primary extinction in the cubic phase is equal to the primary extinction in the tetragonal phase. Thus the parallel and antiparallel domains are identical with the mosaic blocks.

The fact that the corrections for extinction can be evaluated enables one to determine the variation of the structure factor with temperature from the observed variation of the integrated reflection. The decrease of the mean square amplitude of the lattice vibrations with temperature is found to be quite normal in the cubic region. The variation of the structure factor arising at and below the transition point cannot be accounted for by a mere shift of the atomic positions. It is necessary to assume that considerable changes of the thermal vibrations occur in this temperature range. By a trial-and-error method it was possible to find a single solution agreeing within a few percent with the observed variation of the structure factor. The Ti ions and the oxygen ions lying on the same line along the z axis undergo a sudden displacement along this axis in opposite directions at the transition point, this jump being followed by a continuous change as the temperature decreases (Fig. 1).

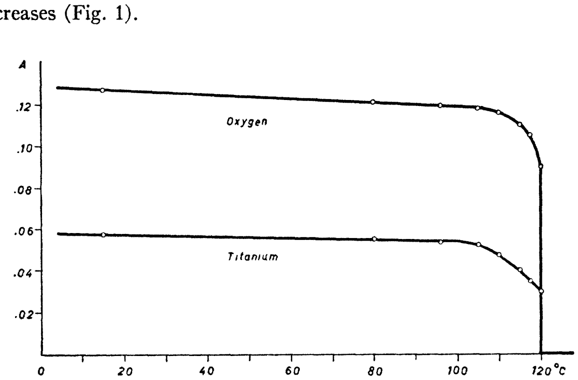

FIG. 1. Variation of the atomic positions (in angstrom units) with temperature.

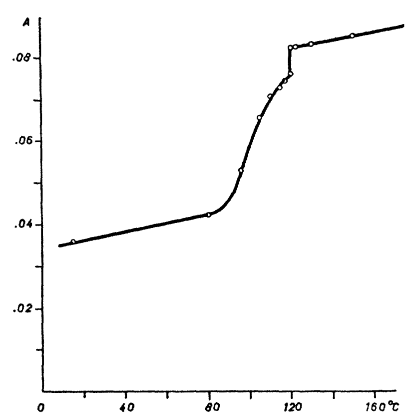

FIG. 2. Variation of the root-mean-square amplitude of the thermal vibration of the Ti ion along the z axis (in angstrom units) with temperature.

The variation of the root-mean-square amplitude of the vibration of the Ti ion along the z axis is shown in Fig. 2. A sudden variation at the transition point is seen to be followed by a continuous rapid decrease below. The Ba ions behave quite normally in the same region. The vibrations in the x direction could not be determined since the reflections $(0h0)$ are too strongly influenced by the anomaly in the extinction. A more detailed study of the lattice vibrations through measurements of the diffuse scattering is being initiated.

The full account of the present investigations will appear in *Helvetica Physica Acta.*

Role of Metastable ($^3P_2$) Hg Atoms in Low Current Discharges in Hg Rare Gas Mixtures

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August 7, 1950

A POSITIVE column d.c. hot cathode discharge of about 1 ma in a few millimeters of a rare gas (e.g., A, Kr, Xe) plus a few microns of Hg in a $3\frac{1}{2}$-cm tube has been found to have a positive characteristic and ordinary running striations. As the current increases these striations weaken and disappear at 60 to 100 ma. The voltage (V) goes through a broad maximum at about the same current. Decreasing the temperature (Hg density) raises this maximum and displaces it toward lower currents. No ballast is necessary in the region of positive characteristic.

At 1 ma strong illumination with Hg radiation (transmissible through glass) nearly doubles V (Fig. 1), doubles the 2537 output (B_u), nearly doubles the electron temperature (T_e), as shown by probe measurements, and nearly suppresses the striations.

Irradiation with the light of the rare gas concerned has no effect above about 16°C. Above 25°C, the rare gas lines could be seen only with Xe and apparently even here the role of rare gas excitation is negligible.

Absorption measurements with 5461, 4358, and 4047 show high concentrations ($\sim 10^{11}$ cm^{-1}) of $^3P_2$ and $^3P_0$ even at 1 ma; $^3P_2$ in pure gas is nearly twice as populous as $^3P_0$. These concentrations increase relatively slowly, above about 4 ma; $^3P_1$ reaches an appreciable concentration only at higher currents.

