

Nov. 22, 1966

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3,287,489

INSULATED HIGH VOLTAGE CABLES

Filed Sept. 8, 1964

FIG. 1.

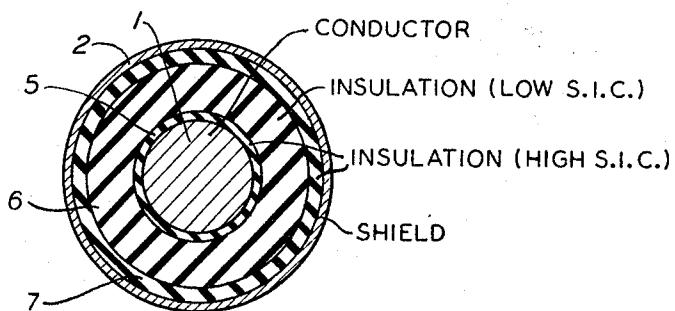


FIG. 2.

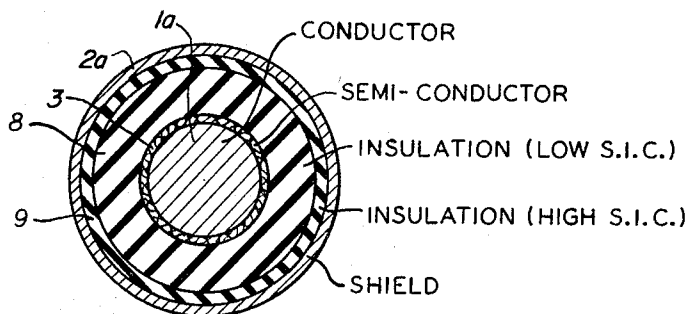
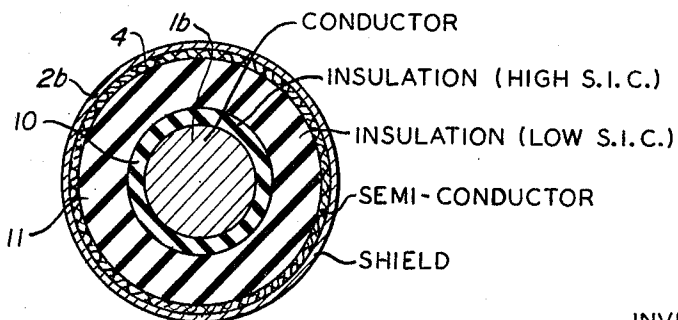


FIG. 3.



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INSULATED HIGH VOLTAGE CABLES

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Filed Sept. 8, 1964, Ser. No. 394,703

6 Claims. (Cl. 174—102)

This application is a continuation-in-part of my pending application, Serial No. 33,450, filed June 2, 1960, and now abandoned.

This invention relates to electric conductors and aims to provide an improved insulated high voltage cable.

The insulated cables with which my invention may be most advantageously employed are those designed for use in carrying power loads of 7,000 volts and above. The ordinary insulated cables that are used for transmission of power at voltages of this magnitude are subject to a very serious drawback in that voids are apt to occur between the conductor and the insulation and between the insulation and the shield. Ionization at such a void results in rapid breakdown of the insulation at that point. Attempts have been made to overcome this by surrounding the conductor, which is conventionally a central core of a metal such as copper which is a good conductor of electricity, with a layer of semi-conducting material and the insulation is placed over it. This insulation is also covered with a layer of semi-conducting material which is surrounded by an outer shield of a material such as metal that is a conductor of electricity.

A disadvantage resulting from the high voltage cable construction referred to above wherein the insulation is covered by a layer of semi-conducting material is that special precautions must be taken at the terminals of the cable. To avoid grounding or flashover at such terminals, the semi-conducting layer must be carefully removed and the surface from which such semi-conducting layer is removed must be carefully cleaned. Among the precautionary measures that it has been necessary to resort to in connection with the terminals of the conventional cables has been the use of stress cones.

I have discovered that it is possible to combat the foregoing disadvantages by insulating the conductor of a high voltage cable with a laminar insulating material of special construction. My laminar insulation includes a thick layer of insulating material of low specific inductive capacity and a thin layer of insulating material of high specific inductive capacity covering a surface of the low specific inductive capacity layer and replacing the semi-conducting material used at such location in conventional high voltage cables.

