If we equate θ_R to θ_D then $\frac{d\ell n\,\theta}{d\ell n\,V}$ can be related to thermodynamic quantities; this was first noted by Gruneisen in 1926. The result is

$$-\frac{d\ell n\,\theta}{d\ell n\,V} = \frac{V\alpha'}{C_V K_T} = \gamma(V) \qquad (1)$$

where $\gamma(V)$ is the Gruneisen parameter, α' the volume coefficient of thermal expansion, K_T the isothermal compressibility and C_V the constant volume specific heat (Lennsen and Michels, 1935).

Values for the characteristic temperatures are obtained by fitting experimental data to the equations, using θ as an adjustable parameter to get the best fit. Values for θ_R come from fits to resistivity-temperature data and θ_D from heat capacity-temperature data (Gschneidner, 1964).

Let us consider the assumption $\frac{d\ell n\,\theta_R}{d\ell n\,V} = \frac{d\ell n\,\theta_D}{d\ell n\,V}$. Ziman (1960) notes that Bloch resistivity theory is derived assuming scattering by longitudinal phonons only. So for a solid fitting the Bloch model we would expect $\theta_R = \theta_L$ which might be quite different from θ_D. The fact that θ_R is within 1% of θ_D for silver ($\theta_R = 223°K$, $\theta_D = 225°K$) may imply that shear waves participate in electron scattering processes to the same extent that they do in thermal processes. Therefore, the assumption $\frac{d\ell n\,\theta_R}{d\ell n\,V} = \frac{d\ell n\,\theta_D}{d\ell n\,V}$ has some plausibility in the case of silver, and for the lattice vibration contribution

$$\left(\frac{d\ell n\,\rho}{d\ell n\,V}\right)_T = -2\,\frac{d\ell n\,\theta}{d\ell n\,V} = 2\,\gamma(V).$$

Several attempts have been made to get the pressure dependence of resistivity from wave-mechanical calculations. Lennsen and Michels (1935) started from Nordheim's formula for resistivity based on a rigid ion model for the potential field around a vibrating ion. For nearly free electrons they derived

$$\left(\frac{\partial \ell n\, \rho}{\partial \ell n\, V}\right)_T = 2\gamma(V) - 1 \qquad T \gg \theta \ ;$$

For $T \sim \theta$ this is modified to

$$\left(\frac{\partial \ell n\, \rho}{\partial \ell n\, V}\right)_T = \left(2 + \frac{\theta^2}{9T^2}\right)\gamma - 1 \ .$$

Using a tight-bonding approximation they derived

$$\left(\frac{\partial \ell n\, \rho}{\partial \ell n\, V}\right)_T = \left(2 + \frac{\theta^2}{9T^2}\right)\gamma + 1 \ .$$

According to Paul (1963), the rigid ion model is hard to justify physically, but it does give pressure dependences similar to that of other calculations. (See also review articles by Dugdale (1969) and Lawson (1956).)

2. A Semi-empirical Approach

Since an exact calculation is not practical (Ziman, 1965), a semi-empirical approach may be the best. Start from the expression

$$\rho = \alpha(V)T = A(V)\frac{T}{\theta^2(V)} \qquad (2)$$

where A is a catch-all parameter for the volume dependence of the band structure, Fermi geometry, Fermi energy, and details of the electron-phonon interaction and $\alpha(V)$ is the temperature coefficient of resistivity. Then,