A trace of molecular impurity greatly increases V and B_u and also the visible line output (B_v); it further suppresses the striations and destroys $^3P_2$. Thus 4μ N_2 increases V and B_u fivefold, B_v threefold, T_e twofold, and reduces $^3P_2$ to nearly zero (though scarcely affecting $^3P_0$), while completely suppressing the striations. It was found that

$$B_u \cong KV, \quad (1)$$

where K is the same for all impurities tried. The addition of N_2 beyond about 4μ precipitates a new intermittent, or flashing form of discharge, described in the following letter.

These results are explained as arising from the destruction of Hg metastables by irradiatiation, the ionization evidently being mainly two-stage. In pure gas $^3P_2$ furnishes most of the ions, but with impurities $^3P_0$ takes over this role (with more difficulty). The

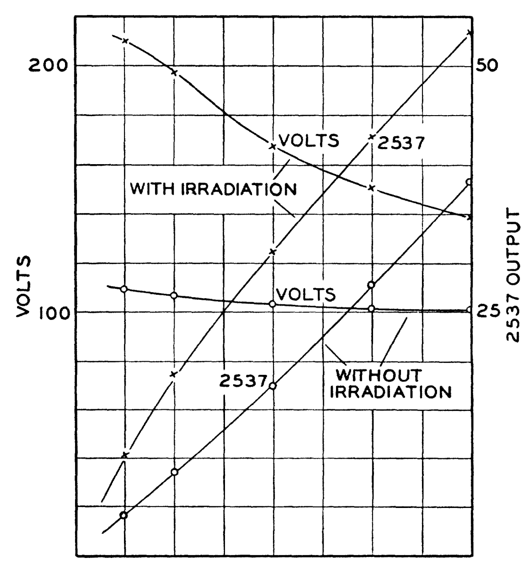

FIG. 1. Effect of illumination with Hg radiation.

quenching of $^3P_2$ by impurities appears to be mainly by $^3P_1$. CO is threefold as effective as N_2. H_2 and CO_2 are comparable to CO, but even at 1 ma, H_2 cleans up rapidly and CO_2 is changed to CO (and HgO). The striations in pure gas evidently depend on the two-stage ionization associated with $^3P_2$.

The apparently small contribution of single-stage ionization may mean that the electron energy distribution is hardly Maxwellian, being deficient at the high speed end and that the cross section for ionization of the ^3P states, especially $^3P_2$, is large[1] compared with that of normal Hg.

Equation (1) indicates that impurities absorb relatively little energy directly from the electrons but act by quenching $^3P_2$ (the main source of ions).

[1] B. Klarfeld, Tech. Phys. U.S.S.R. 5, 913 (1938).

A New Form of Discharge in Gas Mixtures: The Flashing Discharge

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August 7, 1950

IN the previous letter it was shown that when impurities are added to a 1-ma d.c. hot cathode, positive column discharge in 3-mm A+Hg at 27°C in a $3\frac{1}{2}$-cm tube, the voltage rises markedly and the running striations gradually disappear. At about fivefold normal voltage (with $\sim 4\mu$ N_2 or 0.13μ CO) the discharge suddenly breaks into a "flashing" form which the rotating mirror and the oscilloscope show is both striated and current modulated. A typical wave form is shown by Fig. 1A. The frequency may be from 25 to 10,000 c.p.s., increasing with the N_2/Hg ratio, irradiation with Hg light, current, and decreasing A pressure. The current modulation varies from 25 percent with 10 megohms ballast to nearly 100 percent with 0.2 megohm. The striations are sharp and convex on the cathode side (Fig. 1C) and appear stationary; they are one to one-half tube diameters apart, growing closer with more N_2. The flashes are bright with Hg light, but between flashes the tube appears to be dark. Flashing is favored by a high N_2/Hg ratio, by low current and by irradiation with strong Hg light; it has been an over-all positive characteristic. It is less striking in Kr+Hg and is entirely absent with Xe+Hg.

