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MAGNETIC PROPERTIES OF METALS AT LOW TEMPERATURES. IV. INFLUENCE OF HOMOGENEOUS COMPRESSION ON THE DE HAAS – VAN ALPHEN EFFECT IN ZINC CRYSTALS

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A method and apparatus have been developed to investigate the influence of homogeneous compression on the anisotropy of the magnetic properties of crystals at low temperatures. The angular dependence of the oscillation periods of the magnetic susceptibility of free zinc crystals due to the two smallest groups of mobile charges has been established. The effect of homogeneous compression at a pressure of 1700 kg/cm^2 on the period and amplitude of the oscillations due to the smallest group of mobile charges has been investigated. A large (40 to 48%) increase in the periods of these oscillations has been found for all values of the angle θ between the field vector and the direction of the principal axis. The homogeneous compression of the crystal is found to cause a strong decrease of the oscillation amplitude and a change in the temperature dependence of the oscillation amplitude. The experimental data are compared with the semi-phenomenological theory of the influence of deformations on oscillation effects in metals at low temperatures.

1. INTRODUCTION

THE homogeneous compression of crystals, or in other words, the homogeneous and large elastic deformation of the lattice, is one of the most direct methods of external action on the periodic electric field within the crystal, meaning also on the electronic properties of metals (conductivity, magnetic and galvanomagnetic phenomena, etc.)

For a long time experimental investigations of the effect of homogeneous lattice compression on the electric properties of metals have been carried out at high temperatures (room temperature and higher), because Bridgman had developed for these experimental conditions a method for the production and measurement of sufficiently high pressures. The development by one of the authors and by Kan[2] of the "ice method" for producing high pressures made it possible, for the first time, to extend experimental investigations of this kind to the more interesting low-temperature region and, in particular, to investigate in detail the effect of homogeneous lattice compression on the superconductivity of a number of metals.[3] The results of these experiments, together with the study of the isotope effect in superconductivity phenomena (e.g. reference 4), gave evidence of the specific interaction of the electrons with the metal lattice, which later on proved so important for the development of a microscopic theory of superconductivity.

In recent years Alekseevskii and his co-workers used the "ice method" to produce high pressures in order to investigate the effect of homogeneous compression on the electromagnetic phenomena in bismuth[5] at low temperatures. Very recently an investigation has been carried out on the effect of homogeneous lattice compression on the temperature variation of the electrical conductivity of a number of metals.[6]

The effect of homogeneous compression on the magnetic properties of crystals was not studied for a long time even at higher temperatures, because the known methods for producing high pressures could not be applied to the measurement of magnetic susceptibility. The systematic investigation of the magnetic properties of unconstrained crystals of feebly magnetic metals at low temperatures led to the discovery of the de Haas — van Alphen effect in a large group of metals[7,8] and to the establishment by Lifshitz et al.[9] of a connection between this phenomenon and the problem of the energy distribution of charge carriers in metals — one of the most important problems of metal physics. It became essential to clarify the effect of the homogeneous compression of the crystal on the de Haas — van Alphen effect, and thus on the energy distribution of charge carriers in metals.

A method and apparatus were developed in the