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ELASTIC CONSTANTS OF DENTAL AMALGAM

By

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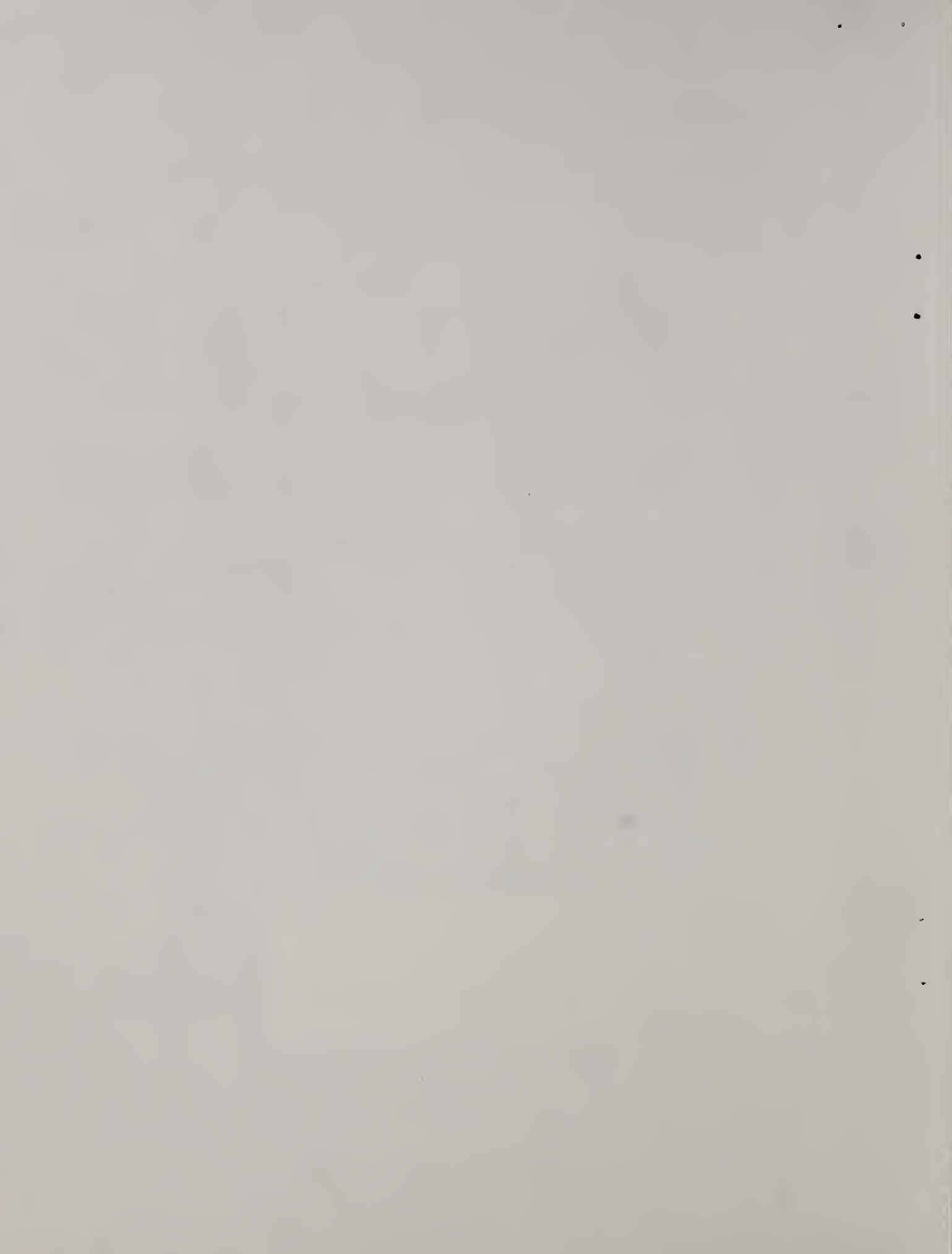
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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS



