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COMMENT ON VOID FORMATION
IN NICKEL AND SILVER
DURING CREEP

T. G. Langdon

September 1967

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In two recent papers, dealing with void formation in nickel[1] and silver[2] respectively, Price has reached conclusions concerning the role of grain boundary sliding in creep. In nickel,[1] voids were first observed at the start of the secondary stage and it was suggested that primary creep was due to deformation within the grains, and that the transition to secondary creep marked the onset of general grain boundary sliding. However, an examination of the extensive literature on grain boundary sliding suggests that both this view and the contrary suggestion,[3,4] that sliding accounts for all of the initial deformation until some "critical" strain when slip first occurs, are untenable.

In a number of investigations of the occurrence of grain boundary sliding during creep, measurements have been taken to determine the average displacement ($\bar{v}$) due to sliding, perpendicular to the surface, between adjacent grains, and these values have been plotted against the total creep strain, ε_t. If deformation within the grains accounts for all of the strain until the onset of secondary creep, then it follows that these plots should reveal zero displacement throughout the primary stage. In fact, a considerable volume of work on a large number of materials (Al,[5,6,7] Al alloys,[5,8] β-brass,[9] Cd,[5] Cu,[10] Cu - 0.37%Be,[5] Fe,[5] Fe - 30% Ni,[11] Mg,[12] Mg - 0.78% Al,[13,14] Ni,[15,16,17,18] Pb,[19] Pb - 2.2% Tl,[19,20] Sn,[5] and Zn[5]) has shown that, at least initially in primary and the early stages of secondary creep, there is a linear relationship between the average sliding displacement and the creep strain. In some cases a deviation from linearity has been reported, such that the sliding thereafter increases at a slower rate than the total strain, but this

usually occurs towards the end of the secondary stage. Typical results for specimens of a Mg - 0.78% Al alloy are shown in Fig. 1. Four specimens, of different grain size, were tested at 200°C under an initial stress of 6000 psi; full details of the experimental procedure are given elsewhere.[13] In each case, the transition to secondary creep occurred at a total strain of ∿2%. Whilst these results refer to measurements taken on the surface, Graeme-Barber[14] has recently used internal oxide markers to show that similar trends pertain in the interior.

Price[1] attempted to determine the total strain due to grain boundary sliding by considering that the primary deformation, which followed the Andrade $t^{1/3}$ law, represented the deformation due to grain strain, and that the same mode of deformation continued throughout secondary creep. By extrapolation, the grain deformation was determined through the secondary stage, and, knowing the total creep strain, the sliding contribution was calculated by difference. The result suggested that, by the start of tertiary creep, the sliding contribution accounted for almost 50% of the total strain. Unfortunately, an accurate assessment of the sliding contribution is not easy, and a detailed analysis of the methods by which this may be calculated is given elsewhere.[21] However, the trend deduced by Price is contrary to results reported on a Mg - 0.78% Al alloy,[13] where a decrease in the importance of grain boundary sliding with increasing strain was inferred from the formation internally of extremely corrugated boundaries during creep. Furthermore, recent results using internal markers have tended to confirm this decrease.[14]

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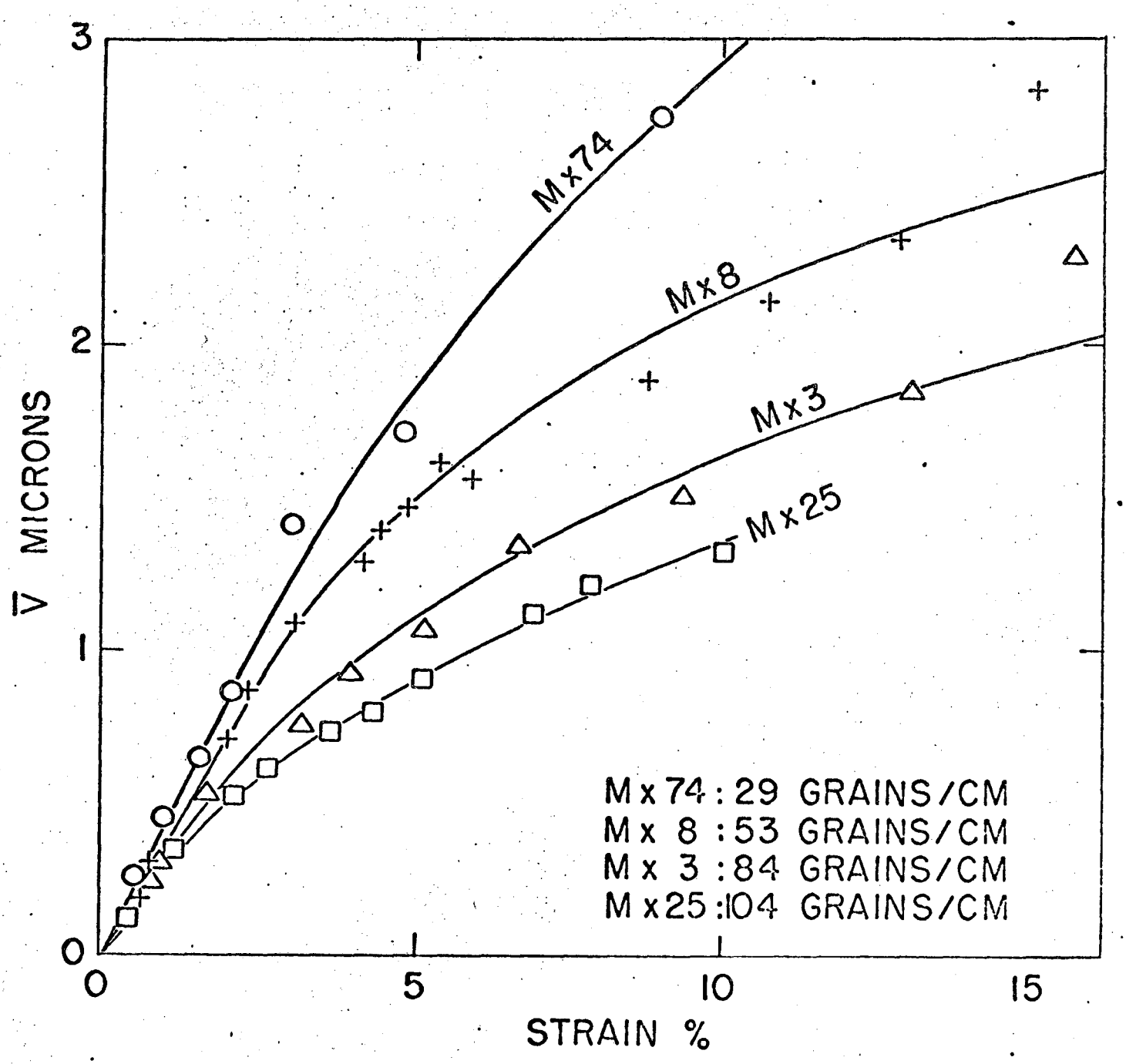

FIG 1

Variation of grain boundary sliding with strain for four different grain sizes

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