stants. If shape anisotropy is ignored, uniaxial anisotropy will be obtained only if either $\lambda_{100}/\lambda_{111} > 0$ or $\lambda_{100}/\lambda_{111} < 0$ with $|\lambda_{111}| > |\lambda_{100}|$. With compressive stress, both cases would require $\lambda_{111} > 0$ in addition to the above.

For σ in the (111) plane, the sum of Eqs. (3) and (17) gives

$$E^{111} = K_1(\sin^4\theta\sin^2\phi\cos^2\phi + \sin^2\theta\cos^2\theta) + \sigma\lambda_{100} - (\sigma\lambda_{111} - \frac{4}{3}\pi M^2)[\sin^2\theta\sin\phi\cos\phi + \sin\theta\cos\theta(\sin\phi + \cos\phi)] + \frac{2}{3}\pi M^2 . \quad (25)$$

By setting $\partial E^{111}/\partial\theta = \partial E^{111}/\partial\phi = 0$, it may be shown that the pertinent extrema move in the three {110} planes which contain the [111] axis. Since these three situations are equivalent, the problem may be solved for only one of them (as with σ in the (001) plane) by setting $\phi = \frac{\pi}{4}$. The first result is that the extremum along the [111] axis does not move. However, the movements of the other extrema in the (110) plane (i.e., $\phi = \frac{\pi}{4}$) are given by

$$(\sigma\lambda_{111} - \frac{4}{3}\pi M^2)/K_1 = \frac{\sin\theta\cos\theta(3\cos^2\theta - 1)}{\sin\theta\cos\theta + \sqrt{2}(\cos^2\theta - \sin^2\theta)} \quad (26)$$

which is plotted in Fig. 3 as θ is varied from zero to π. As the ordinate increases in a positive sense, the extremum at [001] rotates towards the normal [111] direction until it meets the extremum from the [110] axis and both disappear for $(\sigma\lambda_{111} - \frac{4}{3}\pi M^2)/K_1 \geq 0.51$. At the same time, the $[11\bar{1}]$ extremum rotates into the plane at $\theta \simeq 145°$, which is a pole in Eq. (26), thus requiring that $(\sigma\lambda_{111} - \frac{4}{3}\pi M^2)/K_1 \to \infty$ in order to reach the plane. Where $(\sigma\lambda_{111} - \frac{4}{3}\pi M^2)/K_1$ increases in a negative direction,the [001] extremum rotates toward the pole at $\theta \simeq 145°$, and the [110] and $[11\bar{1}]$ extrema merge and vanish at $\theta \simeq 110°$ for $(\sigma\lambda_{111} - \frac{4}{3}\pi M^2)/K_1 \leq -0.15$. These conditions are depicted in Fig. 4.

For convenience,all of the conditions for uniaxial anisotropy discussed above are listed in Table 1. In Table 2, the expressions for E along the normal and different directions in the plane are given together with the differences in energy which represent the effective uniaxial anisotropy constants K_u. These results may be used to calculate K_u once the uniaxial anisotropy conditions have been satisfied.

