X-Ray Reflections from a Quartz Piezoelectric Oscillator in a Bragg Spectrograph

Recently G. W. Fox and P. H. Carr[1] found that the intensity of Laue spots, obtained by passing an x-ray beam through quartz, were increased when the quartz plate was oscillating electrically. However, in a later paper[2] Fox and Cork failed to obtain any changes in intensity of oscillating quartz lines produced by a Bragg spectrograph. C. S. Barrett and C. E. Howe[3] suggested that this failure to get increased intensity was probably due to the existence of an imperfect surface layer in which the extinction had already been reduced to a minimum by the preparation of the crystal. The mode of oscillation of the quartz plate used by Fox and Cork[2] was such that there existed a node of pressure at the surface of the plate from which the x-ray beam was reflected. Hence, even if elastic deformations of the atomic plane spacings were taking place, no widening of the line obtained could be expected from this experiment.

From experiments performed in this laboratory a widening and an increase in intensity for lines reflected from oscillating quartz were obtained. The quartz crystal used in the experiments was prepared in the following manner. Let EE^1 (Fig. 1) represent the electric

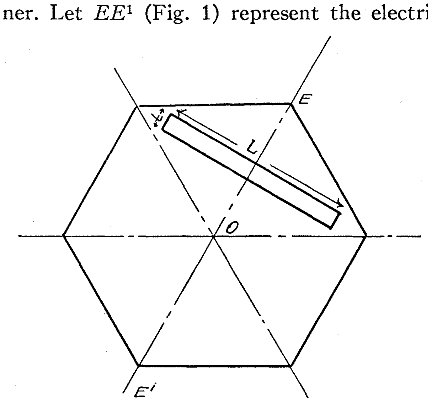

Fig. 1.

axis of a quartz crystal, and let the optic axis pass through O perpendicular to the plane of the paper. The specimen was cut from the crystal as is shown in Fig. 1 with the following dimensions: $L=100$ mm, $t=2$ mm, $w=6$ mm. The dimension L is mutually perpendicular to the electric axis EE^1 and to the optic axis which is perpendicular to the plane of the drawing. The dimension t is parallel to the axis EE^1 and perpendicular to the optic axis. The dimension w (not shown in Fig. 1) is parallel to the optic axis and perpendicular to the electric axis EE^1.

[1] Fox and Carr, Phys. Rev. **37**, 1622 (1931).
[2] Fox and Cork, Phys. Rev. **38**, 1420 (1931).
[3] C. E. Howe, Phys. Rev. **39**, 889 (1932).

The oscillating quartz plate was placed in a Bragg spectrograph between two brass plates which were connected in parallel with the condenser of a resonating circuit. The crystal-to-film distance of the spectrograph was 20 cm. The top brass plate had a window cut so as to allow the x-ray beam to fall on the surface of the quartz which had dimensions 100×6 mm. The crystal was made to oscillate in such a manner that there existed a loop of motion at each end and a node of motion in the center; consequently there was a loop of pressure in the center, and nodes of pressure at the ends. The x-ray beam was reflected from the center of the oscillator. The crystal oscillated at a frequency of 27,400 cycles per second, which result agreed with the calculated value. The source of power was the output of an audio-oscillator connected to an amplifier and inductively coupled with the resonating circuit containing the quartz plate. A shield enabled only half of the film to be exposed at a time. One side of the film was exposed with the crystal not oscillating and the other half with the crystal oscillating. The crystal was kept oscillating at such an amplitude that dL/L was 0.0003 in the L direction. This quantity was measured by means of a calibrated eye piece. The doublet used in the experiment was the $K\alpha_1$ and $K\alpha_2$ lines of molybdenum obtained by the sixth order reflection from the (1 1 0) set of planes. The crystal was rocked through an angle of 5° during the exposures. It was necessary to expose each side of the film for 40 hours. A careful watch was kept on the power in-put of the x-ray tube so that accurate intensity comparisons might be made.

