velocity measurements in the alkali metal show a larger spread of values than is usual in metals, presumably because of the difficulty in measuring shear wave velocities near the melting temperature of a metal (see I for reference to sonic data). This problem is particularly severe for Rb in which shear wave have only been measured below 200°K. The shock data listed is obtained in the usual way[2] from a linear fit to shock velocity measurements.

For Na and K there is an acceptable, if somewhat poorer, agreement between sonic and shock moduli in view of the spread of the sonic data for Na. The static moduli reported in I are also consistent. In Li there is a larger discrepancy between shock and sonic data and a comparable spread between the shock data listed and two other available sets of shock wave data[6]. However, because of the smallness of the thermal corrections and the larger uncertainty in this low pressure data on Li, we shall not attempt to resolve these discrepancies. A much larger discrepancy exists between the extrapolation adiabatic modulus of Rb from shock data and the statically measured value. The sonic values extrapolated from low temperature data also indicate that the shock modulus is too small. In as much as the static modulus was measured to be the same in two very different static apparati in I, and is the only one of the three types directly measured, we must assume the static modulus to be correct. The larger disagreements between various measured values of the pressure derivatives of the bulk modulus, the B' in Table 1, are typical of the differences for normal metals[2].

The implication of the Rb discrepancy is that the extrapolation of shock data to zero pressure is incorrect in this case. The lowest shock data points for Rb which are shown in Fig. 1 also appear to deviate systematically from the single linear fit which is made to the entire range of the Rb shock data. For this reason, the initial compressibility

data of I has been transformed into the shock-particle velocity plane (i.e., the $U_s - U_p$ plane) and is shown together with shock data points in Fig. 2. A best fit to this data is clearly a non-linear $U_s - U_p$ relation. It would be desirable to confirm this non-linearity by further shock velocity measurements at low pressure.

The upward curvature of the $U_s - U_p$ relation is only observed for metals in which there is a presumed change in electronic band structure. These effects have been discussed by Royce[7] as well as in [4]. In the latter reference, the authors actually included Rb in their collection of metals exhibiting electronic phase changes along the Hugoniot on the basis of an indication of a small amount of curvature in the original $U_s - U_p$ data on Rb.

3. DETERMINATION OF GRUNEISEN γ_G, FROM COMPRESSION DATA

By a simple subtraction at fixed volume it is possible to obtain an approximate average Gruneisen coefficient, $\overline{\gamma}_G$ between the
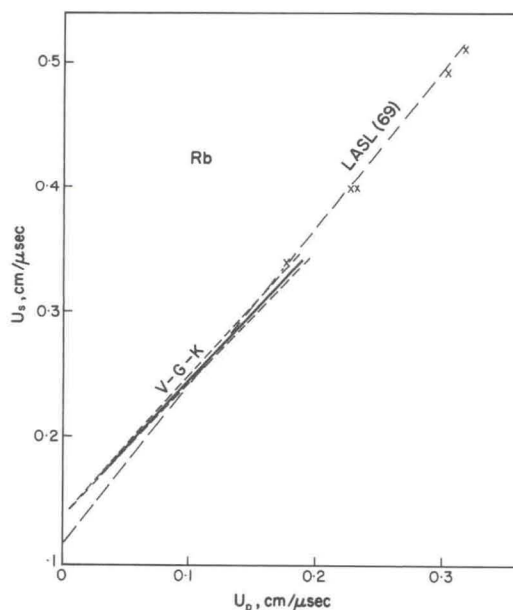

Fig. 2. Compression data in the shock velocity U-particle velocity U_p plane for Rb. x-individual shock points and fit from Ref.[5]. V-G-K-fits to static data from I.

