube 26 is in intimate contact with the oil-impregnated paper (contrary to conventional wisdom). It has been found that the mechanical confining pressure around elastomeric tube 26, imparted by heat recoverable sleeve 32, prevents the absorption of oil into the elastomeric material. In other words, this confining pressure is greater than the osmotic pressure at the oil/elastomer interface. Testing has shown that, with this construction, elastomeric tube 26 does not absorb any significant amount of oil, and no degradation takes place. In fact, the transition joint of the present invention successfully passed several thermal cycling and elevated pressure tests, the most severe of these being at 110° C and 25 PSI ($\approx 1.7 \cdot 10^5$ Pa); this

exceeded industry test requirements.

The transition joint of the present invention effectively converts the terminal end of a PILC cable into a plastic cable. The converted cable may then accommodate the use of various cable accessories which are normally limited to extruded dielectric cables. For example, a connector may be used to attach a termination lug to central conductor 18 or, as shown in Figure 6, a separate splice assembly may be used to connect cable 10 to another cable 40. Cable 40 may be an extruded dielectric cable, or a PILC cable which also has a transition joint.

In Figure 6, central conductor 18 of cable 10 is connected to the central conductor 42 of cable 40 by a connector 44, preferably a crimp-type connector. This connection is formed prior to application of elastomeric tube 26 or heat recoverable sleeve 32. Of course, both of those elements must be threaded onto cable 10 prior to attachment of connector 44, but they are maintained in their expanded states until after the connection is complete. In the connection shown in Figure 6, tube 26 and sleeve 32 preferably overlap connector 44. It is also desirable to utilize another tape layer 51 under tube 26, between the terminal end of paper layer 16 and connector 44; this prevents tube 26 from swelling inwardly, and thus further precludes the absorption of oil by elastomeric tube 26. Connector 44 may then be covered by a closure 46 (e.g., another elastomeric or heat recoverable tube), and the entire connection surrounded by a larger splice housing 48. Splice housing 48 provides protection against environmental influences, particularly moisture penetration, and provides electrical shielding and continuity. Splice housing may be provided with an insulating material 50. For additional environmental protection, two elastomeric tubes (not shown) may be placed over cable 10 overlapping the ends of housing 48. The splice housing illustrated is 3M's QS-II™ 5451A medium voltage molded rubber splice; in this splice, closure 46, insulating material 50 and housing 48 are all formed integrally at the factory, and closure 46 and housing 48 are electrically conductive.

Figure 7 depicts a connection of the converted PILC cable 10 to a "Tee" module 52. Tee module 52 has an internal connector which is attached to the central conductor 18 of cable 10. The free ends of Tee module 52 may be provided with other connectors. In Figure 7, one end is shown covered with a removable cap 54 while the other end is provided with a connecting plug 55 which may be further connected to other cables. The tee module illustrated is 3M's 600A dead-front elbow cable termination. Another elastomeric tube 56 surrounds the main opening of tee module 52 to provide further integrity against environmental influences.

Although the invention has been described with reference to specific embodiments, this description is not meant to be construed in a limiting sense. Various

modifications of the disclosed embodiment, as well as alternative embodiments of the invention, will become apparent to persons skilled in the art upon reference to the description of the invention. For example, the geometry of the cable accessories might require use of an additional elastomeric member surrounding central conductor 18 at a gap between a termination lug and the end of the first heat recoverable sleeve 32; this would also require use of an additional heat recoverable sleeve around the second elastomeric member.

