CHAPTER V

CONCLUSION AND DISCUSSION

The alloy Ni_2MnGe was found to be very weak magnetic at room temperature but highly magnetic at liquid nitrogen temperature. The room temperature unpolarized neutron diffraction data were used in determining the atomic or chemical ordering in the alloy. The following values were found for the atomic ordering and site scattering amplitudes :

$$A = .703\ Ni + .285\ Ge + .011\ Mn, \quad b_A = .9603 \times 10^{-12}\ cm$$

$$B = .022\ Ni + .011\ Ge + .967\ Mn, \quad b_B = -.3162 \times 10^{-12}\ cm$$

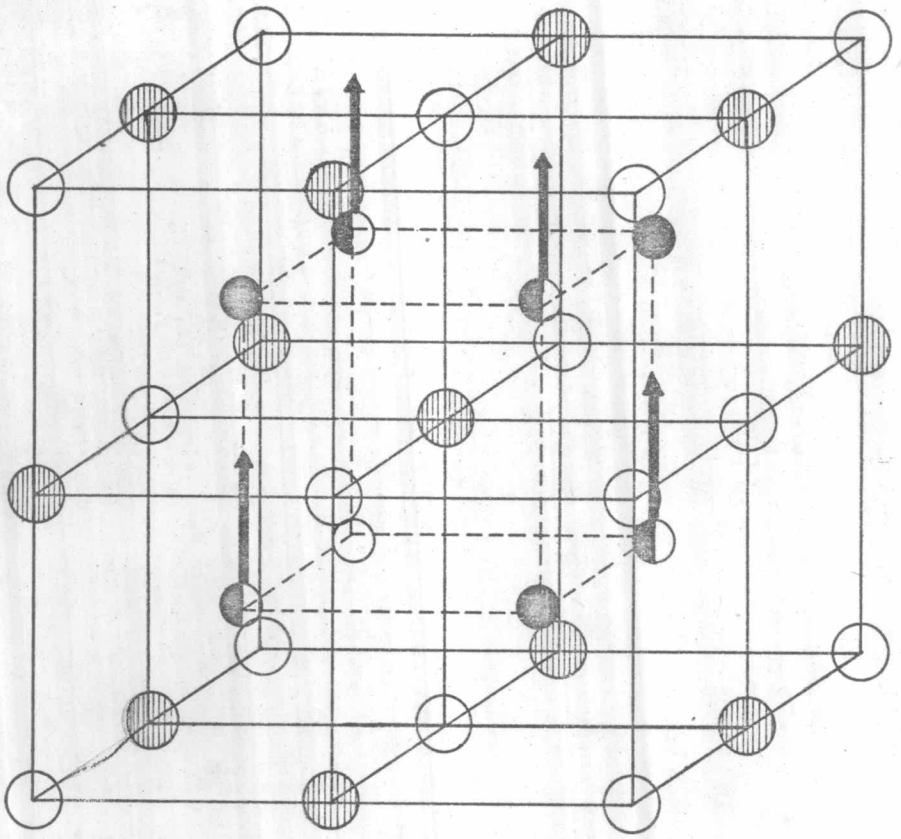
$$C = .703\ Ni + .285\ Ge + .011\ Mn, \quad b_C = .9603 \times 10^{-12}\ cm$$

$$D = .572\ Ni + .417\ Ge + .011\ Mn, \quad b_D = .9354 \times 10^{-12}\ cm$$

The atomic distributions show that in the alloy Ni_2MnGe, the type of disorder is dominated by Ni-Ge disorder while random disorder is also observed. This is shown in figure 7.

Lattice constant of the alloy was found to be 5.9717 A° which does not agree with the value given by Pearson.[21] The reasons for the disagreement might due to the difference in the atomic composition of the alloy as discussed in section (IV.1).

The magnetic ordering in this alloy was determined from the neutron diffraction data taken at 85 $^{\circ}$K. No extra reflection appeared



A , .703 Ni + .285 Ge + .011 Mn

B , .022 Ni + .011 Ge + .967 Mn

C , .703 Ni + .285 Ge + .011 Mn

D , .572 Ni + .417 Ge + .011 Mn

Fig. 7 The chemical and magnetic unit cell of $Ni_2Mn\,Ge$

but an increase in the intensities of the fundamental reflections was observed indicating that the structure is basically ferromagnetic. The analysis of the data yield a magnetic moment of

$$\mu_{Mn} = 3.2\ \mu_B$$

The magnetic moments were assumed to confine to the manganese ions at B sites only. However, it was found in other Heusler alloys[14] that the small percentage of manganese moments on A and C sites aligned antiparallel to those on the B sites and the moments of D sites aligned parallel. The magnetic unit cell should be looked as shown in figure 8. This magnetic ordering can be understood on the basis of the distances between manganese atoms. It was shown by Holtzman[24] that manganese atoms with separations greater than 2.82 A° should have parallel magnetization, and a separation less than 2.82 A° between adjacent manganese atoms results in antiparallel coupling. In the present experiment, manganese atoms in B sites are at distance of 4.225 A°. The nearest distance between a manganese atom on a B site to another manganese atom on a D site is 2.9858 A°.

