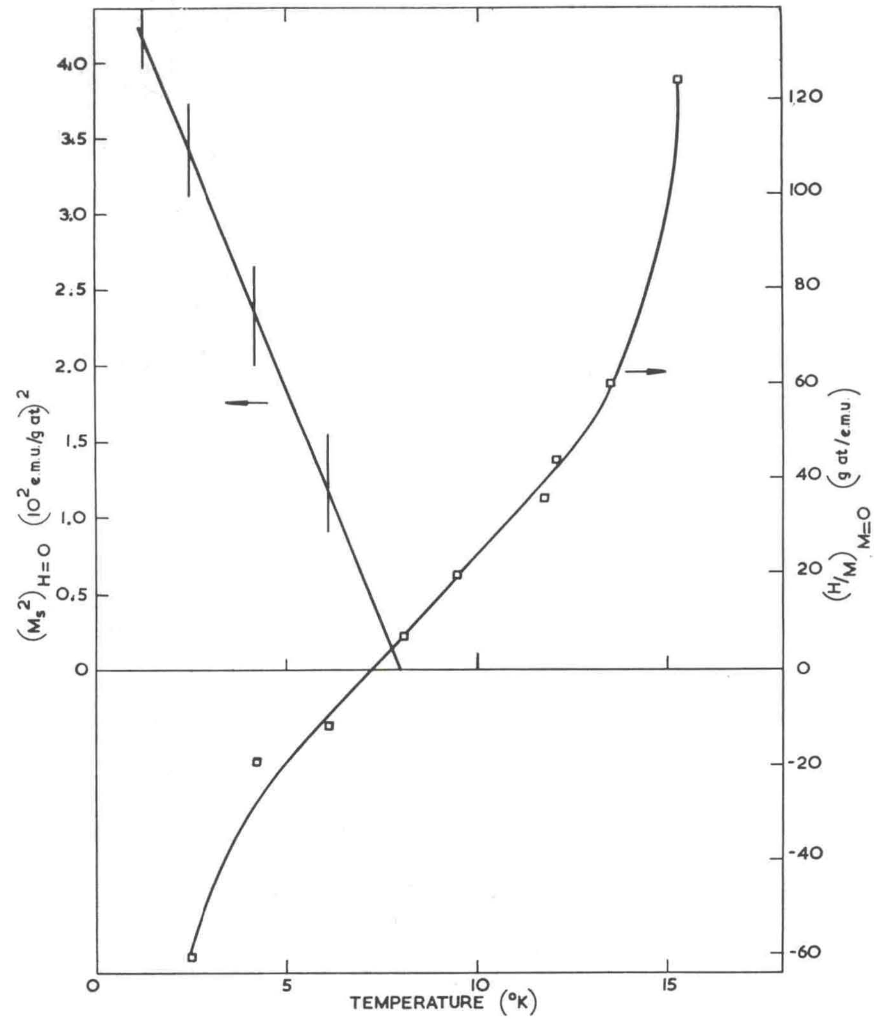

FIG. 6. Determination of the Curie temperature from magnetization data for a sample of a 24.2 at. % In alloy.

origin. Theoretically, such curves should be linear close to T_c, but, unfortunately, in many instances the curves obtained are nonlinear and the extrapolation can become very dubious.

(iii) The third is the behavior of the initial zero-field susceptibility.

We were unable to use the first method since remanence was not observed in measurements above 1000 Oe, the minimum field used with the superconducting magnet. Measurements in lower fields would require an actual determination of the field in the coil, whereas we obtained the field from a measurement of the current. This leads to errors in the field of less than 1% above 2 kOe, but would be unsuitable for lower fields because of the remanence of the coil.

We have however applied the second method to our data as illustrated in Fig. 5, where we have plotted M^2 versus H/M. It is evident that in the temperature range 1.23 to 15.3°K, M^2 is not linear in H/M and that this type of plot does not therefore lead to a precise extrapolation to zero field. Nevertheless, we have indicated reasonable extrapolations of $(H/M)_{M^2=0}$ and $(M_s^2)_{H/M=0}$ in Fig. 5, plotted these values against T in Fig. 6, and thus obtained a value of $T_c=(7.5\pm 0.5)$°K.

Although theoretically at T_c the initial susceptibility (χ_i) becomes infinite, in practice, since the measurements must always be made in finite field, the value of $\chi_i(T_c)$ remains finite. The expected form[20] of the initial susceptibility curve as a function of temperature is drawn schematically in Fig. 7(a), and curves of this shape have been reported for Ni and some ferromagnetic alloys by Belov.[20] However, more generally, the initial susceptibility curve exhibits a broad hump in the vicinity of T_c, and is represented schematically in Fig. 7(b). Such curves, as determined by the "transformer" technique[22] in studies of the pressure dependence of the Curie point, are unsuitable for an accurate determination of T_c. However, these curves do provide an adequate means of determining the change of T_c, with pressure, from their relative displacement. It is

[22] L. Patrick, Phys. Rev. 93, 384 (1954).

