April 17, 1934. A. J. MASLIN 1,955,305

HIGH VOLTAGE BUSHING

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Fig. 1.

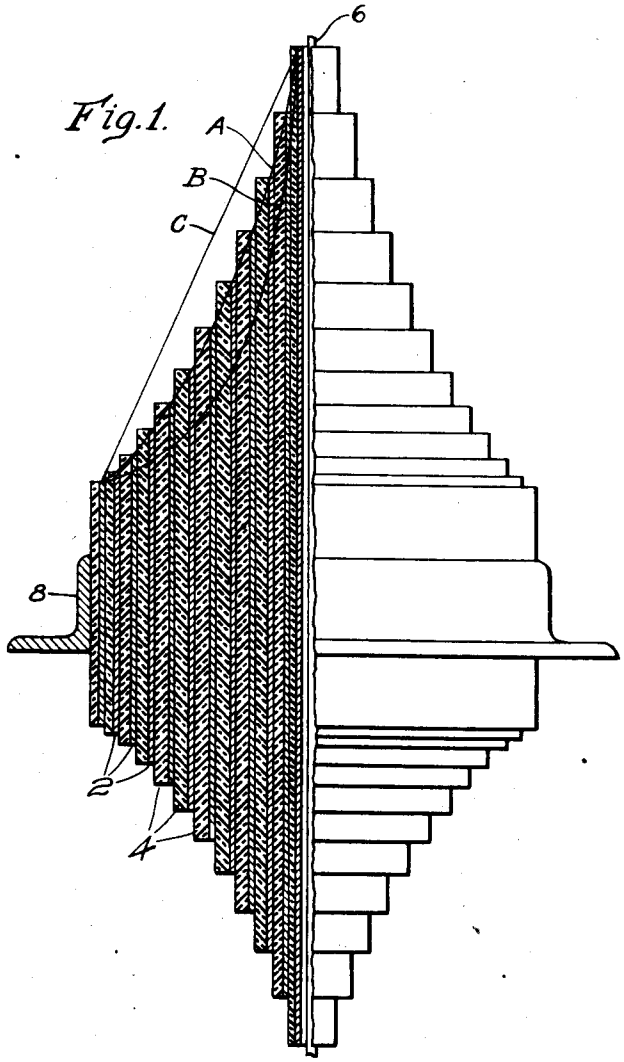
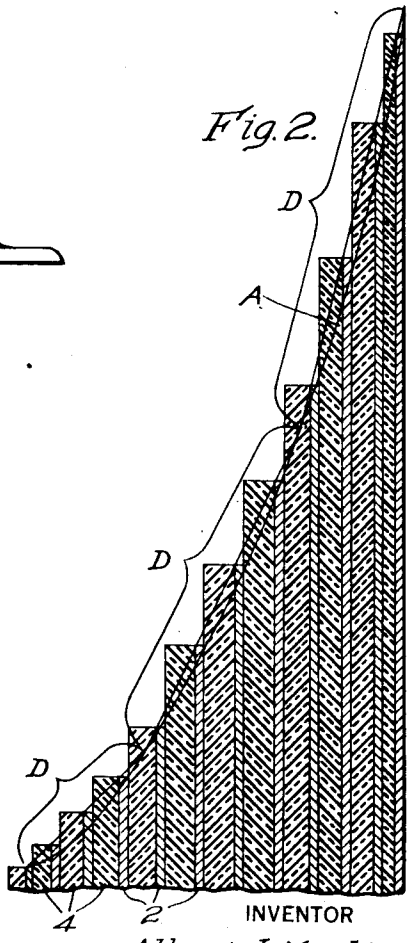



Fig. 2.




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## HIGH VOLTAGE BUSHING

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2 Claims. (Cl. 173—318)

My invention relates to high-voltage bushings and particularly to high-voltage bushings of the condenser type.

One object of my invention is to provide a bushing of the above-indicated character that shall have better impulse flashover characteristics than similar bushings heretofore employed.

Another object of my invention is to provide a multi-layer condenser bushing that shall more nearly conform to the characteristics of an ideal bushing having an infinite number of layers.

Another object of my invention is to provide a condenser bushing of a type embodying conducting cylinders and dielectric cylinders of predetermined variations in wall thickness that shall have greater differences of potential between the conducting cylinders near the ground terminal than is usual in bushings of this type.

Another object of my invention is to vary the lengths of the conducting layers of a condenser bushing in geometric progression, rather than logarithmically or in arithmetic progression, as in bushings heretofore employed.

Another object of my invention is to provide a multi-cylinder condenser bushing in which the cylinders shall be arranged in sets or groups.

