in pressure (at 30.6 kbar) when Composition B-3, for example, is compressed to 86% of its original volume.

The experimental Hugoniot, from Eqs. (1), (2), and (5) is

$$P=A^2(V_0-V)/[V_0-B(V_0-V)]^2, \quad (6)$$

and the bulk modulus is

$$-V\frac{dP}{dV}=\frac{-A^2(V/V_0)\{1+B[1-(V/V_0)]\}}{V_0\{1-B[1-(V/V_0)]\}^3}. \quad (7)$$

The compressibility coefficients, computed from Eq. (7), are diagramed in Fig. 10 as a function of decreasing

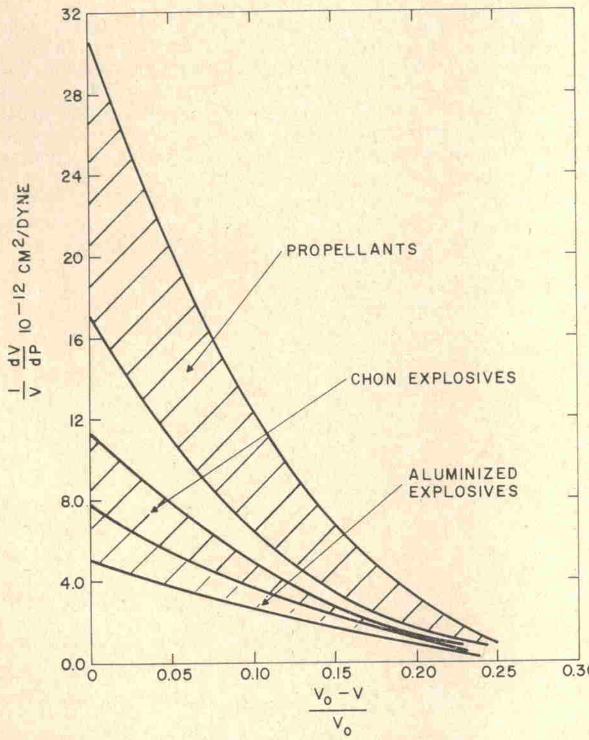

FIG. 10. Compressibility vs relative volume of CHON explosives, aluminized explosives, and propellants.

specific volume (increasing pressure). The two curves of lowest initial compressibility, $(1/V_0)(dV/dP)$, (5 to 8×10^{-12} cm²/dyn) show the range of data for the aluminized explosives HBX-1, HBX-3, and H-6. All solid CHON explosives with initial densities ≥98% of crystal density probably are within the range of the second set of curves. Composition B-3, e.g., has an initial compressibility of 8.1×10^{-12} cm²/dyn; TNT, 10.9×10^{-12} cm²/dyn; and TNB, 11.3×10^{-12} cm²/dyn. The composite and double-base propellants are easily compressed and form the upper range of data with initial compressibility coefficients of 17 to 31×10^{-12} cm²/dyn.

Finally, it is of interest to determine the peak (spike) pressures ahead of the detonation front in the explosives according to von Neumann's theory. We have obtained

TABLE IV. Detonation parameters of several explosives.

Explosive	P(spike) (kbar)	P_{C-J} (kbar)	D (mm/μsec)
TNT	237	189	6.81
TNT[a]	327	210	6.99[b]
Composition B-3	382	283	7.95
DATB	336	251	7.60
TATB	340	259	7.66
H-6	360	245	7.40
HBX-3	370	206	7.53
TNA	235	176	7.00
TNB	307	219	7.27

[a] See Ref. 3.
[b] See Ref. 28.

these pressures by a linear extrapolation of the U_s-vs-u_p data and the assumption that our U_s-vs-u_p relations represent nonreactive Hugoniots to the detonation velocities of the explosives. The P-vs-V/V_0 curves obtained from the extrapolation show the complete shock Hugoniot for the unreacted explosive, if one assumes that the linear U_s-vs-u_p relation holds all the way up to the spike pressure. On the basis of von Neumann's model of a plane detonation, the intersection of this

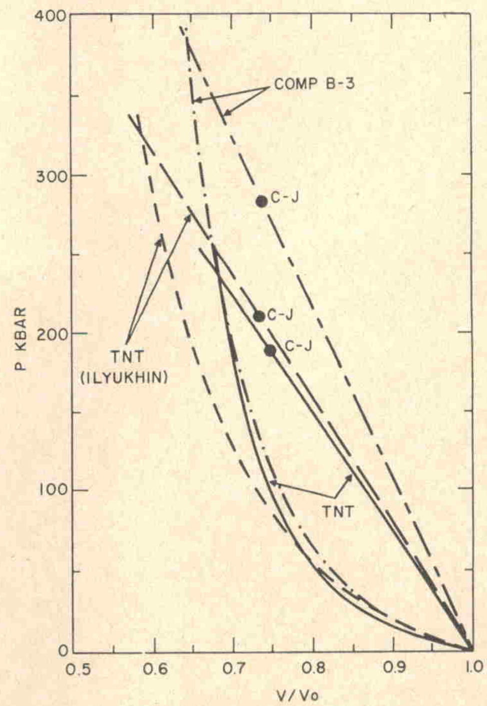

FIG. 11. The shock Hugoniots for nonreacting TNT and Composition B-3, extrapolated to the von Neumann spike pressure.

Hugoniot curve with the Rayleigh line[26] will yield the von Neumann spike pressure. The Rayleigh line is the straight line on the P-vs-V/V_0 plane, of slope $-\rho_0 D^2$, passing through the point (0, 1). (D is the steady-state detonation velocity of the explosive.) By means of this procedure the spike pressures listed in Table IV were obtained.

Our data show that the spike pressure exceeds the Chapman–Jouguet (C–J) pressure,[27] e.g., by 35% in Cast Composition B-3, and by 25% in Cast TNT. However, the second set of TNT data, Ilyukhin,[3] gives a spike pressure some 55% greater than 210 kbar, the pressure considered correct by Ilyukhin for the C–J point. Despite the differences[28] in P_{C-J} (and D), the principal discrepancy in the two sets of data is due to the differences in the measurement of the dynamic compressibility of TNT as shown in the Hugoniot curves of Fig. 11. This discrepancy indicates a need for further refinement in the experimental techniques in order to increase the accuracy of such measurements.

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[26] The conservation relations, Eq. (1) and (2), yield the equation $P=\rho_0 U_s^2[1-(V/V_0)]$. von Neumann's analysis shows that the straight line on the P, V/V_0 plane satisfying this equation (the Rayleigh line), where U_s is replaced by D, intersects the shock Hugoniot of the unreacted explosive at the spike pressure point.

[27] N. L. Coleburn, Naval Ordnance Laboratory Technical Report 64-58 (1964).

[28] Ilyukhin's data were obtained with *cast* TNT. The D value he used is that of *pressed* TNT. See M. J. Urizar, E. James, Jr., and L. C. Smith, Phys. Fluids **4**, 262 (1961). Our data indicate that the detonation velocities of *pressed* and *cast* TNT are statistically different for equal initial densities < crystal density (1.654 g/cm^3). However, the differences in detonation velocities do not account for the discrepancy between Ilyukhin's value and our value for the spike pressure of TNT.