Electrical Discharge Phenomena in Insulation Under High Continuous Potentials

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Two years ago the authors reported before this group on their method of detecting the presence of electrical discharge phenomena in the insulation of electric wires and in the space between the outer surface of the wire insulation and a flat metal test plate upon which the test specimen rested. About a year ago the authors found that when high continuous potentials were applied to the conductor of an insulated wire and a metal plate touching the insulation, electrical discharge phenomena could be detected by means of suitably arranged filters and amplifiers. As this is believed to be a hitherto unobserved phenomenon in a dielectric it should be brought to the attention of those working in the fields of theoretical and applied electricity.

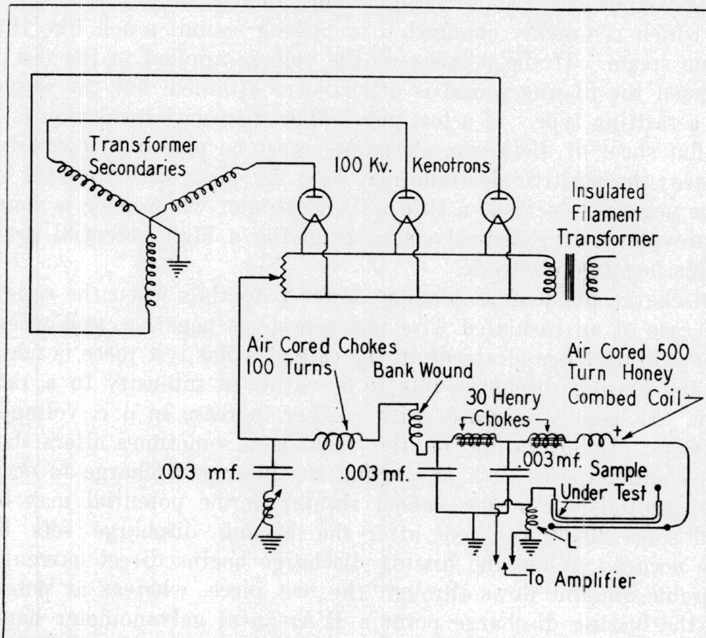

Fig. 1.—Rectifier filter for high voltage D. C. supply.

The high voltage d. c. supply is obtained from a three-phase kenotron tube rectifier and filter shown in Fig. 1. Three phase rectified output pulsates 13 per cent, and this must be smoothed out with an adequate filter. In addition to this, steep wave front discharges occur inside the glass envelopes of kenotron tubes at high potentials, and the filter must be so designed as to suppress these also. A filter design that has proved effective for the authors is indicated in the figure. It is essential that the rectified d. c. potential at the output end where the test piece is connected be entirely free from any steep wave front disturbance and from any harmonic pulsation. The input connections to a high gain resistance coupled amplifier are placed across the inductance L in the figure. Hence any fluctuating current flowing through L will excite the amplifier. The amplifier must have a response that is constant for frequencies up to at least 20 kilocycles, and it must have a voltage gain of at least 75 decibels. A high grade telephone receiver and a good output rectifier type voltmeter should be provided to listen to and to obtain quantitative readings of the discharge intensity.

The test piece of dielectric such as a sample of insulated wire is placed upon the metal test plate and the latter connected to the positive terminal of the d. c. voltage supply, and the conductor of the test piece is negative when connected to ground through the inductance L. When the voltage is raised to a certain value there is noted occasional popping sounds in the telephone receiver. As the voltage is further raised the popping sounds occur more rapidly, and finally merge into a steady rattle which is quickly changed to a hissing sound, much like that of escaping steam. If the polarity of the voltage applied to the test piece is reversed the hissing sound is often never attained, but the sound remains a rattling type. If a test piece other than wire insulation is used, say a flat sheet of dielectric, electrodes must be placed in contact with each face; the positive electrode may be a flat plate with rounded edges, and the negative electrode a thin walled cylinder whose edge is rounded. This provides a ring shaped electrode giving a high potential gradient near this negative electrode.

Discharge phenomena occur at lower potentials when the conductor in the case of an insulated wire test sample is negative, and when the ring or cylinder edge electrode in the case of a flat test piece is negative. After the hissing discharge sets in it varies in intensity in a random fashion. It usually increases with further increase in d. c. voltage, but not always. Deterioration of the insulation sometimes alters the discharge characteristics such as causing the hissing discharge to occur at lower potentials. For new rubber insulation the potential may be increased some 20–30 per cent after the hissing discharge sets before failure occurs. When the hissing discharge begins direct current of a measurable amount flows through the test piece, whereas at potentials below the hissing discharge point a D'Arsonval galvanometer having a sensitivity of 10^{-9} amps. per m. m. at 1 meter showed no deflection. These observations indicate that when insulation is stressed beyond a critical value frequent pulses of unidirectional current pass through the solid body of the insulation, and that the direct current is not a steady stream of drifting electrons. Ionization of the solid dielectric has probably played an important part. The foregoing may be an aid in the study of the mechanism of break down of solid insulation.