seen in Fig. 1 for $(Fe_{1-x}Ni_x)_2P$ compounds, we know that K_2 is negligibly small. The concentration dependence of K_1 at 4.2 K is shown in Fig. 7 for $(Fe_{1-x}Ni_x)_2P$ compounds. The value of K_1 decreases rapidly with increasing x and becomes almost zero for the compounds near $x=0.3$. Since Ni atoms substitute preferentially for Fe atoms on M_I site in the range $x<0.3$, it might be deduced that the magnetic anisotropy is due to the crystal field anisotropy of the Fe atoms on M_I site rather than those on M_{II} site. Furthermore, if the magnetic anisotropy comes from the crystal field effects, K_1 should be proportional to the third power of the magnetization.[5] The temperature dependence of K_1 in Fig. 8, however, appears to be represented by the fifth power function of the spontaneous magnetization in low temperatures. This suggests that the anisotropy may originate in not only the crystal field effects, but also the other mechanisms, such as the anisotropy of exchange interactions or the magnetoelastic interactions.

Accepting that only Fe atom contributes to the magnetic moment in the compound, we can estimate the magnetic moments per iron atom in the ferromagnetic and paramagnetic states, μ_f and μ_p, respectively. In Fig. 9, the estimated values of μ_f and μ_P are plotted against x. The value of μ_P decreases monotonically with increasing x, but that of μ_f slightly changes in the range $0 \leqq x < 0.3$ and decreases with increasing x for $x>0.3$. This means that substitution of Ni atom for Fe atom on M_I site produces little change

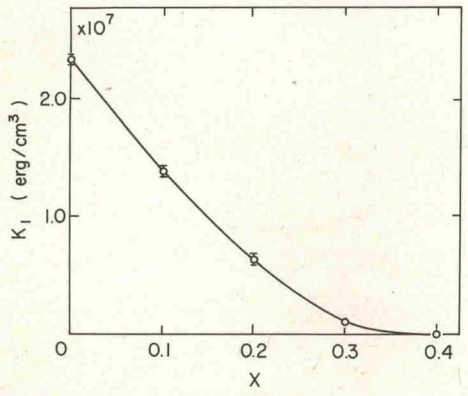

Fig. 7. Anisotropy constant at 4.2 K as a function of composition for $(Fe_{1-x}Ni_x)_2P$.

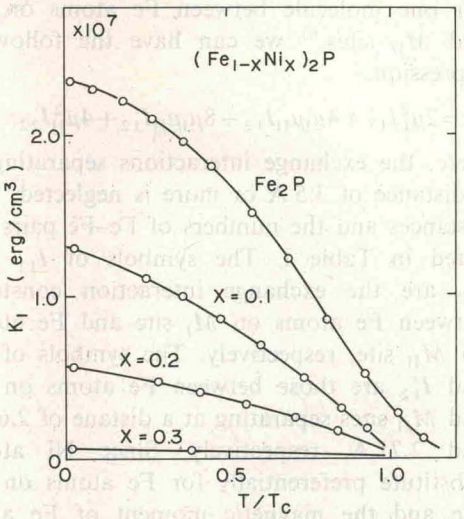

Fig. 8. Temperature dependence of the anisotropy constant K_1 for $x=0.0$, 0.1, 0.2 and 0.3 in $(Fe_{1-x}Ni_x)_2P$.

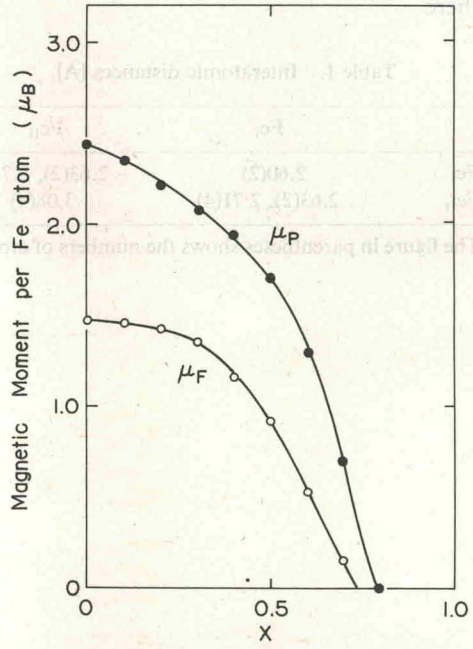

Fig. 9. Concentration dependence of the magnetic moments per Fe atom in the ferromagnetic and paramagnetic states μ_f and μ_P, respectively.

in μ_f and the decrease of μ_f is due to substitution of Ni atom for Fe atom on M_{II} site.

