boundary upon rotation of the magnetization, can cause a dramatic change in these fine structures. Perhaps an interpretation for the sharp peak in the curve $L_A/(\sin 2\theta \times \cos 2\theta)$ at 4.2 °K, given in figure 1, has to be sought in such effects. Measurements on the magnetic anisotropy energy could be helpful in this way to understand some of the fine details in the band structure of nickel.

A second point that asks for further experimental studies is the sensitivity of the anisotropy energy to the position of the Fermi level with respect to the 3 d-bands. By alloying nickel with cobalt or copper the Fermi level can be influenced and a comparison can be made between the calculated and the experimental change in the anisotropy energy. Using a rigid band approximation and taking values for the density of states and its derivative at the Fermi level from the work of Hodges e.a. [39], we find that a concentration of one percent cobalt in nickel causes a shift in the Fermi level downwards over 0.006 eV. Furey calculated for this shift a 25 percent lower value for the absolute value of K_1 ; the experiments result in nearly the same percentage. As a consequence one would expect to find an increase in the anisotropy energy by adding small percentages of copper to nickel. The experiments, however, show a decrease in this case too, though less pronounced than with cobalt.

It is not so difficult to construct situations in Furey's model in which an increase as well as a decrease in the Fermi energy leads to a decrease in the anisotropy energy. The position of the Fermi level at a cross point of the same band at two orientations of the magnetization is such a situation that is not excluded by the data of figure 3. The influence of the impurities on the fine structures in the anisotropy energy is even larger. These fine structures for nickel and some nickel alloys are presented in figure 5, where the energy in the (110) plane, reduced by the contribution of k_4, is plotted as a function of the orientation of the magnetization at 4.2 °K. Results for pure nickel (purity at least 99.99 %) at higher temperatures are also collected in this figure in order to direct the attention to the fact that the effects of alloying or raising temperature on the magnetic anisotropy energy are closely related. The magnetic anisotropy energy of nickel with one percent cobalt at 4.2 °K is nearly identical to that of pure nickel at 77 °K.

The identification of the anisotropy energy of nickel with the energy states near the point X turns out to be successful : it results in a value for the first anisotropy constant in the right order of magnitude ; it explains the rapid decrease of this energy in the low temperature region ; it predicts a large influence of impurities ; it presents a way of understanding complicated structures in this energy and it can account

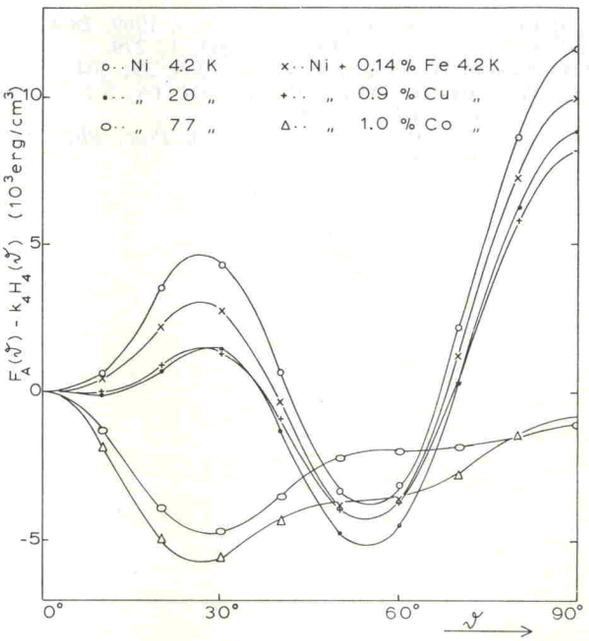

FIG. 5. — Higher order contributions to the magnetic anisotropy energy in the (110) plane for Ni at 4.2, 20 and 77 °K and for some Ni-alloys at 4.2 °K (ref. [28]).

qualitatively for the effects under pressure. By this identification we arrive for nickel in a relatively simple situation since in order to explain the properties of the anisotropy energy we have to investigate only a few bands in a small region of the zone. In the observation of these bands we have considerable help from other experimental methods, in particular from the study of the De Haas-Van Alphen effect.

I should like to thank my colleagues at the Natuurkundig Laboratorium for many cordial discussions on problems concerning the magnetic anisotropy.

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