ELASTIC CONSTANTS OF DENTAL AMALGAM

George Dickson and Philip L. Oglesby

Abstract

Elastic constants of dental amalgam were determined by an ultrasonic pulse-echo technic. Longitudinal and transverse wave velocities of a 5.5 MHz pulse were determined in cylindrical amalgam specimens 8 mm in diameter by 6 to 15 mm in length. Values of 9.1×10^6 psi for Young's modulus, 3.4×10^6 psi for shear modulus, 9.1×10^6 psi for bulk modulus and 0.33 for Poisson's ratio were obtained for amalgams containing 49% mercury. Values for all of these constants increased as the mercury content of specimens was reduced to 35%.

ELASTIC CONSTANTS OF DENTAL AMALGAM

Elastic constants of dental amalgam were determined by an ultrasonic pulse-echo technic. Pulses with a frequency of 5.5 MHz, a length of 0.5 to 1.0 microsecond and a repetition rate of 6 kHz produced by a pulsed oscillator were passed through an attenuator to a quartz transducer to which the specimen was coupled with Dow resin 276-V9. Signals representing the first transit and subsequent echoes from a second quartz transducer on the opposite end of the specimen were amplified with a wide band amplifier and transit times were determined with an oscilloscope with a dual trace unit which also displayed the input pulse. Pulse repetition rate and oscilloscope sweep initiation were controlled by a waveform generator. Transit times ranged from 2 to 11 microseconds depending upon whether longitudinal or transverse waves were used and upon the length of the specimen.

Specimens were made by condensing dental amalgam (Caulk Micro Alloy Pellets, certified to comply with American Dental Association Specification No. 1 for Dental Amalgam Alloy) mechanically triturated with an 11 to 8 Hg-alloy ratio in a steel die. The cylindrical specimens were 8 mm in diameter by 6 to 15 mm in length depending upon the amount of material and the pressure used. Pressures of 5000 to

25,000 psi produced specimens with Hg contents of from 35 to 49%.

Measurements were made at $23 \pm 1^\circ\text{C}$. Precision of results was limited by the reproducibility of transit time determinations which varied by as much as $\pm 0.5\%$. Errors resulting from uncertainties in specimen length (0.1%), time base calibration, or effects of coupling material were of less consequence.

Elastic constants shown in the figure and table were calculated from the following equations:

$$\text{Young's modulus} \quad E = \rho V_T^2 \left(\frac{3V_L^2 - 4V_T^2}{V_L^2 - V_T^2} \right)$$

$$\text{Shear modulus} \quad G = \rho V_T^2$$

$$\text{Bulk modulus} \quad K = \rho \frac{(3V_L^2 - 4V_T^2)}{3}$$

$$\text{Poisson's ratio} \quad \gamma = \frac{V_L^2 - 2V_T^2}{2(V_L^2 - V_T^2)}$$

