can now write an expression for the adiabate of shock compression from a state with the initial volume $v_{00} \geq v_0$. Solving (13) with respect to P_H, we obtain

$$P_H(v_{00};\ v) = -\frac{(h-1)\,\partial E_c / \partial v + 2E_x / v}{h - v_{00} / v}$$

$$= \frac{(h-1)\ P_c - 2E_c/v}{h - v_{00}/v}\,. \qquad (17)$$

The curve P_c of cold compressibility, the experimental adiabate of solid iron (9) and the adiabate of porous iron with initial volume $v_{00} = 1.412\,v_0$ are compared in $P - v$ diagrams (Fig. 8). Thermal pressure plays a strikingly large part, especially in the shock compression of porous iron.

We note in conclusion that the equation of state (12) and the expressions that have been found for γ and E_c are valid in the region bounded by the curve for cold compressibility P_c and the shock adiabate of porous iron.

5. EXTRAPOLATION OF THE COMPRESSIBILITY CURVE OF IRON

The compressibility of matter at absolute zero can be studied by quantum statistical methods. However, the Thomas-Fermi and Thomas-Fermi-Dirac statistical models of the atom hold true only at very high pressures of hundreds of millions of atmospheres, when the electronic shells of the atoms are pressed together and lose their individual structure.[11]

At relatively low compression up to 2 or $3\rho_0$ statistical methods yield highly exaggerated values of the pressures. Figure 10 is a logarithmic plot for iron of density-pressure curves which were computed by the Thomas-Fermi method[11] and by the Thomas-Fermi-Dirac method,[11] with an exchange correction. According to Kompaneets and Pavlovskii,[13] the Thomas-Fermi-Dirac results are correct when the exchange correction is small, which undoubtedly occurs for compression close to $\rho = 8 - 10\rho_0$. The lower branch of the compressibility curve up to $\rho = 1.7\rho_0$ has been obtained experimentally by the present authors.

From a knowledge of the upper and lower portions of the function $P_c(\rho)$ we are able to interpolate it satisfactorily for the intermediate region from $\rho = 1.7\rho_0$ to $\rho = 8\rho_0$ (see the dashed line in Fig. 10). The same graph shows Jensen's interpolation,[14] which lies considerably above both the curve for P_c and the dynamic adiabate. The error in Jensen's curve resulted from the lack of experimental information on the compressibility of iron at pressures of several million atmospheres.

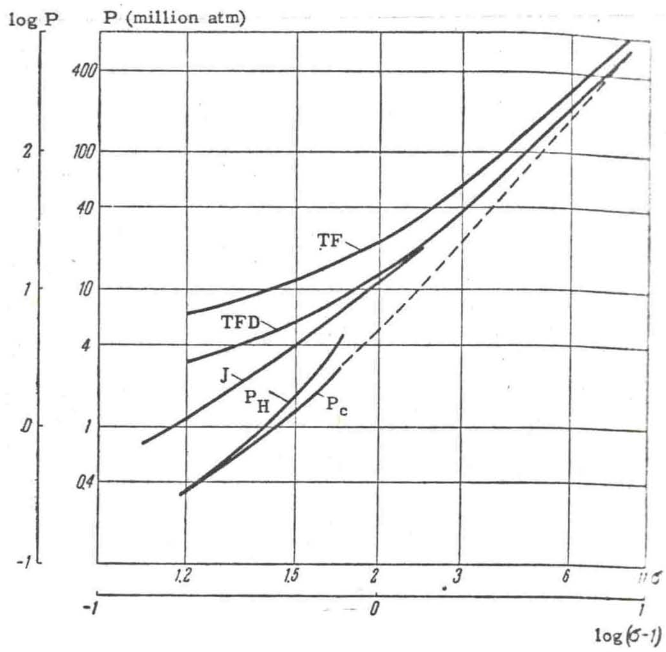

FIG. 10. Extrapolation of the compressibility curve at $T = 0°K$. TF was computed with the Thomas-Fermi model; TFD was computed with the Thomas-Fermi-Dirac model; P_c is an experimental portion of the isotherm $T = 0$; J is the isotherm $T = 0$ according to Jensen; P_H is the experimental dynamic adiabat. The dashed line is the extrapolated portion of the isotherm $T = 0$.

CONCLUSION

Dynamic methods of investigating compressibility greatly broaden the experimental possibilities in high pressure physics. Our deceleration method is especially promising since it enables us to perform measurements up to a few million atmospheres of pressure. We were thus able to determine the dynamic adiabate of iron with different initial densities from 4×10^5 to 5×10^6 atm.

The dynamic adiabate of porous iron with its reduced initial density lies considerably higher than the adiabate of the solid material in the pressure-density diagram. This is evidence of the large part played by the thermal components of the pressure in shock compression.

On the basis of our experimental findings, we have derived an empirical equation of state for iron and have obtained the cold compressibility curve up to densities $\rho = 1.7\,\rho_0$. The isotherm at $T = 0°$ has been extrapolated to pressures at which quantum statistical methods of computation are applicable.

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