The aim of the present work was to study the distribution of nonequilibrium vacancies in diffusion zones and to analyze the vacancy mechanism of diffusion; the concentration curves of the diffusing atoms were taken to be known functions of the coordinates and time.

Let us assume that diffusion of i-elements (which have a vacancy mechanism of diffusion) takes place in a zone \( \alpha \leq x \leq \beta \), and let us analyze processes which affect the vacancy concentration in the diffusion zone, starting from the derivation of mathematical expressions which describe each of these processes.

Let us consider a small volume of the diffusion zone and examine the time-dependence of the nonequilibrium vacancy concentration \( \Delta \xi (x, t) \)

\[
\Delta \xi (x, t) = \xi (x, t) - \xi_{eq} (x, t); \quad (1)
\]

where \( \xi (x, t) \) denotes the actual and \( \xi_{eq} (x, t) \) the equilibrium concentration of vacancies. The behavior of \( \frac{\partial \Delta \xi (x, t)}{\partial t} \) is affected mainly by three processes: diffusion of atoms, diffusion of vacancies, and interaction of vacancies with vacancy sinks and sources.

The cause of the appearance of nonequilibrium vacancy concentration is the redistribution of atoms taking part in diffusion through vacancies, the change in the nonequilibrium vacancy concentration being negative in respect to the change in atom concentration. For this reason, the change in vacancy concentration, which is determined by the diffusion of atoms of the system studied, is described by

\[
\frac{\partial c_i}{\partial t} + \sum \frac{\partial c_i (x, t)}{\partial x} = \frac{\partial}{\partial x} \left[ D_i \frac{\partial c_i (x, t)}{\partial x} \right]; \quad (2)
\]

If the concentrations considered are in the solid solubility range, the condition for continuity of the diffusion flux is satisfied;

\[
\frac{\partial c_i (x, t)}{\partial t} = - \frac{\partial}{\partial x} \left[ D_i \frac{\partial c_i (x, t)}{\partial x} \right]; \quad (3)
\]

consequently, instead of (2) we may write

\[
\sum \frac{\partial}{\partial x} \left[ D_i \frac{\partial c_i (x, t)}{\partial x} \right]. \quad (4)
\]

It is known [1, 2] that, irrespective of its origin, nonequilibrium vacancy concentration is not a stable state and reverts to equilibrium by annihilation of excess vacancies in vacancy sinks or, when there is a deficiency of vacancies, by generation of vacancies in their sources. The rate at which nonequilibrium vacancy concentration reverts to equilibrium should be described by a function of all the above parameters:

\[
f (T^0, p; a; u; c_i (x, t); \Delta \xi (x, t)). \quad (5)
\]

It was shown in [3, 4] that in the case of pure metals with not too large an excess of vacancies the reduction in vacancy concentration during isothermal annealing is an exponential function of time:

\[
\Delta \xi (x, t) = \Delta \xi_0 \cdot \exp (-f_1 \cdot t); \quad (6)
\]

where \( f_1 \) is a parameter which depends on the density of sinks, adsorption characteristics, and vacancy mobility. Such a functional relationship is possible when the diffusion of vacancies to sinks is described by an equation in the form

\[
\frac{\partial \Delta \xi (x, t)}{\partial t} + f_1 \cdot \Delta \xi (x, t) = 0; \quad \Delta \xi (x, 0) = \Delta \xi_0. \quad (7)
\]

In our case of low vacancy saturation, when the rate at which vacancies disappear at sinks may be expressed in terms of the probability of a vacancy meeting a sink, Eq. (5) may be written in the form
The nonequilibrium vacancy concentration caused by diffusion processes is different at various points of the diffusion zone and becomes equalized as a result of diffusion of vacancies from high to low vacancy concentration zones. This process is described by

\[ f(T_0; p; a; u; c_i; \Delta \xi) = -f_i(T_0; p; a; u; c_i) \cdot \Delta \xi(x, t). \]  

(8)

In solving Eq. (10) we take \( f_i = \text{const.} \)

In order to describe fully the change in nonequilibrium vacancy concentration in the diffusion zone, it is necessary to know the conditions at the boundaries of the diffusion zone and the state of the system at the initial moment. The following diffusion system, which corresponds closely to those encountered in real solids, is often met in experimental studies. Two specimens are in contact along a plane interface at a point \( x = 0 \). The right-hand specimen contains \( m \) elements in solid solution, their initial concentration being \( c_{i_1}, c_{i_2}, \ldots, c_{i_m} \); the left-hand specimen contains \( i-m \) elements whose initial concentration is \( c_{i_1}, c_{i_2}, \ldots, c_{i_i} \).

The contact between these two specimens is such that the density and distribution of vacancy sinks at the interface is not in any way different from those in the specimen interior. Each specimen may be regarded as semi-infinite, i.e., if no discernible changes in the concentration at its outer end occur during diffusion annealing, i.e., if

\[ \frac{\partial c_i(x, t)}{\partial t} \bigg|_{x=a} = \frac{\partial c_i(x, t)}{\partial t} \bigg|_{x=b} = 0. \]  

(11)

The solution of (10) for boundary conditions (12) is given by

\[ \Delta \xi(x, t) = -\int_0^t \frac{e^{-\lambda(t-\tau)}}{2V\pi\cdot D_v(t-\tau)} d\tau \int_0^\infty \sum_i \frac{\partial c_i(y, z)}{\partial z} e^{-\frac{(y-x)^2}{4D_v(t-\tau)} d \tau.} \]  

(13)

In practice, it often happens that at the interface of a diffusion couple there is a large number of voids and other imperfections which form a local zone with specific conditions for the sinking of excess vacancies. In mathematical notation this will be reflected in the form of additional boundary conditions for the region at the point \( x = 0 \); these conditions may be in the form

\[ \frac{\partial \Delta \xi(x, t)}{\partial x} \bigg|_{x=0} - H \cdot \Delta \xi(x, t) \bigg|_{x=0} = 0. \]  

(15)

The first boundary condition stipulates that there must always be an equilibrium vacancy concentration at the interface; the second condition requires that the flow of excess vacancies into the region of imperfections at the inter-