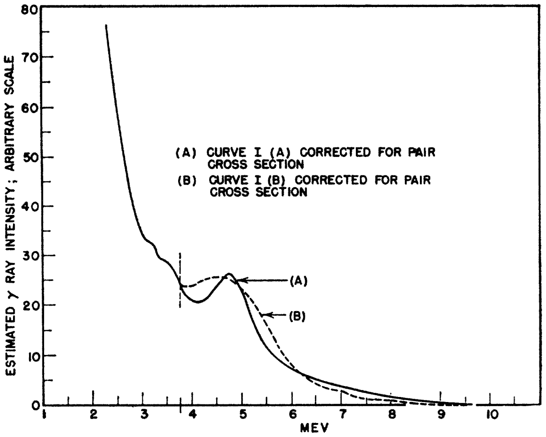

FIG. 2. (a) Curve 1(a) corrected for pair cross section. (b) Curve 1(b) corrected for pair cross section.

Compensation for pair-production cross section of the curves of Fig. 1(a) and 1(b) gives the curves of Figs. 2(a) and 2(b), respectively, plotted to an arbitrary scale.

It is observed that the high energy tail of the gamma-ray distribution extends to 8.7 Mev (±0.6 Mev). Some significance should ge given to this value of $E_{\max}$ since in the run 8 pairs were observed with energies above 7.0 Mev while in $\frac{1}{4}$ as many background pictures which include the effects of the high energy neutrons in the beam no high energy gamma-rays were found.

* This document is based on work performed under Contract No. W-7405, eng. 26, for the Atomic Energy Project at Oak Ridge National Laboratory.

** Data of this run were reported in paper Z-6 at the Washington meeting of the American Physical Society, April 29, 1948. C. D. Moak and J. W. T. Dabbs, Phys. Rev. 74, 1249 (1948).

New Ferroelectric Crystals

B. T. MATTHIAS
Bell Telephone Laboratories, Murray Hill, New Jersey

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THREE different groups of crystals are known which show an anomalous dielectric behavior somewhat analogous in their phenomenological aspects to ferromagnetism. The crystal groups are: Rochelle salts; KH_2PO_4 and the corresponding isomorphous crystals; and barium titanate and its solid solutions with the strontium and lead salts.

The mechanism responsible for the high dielectric constant in the first two groups is generally considered to be associated with hydrogen bonds, whereas in $BaTiO_3$ the high polarizability of the TiO_6 octahedras combined with the polarizability of BaO is thought to be responsible for the occurrence of a spontaneous polarization.[1] The latter assumption is reasonable in view of the high dielectric constants of rutile and BaO.

As expressed previously[2] the occurrence of ferroelectricity in Rochelle salt and $BaTiO_3$ seems to be of an accidental nature, insofar as none of their isomorphous crystals are ferroelectric. In the case of $BaTiO_3$ it was thought probable that crystals would be ferroelectric, regardless of valency, if the metal-oxygen octahedra were of identical size and of similar electronic configuration to the $Ti\text{-}O_6$ octahedra in $BaTiO_3$. From this point of view the metals columbium and tantalum appeared to be of interest. Both the Cb^{+5} and Ta^{+5} ions have a noble gas configuration similar to Ti^{+4} and have the same octahedral radii. In the fourth row of the periodic table Ga^{+3} might be considered, though it is slightly smaller and its electronic core, although having closed shells, has not a noble gas configuration. The compounds of the foregoing metals which have a perovskite structure are $KCbO_3$, $NaCbO_3$, $KTaO_3$, $NaTaO_3$ and $LaGaO_3$.

Verification of the ferroelectric behavior of the alkali columbates and tantalates has recently been reported.[3] These crystals are piezoelectric, show a dielectric hysteresis loop and go through one or more polymorphic transitions below their Curie points. Their c/a ratios, as determined from powder pictures (under the assumption of a tetragonal symmetry) at room temperature, are between 0.98 and 0.99 for the columbates. For the tantalates they are even closer to 1, but remain *below* this value.

$NaCbO_3$, $KCbO_3$, $NaTaO_3$, and $KTaO_3$ have been obtained in clear crystals of 1 to 2-mm cube edge. The Curie points can be observed either by dielectric measurements or by optical observation, since at this point the crystals go from an anisotropic state to an isotropic one. The peak of the dielectric constant at the Curie point can be well observed as long as this temperature is not too high (Fig. 1). At higher temperatures, however, the dielectric tests become sowmheat more difficult due to the increase in conductivity. While the Curie point of $NaTaO_3$ around 475°C is the highest so far observed, that of $KTaO_3$ is even lower than reported previously[3] and comes close to room temperature.

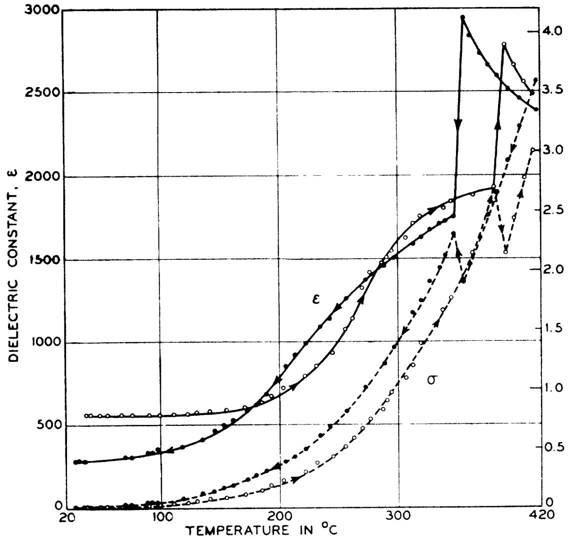

FIG. 1. Dielectric constant and loss of a $NaCbO_3$ crystal.

It is expected that crystals of $LaGaO_3$ and $LaFeO_3$ may exhibit similar polymorphic transitions. Though the powder picture hardly indicates deviations from the cubic system for $LaFeO_3$, the crystals appear optically anisotropic. With increase of temperature their birefringence gradually decreases until, near 200°C, they are quite isotropic. For $LaGaO_3$, x-rays show a (tetragonal, $c/a>1$) deviation from the cubic system. The crystals undergo a marked optical transition between 90° and 100°C. Below this temperature they show parallel and 45° extinction, but above the transition they show only 45° extinction.

The dielectric constant of $LaGaO_3$ shows a discontinuity at its transition temperature. $LaFeO_3$ could not be tested dielectrically because of its high conductivity.

The x-ray investigation of these compounds and the optical investigation were carried out by Elizabeth A. Wood. The writer wishes to express his appreciation for her assistance.

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[1] G. H. Jonker and J. H. van Santen, Chemisch Weekblad 43, 672 (1947).

[2] Phase Transition meeting of the NRC, Cornell (1948).

[3] Bull. Am. Phys. Soc. 24, No. 4, April 28-30, 1949, abstract L6.