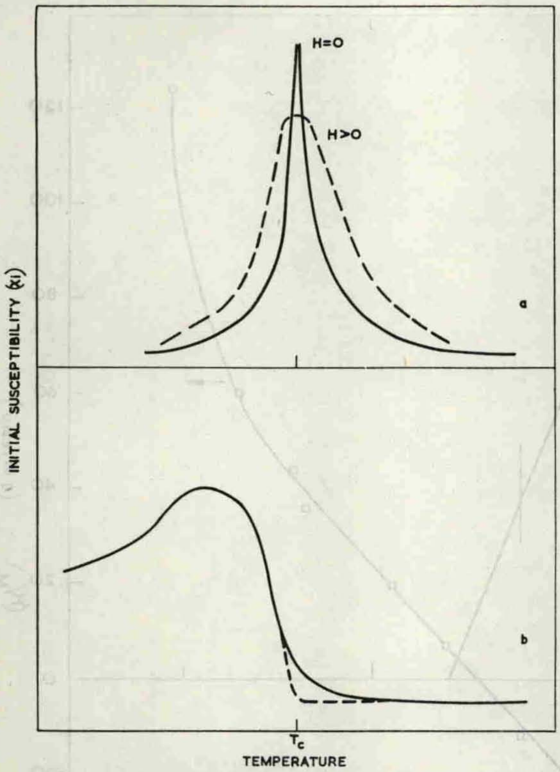

FIG. 7. Initial magnetic susceptibility as a function of temperature: (a) Theoretical curves for $H=0$ and $H>0$. (b) Typical curve obtained by means of the "transformer technique."

customary to extrapolate the sharply rising portion of the curve to intersect an extrapolation of the background reading and to define this point as an arbitrary Curie point $T_c(P)$ for the purpose of determining the pressure dependence.

In Fig. 8 we present the initial susceptibility curves observed for the 24.2 at. % In sample at 1 bar, 6.1 and 13.6 kbar between 12.5 and 1.2°K. Although only a limited number of initial susceptibility curves of ferromagnetic materials are available for comparison, it is evident that the present curves have a more complex structure than is usually observed. They do, however, have a remarkable similarity to those observed[23] for the ferromagnetic transition in Gd. It has now been established[24] that the magnetic properties of Gd in weak fields result from a strong magnetocrystalline anisotropy close to T_c, and are not, as originally proposed by Belov,[25] due to the formation of a helical antiferromagnetic state.[26] In view of the hexagonal structure of the Sc_3In phase, anisotropy may also be responsible for the observed behavior in the present case. In this respect we note that $ZrZn_2$, which has a cubic structure, does not exhibit any unusual features in its initial susceptibility curve.[8]

Because of broadening, the structure observed in the curves taken at 1 bar and 6.1 kbar cannot be resolved in the curve taken at 13.6 kbar, but it reappeared in the curve obtained when the pressure was removed. We obtained a mean value of T_c ($P=1$ bar) $=6.1\pm 0.1$°K from the curves taken before and after the application of pressure. This value corresponds more closely to that obtained from the high-field measurements than in the case of $ZrZn_2$ where there is a marked difference in the values obtained by the two methods.[6]

It is clear that $T_c(P)$ increases with pressure and extrapolations similar to the one used at atmospheric pressure yield values of $T_c(P)$ at 6.1 and 13.6 kbar. A plot of these values, as a function of pressure, is given in Fig. 9, from which we obtain $\partial T_c/\partial P=1.9_5\times 10^{-4}$ °K bar^{-1}. The pressure dependence of the low-temperature peak in the susceptibility curve is also shown in Fig. 9. Following an initial increase of 1.1×10^{-4} °K bar^{-1} the pressure dependence falls off rapidly at high pressure, in contrast to the pressure dependence for T_c. However, in view of the broadening associated with the 13.6-kbar transition the relative value of $T_c(P)$ obtained at this pressure is questionable, and thus it is not impossible that $\partial T_c/\partial P$ may also be pressure-dependent.

DISCUSSION

Magnetic Susceptibility above T_c

The interpretation of strongly temperature-dependent magnetic-susceptibility data is "traditionally" carried out by plotting $1/\chi$ versus T and, if the variation is linear, the Curie-Weiss relationship

$$\chi=C/(T-\theta)=p_{\rm eff}^2/8(T-\theta) \qquad (1)$$

may be applied to determine the parameter $p_{\rm eff}$. Since the Curie-Weiss relationship is derived, theoretically, from the energy states of a system of atomiclike magnetic moments, the applicability of this equation to a given material is often cited as evidence for the existence of such moments. The nature of the interaction between these moments (i.e., ferromagnetic or antiferromagnetic) is then deduced from the sign of θ. As such moments are localized and do not contribute to the band-dependent properties of the solid a correction for the magnetic contribution from the conduction

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