The field dependence of the magneto-resistance as a function of the orientation of a single crystal sample has been used by Russian workers to distinguish between open and closed electron orbits on the Fermi surface [28]. This method has been used to examine sodium and has led to the conclusion that the Fermi surface is closed.

These are the techniques used to determine the Fermi surface in metals. They require the use of single crystals and low temperatures and the results are difficult to interpret without some theoretical model of the Fermi surface. The alkali metals are relatively simple from the theoretical viewpoint, but are difficult for the experimenter to prepare and handle. In this case there is some information about the shape of the Fermi surface, which we expect to be nearly spherical, but unfortunately no direct experimental determination of the surface. There is, however, some indirect evidence as to the shape of the Fermi surface in the alkalis.

C. The Fermi Surface in the Alkalis - Experimental Evidence

As we have mentioned above, the magneto-resistance data on single crystals can be used to make some deductions about the shape of the Fermi surface. In the case of the alkalis the available data are almost exclusively on polycrystals and do not give the magneto-resistance coefficients directly. The only single crystal work is a measurement on sodium, where the single crystal nature of the sample was inferred from anisotropy in the transverse magneto-resistance, but not verified by X-ray data [29] and the Russian work mentioned before [30] which gives no detailed information. García-Moliner has undertaken to analyze the polycrystal data, taken in the range 4-20° K, in an effort to obtain some information about the shape of the surface [31]. He assumes that the scattering time is isotropic at low temperatures and that the wave vector at the Fermi surface can be expressed in an expansion in Kubic harmonics:

$$k = K_o(E_k) + K_1(E_k)\ Y_4(\theta,\phi) \qquad (I-2)$$

where $Y_4(100) = 1$, $Y_4(110) = -1/4$, $Y_4(111) = -2/3$. He defines the

parameters

$$A = (K_1/K_o)_{E_F} \qquad A' = (K'_1/K'_o)_{E_F} \qquad (I\text{-}3)$$

where the ' indicates the derivative with respect to the energy E_k, and E_F is the Fermi energy. Davis has calculated the transverse and longitudinal magneto-resistance for a Fermi surface of this type, assuming the current to be along a 100 axis [32]. García-Moliner uses these calculations to obtain an expression for the transverse magneto-resistance of a polycrystalline sample. Because Davis' calculations do not give the three magneto-resistance coefficients for single crystals directly, but rather those combinations of them which give the transverse and longitudinal magneto-resistance for current in the 100 direction, García-Moliner equates the calculated ratio of longitudinal to transverse (polycrystal) magneto-resistance to the experimentally observed value in order to get a relation between the three coefficients which allows him to use Davis' results. He also needs to assume a value for A'/A. With these assumptions he can calculate A, which expresses the warping of the Fermi surface, from the available data on polycrystals. His results are shown in Table 1-1, which tabulates a number of properties of the alkalis. The values for rubidium and cesium are uncertain, since the experimental information is inadequate for a reliable calculation. Because the anisotropy parameter A enters in the expression for the magneto-resistance as A^2, small differences in the anisotropy predicted by various band structure calculations cause large differences in the predicted magneto-resistance; this approach is used to suggest that the 1934 calculation of Jones and Zener gives the best fit to the experimental data for lithium [33]. Moliner gives the alkalis in order of increasing anisotropy as sodium, rubidium, potassium, cesium and lithium; although the relative order of the intermediate metals is not definite, the extremes of the series are well determined.

Since both sodium and lithium undergo martensitic transformations from the body centered cubic to the close packed hexagonal form in cooling to below hydrogen temperature, it is not clear that the low temperature magneto-resistance data on these metals are meaningful [34, 35]. Even if the approach used by García-Moliner gives a correct picture of the relative anisotropies of