THICKNESS EFFECT IN THE X-RAY K ABSORPTION EDGE OF NICKEL

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ABSTRACT
Effect of absorber thickness on the X-ray K absorption edge of nickel has been recorded photographically. The extended structures show a variation in their relative intensities. In agreement with the earlier observations of Parratt and Sawada the structures in the immediate neighbourhood of the edge show a decrease in their absorption intensities and the fluctuations following them up to 140 eV. remain unaltered. In addition, it is found that the structures lying beyond 150 eV. from the edge become more pronounced on the increase of absorber thickness.

INTRODUCTION
The effect of thickness of the absorber on the extended Kronig structure of X-ray absorption edges has been pointed out by several workers. However, Parratt et al. (Parratt, Hempstead and Jossem, 1957) were the first to study the effect in some detail. They studied the K edge of chlorine in crystalline KCl using a two-crystal spectrometer and plotted the μ-curve up to about 20 eV. from the absorption edge. The successive structures were named as A, α, B, β, C, γ, D, etc. It was found that the intensity ratios A/α, A/β, and A/γ decrease with increasing absorber thickness. The structures γ and D lying between 10–15 eV. from the edge do not show any change with the increase of absorber thickness. Sawada et al. (Tsutsumi, Obashi and Sawada, 1958) confirmed these results in the case of K absorption edge of copper in metal and some salts of copper and also in the K edge of cobalt in some cobalt salts. The present paper describes the experiments on the K edge of nickel in foils of nickel metal. Thickness effect has been studied not only in the vicinity of the absorption edge but also in regions extending up to 250 eV. from the edge.

EXPERIMENTAL
A transmission X-ray spectrograph with mica crystal bent to a radius of 20 cm. was used to record the spectra. The (100) planes were used to
reflect in the 1st order. Dispersion in the region of nickel K edge was 20 x.u./mm. The spectra were recorded on Agfa X-ray films.

A Hilger demountable X-ray tube was used with a copper target, operating at 10 kV and 10 mA. Since the usual tungsten filaments of the tube deposit by evaporation, considerable quantities of tungsten on the anticathode, giving rise to strong WLₐ lines which interfere with the nickel K edge, it was necessary to replace tungsten by some other material like molybdenum or tantalum. Both the materials were used to make the filament and in particular, the life of tantalum filaments was found to be long enough to allow 20 hours of continuous exposures. Long exposures with freshly cleaned anticathode were given and the cleaning continued till the faintest traces of the tungsten L-lines excited due to the previously deposited tungsten completely disappeared from the spectrum. The tantalum deposits on the anticathode gave tantalum L lines which served as extra reference lines besides those emitted by copper.

Single foils of nickel having thickness 4, 6 and 8 microns were used as absorbers. The exposure times ran as follows: for 4 micron foil, 13 hours, 6 micron, 20 hours and 8 micron, 30 hours. These times were so adjusted that the microphotometer records of the spectra showed nearly equal optical density at the main absorption edge. All the spectra were scanned by a Jarrell-Ash microphotometer at a scanning rate of 2 mm./minute giving a magnification of 47 on the strip chart. On the photometer curves, 3.3 mm. represents 10 eV.

RESULTS AND DISCUSSION

The microphotometer records for the nickel K edge obtained by using 4, 6 and 8 micron foils are reproduced in Fig. 1. Each curve is an average over five independent records. These show the main absorption edge followed by a series of fluctuations of intensity or extended structures on the higher energy side. In fact even the main K edge also has a structure which is clearly resolved in Hayasi's experiments (Hayasi, 1949). The dispersion and resolution of the spectrograph used in the present experiments are much smaller than those of the instruments used by Hayasi. However a slow scanning rate of the microphotometer gives an indication that the doublet structure of K edge is just resolved in our instrument.

The structures have been named as usual by the letters A, a, B, β, C, γ, etc., and their distances in eV. from the main edge are tabulated in Table I, where also Hayasi's values have been shown for comparison. In
view of the low dispersion used in the present work, the agreement is considered satisfactory.

**Fig. 1.** The K absorption edge of nickel and the extended structures obtained for various foil thicknesses.

**TABLE I**

*Extended structures in nickel K edge. Distance in eV. from the main edge*

<table>
<thead>
<tr>
<th>Structures</th>
<th>A</th>
<th>α</th>
<th>B</th>
<th>β</th>
<th>C</th>
<th>γ</th>
<th>D</th>
<th>δ</th>
<th>E</th>
<th>ε</th>
<th>G</th>
<th>ζ</th>
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<td>Present values</td>
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<td>Hayasi’s values</td>
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The following observations may be pointed out from the curves of Fig. 1:—

(a) The dip A lying at 15 eV. becomes less pronounced at greater thicknesses. This observation is in conformity with the behaviours observed by Parratt and Sawada.

(b) The structures in the range 22 eV. to 100 eV. do not show any significant variation in their relative intensities. The curves published by Parratt and Sawada also indicate that the structures beyond 20 eV. from the edge remain unaltered by the thickness of the absorber.

(c) The structures $\epsilon$ and $\zeta$ lying at 145 and 170 eV. from the edge become more pronounced as the thickness of the absorber is increased. This is strikingly shown in the curves and forms an interesting effect which has not been reported by earlier workers and which goes against Parratt’s interpretation that the structure of the absorption band is obliterated at the higher frequency side as the thickness of absorber is increased like in the general case of optical absorption. Failure to observe the effect by earlier workers may be due to the fact that the working ranges of two-crystal spectrometers are rather limited. Therefore an investigation up to 250 eV. from the main edge was not carried out earlier particularly with this point in view.

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REFERENCES

and Jossem, E. L.