It is to be understood that the terms "insulating material" and "semi-conducting material" are used in the preceding paragraph, and throughout this application, in the sense in which they are customarily used in the high voltage cable art. As so used, they are mutually exclusive: Thus, "insulating material" signifies a substance characterized by a very high room temperature resistivity (above 10^{10} ohms-cm.) and having, in addition thereto, good dielectric strength (above 100 volts/mil) and readily measurable specific inductive capacity; whereas "semi-conducting material" signifies a substance whose room temperature resistivity is below 10^{10} ohms-cm., but its dielectric strength is without significance and, so far as I am aware, the substances that are used as semi-conducting material in high voltage cables have virtually no dielectric strength. Since it is practically impossible to measure the specific inductive capacity of any of the substances that are used on high voltage cables as "semi-conducting material," such substances are not referred to in terms of specific inductive capacity in the high voltage cable art.

An insulated high voltage cable embodying my invention comprises a central core of metal of high conductivity and an outer metallic shield. Laminar insulation is located between the core and the shield. Such laminar insulation includes a thick layer of insulating material of low specific inductive capacity and a thin layer of insulating material of high specific inductive capacity covering at least one face of the thick layer of low specific inductive capacity insulating material.

When the thin layer of high specific inductive capacity insulating material replaces the semi-conducting material conventionally placed between the conductor and the insulation of a high voltage cable the ionization that normally occurs at that location is very substantially reduced or eliminated. When the layer of high specific inductive capacity insulating material replaces the semi-conducting material conventionally used between the insulation and the shield in a high voltage cable, the difficulties referred to above at the cable terminals are overcome and the use of stress cones at the terminals of my new cable is unnecessary. Accordingly, I prefer to cover each face of the thick layer of low specific inductive capacity insulation with a thin layer of high specific inductive capacity insulation.

Cables constructed in accordance with my invention are illustrated in the accompanying drawing in which:

FIG. 1 is a cross-section of a cable embodying my invention in the form that I now prefer;

FIG. 2 is a cross-section of a modified cable embodying my invention; and

FIG. 3 is a cross-section of a further modification of a cable embodying my invention.

The cable illustrated in FIG. 1 includes a conductor 1 consisting of a metal such as copper surrounded by layers of insulation designated, respectively, by the numerals 5, 6 and 7, encased in a conventional shield 2 of metal. The principal insulation is provided by the thick layer 6 which is made of an insulating material such as a natural or synthetic rubber or another plastic material such as polyethylene (by which term I refer to an insulating grade thereof). The specific inductive capacity of the insulation 6 is within the range of about 2 to about 4.5. The layers 5 and 7 of insulation, which are considerably thinner than the layer 6, are also made of a natural or synthetic rubber or a plastic such as polyethylene, modified by incorporating therein particles of a material such as titanium dioxide or carbon in sufficient quantity to raise the specific inductive capacity of the insulation layers 5 and 7 to the range of about 10 to about 25.

Modification of the insulating properties of a rubber or plastic insulating material by the addition thereto of an appropriate quantity of particles of a material such as titanium dioxide or carbon is known. In the practice of my invention, care must be exercised in the selection of the particular modifying agent so employed to make sure that its qualities will not, and that the quantity employed is not sufficient to, lower the room temperature resistivity of the insulating material to the point where it is converted into a semi-conductive material. It is advantageous to employ titanium dioxide as such modifying agent because the use of a sufficient quantity of that material to raise the specific inductive capacity of insulating material from the range of about 2 to about 4.5 to the range of about 10 to about 25 is accompanied by minimal adverse effects upon the dielectric strength and room temperature resistivity of such insulating material.

The respective layers 5, 6 and 7 of insulation are incorporated in the cable so as to get good physical contact between their facing surfaces. This can be conveniently done through known extrusion processes.

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After the last layer 7 of insulation is applied to the cable it is covered by a metallic shield 2 in known manner.

