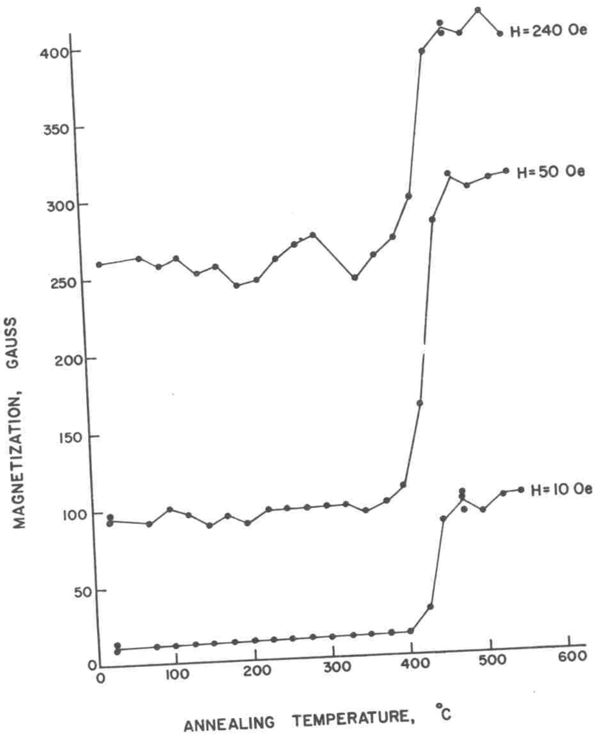

FIG. 3. Isochronal annealing curve for *M* at various *H* levels.

It can be seen from Fig. 2 that the initial slope of the magnetization curve is a region I parameter. This slope defines the initial susceptibility χ_0 which is related to the angle θ that the magnetization curve makes with the axes through the relation

$$\theta = \tan^{-1}\chi_0 .$$

The variation of θ with annealing temperature is shown in Fig. 4 where it can be seen that pronounced recovery begins at about 400 °C. However, in the annealing range between 25 and 400 °C there is a considerable amount of fine structure which may be related to low-temperature recovery processes. To examine this proposition, it was necessary to extract parameters which were clearly sensitive to low-temperature structure changes, i.e., point-defect processes. This was done as follows.

The ratio M/H is called the susceptibility χ and this parameter represents the relative increase in magnetic moment caused by the application of the magnetic field. Theoretically[7] it is found that this quantity is particularly sensitive to dislocation structure at high fields. Figure 5 shows the susceptibility curves for several samples. Characteristic of each susceptibility curve is the maximum susceptibility χ_m and the corresponding value of the field H_m. Figure 6 shows these parameters plotted as functions of the annealing temperature. These two curves show the desired sensitivity. For annealing temperatures between 25 and 400 °C, χ_m is nearly constant but H_m shows two minima. Between 400 and 475 °C both curves show significant change. Above 475 °C, the behavior is reversed with H_m remaining nearly constant and χ_m showing change.

The recovery of shocked high-purity polycrystalline nickel has been studied by Kressel[23] using standard resistivity methods. At a peak pressure of 330 kbar, the recovery spectrum above room temperature consisted of three well-defined annealing stages (stages III, IV, and V). Stage III had an activation energy of 1.1 eV and was centered around 88 °C. The activation energy for stage IV was found to be 1.5 eV and the recovery peak was centered around 260 °C. As shown in Fig. 6, this behavior correlates very well with the behavior found in the present study. The center of the low-temperature recovery peaks found by Kressel correspond exactly to the minima A and B.

Stage III and stage IV recovery are known to be associated with point-defect processes. Stage III is usually attributed to the migration of mobile interstitials to fixed vacancies.[24] However, some of Kressel's data suggest also the possibility of defect migration to dislocations. Stage IV recovery is interpreted as the annihilation of single vacancies.[25]

The recovery above 350 °C is caused by the rearrangement and annihilation of dislocations. Clearly, these processes affect all the magnetic parameters measured in this study. The points C and C′ in Fig. 6 suggest the interaction of dislocations with some type of point defect, probably vacancy clusters. However, there is some question to this interpreta-

