Evidence of what appears to be the occurrence of forbidden reflections is met with, not infrequently, in electron diffraction patterns, more often in patterns produced by single crystals, but in powder patterns as well. Among the explanations of these anomalies which have been proposed is this one of double reflections.[1] The possibility of double reflections in single crystals has thus long been recognized.

We have succeeded recently in demonstrating double x-ray reflections in quartz: A beam from a copper target tube operated at 24 kv and 25 ma is brought onto an etched z-cut (normal to principal axis) quartz crystal at the Cu$K\alpha$ Bragg angle for the non-existent $00\cdot2$ reflection (16° 36′). A film in a semicircular cylindrical holder is set to receive a regularly reflected beam through a 140-degree paper-covered window in the holder's inner wall. The crystal and holder rotate together at a uniform rate about an axis normal to the crystal surface (z axis). The axis of the holder coincides with the axis of rotation, and the primary beam meets the crystal on this axis. Half of the time the crystal is eclipsed by the holder which is receiving the primary beam on its outer wall; the other half, the primary beam, reaches the crystal, and any beam which emerges in the direction of regular reflection, while the window is in opposition, reaches the film. At certain angular positions of the crystal the primary beam satisfies not only the condition for $00\cdot2$ reflection but for some other reflection (or reflections) as well. As the rotating crystal passes through these positions, the doubly-reflected beams flash out. Those which reach the film produce a characteristic pattern, an example of which is reproduced in Fig. 1—exposure time 72 hours.

The chief features of the pattern are pairs of strong spots. The members of the pair are separated by a little more than 8 degrees, and the pairs themselves by 60 degrees. These are produced by double reflections of the type $(01\cdot1+0\bar{1}\cdot1)$. The spot midway between the strong pairs is itself a close pair, each member of which is produced by two simultaneous double reflections of the type $(01\cdot3+0\bar{1}\cdot\bar{1})$ and $(01\cdot\bar{1}+0\bar{1}\cdot3)$. The identities of the other spots have not yet been worked out. Most of them will be found to have been produced by the simultaneous double reflections.

The complete circular pattern has 6-fold symmetry about its center, and six 2-fold diametric axes. The number of spots discernible in a 60-degree interval of the original of the pattern here shown is 18, making 108 in the whole pattern. The total number of flashes per complete rotation can be calculated from the density of points in the quartz reciprocal lattice and other considerations—the number is about 700. The intensities of most are below the threshold of the present observations.

The masking effects of the generally scattered radiation from the crystal and of the $00\cdot3$ Laue beam from the continuous spectrum are suppressed by shielding and filtering; that of the $00\cdot6$ and higher order Laue beams is avoided by limiting the tube voltage to exclude the $00\cdot6$ wave-length from the spectrum.

A number of interesting questions present themselves. There is, to mention but one, the question of the phase relation between the two beams produced by simultaneous double reflections. These beams are coherent and superposed, and must therefore interfere.

[1] H. Raether, Zeits. f. Physik **78**, 527 (1932); J. A. Darbyshire and E. R. Cooper, Proc. Roy. Soc. **A152**, 104 (1935).

Enhanced Thermionic Emission

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A NEW type of electron emission from oxide-coated thermionic cathodes is disclosed by a method of measuring simultaneous thermionic and secondary emission. In this method the heated oxide target is bombarded by the primary electrons from a gun in which the high voltage electron stream can be turned on by a small auxiliary voltage. The steady collector voltage is first applied so that before the bombardment starts the circuit is in electrical equilibrium. The thermionic current is then read by a d.c. meter. Short-time changes in the current to or from the target are observed on an oscilloscope with an intervening amplifier from which d.c. is excluded. Time as short as 2×10^{-7} sec. can be resolved.

When now the primary bombardment is started the oscilloscope shows at first an abruptly rising flow of electrons from the target, followed by a gradual rise to an equilibrium value many microseconds later. When the bombardment is stopped, the electron current drops abruptly by the same amount as the initial rise, and there then follows a more slowly decreasing current. The bombarding primary current shows none of this behavior but begins and ends sharply.

The initial rise or final drop of current is interpreted as the beginning or end of normal secondary emission of the target. It changes little with temperature and varies in the usual way with the primary voltage. At a primary voltage of 1200 to 1500 volts, the ratio of the maximum value of the secondary current to primary current varies from 3 to 5. The emission which persists after the end of the bombardment can hardly be secondary emission but must be of thermionic origin, and presumably the equal rise of emission during the bombardment is of the same kind. This emission varies with the temperature of the target in about the same way as the steady emission, thus following roughly the Richardson law. It increases with bombarding voltage and current density, and may exceed the steady thermionic current in value. It is undoubtedly an enhanced thermionic emission excited by the electron bombardment.

A natural assumption is that the increased emission is caused by a rise in target temperature caused by the bombardment. The temperature rise of the *surface* of the target may be calculated, and is far too small to explain the effect. One must conclude instead that the bombardment temporarily changes the thermionic activity of the oxide target.

This effect no doubt explains the exponential rise with temperature that has been reported for the secondary emission factor of oxide cathodes.[1]

[1] N. Morgulis and A. Nagorsky, J. Tech. Phys. U.S.S.R. **5**, 848 (1938).