TABLE II. Summary of the heat treatment and the phase composition of the Sc–In alloys studied.

Alloy (at.% In)	As cast	Phase composition[a] 800°C anneal one week	400°C anneal 4 days	Anneal 1000°C 15 h, quenched
21.1	8% Sc_2In[b]	10% Sc–In[c] (~30%)[d]	no change	no data
23.2	no data	1% Sc_2In[b]	no change	9% Sc_2In[b]
24.2	no data	5% Sc_2In[b]	no change	no data
26.2	46% Sc_2In[b]	30% Sc_2In[b]	no change	no data

[a] Volume percent, remainder Sc_3In phase.

[b] Volume percentages determined by quantitative television microscope.

[c] Volume percentage determined by x rays.

[d] Volume percentage determined by visual estimate.

800°C and then heavily deformed (~10:1 reduction) by rolling between brass plates.

MAGNETIZATION MEASUREMENTS

The magnetization measurements were made by the Faraday method, the force on the sample being determined with a Sartorius balance with a resolution of 1 μg. The susceptibility results were obtained using an electromagnet[14] capable of producing 13 kOe, whereas magnetization measurements in fields up to 40 kOe were made in a superconducting solenoid. A uniform field gradient of 100 Oe/cm over a region ~1 cm in length was superimposed on the main solenoid field at the sample by means of two opposed coils situated at the ends of the main superconducting coil.

The superconducting magnet was maintained at 4.2°K in a liquid-helium bath. The sample was suspended at the center of the main coil in a copper tube surrounded by a separate helium bath, which on pumping could reduce the temperature at the sample to 1.2°K. Thermal contact between the sample and this variable bath was maintained by means of helium exchange gas. Temperatures between 4.2°K and room temperature could be established and maintained to ±0.1°K by passing a current through a Pt–Rh heater wound around the bottom of the sample tube. Temperatures were determined by one of three thermometers, depending upon the temperature range. From 1.2 to 4.2°K the vapor pressure over the helium refrigerant bath served as its own thermometer; between 4.2 and 30°K a calibrated Honeywell-Brown germanium resistance thermometer, mounted inside the sample tube close to the sample, was used; and temperatures above 30°K were determined by a copper-constantan thermocouple attached to the sample tube. A full description of the design and operation of this apparatus will be published elsewhere.[15]

Using the above arrangement magnetic isotherms were determined between 1.2 and 35°K in magnetic fields up to 40 kOe.

ZERO-FIELD CURIE-POINT DETERMINATION

The zero-field Curie point was determined from measurements of the initial susceptibility which were made in a separate apparatus capable of containing pressures up to 20 kbar. The pressure, generated in a hardened Be–Cu alloy cylinder at room temperature and transmitted to the sample through powdered Teflon, was retained by means of the "clamp" technique[16] prior to cooling to the low temperature. The pressure at the low temperature was determined from the superconducting transition temperature of a lead manometer[17] which was included in the sample assembly.

The initial susceptibility of the sample was followed as a function of temperature below 15°K by means of a standard inductance-measurement technique using a frequency of 100 cps and a signal strength equivalent to a peak-to-peak field of ~0.25 G at the sample. The temperature was determined from a Honeywell-Brown germanium resistance thermometer which had been calibrated against the zero-pressure superconducting transition temperature of lead, taken as 7.193°K,[18] and the vapor pressure of liquid helium at a number of temperatures between 4.2 and 2.5°K.

RESULTS

Magnetic Susceptibility

The magnetic susceptibility data below 250°K obtained on the 21.1, 23.2, 24.2, and 26.2 at. % In samples, following the 800°C anneal, are presented in Fig. 2. The 21.1 and the 26.2 at. % samples were also measured immediately after arc casting. Above 50°K the susceptibility values which were obtained for the arc-cast samples did not differ significantly from the values obtained for the annealed samples, but at lower temperatures they were some 5–10% higher than those shown in Fig. 2. It was also observed that the susceptibility decreased a further 10–15% from that shown in Fig. 2 below 25°K for the 21.1 and 24.2 at. % In samples after the 400°C anneal. It is clear therefore from the variation of the magnetic susceptibility observed for these four alloys that the magnetization of the Sc_3In phase critically depends upon the heat treatment that a sample has received.

In order to correct for the presence of Sc_2In in these samples the susceptibility of a sample of this composi-

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[14] W. E. Gardner and A. Davies, Atomic Energy Research Establishment Report M 1352 (unpublished).

[15] W. E. Gardner (to be published).

[16] P. F. Chester and G. O. Jones, Phil. Mag. **44**, 1281 (1953).

[17] T. F. Smith and C. W. Chu, Phys. Rev. **159**, 353 (1967).

[18] J. P. Franck and D. L. Martin, Can. J. Phys. **39**, 1320 (1961).

