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Velocity of Cadmium Atoms Regularly Reflected from a Rock Salt Crystal

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In the accompanying figure, curve (1) represents the temperature of the liquid in which the cylinder is immersed. The liquid is radiating into a medium at zero temperature. The cylinder which had an initial uniform interior temperature of 30° heats according to curve (2). In case the liquid boils at 80° and maintains this temperature indefinitely the cylinder heats according to curve (3).

The constants used in the equations were

$$\Theta_\infty = 100° ; \qquad \Theta_0 = 0 ; \qquad \alpha = 0.04 ; \qquad R = 0.109.$$

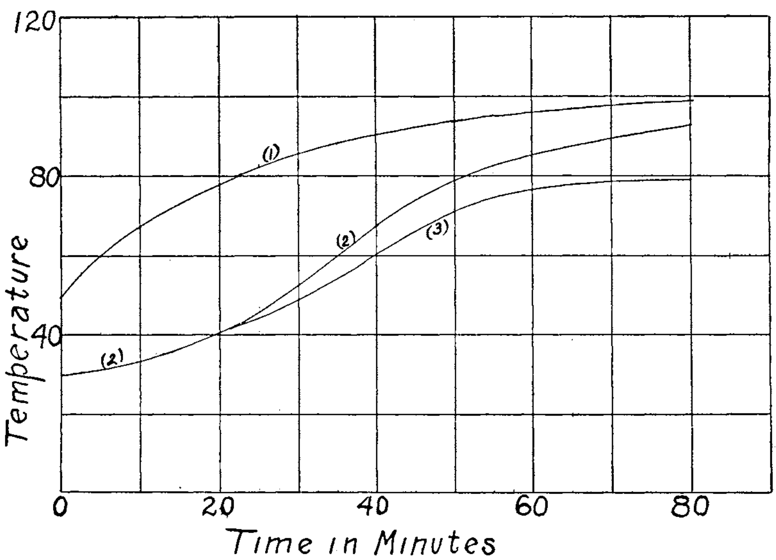

Figure I

Iowa State College.

VELOCITY OF CADMIUM ATOMS REGULARLY REFLECTED FROM A ROCK SALT CRYSTAL

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We have previously shown that a beam of Cadmium atoms incident upon a cleavage face of a rock salt crystal is reflected so that the incident and reflected beams make equal angles with the normal to the crystal surface. At that time we suggested that this phenomenon could be interpreted in terms of the phase waves of de Broglie. The existence of a reflected beam making the same angle with the normal as does the incident beam suggests at once the possibility that we have here a situation in which the phase waves behave as X-rays do in the Bragg type of reflection.

We have now measured the velocity and velocity distribution of such reflected beams for three angles of incidence, 22.5°, 45° and 67.5°, using a rotating sectored disc velocity filter in the reflected beam. We find that within the limits of resolution of our apparatus the reflected beam is "monochromatic," i.e. it contains atoms whose velocities are very nearly the same. The velocity of the atoms in the specularly reflected beam is independent of temperature of the reflecting crystal for temperatures from 200° to 500° C.

The results are given in the table:

ϑ	Velocity Observed m. / sec.	Velocity Calculated m. / sec.
22.5°	500	494
45°	530	530
67.5°	600	605

The assumption of de Broglie is that there is associated with a particle of mass m and velocity V a phase wave of wave length $\lambda = \frac{h}{mV}$. We wish now to assume that this equation applies only to the three elementary particles, the photon, electron and proton, and that the wave length associated with an atom whose velocity is V is $\frac{h}{MV}$ where M is the mass of a proton and not the mass of the atom. That is to say we assume that the fundamental periodicity associated with a proton does not change when it combines with other protons to form an atom. We will further assume, following Eckart,[1] that the velocity of phase waves is not the same in a crystal as in free space, so that the form of Bragg law to be used is that used by Davisson and Germer [2] in their work on reflection of electrons by crystals of nickel. That is

$$n\lambda = \frac{nh}{MV} = 2\,d\,(\mu^2 - \mathrm{Sin}^2\,\vartheta)^{1/2}$$

If n were greater than one we would find two or more velocities in the reflected beam. With n equal one we have but one arbitrary constant, μ, the refractive index for phase waves. Using the velocity of the atoms reflected at 45° we find $\mu = 1.50$ and putting this value in the equation we get for the velocities to be expected at 22.5° and 67.5° values of 494 and 605 meters per second, as compared with observed values of 500 and 600 meters per second respectively.

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1 Eckart, Proc. Nat. Acad. Sci. 13, 460 1927.
2 Davisson and Germer, Proc. Nat. Acad. Sci. 14, 317, 1928.