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HIGH TEMPERATURE RADIO FREQUENCY CABLE
AND METHOD OF MAKING THE SAME
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FIG. 1

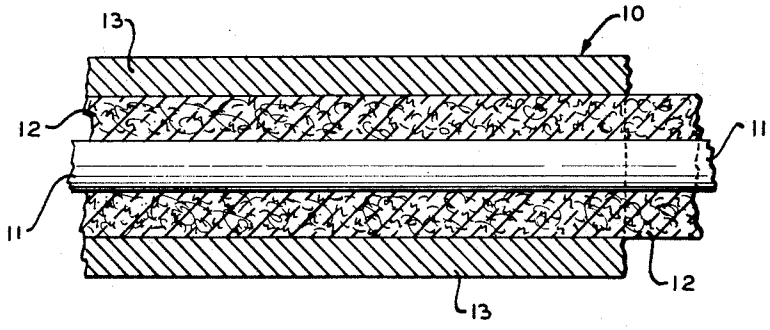
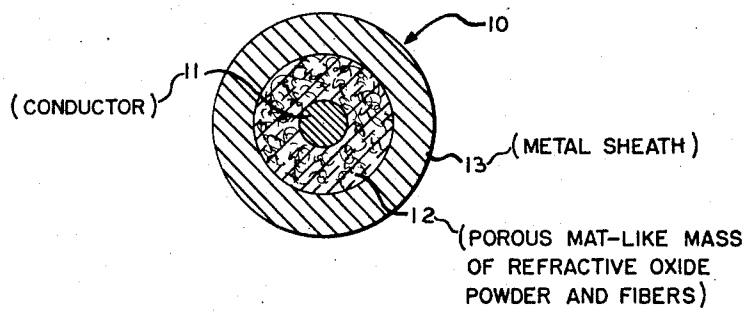


FIG. 2



INVENTOR.
WALTER A. DONOHUE

BY
George H. Fritzinger

AGENT

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HIGH TEMPERATURE RADIO FREQUENCY CABLE AND METHOD OF MAKING THE SAME

Walter A. Donohue, Scotch Plains, N.J., assignor to McGraw-Edison Company, Elgin, Ill., a corporation of Delaware

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1 Claim. (Cl. 174—102)

This invention relates to an improved coaxial cable capable of use under high temperature conditions and of transmitting a wide band of frequencies with very low loss.

The stringent requirements of modern control equipment especially for aircraft and missiles have given rise to the need for an electric cable having very low loss and a uniform frequency transmission through wide frequency bands from one to ten thousand megacycles under continuous temperatures up to 500° C. An object of the present invention is to provide an improved coaxial cable capable of fulfilling these requirements.

Cables with the lowest possible dielectric loss are those having essentially an air medium between the conductor and outer sheath, but such cables require the use of thin insulating beads at regular intervals on the center conductor to hold it in concentric relation with the sheath. Such spaced beads introduce standing waves in the cable which give it a very non-uniform transmission characteristic. An object of my invention is to provide a cable with an insulating medium of a novel and economical composition which has a very low dielectric loss approaching that of air and which has still a very low voltage standing wave ratio.

A further object is to provide such improved electric coaxial cable which is capable of being cycled through wide temperature ranges up to 500° C. without undergoing significant changes in its electrical or physical properties.

As will appear, a benefit of achieving a low dielectric constant is that for any given characteristic impedance for the cable the ratio of diameter of the center conductor to the inside diameter of the sheath can be increased. This permits the use of larger conductors for any given overall size of cable with a resultant reduction in metal losses or, alternatively, it permits a reduction in overall size of the cable for any given center conductor with a resultant reduction in weight. Although the new insulating composition of my invention has very high porosity giving it a very low dielectric constant, it has stable structural properties enabling it to hold the conductor positively in concentric relation to the sheath even when the sheath and conductor are relatively closely spaced to each other. Moreover, the present cables are capable of being flexed repeatedly on small radii of curvature without undergoing changes in their electrical and physical properties. A further object therefore is to provide a new dielectric medium for electric cables which has a low loss and a stable structural form throughout wide temperature ranges. A still further object is to provide such improved cable which is economical to produce.

These and other objects and features of my invention will be apparent from the following description and the appended claim.

In the description of my invention reference is had to the accompanying drawings of which:

FIGURE 1 is a longitudinal sectional view of a cable according to the invention; and

FIGURE 2 is a cross sectional view of this cable.

