LETTERS TO THE EDITOR

ELASTIC CONSTANTS OF QUARTZ

THE elastic constants of quartz have been determined by Voigt[1] by static methods, and by Atanasoff and Hart[2] by dynamical methods employing high frequencies. Variously oriented quartz plates were used by these authors. In the present investigation, the phenomenon of the diffraction of light by ultrasonic waves set up in liquids has been utilised for detecting the resonant frequencies of the piezoelectrically-driven plates of quartz.

Quartz (point group D_3) has six elastic constants. The velocities of propagation of a sound wave in a direction normal to the face of an X-cut plate are the roots of

$$(C_{11}-\rho c^2)[(C_{66}-\rho c^2)(C_{44}-\rho c^2)-C_{14}^2]=0 \quad \ldots \quad (1)$$

The linear mode corresponds to a longitudinal vibration which gives intense diffraction patterns if the plates are silvered uniformly and these are used for evaluating C_{11}. The quadratic form represents two more complicated modes, one of which can be made to appear when the plates are unsymmetrically silvered. Similarly the velocities in a direction normal to a Y-cut plate are the roots of

$$(C_{66}-\rho c^2)[(C_{11}-\rho c^2)(C_{44}-\rho c^2)-C_{14}^2]=0 \quad \ldots \quad (2)$$

The linear factor comes out as an independent torsion even when fully silvered plates are used and yields C_{66}. From the relation $C_{66}=(C_{11}-C_{12})/2$, C_{12} may be calculated. The coupled modes corresponding to the quadratic factor in (2) are excited by adopting unsymmetrical silvering. Solving the quadratic factors of (1) and (2), the constants C_{44} and C_{14} are evaluated. For a plate cut with its normal in the YZ plane and making an angle of 135° with the Z axis, the velocities of propagation will be the roots of

$$[\tfrac{1}{2}(C_{44}+C_{66}-2C_{14})-\rho c^2][\tfrac{1}{2}(C_{11}+C_{44}+2C_{14})-\rho c^2]\times[\tfrac{1}{2}(C_{33}+C_{44})-\rho c^2]-\tfrac{1}{2}(C_{13}+C_{44}+C_{14})^2=0 \quad \ldots \quad (3)$$

The quadratic factor contains two modes excited by unsymmetrical silvering and one of them is used for evaluating C_{13}. In evaluating the constant C_{33}, a Z-cut plate is taken and the method of transmission evolved in this laboratory and described in a previous paper[3] is employed. A consideration of the modes left out in the above calculations furnishes two or three additional checks. The results thus obtained have been corrected for the forces arising from the polarization produced by the vibrations as pointed out by Lawson[4] and the corrected values along with those of Voigt (static) and Atanasoff (dynamic) are given below:

Elastic Constants of Quartz

	Author	Voigt	Atanasoff
C_{11}	86·94	86·82	86·75
C_{12}	6·96	7·09	6·87
C_{44}	57·12	58·23	57·86
C_{13}	15·60	14·38	11·20
C_{33}	10[illegible]·[illegible]0	107·45	1[illegible]6·80
C_{14}	17·43	17·15	17·96

Agreement is satisfactory in respect of all the constants except C_{13}. In this case Atanasoff used an orientation which results in a very complicated expression and a large correction. The discrepancy is probably due to this.

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December 11, 1944.

1. Voigt, W., *Lehrbuch der Kristall physik*, 1928. 2. Atanasoff, J. V., and Hart, P. J., *Phys. Rev.*, 1941, **59**, 85. 3. Bhagavantam, S., and Ramaseshachar, L., *Proc. Ind. Acad. Sci.*, 1944, **20**, 298. 4. Lawson, *Phys. Rev.*, 1941, **59**, 838.