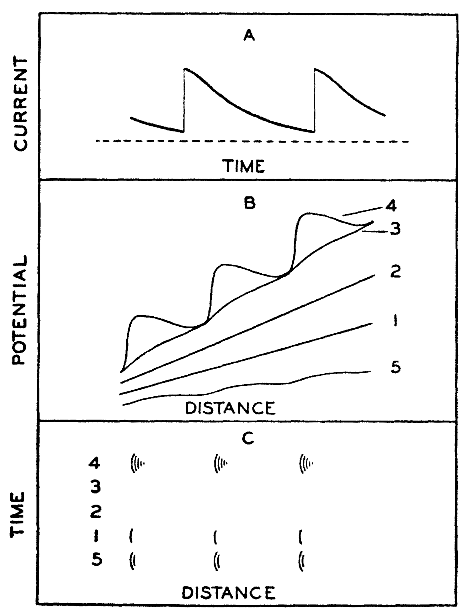

FIG. 1. Characteristics of the flashing discharge.

The following explanation of flashing appears to be in accord with all the observations. At times 1 and 2 (Fig. 1) the gradient is essentially uniform and rising, the brightness (essentially an afterglow) low and the discharge only partly self-maintaining because of net loss of ions by diffusion to the walls. At time 3 the gradient has risen so high as to be unstable, tending to localize. This process takes place extremely rapidly so that at time 4 the gradient is sharply stepped, producing electrons with 12 to 14 volts energy, as indicated by the observed volts per striation. These electrons strongly excite A metastables (and resonance atoms), A′, which quickly ionize Hg. Argon resonance radiation meanwhile diffuses rapidly and the resulting resonance atoms and metastables produce Hg ions by collision in the regions between the striations. The result is that in an extremely short time very high ion densities are built up locally and to a lesser extent throughout the tube. The high stepped gradient meanwhile collapses, while the current rises abruptly. It may be just at the beginning of this time or slightly before that the visible light is mainly produced. In the period just following, few ions are produced but the ionization is decreasing by diffusion to the walls and perhaps recombination. As a result the voltage rises and there is progressively more ionization, probably two stage via $^3P_0$ (since irradiation shortens the time between flashes), but the discharge never becomes self-maintaining till the onset of the next flash.

In the dark period, e.g., at 2, Fig. 1, most of the energy is going into 2537 via $^3P_2$ (quenched by the N_2) and $^3P_1$, ions coming largely from $^3P_0$, while at 4 it is going mostly into Hg ionization via A′. The two processes require such different conditions that both can scarcely occur together. The result is an almost cataclysmic change from one to the other; and a sharp jump in the current is the unfailing sign of flashing.

Flashing does not occur with Xe because Xe′ cannot ionize Hg. A little Xe added to A+Hg+N_2 stops flashing because the Xe absorbs the energy that would otherwise have gone to excite A, Kr+Hg flashes because two of the Kr′ states can ionize Hg.

Grain Counts and Corrected α-Particle Range-Energy Curve for Ilford E-1 Emulsions*

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May 29, 1950

IN 1937 Wilkins[1] published a set of curves showing the number of grains in corresponding lengths of proton, deuteron, and α-particle tracks. These tracks were recorded in Ilford R-2 emulsions, now obsolete. This work has now been repeated using Ilford E-1 nuclear emulsions 200μ thick. The emulsions were from the same batch of plates and were developed together after exposure as recommended by Wilson and Venselow[2] for 200μ emulsions. Grains in equivalent lengths of tracks were counted using a Spencer microscope with 120× objective and 10× eyepieces.

The number of developed grains in 10μ intervals, as measured from the end of the track, was counted. Then an average number for each interval was computed from corresponding intervals of all the similar tracks. Figure 1 represents the average number of grains in a given length of track as measured from the end of the track. Curve I was obtained from 110 proton tracks, curve II was obtained from 48 deuteron tracks, and curve III was obtained from 15 α-particle tracks. Occasionally, near the end of the tracks, the grains were too closely packed to be clearly differentiated, therefore an estimation was made. This assumed number per 10μ interval was 16 for protons, 17 for deuterons, and 20 for α-particles.

In the course of analyzing the emulsions in which elastically scattered α-particle tracks were recorded from the bombardment of various thin targets[3] by 20-Mev α-particles from the Washington University cyclotron, it was noted that the predicted ranges