$$K = \frac{P}{\delta} = \frac{Gd^4}{64nR^3} \tag{1}$$

where P is the applied load, δ is the spring deflection, G the shear modulus, n is the number of turns, d the diameter of wire and R the radius of the helix. The expected change in spring constant with pressure, α is then:

$$\alpha = \frac{1}{K}\frac{\Delta K}{\Delta P} = \frac{1}{G}\frac{\Delta G}{\Delta P} + \frac{4}{d}\frac{\Delta d}{\Delta P} - \frac{3}{R}\frac{\Delta R}{\Delta P} \tag{2}$$

Since

$$\frac{1}{d}\frac{\Delta d}{\Delta P} = \frac{1}{R}\frac{\Delta R}{\Delta P} = -\beta \tag{3}$$

where β is the linear compressibility, the change in spring constant is given by:

$$\alpha = \frac{1\Delta G}{G\Delta P} - \beta \tag{4}$$

The quantity $\frac{1}{G}\frac{\Delta G}{\Delta P}$ has been measured by Bridgman[16] on hard drawn piano wire and by Birch[17] on drill rod. Their values are 2.19 and 2.4 x 10^{-6} bar^{-1} respectively. The average, 2.3 x 10^{-6} per bar, was chosen as a representative value. The value of β is estimated to be 2 x 10^{-7} bar^{-1} based on Bridgman's measurements[18] of $\Delta V/V_o$ on stainless steel "H29". The value for α is then ~ 2.1 x 10^{-6} per bar. Deviations from the expected pressure response are due to the change in load cell sensitivity with pressure.

In a typical spring constant calibration experiment, the amplification of the load cell output is adjusted to produce either 0.1 volts per pound or 0.5 volts per pound while dead loading the cell with a 1.5 lb. weight. The load-extension curve is measured at atmospheric pressure and at high hydrostatic pressure (up to ~ 30 kbar). The slope of the curve (see Figure 7) after the initial portion, represents the spring constant. If K_1 represents the spring constant at atmospheric pressure and K^*_P is the measured spring constant at pressure P, C, the correction factor by which measured loads must be divided to obtain true values is given by:

$$C = \frac{\text{Measured Spring Constant at Pressure}}{\text{Theoretical Spring Constant at Pressure}} = \frac{K_P}{K_1(1+\alpha P)} \quad (5)$$

The best values of C deduced from spring constant calibration experiments are shown in Fig. 8 and are represented by a linear least square fit. It may be seen that as the pressure increases, the load sensitivity decreases. It is estimated that a small part of this decrease is due to an increase of stiffness with pressure of the load cell beam, the remainder of the decrease

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*It should be noted that the output of the unloaded load cell (zero level) changes somewhat with pressure. This will be discussed later in the paper. The values of K_P have been deduced from the measured slope of the load deflection curve by subtracting the slope of the zero level with deflection. The pressure level also changes somewhat during the spring loading owing to the fact that the pressurizing piston is used to apply the sample load. The spring constant however remains essentially constant in this small pressure interval.