On I.T.C. Measurements (*) (**).

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Summary. - Expression are given for the ultimate polarization of a
sample in a uniform electric field which is cooled to 0 °K either uniformly
or hyperbolically.

1. – Introduction.

The thermally stimulated current technique has been used successfully in
the study of electrets (1, 2). Its importance in the field of ionic crystals was
shown by BUCCI, FIESCHI and GUIDI (3) and since then it has provided an
alternative to the dielectric relaxation technique for the study of dispersed
defects such as impurities and associated vacancies and even off-centre ions (4).
The technique may be described as follows. Firstly the sample is polarized
at a high temperature. Secondly, while keeping the field on, the temperature is
decreased to a low value and the field is then switched off. Finally, the sample
is heated under short or open circuit conditions. In the first case, current,
and in the latter case, voltage (*) may be measured to give information about

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(1) B. Gross: Charge Storage in Solid Dielectrics (Amsterdam).
(2) J. Van Turnhout: Thermally stimulated discharge of polymer electrets, TNO-Comun. 471-Delft.
the depolarizing centres. The theory dealing with the heating cycle is well known \(^{(3,5)}\). In the present article we are concerned with the final polarization achieved at the end of the cooling stage and the influence which the cooling process might have on this value. In order to calculate this, it is necessary to define the function relating temperature and time. We have chosen to discuss uniform and hyperbolic cooling rates. It is supposed that the cooling rate is uniform throughout the sample.

2. – General theory.

The equation describing the polarization process for a single class of dipoles is the Debye differential equation

\[
\frac{dP}{dt} = \frac{1}{\tau} (P_s - P),
\]

where \(P\) is the actual polarization, \(P_s\) the equilibrium polarization and \(\tau\) is the relaxation time given by

\[
\tau = \tau_0 \exp \left( \frac{U}{kT} \right)
\]

at temperature \(T\), \(k\) being Boltzmann’s constant. In most cases \(\tau_0\) is of the order of \(10^{-13}\) s and \(U\), the activation energy, a fraction of an eV. For \(U = 0.5\) eV and \(T = 300\) °K, \(X = U/kT \approx 20\). In terms of the applied field \(E\) (and far away from saturation effects), \(P_s\) is given by \(^{(6)}\)

\[
P_s = \alpha N \mu^2 E/kT
\]

and is a function of time through \(T(t)\) if the crystal is polarized while the temperature is lowered. Here \(N\) is the number of dipoles per cm\(^3\), \(\mu\) their dipole moment and \(\alpha\) a constant. The integral of eq. (1) is

\[
P \exp \left[ \int \frac{dt}{\tau} \right] = \int \frac{P_s}{\tau} \exp \left[ \int \frac{dt}{\tau} \right] dt + C.
\]

We now use this equation to discuss two different cooling rates.

3. – Constant rate.

3’1. High-temperature case. – Suppose that

\[
T = T_i - bt, \quad t > 0,
\]