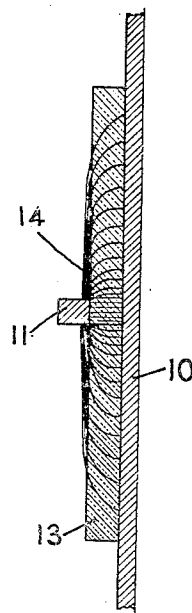
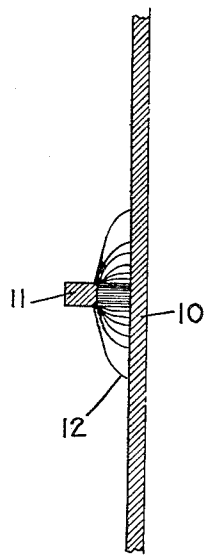
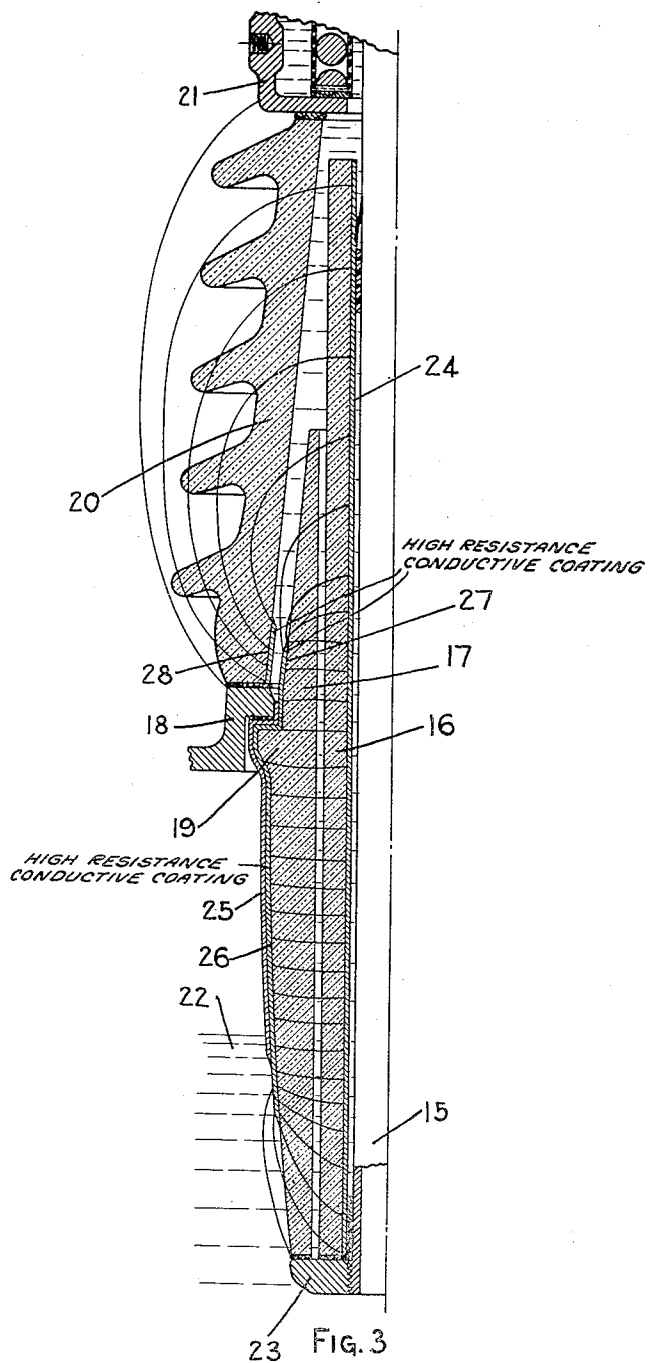


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BUSHING INSULATOR
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BUSHING INSULATOR

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2 Claims. (Cl. 174—31)

This invention relates to electric insulator bushings and has for one of its objects the provision of a bushing in which the electrostatic stress and consequently the voltage gradient is more effectively distributed than has heretofore been possible.

