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PREFABRICATED STRESS RELIEF CONE

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FIG. 1 (PRIOR ART)

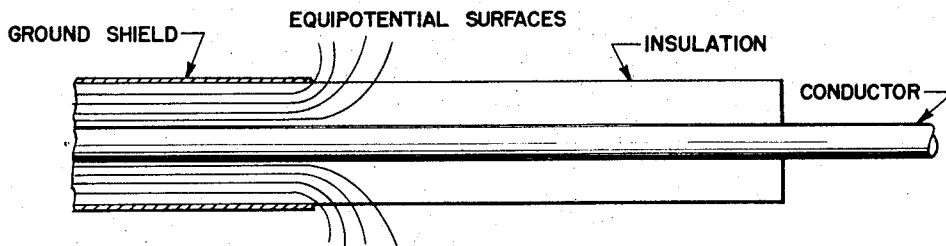


FIG. 2 (PRIOR ART)

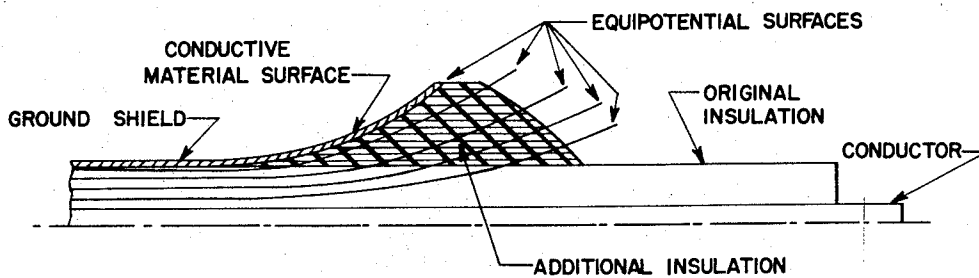


FIG. 3

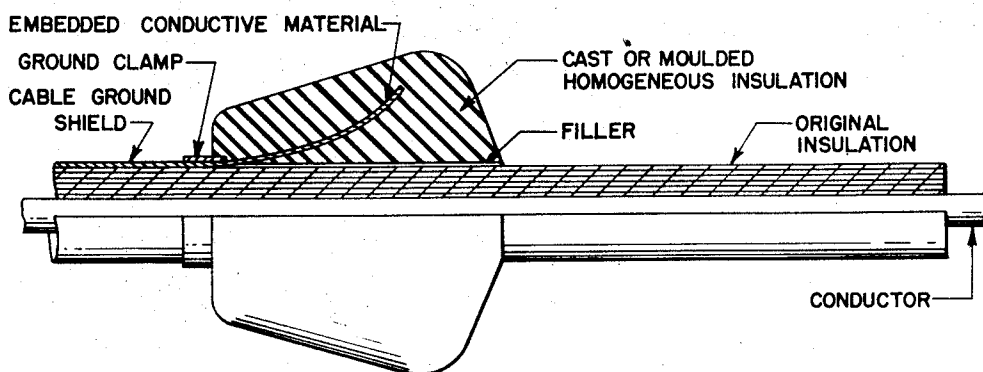
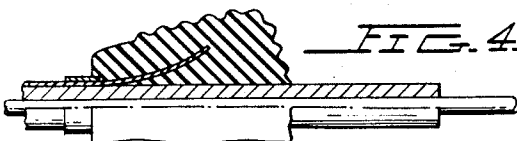


FIG. 4



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PREFABRICATED STRESS RELIEF CONE

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My invention relates to a prefabricated stress relief cone for preventing electrical breakdown at the terminal points of high-voltage, ground-shielded cables.

High voltage cables are normally provided with ground shields for the purpose of controlling the dielectric stresses on the cable insulation. The ground shield consists of a thin layer of conducting material, immediately adjacent to the outermost layer of insulation on the cable, and connected to ground. This ground shield constitutes, in effect, an equipotential surface concentric with the axis of the conductor, and its presence causes the electric field distribution around the conductor to be radial, with maximum potential gradient at every point predictable by calculation, with zero gradients in the longitudinal direction of the cable.

At the cable termination, the ground shield must be removed sufficiently far back from the exposed conductor end to prevent electrical breakdown of the adjacent air between the exposed conductor and the ground shield and to prevent creepage along the surface of the cable insulation between these points. This, however, results in excessive potential gradients near the terminal edge of the ground shield as hereinafter illustrated in more detail.

