$$P_{AA}\bar{g}_{AA}x^2 + 2P_{AB}\bar{g}_{AB}x(1-x) + P_{BB}\bar{g}_{BB}(1-x)^2$$

where the constants are appropriate to reactions between the various pairs of species. (In general, higher terms in x are necessary in $\overline{pg}$, to account for interactions with all neighbors, or where phase transformations are involved.) As a criterion of hardness that will show the same dependence upon alloy composition as Brinell number, we may take that value of stress necessary to produce a certain standard velocity of deformation $\frac{ds}{dt} = \lambda v_{\text{net}}$; for which velocity we choose the convenient value $4\lambda\bar{v}$, where λ represents the average deformation occurring with each elementary slip process. For the high local stresses associated with Brinell impressions, we replace $\sin h p\bar{b}\overline{m}\sigma$ by ½ exp $p\bar{b}\overline{m}\sigma$ in equation (3) and obtain

$$\sigma = \frac{P_{AA}\bar{g}_{AA} + P_{BB}\bar{g}_{BB} - 2P_{AB}\bar{g}_{AB}}{\bar{b}} x^2 + 2 \times \frac{P_{AB}\bar{g}_{AB} - P_{BB}\bar{g}_{BB}}{\bar{b}} x + \frac{P_{BB}\bar{g}_{BB}}{\bar{b}} \qquad (4)$$

where σ is taken to be a linear function of Brinell number.

The intimate similarity between this mechanism of plastic flow and that of electrical conductivity cannot be overlooked. In a very simple model for the latter, current is proportional to the average frequency with which electrons pass the electrostatic barriers offered by quasi-crystalline fields in the regions between adjacent atoms. Neglecting slight geometrical considerations, plastic slip of one atom past another constitutes a "relative current" of th's same type; accelerating voltage being provided by the fields of displaced atomic kernels in one case, and externally applied in the other. It is to be expected that equation (3) may, therefore, also give a qualitative account of rate of current flow if the relative energy of barrier lowering, $\overline{m}bp\sigma$ in the plastic flow case, be replaced by $eb'\varepsilon$ where e and ε represent the electronic charge and applied field, and b' is a constant related to $\bar{b}$. Since the applied fields are small in comparison to those atomic fields encountered in plastic flow, the sin*h* factor in (3) may now be expanded, as well as the exponential factor. Absorbing the $\overline{mp}$'s into the g's, we get for the resistivity R of an alloy,

$$R = \frac{\varepsilon}{J} = \frac{(g'_{AA} + g'_{BB} - 2g'_{AB})x^2 + 2(g'_{AB} - g'_{BB})x + g'_{BB} + 1}{8Ne^2l\nu'b'}, \qquad (5)$$

where N is the effective density of electrons, l the mean path length between barrier collisions, and the primed constants are related to those unprimed, above. Temperature dependence arises in the integration of parameters.

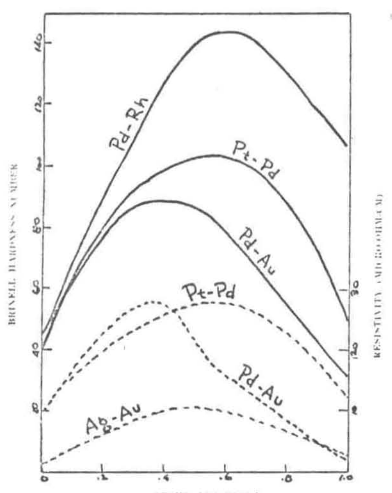

FIG. 1 (3).

In Fig. 1 is sketched the experimental variation of Brinell hardness with composition (solid lines) for some binary systems of similar elements, and of resistivity (dashed lines), (all taken from R. F. Vines (4) except Ag-Au curve, from Mott and Jones). The pure states of the first-mentioned elements are on the left in the diagram. The parabolic character predicted by equations (4) and (5) is evident, as well as the similarity of hardness and resistivity curves for the systems Pt–Pd and Pd–Au.

Magnetism, another phenomenon to which the "relative current" principle may be applied, will be treated elsewhere.

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Quantum-Theoretical Densities of Solids at Extreme Compression

Walter M. Elsasser

Department of Physics,
University of Utah, Salt Lake City

In no way, perhaps, is a new theory more apt to show its power and range than in extrapolation and prediction related to phenomena previously inaccessible. One example of this, applied to quantum mechanics, is the computation of the behavior of matter under extreme pressures and temperatures, particularly the well-known applications to the interior of the stars. A less well-known example is furnished by similar applications to the interior of the earth.

In recent years, Bridgman (1) has succeeded in determining the densities and compressibilities of a large number of elements and compounds up to a pressure of 100,000 atmospheres. All his values for elements and a few selected ones for compounds are plotted on the left-hand side of Figs. 1–3 in a double-