June 29, 1965 J. J. LA FOREST 3,192,310

EHV TRANSMISSION LINE AND SHIELD ASSEMBLY

Filed Sept. 18, 1963

Fig. 1.

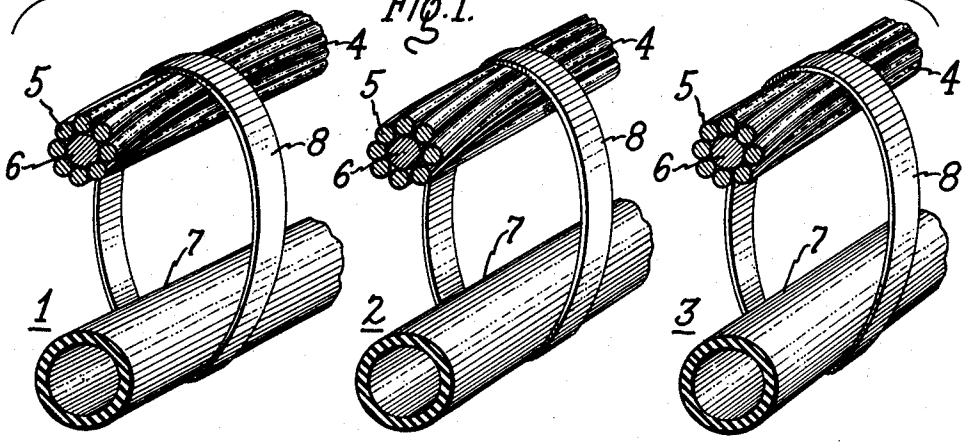


Fig. 2.

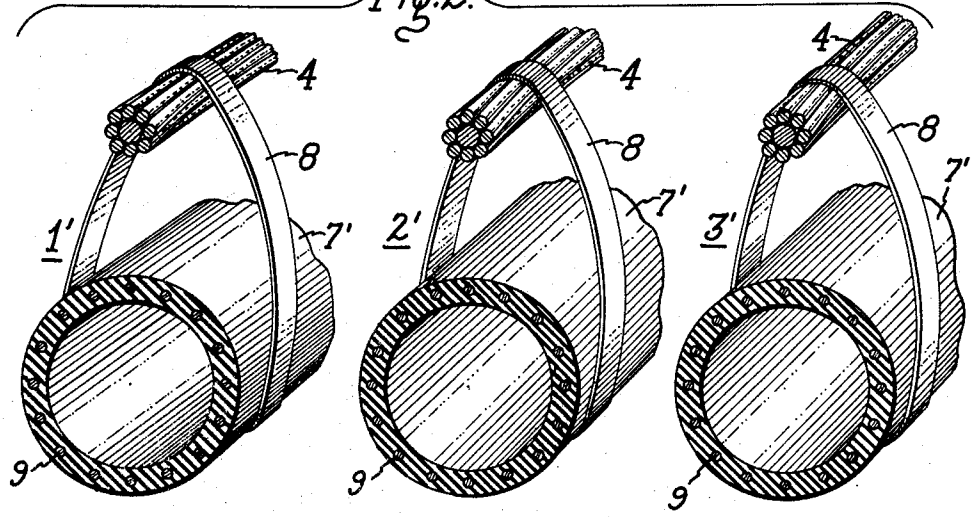


Fig. 3.

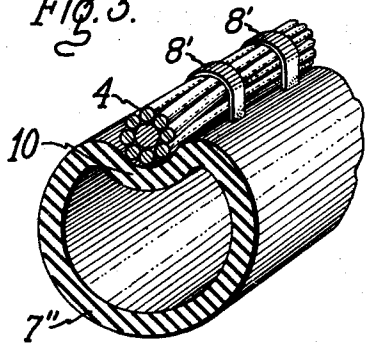
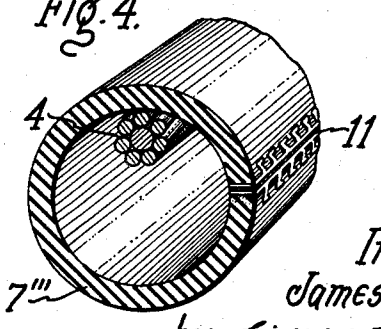


Fig. 4.



