ECTRICAL CONDUCTIVITY

rstanding how the electrical
ssure. We shall be concerned
metals, i.e., the alkali metals
the other. On the other hand,
retical developments relating
ne, 1967; Vasvári *et al.*, 1967)
l findings of Drickamer and
63; Drickamer 1965; see also
53; and Landwehr, 1965).

G PROCESSES

efly some of the mechanisms
metals. The electric current is
hich in the monovalent metals
rons form a highly degenerate
estimated on the assumption
e-electron gas confined within
rgy therefore depends on the
from about 80,000° K in Cu
al pressure). We see therefore
o-point kinetic energy of the
a typical thermal energy kT.
a perfect lattice (i.e., a lattice
ions) the conduction electrons
in a perfect periodic structure.
eing scattered, and the metal
his is not to be confused with
ite different and distinct prop-

or physical imperfections, in-
ductivity of the metal in its
ity that remains at the lowest
perature is called the residual
netals, it can be made a very
resistivity; typically, in such
erature to residual resistivity

The periodicity of the ideal lattice thus explains the vanishing of resistance in pure, perfect metals as the absolute zero is approached. The success of the picture in this respect has tended to focus attention on the periodic structure of metals even when their electrical conductivity at high temperatures is under consideration. As we shall see below, this is in some ways a mistaken approach and for high-temperature purposes this emphasis on the periodic lattice is not necessarily the most helpful.

In addition to the electrical resistivity that arises from the scattering of the conduction electrons by chemical impurities and physical imperfections there is also, at any temperature above the absolute zero, scattering due to the thermal vibrations of the lattice, i.e., to phonons. It is this scattering by phonons that gives rise to the temperature-dependent part of the electrical resistivity ϱ_{ph}. As a first approximation we assume that the total electrical resistivity, ϱ, at any temperature is given by:

$$\varrho = \varrho_{\mathrm{ph}} + \varrho_0 \tag{36}$$

This is known as Mattheissen's rule, and although a valuable generalization it is not strictly valid, and as we shall see below it can, in certain circumstances, give misleading information.

We turn now to a more detailed discussion of the scattering of electrons by phonons. Suppose that an electron of wavenumber k and energy E_k is scattered by absorbing a phonon of wavenumber, q, frequency ω and energy $\hbar\omega$ into a state k' of energy $E_{k'}$. Conservation of energy then requires that:

$$E_{k'} - E_k = \hbar\omega \tag{37}$$

We also require that:

$$k' - k = q + G \tag{38}$$

where G is a reciprocal lattice vector. This relationship is in some way analogous to conservation of momentum. When G is zero, we have a socalled normal process and when G is non-zero we have an Umklapp process. The Umklapp process (U-process, for short) can be interpreted in the following way. If $k' - k = G$, this means that the electron satisfies the Bragg condition for reflection from the lattice planes corresponding to the reciprocal lattice vector G; consequently, we may think of the scattering process, described by the process above, as implying that the electron is scattered by a phonon of wavenumber q