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# THE COMPRESSIBILITY OF BISMUTH AND ITS UPPER TRANSITION PRESSURE

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**Abstract**—We have measured the compression of bismuth to over 60 kbar under nearly hydrostatic conditions by the inductive coil technique. The over-all results are in close agreement with Bridgman's data, but some significant differences occur in the region of the transitions. The $Bi_{I-II}$ and $Bi_{II-III}$ transitions were clearly resolved with compressions, $-(\Delta V/V_0)$, of 0·064 to 0·122 and 0·124 to 0·160, respectively. Bridgman's extreme compressions across both transitions are 0·064 to 0·150. There was no evidence of either of the two transitions reported by Bridgman at 44 and 64 kbar.

The pressure value at which the upper bismuth transition occurs was re-examined by the use of a manganin gauge with integral calibrants and by a multiple event resistance cell. The results indicate that the transition occurs at a pressure no higher than 81–82 kbar in agreement with recent results. The observed volume change at this transition is approximately 1·5% which is in good agreement with Bridgman's value.

## 1. INTRODUCTION

BISMUTH (Bi) has been more thoroughly investigated under pressure than any other material, because it has a number of pressure-induced polymorphic transitions that have been widely used as pressure calibration points. These transitions were discovered by Bridgman using volumetric and electrical resistance measurements.[1–3] The values for the transition pressures at room temperature are: $Bi_{I-II}$ 25·4 kbar, $Bi_{II-III}$ 26·8 kbar, and the upper Bi ~ 80 kbar. The first two values are accurate to about ±1%; however, the third is much less accurately known.

The only detailed study of the compression of Bi is that of BRIDGMAN[1,2] who determined the vol. change up to 100 kbar using the piston-cylinder displacement technique. His data are reproduced in Fig. 2. The two small transitions at 44 and 64 kbar were not observed by Bridgman in his electrical resistance measurements[3] and have not been substantiated by other workers by either electrical resistance or differential thermal analysis[4] techniques.‡

Efforts by numerous workers to study the volume changes and crystal structures of the various phases of Bi by high pressure X-ray methods have so far failed to yield any useful results.

Because of the importance of Bi as a high pressure standard, it was felt desirable to re-examine its compression by an independent method, namely, our inductive coil technique.[5] We have measured the compression of Bi to 60 kbar under nearly hydrostatic conditions and also re-examined the pressure value of the upper transition. The results are presented and discussed below.

## 2. EXPERIMENTAL TECHNIQUES

The apparatus and inductive coil technique have been described elsewhere.[5] High purity (99·999%) Bi was used. For most experiments, the material was melted in a pyrex tube under an

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‡ Bridgman detected the 44 kbar transition by shearing measurements also. (See ref. 9.)