al. with KCl + KH, this band is assumed to be due to hydrogen; and the ultraviolet absorption band which remains after warming the crystal to room temperature is assumed to be the oxide

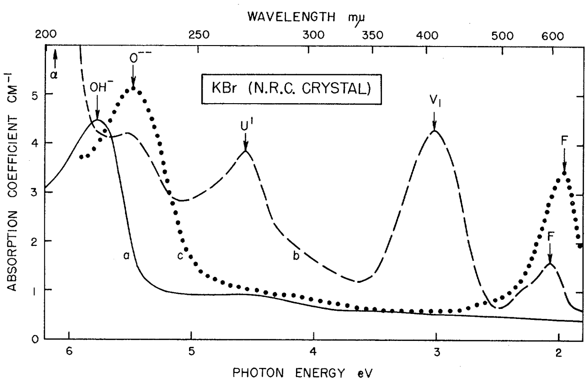

FIG. 2. Absorption spectra of KBr crystal, irradiated at 78° K: (a) untreated crystal, measured at 78° K, (b) crystal irradiated for 88 minutes with *AH*-4 lamp at 78° K, measured at 78° K, (c) after warming to 300° K.

absorption band, by analogy with the results obtained after irradiation of KCl + KOH at liquid nitrogen temperature. The V_1 band also appears very strongly on low temperature irradiation. The reasons for its appearance are not at present clear.

The author wishes to thank Mr. R. Boulet for growing the crystals and Dr. J. H. Simpson for much helpful discussion.

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MAGNETIC FIELD EFFECTS ON BOW SHOCK STAND-OFF DISTANCE

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Combined theoretical and experimental investigations have been carried out by the authors to find the effects of applying magnetic fields to the ionized flow about a blunt body of revolution. Reported here is the effect of the magnetic field on the shock wave stand-off distance.

The effect of a magnetic field on a bow shock wave of an unyawed body of revolution was studied theoretically by the following model[1]:

(a) The fluid in the free stream has negligible electrical conductivity and has uniform velocity (U) parallel to the axis of symmetry.

(b) The shock wave is treated as a mathematical discontinuity.

(c) In the shock layer, the Mach number is low enough so that the density (ρ) and enthalpy are approximately constant. The viscosity and thermal conductivity are neglected, but the electrical conductivity due to the ionization is not neglected. Consistent with the prior assumptions of constant density and enthalpy in the shock layer, the assumption is made that the electrical conductivity is constant.

For this model, the flow in the shock layer is governed by the following equations:

$$\nabla\cdot\vec{q} = 0,$$

$$\nabla\times[(\nabla\times\vec{q})\times\vec{q}] = (\sigma/\rho)\nabla\times[(\vec{q}\times\vec{B})\times\vec{B}],$$

$$\nabla\cdot\vec{B} = 0,$$

$$\nabla\times\vec{B} = \sigma\mu(\vec{q}\times\vec{B}),$$

where $\vec{q}$ = velocity vector, $\vec{B}$ = magnetic field vector, σ = electrical conductivity, and μ = magnetic permeability. To simplify the mathematical analysis, the shape of the shock and the magnetic field upstream from the shock are taken to be known and the shape of the body and the magnetic field at the body are found.

For a spherical shock of radius c and the magnetic field in the free stream that due to a dipole located at the origin of the sphere,

$$\vec{B} = 2\alpha c^3 \cos\theta\,\vec{e}_\gamma/r^3 + \alpha c^3 \sin\theta\,\vec{e}_\theta/r^3 \text{ for } r > c,$$

the nonlinear differential equations were solved on the Remington Rand 1103A digital computer with $\epsilon = 0.0909$ (for air), $Re_M = 0.2$ and 1.0, and Q varying from 0 to 4. ($\epsilon = \rho_\infty/\rho$; $Q = (\sigma\alpha^2 c)/\rho_\infty U$; and $Re_M = \sigma\mu c U$). For this range of Q, a body that is consistent with the analysis is a sphere concentric with the shock. The theoretical stand-off distance, $\Delta \equiv (c - r_b)/r_b$, increases with increasing Q but is relatively unaffected by Re_M for the range of Re_M considered.

The experimental investigation of the effects of an applied magnetic field on the bow shock stand-off distance was performed in a 3 in. diameter electromagnetic shock tube of the tapered tube type.[2] The shock wave was driven by the discharge, through a spark gap, of six 1-μf capacitors at 20 kv. The model was a 2.0-cm diameter cylinder with a faired nose with a radius of 1.2 cm. Magnetic field strengths of up to 35 kilogauss were produced by a pulsed 6.3-mm i.d. coil contained in the nose with its axis parallel to the model axis. The magnet current was supplied by two 100-μf capacitors charged to voltages up to 1500 v. A pickup coil was used to trigger and synchronize the discharge through an ignitron circuit. The stand-off distance was scaled from image converter camera photographs of the bow shock taken with an exposure time of 110 millimicroseconds.

