A NEW ULTRASONIC METHOD FOR DETERMINING ELASTIC CONSTANTS

It is very well known that the breadth of resonance for a piezoelectric plate excited at one of its natural frequencies, is wide enough to allow the excitation of the crystal with sufficient power throughout a considerable frequency range. The author employs this broad frequency region of vibrations in the neighbourhood of one of its natural frequencies as the continuous source for finding transmission maxima through a crystal whose elastic constants are to be determined.

An X-cut quartz plate of thickness 2 mm., silvered on both sides, is made to excite vibrations in a thick plate of a crystal whose fundamental must be of the order of 0·1 to 0·3 Mc/sec. and the ultrasonic wave transmitted by the crystal is communicated into a liquid contained in a glass trough. The diffraction pattern of the ultrasonic grating set up in this liquid is seen with the usual arrangement. When the frequency of the oscillator is varied continuously in the region of one of the natural frequencies of the piezoelectric plate, it is found that the diffraction pattern due to the ultrasonic wave transmitted by the crystal exhibits a series of sharp maxima which are close to each other. Each of these transmission maxima corresponds to the excitation of one of the harmonics of the longitudinal vibrations of the crystal block and the differences between the successive maxima are found to be identical, corresponding very nearly to the longitudinal fundamental of the crystal plate. Such transmission maxima are observed in the neighbourhood of all the natural frequencies of the piezoelectric plate. More number of these transmission maxima are observed in the lower frequency region and with higher powers of the oscillator. Using the longitudinal fundamental frequency of the crystal thus determined and the thickness of the crystal, the longitudinal velocity and hence the effective elastic constant in the particular direction is calculated with the help of the familiar formulæ. With this type of set-up it is found that the shear modes do not come up prominently. This is also one of the difficulties sometimes encountered in the wedge method developod by Bhagavantam and Bhimasenachar.[1] To overcome this difficulty the author employed a Y-cut quartz plate for determining velocities of shear modes. In place of the X-cut quartz plate, a Y-cut quartz plate is cemented to the crystal and the transmission maxima studied as in the previous case. It is now found that the shear modes are excited more prominently than the longitudinal ones. From transmission maxima thus observed, the shear modes are easily sorted out and the corresponding fundamental frequency determined taking note of their high intensity. The velocity and the elastic constant for shear wave, in the particular direction, is then calculated in the usual manner.

Using this method the author has determined the elastic constants of potash alum employing crystals of thickness about 1 cm. The values for the elastic constants thus obtained are given in the following table along with those reported earlier.

	C_{11}	C_{12}	C_{44}
Author ..	2·56	1·07	0·85
Voigt[2] ..	2·43	1·009	0·843
R. V. G. Sundara Rao[3] ..	2·56	1·07	0·86
Bhagavantam and B. R. Rao[4]	2·54	1·07	0·84

This method has the main advantage that employing a Y-cut plate shear modes are excited in any crystal with ease. Further, higher accuracy in determination of elastic constants is attained in this method because of the large thickness of the crystal used and the increased number of transmission maxima obtained with moderate powers of the oscillator. On the other hand, the method has the drawback that it requires a crystal block of thickness of the order of 1 to 1·5 cm. and is not suitable for crystals available only in very small sizes. It is also found that there is a definite size effect on the vibrations of the crystals which is being investigated in detail.

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