## The Enthalpies of Formation of Ferromagnetic Cu-Mn-Sn Alloys

## M. A. MEYERS AND M. T. HEPWORTH

The enthalpies of formation at 298.16 K of five alloys closely approaching the composition Cu<sub>2</sub>MnSn were determined by solution calorimetry with tin as a solvent. The alloys are in the ferromagnetic  $\beta$  phase range; their compositions, as well as the maximum range for the  $\beta$  phase are shown in Fig. 1. This phase is ordered and presents reasonably high magnetizations (up to 660 emu/cm³). The  $\beta$  phase decomposes upon cooling below 400°C. Alloys were prepared by arc melting. They were homogenized and quenched to retain the  $\beta$  phase at room temperature.

The liquid-metal solution calorimeter used in this investigation has been described elsewhere.  $^1$  At the start of each series of measurements, the solvent bath consisted of about 0.4 g-atom of 99.9+ pct pure Sn. The heat capacity of the calorimeter was determined by two tin drops before each series of experiments. The only heat effect due to a tin drop is the sensible heat of the specimen. The heat content of tin is well established and is presented in the compilation of Hultgren  $et\ al.^2$ 

The calculation of the enthalpies of formation of the alloys was made on the basis of the enthalpies of solu-

Manuscript submitted May 22, 1972.

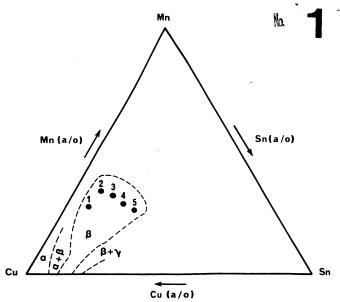


Fig. 1—Alloys studied in Cu-Sn-Mn system.

Table I. Enthalpies of Formation as a Function of Composition in the Cu<sub>2</sub> Sn-Mn System

Chemical Unit	Alloy	$\Delta H^f$ (cal/mole)
Cu <sub>2,445</sub> Mn <sub>1,0</sub> Sn <sub>0,215</sub>	1	-3,400 ± 1,000
Cu <sub>1.783</sub> MnSn <sub>0.313</sub>	2	$-3,100 \pm 1,100$
Cu <sub>1.828</sub> MnSn <sub>0.510</sub>	3	$-3,900 \pm 700$
Cu <sub>2.020</sub> MnSn <sub>1.012</sub>	4	$-2,200 \pm 1,000$
Cu <sub>2.323</sub> MnSn <sub>1.805</sub>	5	$-1,600 \pm 1,200$

tion of the alloy and of the constituent elements, as shown in the expression below:

$$\begin{split} \Delta H^f_{\text{Cu}_x \text{Mn}_y \text{Sn}_z} &= x \Delta H^{\text{soln}}_{\text{Cu}} + y \Delta H^{\text{soln}}_{\text{Mn}} + z \Delta H^{\text{soln}}_{\text{Sn}} \\ &- \Delta H^{\text{soln}}_{\text{Cu}_x \text{Mn}_y \text{Sn}_z} \end{split}$$

The results obtained are shown in Table I.

The financial support of the National Science Foundation Engineering Materials Program Grant GK-12527 is acknowledged.

M. A. MEYERS and M. T. HEPWORTH are Graduate Research Assistant and Chairman of Programs, respectively, Department of Chemical Engineering and Metallurgy, University of Denver, Denver, Colo. 80210.

<sup>1.</sup> M. J. Pool: Trans. TMS-AIME, 1965, vol. 233, pp. 1711-15.

R. Hultgren, R. L. Orr, P. D. Anderson, and K. K. Kelley: Selected Values of Thermodynamic Properties of Metals and Alloys, John Wiley and Sons, 1963.