C. LE G. FORTESCUE.

HIGH VOLTAGE INSULATING BUSHING.

APPLICATION FILED JUNE 4, 1915.

1,217,890. Patented Feb. 27, 1917.

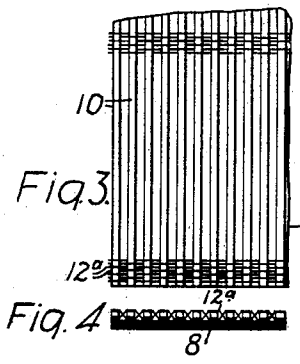


Fig. 3.

Fig. 4.

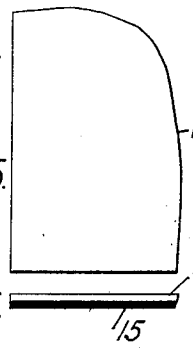


Fig. 5.

Fig. 6.

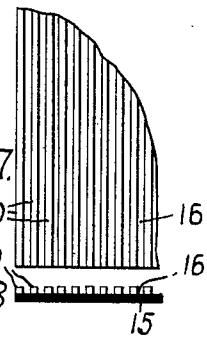


Fig. 7.

Fig. 8.

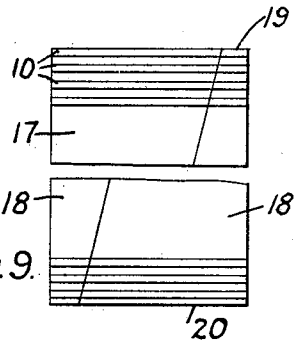


Fig. 9.

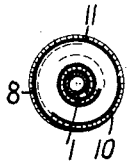


Fig. 2.

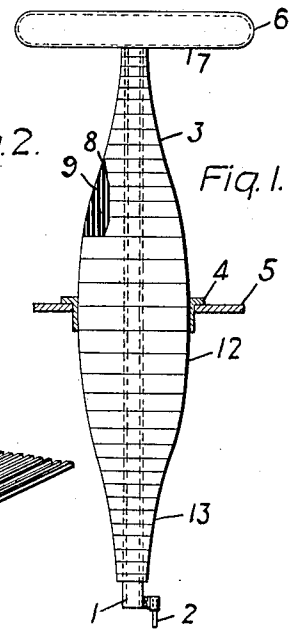


Fig. 1.

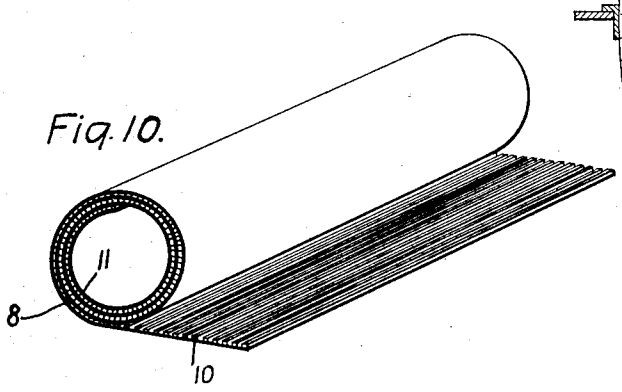


Fig. 10.

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HIGH-VOLTAGE INSULATING-BUSHING.

1,217,890. Specification of Letters Patent. Patented Feb. 27, 1917.

Application filed June 4, 1915. Serial No. 32,185.

To all whom it may concern:

Be it known that I, CHARLES LE G. FORTESCUE, a subject of the King of Great Britain, and a resident of Pittsburgh, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in High-Voltage Insulating Bushings, of which the following is a specification.

My invention relates to electrical insulators, and it has special reference to insulating structures that may be employed as bushings to insulate high-potential conductors.

More particularly, my invention relates to insulating bushings in which electrostatic lines of force are precluded from concentrating upon the external surfaces thereof.