Another object of my invention is to provide a multi-cylinder condenser bushing, having substantially equal capacitance between its cylinders and in which points on corresponding ends of the conducting cylinders in an axial plane of the bushing shall define a curve that is a predetermined compromise between a logarithmic curve and a curve through similar points that are uniformly longitudinally spaced.

A further object of my invention is to provide a condenser bushing that shall be simple and durable in construction, economical to manufacture and effective in its operation.

Heretofore, high-voltage condenser bushings, particularly of the type embodying alternate interfitting metal-foil conducting and fibrous-material dielectric cylinders, have been constructed with the thicknesses of the dielectric layers equal; the lengths of the layers being proportioned to the logarithm of the ratio of the layer diameters, to compensate for the differences in diameter thereof, and to thereby have the conducting layers of substantially equal capacitance therebetween.

In such structure, the length of the metal-foil layer at either side of each dielectric layer, or the average or mean length of these foil layers may be selected to follow the logarithmic law above mentioned, but not all of these lengths may be so selected. This design results in a very small difference in length of the successive foil layers or cylinders near the ground cylinder, or cylinder of largest diameter, which is a serious limitation because the minimum difference in length between adjacent cylinders must be sufficient to withstand the voltage stress between the cylinders. Also, at the surface of the bushing the gradient along the length thereof is small at the line end and higher at the ground end; this condition being desirable in that it tends to offset the gradient external to the bushing which is high at the line end and low at the ground end.

Bushings have also been designed having the successive cylinders varying in length by a constant amount. Such construction results in a substantially uniform gradient along the length of the bushing but this condition is not desirable because of the characteristics of the external field, as pointed out above.

The thickness of the dielectric layer is varied so that it will be small next to the line, or conductor, gradually increase to a maximum near the radial center of the bushing side wall and decrease toward the ground terminal. This condition is desirable because the dielectric layers, which are subject to the weaker electrostatic stresses, are in the hotter portion of the bushing wall, thus compensating for the lower strength of the hotter material.

My invention contemplates the retention, as nearly as possible, of the gradient along the bushing of the first form of bushing above mentioned, in which the dielectric layers are of constant thickness, but with an increase in the lengths of the conducting cylinders near the ground end; a varying dielectric-layer thickness similar to the second form of bushing above mentioned being retained in view of the aforesaid advantage thereof.

This objective is attained by varying the lengths of the metal cylinders in geometric progression, rather than logarithmically, as in the first above-mentioned bushing, or by a constant, as in the second mentioned bushing.

Thus, a curve, defined by points on the ends of the conducting cylinders of my bushing in an axial plane of the bushing differs from, or is a predetermined compromise between, the logarithmic curve of the first-mentioned bushing and the slightly reverse or substantially straight-line curve of the second-mentioned bushing in which the lengths of the conducting cylinders vary by a constant.

The logarithmic-curve bushing and my bush-

ing, in its ideal form, both have the manufacturing inconvenience, over the straight-line bushing, of requiring separate calibration of the length of each conducting cylinder. To overcome this inconvenience, in a modified form of my invention the conducting cylinders are arranged in groups, the cylinders included in each group varying in length by a constant differing from the constants of the other groups. The resultant curve through points on the ends of the conducting cylinders, is a series of chords of a geometric curve in accordance with the ideal form of the invention.

Figure 1, of the accompanying drawing, is a semi-diagrammatic view, partially in side elevation and partially in longitudinal section, of a condenser bushing embodying the invention in its more theoretically perfect or ideal form, as pointed out above, and

Fig. 2 is a diagram indicating the aforementioned modification thereof embodying the grouped metal layers or cylinders.

For clearness, both figures show a structure of exaggerated width compared to the length of a bushing as actually constructed.

Referring to Fig. 1, conducting cylinders 2 and dielectric cylinders 4, preferably of paper or other fibrous material provided with a binder or a surface adhesive material, are disposed in tightly interfitting coaxial relation in the form of a multi-layer condenser through which a line conductor 6 extends and about which a grounded conducting supporting element 8 is disposed.

The condenser may, instead of having metal cylinders, be constructed of alternate layers or cylinders of insulating material having different dielectric constants, such as, oil and micarta or oil and porcelain, or be otherwise constructed to provide condenser effect.

The conducting cylinders 2, preferably of metal foil, are constructed and related to have substantially equal capacities therebetween, with the result that they are of radially-outwardly decreasing lengths. This construction gives the effect of tapered ends to the condenser or bushing, the length and slope of which depend upon the voltage imposed and the medium in which the ends are disposed.