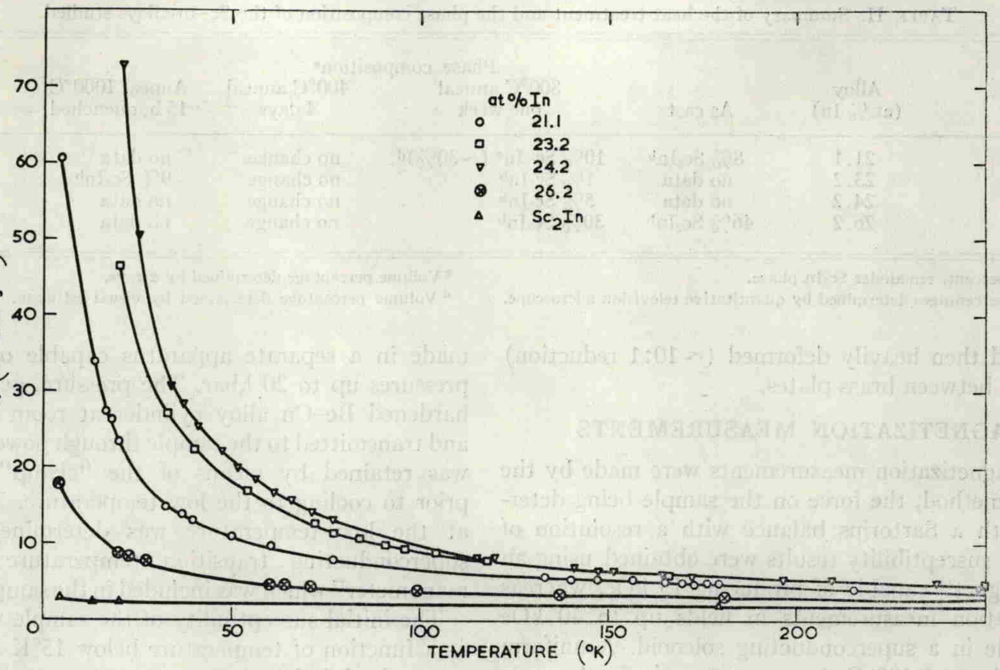

FIG. 2. Variation of the magnetic susceptibility with temperature for a number of Sc–In alloys annealed at 800°C.

tion was also determined and the data are also given in Fig. 2. Sc_2In is very nearly a temperature-independent paramagnet with χ_g varying from 1.90×10^{-6} emu/g at room temperature to 2.68×10^{-6} emu/g at 4.2°K.

The metallographic and x-ray examinations indicate that the 23.2, 24.2, and 26.2 at. % In samples are in the Sc_3In+Sc_2In phase field. The Sc_3In phase present in all three samples should, thermodynamically, have

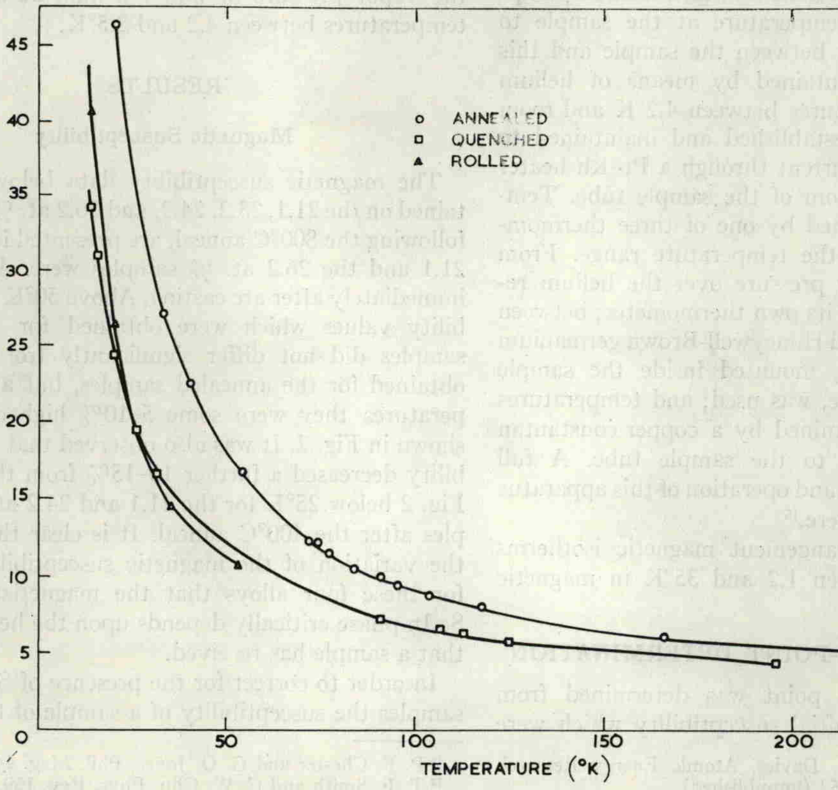

FIG. 3. Variation of the magnetic susceptibility with temperature for samples of a 23.2 at. % In alloy following various heat treatments and mechanical cold work.