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COAXIAL HIGH FREQUENCY CABLE AND INSULATING SPACER

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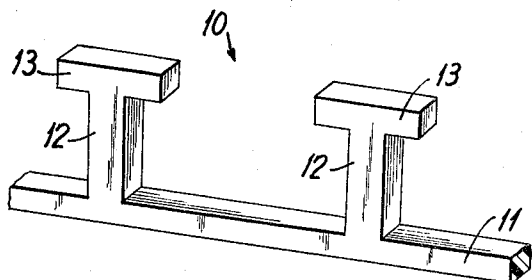


FIG. 1

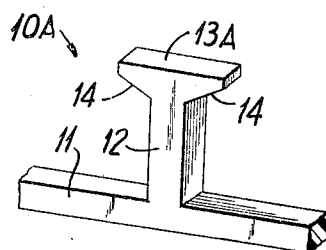


FIG. 2

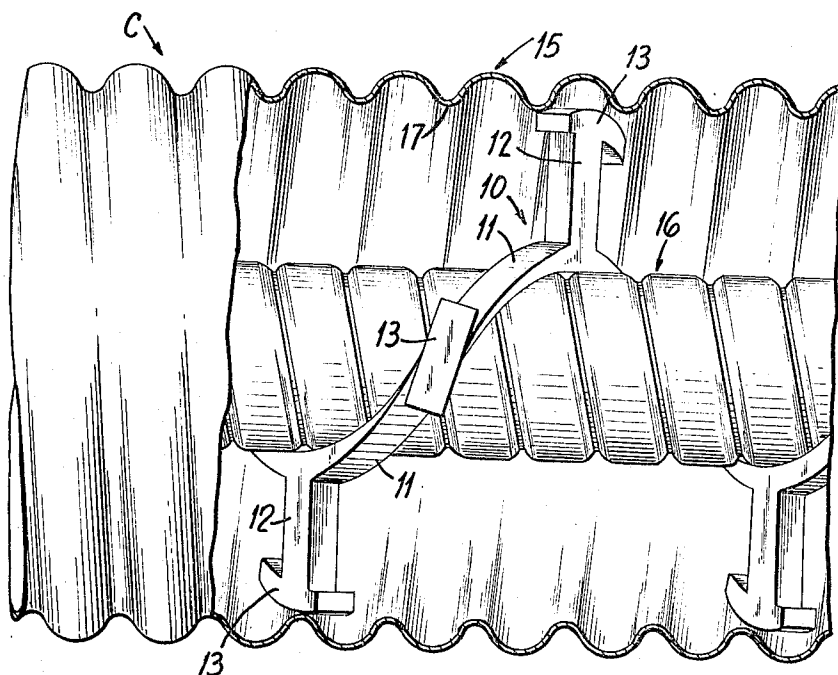


FIG. 3

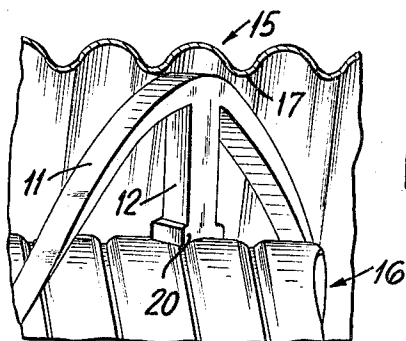


FIG. 4

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This invention relates to coaxial high frequency cables and more particularly, concerns cables having improved spacer means between the inner and outer conductors thereof.

In high frequency cables, attenuation is an important characteristic thereof. This is particularly significant in cables used to transmit substantial amounts of high frequency power. The following relationships show that the transferable power N , in kilowatts and the efficiency of transmission n in a high frequency cable are a function of the attenuation α , expressed as neper per kilometer:

$$n = e^{-2\alpha l}, N = N_v / 2\alpha$$

where e is the base of the natural logarithm; l is length in meters; and N_v is the heat loss per unit length expressed as watts.

Thus, the efficiency of the energy transmission and the degree to which the capacity of the high frequency cable can be used increase with decreasing attenuation.

Attenuation in high frequency cables is composed of two parts: (1) resistive attenuation due to the high frequency resistance of the conductor, and (2) dielectric attenuation resulting from dielectric losses in the insulating material of the cable.

