panied by simultaneous changes in air temperature and relative humidity.

These investigations are being continued, and extended to other sites.

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Embrittlement of Tungsten Wires by Contaminants

TUNGSTEN in a fully recrystallized state is well known to be brittle, but in a drawn state or even after primary recrystallization¹ is reasonably ductile and amenable to forming. This mechanically favourable state can be impaired by discontinuities in the structure, imparted by surface defects or the consequences of contamination. Disastrous contamination by traces of some metals has long been recognized in industry and the effect of nickel has been reported²; embrittlement by gases also has been observed³.

The explanation of the embrittlement lies in the notch sensitivity manifested by tungsten: small surface defects or even deep etching will destroy the forming properties of wire and, conversely, electropolishing will greatly enhance these properties without loss of strength^{1,4}.

Even traces of iron, nickel or cobalt, owing to their low solubility in tungsten, form a local region showing a second phase (see Fig. 1) and thus exert an effect disproportionate to the extent of contamination. Attack becomes catastrophically rapid at temperatures above the melting point of the contaminants, when low-melting phases are immediately formed with less than 1 per cent of the contaminant. This is, of course, applicable to many other elements, such as aluminium, carbon or silicon, which have a slight but significant solubility.

Even at a temperature below the solidus, as diffusion of the contaminant proceeds, the phase change at the advancing interface leads to recrystallization with a loss of the ductile fibrous structure. The recrystallized regions fracture easily under stress and hence readily initiate a break through the whole specimen, so that resistance to tension, and more particularly to bending (where the stresses are concentrated near the defective surface region), is

Fig. 1. Section at the surface of tungsten wire contaminated by cobalt, etched. ($\times 1,200$)

much reduced. Inspection of the equilibrium diagrams of the respective systems indicates that the effects are likely to decrease on passing from cobalt to nickel to iron. This has been found to be the case, cobalt being particularly aggressive.

However, this embrittlement only applies to low temperatures. Uncontaminated tungsten has a rather gradual transition from the brittle to the ductile state, which, in wires less than 0.5 mm., is usually near 200–300° C. (Elongations exceeding 20 per cent have been obtained¹ at 250° C.). Tungsten contaminated with iron and cobalt may remain brittle at temperatures up to about 700° C.

If contamination is not excessive, reasonable ductility can be restored by holding the wire at high temperatures for some time to dilute the contaminant, through its diffusion, illustrating the localization of the effect. However, there is some evidence that the 'recrystallization' temperature of the wire is lowered, so that, for certain applications, the quality of the wire is impaired.

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¹ Davis, G. L., Ph.D. thesis (London, 1952).

² Thomson, B., *Nature*, **176**, 360 (1955).

³ Davis, G. L., *Metallurgia*, **54**, 18 (1956).

⁴ Sedlatschek, K., and Thomas, D. A., *Plansee-Berichte*, **5** (1), 27 (1957).

Anomaly in the Age-Hardening Behaviour of Aluminium-Zinc Alloys

THE very rapid hardening which occurs at room temperature after solution treatment in aluminium alloys containing about 10 per cent zinc¹ has been considered to be due to a similar mechanism to that which accounts for the hardening observed in aluminium-copper alloys aged at higher temperatures². The reason for this suggestion appears to be the observations on higher zinc alloys (20–25 per cent zinc) of Geisler, Barrett and Mehl³ and of Guinier⁴ using X-ray techniques that, during the initial stages of ageing, coherent zinc-rich clusters are formed. Some recent work in these laboratories suggests that, while this explanation may be true of alloys aged at elevated temperatures, the behaviour at room temperature of alloys containing about 10 per cent zinc does not conform to that shown by other binary aluminium systems at elevated temperatures. The evidence for this view is:

(1) The extent of hardening is dependent upon the temperature within the single-phase region from which the alloy is quenched, whereas such a dependency is not observed in other precipitation hardening systems.

(2) The hardness rises to a maximum value and does not afterwards decrease in the manner of systems showing over-ageing. The high rate of hardening suggests that if this was due to a normal precipitation mechanism, then over-ageing might reasonably be expected.

(3) An alloy aged to maximum hardness at room temperature shows only a very slow decrease of hardness on subsequent ageing at 100° C. Alloys of other