# ULTRASONIC VELOCITIES IN LIQUIDS BY A NEW METHOD

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## 1. Introduction and Experimental Details

In a recent communication,[1] the author has proposed a simple and new method for determining the velocities of ultrasonic waves in liquids which is based on a principle similar to the wedge method developed by Bhagavantam and Bhimasenachar[2] for elastic constants of solids. While studying the frequency spectrum of different types of wedges, the author has come across a curious result that continuous ranges of ultrasonic waves generated by a wedge exhibit sharp maxima when communicated to the diffraction cell through a thin uniform liquid film. This enabled a new method to be devised for measuring the ultrasonic velocities in liquids using the liquid in the form of a plate and determining its resonance frequencies.

In this method a small liquid cell is made out of a brass annular disc of uniform thickness (about 2 mm.) by closing both sides with two thin cover glass slips. The space enclosed by the cover slips can be completely filled up by about 0·25 c.c. of liquid which is introduced through a side hole provided in the brass disc. The liquid spreading in between the cover slips forms, as it were, a liquid plate of uniform thickness. Ultrasonic waves generated by a suitable tourmaline wedge giving a range of 3-7 Mcs./sec. are transmitted through this liquid cell and communicated to water contained in a glass trough. The ultrasonic wave thus transmitted through the liquid plate sets up an ultrasonic grating in the water contained in the glass trough whose diffraction effect is observed with the usual arrangement. The transmission maxima of the liquid plate are determined by observing the maxima in the intensity of the diffraction pattern. These maxima which correspond to the resonance frequencies of the liquid plate will enable the estimation of the fundamental resonance frequency. The fundamental resonance frequency of the liquid plate being of a low order (about 0·3 Mcs./sec.) a good number of transmission maxima are observed using a wedge of a short frequency range enabling a reasonably accurate determination of the fundamental frequency. All observations are made at constant temperature and the oscillator employed is of the usual Hartley type covering a wide range of frequencies which are measured with a standard Philips Heterodyne Wavemeter using a rectifier and audioamplifier for hearing the beat note.

## 2. RESULTS

Table I gives some of the large number of transmission maxima observed in the case of water along with the order of harmonic that is excited and the fundamental frequencies deduced from them.

TABLE I

| Resonance Frequencies of water plate in Mcs./sec. | Order of harmonic | Fundamental frequency in Mcs./sec. |
|---|---|---|
| 4·62 | 15 | 0·308 |
| 4·91 | 16 | 0·307 |
| 5·20 | 17 | 0·306 |
| 5·51 | 18 | 0·306 |
| 5·79 | 19 | 0·305 |
| 6·08 | 20 | 0·304 |
| 6·38 | 21 | 0·304 |

The fundamental frequency thus evaluated, though fairly constant, clearly indicated a slight dependence on the transmission frequency. This effect has to be interpreted as due to the size of the container but not as an evidence of dispersion. Detailed investigations are in progress regarding the size effect of the container by taking various sizes of liquid cells. In fact, it is found that there is not much of a variation in the value of the fundamental beyond 6 Mcs./sec. Taking the value obtained at the high frequencies as the true fundamental, the velocities are calculated in the usual manner. There is also slight evidence of damping of the liquid plate by the water contained in the glass trough. This can be avoided by resorting to an electrical method for detecting and amplifying the transmitted ultrasonic beam. This would also enable the setting of the oscillator for the maximum intensity of the diffraction pattern more precisely than by the visual judgment of its intensity.

Results obtained for the velocities by a number of transparent and opaque liquids are given in Table II along with the values reported in the literature. Agreement is satisfactory in spite of the probable sources of error due to damping and size effect.

TABLE II

| Liquid | Fundamental frequency (Mcs./sec.) | Velocity calculated in metres per sec. at 30° C. | Velocities obtained by other methods at (23°-27° C.) | References |
|---|---|---|---|---|
| Glycerine .. | 0·390 | 1950 | 1986 | 3 |
| Water .. | 0·304 | 1520 | 1500 | 3 |
| Mercury .. | 0·285 | 1425 | 1440 | 4 |
| Toluene .. | 0·260 | 1300 | 1300 | 3 |
| Ethyl alcohol .. | 0·231 | 1155 | 1150 | 3 |
| Carbon tetrachloride .. | 0·181 | 905 | 930 | 3 |

## 3. DISCUSSION

The capacity of the liquid cell used in the above investigation is only 0·25 c.c. and thus velocities in liquids available even in such small quantities can be determined. The method is simple and rapid being particularly suitable for opaque liquids for which the only method of obtaining velocities at high frequencies is by the pulse technique. The investigation of dispersion of sound velocity at very high frequencies in liquids having high absorption coefficient is not possible by the Debye-Sears' method in view of the feeble intensity of diffraction pattern as well as the temperature disturbance. This method can be used with advantage in such cases as the amount of ultrasonic energy absorbed will not be considerable for small quantities of liquids. The possibility of extending this method for study of dispersion is being investigated.

## 4. SUMMARY

A new method of determining velocities in transparent and opaque liquids using ultrasonic frequencies over a wide range has been described. Results obtained for a number of organic and inorganic liquids are given. They compare well with values reported earlier in the literature. Only a small quantity of 0·25 c.c. is all that is required and hence the method is particularly suitable for liquids available in very small quantities. The possibility of extending this method for study of dispersion in a variety of liquids is envisaged.

## REFERENCES

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