Letters to the Editor

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Communications should not in general exceed 600 words in length.

Dislocations and Magnetization

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THE writer recently suggested[1] that line concentrations of force might be responsible for the term a/H in the empirical formula for the magnetization curve of nickel at high fields, $J=J_s-a/H-b/H^2+CH$, and tentatively identified these line concentrations with the "dislocations" of plasticity theory. The following approximate calculation, based directly on dislocation theory, shows that both the occurrence of the a/H term and the increase of a and b with plastic strain may be attributed to internal stresses produced by the dislocations.

Let Oy be the direction of the field and of the specimen axis, Oz the direction of the dislocation lines (radially outward from the axis in the region under consideration), and Ox the direction of slip; this is roughly the situation in a twisted wire. If $\alpha=\cos(\mathbf{J}, x)$ is small, the magnetostrictive energy density[2] for a specimen with saturation magnetostriction $-\lambda_\infty$ is $3\lambda_\infty X_y\alpha$. The shearing stress X_y at a distance r from a dislocation[3] is $\lambda_0 G'\phi(\theta)/\pi r$, where λ_0 is the distance between atoms along Ox, $G'\cong$the rigidity, and $\phi(\theta)$ is an angular factor. For a single dislocation, therefore, α varies in the xy-plane in accordance with the equation[1]

$$\nabla^2\alpha-\eta\alpha=k\phi(\theta)/r, \tag{1}$$

where $k=3\lambda_\infty G'\lambda_0/\pi C$, $\eta=HJ_s/C$; $C\cong 10^{-6}$ erg/cm measures the strength of the interatomic coupling forces. Transformation to the dimensionless variable $v=\eta^{\frac{1}{2}}r$ shows that

$$\alpha=k\eta^{-\frac{1}{2}}f(v, \theta), \tag{2}$$

where the function f is dimensionless.

For n dislocations per cm², distributed at random, $1-J/J_s$ is found by integrating $\frac{1}{2}\alpha^2$ over the xy-plane and multiplying by n. Since $dxdy=\eta^{-1}vdvd\theta$, the result is $c_1 n\pi k^2/\eta^2$, where $c_1=\int f^2 vdvd\theta/2\pi$ is a numerical constant; or $J_s-J=b/H^2$, with

$$b=(9c_1/\pi)n(\lambda_\infty G'\lambda_0)^2/J_s. \tag{3}$$

This may be rewritten

$$J/J_s=1-c_1'(\lambda_\infty\sigma_i/HJ_s)^2, \tag{4}$$

with

$$\sigma_i=c_2 G'\lambda_0\sqrt{n}, \tag{5}$$

where c_1' and c_2 are numerical constants. Equation (4) is identical with that given by the Becker-Kersten rotation theory[2] for "internal stress" σ_i; Eq. (5) suggests that σ_i may be identified with the stress produced by the dislocations in Taylor's theory of hardening.[3] In Becker's theory $c_1'\cong\frac{2}{5}$, and in Taylor's $c_2\cong\frac{1}{5}$. If the tentative value $9c_1/\pi=c_1'c_2^2=3/125$ is inserted in Eq. (3), n may be calculated from Kaufmann's data on the increase of b with plastic twist.[4] The result is $n/\gamma\cong 10^{12}$ dislocations per cm² per unit of plastic shear (γ), in agreement with the value calculated from purely mechanical data by Taylor's theory.[1]

Dislocations are of two signs, and opposite kinds attract each other toward a common value of x. They therefore tend to form pairs separated by a short distance l parallel to Oy. The value of α for such a doublet may be found by applying the operator $-l\partial/\partial y$ to the right member of Eq. (2); it is of the form $\alpha=klg(v, \theta)$. For n' doublets per cm², $J_s-J=a/H$, with $a=(9c_3/\pi)n'l^2(\lambda_\infty G'\lambda_0)^2/C$. If $n'\cong n$ and $10^{-2}\leq 9c_3/\pi\leq 1$, Kaufmann's values of a give 10^{-5} cm $\geq l\geq 10^{-6}$ cm; thus l is less than the mean distance between dislocations but considerably greater than the interatomic distance—a plausible result.

