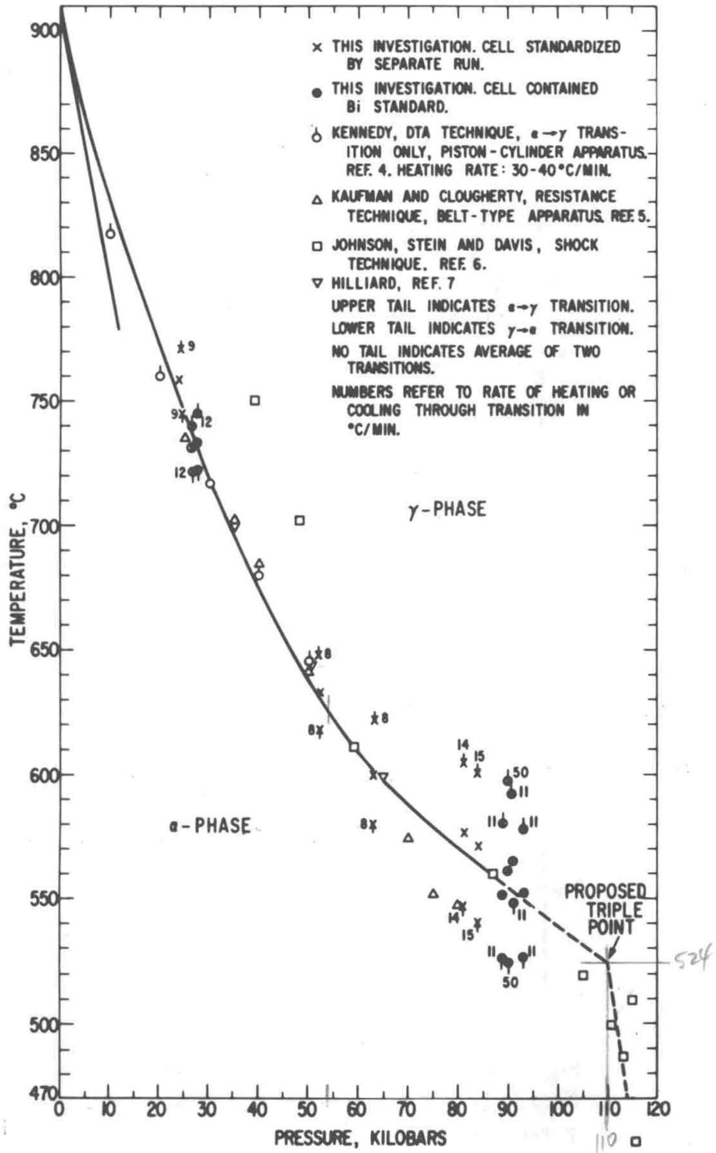

Fig. 4 Pressure-temperature curve for α - γ transformation in iron

Preparation of Alloys

The pure-iron reference samples used were Johnson-Matthey spectroscopic grade.

The iron alloys used in this study were vacuum-induction-melted from electrolytic iron and from a second component of comparable or higher purity. The ingot was hot-forged to 150 mils dia, decarburized in wet hydrogen at 700 C for 16 hr, and centerless ground to 100 mils diameter. The specimens were machined from these rods.

EXPERIMENTAL RESULTS

The α-γ Transformation in Iron--The Development of a Standard Reference Curve

The success of the duplex DTCA technique, in describing an accurate pressure-temperature transformation curve for any given material, depends upon the accuracy with which the pressure-temperature curve of a reference material is known. The data on the α-γ transformation of pure iron serve to define such a standard reference curve, shown in Fig. 4, and all of the subsequent data presented in this paper will be related (directly or indirectly) to this reference P-T curve. The data used to develop this iron curve were derived from simple DTCA runs, where iron was compared with a nontransforming material. The temperatures in the plot are averages of the forward and the reverse transformations.

Other available data on the α-γ iron transformation are included in the curve in Fig. 4. The data by Kennedy (4) taken by a DTA technique, are for the forward, α→γ, transformation only, and hence would be somewhat higher than the average of the forward and the reverse transformation temperatures. Advantageously, these data were obtained with a piston-cylinder apparatus, which one might expect to be a primary pressure-calibrating apparatus.

The data of Kaufman and Clougherty (5) were obtained with a belt-type apparatus similar in design to that used in this investigation. The iron transformations were observed by resistance changes in a wire, a thermocouple being located near the midpoint of the wire. There may be some question whether the location of the thermocouple always permits a precise observation of the transformation temperature, since the temperature gradient in the wire might permit a transformation to take place initially at the ends away from the thermocouple in some circumstances. The data of Johnson, Stein and Davis (6) were obtained by a shock technique. These data agree well in the 85-115 kb region with those of this investigation, which extend to 90 kb. The triple point at 115 kb and 503 C, proposed as the result of the shock experiments, lies close to an extrapolation of the present static data. However, the low-pressure shock data are much higher than the data from static apparatuses. At present it is not understood why at the higher pressures the shock data agree with the static data and at low pressures large deviations occur. The iron-transformation studies at 35-65 kb by Hilliard (7) agree well with the present iron curve. Here, the method of detection of the phase transformation was metallographic observation of recrystallization of that part of the α- iron which had been transformed to γ-iron.

