Chapter 7
The Application of the Boundary Theory to Isobaric Phase Diagrams

7.1 Brief Review of the Application for the Boundary Theory

Through application of the boundary theory, Palatnik-Landau’s contact rule for phase regions is deduced. Then, and in accord with the course of deduction of this rule, its limitations in some of its application have been examined. Comparison of the Palatnik-Landau’s contact rule with the boundary theory, has been discussed in detail.

The relationship among the NPRs and their boundaries, for both simple and complex phase diagrams, has been discussed. Rhines’ ten empirical rules for the construction of complicated ternary phase diagrams, from corresponding phase diagram units, have been explained. The boundary theory, dealing as it does with the isothermal and isopleth sections of multicomponent systems, has been well worked out.

In the practice of applying boundary theory, isothermal multi-component sections may be constructed with the presently limited information.

7.2 The Analysis of the Fe-Cr-C Isopleth Section

The Fe-Cr-C ternary phase diagram is a very important tool in the research and development of stainless steel compositions. Fig. 7.1 is an isopleth section of the Fe-Cr-C system, located at the 0.2 mass% carbon content [Perkner, 1977].

What is the meaning of each of the boundary lines displayed in the figure? Can the equilibrium compositions of the phases present be read from the boundary lines in the diagram? The answers to these and other related questions may be obtained with the application of the boundary theory.

There are boundary lines for three different types in the section.

1. The NPRs type with parameters: $\Phi = 2$ and $\phi_C = 1$

NPRs $\delta/(\delta + \alpha)$, $\gamma/(\alpha + \gamma)$ and $\gamma/(\gamma + \kappa_1)$ are all able to satisfy the conditions: $\Phi = 2$, $\phi_C = 1$. 
The characteristics of the boundary between these pairs of NPRs, in the corresponding spatial phase diagram, are:

$$R_1 = N - \Phi + 1 = 4 - 2 = 2$$

$$R'_1 = R_1 + \phi_C - 1 = 2 + 1 - 1 = 2$$

And the dimensions of the boundaries and phase boundaries in the isopleth section, are as follows:

$$(R_1)_i = R_1 - 1 = 2 - 1 = 1, \quad (R'_1)_i = R'_1 - 1 = 2 - 1 = 1$$

$$(R_1)_i = (R'_1)_i = 1$$

Thus, boundary lines of this type in the isopleth section are also phase boundary lines. They consist not only of the system points, but also of the phase points. At a given temperature, the equilibrium compositions of common phases (e.g. phases $\delta$ and $\gamma$) may be read from these phase boundary lines.

2. The type of NPRs with parameters: $\Phi=3$ and $\phi_C=2$.

The NPRs $(\alpha + \gamma)/(\alpha + \gamma + \delta)$, $(\delta + \alpha)/(\delta + \alpha + \gamma)$, $(\delta + \alpha)/(\delta + \alpha + \kappa_1)$, $(\alpha + \kappa_1)/(\delta + \alpha + \kappa_1)$, $(\alpha + \kappa_1)/(\gamma + \kappa_1 + \alpha)$, $(\alpha + \gamma)/((\alpha + \gamma + \kappa_1)$ and $(\gamma + \kappa_1)/(\alpha + \gamma + \kappa_1)$ satisfy the conditions of $\Phi=3$ and $\phi_C=2$, so the dimensions of the phase boundaries and the boundaries in the corresponding spatial phase diagram, are as follows:

$$R_1 = 4 - \Phi = 4 - 3 = 1$$