THE DIFFRACTION OF LIGHT BY HIGH FREQUENCY SOUND WAVES: GENERALISED THEORY.

The Asymmetry of the Diffraction Phenomena at Oblique Incidence.

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1. Introduction.

In a series of five papers published in these Proceedings, the theory of the diffraction of light by high frequency sound waves has been developed. There have been however two stages in the development of the theory. The first one had a restriction in the theory in order to simplify the treatment of the problem and bring out its essential features without unnecessary complications. In the second one, the above restriction in the theory has been removed and the theory of the phenomenon under general conditions has been developed. The general theory includes the preliminary one as a special case.

Preliminary Theory.—In Parts I, II and III, the essential idea is that the optical effects are due to the corrugated form of the emerging wave-front and that the corrugations due to the density fluctuations could be simply calculated by the phase changes accompanying the traversing beam ignoring the amplitude changes. The exact condition under which this restriction could be realised in practice is indicated in the papers. The theory accounts for the appearance of a large number of diffraction orders and also the wandering of the intensity of light amongst them as the length of the cell, the supersonic intensity and the wave-length of the incident light are changed. All these results have been strikingly confirmed quantitatively by Bär who actually realised in practice the restriction we had imposed in our preliminary theory. The intensity variations and the symmetry of the diffraction effects in the case of oblique incidence have been also confirmed by Bär. In Part III of the theory, we investigated the Doppler effects in the diffraction orders when the supersonic wave is either a progressive one or a standing

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one. The results in the case of a standing wave are really interesting. We obtained the result that any order would cohere partly with any other order counted in an even sequence from it while it would not cohere with the remaining ones lying on an odd sequence from it. This result is in remarkable agreement with the same result obtained by Bär\textsuperscript{3} experimentally.

**Generalised Theory.**—In Parts IV and V, the restriction of the preliminary theory was removed by considering the partial differential equation governing the propagation of light in a quasi-homogeneous medium. The results regarding the coherence phenomena amongst the diffraction orders were found to be true even if the supersonic wave be a general periodic progressive one or a standing one. We then considered the cases of a simple periodic progressive wave and a standing wave to investigate the amplitudes of the various diffraction orders. A difference—differential equation was obtained whose solutions correspond to the amplitudes of the diffraction orders. This equation enabled us to show that, in the case of oblique incidence, the diffraction pattern will be, in general, asymmetric which agrees with the results of Debye and Sears, Lucas and Biquard, Bär and Parthasarathy. The purpose of this paper is to solve the difference—differential equation occurring in the theory by the series method and offer an explanation for the quantitative experimental results obtained by Parthasarathy\textsuperscript{5} in the case of the oblique incidence.

In this connection we desire to make some remarks regarding Brillouin's theory. The idea of characteristic reflection in these experiments does not seem very appropriate in view of the fact that the wave-length of the periodic fluctuation of the density is large compared with the wave-length of the light. The concept of reflection does not explain the presence of other orders and the non-sharpness of the maximum intensity of the reflected order at the characteristic obliquity of light to the sound waves. Thus, the use of the general word 'propagation' is certainly preferable to the word 'reflection' for we know only and are here concerned with the equation governing the propagation of light in the medium. In Brillouin's rigorous theory\textsuperscript{4} of the diffraction phenomenon, he starts from the well-known partial differential equation governing the propagation of light in a quasi-homogeneous medium as we have also done. Thus the basis of Brillouin's rigorous theory and our general theory are the same. But the developments of the theory are different. His fundamental idea is that the emerging wave-front will be equivalent