linear system whose frequency is not amplitude dependent. An analysis of this problem shows that if the amplitude of oscillation exceeds 10% of the effective length of the specimen, it is possible to get systematic non-linearity errors which are commensurate with the other measurement errors.

Direct observations indicated that the logarithmic decrement of the damped oscillations of the specimen placed in the instrument did not exceed $5 \cdot 10^{-4}$. Such magnitudes of the decrement may give rise to a change in the frequency of less than $10^{-6}$, which is significantly smaller than the random measurement errors in the use of the instrument. Hence, corrections for the damping need not be applied to the results of the measurements.

The necessity of working with comparatively long specimens with a low natural frequency is corroborated in experiments on the effect of the support on the frequency of oscillation [5]. The greater the length of the specimen with respect to its thickness, the smaller is the effect of its deformation in the neighborhood of a support. This is a very important consideration since the length of the specimen enters into (1) according to its fourth power.

The basic accuracy of the measurement of the modulus of elasticity of thin sheet materials is governed by errors in the measurement of the thickness of the specimen, which in practice varies along the specimen's length.

The elastic moduli were measured to relative errors of 0.5-1.0%, depending on the quality of the material and its thickness. The values of $E_l/E_0$ can be determined with a relative error of less than 1% even under the most unfavorable conditions.

**SUMMARY**

By the use of a photoelectric pickup and an electronic counting circuit, the instrument which has been described allows one to measure infrasonic damped oscillations with great accuracy. Further, the measurements have been automated.

In order to attain a high accuracy of measurement of the modulus of elasticity, it is necessary that the amplitudes of oscillation of the specimen be as small as possible with respect to its length. This allows one to determine the modulus of elasticity and its temperature coefficient for flexible sheet materials.

**LITERATURE CITED**


**MEASUREMENT OF FRICTION FORCE IN PISTON GROUP OF ENGINE**

K. A. Polnitskii

In the V. I. Lenin Kharkov Polytechnical Institute work has been conducted on the measurement of the friction force in the piston group of the IaAZ-204A engine. The friction force was determined in relation to temperature changes, the quality of the lubricating oil, changes in speed of the piston, and the normal force.
The friction force was measured from the liner displacement, which depends on the magnitude of the friction force between the piston and the liner. The liner was held on flexible supports which limited its movement and centered it relative to the cylinder.

When the liner moved it did not come in contact with the cylinder, since its outer radius had been reduced by 1.2 mm by turning on a lathe. The liner supports consisted of a crosspiece fastened with 4 bolts at the bottom, and at the top 4 flexible strips on which the end face of the liner rested and which transmitted the friction force of the piston as it completed a reciprocating movement. The supports were deformed as a result of the movement of the liner.

For the measurement of the mechanical deformations we used a bridge composed of 4 equal-resistance wire gauges cemented on one strip, which was strained as a result of the liner movement. Two gauges were cemented to the upper side of the strip, and the other two on its underside. This arrangement of the gauges increased the sensitivity of the measuring bridge, since on deformation one pair of wire gauges responds to the compression strain, and the other to the expansion strain.

The supply and measuring diagonals of the bridge were connected to a six-filament three-stage amplifier operating from an ac supply.

The results of the measurements were recorded by a nine-loop oscillograph through a voltage stabilizer.

For simulating in experimental conditions the actual conditions of operation of the engine, the water and oil were heated by electric heaters. The temperature of the oil and liner were regulated, where necessary, to the temperature in the engine on a full load at 1100 rpm.

The strips with the cemented wire gauges were calibrated by a milliammeter and oscillograph in the following manner. The engine was cranked without the piston of the test cylinder and with the electric oil and water heaters switched on. After the bridge had been balanced and the scale of forces determined, the supporting strips were loaded successively with weights up to 15-20 kg. When the loading weight was increased, the strips were strained and the unbalance of the bridge increased as a result of the deformation of the strips. Corresponding to each load the milliammeter showed the value of the current on the amplifier output, and on the oscillograph screen we obtained the deflection of the spot of the loop mirror. The value of the current on the amplifier output and the deflection of the spot on the oscillograph with the same load on the strip were not the same and depended on the temperature state of the engine.

A calibration of the strips with the gauges was made at different temperatures of the liner.

The experiments were conducted by cranking the engine with an electric motor at a set number of revolutions in the range 1100-1500 rpm and with the corresponding temperature of oil and liner.

During the movement the following forces act between the liner wall and the piston with rings: a) friction of ring surface on liner wall; b) friction due to displacement of oil layer on sleeve wall by sharp edges of ring; c) friction due to action of normal force; d) friction of piston surface and liner wall across the oil layer separating them.

These forces, as well as the inertia forces of the liner, were recorded on an oscillogram by means of the sensitive element.

The inertia forces of the liner arose in consequence of its uneven motion due to the alteration of the friction force with the angle of rotation of the crankshaft and this affected the deformation of the supports.

The figure depicts an oscillogram showing the variation in the friction force of the piston with rings and the inertia force of the liner with respect to the angle of rotation of the crankshaft at 1100 rpm and oil temperature 80°C for one stroke of the piston.