EXPERIMENTAL INVESTIGATIONS OF NONRESONANCE PARAMETRIC INTERACTIONS OF ELASTIC WAVES IN SOLIDS

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Results are presented of experimental investigations into nonresonance parametric interactions of elastic waves in isotropic solid media conducted on the base of audio modulation by sound in an aluminum alloy. It is shown that the experimental results agree well with the theory. Third-order elasticity constants and the absolute values of dynamic elastic fields are measured.

The theory of elastic-wave interactions has previously [1, 2] been examined. In this work phase modulation of high-frequency longitudinal, shear, and surface elastic waves with the low-frequency elastic field of a standing wave is investigated. Measurements of the phase-modulation index of elastic waves were conducted by means of an instrument using the flow chart depicted in Fig. 1. An electrical signal from a sinusoidal signal generator 1 was fed to a piezoelectric radiator 2 (of shear, longitudinal, or Rayleigh waves).

The wave emitted by the piezoelectric transducer 2 passes through the solid specimen 3 and is taken up by the piezoelectric receiver 4. The phase-modulated signal enters the phase-detecting circuit (radio receiver or selective voltmeter) 6 through the filter 5. The filter 5 is used to attenuate an undesired low-frequency modulating signal which can be directly taken up by the piezoelectric receiver. The signal separated and amplified by the receiver 6 is observed on the oscillograph screen 7 or measured by the voltmeter 8. A low-frequency modulating field in the specimen 3 is excited by the piezoelectric transducer 9 to which the electric signal from the generator 10 is fed.

A sinusoidal modulating elastic field with frequency 19.5 kHz was excited by mounting a vibrator in a bar.

Investigations into the modulation of longitudinal waves and other types of waves were conducted on a rod made of alloy D16T measuring $270 \times 50 \times 20$ mm^3. The length of the bar in this case equaled the wavelength of the modulating field at a frequency of 19.5 kHz. Investigations into the modulation of longitudinal waves with frequency of 2.5 mHz comprised the study of the index of modulation of the wave across the bar as a function of the coordinate of the radiator and receiver of the modulated wave along the bar and as a function of the angle between the wave vectors of the interacting waves. The dependence of the index of modulation on coordinates along the bar is depicted in Fig. 2 (distance from the end of the bar to the radiator is layed out along the x axis, and the index of modulation relative to the maximal value is layed out along the y axis). The solid line represents the theoretical dependence on all graphs. The experimental points (triangles) coincide within the measurement error with the theoretical curve 3. The results of an experimental investigation into the angular dependence are depicted in Fig. 3. Here there also exists good agreement between experiment (triangles) and theory (curve 2; the third-order constants used in the theoretical calculations are taken from [3].

Investigations into the modulation of shear waves 2.5 mHz in frequency comprised the study of the angular dependences of two types of indices of modulation, namely, when the polarization vector lies in a

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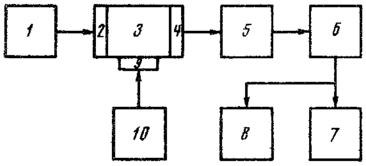

Fig. 1

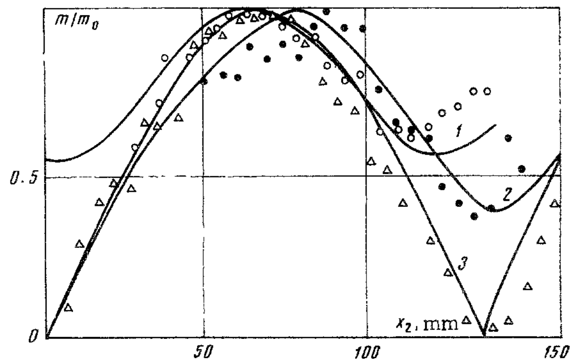

Fig. 2

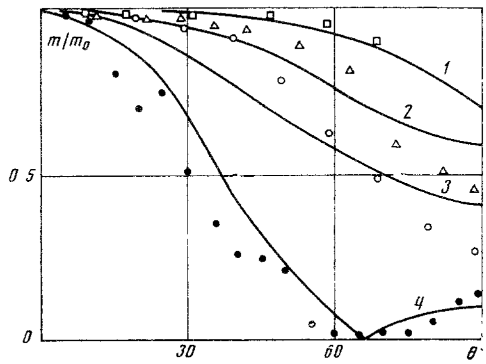

Fig. 3

plane passing through the wave vector of the modulated wave and the longitudinal axis of the bar, and when the angle between the polarization vector and its projection on this plane varied. For this purpose V-shaped radiators with different angles of inclination were used in the first case, while in the second case the radiator and receiver were simultaneously rotated about an axis passing through the field antinode.

The results of the experimental investigation into the dependence of the index of modulation on coordinates along the bar are not presented here, since they are analogous to the corresponding results for longitudinal waves.

The results of the investigation into the angular dependences are depicted on the curves of Fig. 3 for the first type (squares) and second type (circles). The solid curves 1 and 3 in the figure depict the theoretically calculated dependences. The index of modulation in the figure is presented in relative units (relative to the maximal theoretical value).

In this work an experimental investigation was conducted into the modulation of travelling Rayleigh waves with vibration frequency 1.8 mHz. The dependences of the index of modulation on coordinates along the bar, assuming propagation of the Rayleigh wave along the modulating field (for an interaction path of 50 mm) and on the interaction path were investigated. The dependence of the index of modulation on interaction path was determined for a radiator located at the node of the modulating field. The receiver was shifted along the bar (a surface wave also propagates along the bar).

Results of an experimental investigation into the dependence of the index of modulation on the angle between the wave vectors of the interacting waves are depicted in Fig. 3 (points) and the dependences of the index of modulation on coordinates along the bar for longitudinal propagation and on interaction path are depicted in Fig. 2 (points, circles, curves 2 and 1, respectively). The continuous curves were theoretically calculated using previously given formulas [2]. The values of the index of modulation are plotted relative to the maximal value. These results also agree well with theory.

Let us present results of a calculation of third-order elasticity constants for the D16T alloy based on these experiments. The theoretical foundations for such a calculation were examined in [1]. The Murnaghan constants were determined here for convenience for comparison to the results of other authors [3]. The results of the measurements are as follows:

$l \cdot 10^{-10}$ N/m^2	-29 ± 6	-35	[3]
$m \cdot 10^{-10}$ N/m^2	-31 ± 6	-37	[3]
$n \cdot 10^{-10}$ N/m^2	-26 ± 5	-27	[3]

Values for density are taken from the literature. Second-order elasticity constants were measured relative to the velocity of shear waves.

It is evident that the third-order elasticity constants determined relative to audio modulation by sound coincide to within the measurement error with the mean values of the constants presented in a previous study [3]. It is necessary to take into account the dispersion of the elasticity constants, which depends on the data processing.

The pressure amplitude at the modulating field antinode was calculated from the experimental results presented here. The pressure amplitude, calculated by the results of a measurement of the index of modulation of elastic waves at a frequency of modulating field of 19.5 kHz, was $5 \cdot 10^6$ dyn/cm. This result agrees well with the result of determining the pressure amplitude in terms of the magnitude of the piezoelectric modulus of the piezoelectric transducer and in terms of the magnitude of the electric modulating signal. In this case the pressure amplitude for a quality of 60 for the bar at a frequency of 19.5 kHz, was $5.8 \cdot 10^6$ dyn/cm^2 at the antinode.

LITERATURE CITED

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