The shock tube tests were made in air at an initial pressure of 70 microns with a primary shock Mach number of 22. About 15 μsec. of steady flow were obtained, providing during this time free-stream conditions of $U = 6\,890$ m/sec, $M = 4.5$, $\rho/\rho_0 = 1.22 \times 10^{-3}$, and $T = 6\,450$°K, as determined from the thermodynamic properties of air.[3] The resulting conditions in the shock layer were $\rho/\rho_0 = 1.93 \times 10^{-2}$, $T = 17\,000$°K, and $\sigma = 130$ mho/cm.

The stand-off distance was measured for various strengths of the applied magnetic field and was found to increase with increasing field strength as shown typically in Fig. 1. To facilitate comparison with experimental data, the theoretical parameter Q was converted to $Q^* \equiv \sigma B_0^2 r_b/p_\infty U$ in which B_0 is the field strength at the stagnation point on the body and r_b is the nose radius. The theoretical curve and the experimental data are shown in Fig. 2 and are seen to correlate quite well for the range of Q^* investigated.

Work is now in progress which will extend the experimental data to variations in free-stream density and velocity and to other gases.

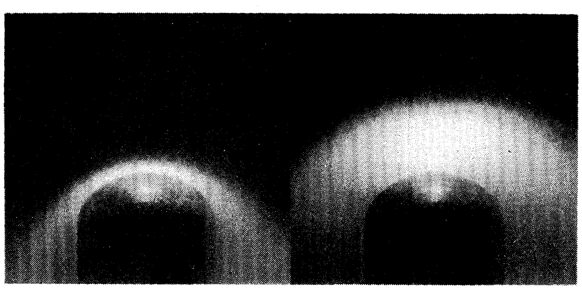

FIG. 1. Typical picture of bow shock without (left) and with applied magnetic field.

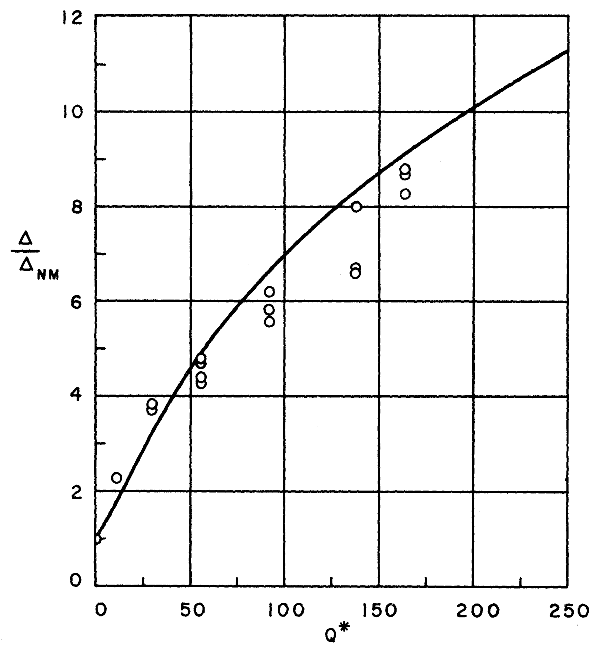

FIG. 2. Experimental data and theoretical curve for the variation of stand-off distance with Q* for air. Free stream conditions are $\rho/\rho_0 = 1.22 \times 10^{-3}$, $T = 6450$°K, $U = 6890$ m/sec and $M = 4.5$.

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OBSERVATION OF MICROWAVE CYCLOTRON RESONANCE BY CROSS MODULATION*

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(Received June 2, 1958; revised manuscript received June 19, 1958)

A new method of observing microwave cyclotron resonance in semiconductors has been de-

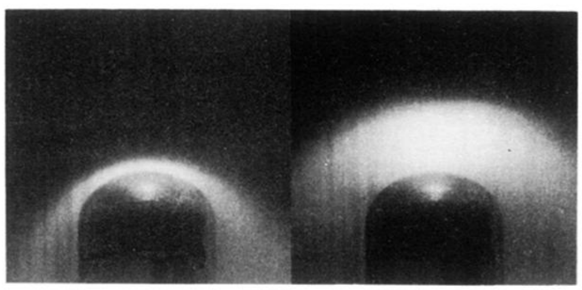

FIG. 1. Typical picture of bow shock without (left) and with applied magnetic field.