of an extrapolation from 65 kbar, KLEMENT *et al.*[4] have suggested that the transition probably occurs more nearly around 80 kbar. It was earlier suggested[8] that the manganin gauge with integral calibrants can be used to obtain a fairly accurate value for this transition. An experiment was designed to do this. The gauge consisted of 0·012 mm dia. manganin wire wound on a threaded 0·035 cm thick silver chloride sleeve enclosing a Bi–Tl–Ba core. The core consisted of concentric cylindrical sleeves of Bi and Tl with a Ba inner core. The over-all gauge dimensions were 0·41 cm dia. × 0·71 cm long. A multiple event resistance cell was also used in the experiment. Both sensors were monitored simultaneously.

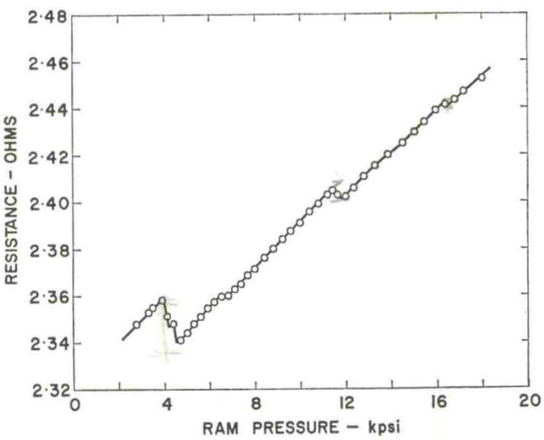

FIG. 4. Response of manganin gauge used in re-examining the pressure value of the upper Bi transition.

The response of the manganin gauge is shown in Fig. 4.* Figure 5 shows the derived calibration curve. Up to the Ba transition, the slopes of the various straight line segments of the curve are about equal. It is reasonable to expect that the same will hold true between the Ba and upper Bi points. The value of the resistance at the upper Bi transition is 2·4420 Ω. Extrapolating the calibration in Fig. 5 linearly as shown by the dashed line gives for this value of the resistance a transition pressure of 81–82 kbar. For the transition to be at 88 kbar, the slope of the curve will have to change drastically (dotted line), and, on the basis of accumulated experimental experience, this is unlikely.

This value for the transition pressure is confirmed in another way. We have previously shown[7] that for our apparatus, using standard size (7·30 cm on edge) prophyllite sample containers with preformed gaskets, the points for the Bi_{I-II}, Tl, and Ba transitions fall on a straight line on a plot of true pressure vs. applied ram pressure. Figure 6 shows results from the present experiment. The open triangles represent the points from the manganin gauge. The linearity of the calibration up to 60 kbar is clearly exhibited. Extrapolating this response beyond 60 kbar yields a value of 81 kbar for the upper Bi transition which occurred at an applied ram pressure of 16,400 psi. For the transition to be at a higher pressure than this would indicate an improvement in pressure generating efficiency, whereas generally the contrary is true. The "88-kbar" value is indicated in Fig. 6 by the closed triangle.

Figure 6 also shows the results from the resistance cell (open circles). The transitions in the calibrants were observed at different applied pressures than in the manganin gauge,† but this

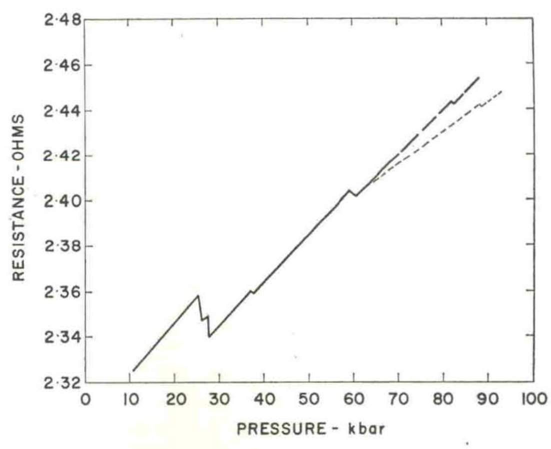

FIG. 5. Resistance vs. pressure curve obtained from the data in Fig. 4 and showing the upper Bi transition at 81–82 kbar.

* There was some evidence of the silver chloride transition at ∼ 14,500 psi ram pressure (71–72 kbar true pressure), but the response was not sharp enough because of the small amount of silver chloride used.