In order to prevent electrical break-down at cable termination points, it has been customary at the termination of the ground shield to provide additional insulation and a generally bell shaped extension to the ground shield. This assembly, well known to the art, is called a dielectric stress relief cone, or more briefly, a stress cone.

Such stress cones, however, are completely dependent on the skill of the workman who winds the tape and often are unpredictable in their dielectric qualities because of air spaces, poor centering, and lack of homogeneity of the insulating material.

The present invention overcomes these deficiencies by providing a prefabricated stress relief cone made of a cast resin which can be molded to provide a unit of predetermined and consistent dielectric strength. Such a unit is also readily installed by even relatively unskilled workmen.

Accordingly, it is an object of my invention to provide a prefabricated stress relief cone which may be accurately produced and centered on a high voltage cable axis independently of the skill of the workmen attaching the same to the cable.

Another object of my invention is to provide a stress relief cone which can be made in any predetermined shape and of predetermined dielectric strength so as to provide consistently and accurately the proper degree of insulation at cable termination points.

Still another object of my invention is to provide a stress cone which is easily installed by relatively unskilled workmen.

These and other objects of my invention will become

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apparent from the following description when taken in connection with the drawings, in which:

Figure 1 is illustrative of the field around a conductor showing the change of such field at the point of termination of a ground shield.

Figure 2 shows the electric field as it would be distributed when a tape wound stress relief cone of the prior art is applied at the termination point of the ground shield.

Figure 3 illustrates the cast stress relief cone of the present invention as it would appear when assembled around the cable.

Figure 4 is another embodiment of the present invention shown in Figure 3 in which the external surface of the insulating material is corrugated so as to increase resistance to creepage.

Essentially the present invention comprises a prefabricated stress relief cone for preventing electrical breakdown at cable termination points, which cone comprises a mass of homogeneous insulating material having a cylindrical hole therethrough, a conductive material embedded in said insulating material, and means for electrically securing said conductive material to the cable ground shield.

Referring first to Figure 1, it can be seen that the electric field around the conductor is normally radial. Therefore, at the cable termination, the ground shield must be removed sufficiently far back from the exposed conductor end to prevent electric breakdown of the adjacent air between the exposed conductor and the ground shield, or creepage along the surface of the cable insulation between the same points. The removal of the ground shield for any specified length from the termination is not a sufficient condition for preventing dielectric failure from conductor to ground, for the reason that excessive values of potential gradient may exist in the region adjacent to the terminal edge of the ground shield. This is illustrated in Figure 1. The electric field in the mentioned region will take a configuration which depends on the relative dielectric constants of the insulating layers on the cable and of air, proximity to other objects and potential of those objects. Potential gradients in a longitudinal direction may attain excessive values, causing cable and/or air insulation breakdown.

In order to prevent cable insulation failure, it has been customary to provide at the termination of the ground shield a generally bell-shaped extension of the type shown in Figure 2. This is the typical stress cone as known to the prior art. Here the additional insulation is built up by winding layers of insulating tape so as to obtain the desired cross sectional contour. Conducting tape, foil or gauze is then placed over the additional insulation, and electrically bonded to the cable ground shield. A sufficient length of the original cable insulation is left between the cable end and the stress cone, to extend the creepage path from conductor to ground shield over the surface of this insulation.

The bell-shaped conductive layer constitutes a divergent extension of the ground shield on the cable. Its presence serves to control the configuration of the electric field both radially and longitudinally so that the potential gradients are kept within safe limits. For best results, the stress cone profile should follow a curve corresponding to a mathematically derived function, and the additional insulation should contain no air spaces where corona can occur. These requirements are very difficult to satisfy when the stress cone is built up in the

form of wound layers of tape, and require considerable skill.

In accordance with the present invention, a prefabricated stress relief cone is provided which can be installed in the field by a relatively unskilled workman. As seen in Figure 3, a conductive material which is of a generally conical shape and diverges from the axis of the cable is embedded in a mass of cast homogeneous insulating material. This mass of insulating material has a cylindrical hole therethrough, concentric with the axis of the conical shaped conductive layer, and having a diameter slightly larger than the outside diameter of the cable insulation.

