3 No direct comparison of our results and the results of Budiansky and Vidensek can be established. The required conditions of similitude that we have indicated in the paper are not fulfilled. It is interesting, however, that both results show that the σ_2 stresses change very little from the elastic to the plastic state.

On the Boundedness of the Dimensionless Index of Performance of a Nernst Effect Generator[1]

J. M. HONIG.[2] Since the paper was submitted, there has been rapid progress in the area of Nernst-Ettingshausen energy-conversion studies; for this reason, a number of statements in the paper are now out of date and require revision. The most important of these concerns the case of "Strong Magnetic Fields and Extrinsic Materials." There is nothing wrong with the procedure as such; however, the derivation is unfortunately based on the use of equation (25) for the electronic contribution to the total thermal conductivity. This relation, derived by Bass and Tsidil'kovskii, is incorrect; it cannot be correlated with the thermodynamic expression for λ_{ec} obtained by Putley through straightforward manipulations of the fundamental phenomenological equations.

The discusser would like to offer the following alternative derivation which shows that, for the case under discussion, the upper bound on $\theta\bar{T}$ can indeed approach unity: Beginning with the results of Putley, Harman[3] has cited expressions for Q, λ, and ρ for a two-carrier model in terms of one-carrier transport coefficients and properties. We now impose the conditions (i) $\mu_e B$, $\mu_h B \gg 1$ and (ii) $n_e = n_h \equiv n$, both of which are consistent with the particular case under discussion. Then, the relations cited by Harman reduce to the form

$$Q = \mu_e\mu_h(|S_e| + |S_h|)/(\mu_e + \mu_h) \quad (1)$$

$$\lambda \equiv \lambda_l + \lambda_a = \lambda_l + ne\mu_e\mu_h T(|S_e| + |S_h|)^2/(\mu_e + \mu_h) \quad (2)$$

$$\rho = \mu_e\mu_h B^2/ne(\mu_e + \mu_h) \quad (3)$$

Accordingly

$$\theta T \equiv TB^2Q^2/\rho\lambda = [1 + 1/M]^{-1} \quad (4)$$

where

$$M \equiv ne\mu_e\mu_h T(|S_e| + |S_h|)^2/\lambda_l(\mu_e + \mu_h) \equiv \lambda_a/\lambda_l \quad (5)$$

Since all quantities in (5) are positive, the upper bound θT is precisely unity, this bound being attained in the limit $M = \lambda_a/\lambda_e \to \infty$. Thus, two-carrier, intrinsic materials subjected to very high magnetic fields, and fulfilling the requirement $\lambda_a \gg \lambda_l$ should exhibit unusually high indices of performance. One should note that $\lambda \approx \lambda_l + \lambda_a$ need itself not be small. Further detailed discussion is provided elsewhere.[4]

Requirement (ii) is more readily achieved with semimetals overlapping bands) than with intrinsic semiconductors. Requirement (i) means that materials for which μ_e or μ_h is less than $\sim 10^4$ cm^2/v-sec are not likely to be of commercial interest. At present, Bi, Bi-Sb alloys, HgTe, HgSe, gray Sn, Mg_2Pb, Cd_3As_2, and graphite would seem to be among the most promising materials. So far, only Bi and Bi-Sb alloys have been investigated; indices of performances exceeding 0.4 have been reported[5,6] for these systems.

Finally, the case "Strong Magnetic Field and Extrinsic Materials" is in need of discussion. Again, the results by Bass and Tsidil'kovskii as used in that section are partially in error. The correct transport coefficients for this case read[7]

$$Q = \frac{16k}{9\pi e}(\tfrac{1}{2} - r')\Gamma(3 - r')\Gamma(2 + r')/\mu B^2 \quad (6)$$

$$\lambda = \lambda_L + \frac{16}{9\pi}\frac{k^2T}{e^2}\sigma_0\left(r^2 - 2r' + \frac{13}{4}\right)\Gamma(3 - r')\Gamma(2 + r')(\mu B)^{-2} \quad (7)$$

$$\sigma = \sigma_0(9\pi/16)[\Gamma(3 - r')\Gamma(2 + r')]^{-1} \quad (8)$$

For the special case $r' = 0$ and in this approximation

$$Q^2B^2T/\lambda\rho \approx 1/13 \quad (9$$

Again, it should be pointed out that many of the items cited in this discussion were not available to the author during preparation of this paper. The discusser gratefully acknowledges many instructive conversations with Mr. T. C. Harman on the foregoing subject matter.

The nomenclature is the same as in the paper with the following additions:

S = Seebeck coefficient, μv/deg C
σ = electrical conductivity, ohm^{-1} – cm^{-1}
a = ambipolar (subscript)

Author's Closure

The foregoing corrections and additions are valuable contributions to the original paper. The author is indebted to Dr. Honig for providing his insight to the problem under discussion. The considerable thought and effort which he has devoted to this discussion are sincerely appreciated.

[1] By S. W. Angrist, published in the June, 1963, issue of the JOURNAL OF APPLIED MECHANICS, vol. 30, TRANS. ASME, vol. 85, Series E, pp. 291–294.

[2] Lincoln Laboratory, Massachusetts Institute of Technology, Lexington, Mass. (Lincoln Laboratory operated with support from the U. S. Army, Navy, and Air Force.)

[3] T. C. Harman, "Criteria for the Optimization of the Nernst Figure of Merit," *Journal of Applied Physics*, vol. 34, 1963, p. 13.

[4] T. C. Harman and J. M. Honig, "Nernst-Ettingshausen (Transverse) Energy Conversion," *Semiconductor Products*, July, 1963, p. 19.

[5] K. F. Cuff, R. B. Horst, J. L. Weaver, S. R. Hawkins, C. F. Kooi, and G. M. Enslow, "The Thermomagnetic Figure of Merit and Ettingshausen Cooling in Bi-Sb Alloys," *Applied Physics Letters*, vol. 2, 1963, pp. 145–146.

[6] T. C. Harman, personal communication.

[7] T. C. Harman, J. M. Honig, and B. M. Tarmy, "Galvano-thermomagnetic Effects in Semiconductors and Semimetals III. The Standard and Kane Band Models," *Journal of Physics and Chemistry of Solids*, vol. 24, 1963, p. 835.