† Reference 7 discusses the pressure homogeneity in the cubic apparatus used. The different applied pressures are in agreement with the mapped pressure profiles within the prophyllite container.

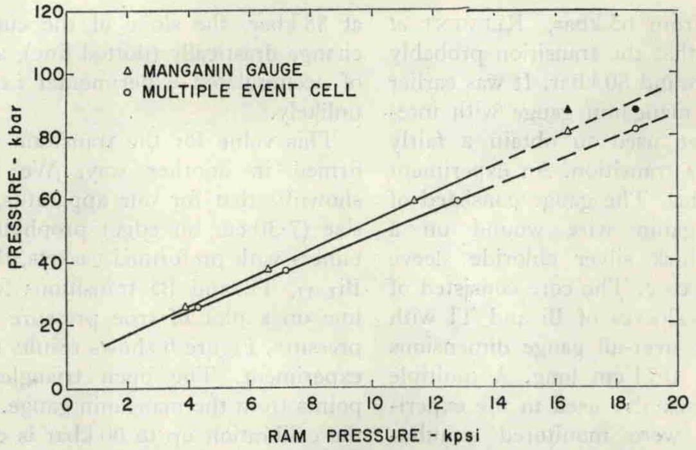

FIG. 6. True pressure vs. applied ram pressure calibration curves showing the upper Bi transition at 82 kbar. The long accepted 88-kbar value is indicated by the dark symbols.

is of no consequence. The upper Bi was observed at a ram pressure of 18,600 psi. Again extrapolating the calibration curve linearly beyond 60 kbar yields a value of 82 kbar for this transition. The "88-kbar" value is indicated by the closed circle in the figure.

We believe these results show that the long accepted 88-kbar value for the upper Bi transition is too high. The obtained value of 81–82 kbar is probably an upper limit. The final value will have to await further determinations, preferably by other techniques.*

It was shown earlier[8] that the manganin gauge can be used to obtain quantitative estimates of unknown volume changes associated with phase transitions. The method assumes that the decrease in the resistance of the gauge at the transition is proportional to the decrease in the vol. of the core. Thus, from the gauge response shown in Fig. 4 and from the known volume changes associated with the Bi I–II–III transitions, namely 10·3%,† the sudden vol. change for the upper Bi transition can be obtained. From Fig. 4 the ratios of the resistance drops are Bi I–II–III/upper Bi = 7/1. This corresponds to a vol. change of 1·47% at the upper transition. BRIDGMAN[2] reported a value of $(1{\cdot}5 \pm 0{\cdot}4)\%$.

* After the completion of this work, it was brought to our attention that W. STARK and G. JURA (ASME pubication 64-WA/PT-28, December 1964) re-examined this transition using the Bridgman-anvil apparatus. Their value is 81 ± 4 kbar.

† The vol. at the start of the Bi_{I-II} transition is taken as the reference vol. in this case.

Acknowledgments—The authors express their appreciation to Drs. EDWARD H. POINDEXTER and J. D. BARNETT for helpful and stimulating discussions. Thanks are extended to F. J. BECKER for his excellent support in component fabrication and to G. E. TOMES for his assistance in performing some of the experiments.

REFERENCES

1. BRIDGMAN P. W., *Proc. Amer. Acad. Arts and Sci.* **74**, 21 (1941).
2. *Ibid* **74**, 425 (1942).
3. *Ibid* **81**, 165 (1952).
4. KLEMENT W., Jr., JAYARAMAN A. and KENNEDY G. C., *Phys. Rev.* **131**, 632 (1963).
5. GIARDINI A. A., POINDEXTER E. H. and SAMARA G. A., *Rev. Sci. Inst.* **35**, 713 (1964).
6. GIARDINI A. A., POINDEXTER E. H. and SAMARA G. A., to be published.
7. SAMARA G. A., HENIUS A. and GIARDINI A. A., *Trans. ASME* (*J. Basic Engr.*), **86**, 729 (1964).
8. SAMARA G. A. and GIARDINI A. A., *Rev. Sci. Inst.* **35**, 989 (1964).
9. BRIDGMAN P. W., *Phys. Rev.* **48**, 893 (1935).
10. LAMORI P. N., in *High Pressure Measurement* (Edited by GIARDINI and LLOYD) p. 321, Butterworths (1963).