Thus, the following relationships apply to such cables. The resistive attenuation increases with the square root of the frequency; the dielectric attenuation increases directly with the frequency. Also, the resistive attenuation decreases with increasing cable diameter; the dielectric attenuation is independent of cable size. The latter value depends only on the effective resulting loss factor of the insulation, i.e., the configuration of the dielectric spacer and the type of insulation used.

The foregoing relationships indicate that in designing high frequency cables, particularly those of the larger diameters for use at elevated frequencies, it is important to keep the volume of the spacer as small as possible. This in turn results in a lower dielectric constant for the insulation, thus reducing the resistance attenuation.

In order to minimize the amount of insulation in high frequency cables, it has been proposed to provide such insulation as spacer discs or spacer helices. The use of polyethylene helices as spacers for such cables is well known in the art. In cables having relatively small diameters, the helix spacer is formed of solid rod of round or square cross section. For larger diameter cables, the spacer is modified to insure flexibility.

In high frequency cables utilizing corrugated conductors so as to provide flexibility in the cable, the insulating spacer has been designed primarily in terms of insuring mechanical stability of the coaxial cable. With increased usage of cables having larger diameters, where a minimized dielectric loss is essential, it has been found that conventional spacer configurations are inadequate. Also, in this connection, it has been found that the mechanical stability inherent in known spacer configurations, is rarely fully utilized.

Accordingly, an object of this invention is to provide in coaxial cables an improved dielectric spacer in which the volume thereof per unit length of cable is markedly

reduced and the configuration thereof lends itself to optimum electrical characteristics for the cable while still maintaining adequate mechanical stability in the coaxial relationship of the inner and outer conductors thereof.

Another object of this invention is to provide in coaxial cables having a corrugated outer conductor, improved dielectric spacer means having a continuous portion disposed relative to one of the conductors and a discontinuous portion disposed relative to the other conductor.

Still another object of this invention is to provide an improved dielectric spacer for coaxial cables, wherein the outer conductor is transversely corrugated and the spacer comprises an elongated member having a continuous portion abutting the inner conductor and spaced portions along the length of the continuous portion extending radially into abutting contact with crest portions of the outer conductor.

In the drawing, FIG. 1 is a perspective view showing one form of dielectric spacer for coaxial cables, embodying the invention;

FIG. 2 is a view similar to that of FIG. 1, showing another form of spacer;

FIG. 3 is an elevational view showing a coaxial cable with the dielectric spacer, with parts in section;

FIG. 4 is a partial view similar to that of FIG. 3, showing a modified form of the invention.

Essentially, in accordance with the instant invention, a high frequency cable, particularly of the type having a corrugated outer conductor to lend flexibility to the cable as a whole, is provided with a dielectric spacer disposed helically between the outer and inner conductors, wherein such spacer comprises a continuous base portion of minimized cross sectional dimensions disposed against one of the conductors and spaced portions extending radially from such base portion toward the other conductor with the outer ends thereof abutting the other conductor.

Thus, as shown in FIG. 1, 10 designates a spacer embodying the invention. The same may be formed of molded plastic such as polyethylene or the like and comprises an elongated base portion 11, shown as square in cross section, with equally spaced upright portions 12, which may be of square or rectangular section. The upright portions 12 terminate at their outer ends in abutment members or shoes 13 which are of rectangular shape. It is understood that spacer 10 may be formed of its constituent elements 11, 12 and 13 by cementing the same together or the complete spacer may be stamped or molded in integral form. As shown in FIG. 2, the spacer 10A is similar to that shown in FIG. 1, except that shoe portions 13A have inclined undersides 14.

The spacer members 10 or 10A are adapted to be mounted in a high frequency cable C, as shown in FIG. 3, wherein cable C comprises the usual outer conductor 15 and inner conductor 16 coaxially related to conductor 15. The outer conductor 15 is formed of metal in tubular form with a welded longitudinal seam and is transversely corrugated to provide helical corrugations, in a known manner, such corrugations having inner crest portions 17. The inner conductor 16 may also be formed of corrugated metal tubing, in a manner known in the art.

The spacer member 10 is disposed between the inner conductor 16 and outer conductor 15 and wound helically at a selected pitch. Preferably, the direction of winding of the spacer 10 is opposite to that of the outer conductor 15. The spacing of the radial portions 12 may be selected so that with a maximum pitch in winding the spacer member 10, there will be three or four radial portions 12 for a single complete convolution of said spacer member 10.

