NOTE ON MODES OF SPECTROGRAPH SLIT IRRADIATION

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ABSTRACT

The mercury lines, 3650–63, have been photographed with very approximately coherent slit irradiation and with a number of different slit-widths. Maximum sharpness and resolution were obtained when the slit-width had a rather critical value. Multiple lines appeared when a multiple of the critical slit-width was used. Diffraction patterns appeared between the lines when the slit was made narrower than the critical value. A more detailed account of the research, of which this is but a small part, will appear later.

THE recent appearance of a mathematical paper by van Cittert[1] has prompted us to publish a small portion of the experimental results which we are accumulating in our study of spectrograph slit irradiation. Although the work has been in progress for nearly a year we do not feel justified in attempting to treat the subject in a general way until the entire program has been covered. The results presented will serve, therefore, merely as an indication of what we are finding, viz., that the width and shape of a line image are influenced to a large degree by the mode of slit irradiation.

We were led to undertake the research by difficulties encountered during the past few years in connection with such things as line absorption and intensity measurements. Evidently others have experienced similar difficulties.[2] Sometimes photographed lines appeared to have absorption cores when there were no assignable reasons for self-reversal. In one instance several lines seemed to suffer a shift of wave-length so great that no known agencies could account for it. Although the false effects could be eliminated usually through adjustment of the optical system, we felt that a systematic investigation should be made in order to remove the necessity for cut-and-try methods. Practically no help was found in the literature.

Van Cittert treats the two special cases, coherent and noncoherent monochromatic irradiation, in some detail and draws conclusions in regard to a few intermediate modes such as would be met in practice. Wadsworth[3] and Schuster[4] had already treated the completely noncoherent case but, as van Cittert suggests, a self-radiant slit which is sufficiently narrow is practically

[1] P. H. van Cittert, Zeits. f. Physik **65**, 547 (1930).

[2] Shenstone, Phys. Rev. **34**, 726 (1929).

[3] Wadsworth, Ast. Jour. **1**, 52 (1895); ibid. **3**, 170 and 321 (1896); ibid. **4**, 54 (1896); Phil. Mag. **43**, 317 (1897).

[4] Schuster, Ency. Brit. Article on Spectroscopy; Ast. Jour. **21**, 197 (1905).

unattainable. Approximately noncoherent irradiation can be realized through the use of a very broad source or by imaging a source on the slit with a very large condenser lens. Departure from noncoherency of irradiation may lead to narrower lines but it can also seriously affect their shapes. In ordinary prac-

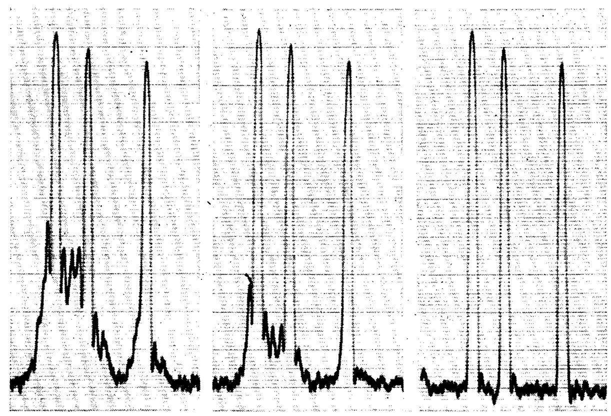


Fig. 1. Slit 2.5 divisions. Note the pronounced diffraction background.
Fig. 2. Slit 3.5 divisions.
Fig. 3. Slit 4.5 divisions. Sharpness and resolution appear to be best with this slit width.

tice this departure may be considerable. For every mode of slit irradiation there exists a slit-width which should not be exceeded. This width being measured in wave-lengths, the correct setting for one spectral region is incorrect for another.

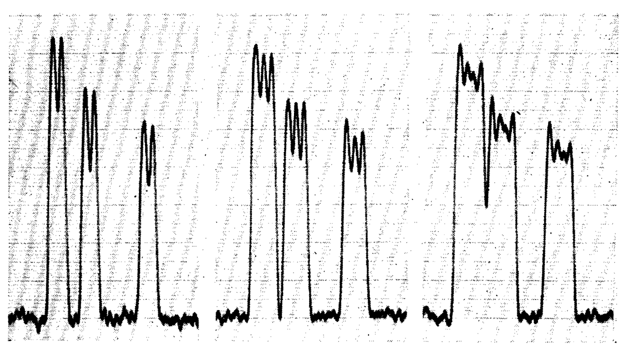


Fig. 4. Slit 9.5 divisions.
Fig. 5. Slit 12.5 divisions.
Fig. 6. Slit 14.5 divisions.

In general, we find our experimental results to be in qualitative agreement with van Cittert's mathematical analysis. We are including intermediate modes of irradiation, however, and consequently are finding different orders of effects and some effects not mentioned in his paper.

In the example selected for this note, the source was a low pressure quartz mercury arc placed 2.25 meters from the slit of a Hilger E2 quartz spectrograph. To narrow the beam of radiation an opaque screen with a window, about one centimeter in diameter, was mounted 25 cm in front of the arc. The arc and screen were carefully adjusted in position so that the radiation passed through the center of the collimator lens. This mode of irradiation, which approached the coherent case, was of such a nature that pronounced diffraction effects were observed, but it was not an extreme case. The 3650–63 lines were photographed with different slit-widths, and then the plates were examined with the aid of a recording microphotometer.

