

FIG. 1. The recorder traces of three typical superconducting transitions. (a) sample V2 at atmospheric pressure; (b) sample V2 at 8.5 kbar; (c) sample Nb2 at atmospheric pressure.

ture, similar to that shown in Fig. 1, in the initial stages of the superconducting transition. This structure is presumably associated with the presence of impurities or strains in the samples although it is also possible that it is a surface effect. Curves (a) and (b) are taken from measurements on the vanadium sample V2; curve (b) taken at 8.5 kbar exhibits the most extensive structure observed. Curve (c), on the niobium sample Nb2, was taken at atmospheric pressure and the transition remained essentially unchanged up to the highest pressure applied. In all cases the sharp, linear region of the transition curve was used to determine the superconducting transition temperature. This was taken, for both the warming and cooling cycles through the transition, as the temperature given by the intersection of the extrapolated normal trace and the extrapolation of the linear portion of the transition curve (see the dashed lines in Fig. 1). The mean of the two temperatures thus obtained has been taken as T_c .

Values of T_c for vanadium and niobium, as functions of pressure, are shown graphically in Figs. 2 and 3, respectively. The values of $\partial T_c/\partial P$ deduced from these plots for the different samples of each element agree within the limits of experimental accuracy. The mean value of $\partial T_c/\partial P$ for each element is given in Table II. The atmospheric pressure value of T_c , on the other hand, varies appreciably for the different samples of vanadium and niobium. This variation is again a

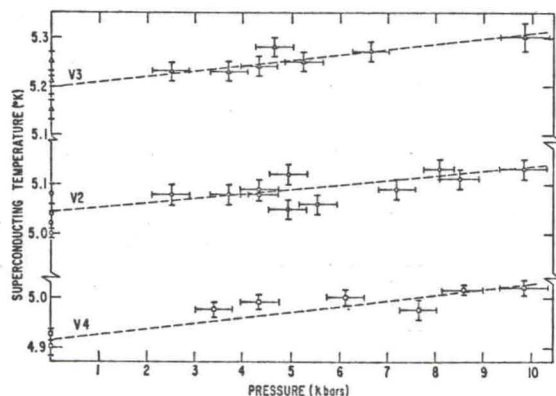


FIG. 2. The variation of the superconducting transition temperature of vanadium with applied pressure.

reflection of the difference in purity and the state of strain of the various samples. A similar insensitivity of the value of $\partial T_c/\partial P$ to the purity of the sample was also observed for tantalum, the remaining group VB element, by Swenson.³

It would be of interest to compare our observed values of $\partial T_c/\partial P$ for each element with the values determined from Ehrenfest's thermodynamic relationship for a phase change of the second kind,⁴

$$\left(\frac{\partial T_c}{\partial P}\right)_{H=0} = \frac{VT_c(\alpha_n - \alpha_s)}{C_n - C_s}, \quad (1)$$

where α and C are the volume thermal expansion coefficient and the specific heat in the normal (n) and the superconducting (s) states, respectively, measured at the superconducting transition temperature in zero magnetic field. Unfortunately, though experimental values of $C_s - C_n$ are readily available,⁵⁻⁷ there are no data for $\alpha_s - \alpha_n$. White⁸ expressed his thermal expansion data on vanadium, niobium, and tantalum in the nor-

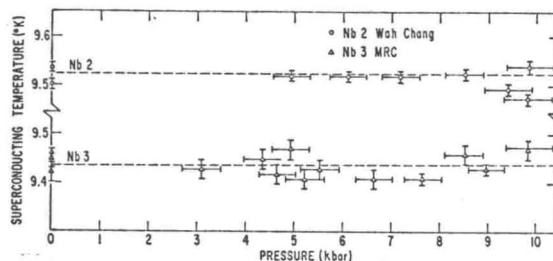


FIG. 3. The variation of the superconducting transition temperature of niobium with applied pressure.

mal and superconducting states in terms of $(\partial H_c/\partial P)$ calculated from the relationship,⁴

$$V_n - V_s = V_s \frac{H_c}{4\pi} \left(\frac{\partial H_c}{\partial P}\right)_T + \frac{H_c^2}{8\pi} \left(\frac{\partial V_s}{\partial P}\right)_T, \quad (2)$$

where $V_n - V_s$ is the difference in the volume between the normal (n) and superconducting (s) states. Unfortunately, due to a lack of reproducibility and to hysteresis effects, the volume change, $V_n - V_s$, could not be measured directly and, therefore, had to be estimated. He used calorimetric values of H_c in his calculations (except for tantalum) and his results are given

³ C. A. Swenson, in *Solid State Physics*, edited by F. Seitz and D. Turnbull (Academic Press Inc., New York, 1960), Vol. 11, p. 119.

⁴ See D. Shoenberg, *Superconductivity* (Cambridge University Press, Cambridge, England, 1960) for derivations of the necessary thermodynamic relationships.

⁵ W. S. Corak, B. B. Goodman, C. B. Satterthwaite, and A. Wexler, *Phys. Rev.* 102, 656 (1956).

⁶ D. White, C. Chou, and H. L. Johnston, *Phys. Rev.* 109, 797 (1958).

⁷ C. Chou, D. White, and H. L. Johnston, *Phys. Rev.* 109, 788 (1958).

⁸ G. K. White, *Cryogenics* 2, 292 (1962).