

were numerically the same for all the media concerned, the reproducibility of the pressurization was regarded as satisfactory. Furthermore, the corrections due to frictions caused by the various sources could be considered to be constant during different runs.

In the first place, the manganin resistance was calibrated at room temperature using the Bi I \rightarrow II transition pressure. In the measurement of the resistance of Bi as a function of the change in resistance of the manganin, the transitions of Bi I \rightarrow II (25.4 kbar) and II \rightarrow III (27.0 kbar) were clearly observed with the same characteristics as have been observed in general. Since the resistance of the manganin at room temperature had been confirmed to vary linearly with pressure in a pressure range presently concerned,⁸ the result at Bi I \rightarrow II transition was sufficient for the correct determination of the pressure coefficient of the manganin resistance at room temperature. The mean value thus determined was 0.24%/kbar, while the results are 0.23%/kbar by Nomura *et al.*,⁸ 0.238%/kbar by Zeto and Vanfleet⁹ and 0.23%–0.24%/kbar by Yamamoto.¹⁰

The pressures at lower temperatures except near 4.2 K were determined by the manganin resistance. For that purpose, the temperature dependence of the manganin resistance was observed first from 300 down to 77 K. Figure 4(a) exemplifies the results under different starting pressures at 300 K. The curves A, B and C are under pressures and curve D is at atmospheric pressure $p = 0$ kbar. The medium was a mixture of 1:1 n pentane and isoamyl alcohol. The cooling of the apparatus was made very slowly with every possible

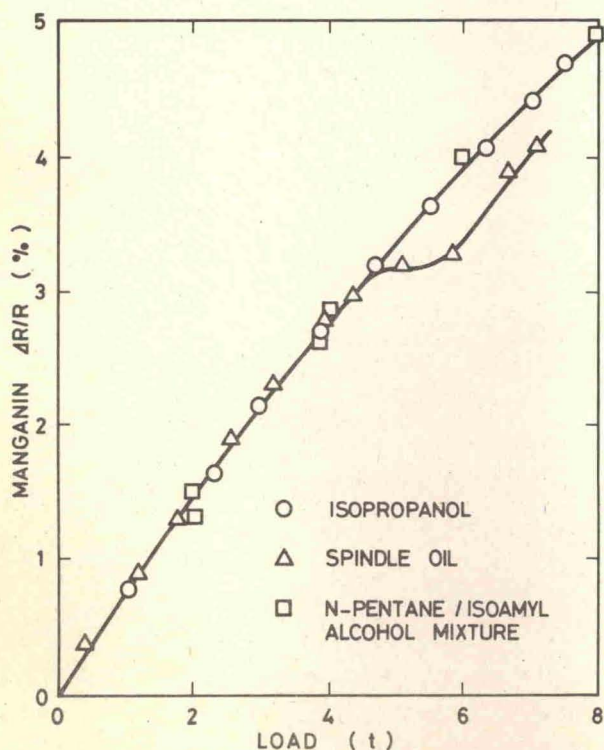


FIG. 3. Relative change in resistance $\Delta R/R$ of manganin wire as a function of load. Measurement was made at room temperature and the reference resistance was taken at room temperature.