It has been assumed here that the integrals c_1 and c_3 converge. Actually c_1 diverges logarithmically at $v=\infty$; in the rigorous theory b is not exactly constant, but contains a logarithmic term in H.

[1] W. F. Brown, Jr., Phys. Rev. **58**, 736 (1940).
[2] R. Becker and W. Döring, *Ferromagnetismus* (Springer, Berlin, 1939), p. 146; pp. 167–8, 175.
[3] G. I. Taylor, Proc. Roy. Soc. **A145**, 362 (1934); J. M. Burgers, Proc. K. Ned. Akad. Wet. **42**, 293 (1939), especially pp. 305–6.
[4] A. R. Kaufmann, Phys. Rev. **57**, 1089A (1940) and private communication.

Rotational Analysis, Perturbation and Predissociation in the CD and CH Bands

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IN strongly condensed high frequency electric discharges through vapors of deutero-paraffin and ordinary benzol under various pressures, the entire CD and CH spectrum was photographed with a grating spectrograph of high dispersion and good resolution.

Rotational analysis of the CD bands in the region of 3150A has been made and the branches of the bands (0,0), (1,1) and (2,2) were followed up to $K'=39(v'=0)$, $K'=34(v'=1)$ and $K'=27(v'=2)$, where predissociation of the $C^2\Sigma^-$ state occurs. The corresponding predissociation in the CH bands has been suspected[1] and we found confirmation by observing the effect at $K'=26(v'=0)$ and $K'=21(v'=1)$ on the $C^2\Sigma^-$ state of CH.

A comparison of the predissociation effects on the 4300A CD and CH bands completes the findings of a previous paper,[1] based on pictures of CH bands alone, as follows: The $A^2\Delta\rightarrow X^2\Pi$ bands show *two* predissociation phenomena. The lower one—corresponding to the effect on the $B^2\Sigma^+ \rightarrow X^2\Pi$ bands, observed by Shidei[2]—takes place at $K'>33$ for CD and $K'>23$ for CH on the $v'=0$, i.e., at $K'>25$ for CD and $K'>13$ for CH on the $v'=1$ vibrational level of the $A^2\Delta$ state and affects rather more the F_{1c} sublevel sets. The upper one cuts the rotational sets with $K'>36$ for CD and $K'>26$ for CH on the $v'=0$, i.e., with $K'>29$ for CD and $K'>17$ for CH on the $v'=1$ level of the $A^2\Delta$ state.

As has been pointed out[3] on the basis of Shidei's measments,[2] the relative positions of the band origins in the $A^2\Delta \rightarrow X^2\Pi$ systems of CD and CH cannot be explained by the usual vibrational isotopic shifts and a perturbation of the $A^2\Delta$ state was suspected, the perturbing state being of the same $^2\Delta$ symmetry. This is confirmed now by constructing the $(B'-B'')$ curves[4] for all the carefully analyzed bands of the $A^2\Delta \rightarrow X^2\Pi$ system. The shape of the perturbations suggests that the convergence limit of the perturbing $^2\Delta$ state must lie rather low.

The spin-doublet separation of the $X^2\Pi$ ground state decreases with increasing quantum numbers for CD more rapidly than for CH and vanishes in the regions $8<K<16$ for CD, i.e., $13<K<18$ for CH on the c sublevels and $9<K<23$ for CD; also $16<K<24$ for CH on the d sublevels of the Λ-type doublet components. Above these regions a reversed splitting, increasing with K, sets in. The relative intensity, before they merge, of the lines having these new doublets as lower states differs markedly from that of the ordinary spin-doublets; the violet components are explicitly weaker, especially in the Q branches of the two $^2\Sigma \rightarrow {}^2\Pi$ systems. This circumstance and the unequal splittings at the same K of the c and d sublevels explains now the observations of earlier workers[5] on the 3900A CD bands showing a semi-singlet structure at medium and higher rotational quantum numbers.

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[2] T. Shidei, Jap. J. Phys. **11**, 23 (1936).
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[5] A. McKellar and Ch. A. Bradley, Jr., Phys. Rev. **47**, 787 (1935).