, G. J. F., and L. Knopoff, On the
composition of the outer core, Geo-
, 284–297, 1958.
R. G., J. N. Fritz, and S. P. Marsh,
omposition of the earth's interior, J
Res., 69, 2947–2965, 1964.
R. G., and S. P. Marsh, Equation of
nineteen metallic elements from shock-
asurements to two megabars, *J. Appl*
1253–1269, 1960.
R. G., and S. P. Marsh, Shock wave
ion of iron nickel alloys and the
ore, *J. Geophys Res., 71*, 1751–175

A. E., On the chemical evolution and
of the planets, *Geochim. Cosmochim*
257–283, 1959.
M., The experimental fusion curve of
6,000 atmospheres, *J. Geophys. Res.,*
1959.
T., and W. A. Bassett, The composi-
the earth's interior, *Sci. Am., 213*, 100-
1965.
T., and W. A. Bassett, Discussion of
g paper by McQueen and Marsh, J
Res., 71, 1757, 1966.
M., and R. H. Christian, Equation of
metals from shock wave measurements
v., 97, 1544–1556, 1955.
M., M. H. Rice, R. G. McQueen, and
Yarger, Shock wave compression of
even metals. Equations of state of
hys. Rev., 108. 196–216, 1957.
G., C. M. Fowler, F. S. Minshall, and
rke, The behavior of iron-silicon alloys
mpulsive loading, *Trans. AIME*, 2
1963.

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Friction Effects and Pressure Calibration in a Piston-Cylinder Apparatus at High Pressure and Temperature

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The pressure of a piston-cylinder apparatus was calibrated at a temperature of 1100°C. The calibration is based on the quartz-coesite phase transition. Pressure losses are considerable and a correction of −11% at 1100°C and 35 kb is indicated for a compression run with talc as the pressure-transmitting medium. This correction was evaluated by comparing results obtained with talc and silver chloride pressure-transmitting mediums.

INTRODUCTION

In recent years increasing use of piston-cylinder apparatus at high pressure and temperature has been made in phase-equilibrium studies. It has been shown that hydrostatic pressure conditions are more closely attained in this type of apparatus than in an anvil apparatus [*Boyd and England,* 1960*a*]. However, there are uncertainties as to the pressure loss due to friction between the piston and the walls of the pressure vessel and due to friction and other possible effects inherent in the talc pressure-transmitting medium. We have investigated the magnitude of pressure losses in the piston-cylinder apparatus at high temperature by using two different pressure-transmitting mediums. Talc is normally used, but it has a substantial shear strength. Silver chloride was chosen as the pressure medium for comparison with talc because of its much lower shear strength.

Early estimates of the magnitude of pressure losses were based on calibrations using the bismuth and thallium transitions at room temperature [*Boyd and England,* 1960*b*]. They used silver chloride and talc pressure-transmitting mediums and determined the correction needed to account for pressure loss in the talc medium, assuming that silver chloride has a negligible strength. They concluded that a friction correction of −13% is needed at room temperature. They attributed the pressure loss to the shear strength of talc, and, since this will decrease with increasing temperature, they suggested that at high temperatures the friction correction would be closer to −8 ± 5% [*Boyd and England,* 1960*a*; Boyd, 1962]. In later work *Boyd and England* [1963] considered that at high temperatures the shear strength of talc is very low, and they no longer applied a friction correction.

Kitahara and Kennedy [1964], in their study of the quartz-coesite transition, applied a friction correction of −12% at 17.1 kb, −8% at 30 kb, and −7% at 41 kb for a compression cycle. They estimated this correction from a study of the melting point of mercury at different pressures [*Klement et al.,* 1963]. Their friction correction was determined at any specific pressure as half the difference between the compression and decompression strokes. They assumed that the pressure loss on a compression run was the sum of the piston-cylinder friction and friction in the talc.

Newton [1965], in work at pressures of 4 to 8 kb and temperatures of 640 to 860°C and using a piston-cylinder apparatus similar in design to Kennedy's apparatus, applied a pressure correction of −1.5 kb over the 4- to 8-kb pressure range; this represents a −37% to −19% correction. It was determined using the LiCl melting curve at about 700°C as the calibration point.

EXPERIMENTAL METHOD

The quartz-coesite phase transition at 1100°C has been chosen as the calibration point, since a considerable amount of high-pressure work in this laboratory has been done in the neighborhood of this temperature. Also, experience showed that when the sample temperature