The cable illustrated in FIG. 2 contains two layers 8, 9 of insulation which may be made of a natural or synthetic rubber or a plastic such as polyethylene. The principal insulation is supplied by the thick layer 8 whose specific inductive capacity is within the range of about 2 to about 4.5. The layer 8 is covered by a thinner layer 9 of insulation whose specific inductive capacity is within the range of about 10 to about 25. The conductor 1a, which is of a metal such as copper, is first covered by a semi-conductor 3 of conventional construction. It may consist of a cotton braid or fabric tape impregnated with a material that will conduct electricity. Such semi-conductor is wrapped around the conductor. Thereafter, the insulation 8 is applied. The insulation 9 is then applied thereto and the cable is finally covered with a metallic shield 2a in known manner. I prefer to apply the layers 8 and 9 by extrusion in order that the inner surface of the layer 8 will be in good physical contact with the outer surface of the semi-conductor 3 and the inner surface of the layer 9 will be in good physical contact with the outer surface of the layer 8. It will be appreciated, however, that such layers may be applied as tapes provided they possess the required insulating and specific inductive capacity characteristics.

In the cable illustrated in FIG. 3, the conductor 1b, which is of a metal such as copper, is first covered with a thin layer 10 of insulation whose specific inductive capacity is within the range of about 10 to about 25. This in turn is covered with a thick layer 11 of insulation whose specific inductive capacity is within the range of about 2 to 4.5. Such insulation may consist of a material such as a natural or synthetic rubber or a plastic such as polyethylene, compounded so as to impart thereto the desired specific inductive capacity. The layers 10 and 11 are preferably applied by extrusion so as to get good physical contact between their facing surfaces and between the outer surface of the conductor 1b and the inner surface of the insulation layer 10. A semi-conductor 4 made of a material such as a cotton braid or fabric tape impregnated with a conductor of electricity is tightly wrapped around the layer 11 and then is covered with a metallic shield 2b in conventional manner.

What I claim is:

1. An insulated high voltage cable comprising the combination with a central core of metal of high conductivity and an outer metallic shield of high conductivity, of laminar insulation located between the core and the shield and including a thick layer of insulating material of specific inductive capacity not greater than 4.5, and a thin layer of insulating material of specific inductive capacity not less than 10 covering at least one face of said first-named layer of insulating material.

2. An insulated high voltage cable comprising the combination with a central core of metal of high conductivity, of a thin layer of a semi-conductor surrounding

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said core, laminar insulation surrounding said semi-conductor and including a thick layer of insulating material of specific inductive capacity not greater than 4.5, and a thin layer of insulating material of specific inductive capacity not less than 10 covering the outer face of said first-named layer of insulating material, and a metallic shield of high conductivity surrounding said insulation.

3. An insulated high voltage cable comprising the combination of a central core of metal of high conductivity, laminar insulation surrounding said core and including a thin layer of insulating material of specific inductive capacity not less than 10 covering said core, and a thick layer of insulating material of specific inductive capacity not greater than 4.5 covering the outer face of said first-named layer of insulating material, a thin layer of a semi-conductor surrounding said insulation, and an outer metallic shield.

4. An insulated high voltage cable comprising the combination with a central core of metal of high conductivity and an outer metallic shield of high conductivity, of laminar insulation located between the core and the shield and including a thick layer of insulating material of specific inductive capacity not greater than 4.5 between and in intimate physical contact with two thin layers of insulating material of specific inductive capacity not less than 10.

5. An insulated high voltage cable comprising the combination with a central core of metal of high conductivity and an outer metallic shield of high conductivity, of laminar insulation located between the core and the shield and including a thick layer of insulating material having a specific inductive capacity in the range between about 2 and about 4.5, and a thin layer of insulating material having a specific inductive capacity in the range between about 10 and about 25 covering at least one face of said first-named layer of insulating material.

6. An insulated high voltage cable comprising the combination with a central core of metal of high conductivity and an outer metallic shield of high conductivity, of laminar insulation located between the core and the shield and including a thick layer of insulating material having a specific inductive capacity in the range between about 2 and about 4.5, and a thin layer of insulation having a specific inductive capacity in the range between about 10 and about 25 on each side of said first-named layer and in close physical contact therewith.

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55 LARAMIE E. ASKIN, *Primary Examiner*.

H. HUBERFELD, *Assistant Examiner*.