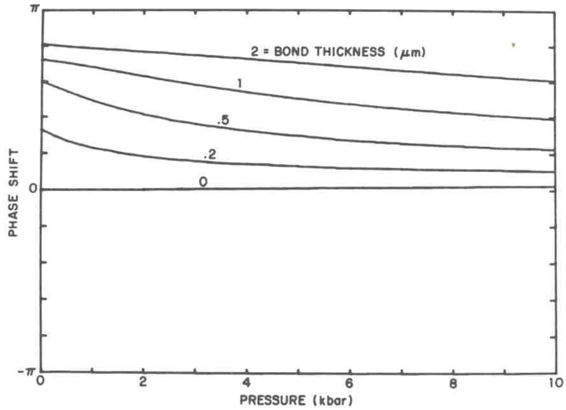

Fig. 11. Calculated transducer-bond phase shift versus pressure for the case where the operating frequency is kept at the frequencies of maximum amplitude of Figure 10.

magnitude of the phase shifts could cause errors of the order of ½% in determining absolute velocities, and errors of several tens of percent in pressure derivatives of velocities for typical minerals.

These potential errors are large, and would be best avoided. This is easily done by operating the transducer at its free resonant frequency in experiments using the pulse superposition technique. It is not clear from published reports of experiments if this procedure has been always used in pulse superposition measurements, but in at least some experiments the transducer has been operated at the maximum amplitude frequency rather than at the free resonance frequency [*E. Schreiber*, personal communication].

VI. BUFFER ROD-BOND PHASE SHIFTS

The phase shift which occurs upon reflection in the sample at a buffer rod-sample interface (Figure 2) is [*McSkimin*, 1950; 1957]

$$\phi_r^- = \tan^{-1} \frac{2Z_f Z_s (Z_b^2 - Z_f^2) \tan \theta_f}{Z_f^2 (Z_b^2 - Z_s^2) + (Z_f^4 - Z_s^2 Z_b^2) \tan^2 \theta_f} \quad (17)$$

where subscript b denotes buffer rod properties, and superscript "-" denotes the reflection of a wave traveling in the negative (leftward) direction (Figure 2). This phase shift (plus the phase shift of π occurring at the free end of the sample) applies to superpositions of all but the first and second reflections received by the transducer. Since the first reflection is from the buffer side of the interface, and the wave does not penetrate the sample, whereas the second and succeeding reflections are transmitted twice through the interface, the appropriate phase difference due to the interface is

$$\phi_1 = 2\phi_t - \phi^+_r \tag{18}$$

where ϕ_t, the phase shift on transmission, is

$$\phi_t = \tan^{-1} \frac{Z_s Z_b + Z_f^2}{Z_f (Z_s + Z_b)} \tan \theta_f \tag{19}$$

and ϕ^+_r has the same form as (17), but with Z_b and Z_s interchanged. The superposition of the first and second reflections will be referred to as echo 1, and succeeding combinations as echoes 2, 3, and so on.

An example of calculated buffer-bond phase shifts is shown in Figure 12 for the case of shear waves in the [100] direction in spinel, with a fused quartz buffer rod and a V9 bond. The

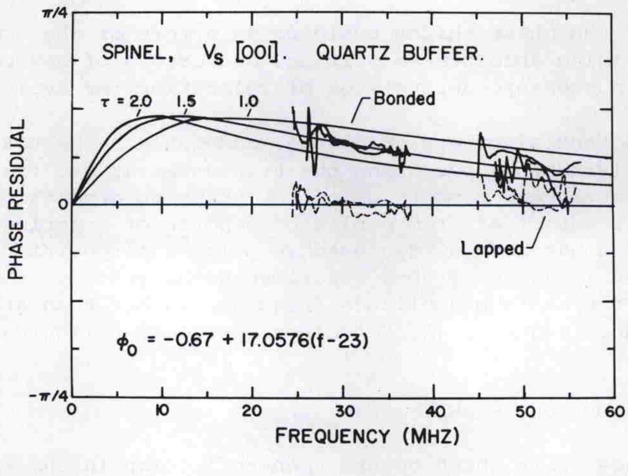

Fig. 12. Measured phase residuals (solid traces) relative to phase with dry lapped buffer-sample contact (dashed traces) for shear [100] waves in spinel, with fused quartz buffer rod bonded to sample, compared with calculated buffer-bond phase shifts (solid curves) for τ_f *= 1.0, 1.5, and 2.0 nsec.*

relevant properties are given in Table 2. Curves are shown for three different values of τ_f. It can be seen that the effect of thinning the bond is to increase the frequency at which the maximum phase shift occurs. Compared to these in Figure 12 are some measured phase residuals in two frequency intervals (around the third and fifth harmonics of a 10 Mhz transducer). Measurements with a dry lapped contact between the buffer and sample (i.e., no