Systematization of Certain Binary Metallic Equilibrium Diagrams

As part of an attempt to systematize the knowledge of factors which influence the form of binary equilibrium diagrams, we have examined the available data on binary systems in which no intermediate compounds are formed. This corresponds to a state of affairs where the electrochemical effect[1] is small, and if those systems characterized by a 100 per cent range of solid solubility are ignored, the systems considered fall into two distinct classes; namely, those in which a region of liquid immiscibility is encountered (Fig. 1), of which aluminium–potassium is an example, and those which are characterized by the existence of a eutectic (Fig. 2), of which bismuth-cadmium is an example.

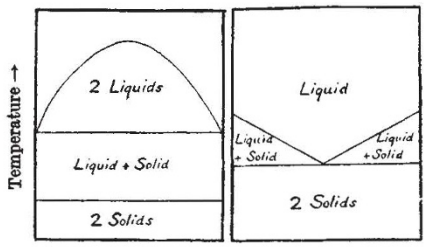

Fig. 1. The aluminium–potassium type of diagram
Fig. 2. The bismuth–cadmium type of diagram

In Fig. 3 we have plotted the size factor of each system, as defined by the relation

$$\text{size factor} = \frac{L - S}{S} \times 100,$$

where L is the closest distance of approach of atoms of the larger atomic species in crystals of the pure element and S is the corresponding value for the smaller atomic species, against a 'temperature factor' $\frac{\Delta\theta}{\frac{1}{2}(\theta_1+\theta_2)}$, where $\Delta\theta$ is the difference between the melting points of the elements and θ_1 and θ_2 are the melting point temperatures on the absolute scale.

Fig. 3 may conveniently be divided into three regions, A, B and C. In region A, where the size-factor and temperature-factor are limited by the values 30 per cent and 0·175 respectively, all systems are of a simple eutectic type (Fig. 2), in which the eutectic point is moderately near the centre of the composition scale. In region B, where the size-factor is everywhere greater than 30 per cent, we find that the two-liquid system predominates. It is, however, quite clear that although a large size-factor strongly favours the formation of a two-liquid type of diagram, size-factor is not the only controlling effect: in region C, for example, there is an approximately equal number of two-liquid and eutectic-type diagrams distributed randomly throughout the region. Moreover, in region B, the system germanium–lead is an outstanding exception to the general rule that a size-factor of more than 30 per cent is associated with a two-liquid type of diagram. This system[2] is characterized by a fairly flat liquidus curve and by having the eutectic point very near the composition of one of the pure metals; and if compared with Figs. 1 and 2, it may be regarded as being of an intermediate type.

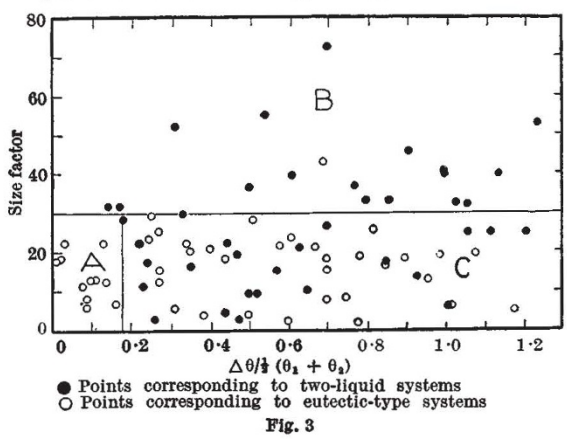

Fig. 3

In view of the existence of this intermediate type of diagram, it is of interest to examine more closely the form of the eutectic-type diagrams in region C. In this region, as the temperature-factor increases from 0·175 to 0·4, the eutectic point moves progressively away from the centre of the composition scale and the diagrams approximate to the form of that for germanium–lead. When the temperature factor is greater than 0·4, the diagrams tend to be of the intermediate type already discussed.

It has not, in the present investigation, been possible to elucidate the factors which control the formation of two-liquid or eutectic-type diagrams in region C of Fig. 3; but it is clear that within this zone a large temperature-factor tends to be associated with a eutectic diagram of the intermediate type.

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[1] Hume-Rothery, W., *Inst. Metals Mon.*, No. 1 (1944).
[2] Briggs, T. R., and Benedict, W. S., *J. Phys. Chem.*, **34**, 173 (1930).

Instability in Pipe Flow

When considering the conditions necessary for the stability of laminar flow in a cylindrical pipe, it may be assumed that the following quantities are involved: transverse velocity gradient (dv/dx) at the point considered; distance (x) of the point from the wall; and kinematic viscosity (ν) of the liquid.

The dimensionless group arising from these quantities is

$$G = \frac{(dv)}{(dx)}\frac{x^2}{\nu} = x \cdot \frac{d}{dx}({}_xRe) - {}_xRe,$$

where ${}_xRe$ is the localized Reynolds number $\frac{vx}{\nu}$.

In fully developed laminar flow the maximum value of G occurs when $x = d/3$, where d is diameter of pipe; and this maximum value is

$$G_{max} = \frac{8\bar{v}d}{27\nu} = \frac{8}{27}Re.$$

From the generalized velocity-distribution curves (for the flow near the entrance to a pipe) given by Nikuradse[1], it may be shown that the value of G_{max} increases downstream, as shown in Fig. 1, where X is downstream distance from the entrance. A value of about 2,000 is frequently assumed for the critical Reynolds number: the corresponding value of G_{max} is about 592.