An ideal insulating bushing would be of such form that, in one direction, it would be an electrical conductor, while in a transverse direction, it would be an electrical insulator. This type of bushing may be termed an "asymmetric conductor," and one form thereof may have the properties of an electrical conductor in an axial direction and those of an electrical insulator in a direction perpendicular to the axis. By properly shaping the end portions of this type of bushing, electrostatic field distributions externally to, and internally of, the bushing may be obtained which will insure the utilization, to a maximum degree, of the insulating properties of the bushing. While a bushing of this character is not yet capable of being realized, my present invention provides an insulator or an insulating bushing, the properties of which, for all practical purposes, accord with the principles stated above. By means of my invention, the potential distribution on the outer surfaces of the bushing corresponds to that resulting from a uniform electrostatic field, the equipotential surfaces of which are uniformly distributed at right angles to the axis of the bushing.

An object of my invention is to provide an insulator which may be easily and cheaply manufactured and which is adapted for very high-voltage service conditions. Moreover, an insulating structure embodying my invention may be very compact and may comprise a minimum amount of insulating material, while, at the same time, it will preclude the formation of corona discharges upon its exposed surfaces.

For a better understanding of the nature and scope of my invention, reference may be had to the following description and the accompanying drawing in which Figure 1 is a view, partially in elevation and partially in section, of an insulating bushing constructed in accordance with my invention; Fig. 2 is a cross-sectional view of the bushing shown in Fig. 1; Figs. 3 and 4 are plan and cross-sectional views, respectively, of a material which I may employ in my insulator; Figs. 5 and 6, and Figs. 7 and 8 are views, corresponding, respectively, to Figs. 3 and 4 and illustrating the method of constructing a substitute material for that shown in Figs. 3 and 4; Fig. 9 is a plan view, showing a form which material embodied in my insulating bushing may assume before performing the wrapping operation, and Fig. 10 is a view, in perspective, showing a method of constructing my terminal bushing.

My invention embodies an insulating bushing of the character above-mentioned which comprises a series of conducting strands insulated from one another and longitudinally disposed with respect to the axis of the bushing. The conducting strands are of relatively small cross-sectional area, and are spaced relatively small and uniform distances from one another, each strand, however, being insulated from adjacent strands. It is desired to have the material comprising my bushing as homogeneous as possible, the number of conducting strands per unit area being the same and the spacing of the strands from one another throughout the structure being uniform. The conducting strands may be arranged in any convenient manner, as will hereinafter be pointed out, upon a continuous sheet of material which is wound upon a mandrel simultaneously with an insulating fabric of high dielectric strength. After the bushing has thus been built up, the ends thereof are so shaped that the conducting strands are cut to proper lengths which correspond to their spacing from the axis of the bushing in order that the desired distribution of potential upon the outer surfaces of the bushing may be obtained.

Referring to Fig. 1, a conducting tubular member 1 which is connected, in any convenient manner, to a high-potential conductor 2, extends through an insulating bushing 3 which is built in accordance with my inven-

tion. The insulating bushing 3 is embraced by a centrally-disposed conducting ring 4 which engages the peripheral walls of an opening formed in a member 5 from which it is desired to insulate the member 1. A discoidal-shaped conducting body 6, having rounded edges, is disposed at the upper end of the bushing 3 in such manner that its lower surface 7 is substantially parallel to the member 5.

The bushing 3 comprises a plurality of alternately disposed convolutions of sheet insulating material 8 and a material 9 having conducting strands 10 which are so arranged as to lend electrical conductivity thereto in the direction of the axis of the bushing only. Each convolution 11, embodied in the bushing 3, comprises a plurality of the insulated conducting strands 10 which are longitudinally disposed with respect to the axis of the bushing.

By referring to Fig. 2, it will be seen that, by reason of the spiral formation of the convolutions 11, the conducting strands 10 are spaced from the central conducting tube 1 varying distances which differ from one another by small increments. Inasmuch as the electrical potential of each conducting strand is dependent upon its position relative to the high-potential conducting lead 1, it will be apparent that the potentials of the conducting strands will vary from one another by increments. The layers or convolutions comprising the conducting strands 10 are interposed between adjacent insulating layers or convolutions 8, the latter imparting the property to the condenser terminal 3 of being an insulator in a direction perpendicular to the axis of the bushing. The layers 9, comprising the longitudinally conducting strands 10, impart the property to the bushing 3 of being an electrical conductor in an axial direction. In this manner, the bushing 3 corresponds, in a sense, to an asymmetric conductor of the character hereinbefore indicated.

