IV. Effect of Pressure on Electrical Conductivity

We turn now to the problem of understanding how the electrical conductivity of a metal varies with pressure. We shall be concerned almost exclusively with the monovalent metals, i.e., the alkali metals on the one hand and the noble metals on the other. On the other hand, there have been recent important theoretical developments relating to the divalent metals (Vasvári and Heine, 1967; Vasvári *et al.*, 1967) stimulated largely by the experimental findings of Drickamer and co-workers (Stager and Drickamer, 1963; Drickamer 1965; see also the reviews by Lawson, 1956; Paul, 1963; and Landwehr, 1965).

A. Phonon–Scattering Processes

As a preliminary, let us consider briefly some of the mechanisms that give rise to electrical resistivity in metals. The electric current is carried by the conduction electrons, of which in the monovalent metals there are just one per atom. These electrons form a highly degenerate electron gas whose Fermi energy can be estimated on the assumption that the conduction electrons form a free-electron gas confined within the volume of a metal. The Fermi energy therefore depends on the atomic volume of the metal and varies from about 80,000° K in Cu to about 20,000° K in Cs (both at normal pressure). We see therefore that even at room temperature the zero-point kinetic energy of the electrons is very large compared with a typical thermal energy kT.

At the absolute zero of temperature in a perfect lattice (i.e., a lattice free from physical or chemical imperfections) the conduction electrons may be thought of as waves propagating in a perfect periodic structure. Consequently they can travel without being scattered, and the metal would therefore have zero resistivity (this is not to be confused with the superconducting state which has quite different and distinct properties).

All real metals have some impurities or physical imperfections, including boundaries, that limit the conductivity of the metal in its non-superconducting state. The resistivity that remains at the lowest temperatures and is independent of temperature is called the residual resistivity, ϱ_0. For very pure perfect metals, it can be made a very small fraction of the room-temperature resistivity; typically, in such pure metals, the ratio of room temperature to residual resistivity may be 10^4 or more.