Claims

1. A transition joint at the terminal end of a coaxial cable (10) having a partially exposed central conductor (18), a partially exposed, oil-impregnated, electrically insulative paper layer (16) surrounding the conductor (18), and an electrically conductive jacket (12) surrounding the paper layer (16), the joint comprising:

an electrically insulative, elastomeric tube (26) having a length which is greater than the length of the exposed portion of the paper layer (16) said elastomeric tube (26) contacting and surrounding the exposed portion of the paper layer (16); characterized in that there is provided

an electrically insulative, heat recoverable, tubular sleeve (32) having a length in its contracted state which is greater than the length of said elastomeric tube (26) said heat recoverable sleeve (32) contacting, surrounding and confining said elastomeric tube (26), the heat recoverable sleeve (32) imparting sufficient confinement pressure about the elastomeric tube (26) to prevent any significant absorption of oil by the elastomeric tube (26).

2. A transition joint according to claim 1 wherein the coaxial cable further includes a partially exposed semiconducting layer (14) between the paper layer (16) and the electrically conductive jacket (12), and the electrically insulative elastomeric tube has a length which is greater than the combined lengths of the exposed portions of the semiconducting and paper layers (14), (16).
3. A transition joint according to claim 1 further including a high dielectric constant tape (24) wrapped around the terminal end of the electrically conductive jacket (12), and wherein the elastomeric tube (26) contacts and surrounds the dielectric tape (24) and the exposed portion of the paper layer (16).
4. A transition joint according to claim 3 wherein the cable includes a partially exposed semiconduct-

exceeded industry test requirements.

The transition joint of the present invention effectively converts the terminal end of a PILC cable into a plastic cable. The converted cable may then accommodate the use of various cable accessories which are normally limited to extruded dielectric cables. For example, a connector may be used to attach a termination lug to central conductor 18 or, as shown in Figure 6, a separate splice assembly may be used to connect cable 10 to another cable 40. Cable 40 may be an extruded dielectric cable, or a PILC cable which also has a transition joint.

In Figure 6, central conductor 18 of cable 10 is connected to the central conductor 42 of cable 40 by a connector 44, preferably a crimp-type connector. This connection is formed prior to application of elastomeric tube 26 or heat recoverable sleeve 32. Of course, both of those elements must be threaded onto cable 10 prior to attachment of connector 44, but they are maintained in their expanded states until after the connection is complete. In the connection shown in Figure 6, tube 26 and sleeve 32 preferably overlap connector 44. It is also desirable to utilize another tape layer 51 under tube 26, between the terminal end of paper layer 16 and connector 44; this prevents tube 26 from swelling inwardly, and thus further precludes the absorption of oil by elastomeric tube 26. Connector 44 may then be covered by a closure 46 (e.g., another elastomeric or heat recoverable tube), and the entire connection surrounded by a larger splice housing 48. Splice housing 48 provides protection against environmental influences, particularly moisture penetration, and provides electrical shielding and continuity. Splice housing may be provided with an insulating material 50. For additional environmental protection, two elastomeric tubes (not shown) may be placed over cable 10 overlapping the ends of housing 48. The splice housing illustrated is 3M's QS-II™ 5451A medium voltage molded rubber splice; in this splice, closure 46, insulating material 50 and housing 48 are all formed integrally at the factory, and closure 46 and housing 48 are electrically conductive.

Figure 7 depicts a connection of the converted PILC cable 10 to a "Tee" module 52. Tee module 52 has an internal connector which is attached to the central conductor 18 of cable 10. The free ends of Tee module 52 may be provided with other connectors. In Figure 7, one end is shown covered with a removable cap 54 while the other end is provided with a connecting plug 55 which may be further connected to other cables. The tee module illustrated is 3M's 600A dead-front elbow cable termination. Another elastomeric tube 56 surrounds the main opening of tee module 52 to provide further integrity against environmental influences.

Although the invention has been described with reference to specific embodiments, this description is not meant to be construed in a limiting sense. Various

modifications of the disclosed embodiment, as well as alternative embodiments of the invention, will become apparent to persons skilled in the art upon reference to the description of the invention. For example, the geometry of the cable accessories might require use of an additional elastomeric member surrounding central conductor 18 at a gap between a termination lug and the end of the first heat recoverable sleeve 32; this would also require use of an additional heat recoverable sleeve around the second elastomeric member.