A further object of the invention is to provide a bushing insulator that will withstand higher voltages for a given size than similar insulators heretofore manufactured.

A further object of the invention is to raise the corona voltage and radio disturbance voltage of bushing insulators.

A further object of the invention is to provide a device of the class named which shall be of improved construction and operation.

Other objects and advantages will appear from the following description.

The invention is exemplified by the combination and arrangement of parts shown in the accompanying drawing and described in the following specification, and it is more particularly pointed out in the appended claims.

In the drawing:

Figs. 1 and 2 are diagrams illustrating typical electrostatic fields about an insulator bushing.

Fig. 3 is a somewhat diagrammatic fragmentary sectional view of a bushing insulator having the present invention applied thereto.

One of the most difficult problems in the design of insulators is to secure an effective distribution of the voltage gradient between the electrodes. In most insulator designs a much greater amount of dielectric material is employed than would be necessary if it were possible to secure a uniform voltage gradient between electrodes, due to concentration of the electrostatic field at one or more points. This problem is particularly difficult in the design of bushing insulators because of the peculiar shape and relation of the electrodes involved.

Fig. 1 illustrates the problem involved in a bushing insulator in which figure the numeral 10 designates the conductor, and the numeral 11 designates the ring forming the opening through which the conductor extends. It will be seen from this figure that the electrode 10 is a long, narrow one while the electrode 11 is substantially uni-planar. The lines 12 in the diagram diagrammatically represent the electrostatic flux between the electrodes 10 and 11. It will be seen that the lines of force are widely distributed along the electrode 10, but are concentrated in the plane of the electrode 11 so that where a conductor passes through a ring shaped opening

as is the case in a bushing insulator, and where there is a uniform dielectric about the electrodes, there is a great concentration of electrostatic flux between the two electrodes in the plane of the ring so that the dielectric immediately surrounding the conductor in this plane is subjected to a much higher stress than is the dielectric in other portions of the field and, when the voltage between the two electrodes is sufficiently high, breakdown will take place along the lines of greatest concentration of stress; that is, between the ring and the conductor in the plane of the ring. In order to counteract this tendency to some extent, it has heretofore been the practice to insert a tubular baffle between the conductor 10 and the ring or bushing flange 11, as indicated at 13 in Fig. 2. This baffle is made of some material such as porcelain which has a higher dielectric strength than air and the expedient increases the breakdown value of a bushing for a given spacing between the electrodes. Available dielectrics for this purpose, however, all have a higher specific inductive capacity or dielectric constant than does air so that the insertion of a dielectric baffle between the conductor and the flange transfers a large portion of the dielectric stress from the interposed baffle to the surrounding air and produces a concentration of stress along the outer surface of the baffle extending from the flange as indicated at 14 in Fig. 2. This gives rise to corona streamers and, where sufficient voltage is applied, to flash-over discharges emanating from the flange and extending along the outer surface of the dielectric baffle.

In Fig. 3 there is shown a bushing insulator having a central conductor 15 surrounded by dielectric baffles 16 and 17. The usual flange 18 engages a shoulder 19 on the outer baffle 17. The usual dielectric cone 20 engages the upper face of the flange 18 and supports the upper terminal 21 of the bushing, which in this case is in the form of an expansion chamber for the oil within the bushing. It is usual to fill bushings of this kind with a dielectric liquid such as transil oil to suppress internal discharges. The lower end of the bushing is shown as submerged in insulating liquid indicated at 22. In bushings of this kind there has heretofore been a tendency for streamers to start along the outer surface of the cone 20 from the upper edge of the flange 18 and also down along the outer surface of the baffle 17 toward the lower bushing terminal 23. These streamers result from the concentration of electrostatic lines of force in the air, the con-

centration being due to the fact that the air has a lower dielectric constant than the porcelain baffles and the oil within the bushing.

