cause paper condensers are rarely used at high frequencies. The use of wax or mineral oil for impregnation adds little to the polarization. Some of the recent synthetic oils, particularly those containing chlorine, have dipole polarizations with relaxation frequencies around 1 Mc.

The exact shapes of the curves of Figure 2 are shown in Figure 3, where frequency, loss factor, and dissipation factor are plotted logarithmically and dielectric constant arithmetically. At the relaxation frequency f_m, where loss factor is a maximum, dielectric constant is changing at the greatest rate and has a value just half way between its low and high frequency values. The shoulders of the loss factor and dissipation factor curves at a considerable distance from the relaxation frequency are linear. Similarly, a plot of the fractional increase in dielectric constant, expressed in terms of the total increase, at frequencies considerably higher than the relaxation frequency is also linear. The slopes of the shoulders of both of these lines are equal.[3]

Representative values for the four different kinds of TYPE 380 Decade-Condenser Units are shown by the lines of Figure 4, which start down from the left. In the case of dissipation factor this would imply very low values at high frequencies. Actually for mica and other low loss dielectrics, such as quartz and polystyrene, there appears to be an underlying polarization which provides an almost constant dissipation factor. The dipole polarization in paper causes a minimum in dissipation factor beyond which, at higher frequencies, the dissipation factor rises.

[3]The slopes are related to the depression angle of the center of the circular arc obtained by plotting loss factor against dielectric constant.[4,5,6] The theories of both Debye and Maxwell demand that such a plot result in a semicircle with its center on the dielectric constant axis. The fact that data obtained from all solid and most liquid dielectrics is well represented by a circular arc with depressed center was pointed out by K. S. and R. H. Cole[4,5,6] in 1941.

[4]K. S. and R. H. Cole, Dispersion and Absorption in Dielectrics, *Journal of Chemical Physics*, Vol. 9, Apr. 1941, pp. 341–351.

[5]R. F. Field, The Basis for the Non-destructive Testing of Insulation, *AIEE Transactions*, Vol. 60, Sept. 1941, pp. 890–895.

[6]W. Kauzmann, Dielectric Relaxation as a Chemical Rate Process, *Reviews of Modern Physics*, Vol. 14, Jan. 1942, pp. 12–44.

RESIDUAL IMPEDANCE

At high frequencies the small inductance and resistance of the leads of a solid dielectric condenser produce an increase in its apparent capacitance and dissipation factor.[7,8,9] The fractional increase in capacitance of the circuit shown in Figure 5, which represents this case, is

$$\frac{\Delta C}{C} = \frac{\omega^2 LC}{1 - \omega^2 LC} = \omega^2 LC \text{ approx.} \quad (1)$$

[7]R. F. Field and D. B. Sinclair, A Method for Determining the Residual Inductance and Resistance of a Variable Air Condenser at Radio Frequencies, *Proceedings of the Institute of Radio Engineers*, Vol. 24, Feb. 1936, pp. 255–274.

[8]D. B. Sinclair, Parallel-Resonance Methods for Precise Measurements of High Impedances at Radio Frequencies and a Comparison with Ordinary Series-Resonance Methods, *Proceedings of the Institute of Radio Engineers*, Vol. 26, Dec. 1938, pp. 1466–1497.

[9]D. B. Sinclair, The Behavior of TYPE 505 Condensers at High Frequencies, *General Radio Experimenter*, Vol. 12, Apr. 1938, pp. 4–8.

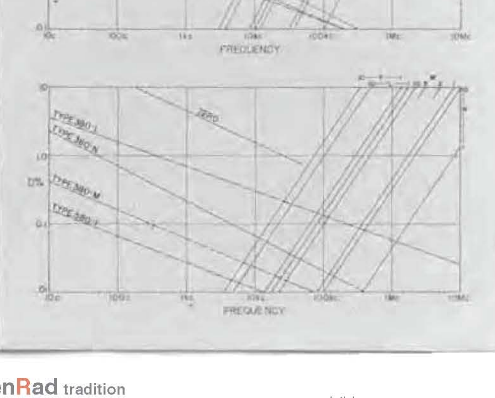

FIGURE 4. Components of fractional capacitance and dissipation factor as a function of frequency. The lines slanting down from the left come from interfacial polarization, those slanting up to the right come from residual inductance and resistance.