Claims

1. A transition joint at the terminal end of a coaxial cable (10) having a partially exposed central conductor (18), a partially exposed, oil-impregnated, electrically insulative paper layer (16) surrounding the conductor (18), and an electrically conductive jacket (12) surrounding the paper layer (16), the joint comprising:
 - an electrically insulative, elastomeric tube (26) having a length which is greater than the length of the exposed portion of the paper layer (16) said elastomeric tube (26) contacting and surrounding the exposed portion of the paper layer (16); characterized in that there is provided
 - an electrically insulative, heat recoverable, tubular sleeve (32) having a length in its contracted state which is greater than the length of said elastomeric tube (26) said heat recoverable sleeve (32) contacting, surrounding and confining said elastomeric tube (26), the heat recoverable sleeve (32) imparting sufficient confinement pressure about the elastomeric tube (26) to prevent any significant absorption of oil by the elastomeric tube (26).
2. A transition joint according to claim 1 wherein the coaxial cable further includes a partially exposed semiconducting layer (14) between the paper layer (16) and the electrically conductive jacket (12), and the electrically insulative elastomeric tube has a length which is greater than the combined lengths of the exposed portions of the semiconducting and paper layers (14), (16).
3. A transition joint according to claim 1 further including a high dielectric constant tape (24) wrapped around the terminal end of the electrically conductive jacket (12), and wherein the elastomeric tube (26) contacts and surrounds the dielectric tape (24) and the exposed portion of the paper layer (16).
4. A transition joint according to claim 3 wherein the cable includes a partially exposed semiconduct-



ing layer between the paper layer and the electrically conductive jacket, the high dielectric constant tape (24) is wrapped around the terminal end of the electrically conductive jacket (12) and the exposed portion of the semiconducting layer (14) and the electrically insulative elastomeric tube (26) has a length which is greater than the combined lengths of the exposed portions of the semiconducting and the paper layers (14), (16).

5. A transition joint according to any preceding claim wherein said elastomeric tube (26) is composed of ethylene-propylene non-conjugated diene terpolymer.
6. A transition joint according to any preceding claim wherein said heat recoverable sleeve (32) has a melting point greater than 125°C.
7. A transition joint according to any preceding claim wherein said heat recoverable sleeve (32) further surrounds a portion of the electrically conductive jacket (12) and a portion of the central conductor (18).
8. A transition joint according to any preceding claim further comprising means for connecting the central conductor (18) to a termination lug.
9. A transition joint according to any preceding claim further comprising means for connecting the central conductor (18) to the conductor of a second coaxial cable.
10. A method of producing a transition joint according to any preceding claim comprising the steps of:
 - removing a portion of the electrically conductive jacket (12) thereby partially exposing the paper layer (16);
 - cutting away a portion of the paper layer (16) thereby partially exposing the central conductor (18);
 - placing an electrically insulating elastomeric tube (26) in tight conformity around the entire exposed portion of the paper layer (16); and
 - applying an electrically insulative heat recoverable tubular sleeve (32) around the elastomeric tube (26) whereby the heat recoverable sleeve (32) imparts sufficient confinement pressure about the elastomeric tube (26) to prevent any significant absorption of oil by the elastomeric tube (26), the heat recoverable sleeve (32) being sufficiently long to overlap the conductive jacket (12) at one end and overlap the central conductor (18) at the other end.
11. A method according to claim 10 wherein the coaxial cable further has a semiconducting layer

(14) between the conductive jacket (12) and the paper layer (16) said removing step partially exposing the semiconducting layer (14) comprising the additional steps of:

trimming a portion of the semiconducting layer (14) prior to the step of cutting away the portion of the paper layer.