Discussion and Conclusions

From the results summarized in Table 1, it is evident that the effect of

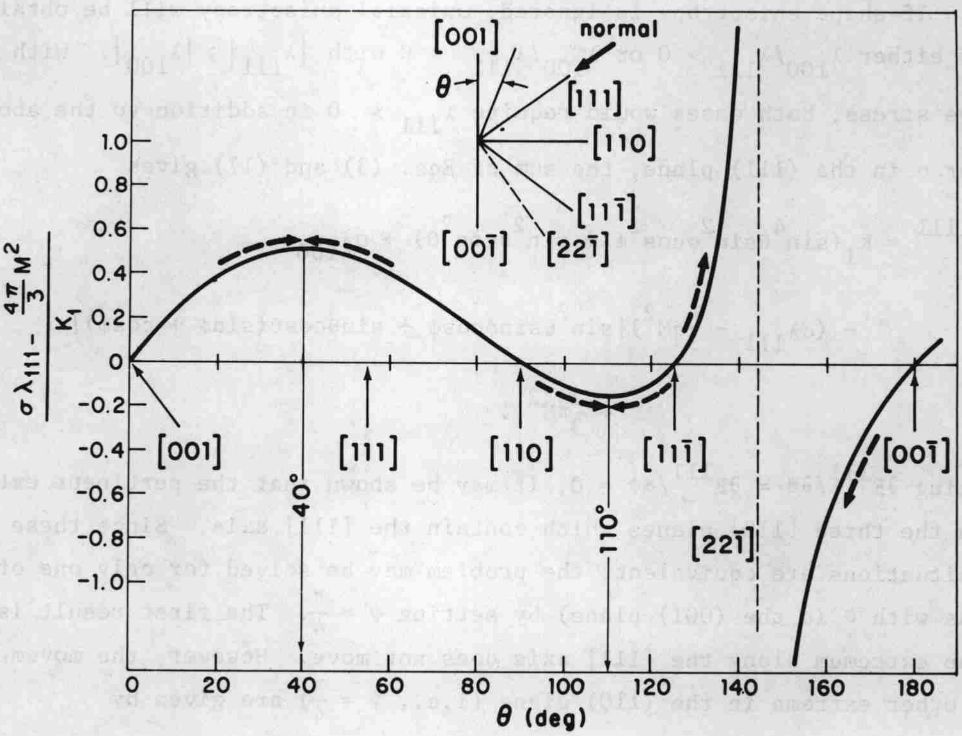

FIG. 3

Variation of $(\sigma\lambda_{111} - \frac{4}{3}\pi M^2)/K_1$ with the polar angle θ in the (110) plane for compressive stress σ in the (111) plane. This curve is a plot of Eq. (26) for $0 \le \theta \le \pi$.

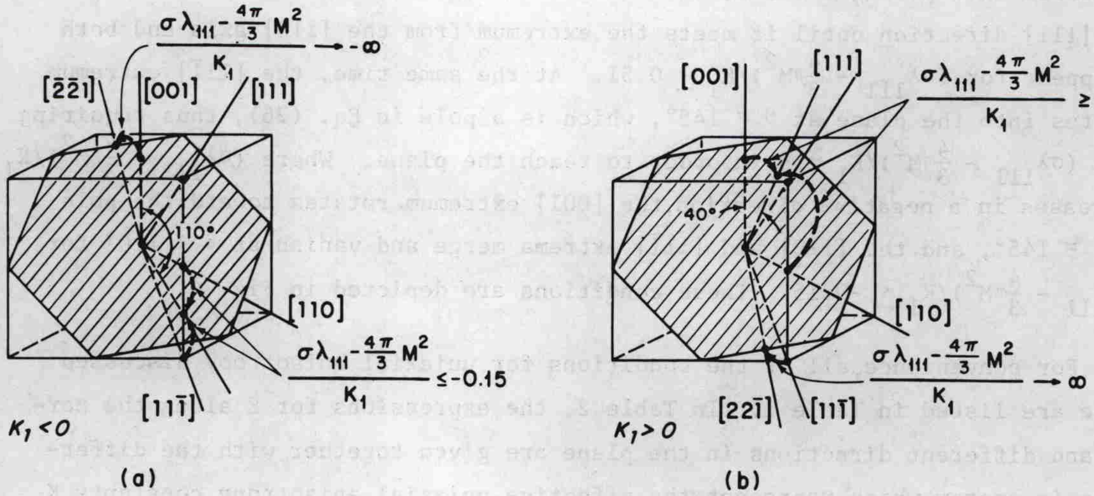

FIG. 4

Movements of important energy extrema and conditions for uniaxial anisotropy with stress in the (111) plane, for (a) $K_1 < 0$ and (b) $K_1 > 0$. Activity in only one of the three pertinent {110} planes is shown and shape anisotropy is assumed to be neglibible.