TABLE 1

Conditions for Stress-Induced Uniaxial Anisotropy

Plane	$K_1 < 0$	$K_1 > 0$
(001)	$\frac{\sigma\lambda_{100} - \frac{4}{3}\pi M^2}{K_1} \leq -2/3$	$\frac{\sigma\lambda_{100} - \frac{4}{3}\pi M^2}{K_1} \geq 1/3$
(110)	$\frac{\sigma(\lambda_{100} + \lambda_{111}) - \frac{8}{3}\pi M^2}{K_1} \leq -2/3$	$\frac{\sigma(\lambda_{100} + \lambda_{111}) - \frac{8}{3}\pi M^2}{K_1} \geq 4/3$
	$\frac{\sigma\lambda_{111} - \frac{4}{3}\pi M^2}{K_1} \leq -2/3$	$\frac{\sigma\lambda_{111} - \frac{4}{3}\pi M^2}{K_1} \geq 2/3$
(111)	$\frac{\sigma\lambda_{111} - \frac{4}{3}\pi M^2}{K_1} \to -\infty$	$\frac{\sigma\lambda_{111} - \frac{4}{3}\pi M^2}{K_1} \geq 0.51$
	$\frac{\sigma\lambda_{111} - \frac{4}{3}\pi M^2}{K_1} \leq -0.15$	$\frac{\sigma\lambda_{111} - \frac{4}{3}\pi M^2}{K_1} \to \infty$

TABLE 2

General Anisotropy Energy Relations for Planar Stress Situations

PLANE	E^n (normal)	E^P (in plane)	Axis (in plane)	$K_u = E^n - E^P$
(001)	$2\pi M^2$	$(3/2)\sigma\lambda_{100}$	[100]	$-(3/2)\sigma\lambda_{100} + 2\pi M^2$
		$K_1/4 + (3/2)\sigma\lambda_{100}$	[110]	$-K_1/4 - (3/2)\sigma\lambda_{100} + 2\pi M^2$
(110)	$K_1/4 + (3/4)\sigma(\lambda_{100} - \lambda_{111}) + 2\pi M^2$	$(3/2)\sigma\lambda_{100}$	[001]	$K_1/4 - (3/4)\sigma(\lambda_{100} + \lambda_{111}) + 2\pi M^2$
		$K_1/4 + (3/4)\sigma(\lambda_{100} + \lambda_{111})$	[1$\bar{1}$0]	$-(3/2)\sigma\lambda_{111} + 2\pi M^2$
		$K_1/3 + \sigma(\lambda_{100} + \lambda_{111}/2)$	[1$\bar{1}$1]	$-K_1/12 - (1/4)\sigma(\lambda_{100} + 5\lambda_{111}) + 2\pi M^2$
(111)	$\sigma(\lambda_{100} - \lambda_{111}) + 2\pi M^2$	$\sigma(\lambda_{100} + \lambda_{111}/2)$	[1$\bar{1}$0]	$-(3/2)\sigma\lambda_{111} + 2\pi M^2$
		$\sigma(\lambda_{100} + \lambda_{111}/2)$	[22$\bar{1}$]	$-(3/2)\sigma\lambda_{111} + 2\pi M^2$

shape anisotropy in films must be overcome by applied stress regardless of the crystallographic orientation or the sign of K_1. From a quantitative standpoint, the effect may be ignored only when $\left|\frac{4}{3}\pi M^2/K_1\right| << 1$. In some cases of nearly compensated ferrimagnetism, shape anisotropy may be small in comparison with magnetocrystalline anisotropy and the effect may be neglected. The following discussion will be focused on these situations, although the conclusions apply qualitatively even where shape effects are significant and the actual values of $\frac{4}{3}\pi M^2/K_1$ must be taken into account in the uniaxial anisotropy conditions.

Based on the above theory and results, the {001} family of planes appears to be the most desirable for applications requiring uniaxial anisotropy induced by planar stress. It is dependent on only the λ_{100} magnetostriction constant and can provide almost uniform energy in the plane if $\sigma\lambda_{100} >> K_1$. As discussed in an earlier section, the requirements for uniaxial anisotropy for {110} planes are complicated because either $\lambda_{100}/\lambda_{111} > 0$ or $\lambda_{100}/\lambda_{111} < 0$ with $|\lambda_{111}| > |\lambda_{100}|$. In addition, it may be seen from Table 2 that although the basic uniaxial conditions can be satisfied, significant anisotropy will usually remain within the plane. For the {111} planes, the uniaxial conditions can be approached only if $\sigma\lambda_{111} >> K_1$. This fact could place restrictions on the use of this common family of planes.

For applications involving ferrimagnetic oxides, some general observations may be made. Most iron garnets have K_1, λ_{100}, and λ_{111} negative at room temperature. According to the relations for K_u listed in Table 2, the required uniaxial anisotropy must be obtained by tensile stress, as was recently reported for Ga^{3+} - substituted $Y_3Fe_5O_{12}$ (5). For spinels, the situation is almost the same except that λ_{111} is positive and compressive stress could be used in {111} planes provided $\sigma\lambda_{111} >> K_1$. Since magnetic oxides are not noted for their tensile strength, one is led to consider methods of altering the signs of anisotropy and magnetostriction constants.

For garnet materials, both λ_{100} and λ_{111} may be changed to positive by substitutions of Mn^{3+} ions in octahedral sites. This type of substitution is particularly effective for λ_{100}, which is the constant that controls uniaxial anisotropy in the {001} planes (9,10). In addition, rare-earth ions such as Tb^{3+}, Eu^{3+}, and Er^{3+} substituted into the dodecahedral sites can affect the signs of the magnetostriction constants and could also permit compressive stress to be employed in some cases (11). Combinations of both Mn^{3+} and rare earths may allow a wide range of magnetostriction constants. Another possibil-