on the side suffering a net loss of atoms. This stress field is supposedly due to the annihilation of vacancies on edge dislocations whose Burger's vectors are not perpendicular to the Kirkendall interface. For the special case where vacancy annihilation occurs predominately on edge dislocations with Burger's vectors perpendicular to the Kirkendall interface, no stress field would be established since relaxation is permitted in the direction of diffusion. Thus, pores would not be formed.

Examination of the DS-NiCr(*gs* 1):Ni couple, Fig. 1(*b*), and the diffusion profile, Fig. 2, reveals that considerable grain boundary area parallel to the Kirkendall interface exists on the chromium-rich side of the couple. The large amount of grain boundary area is due to the high grain aspect ratio and small grain width (high L/D with small D) of DS-NiCr(*gs* 1). It is felt that vacancy annihilation at such boundaries is similar to annihilation at edge dislocations with Burger's vectors perpendicular to the Kirkendall interface. Such behavior results in contraction only in the direction of diffusion.

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An Improved Equation Relating Hardness to Ultimate Strength

J. R. CAHOON

IN 1951 Tabor[1] obtained the expression

$$\sigma_u = \left(\frac{H}{2.9}\right)(1-n)\left(\frac{12.5n}{1-n}\right)^n \qquad [1]$$

relating ultimate nominal stress, σ_u, to the Vickers Pyramid Hardness, H, and the strain hardening coefficient, n. Tabor assumed that true stress in the plastic region is approximated by the familiar equation

$$\bar{\sigma} = k\bar{\epsilon}^n \qquad [2]$$

where $\bar{\epsilon}$ is the true strain and k is a constant. To obtain the nominal stress, σ, Tabor used the approximation

$$\sigma = \frac{k\bar{\epsilon}^n}{(1+\bar{\epsilon})} \qquad [3]$$

By differentiating this equation with respect to $\bar{\epsilon}$, Tabor obtained the true strain at the ultimate stress as

$$\bar{\epsilon}_u = \left(\frac{n}{1-n}\right) \qquad [4]$$

However, it is well known and easily calculated that the nominal stress is related to the true stress by[2]

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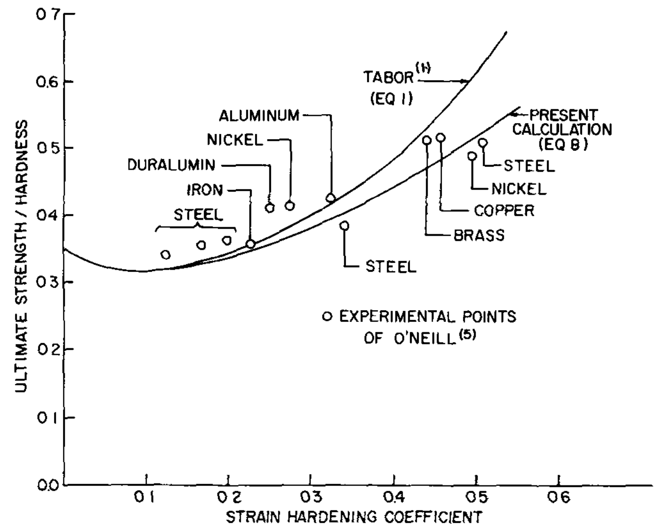

Fig. 1—Relation of ultimate strength to hardness and strain hardening coefficient.

$$\sigma = \frac{\bar{\sigma}}{e^{\bar{\epsilon}}} = \frac{k\bar{\epsilon}^n}{e^{\bar{\epsilon}}} \qquad [5]$$

By differentiating Eq. [5] with respect to $\bar{\epsilon}$ one obtains the true strain at the ultimate nominal stress as[3]

$$\bar{\epsilon} = n \qquad [6]$$

Therefore from Eq. [5], the ultimate nominal stress is given by

$$\sigma_u = k\left(\frac{n}{e}\right)^n \qquad [7]$$

If it is accepted that the true stress on a stress-strain curve at a strain of 0.08 is given approximately by $H/2.9$ as suggested by Tabor[1] and supported by Cahoon *et al.*[4]* then it is easily shown that

*Tabor[1] suggests values in the range $H/2.9$ to $H/3$ while Cahoon *et al.*[4] suggests values in the range $H/2.9$ to $H/3$ 1.

$$\sigma_u = \frac{H}{2.9}\left(\frac{n}{0.217}\right)^n \qquad [8]$$

It is suggested that Eq. [8] is a simpler and more accurate expression relating ultimate tensile strength to hardness. The results calculated from Eq. [8] are compared to those calculated by Tabor (Eq. [1]) in Fig. 1. Tabor[1] noted that his results calculated from Eq. [1] agreed well with the experimental data (converted from the Brinell results of O'Neill[5]) for lower values of the strain hardening coefficient, but deviated considerably from the experimental data at larger values of n. O'Neill's experimental points are included in Fig. 1 which shows that the present expression, Eq. [8], agrees well with the experimental results for all values of the strain hardening coefficient.

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