FIG. 1. Force *vs.* extension.

orientation, the geometry of grain boundaries, and other structural factors.

Under certain conditions the material may react like a "perfectly elastic body" whereas under other conditions it may react like a "viscous liquid." In general our material will be found to behave in some intermediate manner for which several words have been coined such as "elastico-viscous," "firmo-viscous," and even "elastic flow."

Some other phenomena which must also be correlated are: Strain hardening (work hardening) an effect for which yield stress increases with strain; and elastic afterworking. The stress is also found to vary with rate of deformation; for liquids the stress-flow rate slope is a constant related to the coefficient of viscosity. The type of deformation may also vary with the speed of loading and a "ductile" or "malleable" substance may, under certain conditions of rapid loading, behave as a "brittle" substance. Again "aging," which is presumably a slow transition toward a more stable state, is observed as a change of yield stress with time. A similar phenomenon may be observed in glass which although breaking readily along a fresh scratch does this with more difficulty after a lapse of time and eventually will no longer break cleanly along the scratch.

THE ENERGY FUNCTIONS

The current electrical theory of intercrystalline bonding forces is based essentially on an electrostatic model. The electrostatic potential φ at a distance r will include the sum of charge potentials proportional to r^{-1}, of dipole potentials proportional to r^{-2}, of quadrupoles proportional to r^{-3}, of octupoles proportional to r^{-4}, and so on. There are also additional terms arising from interactions, induction and dispersion effects. For example the character of the van der Waals forces has been correlated with polarization forces (always attractive) produced by quadrupoles on molecules which are regarded as deformable distributions of charge; the potential from this effect is proportional to r^{-8}. These forces have also been correlated with the polarization of one molecule by the time varying dipole moment of another; these interaction potentials have been computed as proportional to r^{-6}, with also terms of higher order as r^{-8} and r^{-10}.

From quantum-mechanical considerations the repulsive potential is given by the encroachment energy from overlapping wave functions of the atoms and expressible, to fairly high pressures, by an exponential[1] term. The Thomas-Fermi atom model has been suggested and applied[2] to calculations of densities at very high pressures, i.e., exceeding 10^6 bars (1 bar $= 10^6$ dynes cm^{-1}).

The force field is given by the negative gradient of the electrostatic potential. Our present purpose will be satisfied by noting that we can write the attractive force F on a particular element in the form

$$F = \sum_i C_i r^{-i} - \sum_j C_j r^{-j}, \qquad (1)$$

where the C_i and C_j are, in general, complicated functions of space and direction. The derivative of F with respect to r/r_0 will denote the reciprocal of the linear compressibility, assuming linear symmetry. Volume cannot be arbitrarily substituted for r^3 because of asymmetry with respect to the space coordinates.

The coefficients C_i and C_j cannot, in general, be directly determined or computed; we may, however, expect to learn something of their respective importance from studies of deformation under high hydrostatic pressure. Initial compressibilities have been computed for some

[1] P. M. Morse, Phys. Rev. 34, 57–64 (1929).
[2] J. C. Slater and H. M. Krutter, Phys. Rev. 47, 559–568 (1935). H. Jensen, Zeits. f. Physik 111, 373–385 (1938).