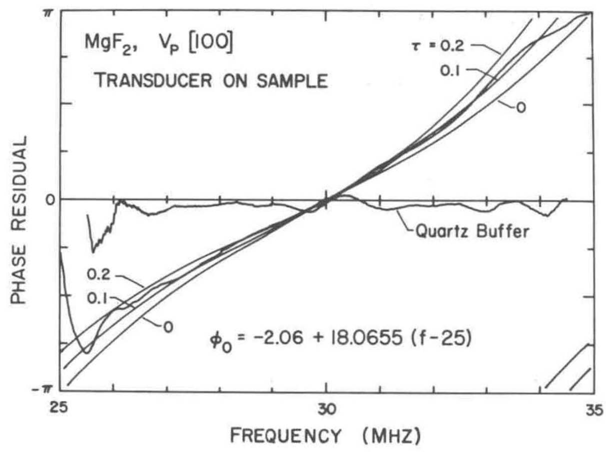

Fig. 5. Comparison of measured transducer-bond phase residuals (relative to phase obtained with buffer rod) with calculated phase shifts assuming τ_f = 0, 0.1, and 0.2 nsec.

expected. *McSkimin* [1961] reports θ_f = 5 to 15°, which, at 20 Mhz, corresponds to about τ_f = 0.7 to 2 nsec.

V. PRESSURE EFFECTS ON TRANSDUCER-BOND PHASE SHIFTS

Pressure affects, of course, all three components of the mechanical system: sample, bond, and transducer, but it is desired to isolate the effect on the sample from the effects on the other two. The effect of pressure on the transducer was considered by *McSkimin and Andreatch* [1962] who noted that the resonance frequency would change. The pressure derivatives of the resonance frequencies of X- and Y-cut quartz transducers (Table 3) were determined by *McSkimin and Andreatch* [1962] and *McSkimin et al.* [1965]. The effect of pressure on the bond was not discussed in detail by *McSkimin and Andreatch* [1962], their point being to establish that the bond phase shift is very small at the transducer resonance frequency and that it should change very little with pressure, providing the resonance frequency is followed. The effect of pressure on the bond phase shift will be discussed in more detail here, since it appears that the latter condition has not been strictly adhered to by many workers (including *McSkimin and Andreatch* [1962]). (*McSkimin and Andreatch* [1962] actually argued that the bond phase shift depends only on the total mass per unit area of the bond, and that the latter would not change with pressure. However, this conclusion depends on the assumption

TABLE 3. Transducer (α-quartz) and Bond Properties and Their Pressure Derivatives

Parameter	α-quartz[a]	Bond[b]
ρ, g/cm^3	2.65	1.0
K, Mbar	0.38	0.02
$\partial K/\partial P$	6.4	5.0
$M_p = \rho v_p^2$, Mbar	0.868	0.033
$\partial M_p/\partial P$	3.28	7.7
$M_s = \rho v_s^2$, Mbar	0.399	0.010
$\partial M_s/\partial P$	-2.69	2.0
$(\partial \ln f_r/\partial P)_p$, Mbar^{-1}	1.51	-
$(\partial \ln f_r/\partial P)_s$, Mbar^{-1}	-3.68	-

a. *McSkimin et al.* [1965].
b. Assumed.

that the bond compresses uniaxially, which is unlikely to be true, since it would require a large shear strength of the bond. Even with the assumption that the bond compresses isotropically, the phase shift changes very little with pressure, because it is so small to begin with, so that their main conclusion is still justified.)

A. Transducer Phase Shifts

A fairly common procedure has been to hold the carrier frequency constant at the zero-pressure resonance frequency, since the transducer resonance frequency varies by only a few percent over a pressure range of 10 kbar [e.g., *McSkimin et al.*, 1965]. A correction can be applied to allow for the changing transducer resonance frequency, and it is usually assumed that the bond effect remains negligible. Close to a transducer resonance frequency, where θ_t is close to an integral multiple of π, and for a vanishingly thin bond (negligible θ_f), equations (3) and (9)