Analysis of Varying Sound

The only reasonable method of frequency analysis applicable to the case of varying sound as yet published is that of Germanšky[1] and Brown[2], using diffraction of light by varying-density sound-film. But the technical difficulties owing to low dispersion seem to prevent further development in practical applications of that method. I have recently used a very simple photographic method of frequency analysis which can be designed so as to satisfy all the requirements met with in the analysis of any sounds or other vibrations.

The essential part of this method is a photographic plate (analysing plate), illustrated in Fig. 1, in which the transmitted light intensity varies as $A + B\sin\frac{2\pi}{d}x$, $(0 < B < A)$, along the x direction in the figure, and the wave-length d varies continuously in the y direction. The incident light intensity is varied according to the sound to be analysed, and a photographic film is moved at constant velocity along the x direction at the back of the analysing plate.

Let the incident light intensity be expressed as $P + Qf(t)$, $(0 < Q|f(t)| < P)$, and the velocity of the film be V; then a point on the moving film receives an amount of light which can be expressed as

$$\int_{-Nd}^{Nd}\left[P+Qf\left(\frac{x-\xi}{V}\right)\right]\left[A + B\sin\frac{2\pi}{d}x\right]dx,$$

where ξ is the co-ordinate of the point at $t = 0$, and $2N$ is the number of waves in the analysing plate. If N is sufficiently large, the above integral reduces to a constant term added to the expression

$$QB\int_{-Nd}^{Nd} f\left(\frac{x-\xi}{V}\right)\sin\frac{2\pi}{d}x\,dx = QB\int_{t_1}^{t_2} f(t)\sin\frac{2\pi}{d}(Vt+\xi)\,dt,$$

which is practically the Fourier component of $f(t)$. On a uniform background, sharp lines, the blackness of which varies sinusoidally, are obtained stroboscopically, one corresponding to each component.

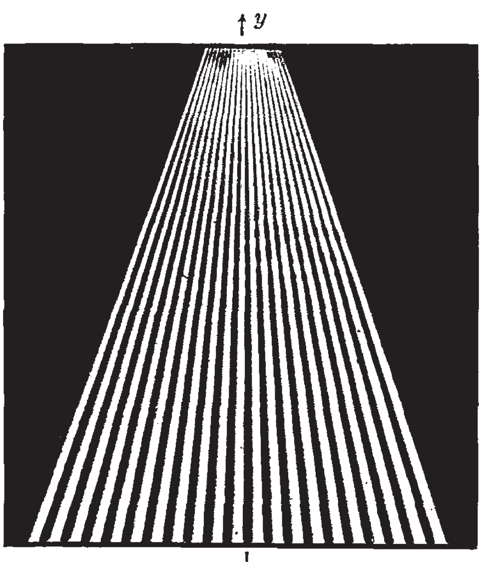

Fig. 1
Analysing Plate

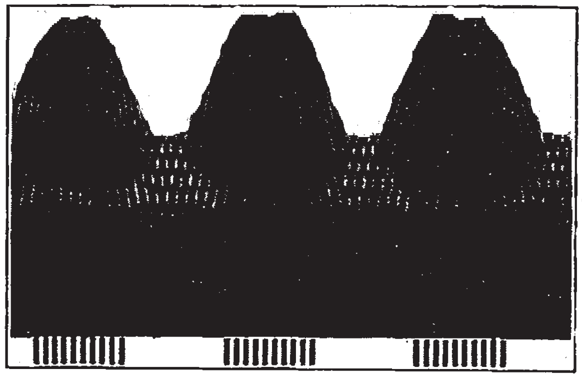

Fig. 2

If the number N is not very large, these lines are broadened to bands, and this broadness limits the resolving power. In the case of varying sound, the variation of the spectrum can be followed by making N sufficiently small, so that the resolving power of frequency and that of time counteract each other. But this is not a defect in the method. The lack of resolving power in frequency is complementary to precise knowledge of time variation, and vice versa.

A simple example is given in Fig. 2, which shows the analysis obtained for the 'square waves' (10 pulses followed by an intermission of 10 periods) shown at the bottom of the figure, n_0 being the fundamental frequency. A preliminary test of the application of this method to the analysis of speech was also undertaken. The variation of word pitch and the crossing of different successive overtones over the formant region of the vowels were clearly observed.

The analysing plate can be modified in various ways for different purposes, Fig. 1 being merely an example. Further, the sinusoidal transmission character of the analysing plate may be generalized to any orthogonal sets of functions, and thus a method is obtained of expanding given functions in series or integrals of some suitable orthogonal functions.

Another application of the analysing plate is found in the artificial composition of sound. By throwing on the plate suitably formed moving rays of light, and receiving the transmitted light on a photo-cell, any desired sound can be produced.

The construction of this analysing apparatus and investigations of some of its applications are now in progress in Prof. Takeo Hori's laboratory. I wish to express my gratitude to Prof. Hori, and also to the Hattori Hokokai for financial support.

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July 2.

[1] Germanšky, B., *Ann. Phys.*, 7, 453 (1930).
[2] Brown, D., Nature, 140, 1099 (1937); *Proc. Phys. Soc.*, 51, 244 (1939).

Atomic Parameters of γ-Silver - Cadmium

Readjusting atomic parameters of γ-brass, we have calculated three successive sets of atomic parameters for γ-silver - cadmium. These sets we tested by comparing the intensities calculated with them with the observed intensities of the reflections of γ-silver - cadmium. For our thrice readjusted atomic parameters, namely, $a = 0{\cdot}105$, $b = 0{\cdot}175$, $c = 0{\cdot}358$, $d = 0{\cdot}310$, and $e = 0{\cdot}038$, the agreement