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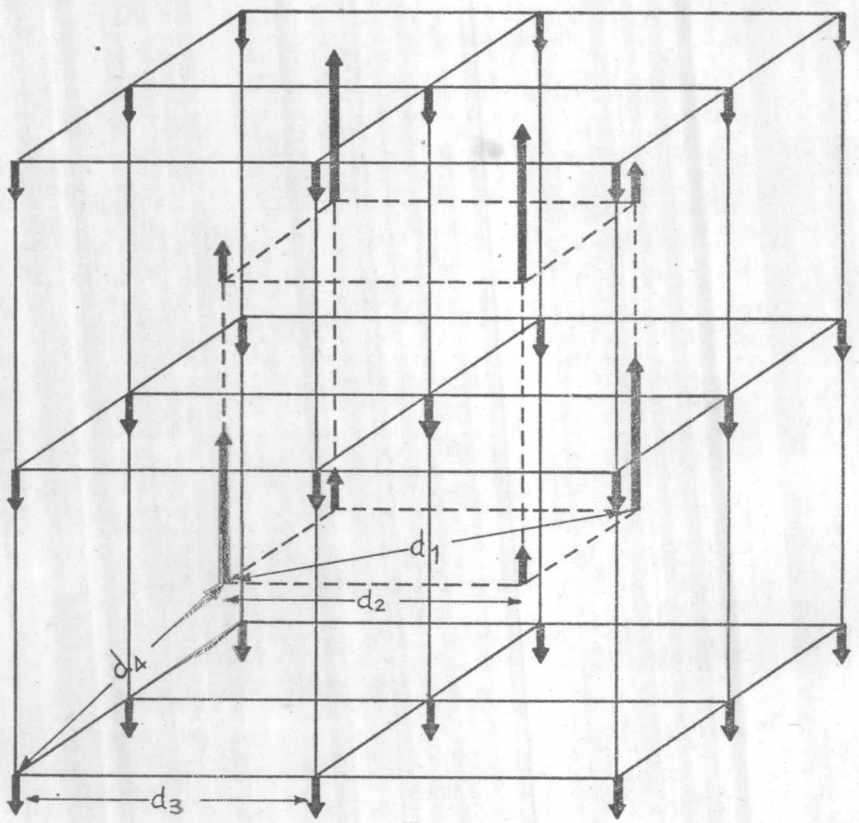
(24) Holtzman, A.H., Ph.D. Thesis, Lehigh University (1958)



d_1 = 4.2225 A° d_2 = 2.9858 A° .967 Mn ↑ .011 Mn

d_3 = 2.9858 A° d_4 = 2.5855 A° ↓ .011 Mn

Fig. 8 The model magnetic structure for disorder Ni_2MnGe. (a = 5.9717 A°)

Hence a ferromagnetic alignment is favoured among manganese atoms. On the other hand, the nearest distance between a manganese atom on an A site to another manganese atom on a C site is 2.9858 A°. This situation also favours a ferromagnetic alignment of the manganese moments. However, the nearest distance between the former two sublattices to the later two sublattices is 2.5855 A°. Hence an antiferromagnetic coupling is favoured.

The magnetic structure of this type has been observed in most Heusler alloys containing manganese when a state of disorder occurs. However, this model magnetic structure cannot be observed in the present investigation due to the fact that for Heusler alloys containing nickel, the nuclear scattering cross-section is much higher than the magnetic scattering cross-section. Hence the magnetic scattering contribution in each Bragg reflection is small compared to the nuclear scattering. This is shown for comparison in table 6. The effect of magnetic scattering from a small percent of disorder manganese atoms on the A, C and D sites cannot be detected.

An attempt was also made to determine the Curie point of Ni_2MnGe. It was found that the alloy was weakly magnetic at room temperature. Small pieces of the alloy sample were attracted to a hand magnet in cold water. The water was slowly warmed up. Marked attraction to the magnet persists up to 80 $^{\circ}$C. In this test, it is

not possible to note a significant difference between paramagnetic attraction above the Curie point and weak magnetic attraction just below the Curie point. Thus, although this test shows that the Curie point is about 80 °C, the actual Curie temperature could not be determined.