

remarked that the appearance of geometric patterns in cleavage plates of diamond exhibiting the local variations in the various physical properties mentioned above is a convincing ocular demonstration of the fact that we are really dealing with distinct allotropic forms of diamond, as also with the consequences of their interpenetration and/or inter-twinning.

The above statement of the case is by way of reply to Mrs. Lonsdale's letter published in *Nature* of February 3 last. She does not discuss the array of facts brought forward in the symposium but 'challenges' what she refers to as a 'speculation' on the basis of certain minor aspects of the X-ray behaviour of diamond, which are not really fundamental to the issues under consideration. Mrs. Lonsdale believes that the specific points mentioned by her controvert the main thesis established by the work of my collaborators and myself; this is not so. As the present letter, however, is already of sufficient length, a detailed examination of those points must be reserved for a separate communication.

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¹ Placzek, G., "Handbuch der Radiologie", Part 2, p. 297, table 9 (2nd Edit., 1934).

² Groth, P., "Physikalische Kristallographie" (Leipzig, 1895), 575.

³ Miers, H. A., "Mineralogy" (Macmillan, 1902), 282.

⁴ Raman, C. V., and collaborators, *Proc. Ind. Acad. Sci.*, A, **19**, 189 (1944).

⁵ Ramachandran, G. N., *Proc. Ind. Acad. Sci.*, A, **19**, 280 (1944).

Infra-Red Spectrum of Diamond

THE new theory of crystal dynamics put forward by Sir C. V. Raman¹ leads in the case of diamond to the result that the atomic vibration spectrum of this crystal should exhibit eight distinct monochromatic frequencies. Of these, the mode of highest frequency ($1,332 \text{ cm}^{-1}$) corresponds to the triply degenerate vibration of the two Bravais lattices of carbon atoms with respect to each other, and this is active or inactive in infra-red absorption according as the crystal structure of the diamond possesses tetrahedral or octahedral symmetry. The other seven frequencies represent oscillations of the layers of carbon atoms parallel to the faces of the octahedron or the cube occurring normal or tangential to these planes, with the phase reversed at each successive equivalent layer. By the nature of the case, such oscillations should be *inactive* in the infra-red absorption as fundamentals; but owing to anharmonicity, the octaves of these frequencies should be capable of appearing in infra-red absorption. Besides the octaves, various combinations of these frequencies would also be active in infra-red absorption.

A detailed exploration of the infra-red absorption band exhibited by diamond in the region of wave-lengths between 4μ and 5μ was made by Robertson, Fox and Martin², using a concave grating of one metre focus of echelle type, in conjunction with a prismatic instrument. The investigation showed that the band had an observable fine structure; indeed a whole series of sharply defined peaks or absorption maxima was noticed, the positions of which were capable of exact measurement within a few wave-numbers.

These results must be considered surprising on the basis of the older theories of crystal dynamics, according to which the vibration spectrum of a crystal is essentially a continuous one. Indeed, it is not easy to see how any explanation of the experimental facts could be offered on the basis of those theories. On the other hand, they find a natural explanation on the basis of the new dynamics as explained above.

Both in the earlier investigation of Robertson, Fox and Martin³ and the later one mentioned above, the two most conspicuous and sharply defined absorption peaks are those at wave-numbers 2170 and 2028. These agree within a wave-number or two with the octaves of 1088 and 1013 respectively which represent the frequencies (determined by other spectroscopic methods) of the atomic vibrations normal to the octahedral planes. The other peaks in Robertson, Fox and Martin's curve may also be explained quite accurately as allowed combinations of the lattice frequencies.

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¹ Raman, C. V., *Proc. Ind. Acad. Sci.*, A, **18**, 237 (1943).

² Robertson, Fox and Martin, *Proc. Roy. Soc.*, A, **157**, 579 (1936).

³ Robertson, Fox and Martin, *Phil. Trans. Roy. Soc.*, **232**, 463 (1934).

Shear Modes in Non-Piezo-Electric Crystal Plates

RECENTLY we described a new method¹ for the determination of the elastic constants of crystals, utilizing ultrasonic waves of continuously varying frequency. At that time, it was thought that the method would not permit the thickness transverse vibrations to be detected. The full set of elastic constants could be obtained only after supplementing the work by a few static torsion observations.

Further work has now revealed that these transverse or shear modes can also be transmitted through crystal plates and communicated to liquids in the form of consequential longitudinal strains. Associating such transmission maxima with thickness transverse frequencies, torsion constants for crystal plates can be calculated and the full set of elastic constants obtained by purely dynamical methods. This result has now been used for checking previous measurements on some crystals and to make new measurements on others. Full details and the numerical results are being published elsewhere.

It may be pointed out here that this observation is analogous to that of Bhagavantam and Suryanarayana², who have recently demonstrated that besides the usual longitudinal ones, shear modes also can be excited in piezo-electric crystal plates and transmitted to liquid media as corresponding longitudinal waves.

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¹ Bhagavantam, S., and Bhimase�achar, J., *Proc. Ind. Acad. Sci.*, A, **20**, 298 (1944).

² Bhagavantam, S., and Suryanarayana, D., *Nature*, **155**, 171 (1945).