TABLE 1. Elastic constants measured by pulse echo method in Ni–Cu alloy plates with [100] orientation

Composition at.% Cu	Plate thickness cm	$C_{11} \times 10^{-12}$ dyn/cm²			$C_{44} \times ^{-12}$ dyn/cm²	
		Magnetically saturated	Unmagnetized	Unmagnetized plates by resonance method[a]	Magnetically saturated	Unmagnetized
Ni	0.69	2.504	2.481	2.478	1.258	1.244
6.4	0.64	2.449	2.421	2.395	1.223	1.209
20.1	1.61	2.298	2.294		1.132	1.130
23.1	0.62	2.291	2.280	2.280	1.131	1.125
36.6	0.64		2.144	2.156		1.064
36.6	1.26	2.145	2.138			1.057
83.8	1.88		1.800			0.825
Cu	0.74		1.697	1.683		0.753

Notes:
[a] For comparison with pulse-echo results; specimen thickness approximately 0.25 cm.

varying thicknesses cut from the same crystal. The transit time delays found by these procedures were 0.02 μ-sec for longitudinal waves and 0.04 μ-sec for shear wave propagation. Measurements on pure nickel and alloys containing up to 40 at.% Cu were made by the pulse-echo technique in both the magnetically saturated and unmagnetized conditions. All of the resonance measurements were taken on unmagnetized specimens.

EXPERIMENTAL RESULTS

The ultrasonic transit time for each crystal was established at 25°C from transit time *versus* temperature curves constructed from the pulse-echo data. After applying the appropriate transit time corrections, velocities of wave propagation were determined. The elastic constants, C_{ij}, were calculated from the velocity v and the density ρ according to the relationships given below. For wave propagation in the [100] crystallographic direction:

$\rho v_1^2 = C_{11}$ for a longitudinal wave,

$\rho v_2^2 = C_{44}$ for a transverse wave polarized in any direction in the [100] plane.

For wave propagation in the [110] crystallographic direction:

$\rho v_3^2 = C_L' = \frac{1}{2}(C_{11} + C_{12} + 2C_{44})$ for a longitudinal wave,

$\rho v_4^2 = C_{44}$ for a transverse wave polarized in the [001] direction,

$\rho v_5^2 = C' = \frac{1}{2}(C_{11} - C_{12})$ for a transverse wave polarized in the [$1\bar{1}0$] direction.

The adiabatic elastic constants obtained by the pulse-echo and resonance techniques are presented in Tables 1 and 2. The application of a magnetic field to the nickel-rich specimens resulted in an increase of about 1 per cent in the elastic constants, and a marked dimunition in the attenuation of the ultrasonic vibrations. As Levy and Truell[10] have shown, the shear modes induce much greater acoustic losses in nickel than the longitudinal modes. The rate of attenuation was so great that only one echo could be detected with the shear wave polarized in the [$1\bar{1}0$] direction in the nickel-rich alloys in the unmagnetized condition. This prevented our obtaining a reliable

TABLE 2. Elastic constants measured by pulse echo method in Ni–Cu plates with [110] orientation

Composition at.% Cu	Plate thickness cm	$C_L' \times 10^{-12}$ dyn/cm²			$C_{44} \times 10^{-12}$ dyn/cm²		$C' \times 10^{-12}$ dyn/cm²	
		Magnetically saturated	Unmagnetized	Unmagnetized plates by resonance method	Magnetically saturated	Unmagnetized	Magnetically saturated	Unmagnetized
Ni	0.65	3.298	3.255	3.226	1.254	1.241	0.489	too much attenuation
Ni	1.80	3.272	3.259		1.247	1.243	0.486	too much attenuation
7.3	0.61	3.210	3.163		1.217	1.201	0.454	too much attenuation
17.8	0.56	3.079	3.041	3.030	1.159	1.146	0.407	too much attenuation
22.8	0.55	3.010	2.990	2.995	1.125	1.113	0.385	too much attenuation
34.5	0.56		2.879			1.062		0.352
34.5	1.19		2.875			1.061		0.353
46.2	0.77		2.766	2.767		1.009	Non-magnetic	0.329
68.9	1.20		2.501			0.896	Non-magnetic	0.286
Cu	0.70		2.204	2.213		0.760	Non-magnetic	0.236
Cu	1.87		2.205			0.754	Non-magnetic	0.235