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ELECTRODE AND INSULATOR WITH SHIELDED DIELECTRIC JUNCTION

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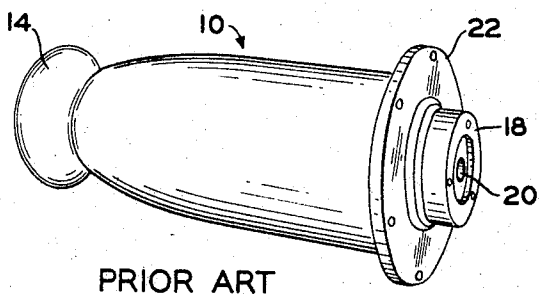


FIG. 1

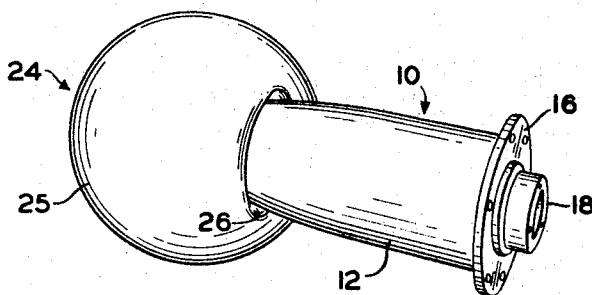


FIG. 2

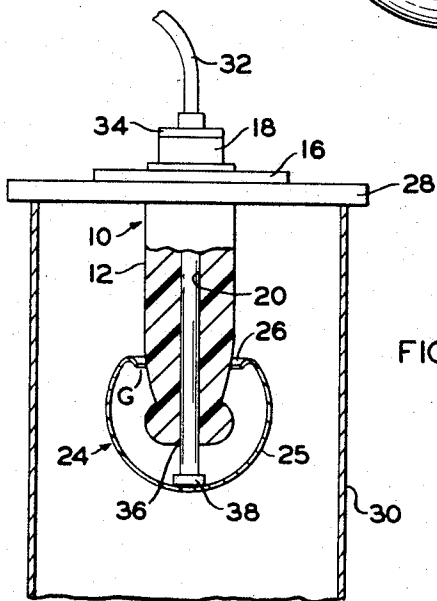


FIG. 3

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ELECTRODE AND INSULATOR WITH SHIELDED DIELECTRIC JUNCTION

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5 Claims

ABSTRACT OF THE DISCLOSURE

A hollow spherical electrode forms a shield about the negative junction of an insulator in high vacuum to increase vacuum voltage standoff capabilities.

Notice of Government ownership

The invention described herein was made by employees of the United States Government and may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

Background of the invention

This invention relates to an improved high voltage vacuum feedthrough having a shielded dielectric junction.

High electric stresses normally occur at the dielectric junction between a high voltage electrode and an insulator. These stresses tend to cause breakdowns and flashovers when an insulator is used as a high voltage feedthrough to a negative electrode in a vacuum system. The breakdowns originate at the triple junction of dielectric, vacuum, and negative electrode and a prime source of trouble is the interface between the dielectric and the negatively charged electrode. Due to microscopic gaps in this interface, high localized stresses are set up and cause electron emission. Because of the long mean free path inherent in any high vacuum system, emitted electrons are free to strike the positively charged electrode, liberating positive ions and causing a flashover.

In order to prevent such flashovers, feedthroughs have been made physically very large or constructed of laminations. They have usually been of the oil-filled porcelain type or laminated of Pyrex and aluminum. Some have been cast of epoxy but of necessity are extremely large to support the necessary potential.

In the case of high voltage standoffs, deep wells have been formed in the insulation material to trap electrons and prevent them from striking the positive electrode. Such an approach is not suitable for use with feedthroughs. There have also been attempts to bury a negative dielectric junction within a negative electrode but without appreciation or provision of desirable relationships or proper construction for effectively shielding the junction.

Summary of the invention

In accordance with this invention a negative electrode in the form of a hollow sphere surrounds and shields a juncture between a high voltage conductor connected to the shield and an insulator around the conductor. The insulator is maintained out of contact with the spherical

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electrode. In the preferred construction, the electrical conductor and surrounding insulator pass through an opening in the shield. The opening is larger than the cross section of the insulator. Preferably the opening and cross section of the insulator are circular and an essentially uniform gap is maintained between the insulator and the periphery of the opening in the electrode. A connection between the spherically shaped electrode and the conductor is made within the sphere so that the electrode shields the junction between the insulator and the conductor. This arrangement is especially suitable for terminating a high voltage cable, either single- or multi-conductor, into a high vacuum environment. It is also suitable with appropriate modification for operation as an air to vacuum, gas to vacuum or oil to vacuum feedthrough.

