## Sound-Films as Diffraction Gratings for the Visual Fourier Analysis of Sound-Waves

It may be of interest to give a preliminary account of what I believe to be a new method of producing acoustic spectra. The method, which is to employ the striations on "variable-density" sound-film as a diffraction grating for monochromatic light, permits an instantaneous separation of sound into its components which is analogous to the directness with which a spectroscope analyses light. If sound-film is modulated by a pure tone, a visual appreciation of frequency is clearly possible, the diffraction angle increasing with frequency. It might be anticipated that in the case where numerous frequencies are present, the diffraction pattern might contain a confused series of combination frequencies, after the manner of the 'ghosts' which appear with imperfect diffraction gratings possessing extraneous periodicities. A further complication might be expected from the fact that the range of frequencies recorded on the film extends over at least seven octaves, producing a correspondingly great overlapping of orders of spectra.

Theoretical investigation, however, reveals a very interesting state of affairs, which is briefly outlined below. Some of the conclusions are not new, but they are re-expressed because of their present application, and because they represent a departure from the traditional view of optical gratings.

(*a*) The Fraunhofer diffraction effect achieves as a physical process the same integrations that furnish the amplitudes and phases of the terms of a Fourier series. The function which the series represents is the variation of the light-amplitude on traversing the grating, which may be called for brevity its transparency curve.

(*b*) The customary orders of spectra of an optical grating represent the harmonics present due to the abrupt discontinuities in the transparency curve.

(*c*) A sound-film with a purely sinusoidal variation in the amplitude of the light transmitted will give rise to a first-order diffracted beam only; a film with any number of such periodicities superposed will give one diffracted beam for each component and no others.

There is thus no question of orders overlapping, and furthermore, if ghosts appear, they are merely a proper indication that a component of one frequency has been modulated by another frequency, the ghosts arising in the same way as the upper and lower side-bands which occur in wireless. One of the possibilities suggested by the theory is the analysis of transient sounds. Taking as the simplest case a pure tone of short duration, the record on the film acts as a grating of limited resolving power, and the resulting spread of the diffracted beam is just such as corresponds to the frequency range required to form the original 'wave-packet'.

It is necessary to employ for the recording apparatus a light-shutter the response of which is proportional to the square of the amplified audio-frequency current (for example, a shutter operating on the dynamometer principle) in order that the amplitude and not the intensity of the transmitted light may follow the wave-form of the sound pressure.

A simple experiment illustrates the way in which a complex wave-form can be analysed by this method. If interference fringes are formed on a photographic plate with a mercury arc, each actinic wave-length of the source impresses a different set of sinusoidal bands upon the plate. The developed plate used as a grating with a sodium lamp as source reproduces the lines of the mercury spectrum in yellow light, but in the first order only.

A fuller account of this work will be presented for publication elsewhere.

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## Adiabatic and Isothermal Compressibilities of Heavy Water

About 50 grams of heavy water supplied by the Norsk Hydro-Elektrisk Kvaelstofaktieselskab as 99·2 per cent pure ($d_4^{20} = 1{\cdot}1049$) has been used in the present investigation. The refractive index of the sample has been found to be 1·3278 for the *D* line at 30° C., which may be compared with 1·3276 given by Luten[1] under the same conditions. Using a piezometer made of soda glass and similar in construction to that employed by Tyrer[2] and recently by Dakshinamurti[3], the adiabatic compressibilities of heavy and ordinary water are determined. Tyrer's value for ordinary water is also given below for comparison. The specific volume, its variation with temperature and the specific heat in each case are taken from the existing literature and used for calculating the isothermal compressibility with the help of the well-known thermodynamical equation. Small variations in these do not appreciably affect the result, and hence the degree of accuracy with which they have been determined is of little consequence.

| | | Temp. | Spec. vol. | $dV/dT$ | $Cp$ | $\beta_\varphi \times 10^6$ | $\beta_T \times 10^6$ |
|---|---|---|---|---|---|---|---|
| Water | Tyrer | 30·0 | 1·00434 | 0·000304 | 0·9979 | 44·5 | 45·2 |
| | Authors | 29·2 | 1·00434 | 0·000304 | 0·9979 | 45·9 | 46·6 |
| Heavy water | Authors | 29·5 | 0·9123 | 0·000277 | 1·003 | 42·0 | 42·6 |

The compressibility of heavy water is nearly the same as that of ordinary water, and the ratio of the isothermal to the adiabatic compressibility is very close to unity as in the case of water. The above figures also enable us to predict that the intensity of the Rayleigh scattering in heavy water will be of the same order as that in ordinary water.

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[1] *Phys. Rev.*, **45**, 161 (1934).
[2] *J. Chem. Soc.*, **105**, 2534 (1914).
[3] *Proc. Ind. Acad. Sci.*, **5**, 385 (1937).

## Drift of Net Assimilation Rate in Plants

In a recently published note[1], the effect of age on net assimilation and relative growth-rates in the cotton plant is discussed. Although details[2] of the experiments have not reached me, it is evident from the note that O. V. S. Heath's results conflict with data already published[3,4] from this laboratory. In the experiments with cotton, no general rise or fall in the net assimilation rate (dry weight basis) was