The slope of the iron curve at atmospheric pressure was adjusted in agreement with that calculated from the heat of the α-γ transformation, 215 cal per g atom (8) and the volume change,

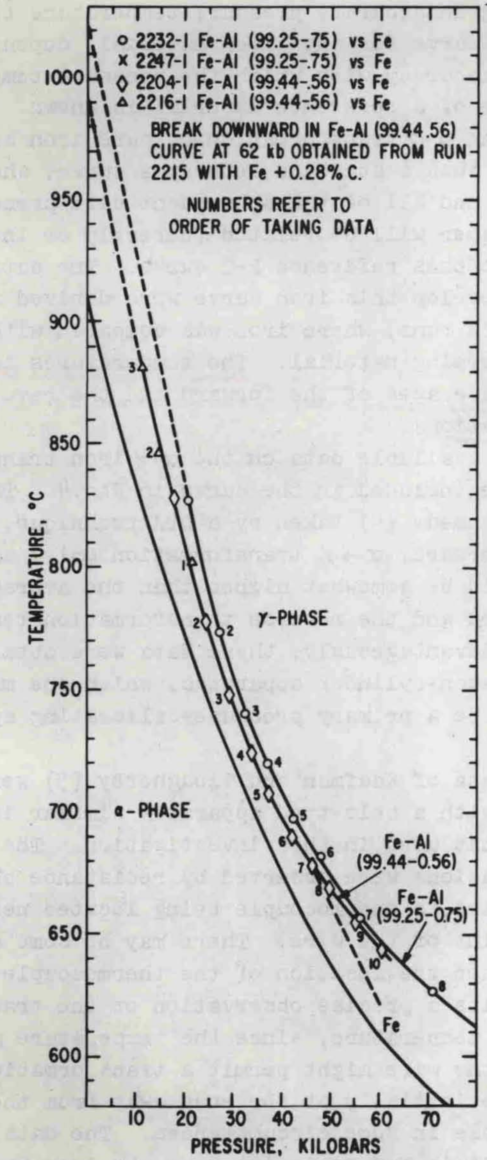

Fig. 5 P-T plots for α - γ transformations in Fe-Al alloys. Average temperature curves

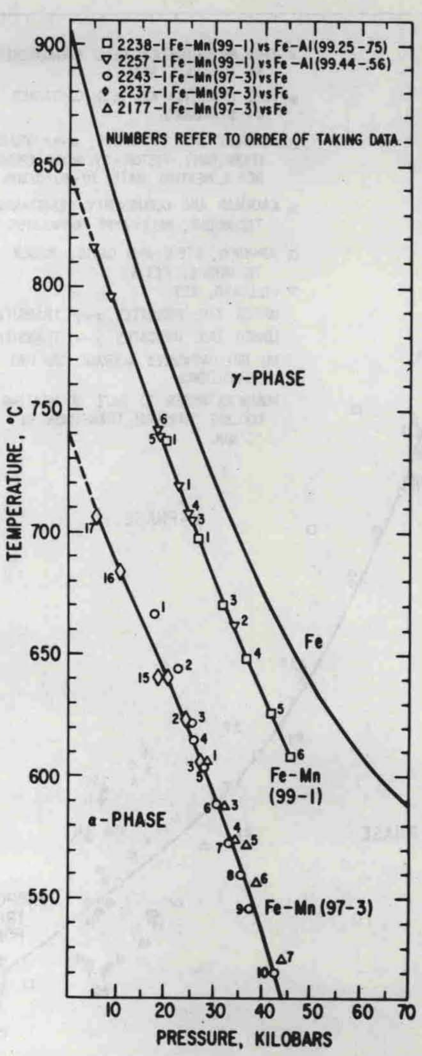

Fig. 6 P-T plots for α - γ transformations in Fe-Mn alloys. Average temperature curves

0.0746 cc per g. atom (9), in going from α to γ; this slope is 9.85 deg per kb.

Certain α-γ transformation data had shown discontinuities in the region of 30 kb. However, the averaged data generally were much smoother, and this break may be related to a general increase in sluggishness in the transformations in both the forward and the reverse directions. The P-T curve for pure iron, as shown in Fig.4, is reproduced in subsequent figures for reference purposes.

α-γ Transformations in Iron Binary Alloys

The average temperature-pressure curves for the alloy transformations are shown in Figs.5-9. The average temperature data were generally smooth, with few exceptions, over the entire pressure region indicating no new phases in either the alpha or the gamma fields. Numbers beside data points refer to the order of taking data.

Both the actual transformation temperatures and the average temperatures for the binary alloys are summarized in Table 1. The data were smoothed at the three indicated pressures. When the iron P-T curve is known with greater precision, the heading pressures in this table can simply be revised accordingly.

(a) Iron-Aluminum Alloys. The data for two Fe-Al alloys containing 0.56 and 0.75 percent Al, are shown in Fig.5 and Table 1. The 0.75 percent Al alloy is characterized by a smooth plot up to 71 kb. A change in slope at about 46 kb appeared in one run with Fe-Al (0.56 percent) measured against Fe-C (0.28 percent) standard, while a second run with the same Fe-Al alloy measured against