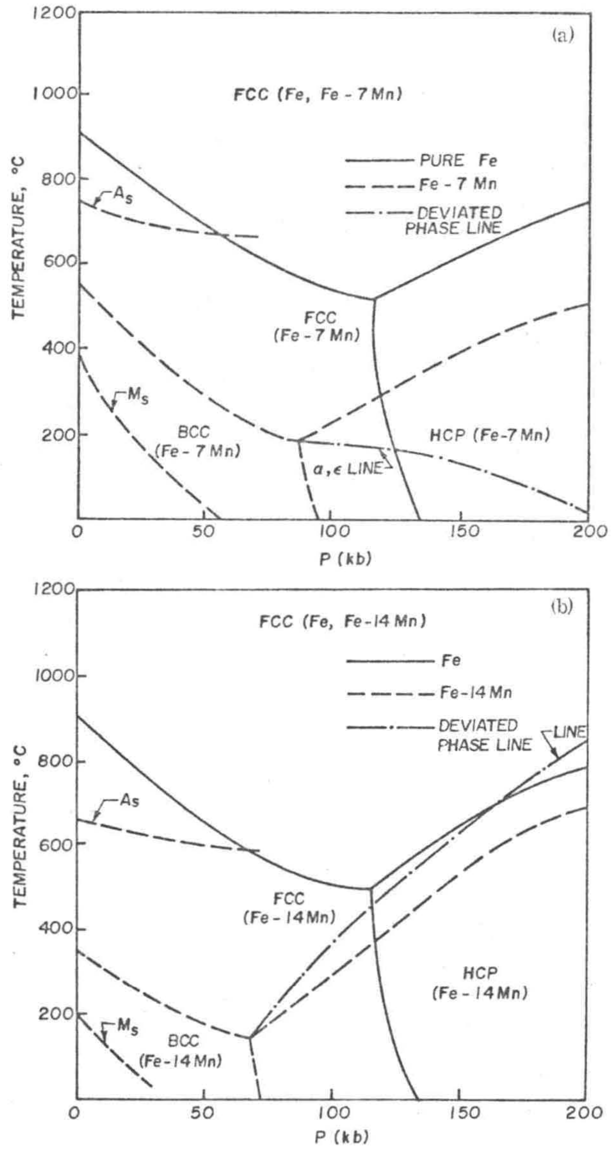

FIG. 12. Equilibrium temperature-pressure diagram for Fe–Mn showing the effect of manganese on the triple point: (a) Fe–7Mn and (b) Fe–14Mn.

observation. It is of interest to calculate the change in density which is produced only by shock-generated dislocations and point defects. The density change from dislocations[13] is given by

$$\Delta D/D = \tfrac{3}{2} b^2 \rho_D, \tag{2}$$

where ρ_D is the density of dislocations, D is the material density, and b is the Burgers vector. Using the dislocation density observed for iron at 300 kbar, a decrease in $\Delta D/D$ of 7.3×10^{-5} should result. This value is too small to be observed experimentally, and by itself it should have produced a decrease in density, while an increase was observed in the present case. The point-defect density based on the observations of Kressel and Brown[14] is too small to be observed experimentally.

Saturation magnetization of annealed Fe-Mn alloys as measured previously[15] is consistent with the results of this investigation and showed a sudden change in the slope of the saturation magnetization vs manganese curve at 7 wt% Mn. Shock deformation produces a significant drop in the saturation moment when the wt% Mn concentration exceeds 4%, as shown in Fig. 10(b). This drop occurs at all shock pressures. It should be noted that after shock deformation, the approach to saturation is more gradual due to the dislocations and point defects produced by the shock. This factor increases the uncertainty in the location of the saturation field, and it is probable that saturation was not actually reached at fields of 1000 Oe. Thus the decrease in saturation magnetization after shock loading Fe-0.4Mn should be attributed to dislocations and point defects rather than to a retained close-packed phase.

Density, saturation magnetization, and susceptibility[6] measurements indicate that the transformation occurs at pressures below 90 kbar. This agrees with the work of Keeler and Mitchell[4] who found that a partial phase transition to the nonmagnetic hcp phase can occur at shock pressures as low as 50 kbar. It is obvious that the addition of manganese to iron lowers the transition pressure. This is consistent with the magnetization data of Fig. 10(b). It is noted in Fig. 10(b) that the changes in saturation magnetization for the Fe-14Mn alloy occurs well below 90 kbar, and for the lower manganese alloys the transformation seems to occur at about 90 kbar. The transformation pressures, according to the Hugoniot curves of Fig. 11,[16,17] are generally higher for each corresponding manganese content.

Bowden and Kelly[18] using electron microscopy have studied the pressure-induced phase transformation in Fe-C and Fe-Ni-C. In the case of Fe-Ni-C it was found that the high-pressure phase was fcc, which was retained after the passage of the shock wave. These authors, however, were not able to retain the high-pressure phase in the Fe-C alloys. In a separate study Leslie, Stevens, and Cohen[19] were able to retain the high-pressure fcc phase of a shock-loaded α-martensite Fe-32% Ni alloy. Bowden and Kelly[18] found that under shock-loading conditions, α' transforms to γ by an exact reversal of the original transformation which produced the α' martensite. This finding is consistent with our optical observations on the Fe-7Mn alloy. Koul and Breedis[20] likewise were able to retain high-pressure phases of shocked titanium alloys. It is also noted that a commercial method of producing diamonds is based on the retention of the high-pressure phase after shock loading. Table V summarizes previous work done on retained high-pressure phases in alloys.

B. Thermodynamic and Stability Considerations

The results of the present investigation have shown that the high-pressure phase has been retained after the passage of the shock wave. The addition of manganese to iron has modified the temperature-pres-