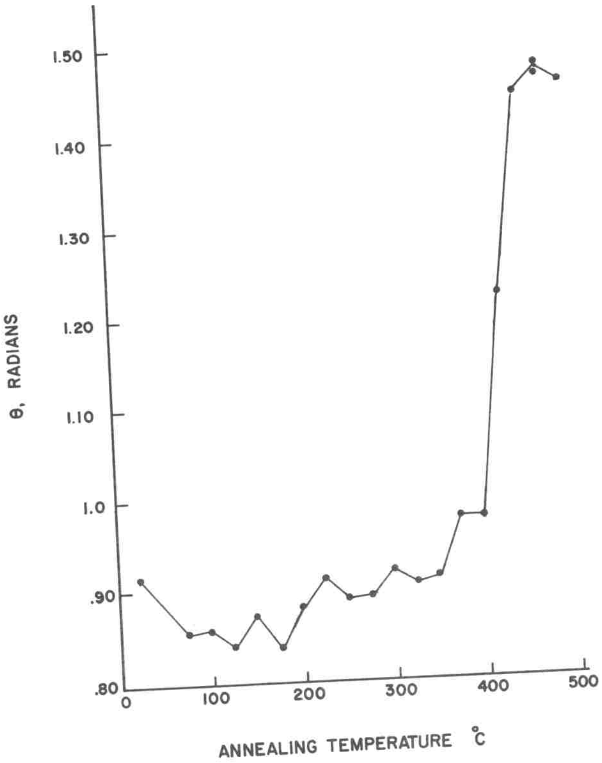

FIG. 4. Isochronal annealing curve for angle θ.

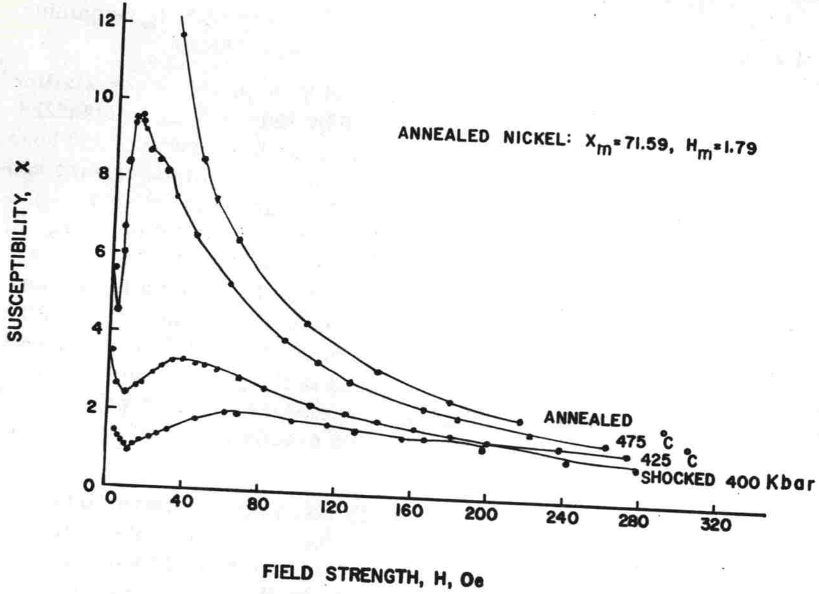

FIG. 5. Susceptibility curves for nickel after shocking and annealing.

tion because the temperature corresponding to these points is approximately equal to the Curie temperature for nickel. The effect of cycling through the Curie temperature is currently under study to clear up this point. The major recovery stage V should contain two regions which correspond to polygonization and primary recrystallization. In the present study the primary recrystallization phase was not resolved because the experiment did not extend to high enough temperatures. Annealing was discontinued because quenching stresses began to interfere with the measurements.

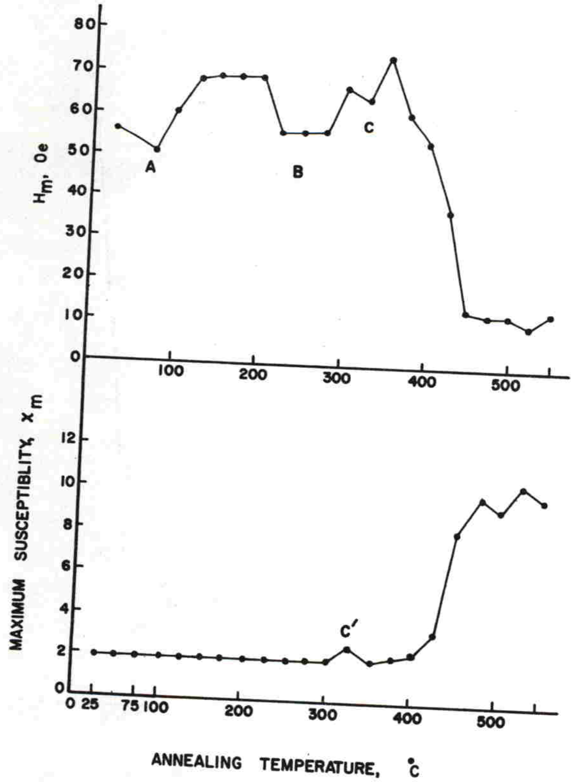

FIG. 6. Isochronal annealing curves for χ_m and H_m.

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