INVESTIGATION OF CABLE INSULATION BY IONIZATION CHARACTERISTICS

METHODS OF DETECTION AND MEASUREMENT OF IONIZATION IN DIELECTRICS *

BY

J. TYKOCINSKI TYKOCINER

University of Illinois, Urbana, Illinois

SUMMARY

The results of the investigation on methods of detection and measurement of ionization in dielectrics may be summarized as follows:

(1) The assumption of the existence of surges and oscillations due to ionization in dielectrics has been experimentally verified.

(2) These oscillations were studied and utilized in the development of apparatus for detecting and measuring the relative intensity of ionization.

(3) Characteristic curves were obtained which correlate the applied voltage and the effective values of oscillations due to ionization. These curves make possible the study of the effect of applied voltage on certain properties of dielectrics and especially of cables.

(4) The existence of a time effect in connection with the intensity of oscillations due to ionization and the applied voltage has been ascertained.

(5) It was found that the time effect is characteristic of the quality of a cable in regard to impregnation and to a property which tends to shift the voltage at which copious ionization sets in.

(6) Ionization in a cable can be detected by radio-engineering methods, utilizing the electric impulses which ionization produces.

(7) A large range of frequencies was used in designing the apparatus. Frequency ranges as high as 30,000 kc. and as low as 100 kc. were tried and all gave similar results. Also audio-frequencies of about 2 to 5 kc. have been utilized in a great number of investigations on cables.

(8) The radio-frequency oscillations produced by ionization were utilized in three different ways. The first method was to amplify the magnitude of modulated radio-frequency currents and measure their effective values with thermoelectric and thermionic instruments. The second method was to apply intermediate detector action, and to measure amplified group frequency. The third method was to suppress the radio frequencies by rectification, and to select definite group frequencies for measurement.

(9) The utilization of lower group frequencies necessitated the use of special bridge arrangements for balancing the charging current. On the other hand the application of higher frequencies required special provision for guarding against interference from outside electromagnetic fields.

(10) The curves obtained with both types of apparatus are similar in character. They give the relation between the voltage applied to the cable and the intensity of the sum of the oscillations produced in a cable when ionization takes place.

(11) Both types of surge-measuring apparatus indicate the existence of bubbles and airpockets in a cable, if provision is made to prevent discharges taking place in transformers, condensers, and other parts of the circuits connected with the cable. They may thus be used as impregnation-testing apparatus.

* Published in full in University of Illinois Engineering Experiment Station Bull. 259, 1933.

(12) An application was made of the radio-frequency method to the testing of samples of paper moving between rotating nickel electrodes in air. Characteristic curves were obtained showing that the voltage at which corona discharge sets in, and the relative effective values of oscillations produced, are indicative of the character of the surface and texture of the paper.

(13) Methods have been devised for locating sources of ionization in cables. The underlying principles were verified by a number of experiments. Their applicability for testing of cables, however, was found to be limited to special cases.

Conclusions.- The following conclusions may be drawn from these results:

(1) In the oscillations associated with ionization in the form of discharges in dielectrics, especially in cables subjected to high alternating potentials, a clue has been discovered which makes possible the detection of early stages of deterioration.

(2) The various methods developed for measuring these oscillations have laid the foundation for the study of composite dielectrics from a new point of view, namely, that of correlating the processes which take place in dielectrics with the frequencies, amplitudes, and wave form of these oscillations.

(3) With the embodiment of these methods into apparatus new tools have been added to the equipment of research and testing laboratories. These apparatus may serve to control the processes of manufacturing condensers and cables, to safeguard their operation, and to assist in systematic work towards improvements.