

the region corresponding to zero compressive stress, i.e.,

$$\zeta(T, \pi, p) = \zeta'(T, p), \quad (7)$$

the prime referring to the liquid phase, then the solid would melt to the liquid phase at  $(T, p)$  provided the stressed region is permeable to, i.e., not be active on, the liquid.

The thermodynamic potential is defined by the expression

$$\zeta = \psi + \pi r \quad (8)$$

and  $\partial\zeta/\partial\pi = r$ .

A schematic plot of  $\zeta$  as a function of  $r$  at the *stressed face* is given in Fig. 3.  $\zeta$  will be observed to increase with increasing compression but to decrease with increasing tension until it reaches a minimum,  $\zeta_0$ , at  $r_m$ . At the *free face*  $(\zeta)_{FF} = (\psi_0)_{FF}$  and thus at this face  $\zeta$  increases with  $\psi_0$  for both tension and compression. It should perhaps be emphasized that in the direction at right angles to the stress  $\psi$  is always at its minimum value on the curve which however changes by virtue of the change in our expression for  $F$ .

The use of the terms "liquid" and "melting" may seem confusing and should perhaps be amplified. The process of the two-phase transfer type of mechanism suggested here involves the transition from an immobile solid phase to a mobile phase and thence back again to the solid. The mobile phase should more aptly be called the "fluid" phase and includes not only the condition ordinarily accepted as melting but also any other similar mechanism such as the one known as "migration of lattice points" and diffusion. To make this point somewhat clearer the creep relations will be derived later for a solid in contact with a liquid in which it is slightly soluble and, for this case, the fluid phase is the solution.

We have then two possible mechanisms to transport our system into the region of lower internal energy—one by snapping the cohesive bonds, determined by the strain energy potential; and the other by transition to, and flow of, a fluid phase, solid→fluid→solid; this is determined by the thermodynamic potential relations. The "fundamental strength" of our material is therefore not only a function of the strain energy

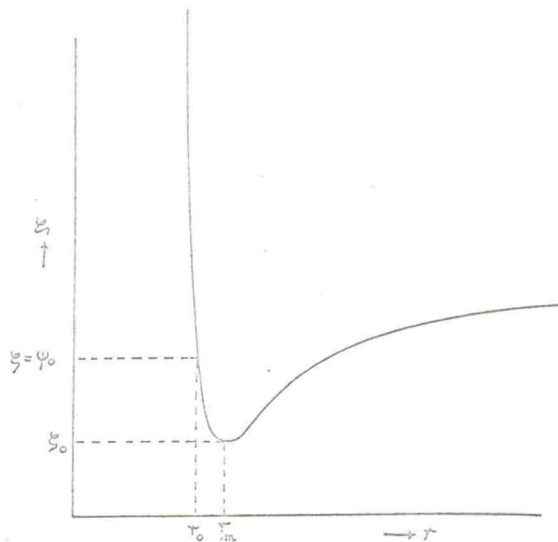


FIG. 3. Free energy for the stressed face vs. extension.

potential but also of the thermodynamic potential.

The internal energy of the system is merely a statistical mean of the lattice point energies and, on any surface, elements will be found with energy levels exceeding the mean value. The lattice structure is also more or less distorted because of impurities and other irregularities with resulting non-uniform stress distribution. Phase change is initiated at such regions of localized high energy values and results in still further localization of high stress areas. The process therefore tends to accelerate until the concentration of strain energy becomes too high to be borne by the remaining bonds and the specimen fails by shear, a combined "fluid" and "brittle" release.

An increase in compressive load thus acts similarly to an increase in temperature with respect to our "two-phase" mechanism. Phase change is initiated at, and proceeds from, loci of high energy levels at a finite rate, and not as an instantaneous disintegration of the lattice configuration. The time gradient of energy interchange set up by change in the external conditions is also an important factor. The transfer of thermal energy will lag behind that of strain energy. This is evident from explosive phenomena wherein the rotational and vibrational energies can be observed to lag behind the translational energy.