In order to avoid high concentration of electrostatic stress within the oil zone immediately surrounding the conductor, it has been found advantageous to coat the inner surface of the inner baffle 16 with a conducting coating 24 which may or may not be electrically connected to the conductor. This prevents overstress of the oil immediately adjacent the conductor. To prevent discharge streamers on the outer surface of the baffle 17 within the apparatus housing upon which the bushing is mounted, it has heretofore been the practice to employ a conducting sleeve known as a ground sleeve, extending downwardly from the flange 18 to below the surface level of the oil in the apparatus housing. Such a sleeve is shown at 25 in Fig. 3 of the drawing and may be a metallized coating over the surface of the baffle 17. One method of applying such a coating is described in the patent to Ray Higgins, No. 2,119,989 dated June 7, 1938 and assigned to The Ohio Brass Company. As explained in that patent, the metal may be sprayed over a prepared surface indicated at 26 and disposed between the dielectric member and the outer coating 25. The coatings 25 and 26 as shown in the drawing, are relatively much thicker than they are in actual construction, it being impossible to show these coatings in their true proportions in a drawing of the scale used.

The ground sleeve as heretofore used, however, does not overcome the concentration of electrostatic stress illustrated in Fig. 2, but merely carries the point of greatest stress downwardly from the lower edge of the flange 18 to a point below the insulating oil. Since the oil has a higher dielectric constant than air, the stress at the lower end of the coating 25 will not be as great as it would be at the lower edge of the flange if there were no ground sleeve and if the flange is not covered by oil. Furthermore, the oil has a higher dielectric strength than has air, and consequently, the use of a ground sleeve which projects below the oil counteracts to some extent the tendency to discharge from the flange within the apparatus housing. It does not, however, entirely remove the tendency to discharge at the lower end of the sleeve, and if the voltage is high there may be formation of corona at the lower edge of the sleeve even when the end of the sleeve is covered with oil. Moreover, the ground sleeve does not affect the high stress in the air at the upper edge of the flange so that in bushings as heretofore constructed there has been a considerable overstress and tendency to form corona discharge from the upper edge of the flange.

I have found that a much more uniformly distributed field, and consequently a much more uniform distribution of voltage gradient can be obtained by the use of a high resistance conducting coating disposed on properly selected portions of the dielectric members of the insulator. Any suitable high resistance coating which will permanently adhere to the ceramic surface may be employed. The resistance of this coating may vary between rather wide limits. One method of measuring the resistance is by contacting spaced points on the surface by the electrodes of a megger. Measuring the resistance of the surface in this way with contact wires $\frac{1}{8}$ " in diameter and having hemispherical contact ends and with the wires spaced $\frac{1}{2}$ " apart, I have found that surfaces having a resistance between

points $\frac{1}{2}$ " apart of approximately 5,000 megohms, give very satisfactory results. However, beneficial results can be obtained with surfaces in which the resistance may range from 100 to 50,000 megohms when so measured. The resistance of the coating should be sufficient to reduce the voltage at the edge of the coating to a value at which discharge will not take place. The voltage at which discharge will take place, and consequently the amount of resistance necessary to prevent discharge will depend somewhat upon the nature of the dielectric covering the edge of the coating. A greater reduction in voltage is necessary where the edge of the coating is exposed to the atmosphere than is required where the edge of the coating is covered with oil since oil has a greater puncture strength and a higher dielectric constant than air. If the edge of the coating is covered with wax or other material having a high puncture strength and a high dielectric constant, the resistance of the coating can be less than where the edge is exposed in the atmosphere, and consequently the resistance of the coating need not be so great where the terminal edge is thus covered.

