

### Structure of a New System of CO Bands

IN a previous note<sup>1</sup> the discovery of a new system of red-degraded CO bands, placed just before the heads of the violet-degraded Third Positive system, was reported. Inspection and measurement of high-dispersion spectrograms now show that the new bands have a structure appropriate to a  ${}^3\Sigma \rightarrow {}^3\Pi$  band-system, the lower state being the  $a^3\Pi$  state, which is the usual final state of the CO triplet systems. The upper  ${}^3\Sigma$  levels of the new bands lie about  $83705\text{ cm.}^{-1}$  and  $85885\text{ cm.}^{-1}$  above the CO ground state; they have observable spin-splittings and rotational constants  $B' = 0.7$  to  $0.8\text{ cm.}^{-1}$ . The system may tentatively be designated as  $f^3\Sigma \rightarrow a^3\Pi$ . It may be considered, however, as probably due to transitions from the higher vibrational levels of  $a'^3\Sigma$  to the lower vibrational levels of  $a^3\Pi$ . For, within the heights of the initial levels  $f^3\Sigma$  of the new bands occur also the initial levels  $b^3\Sigma$  of the Third Positive bands, and the latter are strongly perturbed, as has already been established<sup>2</sup>, by vibrational levels of the  $a'^3\Sigma$  state, for which we have predicted term values and rotational constants of the magnitude now observed for the new bands.

Rotational analysis and details will be published shortly elsewhere.

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<sup>1</sup> Schmid, R., and Gerö, L., *Naturwiss.*, **25**, 90 (1937).

<sup>2</sup> Schmid, R., and Gerö, L., *Z. Phys.*, **105**, 36 (1937) **106**, 205 (1937).

### $L$ -Emission Bands of Zinc, Copper, Nickel and Cobalt

I HAVE studied the intensity of the  $L$ -emission bands of metals from Co (27) to Zn (30). The apparatus used was a vacuum spectrograph using a bent crystal of mica, and the source of the radiation was an X-ray tube.

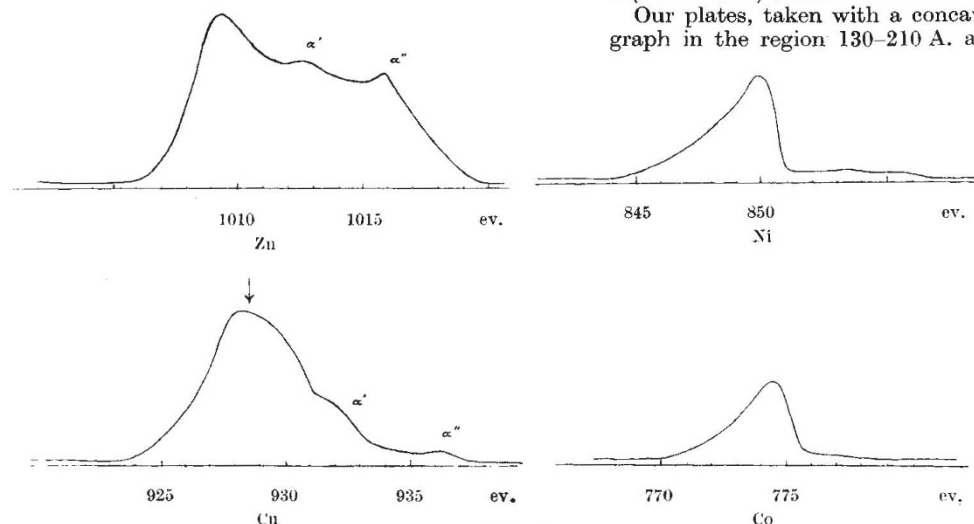


Fig. 1

To obtain the actual intensity distribution of the emitted radiation, the plate was calibrated by a method already described<sup>1</sup>. The curves giving the intensity of the  $L_a$  bands against energy (in electronvolts) are shown in Fig. 1.

It is well known that the  $L$ -emission bands are emitted when  $M_{IV}$ ,  $\nu$ -electrons make transitions into the  $L_{II, III}$ -levels ( $L_{\alpha_{1,2}}$  and  $L_{\beta_1}$ ). There are also transitions of  $N_I$ -electrons into the  $L_{II, III}$ -levels. For these metals the  $N_I$ - or  $4s$ -electrons are the conduction electrons, and occupy levels which overlap in energy those of the  $M_{IV}$ ,  $\nu$ - or  $3d$ -electrons.<sup>2</sup> Thus the observed bands represent transitions of both  $3d$ - and  $4s$ -electrons. But for copper and zinc, unfortunately, the short wave-length ends of the bands, which are probably due to the  $4s$ -electrons, are completely masked by satellites, which are strongly enhanced by the reorganization of the atom on account of the Auger effect<sup>3</sup>,  $L_I-L_{III}$ .

The position of the short wave-length edge of the  $L_a$ -bands may be estimated from the  $L$ -absorption spectra, and is given by the wave-length of the slope of the absorption curve near the minimum absorption. For copper, we can deduce from the absorption curve of Sandström<sup>4</sup> that the edge of the  $L_a$ -emission band is given by the arrow marked on Fig. 1. From the comparison of the  $L$ -emission and absorption bands it is obvious that the width of the  $L_a$ -band is about 5 ev.

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Aug. 3.

<sup>1</sup> *Comptes rendus*, **204**, 1242.

<sup>2</sup> See Mott and Jones, "The Theory of the Properties of Metals and Alloys" (Oxford, 1936), p. 191.

<sup>3</sup> See Coster and Kronig, *Physica*, **2**, 13 (1935).

<sup>4</sup> Sandström, A., Thesis, Uppsala (1935).

### $M$ -Emission Bands of Zinc, Copper and Nickel

WE have had the opportunity of seeing Dr. Farineau's letter before it was sent to press. We have recently observed the  $M$ -emission bands of nickel, copper and zinc metals, and it seems worth while to add a note, since the two sets of results, especially taken together, allow one to draw certain conclusions about the structure of the  $3d$ - and  $4s$ (conduction)-electron bands in these metals.

Our plates, taken with a concave grating spectrograph in the region 130–210 Å. and with an X-ray

tube run at 3,000 v. as source, give results which, on a scale of energy, are almost identical with Farineau's  $L$ -emission bands. This is good evidence that, apart from transition probability factors, the curves represent features of the density-functions of the combined  $3d$ -conduction-levels of the

metals. We also obtain for zinc and copper the peaks marked  $\alpha'$  and  $\alpha''$  by him. But, contrary to his conclusion, when we compare the wave-lengths of points on the  $M$ -emission bands with the wave-lengths of the  $M$ -absorption edges which we have determined<sup>1</sup>, we