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

where the constants are appropriate to reactions between the various pairs of species. (In general, higher terms in x are necessary in $p\bar{g}$, 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 $\sin h p\bar{b}\bar{m}\sigma$ by ½ exp $p\bar{b}\bar{m}\sigma$ 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, $\bar{m}bp\sigma$ 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 $\bar{m}p$'s into the g's, we get for the resistivity R of an alloy,

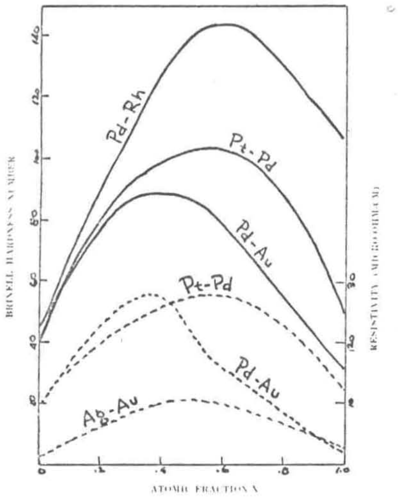

FIG. 1 (*3*).

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

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.

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

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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-

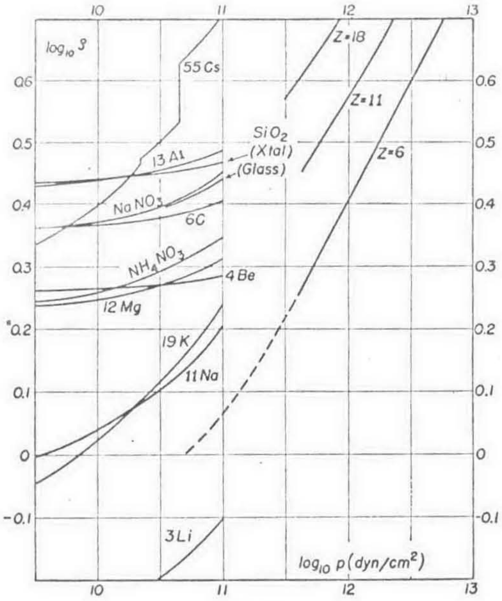

FIG. 1.

logarithmic diagram. The curves on the right are obtained from quantum theory. They are based on a Thomas-Fermi-Dirac model of the electronic density in a closest packed, cubic, monatomic lattice. The curves have been drawn mostly on the basis of the computations of Feynman, Metropolis, and Teller (*2*); some use has also been made of the earlier results of Slater and Krutter (*3*), and of Jensen (*4*). These curves contain only one parameter, the atomic number, *Z*, of the constituent element. All available theoretical evidence indicates that the curve should be reasonably accurate at pressures of a few million atmospheres and above, beginning at somewhat higher pressures for the lighter, and at somewhat lower pressures for the heavier, elements. It is fairly easy to interpolate between the measured values at low pressures, and the limiting computed values at very high pressures; the resulting uncertainty in determination of the true density should hardly exceed 15–20% anywhere.

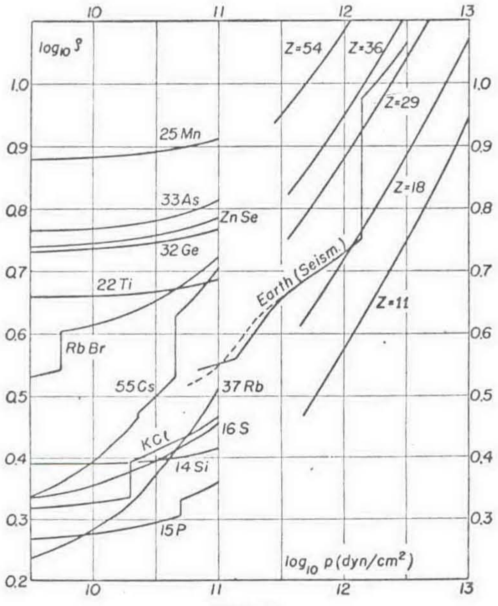

FIG. 2.

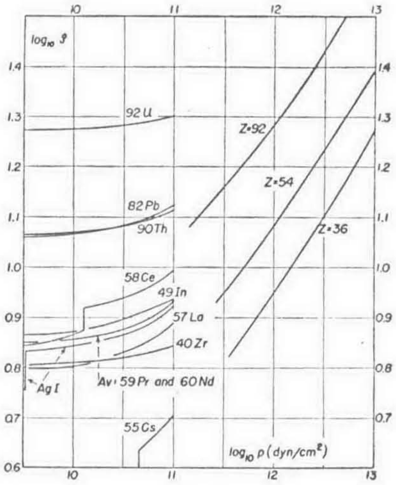

FIG. 3.