One suitable high resistance coating for controlling the stress distribution in bushing insulators is the base coating described in Patent No. 2,119,989 mentioned above. The coating shown at 26 in Fig. 3 of the drawing may be such a coating, and where a coating of this nature is used, the metal forming the ground sleeve coating 25 may be sprayed on directly over the outer surface of the base coating 26. The ground sleeve coating terminates slightly below the surface level of the oil in the apparatus housing, but the high resistance conducting coating extends beyond the termination of the ground sleeve coating for some distance. The distance that the base coating extends beyond the ground sleeve coating may be from $\frac{1}{2}$ to 3 or more inches, depending upon the voltage to which the insulator is subjected and the resistance of the coating. Due to the fact that this base coating is slightly conducting, the charging current will follow the coated surface so that it will not break down the surrounding dielectric, and thus it will suppress any tendency for corona to form at the lower edge of the ground sleeve. Since the coating has a high resistance there, of course, will be a voltage gradient due to the flow of the charging current in this coating so that the voltage will gradually decrease from the lower edge of the ground sleeve coating to the lower edge of the base coating, thus preventing a concentration of voltage at the lower edge of the ground sleeve and producing a distribution of the electrostatic flux along the high resistance conducting coating, as indicated in Fig. 3.

Concentration of electrostatic stress at the outer upper edge of the flange 18 may also be avoided by continuing the high resistance conducting coating along the outer surface of the baffle 17 to a point above the flange 18 as indicated at 27 in Fig. 3, and by coating the lower portion of the inner surface of the cone 20 as indicated at 28 in Fig. 3. The high resistance conducting coatings 27 and 28 produce a voltage gradient along the surface on which they are deposited and thus produce a distribution of electrostatic stress in the surrounding dielectric as indicated in Fig. 3 of the drawing. It will be seen that a large proportion of the electrostatic lines of force instead of emanating from the outer upper edge of the flange 18 and passing through the surrounding air, as shown in Fig. 2, will

emanate from the coatings 27 and 28 and extend through the baffles so that they form an electrostatic screen diverting the flux from the outer corner of the flange 18 where it would produce a high stress in the surrounding air and consequent formation of corona. The coatings 27 and 28 not only form electrostatic screens for diverting the lines of force from the danger points, but also produce voltage gradients which give a distribution of the electrostatic field over a considerable area, thus avoiding concentration of the stress at any one point. Of course, a high resistance coating could be deposited on the outer surface of the cone 20 extending upwardly from the flange 18, and such a coating would produce a voltage gradient tending to reduce the stress at the flange. There are certain advantages gained, however, by locating the resistance coating within the dielectric member. One of these advantages is that the extremity of the coating is covered by the oil in the bushing, and another is that the lines of force emanating from the coating must pass through the porcelain shell before reaching the air, thus suppressing formation of corona along these lines.

It has been found in practice that where the electrostatic field about a bushing insulator is distributed by high resistance conducting surfaces as described, a bushing of a given size will withstand several times the voltage without producing discharges that a similar bushing without such controls can withstand.

I claim:

1. The combination with a conductor, an apparatus housing having an opening in the wall thereof through which said conductor extends and insulating liquid within said housing, of a tubular insulator separating said conductor from said housing, a ground sleeve surrounding said conductor but insulated therefrom and electrical-

ly connected with the wall of said housing and extending beneath the surface of said liquid, and means forming a high resistance conducting surface extending beneath said liquid from the termination of said ground sleeve for a distance beyond the termination of said ground sleeve for distributing the electrostatic flux emanating from said ground sleeve and preventing flashover of said bushing.

2. The combination with a housing for electrical apparatus having an opening in the wall thereof, of a conductor extending through said opening, insulating liquid within said housing, a dielectric baffle interposed between said conductor and the wall of said housing surrounding said opening, said baffle having a ground sleeve of conducting material electrically connected with the wall of said housing and extending to a point beneath the surface level of the liquid in said housing, means forming a high resistance conducting surface extending beyond the termination of said ground sleeve and terminating beneath the oil in said housing for distributing the electrostatic flux and preventing concentration of stress at the termination of said ground sleeve, a tubular dielectric shell disposed outside of said housing and separating said conductor from the wall of said housing, insulating liquid surrounding said conductor within said shell and means forming a high resistance conducting surface extending beyond the wall of said housing in the opposite direction from said ground sleeve for diverting the electrostatic flux from the air outside of said shell and for preventing overstress adjacent the wall of said housing surrounding said conductor, said conducting surface terminating within the portion of said shell filled with insulating liquid.

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