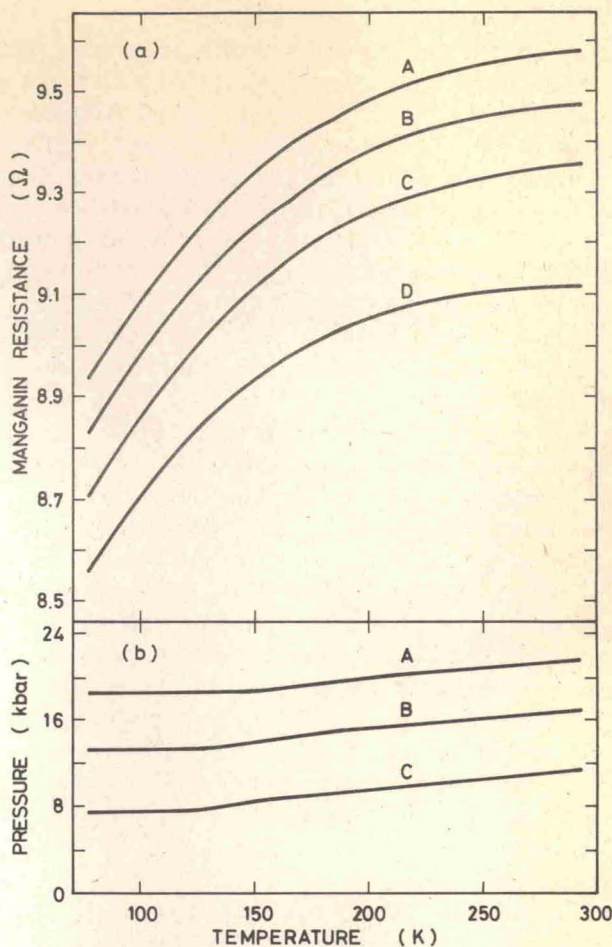


FIG. 4. (a) Temperature dependence of manganin resistance from 300 K down to 77 K. Curves A, B and C are under high pressures and D at atmospheric pressure. (b) Pressure drop as a function of temperature. Different curves correspond to different initial pressures at room temperature. See Fig. 4(a).

care.¹¹ All curves in Fig. 4(a) vary monotonically, except small anomalies locating between 150 and 200 K in curves A, B and C.

In order to determine the pressure, the temperature dependence of the pressure coefficient should be known. Yamamoto¹⁰ has made thorough investigations under various conditions of manganin wires from different manufacturers. The ranges he measured were 123 K to 373 K in temperature and hydrostatic pressures up to 10 kbar. On the other hand, Itskevich¹¹ has measured the resistance at 20.4, 77 K and at room temperature up to 7 kbar. According to their results, the pressure coefficient of manganin resistance might be regarded as constant independently of temperature between 77 and 300 K, with a difference of $\pm 2\%$. In the present work, therefore, the pressure coefficient at room temperature, 0.24%/kbar, for the manganin wire presently employed was used as a coefficient for all temperatures down to 77 K.

The real pressure in the sample cavity at any given temperature was then evaluated from the temperature dependence of the relative change in resistance shown in Fig. 4(a), using the value of the constant pressure coefficient given above. The results obtained down to

77 K are shown in Fig. 4(b) for different starting pressures at 300 K. The curves A, B and C correspond respectively to those in Fig. 4(a). The tendency of change in pressure in the figure is arranged as follows. (i) The pressure reduces linearly as temperature lowers, (ii) the reduction becomes relatively highpitched in the intermediate temperature range, possibly due to the onset of freezing, and (iii) the pressure turns to become almost constant after the completion of freezing. The reduction rates in step (i) were almost the same for exemplified cases A, B and C, and the mean value was -0.015 kbar/deg.

From various runs with different initial starting pressures at room temperature, which could be predetermined from the load pressure using the results in Fig. 3, it has been found that the maximum pressure drop, that is the difference between the initial and almost constant final values, was about 4 kbar for 1:1 n pentane and isoamyl alcohol mixture, so far as the initial pressures were higher or around those quoted in Fig. 4(b). As a result, it has been confirmed that the pressure cell presently designed is capable of generating pressures at least up to about 25 kbar at lower temperature like 4.2 K. Here it should be mentioned that the data on the temperature dependence of manganin resistance such as exemplified in Fig. 4(a) were completely reversible and reproducible. Therefore, together with the experimental fact mentioned above that the reduction in pressure was not practically found after freez-

ing, it might safely be concluded that the pressure was almost hydrostatic through and after freezing.

Although the extrapolated pressure of the curve in Fig. 4(b) could be used near 4.2 K, the pressure was also determined by the use of a superconducting manometer.

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