It will be apparent from a consideration of FIG. 3, that the shoe portions 13 of radial portions 12 will abut at least one of the crest portions 17 of the outer conductor 15. With shoe portions 13 turned angularly toward the axis of the outer conductor 15, the length of such shoe portions may be minimized, thereby decreasing the total volume of the spacer member.

It is understood that the spacing of portions 12 of spacer member 10, as well as the pitch of the helically wound spacer member, may be selected to balance optimum electrical properties and mechanical stability of the spaced conductors 15, 16.

By way of example, a $\frac{1}{4}$ " high frequency cable was made up of an inner conductor having an O.D. of 36.4 mm. to which was applied a spacer strip as described above having a radial dimension of 30.9 mm. and a pitch of 90 mm. The outer conductor has an I.D. of 98.0 mm. Accordingly, the spacer is slightly compressed radially since it has a radial dimension slightly greater than the radial spacing between the inner and outer conductors, thereby establishing a firm mechanical connection between the conductors.

The aforesaid spacer has the continuous base portion thereof formed of polyethylene with a section of 8 mm. x 5 mm., while the spaced portions have a section of 7 mm. x 8 mm. and welded to the base portion at 50 mm. intervals. The outer abutting portions of the spaced portions may have a length of about 25 mm.

The foregoing spacer, on test showed an improvement in dielectric attenuation of the cable, by a factor of 2, as compared to a similar cable having a conventional solid helical spacer member.

As it is desirable to have as much of the spacer member as possible remotely positioned with respect to the inner conductor of a coaxial cable, the spacer member 10 may be disposed in an inverted relation to the conductors, as shown in FIG. 4, wherein the base portion 11 extends along the crests 17 of outer conductor 15 and the portions 12 extend toward the inner conductor 16. The abutment portions 20 at the outer ends of portions 12 may be suitably curved to complement the inner conductor 16 which they engage.

It has also been found that with the instant spacer means, high frequency cables incorporating the same show a higher velocity of propagation. With a coaxial cable having a conventional helical solid space, the velocity of propagation is 90-91%, whereas with the spacer of the instant invention, such value is of the order of 95%.

It is understood that the shoe portions 13 of spacer members 10, 10A may have various configurations to suit the form of the conductor which said shoe portions 13 engage, with the total volume thereof being minimized in terms of stabilizing the coaxial relationship of the inner and outer conductors.

As various changes might be made in the embodiments of the invention herein disclosed without departing from the spirit thereof, it is understood that all matter herein shown or described shall be deemed illustrative and not by way of limitation except as set forth in the appended claims.

What is claimed is:

1. A high frequency cable comprising a tubular outer conductor, said outer conductor being corrugated to provide alternating crest and trough portions along the length thereof, an inner conductor coaxially related to said outer conductor, and dielectric spacer means between said conductors, said spacer means comprising a continuous helically extending portion in contact with the outer surface of said inner conductor and radially extending portions spaced along the length of said continuous portion, each of said radially extending portions including at the outer end thereof a portion of a length sufficient to abut at least one crest portion of said outer conductor.

2. A cable as in claim 1 wherein said portion of each of said radially extending portions abutting at least one crest portion of said outer conductor is a shoe which extends laterally from said radially extending portion.

3. A cable as in claim 2 wherein the helical distance between adjacent shoes is greater than the length of said shoes in the direction of the helical path.

4. A cable as in claim 2 wherein the bearing surface of each of said shoes is substantially rectangular in shape.

5. A cable as in claim 2 wherein the length of a turn of the helically extending portion of said spacer means and the distance between adjacent radially extending portions of said spacer means are so related that the radially extending portions of adjacent helical turns of said helically extending portion are off-set relative to each other, when projected on the cross-section of the cable.

6. A cable as in claim 2 wherein said outer conductor is helically corrugated and the continuous helically extending portion of said spacer means is wound in a direction of pitch opposite to the direction of pitch of the helical corrugations of said outer conductor.

7. A cable as in claim 2 wherein said spacer means is formed of polyethylene.

8. A cable as in claim 2 wherein said inner conductor is transversely corrugated.

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