

UNITED STATES PATENT OFFICE

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HIGH VOLTAGE BUSHING

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My invention relates to high-voltage bushings and it has for one of its objects to reduce the energy losses in the inner or through conductor thereof to substantially a minimum.

Another object of my invention is to prevent losses in the dielectric material of the bushing caused by heating.

Another object of my invention is to provide cooling or heat-radiating means for a bushing adjacent to one end thereof and a single means for controlling the electrostatic field of the bushing and shielding said cooling means.

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

The break-down resistance of solid insulating materials is strongly influenced by heating. Heating, caused by energy losses in the dielectric material of an insulator in an electrostatic field, results in diminishing break-down resistance of the material with increasing temperature.

In modern high-voltage bushings, heating of the dielectric must be carefully considered because the high voltages employed require thick layers of insulation in which the heat losses cannot readily be dissipated, since the conduction of the heat from the warm inner layers of a bushing towards its surface takes place through the insulating material itself. In the latter, being a poor conductor of heat, a very considerable temperature gradient may exist.

To decrease this heating and its consequence, it has been attempted, in condenser bushings, to subdivide the dielectric and to conduct a cooling agent, such as oil, through the gaps. A bushing so constructed is cumbersome and expensive.

By my invention, the dielectric losses may be diminished by suitable selection of material to such an extent that the resulting heating, even with insulating layers of the greatest thickness required by modern practice, does not become excessive. With proper selection of material for the dielectric, it is found that another factor, namely, the

amount of heat resulting from the losses in the inner conductor must be considered. Experiments have shown that this amount of heat, in the usual conductor for bushing insulators having a current density of usual magnitude, attains a multiple of the amount of heat which is developed in the dielectric.

The ohmic losses, with the usual current density in the inner conductor, attain values which appear to be permissible from the point of view of previous practice but which are too high to obtain the result secured by the present invention. The ohmic losses must be diminished to a small fraction of the previously usual figure and, therefore, according to the present invention, a current density is employed which is only a fraction, such as one-third or less, of the current density in a conductor designed for normal conditions and in the open air.

To avoid eddy-current losses in the conductor and the concentration of current, the conductor is subdivided into members of very small cross section, into single wires or even wire strands, and these are stranded together in such manner that every component frequently lies at any position of the cross section. In other words, the conductor may be made up of one or more cables twisted helically in the form of a single large cable, as when, for instance, a number of small wires are first twisted together to form a cable of, say, one-eighth inch diameter, two or more of these eighth-inch cables are twisted together to form a still larger cable and so on. In their construction, the small wires are first wound about the axis of the eighth-inch cable, then about the axis of the next larger cable and so on, depending upon the number of component cables employed, so that, in following one of the small wires longitudinally through the bushing, successive small portions of the length will be found at various positions laterally between the central longitudinal axis and the outer longitudinal surface of the conductor. The inner conductor may also be made tubular which avoids nonuniform current distribution due to current concentration.

The bushing, according to my invention, is

made in such manner that losses in the inner conductor, insofar as they cannot be avoided, are made ineffective in the heat action thereof upon the dielectric. The inner conductor, therefore, is thermally insulated from the dielectric by a layer of kieselguhr, glass fiber or other inorganic dielectric material, and provision is made for the rapid dissipation of the heat losses by means of a large heat-conducting cross-section and a high heat gradient. The inner conductor is, therefore, made of good heat-conducting material, such as copper, of relatively large cross section, and the heat gradient from the middle to the ends is increased by cooling the ends. Effective cooling is obtained by providing large surfaces at the free ends of the conductor which are energetically washed by cooling material, such as air or oil. The heat developed in the conductor, which reaches its highest value at approximately its mid part, therefore, does not flow radially through the heat-insulating layer into the adjoining dielectric but will choose the highly conductive path along the conductor to the cool ends thereof. The dissipation of heat losses originating in the dielectric is negligible.