This invention provides a feedthrough that makes it possible to reduce the overall length of vacuum and air feedthrough insulators while maintaining low leakage and high flashover resistance. In addition, this feedthrough can be fabricated at a lower cost than devices presently available and will handle higher voltages without breakdown and flashover. By way of example, it has been determined through tests that standard molded epoxy cable-to-oil and cable-to-air feedthroughs modified with a spherical electrode in accordance with this invention will have vacuum voltage standoff capabilities five times greater than when used with conventional electrodes that do not provide shielding. Electrodes with dielectric junctions shielded in accordance with this invention also exhibit negligible leakage current right up to the point of flashover.

Accordingly, it is an object of this invention to provide an improved shielded dielectric junction that will support high voltages without flashovers, and more particularly to provide a high voltage vacuum feedthrough having a shielded dielectric junction such that the insulator more nearly approaches the insulation capability of vacuum than heretofore.

These and other objects, features and advantages of this invention will become better understood from the detailed description of a preferred embodiment that follows, when considered in connection with the accompanying drawing.

Brief description of the drawing

FIGURE 1 is a perspective view of a standard high voltage insulator or feedthrough;

FIGURE 2 is a perspective view of the insulator or feedthrough of FIGURE 1, with one end shielded by a spherically shaped electrode, in accordance with the present invention; and

FIGURE 3 is a cross sectional view of an insulator and spherical shielding electrode in an evacuated jar, illustrating the internal construction and arrangement of the spherical electrode.

Description of the preferred embodiment

Referring now to the drawings, a standard cast epoxy high voltage insulator or feedthrough is indicated generally at 10. The insulator 10 includes an elongated body 12, circular in transverse cross section. The body 12 terminates at one end in a corona termination 14 and at the other end in a mounting flange 16 and central boss 18. A central passageway 20 extends through the length of the

body 12, opening through the boss 18 at the one end and through the termination 14 at the opposite end. Apertures 22 extending axially through the flange 16 are adapted to receive mounting screws when the insulator 10 is secured to a mounting plate or other support.

An electrode 24 in the shape of a hollow sphere is shown in FIGURE 2 surrounding the termination end 14 of the insulator 10. Suitably, the sphere 24 is constructed of a thin wall 25 formed from aluminum or stainless steel. A circular opening 26 in the wall 25 permits the body 12 of the insulator to pass through the wall of the hollow sphere.

The relationship between the insulator 10 and the spherical electrode 24 is best shown in FIGURE 3 of the drawing, which illustrates the manner in which the insulator and electrode are mounted for use. As shown in FIGURE 3, the insulator 10 passes through a mounting plate 28 that serves as a cover to a bell jar 30, in which a vacuum has been created. The insulator is secured to the mounting plate 28 by the mounting flange 16, utilizing suitable fastening means and seals (not shown).

An electrical conductor, such as a high voltage cable 32, extends through the central passageway 20 of the body 12 of the insulator. A suitable seal 34 is provided between the cable 32 and the insulator 10 at the central boss 18 of the insulator. The cable 32 extends from the insulator at the termination end 14 of the body 12, forming a junction or interface 36 at the end of the insulator. The conductor terminates beyond the insulator at the inside surface of the spherical electrode 24, opposite the opening 26, and is connected at 38 to the inside surface of the wall 25. Thus, the junction 36 is located within the spherical electrode inwardly of the opening 26 and spaced from the wall 25.

The cable 32 through the connection 38 structurally supports the electrode 24 in fixed relationship with the insulator 10. It will be apparent that, functionally, the portion of the conductor 32 that extends from the insulator is a part of the electrode 24 and the interface 36 is basically between the electrode and the insulator.

A gap G is provided between the periphery of the circular opening 26 of the spherical electrode and the body 12 of the insulator so that at all points on the sphere the electrode is spaced from the insulator 10. As best illustrated in FIGURE 3, the opening 26 has a rolled periphery and the insulator 10 is substantially centered axially within the opening 26 so that the gap G is essentially uniform about the insulator. With this construction, the spherical electrode 24 effectively shields the junction or interface 36 between the electrical conductor 32 and the insulator 10.