Hugoniot and the static isotherm. The average $\bar{\gamma}_G$ is determined from Hugoniot and isothermal pressures, P_H and P_{T_0}, and internal energies, E_H and E_{T_0} according to

$$\bar{\gamma}_G(V) \equiv \frac{V[P_H(V) - P_{T_0}(V)]}{E_H(V) - E_{T_0}(V)}. \quad (1)$$

$P_H(V)$ and $E_H(V)$ can be calculated directly from measured shock velocities by standard conservation equations. $E_{T_0}(V)$ can be calculated from $P_{T_0}(V)$ if the Mie-Gruneisen equation-of-state is assumed for the solid.

$$E_{T_0}(V) = \int_V^{V_0} P_0(V)\,dV - 3RT_0 \int_V^{V_0} \gamma_G(V)\frac{dV}{V}. \quad (2)$$

In principle $\gamma_G(V)$ can be calculated from compressibility data in the solid phase by an iterative solution of equations (2) and (1). However, at larger compressions the contribution of the second term in the right hand side of (2) becomes small and the solution is considerably simplified by making an approx-imate guess for $\gamma_G(V)$ in the integral. On the other hand at small compressions equations (1) and (2) are equivalent to determining $\gamma_G(V)$ from the difference between the initial adiabatic and isothermal bulk moduli. Clearly the moduli in Table 1 are not sufficiently reliable. For this reason we have used, as a first guess, a γ_G equal to its initial value (see Table 1) in equation (2) in order to calculate a γ_G at maximum compression from equation (1). A constant γ equal to the average of these two was then used in (2) to evaluate the final $\gamma_G(V)$ by equation (1). The resulting $\gamma_G(V)$ for Na and K over a restricted range of high densities is shown in Fig. 3. For Rb the necessary shock data below 45 kbar is unavailable as argued above. Therefore, a calculation of γ_G at the lowest shock points around 54 kbar (see Fig. 1) was done ignoring the second term of equation (2) giving a $\gamma_G \sim$ 0·25. The uncertainty even at large compression in the calculated γ_G for Na and K are large, $\sim \pm 20$ per cent, due to the subtraction of pressure and energy data in equation (1).
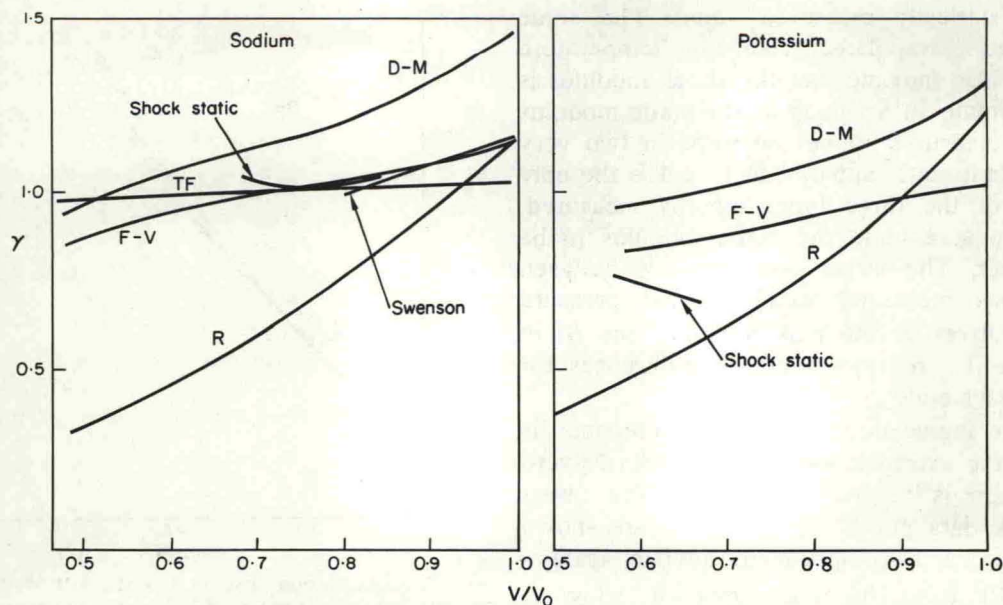

Fig. 3. Comparison of shock-static values of the Gruneisen coefficient with theoretical estimates discussed in Ref.[3].