In the figures there is shown a cable **10** comprising a center conductor **11** preferably of copper surrounded by

a layer of insulating medium **12** according to my invention and encased in a metal sheath **13** of a ductile metal capable of withstanding high temperatures and having high corrosion resistance such as a nickel-iron alloy. The insulating medium **12** is a porous mat-like mass of a refractive oxide, preferably of pure silica or quartz, which is fabricated by mixing in a blender from 7.5% to 15% by weight of silica wool with from 92.5% to 85% of very fine pure silica powder. In this mixing operation the fine fibres or strands of the wool are broken up into a floss and are intertwined with finely divided masses of the powder to form a porous mat-like body of the material. During the mixing operation there is introduced a fine spray of an extruding vehicle of a completely inorganic material which can be wholly evaporated, it being found that pure water is particularly suitable for this purpose. The moistened mat-like mass is then extruded onto the center conductor and dried to remove all moisture, leaving only the pure silica material on the conductor. The mat-like covering so formed on the center conductor has a structural strength from the intertwining of the silica fibres to enable the coated wire to be handled and to be threaded into the metal sheath. Thereupon, the sheath is drawn down to a lesser diameter to compact the insulating material to the desired degree of porosity.

A coaxial electric cable has both metal and dielectric losses. The metal losses depend upon the geometry of the cable and the resistivity of the conductor material, and are directly proportional to the square root of the frequency being transmitted. The dielectric losses are directly proportional to the power factor, the square root of the dielectric constant of the dielectric medium and the frequency being transmitted. In turn, the dielectric constant of any given refractive oxide medium depends upon its porosity, and the power factor thereof depends upon its purity. It has been found that a mat-like insulating medium of pure silica as above described has a dielectric constant of only 1.5. This compares with dielectric constants of 3 to 4 or higher for the insulating media heretofore used. Such approximate two times reduction in the dielectric constant results therefore in a 1.4 ratio in losses, or a saving of the order of 40%. Moreover, the losses from this form of silica are very stable being almost invariant with temperature throughout the range up to 500° C. Also, when no organic contaminant is used in the extruding process, the power factor is very low and is relatively temperature insensitive, it varying typically from about .001 at room temperature to about .002 at 500° C. To avoid the presence of any moisture in the cable it is preferably hermetically sealed notwithstanding that the present silica composition has a markedly low moisture absorptivity.

The reduction in the dielectric constant achieved by the present invention permits also a marked reduction in the metal losses for any cable with a given characteristic impedance Z_0. For example, the characteristic impedance Z_0 is proportional to $1/\sqrt{e}$ multiplied by the log of the ratio of d_2/d_1 where e is the dielectric constant, d_1 is the diameter of the center wire and d_2 is the inside diameter of the sheath. Thus, for any given value of Z_0, the ratio of d_2/d_1 is decreased as the dielectric constant is made smaller. The lowering of the dielectric constant permits therefore either the diameter of the center conductor to be increased for a given overall size of cable with the resultant reduction in the metal losses or, alternatively, it permits a reduction in the overall diameter for any given size of center conductors with the resultant reduction in weight. In a particular case where the center conductor was made larger as permitted by the invention, the total saving in metal losses at 400 mega-

cycles has been found to be 4 db for each 100 feet of cable.

By way of example, a 50 ohm characteristic impedance cable using a silica dielectric medium with a constant of 1.5 may have the following dimensions: an outside diameter of .170", an inside sheath diameter (d_2) of .108" and a diameter (d_1) of center conductor of .040", giving a ratio of $d_2:d_1$ of 2.7. Such cable has a nominal capacitance of 25 micromicrofarads per foot length. Moreover, such cable has stable electrical and physical properties both under cycling through wide temperature ranges and when flexed repeatedly on small radii of curvature.

Although the use of silica in a mat-like composition as above described provides a unique combination of high porosity and high structural strength, other refractive oxides such as magnesia and alumina may be used in the same manner. Magnesia (MgO) has a higher resistivity than either silica (SiO_2) or alumina (Al_2O_3) but otherwise it is inferior for the present purposes because its loss property is very dependent on temperature, being seven times greater at 500° C. than at room temperature. The loss property of alumina, while not especially temperature responsive, is of the order of twice that of silica. Also, whereas silica can be fabricated as above described into an insulating body having a dielectric constant of only 1.5, these alternative oxides have dielectric constants of the order of 3.5 to 4. It is therefore considered that substantially pure silica is a preferred insulating material for purposes of the present invention. However, no unnecessary limitation of the invention to silica is intended.

Although I have herein particularly described my invention in terms of certain preferred materials and methods of fabrication, no unnecessary limitation to the details thereof is intended since the same is subject to changes and modifications without departure from the scope of my invention, which I endeavor to express according to the following claim.

I claim:

A high temperature radio frequency cable comprising a center conductor, a spaced concentric metal sheath, and a dielectric insulating medium between said sheath and center conductor comprising a porous mat-like dielectric composition of fiber and powder ingredients selected from the group consisting of pure silica and quartz, said dielectric composition including from 7% to 15% by weight of said fiber and the balance by weight of said powder, said fiber and powder being intermixed to break up the fiber and to intertwine the same with minute masses of said powder, said sheath holding said composition under compression and said composition having a dielectric constant of the order of 1.5.

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