12. A method according to claim 10 and 11, including the further step of wrapping a layer of high dielectric constant tape (24) around the terminal end of the conductive jacket (12) prior to said step of placing the elastomeric tube around the paper layer.
13. A method according to claim 11 and 12, including the further step of wrapping a layer of high dielectric constant tape (24) around the terminal end of the conductive jacket and around the exposed portion of the semiconducting layer (14), prior to said step of placing the elastomeric tube around the paper layer.
14. A method according to any of claims 10, 11, 12 and 13, further comprising the step of wrapping a marker tape (22) around the electrically conductive jacket (12) proximate its terminal end and wherein the step of placing the elastomeric tube around the paper layer (16) includes the step of aligning one end of the elastomeric tube (26) with the marker tape.
15. A method according to any of claims 10, 11, 12, 13 and 14, further comprising the step of attaching a terminal lug to the central conductor (18).
16. A method according to any of claims 10, 11, 12, 13, 14 and 15, further comprising the step of attaching the conductor (42) of a second cable (40) to the central conductor (18) of the coaxial cable (10) by means of an electrical connector (44).
17. A method according to claim 16 further comprising the step of applying a layer of tape (51) around the central conductor between the paper layer (16) and the connector (44) and wherein the elastomeric tube (26) and the heat recoverable sleeve (32) partially surround the connector, the tape layer preventing inward swelling of the elastomeric tube.
18. A method according to claim 16 further comprising the step of enclosing the connection between the two conductors (18,42) within a splice housing.



Patentansprüche

1. Übergangsverbindung am Anschlußende eines Koaxialkabels (10) mit einem teilweise freiliegenden Innenleiter (18), einer den Leiter (18) umgebenden, teilweise freiliegenden, ölprägnierten, elektrisch isolierenden Papierschicht (16) und einem die Papierschicht (16) umgebenden, elektrisch leitfähigen Mantel (12), wobei die Verbindung
 - einen elektrisch isolierenden elastomeren Schlauch (26) aufweist, der länger ist als der freiliegende Teil der Papierschicht (16) und den freiliegenden Teil der Papierschicht (16) umgibt und berührt,
 - gekennzeichnet durch
 - eine elektrisch isolierende, in der Wärme erinnerungsfähige, rohrförmige Muffe (32), die im kontrahierten Zustand länger ist als der elastomere Schlauch (26) und die den elastomeren Schlauch (26) umgibt, berührt und umschließt und die auf den elastomeren Schlauch (26) um dessen Umfang herum einen so hohen Umschließungsdruck ausübt, daß eine nennenswerte Absorption von Öl durch den elastomeren Schlauch (26) verhindert wird.
2. Übergangsverbindung nach Anspruch 1, in der das Koaxialkabel ferner zwischen der Papierschicht (16) und dem elektrisch leitfähigen Mantel (12) eine teilweise freiliegende halbleitende Schicht (14) aufweist und die Länge des elektrisch isolierenden elastomeren Schlauches größer ist als die kombinierten Längen der freiliegenden Teile der halbleitenden Schicht (14) und der Papierschicht (16).
3. Übergangsverbindung nach Anspruch 1 mit einem um das Anschlußende des elektrisch leitfähigen Mantels (12) herumgewickelten Band (24) mit hoher Dielektrizitätskonstante, wobei der elastomere Schlauch (26) das dielektrische Band (24) und den freiliegenden Teil der Papierschicht (16) umgibt und berührt.
4. Übergangsverbindung nach Anspruch 3, in der das Kabel zwischen der Papierschicht und dem elektrisch leitfähigen Mantel eine teilweise freiliegende halbleitende Schicht aufweist, das Band (24) mit hoher Dielektrizitätskonstante um das Anschlußende des elektrisch leitfähigen Mantels (12) und den freiliegenden Teil der halbleitenden Schicht (14) herumgewickelt ist und die Länge des elektrisch isolierenden elastomeren Schlauches (26) größer ist als die kombinierten Längen der freiliegenden Teile der halbleitenden Schicht (14) und der Papierschicht (14).
5. Übergangsverbindung nach einem der vorhergehenden Ansprüche, in der der elastomere Schlauch (26) aus einem Terpolymer aus Ethylen, Propylen und nichtkonjugiertem Dien besteht.
6. Übergangsverbindung nach einem der vorhergehenden Ansprüche, in der die in der Wärme erinnerungsfähige Muffe (32) einen Schmelzpunkt über 125°C hat.
7. Übergangsverbindung nach einem der vorhergehenden Ansprüche, in der die in der Wärme erinnerungsfähige Muffe (32) ferner einen Teil des elektrisch leitfähigen Mantels (12) und einen Teil des Innenleiters (18) umgibt.
8. Übergangsverbindung nach einem der vorhergehenden Ansprüche mit Mitteln zum Verbinden des Innenleiters (18) mit einer Anschlußfahne.
9. Übergangsverbindung nach einem der vorhergehenden Ansprüche mit Mitteln zum Verbinden des Innenleiters (18) mit dem Leiter eines zweiten Koaxialkabels.
10. Verfahren zum Herstellen einer Übergangsverbindung nach einem der vorhergehenden Ansprüche mit folgenden Schritten:
 - zum Freilegen der Papierschicht (16) wird ein Teil des elektrisch leitfähigen Mantels (12) entfernt;
 - zum Freilegen eines Teils des Innenleiters (18) wird ein Teil der Papierschicht (16) weggeschnitten;
 - der ganze freiliegende Teil der Papierschicht (16) wird mit einem elektrisch isolierenden elastomeren Schlauch (26) dicht passend umgeben; und
 - der elastomere Schlauch (26) wird mit einer elektrisch isolierenden, in der Wärme erinnerungsfähigen, rohrförmigen Muffe (32) derart umgeben, daß sie auf den elastomeren Schlauch (26) um dessen Umfang herum einen so hohen Umschließungsdruck ausübt, daß eine nennenswerte Absorption von Öl durch den elastomeren Schlauch (26) verhindert wird, wobei die in der Wärme erinnerungsfähige Muffe (32) so lang ist, daß sie an ihrem einen Ende den leitfähigen Mantel (12) und an ihrem anderen Ende den Innenmantel übergreift.
11. Verfahren nach Anspruch 19, in dem das Koaxialkabel ferner zwischen dem leitfähigen Mantel (12) und der Papierschicht (16) eine halbleitende Schicht (14) aufweist, die beim Entfernen eines Teils des leitfähigen Mantels teilweise freigelegt wird, wobei



