tion region from below, it produces a reflected wave of the same type, characterized by a reflection coefficient $|R_1| = (1 - e^{-2\delta_0})$. The transmission of the wave is characterized by a transmission coefficient $|D_2| = e^{-\delta_0}$ (cf. Ref. 6). In this case the mean absorbed energy is

$$1 - |R_1|^2 - |D_2|^2 = e^{-2\delta_0}(1 - e^{-2\delta_0}). \quad (4)$$

The real quantity δ_0 is defined by the integral

$$\delta_0 = -\frac{1}{4} ik_0 \oint (n_2 - n_1)\, dz. \quad (5)$$

The integral is taken over a path which encloses the two singularities of the integrand at which $n_1 = n_2$. If, however, an extraordinary wave is incident on the interaction region from above, it is not reflected but is scattered into two waves in the interaction region. The amplitudes of these two waves are (cf. Ref. 5)

$$d_1 = e^{-\delta_0}; \qquad d_2 = (1 - e^{-2\delta_0})^{1/2}. \quad (6)$$

The factor d_1 characterizes the transmission of the ordinary wave. The factor d_2 characterizes the extraordinary wave which is produced in the interaction region and holds in the direction of the pole of the functions $n_2^2(\epsilon)$. This wave is then completely absorbed. The absorption $(|d_2|^2)$ is small only when δ_0 is small. When $\delta_0 \gg 1$, $d_2 \sim 1$ and the wave which is incident from above is almost completely absorbed in the region of high $n_2^2(\epsilon)$.

Because of the thermal motion of the electrons,[2] a wave traveling in the direction of the pole of the function $n_2^2(\epsilon)$ is converted into a plasma wave, the energy of which, in the final analysis, is dissipated in heating the plasma. Thus the absorption effect being discussed is related to the conversion of electromagnetic waves into plasma waves.

Finally we may note that in experiments in which the ionosphere is "sounded" by pulses the interaction mechanism being considered here may explain the fact that only three pulses are observed. The incident wave is presumably split into an extraordinary wave and an ordinary wave. The extraordinary wave is reflected at a level corresponding to $\epsilon = \sqrt{u}$ (first signal); the ordinary wave is reflected in the interaction region ($\epsilon = 0$) (second signal) and partially penetrates as an extraordinary wave into the region $\epsilon < 0$. The extraordinary wave reflected from the point corresponding to $\epsilon = -\sqrt{u}$ passes through the interaction region without reflection and reaches the point of observation as an ordinary wave (third signal). Thus, multiple-reflection effects are impossible.

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RECOMBINATION CAPTURE OF MINORITY CARRIERS IN N-TYPE GERMANIUM BY LATTICE DEFECTS FORMED UPON IRRADIATION BY FAST NEUTRONS

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In an earlier work[1] an estimate was made of the cross-section for recombination capture of minority carriers by radiation defects in the crystal structure of N-type germanium, produced by irradiation with fast neutrons. The following relations were used in the calculations

$$1/\tau - 1/\tau_0 = n_d v_p \theta, \quad (1)$$

$$n_d = n_{Ge} N_n \bar{N}_d \sigma. \quad (2)$$

Here τ is the lifetime of the minority carriers after irradiation, τ_0 the lifetime of the minority carriers before irradiation, n_α the concentration of the radiation lattice defects, v_p the thermal velocity of the minority carriers (holes), n_{Ge} the number of germanium atoms per cm^3, N_n the integral dose of neutrons (expressed in neutrons per

$N_n\left(\frac{\text{neutrons}}{\text{cm}^2}\right)$	$6.7\cdot10^{11}$	$5\cdot10^{11}$	$5\cdot10^{11}$	$4\cdot10^{11}$	$3\cdot10^{12}$	$3\cdot10^{12}$	$3\cdot10^{12}$	$3\cdot10^{12}$	$3\cdot10^{12}$
E_n (Mev)	14	14	14	14	Specimens irradiated in reactor				
ρ_0 (Ω cm)	37	20.5	9.5	4.7	20	9.6	3.7	1.7	0.35
ρ (Ω cm)	42.5	24.0	10.5	5.3	24.5	11.0	3.9	~1.7	~0.35
τ_0 (micron/sec)	450	170	230	29	300	160	130	60	30
τ (micron/sec)	70	20	18	8	23	19	10	7	8
Δn (10^{13} cm^{-3})	1.8	1.6	1.8	3.0	2.0	2.1	2.4	—	—
n_d (10^{13} cm^{-3})	1.4	1.2	1.2	1.2	1.4	1.3	1.3	(1.3)	(1.3)
N_d	260±50	280±30	290±20	(350±100)	—	—	—	—	—
θ (10^{-16} cm^2)	0.8	3.2	3.8	6	2.7	3.3	6.5	8.5	~7

cm^2), $\overline{N}_d$ the average number of displaced germanium atoms per single neutron scattering, and σ the scattering cross-section of the neutrons by germanium nuclei.

To estimate the value of θ, we used values of $\overline{N}_d$ calculated with the formula given by Fan and Lark-Horovitz.[2] To check the correctness of the method employed to calculate $\overline{N}_d$, we set up additional experiments on the irradiation of N-germanium with neutrons. By increasing the doses of neutron irradiation, we obtained measurable values of the change in specific resistivity, $\rho - \rho_0 = \Delta\rho$, which were compared with the lifetime changes in the same specimens. At the doses of neutron irradiation employed, the mobility can be assumed constant, and the change of carrier concentration Δn for given $\Delta\rho$ can be determined from the theoretical relation $\rho = f(n)$ given by Prince,[3] which is found to be well satisfied in the employed germanium single crystals.

Reference 4 gives the experimental values of the number of conduction electrons $(-\Delta n/n_d)$ captured by a single radiation defect when n-type germanium specimens of different specific resistivity are bombarded by neutrons. On the basis of these data, the values of Δn were used to estimate the defect concentration n_d for all the irradiated specimens. Relation (2) was used to determine the value of $\overline{N}_d$ for specimens irradiated by monoenergetic neutrons. The values of the latter quantity are close to 260, in accordance with the formula by Kinchin and Pease.[5]

The data obtained are listed in the table.

The values of θ obtained are one order of magnitude greater than the cross-sections for the capture of carriers by singel Frenkel' defects produced by electron irradiation.[6]

What is interesting is the regular increase in values of θ with diminishing ρ_0, i.e., with displacement of the Fermi level upward from the center of the forbidden band. The value of θ which we introduced into relation (1) is the product of the effective "geometric" cross-section of the defect, as the capture center, by the degree of filling of the corresponding energy level. The increase in θ is therefore obviously due to the fact one of the recombination levels lies in the upper half of the forbidden band.

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