Taking the above values of the force-constants, the frequencies that are to be attributed to the $CaCO_3$ crystal can be evaluated as follows:

A_1 (Raman active, infra-red inactive)—1084.
A_2 (Inactive in both)—877, 213, 0.
B_1 (Infra-red active, Raman inactive)—890, 331, 106.
B_2 (Inactive in both)—1082, 297.
E_1 (Infra-red active, Raman inactive)—1487, 676, 403, 225, 139.
E_2 (Raman active, infra-red inactive)—1438, 703, 277, 141.

The significance of the various force constants and that of A_1, A_2, etc., is fully described in the paper already referred to and is not repeated here for want of space.

The results thus obtained are summarised and compared with the experimental observations in Table I:

TABLE I

Raman effect	Calc.: 141, 277, 703 1084, 1438. Obs.: 155, 282, 709, 1084, 1434.
Infra-red absorption	Calc.: 106, 139, 225, 331, 403, 676, 890, 1487. Obs.: 106, 106, 182, 357, 320, 706, 879, 1429–1492.

The agreement is good. The appearance of lattice lines in the Raman spectrum and of low frequencies in the infra-red absorption, the lack of exact coincidence between the Raman and infra-red frequencies in respect of the degenerate modes, a shift in the value of the total symmetric frequency from the ion to the crystal are amongst the features that are satisfactorily accounted for.

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1. *Proc. Ind. Acad. Sci.*, 1939, **9**, 224. 2. *Ibid.*, 1944 **19**, No. 1.

REFRACTION OF ULTRASONICS AND VELOCITIES IN COLOURED LIQUIDS AND IN SOLIDS

IN the Debye-Sears method of diffraction of light by ultrasonic waves, the intensity of lines on both sides of the central line is symmetrical only when the sound waves are exactly at right angles to the light beam. This phenomenon was used to measure the refraction of sound waves. The vibrating quartz was placed in a metal vessel having a plane mica window and containing a liquid, say xylol. The vessel containing the quartz was placed in a bigger plate-glass vessel containing a second liquid, say water. Through this vessel a monochromatic light-beam was sent for diffraction effect. Now by simple arrangements the quartz plate could be rotated through an angle without disturbing any of the vessels and[2] the assembly of the two vessels could be rotated as a whole through an angle without disturbing the quartz with respect to the vessels. This was done by fixing the whole arrangement for rotating the quartz on to one of the vessels.

To begin with, the plane of the quartz was set parallel to that of the mica window. In this position, the ultrasonics being incident normally upon the mica window would suffer no bending. The outer plate glass vessel was rotated till symmetry of intensity in the spectrum was obtained. The quartz was then rotated through an angle "*i*". "*i*" was then the angle of incidence. The outer vessel was again rotated till symmetry of intensity was obtained. Clearly the angle between the rotations of the other glass vessel was the angle of refraction. Two applications follow immediately, *viz.*, finding velocities in coloured liquids and in solids, transparent or opaque. The coloured liquid is of course to be put in the inner vessel. In case of the quartz cannot be set accurately parallel to the mica window, then more than two settings of the quartz can be used and corresponding refractions found. The method then becomes somewhat mathematically cumbersome. If the coloured liquid is electrically conducting, so that the quartz cannot be directly put in it then an innermost vessel can be put inside the inner vessel containing the coloured liquid. This innermost vessel has to be made of plate-glass and quartz put in it along with some non-conducting liquid, so that the plane of the quartz is always parallel to the side of the innermost vessel. This can be permanently set by cementing the quartz on to the inside of the vessel. The whole innermost vessel has now to be used in place of the quartz alone.

Solids.—A prism or wedge of the solid can be made having a small angle "*i*". The quartz can be cemented plane on one face of the prism containing the angle "*i*". In one way of using it, a permanent line can be drawn at the base of the plate glass-vessel (no inner vessel) and for convenience parallel to its breadth, and along the direction of the beam of the light. The prism is made to stand in the vessel, so that the quartz directly faces the side of the liquid exposed for diffraction, the side of the prism being directly on the line. The vessel is now rotated till symmetry of intensity is obtained. The prism is then turned over, the other face of the prism containing "*i*" being on the ruled line. The waves have now to pass the prism in order to come to the part of the liquid used for diffraction. "*i*" then becomes the angle of incidence. The vessel is again rotated to get symmetry of intensity. The angle between the two rotations is the angle of refraction.

Accuracy.—The accuracy by this new method depends upon the accurate measurement or setting of the following:—

(1) Position of the crystal when intensity is symmetrical.
(2) Plane of the crystal parallel to the plane of the mica window. Of course any other suitable substance can also be used in place of mica, say glass.
(3) Angles of incidence and refraction.

As regards (1), Parthasarathy (1936) found