Figs. 1–10 show that maximum sharpness and resolution of the lines were obtained when the width had a rather critical value, viz., 4.5 divisions on the drum. At multiples of the critical width the lines tended to appear equally

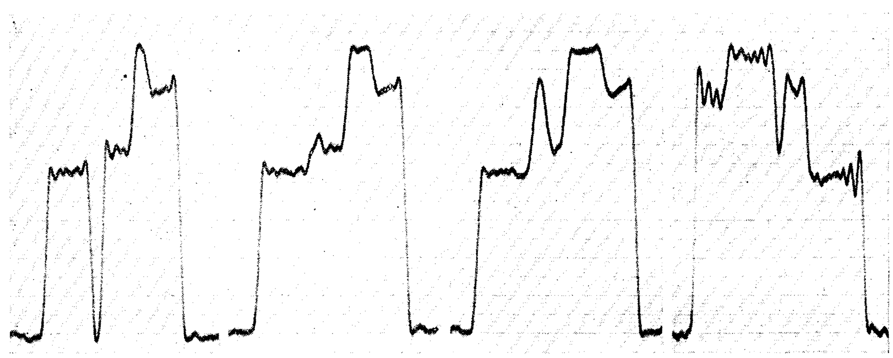
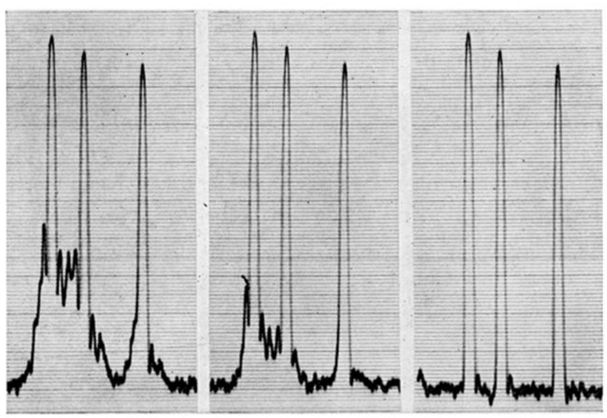


Fig. 7. Slit 21.5 divisions.
Fig. 8. Slit 26.5 divisions.
Fig. 9. Slit 31.5 divisions.
Fig. 10. Slit 36.5 divisions.

multiple, e.g., a doubling occurred at twice the critical slit-width. For widths between multiples of the critical value the diffraction patterns were not as regular. The lines were often well resolved even when they appeared to be multiple. Below the critical width, however, the spaces between the lines were filled with a diffraction background of considerable density.

Evidently accurate estimates of the relative e intensities would be difficult to make in some of the cases illustrated, either through measurement of areas or from reading maximum densities. Furthermore, very misleading information concerning true line shapes could easily be got from an examination of the images. The minima due to doubling might be misinterpreted as an indication of reversal. In extreme cases the diffraction patterns might even suggest fine structure.

We plan to present in much greater detail in a forthcoming paper the results of similar studies made with a number of modes of slit irradiation. Some of these modes give rise to doubling or trebling with wide separations between components.



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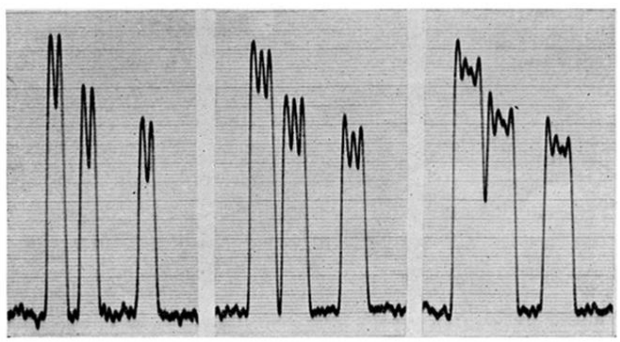

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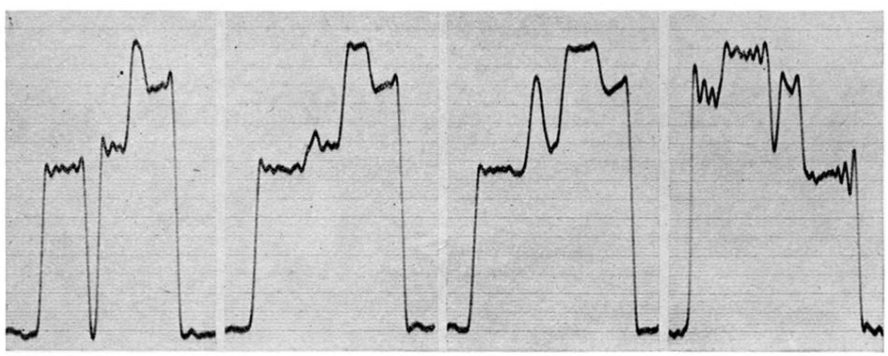

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