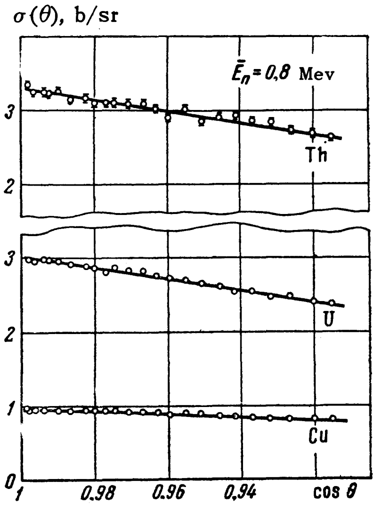

FIG. 2

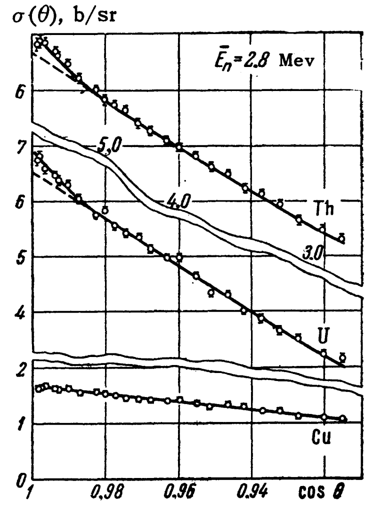

FIG. 3

references 2 and 3, a sharp increase in the scattering cross section of U and Th nuclei is observed in the region of angles smaller than 10°, in spite of allowances made for Schwinger scattering.

It must be observed that the detected phenomenon has not yet been satisfactorily explained.[5]

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PRODUCTION OF NEGATIVE-TEMPERATURE STATES IN P-N JUNCTIONS OF DEGENERATE SEMICONDUCTORS

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If a p-n junction in a semiconductor is biased in the forward direction, then there will be a decrease in the potential barrier due to space charge in the p-n junction, and the concentration of minority carriers near the junction will increase. The concentration of these carriers reaches a maximum once the potential barrier is completely removed by the applied field. This maximum value is about equal to the concentration of the carriers in a region of the crystal where they are the majority carriers (we assume the p-n junction to be abrupt). A negative temperature can arise in a junction only when the Fermi quasi-levels corresponding to the non-equilibrium concentrations of electrons and holes satisfy the relation[1]

$$\mu_e + \mu_p > \Delta, \tag{1}$$

where μ_e and μ_p are the Fermi quasi-levels for electrons and holes, and Δ is the width of the forbidden band. If the p-n junction is now biased in the forward direction, the Fermi quasi-level of the minority carriers near the junction will be close to the Fermi level in that part of the crystal where these carriers are the majority ones. From equation (1) it then follows that in this case in at least some part of the p-n junction the carriers must be degenerate.

Semiconductors with such p-n junctions are tunnel diodes;[2] however, this mechanism for obtaining negative temperatures corresponds to the diffusion, rather than the tunnel, part of the voltage-current characteristic of the tunnel diode.

If the p-n junction is in a strongly degenerate semiconductor, negative temperatures can arise even before the potential barrier is completely destroyed so that quantitative estimates can be obtained with the aid of the theory of the diffusion of current through a p-n junction.

It can be easily shown that the minimum value of the external voltage at which a negative temperature can occur is given by*

$$U_{min} = \Delta/e \qquad (2)$$

where $-e$ is the electron charge. The current density I (of the electronic component, for example) is, in order of magnitude,

$$I \approx -(eDn_p/L)\exp(eU/kT), \qquad (3)$$

where D is the diffusion coefficient, L is the diffusion length, and n_p is the electron density in the p part of the semiconductor. From formula (3) it can be shown that the current density decreases with increasing degeneracy and decreasing sample temperature. A steady state with negative temperature can thus be obtained. However, the absorption coefficient for radiation in the semiconductor becomes negative at fairly high ($\sim 10^{15}$ cm^{-3}) nonequilibrium concentrations of the minority carriers,[3] and as a consequence it is impossible to work at very low current densities.

The negative temperature occurs in a thin layer near the p-n junction, the thickness of the layer being about a diffusion length. In a degenerate semiconductor the high density of the majority carriers surrounding the region of negative temperature can, apparently, serve as reflecting surfaces, i.e., a "resonating cavity" is formed.

It should be noted that lower current densities can be used if the semiconductors forming the p-n junction have forbidden bands of different widths.

Pankove[4] has observed recombination radiation from p-n junctions in degenerate semiconductors. In a negative temperature state, the concentration of current carriers is lower than in the state having negative absorption coefficient, so that to observe a negative temperature state one should look for changes in the voltage-current characteristic when the sample is illuminated with light of suitable frequency.

*In the case of indirect transitions[3] at low temperatures, the quantity Δ in formula (2) should be replaced by $\Delta - \varepsilon$, where ε is the energy of the radiated phonon.

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RAREFACTION SHOCK WAVES IN IRON AND STEEL

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In the case of a medium with a Poisson adiabat some part of which has a curvature of sign other than the usual one ($\partial^2p/\partial V^2 < 0$), a rarefaction jump must be introduced in order to construct the rarefaction wave in this region of pressures, whereas a compression jump is impossible.[1] The kink in the shock-compressibility curve in iron at an ($\alpha \to \gamma$) phase-transition pressure of 132,000 atm, noted by Bancroft,[2] is a limiting case of such an anomalous part of the Poisson adiabat.* That a rarefaction jump can in principle be produced in iron was pointed out by Drummond.[3] It is obvious that when rarefaction shock waves interact, destructive stresses will be reached in a very narrow zone, determined by the width of the front of these waves, and this should lead to the appearance of fractures with much smoother surface than in the case when simple rarefaction waves interact.

We have investigated fracture phenomena in cylindrical specimens of steel on whose surfaces explosive charges were detonated. The diameter of the charge was equal to approximately half its length and to the diameter of the specimen. In all cases where the specimens were damaged, fractures were produced near the contact with the charge, in the form of cores of regular geometric shape with smooth surfaces (Fig. 1a and b). In experiments with steel specimens made in the form of rectangular and triangular right prisms, the lower part of each core, as in experiments with cylindrical specimens, was in the form of a