The curves shown in Fig. 2 were obtained by examining the photographic record with a microphotometer. The film was passed over a photoelectric cell in steps of 0.02 mm each by means of a ruling machine mechanism. A slit of light 0.02 mm wide and 0.05 inches long was placed above the film in such a position as to be directly over the photoelectric cell. This cell was connected to the grid of a vacuum tube which composed one arm of a Wynn Williams bridge. The deflections of the galvanometer were proportional to the amount of light falling on the cell.

Curve A (Fig. 2) was the curve obtained for the oscillating lines, while curve B was the curve obtained for the non-oscillating lines. At half maximum amplitudes the width of the oscillating $K\alpha_1$ line was found to be 0.600 mm, while the width of the non-oscillating $K\alpha_1$ line was found to be 0.540 mm. The values for the widths of the $K\alpha_2$ lines were practically the same at half amplitudes as those of the $K\alpha_1$ lines. If we take the area under the loops as proportional to the intensity of the lines, we find that the $K\alpha_1$ oscillating line is about 1.5 times as intense as the $K\alpha_1$ non-oscillating line, and that the $K\alpha_2$ oscillating line is about 1.5 times as intense as the $K\alpha_2$ non-oscillating line.

It is interesting to note that if we take $\Delta D/D$ to be $\frac{1}{4}$ the magnitude of dL/L where $\Delta D/D$ is to represent the elastic deformations of the plane spacings for the (1 1 0) set which is at right angles to the elastic deformations of magnitude dL/L; and substitute the value in the relation: $dS=2r(\Delta D/D)\tan\theta$, where r is the crystal-to-film distance, and θ is in our case 60.3°, we have for dS the following: $dS=0.0525$ mm. The oscillating lines were found to be 0.060 mm wider at half maximum amplitudes than the non-oscillating lines.

It is not at present known whether this effect obtained is due to extinction reduction solely or whether it is a combination of extinction reduction and elastic deformations of the plane spacings. Experiments are now in progress in which an attempt will be made to take Bragg reflections from quartz plates which are deformed mechanically and in a homogeneous fashion. A detailed account of the experiments performed in this laboratory and further conclusions will be given at an early date.

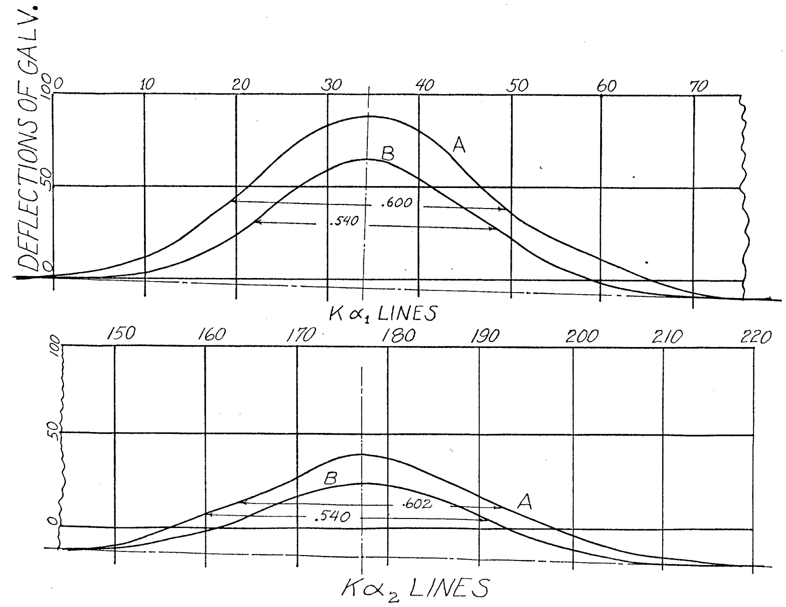

Fig. 2. Settings of ruling machine. One setting = 0.02 mm.

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Determination of e/m for an Electron by a New Deflection Method

In spite of the many measurements which have been made of the specific charge of the electron, there is still some uncertainty especially in connection with the value obtained from free electron measurements. Although two recent measurements[1,2] on free electrons

[1] C. T. Perry and E. L. Chaffee, Phys. Rev. **36**, 904 (1930).

[2] F. Kirchner, Ann. d. Physik [5] **8**, 975 (1931) and [5] **12**, 503 (1932).