Invariant Reactions in Multicomponent Systems

In Vol. 5, No. 3 of the *Bulletin,* Dr. N. Kanani and Prof. K. Löhberg proposed a logical system for naming invariant reactions in multicomponent systems. This system has been adopted for the program on the critical evaluation of ternary alloy systems (see section on invariant equilibria in [80Pet]). Where I part company with the authors is in their new method for graphically representing invariant reactions and their associated monovariant equilibria (see Eq. 2). The essential facts to establish when considering invariant reactions are:

- What are the associated monovariant equilibria at temperatures above and below the invariant equilibrium temperature?
- How do the monovariant equilibria vary with the type of invariant reaction?

Invariant equilibria in isobaric sections of n-component systems are defined by the general relation:

$$\varphi_1 + \varphi_2 + \ldots + \varphi_{i-1} + \varphi_i = \varphi_{i+1} + \ldots + \varphi_n + \varphi_{n+1} \quad \text{(Eq 1)}$$

where $\varphi_1, \ldots,$ and φ_{n+1} are the phases in equilibrium at the invariant reaction temperature, T_R.

The number of monovariant equilibria above T_R equals the number of reactant phases produced on cooling through the invariant reaction $= n + 1 - i$.

The number of monovariant equilibria below T_R equals the number of reacting phases taking part in the invariant reaction $= i$.

The phases coexisting in the $(n + 1 - i)$ monovariant equilibria for $T > T_R$:

$$T > T_R = \left(\sum_1^i \varphi\right) + (n - i)$$

phases from $\{\varphi_{i+1}, \ldots, \varphi_{n+1}\}$ (Eq 2)

The phases coexisting in the (i) monovariant equilibria for $T < T_R$:

$$T < T_R = \left(\sum_{i+1}^{n+1} \varphi\right) + (i - 1)$$

phases from $\{\varphi_1, \ldots, \varphi_i\}$ (Eq 3)

A simple example of the ternary invariant reaction

$1 + \alpha + \beta \rightleftarrows \gamma \; (\varphi_1 + \varphi_2 + \varphi_3 \rightleftarrows \varphi_4)$

where $n = 3$, $i = 3$ yields

$T > T_R$: $(n + 1 - i) = 1$ monovariant equilibrium.

The coexisting phases are $(\Sigma_1^3 \varphi) + 0$ phases from φ_4, i.e.:

$\varphi_1 + \varphi_2 + \varphi_3 \equiv 1 + \alpha + \beta$

$T < T_R$: $(i) = 3$ monovariant equilibria.

The coexisting phases are $(\Sigma_4^4 \varphi) + 2$ phases from $\{\varphi_1, \varphi_2, \varphi_3\}$, i.e.:

$\varphi_4 + \varphi_1 + \varphi_2 \equiv \gamma + 1 + \alpha$

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An example of a senary invariant equilibrium is given in [83Pri]. Given the generalized invariant equilibrium relation (Eq 1), inserting values for n and i, and using expressions in Eq 2 and 3 defines the invariant equilibrium and the coexisting phases in the associated monovariant equilibria. Contrary to the suggestion of Dr. Kanani and Prof. Löhberg, I would submit that this approach becomes easier the higher the value of n, whereas the use of polygons becomes more cumbersome with increasing n.

References

80Pet: G. Petzow, E.-Th. Henig, H.L. Lukas, F. Aldinger, and A. Prince, *Bull. Alloy Phase Diagrams, 1*(2), 36-40 (1980).
83Pri: A. Prince, *Z. Metallkd., 74*(5), 338 (1983).

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We invite your comments on these or any other topics.
—*Editor*

Addenda

The Ni-Ta System

In Vol. 5, No. 3, page 260, the composition of the Ni_8Ta phase at the peritectoid temperature was erroneously listed as ~12.5 at.% Ta in Table 1. This should have been ~12.2 at.% Ta, in agreement with Fig. 1.

The C-Fe-V and Fe-N-V Systems

In the Fe-N-V evaluation (Vol. 5, No. 2) and the C-Fe-V evaluation (Vol. 5, No. 3), the reference of [84Smi] was given on the basis of a preprint received by Prof. V. Raghavan from Prof. J.F. Smith. Prof. Raghavan finds that the printed Fe-V diagram is considerably different from that in the preprint and suggests, therefore, that it would be more appropriate to change the above reference to [82Kub], which contains the same diagram as in the preprint. The reference [84Smi] should be changed to read:

82Kub: O. Kubaschewski, *Iron—Binary Phase Diagrams*, Springer-Verlag, Berlin, 160-164 (1982). (Review; #)

The Ti-Zn System

Thanks are due to Dr. William G. Moffatt of the General Electric Co. in Schenectady, NY for calling attention to the following correction: the Ti-Zn atomic percent tear-out on page 111 of Vol. 5, No. 1 should reference the evaluation on page 52.