Finally, we will briefly describe the exchange interaction in Fe_2P by using the concentration dependence of the Curie temperature of $(Fe_{1-x}Ni_x)_2P$ system. If the Curie temperature is given by the sum of the exchange energy

per one molecule between Fe atoms on M_{I} and M_{II} sites,[6] we can have the following expression,

$$T_c=2\mu_{\mathrm{I}}^2 I_{11}+4\mu_{\mathrm{I}}\mu_{\mathrm{II}} I_{12}+8\mu_{\mathrm{I}}\mu_{\mathrm{II}} I'_{12}+4\mu_{\mathrm{II}}^2 I_{22}. \quad (3)$$

Here, the exchange interactions separating at a distance of 3.5 A or more is neglected. The distances and the numbers of Fe–Fe pairs are listed in Table I. The symbols of I_{11} and I_{22} are the exchange interaction constants between Fe atoms on M_{I} site and Fe atoms on M_{II} site, respectively. The symbols of I_{12} and I'_{12} are those between Fe atoms on M_{I} and M_{II} sites separating at a distane of 2.63 A and 2.71 A, respectively. Since Ni atoms substitute preferentially for Fe atoms on M_{I} site and the magnetic moment of Fe atom slightly changes for the compounds with $x<0.3$, T_c is expressed as follows,

$$T_c=2(1-x)^2 T_{11}+4(1-x)T_{12}+4T_{22}, \quad (4)$$

where

Table I. Interatomic distances [A].

	$\mathrm{Fe_I}$	$\mathrm{Fe_{II}}$
$\mathrm{Fe_I}$	2.60(2)	2.63(2), 2.71(4)
$\mathrm{Fe_{II}}$	2.63(2), 2.71(4)	3.08(4)

The figure in parentheses shows the numbers of atoms.

$$T_{11}=\mu_{\mathrm{I}}^2 I_{11}, \quad T_{12}=\mu_{\mathrm{I}}\mu_{\mathrm{II}} I_{12}+2\mu_{\mathrm{I}}\mu_{\mathrm{II}} I'_{12},$$

and

$$T_{22}=\mu_{\mathrm{II}}^2 I_{22}. \quad (5)$$

From the concentration dependence of T_c in Fig. 6, we obtained the values of $T_{11}=-1950$ k, $T_{12}=1660$ k and $T_{22}=-630$ k. The dotted line of T_c in Fig. 5 is the calculated curve and is in fairly good agreement with the experimental curve within $x<0.3$. It might be concluded that the exchange interaction between the first nearest neighbor Fe atoms is strongly antiferromagnetic and the exchange interaction between the 3rd neighbor atoms is weakly antiferromagnetic, but the 2nd neighbor exchange interaction is strongly ferromagnetic.

References

1) H. Fujii, T. Hōkabe, T. Kamigaichi and T. Okamoto: J. Phys. Soc. Japan **43** (1977) 41.
2) Y. Maeda and Y. Takashima: J. inorg. nucl. Chem. **35** (1973) 1963.
3) R. Fruchart, A. Roger and J. P. Senateur: J. appl. Phys. **40** (1969) 1250.
4) W. S. Sucksmith and J. F. Thompson: Proc. Roy. Soc. (GB) **A225** (1954) 362.
5) H. B. Callen and E. Callen: J. Phys. Chem. Solid **27** (1966) 1271.
6) T. Mizoguchi, M. Akimitsu and S. Chikazumi: J. Phys. Soc. Japan **34** (1973) 932.