with wave vector difference Q, represent the electron and hole Fermi surfaces, and the Coulomb attraction between electrons and holes is described by a single parameter V. Mathematically the model is very similar to the BCS model for superconductivity, and so is the resulting expression for the transition (Néel) temperature, which reads:

$$k_B T_N = E_B \exp(-1/\lambda), \tag{3}$$

where E_B is of the order of the band width and $\lambda = VN(0)$, $N(0)$ being the density of states at the Fermi level.

From the experimental results mentioned in the introduction [2,7] it is clear, that the effect of pressure and that of reducing the electron/atom ratio by alloying on the Néel temperature of Cr are very similar. In view of the result (3), this is not surprising: in fact α and β of eqs. (1) and (2) can be considered to be the first coefficients in a power-series expansion of $\lambda^{-1}(n, p)$.

Recently Rice et al. [14] devised a model, based on an assumption regarding the joint density of states function, which predicts the concentration and pressure dependence of T_N, eqs. (1) and (2), correctly. The joint density of states, a function of two energy variables, x and y, is defined as:

$$N_Q(x, y) = \sum_k \delta[x - \tfrac{1}{2}(\varepsilon_k^e - \varepsilon_{k+Q}^h)] \, \delta[y - \tfrac{1}{2}(\varepsilon_k^e + \varepsilon_{k+Q}^h)],$$

where $\varepsilon_k^{e(h)}$ is the single-particle energy in the electron (hole) band. If the two bands are identical, N_Q is almost independent of x and is proportional to $\delta(y)$. The model of Rice, Halperin, Barker and McWhan is defined by:

$$N_Q(x, y) = C_1\phi_1(y) + C_2\phi_2(y), \tag{4}$$

where $\phi_1(y)$ is sharply peaked at $y = 0$ and $\phi_2(y)$ has appreciable values only for $y > k_B T_N$. It has been shown [14], that if C_1 and C_2 vary linearly with the electron/atom ratio and pressure, eqs. (1) and (2), respectively, are obtained from (4).

The experimental results quoted above [2,7] can be considered to justify the model for N_Q, eq. (4). However, since the implications of the model regarding the band structure are not obvious, it is altogether not clear whether C_1 and C_2 are to be taken as constants plus linear combinations of n and p,

$$C = C_0 + C_n n + C_p p, \tag{5}$$

or: a "cross term" proportional to np is also allowed. In terms of the expansion of $\lambda^{-1}(n, p)$ in (3), the question reduces of that of the importance of the term:

$$\frac{\partial^2(\lambda^{-1})}{\partial n \partial p} \Delta np. \tag{6}$$

In the measurements of Trego and Mackintosh [2] and McWhan and Rice [7], the quadratic terms proportional to $\partial^2(\lambda^{-1})/\partial n^2$ and $\partial^2(\lambda^{-1})/\partial p^2$, respectively, were found to be negligible within the experimental error, but as in the experiments T_N was measured varying the electron concentration or the pressure, the importance of the cross term (6) cannot be ruled out by their evidence. It is only through the simultaneous variation of electron concentration and pressure that one can decide upon the importance of the term in eq. (6).
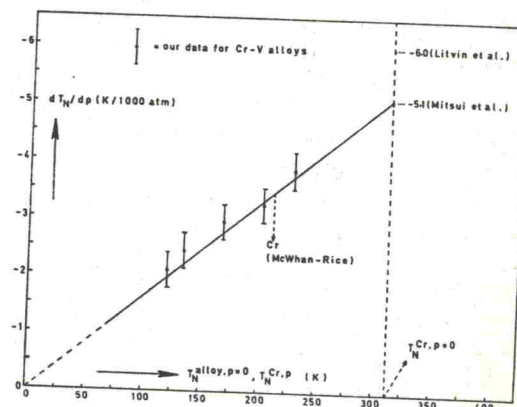

Fig. 5. dT_N/dp as a function of T_N (for Cr–V alloys in the limit $p \to 0$). The solid line represents the measurements of McWhan and Rice on pure chromium.

In fig. 5 we have plotted the slopes $(dT_N/dp)_{p\to 0}$, given in table I, versus the transition temperature T_N. The linearity of $(dT_N/dp)_{p\to 0}$ vs. T_N within the experimental error, together with the exponential dependence of T_N on concentration shown in fig. 3, proves that $(dT_N/dp)_{p\to 0}$ varies exponentially with concentration. This is what one expects from previous measurements [2,7]: uniting (1) and (2) in the most straightforward way we have

$$T_N^{alloy,p} = T_N^{Cr,p=0} \exp[\alpha(n_{alloy} - n_{Cr}) + \beta p],$$

and hence

$$(dT_N^{alloy,p}/dp)_{p\to 0} = \beta T_N^{Cr,p=0} \exp[\alpha(n_{alloy} - n_{Cr})] = \beta T_N^{alloy,p=0}.$$

Note that inserting a cross term of type (6) in the exponent, or, equivalently, allowing for the concentration dependence of β would contradict our experimental results. The slope of the straight line fitted to the points in fig. 5 gives thus β for all concentrations including pure Cr. The small scatter of our points around the line representing the results of McWhan and Rice [7],