magnetic moment and the presence of superconductivity (which excludes the presence of unpaired 4f electrons [16]) in alloys containing as much as 45 a/o Lu. These results and also other measurements made on different rare earth-rare earth alloys do not suggest a common band for the 4f electrons.

Perhaps the assumption that the $\gamma$ values given in Table I are representative of the electronic contribution to the specific heat is not correct. In order to deal with this possibility we shall examine the various contributions to the specific heat. The lattice contribution to the specific heat at low temperatures has a $T^3$ dependence, the nuclear $T^{-2}$ dependence* and the magnetic contribution can have either a $T^3$ dependence for an antiferromagnetic material or a $T^{3/2}$ dependence for a ferromagnetic substance. Rewriting Eqn. (1) as

$$C_p = C_v = \gamma T - BT^3 + CT^{-2} + DT^3 + ET^{3/2} \qquad (4)$$

where $D = 0$ for a ferromagnetic material, $E = 0$ for an anti-ferromagnetic substance, and $D = E = 0$ for a paramagnetic material. Of these contributions both the lattice and nuclear terms rest on sound theoretical grounds, but the magnetic contributions for these rare earth metals in view of their complex magnetic structures and possible Stark splitting of the ground states rest on very shaky ground. If the temperature dependence of one of four components of Eqn. (4) is incorrectly known, then the coefficients of the other terms will be incorrect. In view of the uncertainty of the magnetic contribution to the specific heats it would appear that the $\gamma$ values obtained from the low temperature specific heat data of the magnetic rare earth metals are unreliable. Since trivalent lanthanum, lutetium, scandium and yttrium and divalent ytterbium are weakly paramagnetic, [2] Eqn. (4) reduces to

$$C_p = C_v = \gamma T + BT^3 \qquad (5)$$

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* In some instances higher order terms, such as $T^{-3}$, $T^{-4}$, etc., must also be included.

for these metals and one would expect the $\gamma$ values for these five metals to be quite reliable. Indeed the mean value of $\gamma$ for the four trivalent metals is $24.8 \times 10^{-4}$, with a range from $24.1 \times 10^{-4}$ to $25.8 \times 10^{-4}$ cal/g-at. $\deg^2$.

Although this method for determining the density of states of the rare earth metals which have unpaired 4f electrons is not valid, there is, however, another method by which we can calculate the electronic specific heat constant (and thus the density of states) for these metals. This technique is described below.

## 4. ROOM TEMPERATURE SPECIFIC HEAT DATA

At room temperature $C_v^n$ contribution to the specific heat is negligible since it has a $T^{-2}$ dependence. $C_v^m$ contributes very little or nothing to the specific heat at room temperature since these metals, except gadolinium, are paramagnetic. Thus the room temperature specific heat is given by

$$C_p = C_v^l + C_v^e + C^d + C_v^f \qquad (6)$$

where the new term $C_v^f$ is the specific heat at constant volume due to the thermal excitation of 4f electrons from the ground state to the next higher level (s) of the 4f multiplet. The specific heat due to this contribution is given by

$$C_v^f = N\frac{d}{dT} \left[ \sum_J (2J + 1) E_J e^{-E_J/kT} / \sum_J (2J + 1) e^{-E_J/kT} \right] \qquad (7)$$

where N is Avogadro's number, J the total angular momentum quantum number, $E_J$ the energy levels of the multiplet, and k, Boltzmann's constant. For most of the natural occuring rare earth metals the $C_v^f$ contribution at 300°K is zero and can be ignored. But for cerium, praseodymium, neodymium, samarium and terbium the $C_v^f$ contribution at 300°K is not zero and must be included in our analysis. The $C_v^f$ contribu-