The end portions of the bushing 3 are tapered, and the surfaces thereof are preferably so shaped as to insure a uniform potential gradient on the external surfaces of the bushing. In accordance with the principles disclosed in U. S. Patents Nos. 1,129,463 and 1,129,466, granted to the Westinghouse Electric & Manufacturing Company upon applications filed by me, a substantially uniform potential gradient upon the outer surfaces of the bushing may be established by employing the conducting discoidal-shaped body 6, and by properly shaping the ends of the bushing 3. It may be demonstrated mathematically that, under these conditions, a uniform potential distribution may be obtained by shaping the external surfaces of the end portions of the bushing 3 to provide a double curvature comprising two logarithmic curves, as indicated at 12 and 13. In this manner, a substantially uniform external electrostatic field envelops the bushing 3 and thereby precludes the formation of corona discharges at any point upon the surfaces of the bushing.

To construct my terminal bushing, reference may be had to Figs. 3, 4 and 10. The layers 9 of the terminal bushing 3 comprise a plurality of conducting strands 10, which are conveniently formed as illustrated in Figs. 3 and 4. The conducting strands 10 are relatively small in cross-section and are spaced from one another uniformly and relatively short distances. They may consist of tinsel threads which are interwoven with cross threads 12^a, as shown in Fig. 4. The threads 12^a may be made of silk, asbestos, or any other insulating material which insures that each strand 10 will be insulated from the strands disposed adjacently thereto. A sheet of this material is then disposed upon a sheet of insulating material which may constitute the insulating layers 8 of the terminal 3. Both of these continuous sheets are then simultaneously wound upon a central mandrel (not shown) in accordance with the principles set forth in Patent No. 858,385, granted July 2, 1907 to the Westinghouse Electric & Manufacturing Company, as assignee of Emil Haefely. The form assumed by the insulating sheet and the superposed sheet comprising the conducting strands 10 during the winding process is illustrated in Fig. 10. It will be noted that the conducting strands 10 are interposed between adjacent convolutions of insulating material 8 and, moreover, that each strand is insulated and uniformly spaced from the other strands. After the bushing is wound up in a cylindrical form, as shown in Fig. 10, the end portions thereof may be tapered in any convenient manner to conform to the shape shown in Fig. 1.

Another method of manufacturing my insulating bushing is illustrated in Figs. 5, 6, 7 and 8. A sheet 14 of conducting material, such as tinfoil, is disposed upon a sheet 15 of an insulating material which serves as a means of support therefor. After the conducting layer 14 has been firmly attached, in any convenient manner, to the insulating sheet 15, channels 16 are cut in the conducting sheet 14, as shown in Figs. 7 and 8. In this manner, a plurality of conducting strands 10 are formed each of which firmly adheres to the insulating layer 15. These sheets, comprising the conducting strands 10, are then wound up to form an insulating bushing in the manner explained in connection with the employment of the fabric shown in Figs. 3 and 4.

Inasmuch as the bushing 3 comprises tapering ends, the intermediate portion of

which has a maximum diameter, it may be desirable to cut the sheets 14 and 15 in a manner shown in Fig. 9 before proceeding with the winding operation. A rectangular sheet 17, having the conducting strands 10 disposed thereupon, is cut into half portions 18 each of which has a trapezoidal form. One of the half portions 18 is then wound with the insulating layer 15 in such a manner that the free end of the outermost layer or convolution of the central portion of the completed bushing corresponds to the shorter side 19 of the trapezoidal portion 18. Of course, it will be understood that the longer side 20 of the trapezoidal portion 18 is disposed adjacent to the central mandrel at the beginning of the winding operation. As the insulating layers and the layers comprising the conducting strands 10 are continuously and simultaneously wound into spiral formation, the completed bushing will be provided with tapering ends which subsequently may be formed so as to have the proper shape, as mentioned above. By this means, a large portion of the material, which otherwise would be wasted when shaping the end portions of the bushing, is saved, and two bushings may be thus wound up from a quantity of material which ordinarily would be sufficient for the manufacturing of one bushing only.

