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Technical Note

Magnetic Behavior of Intermediate Phases in Alloys of Transition Elements

by P. A. Beck

ACCORDING to a recent hypothesis of Sully,[1] binary σ phases are characterized by 1.7 bonding 3d electrons per atom, which completely fill the first Brillouin zone. This hypothesis appears to imply that there are no empty 3d orbitals in the σ phase, and that, correspondingly, this phase must be diamagnetic, or at most weakly paramagnetic. On the other hand, Bowen and Hoar[2] reported that a σ phase extracted electrolytically from an alloy steel became ferromagnetic when cooled to about $-113°C$. In view of the fundamental interest of the problem from the point of view of the electron structure of the σ phase, it seemed worthwhile to study the magnetic properties of massive σ phase specimens of various known compositions.

Sigma specimens of the following compositions were tested:

1—40 atomic pct Fe, 40 atomic pct Cr, and 20 atomic pct Mo

2—35 atomic pct Fe, 35 atomic pct Cr, and 30 atomic pct Mo

3—48.7 atomic pct Fe, 50.2 atomic pct Cr, and 1.1 atomic pct W

4—40.7 atomic pct Co and 59.3 atomic pct Cr

All specimens were found to be strongly paramagnetic at room temperature, particularly alloy No. 1. At liquid nitrogen temperature, alloy No. 1 be-

came ferromagnetic; the other σ alloys remained paramagnetic. Even though apparently not all σ alloys become ferromagnetic at liquid nitrogen temperature, in view of their strong paramagnetism it is probable that the electron structure proposed by Sully is not correct.

Similar qualitative studies were made with the μ, P, and δ phases.[3] A μ phase specimen of 57.2 atomic pct Co and 42.8 atomic pct Mo; a P specimen of 19.9 atomic pct Cr, 37.8 atomic pct Ni, and 42.3 atomic pct Mo; and a δ specimen of 50.4 atomic pct Ni and 49.6 atomic pct Mo were tested at room temperature, and all were found to be paramagnetic, although considerably weaker than the σ phase specimens described above. A test at liquid nitrogen temperature gave similar results for all specimens; none became ferromagnetic.

Thanks are due to D. K. Das for preparing several of the alloys and to Pol Duwez of California Institute of Technology for kindly loaning four specimens of σ alloys.

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Correction

In the February 1951 issue: TP 3004E. Cobalt Self-Diffusion: A Study of the Method of Decrease in Surface Activity by R. C. Ruder and C. E. Birchenall. P. 142: The equation for the self-diffusion in pure cobalt given in the text, the summary, and the abstract should read:

$$D_{Co}^{Co} = 0.032e^{-\frac{61900}{RT}} \text{ cm}^2 \text{ per sec}$$

where the activation energy is given as calories per gram atom.