where ρ = density

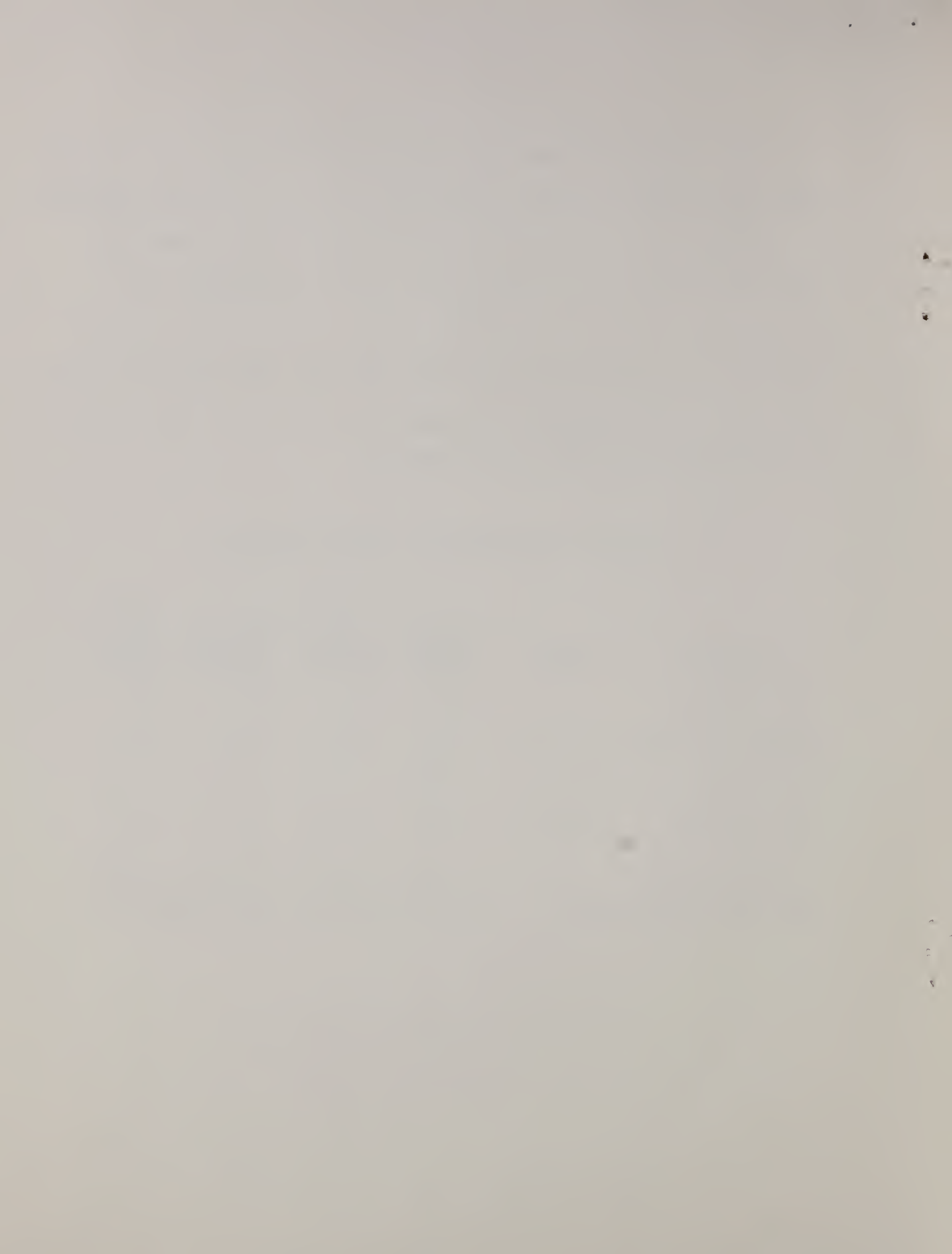
V_T = transverse wave velocity

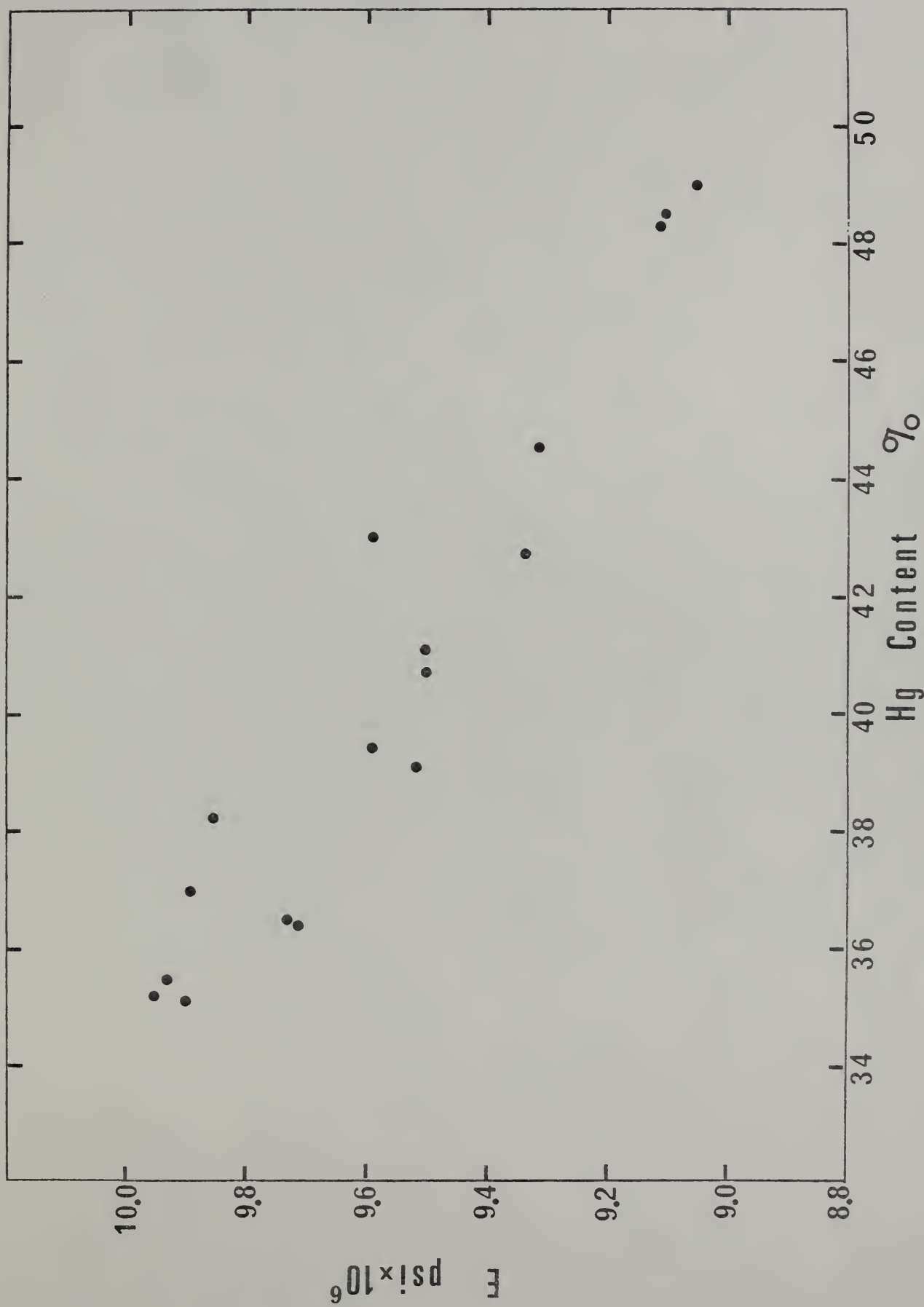
V_L = longitudinal wave velocity

The values obtained for Young's modulus are much higher than previously reported values of 1 to 4 x 10⁶ psi obtained by methods employing conventional stress-strain apparatus and relatively slow strain rates. M. S. Rodriguez and G. Dickson, J. D. Res., 41:840, 1962, reported low values obtained by conventional methods and also reported preliminary results indicating that values up to 9 x 10⁶ psi might be obtained with very rapid loading.

ELASTIC CONSTANTS OF DENTAL AMALGAM

<u>Property</u>	<u>Unit</u>	<u>Average Value</u>	<u>Range of Three</u>	<u>Average Value</u>	<u>Range of Three</u>
Hg Content	%	35.3	0.4	48.6	0.7
Young's Modulus	10 ⁶ psi	9.93	0.05	9.09	0.06
Shear Modulus	10 ⁶ psi	3.685	0.01	3.41	0.03
Bulk Modulus	10 ⁶ psi	10.82	0.30	9.12	0.22
Poisson's Ratio	---	0.347	0.004	0.334	0.005
Specimen Length	mm	12.7, 6.3, 6.3		15.2, 10.4, 7.7	





Effect of mercury content on Young's modulus of a dental amalgam.