vor dem Wegschneiden des Teils der Papierschicht in einem zusätzlichen Schritt ein Teil der halbleitenden Schicht (14) zugeschnitten wird.

12. Verfahren nach Anspruch 10 und 11, in dem in einem weiteren Schritt vor dem Umgeben der Papierschicht mit dem elastomeren Schlauch um das Anschlußende des leitfähigen Mantels (12) eine Schicht aus einem Band (24) mit hoher Dielektrizitätskonstante herumgewickelt wird.

13. Verfahren nach Anspruch 11 und 12, in dem vor dem Umgeben der Papierschicht mit dem elastomeren Schlauch um das Anschlußende des leitfähigen Mantels und um den freiliegenden Teil der halbleitenden Schicht (14) eine Schicht aus einem Band (24) mit hoher Dielektrizitätskonstante herumgewickelt wird.

14. Verfahren nach einem der Ansprüche 10, 11, 12 und 13, in dem in einem weiteren Schritt um den elektrisch leitfähigen Mantel (12) in der Nähe seines Anschlußendes ein Markierungsband (22) herumgewickelt wird und in dem in dem Schritt, in dem die Papierschicht (16) mit dem elastomeren Schlauch umgeben wird, ein Ende des elastomeren Schlauches (26) mit dem Markierungsband gefluchtet wird.