The narrow end of the embedded conductive layer is bonded electrically to a cylindrical conductive piece or ground clamp that extends towards the rear, thereby electrically bonding the conductive material to the cable ground shield. The external surface can be plain, as shown in Figure 3, or corrugated as shown in Figure 4 to increase the surface creepage distance in the longitudinal direction. The air space between the internal wall of the cylindrical hole and the outer surface of the cable surface is filled at the time of installation with a resin curable at room temperature.

The insulating material comprises a cast resin having high dielectric properties. Such resins would include various rubbers, natural and synthetic, halogenated rubbers, polyester and epoxy resins. Of the above, however, because of its excellent casting mechanical and electrical properties, I prefer to use the epoxy resins.

The epoxy resins herein referred to are of the type comprising the resinous product of reaction between an epihalohydrin such as epichlorohydrin and a polyhydroxyphenol such as bis-phenol-A. Resins of this type are referred to in U.S. Patents Nos. 2,324,483, 2,444,333 and 2,458,796. These resins have been found to possess excellent mechanical resistance, resistance to water and alkali and outstanding electrical insulation properties. They are sold under such trade names as "Araldite" and "Epon." Depending upon the desired physical properties, various fillers such as slate, quartz, flint and clays may be incorporated with the epoxy resins.

A sample formulation of the resin used in connection with my invention is as follows:

100 parts, by weight, "Araldite 6060" epoxy resin

(This is a 100% solids content epoxy resin of the acid catalysis type, i.e. an epoxy resin in which the hard infusible product is obtained through the addition of a polycarboxylic acid type cross-linking agent. See United States Patent No. 2,712,535.)

200 parts, by weight, of silica filler (99.8% pure)

30 parts, by weight, of phthalic anhydride

The above mixture is heated to 300° F. and poured under vacuum into a mold. The resin is cured at 320° F. for one hour at atmospheric pressure.

The advantages of the present invention are many. First, the prefabricated stress cone is easily and simply installed. The installation steps would consist merely of stripping the ground shield for the required length, slipping the stress cone on the cable and back to the ground shield termination, electrically bonding the stress cone to the cable ground shield, and filling the air space with the filler or liquid insulating compound curable at room temperature.

The conductive surface constituting the field controlling element can be accurately produced and centered on the cable axis independently of the skill of a workman. This surface can be made to follow any mathematically derived curve without the compromises required when the surface is built up by means of successive layers of tape. Moreover, air spaces where corona could occur are positively eliminated.

The use of homogeneous insulating material insures equal dielectric strength in all directions and permits reducing the overall dimensions of the cone. In the previously used cone, the dielectric strength along the tape layers is much smaller than across them.

The total length of original cable insulation necessary beyond the stress cone for surface creepage considerations can be reduced due to the additional creepage distance provided by this device. A further reduction in the overall length of the cable termination is obtained when providing a corrugated surface for the cast resin surface.

Although I have here described preferred embodiments of my invention, many variations and modifications will now be apparent to those skilled in the art. I prefer to be limited, therefore, not by the specific disclosure herein, but only by the appended claims.

I claim:

1. A prefabricated stress relief cone for the terminal end of a high voltage ground shielded cable to prevent electrical breakdown of said cable; said ground shielded cable comprising a central conductor, a tube of solid insulation surrounding said central conductor and a ground shield of conductive material surrounding said tube of solid insulation; said stress relief cone consisting of a sheath of conductive material and an epoxy resin; said epoxy resin being molded around said conductive material and having a cylindrical opening along its axis; said sheath of conductive material having substantially smooth surfaces for its entire length; said sheath of conductive material having a generally conical shape which diverges along the complete length thereof from the axis of the cone; said epoxy resin forming a mass of homogeneous insulating material and encapsulating said conductive sheath; said conductive sheath having connecting means extending therefrom to electrically connect said conductive sheath to said ground shield; said connecting means comprising an extending portion of said cone at the small diameter thereof; said terminal end of said high voltage cable having said ground shield removed therefrom to expose the outer surface of said tube of solid insulation; said prefabricated stress relief cone being removably connected to said terminal end of said high voltage cable and receiving said exposed surface of said solid insulation in said cylindrical opening of said stress relief cone; said extending portion of said cone having an inner diameter substantially equal to the inner diameter of said ground shield; the end of said extending portion of said cone being adjacent the end of said ground shield.

2. The device as defined in claim 1 wherein the external surface of said epoxy resin mass is corrugated to increase the creepage distance along said surface.

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