Acknowledgments. The authors wish to express their thanks to the Air Force Office of Scientific Research for partial support of this work under Grant AFOSR 62-231. The general support of the Advanced Research Projects Agency and the U. S. Atomic Energy Commission is also gratefully acknowledged.

## Appendix

The jump frequency has been developed very generally by Vineyard<sup>12</sup> as

$$\Gamma = \left(\frac{\kappa T}{2\pi m}\right)^{1/2} \int_{\sigma} e^{-\varphi/RT} \,\mathrm{d}\sigma \Big/ \int_{A} e^{-\varphi/RT} \,\mathrm{d}A \quad (1a)$$

where  $\varphi$  is the potential energy for all the atoms in the crystal, A is an appropriate phase space volume taken at an atom neighboring a vacancy, and  $\sigma$  is an appropriate hypersurface taken at the saddle configuration of the jump. To a first approximation, A is the same for different jump directions in anisotropic systems; hence anisotropy must arise mostly from different  $\sigma_k$  for different jump types k. Thus (1a) becomes

$$\Gamma_{k} = \left(\frac{\kappa T}{2\pi m}\right)^{1/2} \int_{\sigma_{k}} e^{-\varphi/RT} \,\mathrm{d}\sigma_{k} \Big/ \int_{A} e^{-\varphi/RT} \,\mathrm{d}A \quad (2a)$$

Following Girifalco and Grimes,<sup>11</sup> expand  $\varphi$  in terms of the strains,  $\epsilon_i$ , to first order, and define

$$m_i^k = \left\langle \frac{\partial \varphi}{\partial \epsilon_i} \right\rangle_{\mathbf{A}} - \left\langle \frac{\partial \varphi}{\partial \epsilon_i} \right\rangle_{\sigma_k}$$
(3a)

where  $\langle \rangle$  denotes the usual statistical averages over A or  $\sigma_k$ . Now (2a) becomes

$$\Gamma_k(\epsilon) = \Gamma_k(0) \exp\left[\frac{1}{RT} \sum_i m_i^k \epsilon_i\right]$$
 (4a)

The vacancy concentration may be written analogously as

$$n_{\rm v}(\epsilon) = n_{\rm v}(0) \exp\left[\frac{1}{RT}\sum w_i\epsilon_i\right]$$
 (5a)

where

$$w_{i} = \left\langle \frac{\partial \varphi_{0}}{\partial \epsilon_{i}} \right\rangle - \left\langle \frac{\partial \varphi_{v}}{\partial \epsilon_{i}} \right\rangle$$
(6a)

Here  $\varphi_0$  and  $\varphi_v$  are the potential energies of the crystal

without and with a vacancy, respectively. Note that  $w_i$  is independent of direction k.

From the zero strain expression  $D_k(0) = \gamma_k a_k^2 n_v \cdot (0) \Gamma_k(0)$ , the diffusion coefficient of the strained crystal is

$$D_{k}(\epsilon) = D_{k}(0)(1 + \epsilon_{k})^{2} \exp\left[\frac{1}{RT}\sum_{i}M_{i}^{k}\epsilon_{i}\right]$$
(7a)

where

$$M_i^{\ k} = m_i^{\ k} + w_i \tag{8a}$$

The only unknown quantities in (7a) are the  $M_i^k$ . These may be found from

$$\frac{\partial \ln D_k(\epsilon)}{\partial \epsilon_i} - \frac{2\partial \ln (1 + \epsilon_k)}{\partial \epsilon_i} = \frac{M_i^k}{RT} \quad (9a)$$

From elasticity theory we write  $\epsilon_i = \sum_j s_{ij} P_j$ , where the stress,  $P_j$ , is a force per unit area (pressure), and the  $s_{ij}$  are constants. Then (9a) becomes

$$\sum_{j} \frac{\partial \ln D_{k}(P)}{\partial P_{j}} - 2\sum_{j} s_{kj}/1 + \sum_{j} s_{kj}P_{j} = \sum_{i,j} \frac{M_{i}^{k} s_{ij}}{RT}$$
(10a)

From the Zener formalism<sup>22</sup> we have

$$\frac{\partial \ln D_k(P)}{\partial P} - 2\sum_j s_{kj} = \frac{1}{RT} \sum_{i,j} \Delta V_{ij}^* - \sum_j s_{ij}$$
(11a)

so that

$$\sum_{i,j} \Delta V_{ij}^* = \sum_i (M_i^k + \gamma RT\delta_{ik})s_i \quad (12a)$$

where  $\delta_{ik}$  is the Kronacker delta, and we have set  $1 + \sum_{j} s_{ij} P_j$  equal to unity, and where  $\sum_{j} s_{ij} = S_i$ . Summing (12a) over j gives  $\Delta V^k$  in terms of strain components,  $\Delta V_i^k$ , while a sum over i gives the stress components  $\Delta V_j^k$ . Hydrostatic pressure measurements give only their sums so neither set is more significant.

The  $M_t^k$  will have the same relations as the  $s_{ij}$ . For example, for nonshear stresses, the x and y axes of tetragonal crystals are indistinguishable so that only five independent  $M_t^k$  remain, for instance,  $M_1^1$ ,  $M_2^1$ ,  $M_3^1$ ,  $M_1^3$ , and  $M_3^3$ . Hence, five uniaxial and/or hydrostatic diffusion experiments are required to determine fully the  $M_t^k$  in this case.