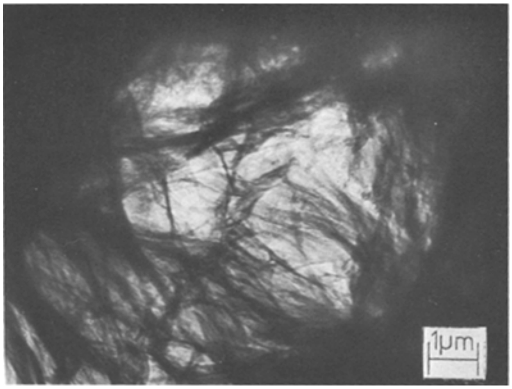

Figure 3 Specimen hydrated for 4 days at 55° C; w/c = 0.5. Calcium silicate hydrate forming an interlocking network.

this delicate structure is not generally seen except when the specimen is kept wet. However, its existence does provide a very important clue to the mechanism of formation of the calcium silicate hydrate found in set cement.

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Solid-solution hardening in b c c metals

The similarities between the movement of screw dislocations by double-kink propagation in pure b c c metals [1], on the one hand, and, on the other, of edge dislocations in concentrated ($c > 1$ at.%) f c c solid-solutions [2, 3], suggests that edge dislocations rather than screws may determine the CRSS in concentrated b c c solid-solutions.

This inversion of the roles of the two types of dislocations in the b c c alloys compared with their behaviour at low temperatures in the pure metals, might be expected to set in at concentrations of the alloying element at which the pinning of the edge dislocations rendered them less mobile than the screws; although the Peierls force for the latter is higher than for edges, the screws, by contrast, would be less susceptible to pinning by the alloy atoms.

To examine the possibility that the CRSS in concentrated b c c alloys was determined by the mobility of edge dislocations, we considered it of diagnostic value to attempt representing suitable data, e.g. those on the CRSS of alloys of niobium single crystals containing either 5 to 16 at.% Mo or 5 to 9 at.% Re, studied in the range 77 to 350 K by Statham and Christian [4], as if the edge dislo-

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TABLE I Values of $\tau_0 (\mathrm{MN\,m^{-2}})$ and U(eV) used in Equation 1 to obtain the curves drawn through the points in Fig. 1. $G \equiv c_{44} = 5.8 \times 10^4\ \mathrm{MN\,m^{-2}}$ ($5.8 \times 10^5\ \mathrm{kgf\,cm^{-2}}$), $Gb^3 = 8.7$ eV, $n = 1.2$. τ_0 was determined by extrapolation of the experimental τ/T-relation

Solute	c (at.%)	$\tau_0 (\mathrm{MN\,m^{-2}})$	U (meV)
Mo	5.0	400	80
	8.5	530	80
	16.0	650	73
Re	5.0	650	130
	9.0	800	120

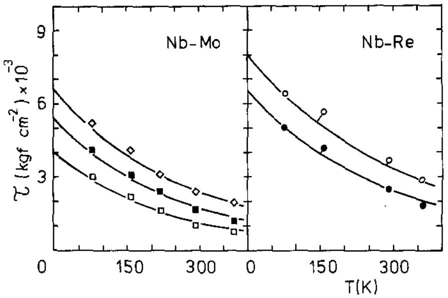

Figure 1 The CRSS of concentrated single crystals of niobium alloys in the range 77 to 350 K. The curves were obtained from Equation 1 with values of U and τ_0 given in Table I. Concentrations of the Nb–Mo alloys were, from top to bottom: 16.0, 8.5 and 5 at.%, and for the Nb–Re alloy 9.0 and 5.0 at.%.

cations were, in fact, determining the onset of macro-flow. The dependence of the CRSS on temperature, alloy content and strain rate ought to be functionally of the type appropriate for fcc solid-solutions if the hypothesis applied.

Now, in the theory used by Butt and Feltham [2, 3] in correlating such results on the CRSS of fcc solid-solutions, disregarding for the present purposes any low-temperature corrections to τ, which might become relevant below about 80 K [2, 5], the CRSS, $\tau(T)$, is given by

$$\tau = \tau_0\theta/[1 + \theta)^{1/2}]^2, \qquad (1)$$

$$\tau_0 = 4Uc^{1/2}/nb^3$$

where

$$\theta = 4n^2 Gb^3 Uc^{1/2}/[kT \ln(\dot{\gamma}_0/\dot{\gamma})]^2,$$

with, generally,

$$\ln(\dot{\gamma}_0/\dot{\gamma}) \approx 25. \qquad (2)$$

Here $\tau \rightarrow \tau_0$ as $T \rightarrow 0$, c is the alloy concentration, U the mean binding energy between an alloy atom and the dislocation considered, n the average number of interatomic spacings by which a "kink" would jump forward in the process of activation, $\dot{\gamma}$ is the shear rate of the crystal, $\dot{\gamma}_0$ a constant of the order of $10^7\ \mathrm{sec^{-1}}$, and G and b have their usual meanings. The values of n and U cannot be selected arbitrarily; they are determined by the requirement of specifying the correct values of both τ_0 and θ; those appertaining to the curves (Equation 1) drawn through the experimental points of Statham and Christian in Fig. 1, are referred to in Table I. The value of n was, in all cases, found to be close to 1.

Agreement can be seen to be satisfactory. The results suggest, in accordance with the hypothesis, that in concentrated bcc solid-solutions the CRSS is determined primarily by the mobility of edge dislocations.

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