15. Verfahren nach einem der Ansprüche 10, 11, 12, 13 und 14, in dem an dem Innenleiter (18) eine Anschlußfahne angebracht wird.

16. Verfahren nach einem der Ansprüche 10, 11, 12, 13, 14 und 15, in dem an dem Innenleiter (18) des Koaxialkabels (10) mit einem elektrischen Verbinder (44) der Leiter (42) eines zweiten Kabels (40) angebracht wird.

17. Verfahren nach Anspruch 16, in dem zwischen der Papierschicht (16) und dem Verbinder (44) der Innenleiter mit einer Schicht aus einem Band (51) umgeben wird und in dem der Verbinder teilweise von dem elastomeren Schlauch (26) und der in der Wärme erinnerungsfähigen Muffe (32) umgeben ist, so daß die Schicht aus dem Band ein Einwärtsquellen des elastomeren Schlauchs verhindert.

18. Verfahren nach Anspruch 16, in dem in einem weiteren Schritt die Verbindung zwischen den beiden Leitern (18, 42) in einem Spleißgehäuse eingeschlossen wird.

Revendications

1. Joint de transition placé à l'extrémité terminale d'un câble coaxial (10) ayant un conducteur central partiellement découvert (18), une couche de papier électriquement isolante, imprégnée d'huile et partiellement découverte (16) entourant le conducteur (18), et une gaine électriquement conductrice (12) entourant la couche de papier (16), le joint comprenant :

un tube en élastomère électriquement isolant (26) ayant une longueur plus grande que la longueur de la partie découverte de la couche de papier (16), ledit tube en élastomère (26) étant en contact et entourant la partie découverte de la couche de papier (16) ;

caractérisé en ce qu'il comprend :

un manchon tubulaire thermocontractable électriquement isolant (32) ayant une longueur, dans son état contracté, qui est plus grande que la longueur dudit tube en élastomère (26), ledit manchon thermocontractable (32) étant en contact avec ledit tube en élastomère (26) et entourant et confinant ce dernier, le manchon thermocontractable (32) exerçant une pression de confinement suffisante autour du tube en élastomère (26) pour empêcher toute absorption notable d'huile par le tube en élastomère (26).

2. Joint de transition suivant la revendication 1, dans lequel le câble coaxial comprend en outre une couche semiconductrice partiellement découverte (14), entre la couche de papier (16) et la gaine électriquement conductrice (12), et le tube en élastomère électriquement isolant a une longueur qui est plus grande que les longueurs combinées des parties découvertes de la couche semiconductrice (14) et de la couche de papier (16).

3. Joint de transition suivant la revendication 1, comprenant en outre un ruban adhésif à constante diélectrique élevée (24) enroulé autour de l'extrémité terminale de la gaine électriquement conductrice (12), dans lequel le tube en élastomère (26) est en contact et entoure le ruban diélectrique (24) et la partie découverte de la couche de papier (16).

4. Joint de transition suivant la revendication 3, dans lequel le câble comprend une couche semiconductrice partiellement découverte, entre la couche de papier et la gaine électriquement conductrice, le ruban de constante diélectrique élevée (24) est enroulé autour de l'extrémité terminale de la gaine électriquement conductrice (12) et de la partie découverte de la couche semiconductrice (14), et le tube en élastomère élec-



triquement isolant (26) a une longueur qui est plus grande que les longueurs combinées des parties découvertes de la couche semiconductrice (14) et de la couche de papier (16).

