NOTES

THERMAL TRANSPIRATION IN HELIUM IN THE PRESSURE RANGE 10^{-8} TO 20 TORR*

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Podgurski and Davis (1961) have measured deviations of 8% from the limiting thermal transpiration ratio $R = (T_1/T_2)^{1/2}$ at pressures of neon and hydrogen as low as 5×10^{-4} torr. Here R is the pressure ratio P_1/P_2, at equilibrium, for portions of the system at temperatures T_1 and T_2 respectively. At a pressure of 5×10^{-4} torr the mean free path λ is large compared with the tubing diameter used (d = 2 mm), particularly for hydrogen. The condition $\lambda/d \gg 1$ is frequently given (Young and Crowell 1962) as the condition required for the appearance of $R = (T_1/T_2)^{1/2}$.

We report here experimental values of R for helium gas, measured by the absolute method in an ultrahigh-vacuum system over the pressure range $10^{-8} \leqslant P_2 \leqslant 20$ torr. The cold volume (Fig. 1) was a Pyrex bulb of volume

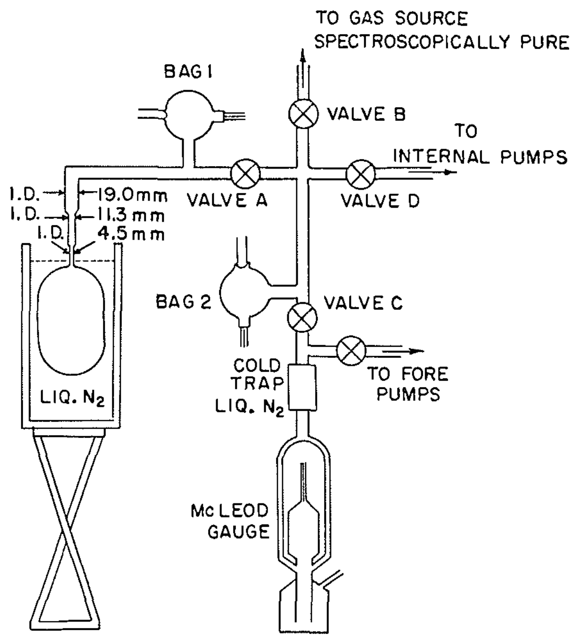

FIG. 1. Apparatus. Ultrahigh-vacuum portion is above valve C.

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3.4 liters connected to the system by tubes of internal diameters 4.5, 11.3, 19.0 mm, and lengths 5, 9, 11 cm, respectively. R was measured with the level of liquid nitrogen ($T_1 = 77.4°$ K) at the center of each tube. In the measurements $T_2 = 295°$ K. Three independent measurements of R were made in the appropriate pressure ranges: (1) using Bayard-Alpert gauge 1 [BAG-1], valve A closed; (2) using BAG-2, valve A open, valves B, C, D closed; (3) using McLeod gauge, valves A, C, D open [internal pumps off], valve B closed. Corrections for background (approximately 2×10^{-10} torr) were made when necessary. All gauges were calibrated for measuring pressure ratios accurately by expansion of helium from one known volume to another. Errors in pressure ratios caused by pumping of mercury vapor by the cold trap (Podgurski and Davis 1961) were eliminated by this method. The ion gauges were calibrated absolutely against the McLeod gauge. Gauge pumping and time dependence of results were negligible up to periods of two hours.

Results are shown in Fig. 2, where the expected limiting values of $R = 1$ and $R = 0.512$ are shown dashed. Two main results are found: (a) the lower limit for R is not reached in the pressure range studied; (b) the results obtained with the McLeod gauge are in essential agreement with the experimental results of others over a similar pressure range (Bennett and Tompkins 1957).

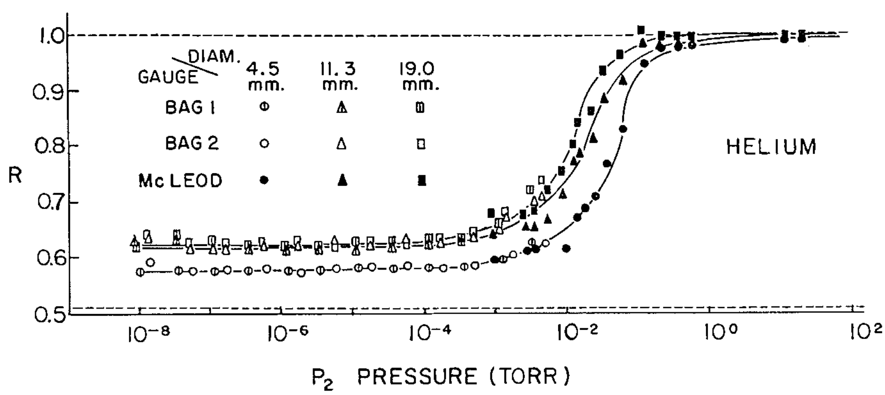

FIG. 2. Measured values of thermal transpiration ratio $R = P_1/P_2$ versus P_2 (pressure at room temperature) for helium. Cool temperature, 77.4° K.

Measurements of R for neon in the same apparatus gave low-pressure values of $R = 0.590, 0.628, 0.632$ at $d = 4.5, 11.3, 19.0$ mm, respectively, thus demonstrating that result (a) above was not specific to helium.

The three tubes of Fig. 1 were replaced by a single tube with I.D. 4.8 mm and length 27 cm, and R was measured at low pressures in helium as a function of the level of liquid nitrogen. The low-pressure values of R were 0.57 at the junction of flask and stem, rising to a constant value of 0.67, 13 cm above the junction. Thus the magnitudes of the limiting values of R shown in Fig. 2 are not simply related to the tube diameters.

Our central conclusion is that the condition $\lambda/d \gg 1$ is a necessary but not sufficient condition for the appearance of the limiting theoretical value of $R = (T_1/T_2)^{1/2}$. In these measurements λ reached a value of 10 miles.

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TRANSVERSE MAGNETORESISTANCE OF HIGH-STRENGTH COPPER ALLOYS*

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Recently two copper alloys have been developed, chromium–copper (0.3% Cr) and zirconium–copper (0.12% Zr), which have room-temperature conductivities comparable with that of copper and which have tensile strengths greater than 60,000 p.s.i. They are of technical interest in the design of high-performance electrical apparatus which must be operated at low temperatures. The present paper reports some measurements on their electrical properties.

Relatively little information is available about the metallurgy of the alloys. Heat treatment at about 800° C is said to cause a solid solution alloy with good conductivity but relatively low strength. Ageing at about 400° C produces a high mechanical strength which is evidently due to a precipitation hardening. The wires used in the present experiments were produced by Little Falls Alloys Inc., Newark, New Jersey. The metal stock was annealed at 800° C for two hours and drawn into wire of 0.040 in. diameter. It was then aged for three hours at 410° C and drawn to 0.005 in. diameter. At this point it was annealed briefly at 590° C and drawn to 0.0025 in., the final diameter. The resistivities at 17.8° C were, for the Cr–Cu alloy, 1.93×10^{-6} Ω-cm., and for the Zr–Cu alloy, 1.63×10^{-6} Ω-cm.

The low-temperature resistance of the alloys was very profoundly affected by the drawing process. The resistance ratio of the alloys in their original condition was, for the Cr–Cu alloy, 2.3 at liquid air temperature and 2.4 at liquid helium temperature; for the Zr–Cu alloy the resistance ratios were 3.4 at liquid air and 5.6 at liquid helium temperature. This small reduction in resistance was improved by annealing the samples for 11 hours at 500° C in an argon atmosphere, followed by a water quench. The low-temperature

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