These densities refer to zero temperatures, but, at a pressure of a million atmospheres and above, the internal energy of compression is so large that thermal energies are negligible in comparison, up to a few thousand degrees. Correspondingly, the expansion at melting is very small at these pressures, and the curves should also be applicable to such substances as molten iron, assumed to exist in the earth's core.

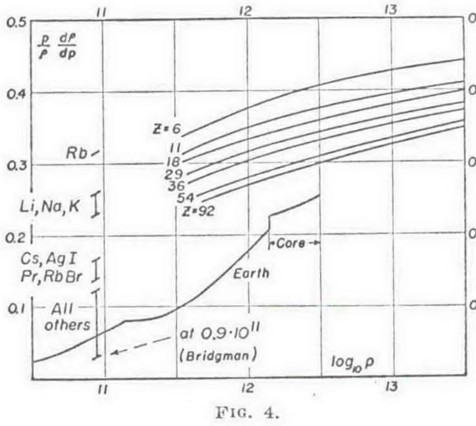

FIG. 4.

In Fig. 2 there also is shown a curve, representing the density variation inside the earth, computed by Bullen (*5*) from seismic data. The dashed part shows a modification proposed by Gutenberg (*6*). It is seen that the curve corroborates the usual assumption that the earth's outer part, the mantle, consists mainly of silicates, whereas the central part, the core, consists of iron. It is extremely difficult to reconcile this curve even qualitatively with any other assumption about the earth's constitution that is consistent with the known cosmic abundance data of the elements (*7, 8*). In particular, the assumption of Ramsey (*9*) that the earth's core consists of silicates seems to be excluded, and still more so the sugestion that the earth's interior contains large amounts of compressed hydrogen.

Fig. 4, finally, shows the quantity $d \ln \rho / d \ln p$, essentially the compressibility, as a function of the pressure. The figure conveys the suggestion that Bullen's values for the earth might have to undergo some slight adjustments to agree better with the curves obtained by joining the experimental data to the high-pressure part of the theoretical data.

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News and Notes

The International Oxford Conference on Nuclear Physics

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THE INTERNATIONAL NUCLEAR PHYSICS CONFERENCE took place in historic Oxford last September 7–13. Sponsored by the British Ministry of Supply, it was organized—and excellently so—by the British Atomic Energy Research Establishment (AERE). About 200 physicists participated; half of them came from British universities, about 30 from AERE itself, nearly as many from America, and approximately 40 from the European continent. Pontecorvo's name was in the list of participants, but actually he was not present. There was no direct delegation from behind the Iron Curtain.

Most of those who came alone were housed in Brasenose College, Oxford; the couples were pleasantly quartered in the country in a palatial house provided by the Ministry of Supply. A guided tour through the AERE Laboratories at Harwell made a deep impression on many of us. In spite of the very much smaller funds at the disposal of the British counterpart of the U. S. Atomic Energy Commission, and in spite of the shorter history of the British atomic energy program, one sensed the stability of the organization, the permanency of the installation, and the well-settled personal relations within the AERE Laboratories. The scientific and technical accomplishments of the Harwell Laboratory are quite impressive. It was also refreshing to find its director, Sir John Cockcroft, participating in the whole conference.

The principal subjects of the conference were high-energy physics, physics of light nuclei, reactor physics, and theory. Naturally this summary will be only illustrative of the subjects discussed and can cover only a few examples to show the type of results presented. Not even examples will be given of the discussion of experimental techniques and apparatus.

Several new and important results were announced on the high-energy program. Moyer described the experiments (Steinberger and Bishop, Berkeley) which led to the discovery of the neutral π meson. The mass of this particle is slightly lower than that of the charged π mesons; it is about 265 against 275 electron masses. Evidence was presented that its lifetime is very short: in about 2×10^{-13} seconds it disintegrates into two light quanta. Experiments proving the existence of the neutral π mesons and their disintegration were presented also by King (Bristol).

New data were presented also on the high-energy proton-proton and proton-neutron scattering, originating in Berkeley, AERE, Rochester, and Harvard. The cross section for a collision between a neutron and a proton is considerably smaller than that for a collision between two protons. The latter cross section seems to depend very little on energy in the high-energy region, and the collision appears to be spherically symmetric. Its absolute value is around 4.5×10^{-27} cm^2 per unit solid angle. These data were discussed by Pais (Princeton) from the theoretical point of view. He showed that, assuming a spin-orbit type of interaction, it is possible to explain the data in such a way that the interaction is, fundamentally, the same between a proton-neutron and a proton-proton pair. The difference in the actual cross section arises from the Pauli exclusion principle (Case and Pais).

Professor Blackett (Manchester) presented evidence for mesons of about 800 electron masses.

Level schemes for several nuclei, including Li^7, Be^7, O^{16}, C^{13}, and O^{17}, were presented in the session on light nuclei. Some of these apparently showed remarkable regularities which are not understood. Extensive data were given also on the reactions of the various hy-