In operation a negative electrode 24 and a positive electrode (not shown) are supported in a high vacuum (below 5×10^{-4} torrs) environment. The negative electrode 24 is supported by the insulator 10 in the manner described above, and a high voltage potential such as a potential of 600 kilovolts or more is applied across the two electrodes in the vacuum. The high vacuum makes it possible to maintain the high potential between the positive and negative electrodes. The electrode 24 shields the junction 36 so that electrons are not emitted due to the reduction in the localized stress at microscopic gaps at the interface or junction between the conductor and the insulator. Flashover is prevented and a high voltage holdoff is attained.

The relationship between the insulator 10, electrode 24, and electrical conductor 32 account for the ability of the assembly to attain high voltage holdoff levels. A gap G is always maintained between the opening 26 into the spherical electrode 24 and the body 12 of the insulator 10. Also, the insulator is located within the spherical electrode 24 with a space between the interface 36 of the conductor and insulator and the inside surface of the sphere. It has been found that with small gaps G between the insulator and electrode, the holdoff

levels attained are a strong function of the distance between the positive and negative electrodes. Also, with the small gap, the holdoff voltage increases with the degree of penetration of the insulator 10 into the sphere 24, but only to a point. Thereafter, the holdoff voltage decreases. Thus, an insulator that does not extend to the inside surface of the negative electrode 24, will attain greater holdoff voltages than one that extends to the inside surface.

The cause of the adverse effect from too little or too great a penetration of the insulator into the electrode is the practical necessity of piercing the spherical electrode. This destroys what would otherwise be a field-free region about the interface or junction 36. As a result, with insufficient penetration there is insufficient field reduction at the negative dielectric junction 36, causing electron emission and flashover along the insulator surface. Excessive shielding, i.e., extending the insulator too deeply within the spherical electrode 24, distorts the electrical field and results in excessive stress across the gap G between the sphere and insulator, and flashover occurs sooner than it would with less shielding. Where excessive shielding is avoided by spacing the end of the insulator 10 from the surface of the electrode 24 opposite the opening 26, flashovers across the gap G can be minimized or eliminated, and insulator marking and degradation will be held to a minimum.

By way of example to illustrate the effectiveness of the shielding of the dielectric junction between the insulator and electrode, a standard molded epoxy feedthrough as shown in FIGURE 1 of the drawings was tested and found to hold 65 kilovolts with 180 microamperes leakage without flashover. After the installation of a spherical shielding electrode such as the electrode 24 shown and described herein, the same feedthrough held 365 kilovolts with less than four microamperes leakage for 16 minutes without breakdown. Thus, by shielding the negative dielectric junction in the manner described herein, the vacuum voltage stand-off capabilities of a standard feedthrough can be enhanced by a factor of five or more.

While a preferred embodiment of this invention has been described in detail, it will be understood that various modifications or alterations may be made therein without departing from the spirit and scope of the invention, as set forth in the appended claims.

What is claimed is:

1. An improved feedthrough for a high voltage cable connected to a negative electrode comprising
 - a vacuum chamber for housing said negative electrode in a high vacuum environment, said cable extending through a wall of said chamber,
 - a tubular body of insulating material adjacent said wall of said chamber, said cable extending through said body and having an end portion protruding therefrom remote from said wall thereby forming an interface between said end portion and said cable, and
 - a hollow metal sphere forming said electrode in said vacuum chamber, said sphere having a diameter greater than the length of said end portion of said cable and an aperture larger than the diameter of said tubular body, said sphere being mounted on said end portion of said cable with the periphery of said aperture being spaced from said tubular body thereby forming a gap whereby said sphere shields said interface.
2. An improved feedthrough for a high voltage cable connected to a negative electrode as claimed in claim 1 wherein said chamber has a high vacuum below 5×10^{-4} torrs.
3. An improved feedthrough for a high voltage cable connected to a negative electrode as claimed in claim 1 wherein said hollow metal sphere has a negative potential of at least 600 kilovolts.

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4. An improved feedthrough for a high voltage cable connected to a negative electrode as claimed in claim 1 wherein said body of insulating material terminates in a corona termination within said hollow metal sphere.

5. An improved feedthrough for a high voltage cable connected to a negative electrode as claimed in claim 4 wherein said end portion of said cable extends from said corona termination to the inner surface of said hollow sphere.

2,082,055	6/1937	Higgins -----	174—142	X
2,474,211	6/1949	Back -----	313—240	
2,784,386	3/1957	MacFadden -----	174—127	X
3,126,439	3/1964	Denholm et al.	174—142	X

FOREIGN PATENTS

1,390,355	1/1965	France.		
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LARAMIE E. ASKIN, *Primary Examiner.*

U.S. Cl. X.R.

References Cited

UNITED STATES PATENTS

1,957,982	5/1934	Smith -----	174—142	X
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174—142