5. Joint de transition suivant une quelconque des revendications précédentes, dans lequel ledit tube en élastomère (26) est composé d'un terpolymère d'éthylène-propylène-diène non conjugué.
6. Joint de transition suivant une quelconque des revendications précédentes, dans lequel ledit manchon thermocontractable (32) a un point de fusion supérieur à 125°C.
7. Joint de transition suivant une quelconque des revendications précédentes, dans lequel ledit manchon thermocontractable (32) entoure en outre une partie de la gaine électriquement conductrice (12) et une partie du conducteur central (18).
8. Joint de transition suivant une quelconque des revendications précédentes, comprenant en outre des moyens de connexion du conducteur central (18) à une patte de terminaison.
9. Joint de transition suivant une quelconque des revendications précédentes, comprenant en outre des moyens de connexion du conducteur central (18) au conducteur d'un deuxième câble coaxial.
10. Méthode de fabrication d'un joint de transition suivant une quelconque des revendications précédentes, comprenant les étapes de :
 - enlèvement d'une partie de la gaine électriquement conductrice (12), de manière à découvrir partiellement la couche de papier (16) ;
 - coupe et enlèvement d'une partie de la couche de papier (16), de manière à découvrir partiellement le conducteur central (18) ;
 - mise en place d'un tube en élastomère électriquement isolant (26) en conformité serrée autour de toute la partie découverte de la couche de papier (16) ; et
 - application d'un manchon tubulaire thermocontractable électriquement isolant (32) autour du tube en élastomère (26) de sorte que le manchon thermocontractable (32) exerce, autour du tube en élastomère (26), une pression de confinement suffisante pour empêcher toute absorption notable d'huile par le tube en élastomère (26), le manchon thermocontractable (32) étant suffisamment long pour chevaucher la gaine conductrice (12) à une extrémité et chevaucher le conducteur central (18) à l'autre extrémité.

11. Méthode suivant la revendication 10, dans laquelle le câble coaxial comprend en outre une couche semiconductrice (14) entre la gaine conductrice (12) et la couche de papier (16), ladite étape d'enlèvement découvrant partiellement la couche semiconductrice (14), qui comprend les étapes additionnelles de :

enlèvement d'une partie de la couche semiconductrice (14) avant l'étape de coupe et d'enlèvement de la partie de la couche de papier.

12. Méthode suivant les revendications 10 et 11, comprenant l'étape supplémentaire d'enroulement d'une couche de ruban à constante diélectrique élevée (24) autour de l'extrémité terminale de la gaine conductrice (12) avant ladite étape de mise en place du tube en élastomère autour de la couche de papier.

13. Méthode suivant les revendications 11 et 12, comprenant l'étape supplémentaire d'enroulement d'une couche de ruban à constante diélectrique élevée (24) autour de l'extrémité terminale de la gaine conductrice et autour de la partie découverte de la couche semiconductrice (14), avant ladite étape de mise en place du tube en élastomère autour de la couche de papier.

14. Méthode suivant une quelconque des revendications 10, 11, 12 et 13, comprenant en outre l'étape d'enroulement d'un ruban adhésif de marquage (22) autour de la gaine électriquement conductrice (12) près de son extrémité terminale, et dans laquelle l'étape de mise en place du tube en élastomère autour de la couche de papier (16) comprend l'étape d'alignement d'une extrémité du tube en élastomère (26) avec le ruban de marquage.

15. Méthode suivant une quelconque des revendications 10, 11, 12, 13 et 14, comprenant en outre l'étape de fixation d'une patte terminale au conducteur central (18).

16. Méthode suivant une quelconque des revendications 10, 11, 12, 13, 14 et 15, comprenant en outre l'étape de liaison du conducteur (42) d'un deuxième câble (40) au conducteur central (18) du câble coaxial (10) au moyen d'un connecteur électrique (44).

17. Méthode suivant la revendication 16, comprenant en outre l'étape d'application d'une couche de ruban adhésif (51) autour du conducteur central, entre la couche de papier (16) et le connecteur (44), et dans laquelle le tube en élastomère (26) et le manchon thermocontractable (32) entourent partiellement le connecteur, la couche de ruban



empêchant un gonflement du tube en élastomère vers l'intérieur.

18. Méthode suivant la revendication 16, comprenant en outre l'étape d'inclusion de la connexion entre les deux conducteurs (18,42) à l'intérieur d'un boîtier d'épissure.

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