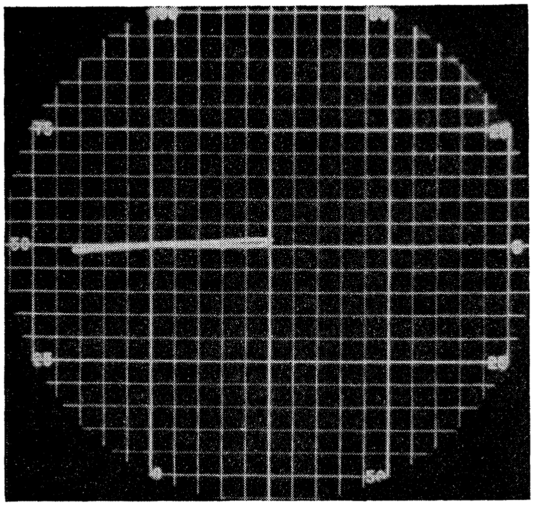

FIG. 2. Current-voltage characteristic after breakdown. Scale calibration is the same as in Fig. 1.

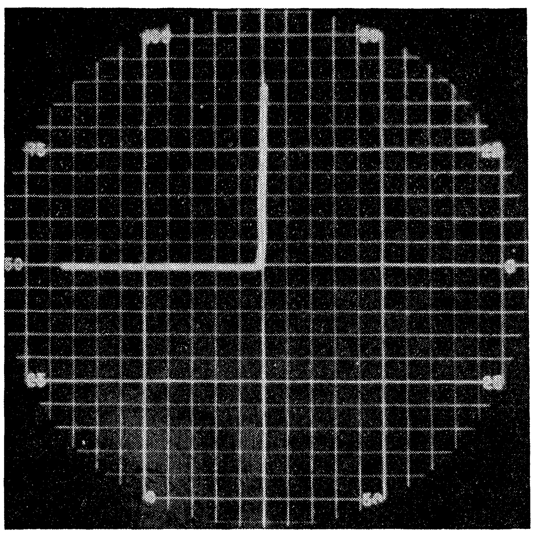

FIG. 3. The same characteristic shown in Fig. 2 except that the vertical scale calibration has been changed to 2 milliamperes per small division.

voltage characteristics after breakdown. In Fig. 3 current sensitivity has been decreased by a factor of 10^3. The peak forward current of 15 milliamperes is limited by external resistance. A thermocouple fused to the diode indicates no detectable (<0.05°K) increase in temperature after many minutes of operation under these conditions. The breakdown may be extinguished by decreasing the series resistance, permitting sufficiently high forward currents to heat the Ge to $\sim$100°K.

The process described has been termed injection breakdown. Although the kinetics of the voltage-induced breakdown are not quantitatively understood, the steady-state breakdown condition may be explained by assuming high, nonequilibrium conduction in the Ge due to mobile electrons which neutralize trapped holes, with injected holes continuously being retrapped, replacing evaporation or recombination losses. On sixty-cycle operation, a sufficient number of nonequilibrium carriers remain after the reverse cycle so that applied forward voltage again localizes at the junction and injection saturates the traps during the first part of the forward cycle (assuming sufficient current density). Because of this reloading process, a small discontinuity is always observed in the current voltage characteristic during the first part of the forward cycle. This is barely discernible in Fig. 3 as a change in slope near the origin. Heating the Ge to $\sim$100°K increases the rate of hole evaporation sufficiently that it is difficult to maintain the breakdown condition.

Two observations of Newman support the model proposed for the steady-state operation of the breakdown diode. The infrared absorption of injected carriers in the breakdown diode does not show the structure characteristic of hole absorption which is found in most normal diodes.[2] With the applied voltage just greater than the minimum sustaining voltage, it is possible to extinguish the breakdown by irradiation of the diode with monochromatic light in the wavelength interval ($\sim$0.35 to 0.7 ev) which had previously been found effective in quenching intrinsic photoconductivity in n-type Fe-doped crystals.[3]

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Effect of Dislocations on the Optical Absorption Edge in Nonmetals*†

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THE absorption spectra of many nonmetals exhibit a long-wavelength tail which has been attributed to lattice disorder.[1] Seitz[2] discussed the absorption spectra of the silver halides in the near ultraviolet and concluded on the basis of the magnitude of the radiation matrix element for a crystal containing edge type dislocations, that this type of lattice disorder can account for the long-wavelength tail observed.[3] This letter summarizes the results of calculations on the order of magnitude of the absorption coefficient to be expected in a crystal containing edge-type dislocations.