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EHV TRANSMISSION LINE AND SHIELD ASSEMBLY

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This invention relates to EHV transmission lines and more particularly to improvements in shielded conductor configurations for such lines.

EHV as used herein covers a range of 287–1000 kilovolts and above. A major problem associated with the design of EHV systems is the fact that, as voltages have been increased, the conductor size has had to be increased in order that the electric field strength perpendicular to the surface of the conductor be kept low. This increase in conductor size has proceeded, in many cases, to the point where the current carrying capacity of the conductor is far in excess of what is required for the line load. This problem has been met in the past by the "bundled" or "expanded" conductor designs where unneeded metallic cross section is replaced by air or impregnated paper. In all such arrangaments, the same element provides both the current carrying and the corona shielding functions which tends to increase the size and cost of the EHV lines.

In accordance with this invention, the load current carrying function and the corona shielding function are provided by separate and distinct elements substantially different in kind. Thus the load current carrying function is provided by a conventional conductor such as an ACSR (for aluminum cable steel reinforced) conductor which has high electrical conductivity, high mechanical tensile strength and which has a cross section or diameter no greater than is necessary for carrying the load current. The corona shielding or prevention function is provided by a relatively low conductivity, light weight, low tensile strength conductor or semi-conductor electrically and mechanically connected to the current carrying conductor so as to be supported by and have the same potential as the current carrying conductor while not carrying any appreciable part of the load current or appreciably increasing the weight of the line.

An object of the invention is to provide a new and improved EHV line multiple shielded conductor.

Another object of the invention is to provide a novel multiple conductor for EHV lines in which the current carrying and corona shielding functions are provided by separate elements differing in kind.

The invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the drawing,

FIG. 1 is an illustration of an embodiment of the invention for upgrading an existing line either as to line voltage or corona loss or radio noise performance,

FIG. 2 is an illustration of a modification suitable for use in new lines especially in the 500 kv. region and up where the foul weather performance becomes most important,

FIG. 3 is a further modification showing the different physical relationship of the current carrying and corona shielding elements, and

FIG. 4 is another modification in which the current carrying conductor is inside the tubular corona shielding high resistance conductor.

Referring now to the drawing and more particularly to FIG. 1, there is shown therein the three phase conductors 1, 2, and 3 of an existing three phase EHV transmission line which has been upgraded as to voltage and

corona performance in accordance with the present invention. Each conductor consists of a conventional line current carrying conductor 4 such as an ACSR conductor having a plurality of aluminum strands 5 surrounding a steel core 6. In order to permit this line to operate at substantially higher voltages without forming corona or producing resulting objectional radio interference, relatively light weight low conductivity tubes 7 are suspended below the conductors 4 by electrical conductive supporting means 8 which may be in the form of metallic straps or bands. The relative cross section or diameter of the current carrying conductors 4 and corona shielding tubes 7 will be determined by the voltage and corona performance desired. They are shown by way of example as having substantially equal diameter or cross section. However, the corona shielding tube 7 might be larger in diameter or cross section than conductors 4. The corona shielding element 7 may be made of extrudable plastic material such as synthetic rubber, butadiene or polyethylene containing a predetermined amount of uniformly dispersed filler material such as carbon black or graphite to impart a relatively low electrical conductivity to the tubes 7 in comparison with the conductors 4. For example, the conductivity of the tubes 7 may be in the range of 10^3 to 1 mhos per meter whereas aluminum typically has a conductivity of 3.6×10^7 mhos per meter. By means of the construction shown in FIG. 1 practically all of the load current is carried by the conductors 4 but the shielding elements 8 have the same potential as the conductors 4 due to the electrical connections provided by the elements 8 so that the electric field intensity at the surface of the conductor is reduced considerably, thus greatly reducing its propensity to produce corona discharges.

In the modification shown in FIG. 2, the modified multi-part line conductors 1', 2', 3' each have current carrying conductors 4 essentially the same as in FIG. 1 but for higher voltage operation such as 500 kv. and above and particularly for controlling corona under rain or snow or sleet conditions substantially larger diameter shielding conductors 7' are provided, these being shown as having a diameter about four times the diameter of the conductors 4. They may, however, be made of the same material as the shielding conductor 7 of FIG. 1.