Figure 1, of the accompanying drawing, is a view, partially in side elevation and partially in section, of a bushing embodying my invention, and

Fig. 2 is a view taken along the line II—II of Fig. 1.

The device comprises, in general, a supporting member 2, a tubular insulating body 3, a through conductor 4, a heat-resistant sleeve or barrier 5 between the conductor 4 and the body 3 and upper and lower elements 7 and 8 for respectively cooling the conductor 4 and controlling the electrostatic field of the bushing. The supporting member 2, preferably of metal, is provided with a cylindrical sleeve portion 10 that is secured to the tubular insulating body 3, as by a body of cement 12, and has a flange portion 14 for mounting the bushing in an opening in the tank cover of a circuit interrupter, a transformer or other high-voltage device.

The tubular insulating body 3, while it may be constructed entirely of insulating material, is preferably of the condenser type having radially-spaced concentric conducting cylinders 15 therein, the dielectric material being preferably of organic character, such as paper, treated with a binder, and wound in concentric layers or cylinders on a supporting cylinder or sleeve 17 that is preferably constructed of metal.

The conductor 4 is preferably of tubular form, constructed of many fine wires or strands that are twisted helically so that each strand extends through various laterally or radially-spaced positions which are of dif-

ferent temperatures and thereby effect better heat transmission along the conductor.

The conductor 4 is provided with spacing sleeves or collars 18 adjacent to its ends which snugly fit the sleeve 17 and provide a space around the greater portion of the length of the conductor 4.

The heat-resistant sleeve or barrier 5 occupies the space provided by the collars 18 around the conductor 4 and is preferably made up of high-heat-resisting material, such as kieselguhr, powdered or spun glass or other inorganic substance.

The upper element 7 comprises a plurality of radial sheet-copper fins 20 or equivalent means connected to, or associated with, the conductor 4 to provide large heat-radiating surface or other cooling means therefor. The upper element 7 further comprises a shield 22 in the form of an inverted cup having a toroidal or widely-rounded bead-like perimetral edge 25 for controlling the electrostatic field of the bushing and shielding the field against the sharp edges of the fins 20. The shield 22 may also be of copper and constitute a part of the heat-radiating means.

The lower element 8 is preferably of inverted substantially hood shape, constructed of sheet metal, such as copper, having openings 24 for the circulation of a cooling fluid, such as oil, and encloses a contact terminal 25 of a circuit interrupter or other device.

In operation, the twisted-strand structure of the conductor 4, the high-heat resistivity of the barrier 5, and the great radiation of the elements 7 and 8 are conducive to rapid dissipation of heat along the conductor and to very slow transfer of heat laterally or radially through the insulating body 3. The parts are also so constructed and proportioned that the conductor 4, when carrying its rated current, has a specific current loading of less than one-third of the current loading of a conductor in open air which is dimensioned for normal conditions.

The invention may be employed in all kinds of insulators or bushings in which an inner conductor is surrounded by a dielectric whether the latter is constructed on the condenser principle or not, or is composed of porcelain, bakelite, hard rubber or other material.

While I have shown and described a particular form 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 high-voltage bushing comprising a tubular body of insulating material, a conductor therein, cooling means connected to said conductor adjacent to one end thereof and a single means for controlling the elec-

trostatic field of the bushing and shielding said cooling means from said field.

2. A high-voltage bushing comprising a tubular insulating body, a ground support
5 therefor adjacent to an intermediate portion thereof, a conductor extending longitudinally through the body and a structure adjacent to one end of said body including a multiplicity of spaced heat-radiating fins and an an-
10 nular field-control element surrounding the bushing between the fins and the bushing.

2. A high-voltage bushing comprising a tubular body of organic dielectric material, a metal tube therein, a conductor in said met-
15 al tube and a tubular body of solid inorganic heat insulating material between the conductor and said metal tube.

In testimony whereof, I have hereunto sub-
scribed my name this 17th day of April,
20 1929, at Berlin-Siemensstadt, Germany.

WALTHER ESTORFF.

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