There are three ways in which dislocations can modify the fundamental absorption edge: (1) Optical (i.e., momentum) selection rules are relaxed by the deviation from periodicity. (2) Local density variations in the neighborhood of the dislocations change the local width of the forbidden gap, permitting lower-energy allowed

transitions to occur between the valence and conduction bands. (3) Various kinds of charged debris are created by and associated with the dislocations; as in the case of the α center, some of these imperfections would be effective in lowering the energy of the transition of the neighboring ions.

The absorption coefficient on the long-wavelength side of the fundamental absorption edge was calculated according to mechanism (1) for a crystal in which the energy contours in k space for the valence band are those for a p band, while those for the conduction band are for an s band. The calculation involved a summation over all k states in the two bands which could be evaluated only by means of simplifying assumptions which restrict the validity of the results to the region near the absorption edge. The length of the tail (measured from the absorption edge toward lower energies) cannot exceed the width of that branch of the valence band which bends upward.

For a dislocation density of 10^{12} lines per cm^2, a crystal with a valence band two volts wide, an energy gap of six volts, and with 0.4 taken to be the ratio of the effective mass of an electron in the conduction band to its mass in the valence band, an absorption coefficient of 20 cm^{-1} is calculated at 1 ev from the edge. In a crystal with a valence band one volt wide, an energy gap of nine volts, and 0.2 for the effective mass ratio, an absorption coefficient of 20 cm^{-1} is reached only 0.2 ev from the edge. The displaced oscillator strength per dislocation line intersection is about 0.2 in both cases. An alternative mechanism, considered by Bardeen and co-workers,[4] for obtaining nonvertical, or forbidden electronic transitions seems much more effective than that treated here for crystals of normal lattice disorder. (In the former mechanism, the transition occurs by the simultaneous emission of absorption of a phonon in order to conserve momentum.)

The shift in the absorption edge due to mechanism (2) was estimated by adopting the Heitler-London point of view and using deformation potential theory[5] to calculate the change in the absorption edge per atom as a function of the local density. This treatment shows that most of the absorption on the long-wavlength side of the edge occurs in the immediate vicinity of the edge and does not extend beyond about 0.5 ev beyond the edge. (This figure was obtained for a maximum dilatation of 0.1 and a reasonable value of 5 ev per unit dilatation for the deformation potential constant.)

It was concluded that neither mechanism (1) nor (2) can account for the long-wavelength tail extending into the visible as observed in the silver halides. However, in a cold-worked crystal, the vacancies, incipient vacancies, clusters, and other charged products of the moving dislocations represent regions of the crystal particularly effective in modifying the fundamental absorption edge. Measurements on the effects of cold working and annealing on good single crystals would be helpful in indicating the importance of mechanism (3).

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Structure of the Intermediate State of Superconductors*

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We have qualitatively verified the observations of Meshkosky and Shalnikov[1,2] on the discontinuous structure of the intermediate state of superconductors. We used lead rather than tin for the sample, and employed a different technique for observing the normal and superconductive regions.

The discontinuous magnetic field changes at the normal-superconductive interfaces were detected by using commercially available magnetic recording tape.[3] After the tape was magnetized at low temperatures, the details of the magnetization were revealed by making a magnetic powder pattern[4] on the tape after it had been warmed to room temperature. A similar technique was tried without success by Shalnikov and Meshkovsky,[1] who finally used the changes in the electrical resistance of an extremely small bismuth wire to detect the discontinuous magnetic field changes.

The sample consisted of two polycrystalline lead hemispheres of 0.25-in. radius cast from Johnson-Matthey and Company lead. Each hemisphere was mounted in a Plexiglass holder, and the two holders were bolted together with the tape in between them so that flat sides of the hemispheres were pressed against the two surfaces of the magnetic tape. The tape is 0.002 in. thick. A small patch of tape was also placed in the bottom of one holder so that it pressed against the outside surface of the hemisphere in the neighborhood of the pole. A bismuth wire was mounted in one of the holders near the equator. Suitable leads were attached so that the electrical resistance of the wire could be measured, and the magnetic field at the surface of the sphere thereby determined.

The sample was cooled in liquid helium to about 1.4°K. A uniform magnetic field was then applied in a direction passing through the poles, and thus transverse to the long direction of the tape between the hemispheres. The field was increased slowly and the resistance of the bismuth wire measured. The initial penetration of the magnetic field into the sphere was