For preventing the accumulation of ice on the shields 7', they may be provided with a series of embedded longitudinally extending relatively low resistance conductor filaments 9 which will carry sufficient current to produce sufficient I^2R heating losses to maintain the temperature of the corona shielding members 7' above the melting point of ice.

In the modification shown in FIG. 3, the tubular corona shielding element 7'' is formed or molded with a longitudinal groove 10 in which the conductor 4 is nested so as to form a more intimate physical relationship between the conductor and the corona shield, they of course being interconnected by suitable members 8' corresponding in function to the members 8 in FIGS. 1 and 2. This particular arrangement enhances the electrostatic shielding properties of member 7''.

In the modification shown in FIG. 4, the conductor 4 is inside the corona shielding element 7''' so that interconnecting means such as 8 or 8' are unnecessary. However, this arrangement has the disadvantage in comparison with the arrangements of FIGS. 1, 2, and 3 in that the shielding element 7''' provides a certain amount of heat insulation surrounding the conductor 4 so that it will not be as effectively cooled by the atmosphere as in the other figures where the conductor 4 is entirely outside the corona shield. This is an important factor because at full load the line conductors are quite hot and have a very substantial temperature rise over the ambient air with the result

that when there are long spans between supporting towers the thermal expansion due to the high temperature causes substantial sag in the line conductors which, of course, materially affects the minimum clearance between the conductors and ground and hence the tower height and the cost of the line.

As shown in FIG. 4, the shielding element 7''' may be provided with a plastic zipper **11** for fitting it over the line conductor **4**.

It is, of course, not essential that the tubular shielding elements extend throughout the entire length of the line, and they can be used selectively along comparatively short lengths of the line such as when the line passes near dwellings and where foul weather performance would be objectionable from a radio interference standpoint.

Due to the hollow tubular shape of the conducting shields, they can be used as microwave guides and thus be made to serve the additional function of a communication channel between their ends as a supplement to or in lieu of conventional carrier current communication channels which use the current carrying conductor.

Another advantage of the invention is that it frees the current carrying conductor from the need for a perfectly smooth surface so that it need not be deburred or carefully handled to prevent surface marring. Without the shielding conductor, such burrs, points or other irregularities on the conductor surface provide potent sources of corona, but with the addition of the tubular shield, the tendency for corona to form is greatly reduced.

While there have been shown and described particular embodiments of the invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention, and therefore it is intended by the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A high voltage transmission line cable assembly comprising an elongated main current carrying conductor of high conductivity electric conducting material having a cross-sectional area of a magnitude designed primarily to conduct a predetermined desired load current without excessive heating, a hollow tubular shielding member suspended from said conductor in parallel closely spaced nonconcentric relation throughout at least a portion of the length of said conductor and having a conductivity of

the order of $1/10^4$ to $1/10^8$ times that of said conductor, said shielding member having an outer cross-sectional area at least as large as that of said conductor and a hollow interior free of high conductivity material over at least a major portion of its interior cross-sectional area, and means electrically connecting said conductor and shielding member together at a plurality of points throughout their contiguous lengths thereby to maintain said conductor and shielding member at substantially equal potentials at adjacent points throughout said lengths, whereby said shielding member reduces the electrostatic field gradient in the region of said conductor while said conductor serves primarily to conduct load current.

2. A cable assembly according to claim **1** in which said current-carrying conductor and said hollow tubular shielding member are disposed in parallel spaced-apart relation and connected at spaced points by electrically conductive coupling members.

3. A cable assembly according to claim **1** wherein said shielding member is of substantially circular cross-section and has a radius of the order of several times the radius of said conductor.

4. A cable assembly according to claim **3** wherein said current-carrying conductor and said hollow tubular shielding member are in substantially continuous lengthwise engagement throughout their contiguous lengths.

5. A cable assembly according to claim **3** wherein said tubular shielding member is formed of an extrudable plastic electric insulating material containing a uniformly dispersed filler of comminuted electric conducting material.

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