While I have shown and described several embodiments of my invention, it will be understood that I desire to be limited only by the scope of the appended claims.

I claim as my invention:

1. An insulating bushing comprising a plurality of convolutions of insulating material and conducting strands which are spaced from one another relatively short distances between adjacent convolutions of said insulating material.

2. An insulating bushing comprising a plurality of convolutions of insulating material and conducting strands which are uniformly spaced from one another relatively short distances between adjacent convolutions of said insulating material, each convolution containing a relatively large number of said conducting strands.

3. An insulating bushing comprising a plurality of convolutions of insulating material and longitudinally disposed conducting strands which are uniformly spaced from one another relatively short distances between adjacent convolutions of said insulating material, each convolution containing a relatively large number of said conducting strands.

4. An insulating bushing comprising a plurality of convolutions of insulating material, and interposed convolutions of material having conducting strands which lend electrical conductivity thereto in one direction only.

5. An insulating bushing comprising convolutions of sheet insulating material and interposed convolutions of sheet material having conducting strands which lend electrical conductivity thereto in one direction only, each convolution of said second sheet material containing a plurality of conducting strands.

6. An insulating bushing comprising convolutions of sheet insulating material and convolutions of sheet material having conducting strands which lend electrical conductivity thereto in one direction only, said second material being interposed between adjacent insulating convolutions and the conducting strands being uniformly spaced from one another.

7. An insulating bushing comprising convolutions of sheet insulating material and convolutions of material having conducting strands which lend electrical conductivity thereto in the direction of the axis of the bushing only, said second material being interposed between adjacent insulating convolutions.

8. An insulating bushing comprising convolutions of sheet insulating material and convolutions of material having conducting strands which lend electrical conductivity thereto in one direction only, said convolutions being of graded lengths and the larger convolutions being within the shorter convolutions.

9. An insulating bushing comprising convolutions of sheet insulating material and convolutions of sheet material having conducting strands which lend electrical conductivity thereto in one direction only, said convolutions being of unequal lengths.

10. An insulating bushing having tapering ends and comprising convolutions of sheet insulating material and convolutions of material having longitudinally disposed conducting strands which are uniformly spaced from one another and lend electrical conductivity in the direction of the axis and of the bushing only.

11. An insulating bushing comprising an asymmetric conductor of homogeneous structure which is an electrical conductor in one direction and an electrical insulator in another direction.

12. An insulating bushing comprising an asymmetric conductor of homogeneous structure which is an electrical conductor in one direction and an electrical insulator in a direction transverse thereto.

13. An insulating bushing comprising a structure having a plurality of conducting strands which are insulated and uniformly spaced relatively small distances from one another, said structure embracing the member to be insulated.

14. The combination with a conductor, of an insulating bushing having tapering ends

and surrounding the conductor and comprising a plurality of conducting strands which lend electrical conductivity thereto in one direction only, said conducting strands being uniformly spaced from one another in a body of insulating material.

15. The method of constructing an insulating bushing having tapering ends which consists in winding simultaneously upon a rotatable member, two continuous sheets of materials one of which is a sheet of insulating material and the other of which comprises conducting material, each of said sheets having a form, in development, of a trapezoid.

16. The method of constructing an insulating bushing having tapering ends which consists in winding simultaneously upon a rotatable member, two continuous sheets of materials, one of insulating material and the other comprising conducting material, each of said sheets having a form, in development, of a trapezoid, the longer parallel sides of the sheets being adjacently disposed to said rotatable member and the shorter parallel sides being substantially centrally disposed intermediate the tapering ends of the bushing.

In testimony whereof, I have hereunto subscribed my name this 26th day of May, 1915.

CHARLES LE G. FORTESCUE.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."