For instance, in the structure illustrated, the portion thereof above the support 8 is for disposition in air, outside a transformer or circuit-interrupter tank, and the portion below the support 8 is for disposition in oil inside the tank. By reason of the different insulating characteristics of air and oil, the tapered end sections are of different lengths. This feature is not a particular element of my invention, being common to other bushings of similar character.

It is to be noted, however, that the dielectric layers 4 are relatively thin near the conductor 6, that they gradually increase in thickness toward the radial center of the side wall of the composite structure and that they gradually decrease from this center toward the ground support 8. This feature is similar to the construction of the second hereinbefore mentioned prior bushing, differing therefrom only in degree, in accordance with the modified slope of the tapered ends constituting my invention.

Curve A, drawn in an axial plane of the bushing through corresponding points on the ends of the successive conducting cylinders 2, represents the slope of the upper end of the bushing of my invention.

Curve B represents the corresponding slope of the first-mentioned prior bushing in which the dielectric layers are of uniform or equal thickness; this curve being a logarithmic curve showing that the lengths of the successive conducting layers differ in accordance with the logarithmic function involved where concentric cylinders have equal capacitances therebetween.

A curve or straight line C represents the corresponding slope of the second above-mentioned bushing in which the lengths of the conducting cylinders differ by a constant and the thickness of the dielectric cylinders vary somewhat, as in my invention.

By reference to curve B, it is seen that, if the upper ends of the conducting cylinders terminate on the curve, the differences in lengths between the cylinders are great near the conductor 6 and relatively small near the support 8, graduating between these positions in accordance with the curve. This construction results in undue concentration of electrostatic stresses between the ends of the outer conducting layers.

To overcome this objection, a bushing was designed in which the conducting cylinders terminated on the curve C, equal distances apart along the bushing. This construction, although providing the desirable graduated thickness of the dielectric layers in which the thicker cylinders are near the radial center of the bushing wall, does not tend to neutralize the external field of the bushing between the upper end of the conductor 6 and the support 8; this field being concentrated to greater and lesser degrees at its line and ground ends, respectively, and widely distributed between these ends.

By my invention, the metal layers 2, instead of varying by a constant, as in the bushing in which the ends of the cylinders follow the curve C, and instead of varying logarithmically, as in the bushing in which the ends of the cylinders follow the curve B, vary in geometric progression. That is, each successive metal cylinder is increased in length over the preceding cylinder by a certain percentage of the length of the preceding cylinder.

This construction results, as indicated, in the curve A which is a predetermined compromise between the curves B and C. It also means that the conducting cylinders near the ground end of the electrostatic system or field, adjacent to the support 8, are spaced greater distances apart than in the case of the bushing having the curve B. Being greater distances apart, these ends tend to neutralize the external field, which is not the case with the bushing following the curve C. Also, the steps between the ends of the inner conducting cylinders are not reduced by any substantial amount affecting the operation of the device because of the steepness of the curves A and B at the upper ends thereof.

It has been stated that the conducting cylinders following the curve C differ in length by constant amounts. This fact renders the cutting of the cylinders a comparatively simple operation, because, by the use of a single set gauge, all of the cylinders may be readily measured.

In the case of the cylinders following the curves A and B, each intermediate cylinder differs in length from the preceding cylinder by a distance different from the distance by which it differs from the succeeding cylinder. This fact requires a different gauge or gauge setting between each adjacent pair of cylinders.

To reduce the above-mentioned inconvenience, the modification of my invention illustrated in

Fig. 2 was provided. In this construction, a series of chords D of the curve A define the lengths of the conducting cylinders which are thereby divided into groups.

Although generally following the curve A, the intermediate cylinders of each group differ in length by a constant which is different from the constants of the other groups; the minute departure from the geometric progression thus produced being of negligible effect and resulting in added convenience of manufacture. The curve may consist of a variety of chord and normal-curve sections grouped in any desirable way.

While I have shown and described particular forms of my invention, changes may be effected therein without departing from the spirit and scope thereof, as set forth in the appended claims.

I claim as my invention:

1. A condenser bushing comprising interfitted alternate dielectric and conducting cylinders, the conducting cylinders constituting layers of condensers of substantially equal capacitance and the lengths of the conducting cylinders varying substantially in geometric progression.

2. A condenser bushing comprising interfitted alternate dielectric and conducting cylinders, the conducting cylinders constituting layers of condensers of substantially equal capacitance, the lengths of certain of the conducting cylinders varying substantially in geometric progression and the lengths of cylinders between said certain cylinders varying by substantially constant amounts.

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