$$\mathcal{E}_{LOC}(E_{ij}, \alpha_i^*, G_{ij})$$

where

$$E_{ij} = \frac{1}{2}\left(\frac{\partial x_k}{\partial a_i}\frac{\partial x_k}{\partial a_j} - \delta_{ij}\right) \qquad (2.10)$$

is the finite strain tensor,

$$\alpha_i^* = \frac{\partial x_k}{\partial a_i}\alpha_k, \qquad (2.11)$$

and

$$G_{ij} = \frac{\partial \alpha_k}{\partial a_i}\frac{\partial \alpha_k}{\partial a_j}. \qquad (2.12)$$

These thermodynamic variables are not the only ones allowed by Cauchy's theorem but are the ones usually selected. (See Brown[5] for a more fundamental set.)

In terms of these variables, $\mathcal{E}_{LOC}$ is arbitrary. A phenomenological expansion in the usual manner yields[30]

$$\mathcal{E}_{LOC} = \mathcal{E}^0_{LOC}(S) + g(\alpha_p^*, S) + g_{ij}(\alpha_p^*, S)E_{ij} + \frac{1}{2!}g_{ijkl}(\alpha_p^*, S)E_{ij}E_{kl}$$

$$+ \frac{1}{3!}g_{ijklmn}(\alpha_p^*, S)E_{ij}E_{kl}E_{mn} + \ldots + \lambda_{ij}G_{ij} + \lambda_{ijkl}E_{ij}G_{kl}$$

$$+ \ldots$$

where

$$g(\alpha_p^*, S) = K_{ij}\alpha_i^*\alpha_j^* + \frac{1}{2!}K_{ijkl}\alpha_i^*\alpha_j^*\alpha_k^*\alpha_l^* + \ldots,$$

$$g_{ij}(\alpha_p^*, S) = \beta_{ij}(S) + b_{ijkl}\alpha_k^*\alpha_l^* + \frac{1}{2!} b_{ijklmn}\alpha_k^*\alpha_l^*\alpha_m^*\alpha_n^* + \ldots,$$

$$g_{ijkl}(\alpha_p^*, S) = C_{ijkl} + B_{ijklmn}\alpha_m^*\alpha_n^* + \ldots,$$

and

$$g_{ijklmn}(\alpha_p^*, S) = C_{ijklmn} + \ldots$$

The various phenomenological constants relate to physical properties and have been accordingly named. The following catalogues those material properties.

K_{ij}, K_{ijkl}	--	various order anisotropy constants
$\beta_{ij}(S)$	--	related to thermal strains
b_{ijkl}	--	first order magnetostrictive constants
b_{ijklmn}	--	Becker-Doring constants
C_{ijkl}	--	adiabatic elastic moduli
B_{ijklmn}	--	second order ME constants
C_{ijklmn}	--	third order elastic moduli
λ_{ij}	--	exchange constants
λ_{ijkl}	--	exchange striction constants

The number of independent elements in the property tensors is reduced by invoking symmetry requirements. They are thermodynamic symmetry which equates certain derivatives of the energy by interchanging the order of differentiation, crystal symmetry which is determined by operators of the crystal class of interest, and magnetic symmetry which is determined by the particular magnetic point group. The expression for cubic symmetry[30] (which includes YIG), correct to second order in magnetoelastic terms and third order in mechanical terms, is