a highly accurate theoretical curve. However the deviation between the theoretical curve and the experimental curve given by Tate and Palmer for 700 volt-electrons is probably real and not to be accounted for by the uncertainty in the $F$ values. It would be interesting to see whether or not the theoretical, and experimental curves would coincide for mercury when higher electrons speeds are used.

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## On the Radiation Originating from a Beam of Electrons in Mercury Vapor and the Mean Life of the $2^3S_1$ State

Previously the writer[1] has obtained photographs of the mercury spectrum produced by a beam of electrons in mercury vapor. The optical arrangement consisted of projecting the image of the electron beam on to the slit of the spectrograph perpendicular to the length of the slit. It was found that some of the lines extended beyond the image of the electron beam, this being particularly true for the resonance line 2537A. This result has recently been confirmed by Lees and Skinner.[2] The extension of the lines beyond the image of the electron beam is caused by the radiation of atoms lying outside of the boundaries of the beam. In Table I is included the most prominent lines obtained which are classified into two groups; extended lines and normal lines. Fig. 1 illustrates a typical spectrogram obtained. In this particular case the electrons

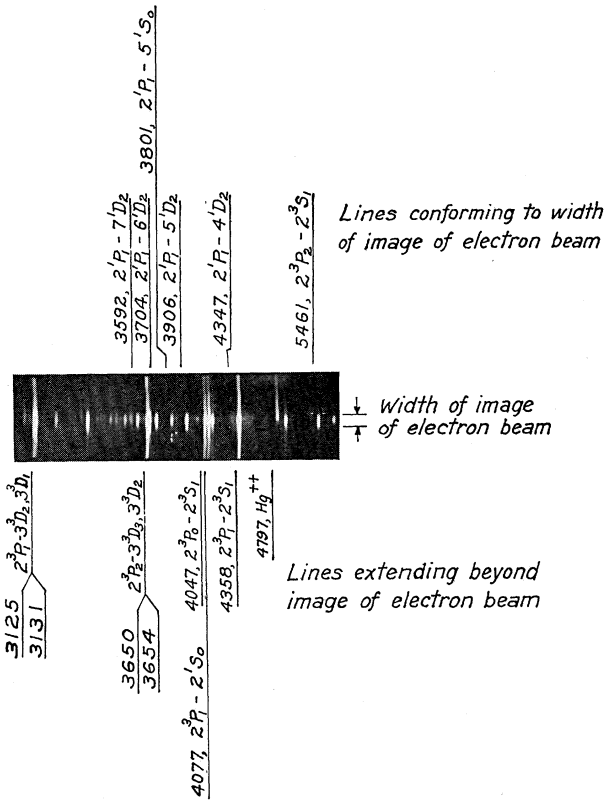


Fig. 1. A portion of the mercury spectrum illustrating the lengthening of lines beyond the image of electron beam.

[1] Maxwell, Phys. Rev. **32**, 715 (1928).

[2] Lees, and Skinner, Proc. Roy. Soc. **137A**, 186 (1932).

were accelerated to a velocity of 200 volts. A transverse electric field was applied for the purpose of drawing out the spark line 4797A as shown in Fig. 1. The shape of the lines was not particularly dependent upon the speed of the electrons. In general the lines having the levels $2^3P_0$, $2^3P_1$, $2^3P_2$, as the final state are lengthened, whereas the lines terminating in the $2^1P_1$ state do not show spreading beyond the image of the electron beam. An exception to this rule, however, occurs for the line $2^3P_2 - 2^3S_1$ (5461A) which does not show any appreciable elongation. The lines of the series $2^1P - n^1S_0$ (4916A, 4108A) showed slight extension beyond the image of the electron beam, but the line 3801A, $2^1P_1 - 5^1S_0$ showed practically no spreading.

The lengthening of the resonance line (2537A) is obviously caused by absorption since it is very easily absorbed at the pressures of about 0.001 mm of Hg used in this case.

TABLE I. *Lines of the mercury arc spectrum.*

| Lines extending beyond image of the electron beam | | Lines conforming to the width of image of electron beam | |
|---|---|---|---|
| $1^1S_0 - 2^3P_1$ | 2537 | $2^1P_1 - 4^1D_2$ | 4347 |
| $2^3P_0 - 2^3S_1$ | 4047 | $2^1P_1 - 5^1D_2$ | 3906 |
| $2^3P_0 - 3^3S_1$ | 2752 | $2^1P_1 - 6^1D_2$ | 3704 |
| $2^3P_0 - 3^3D_1$ | 2967 | $2^1P_1 - 7^1D_2$ | 3592 |
| | | $2^1P_1 - 5^1S_0$ | 3801 |
| $2^3P_1 - 2^3S_1$ | 4358 | $2^3P_2 - 2^3S_1$ | 5461 |
| $2^3P_1 - 3^3S_1$ | 2893 | | |
| $2^3P_1 - 4^3S_1$ | 2576 | | |
| $2^3P_1 - 2^1S_0$ | 4077 | | |
| $2^3P_1 - 3^3D_2$, $3^3D_1$ | 3125, 3131 | | |
| $2^3P_1 - 4^3D_2$, $4^3D_1$ | 2653 | | |
| $2^3P_1 - 5^3D_2$, $5^3D_1$ | 2482 | | |
| $2^3P_2 - 3^3D_3$ | 3650 | | |
| $2^3P_2 - 3^3D_2$ | 3654 | | |

It has been proposed[3] that the lengthening of the other lines was caused by absorption of atoms in the $2^3P_0$, $2^3P_1$ and $2^3P_2$ state located in the vicinity of the electron beam.

Similar lengthening or spreading of spectrum lines has been found for helium[4] and for the case of the lines $2^3P - n^3D$. Lees and Skinner suggested that it was caused by collisions of the type

$$\mathrm{He}(n^1P) + \mathrm{He}(1^1S) = \mathrm{He}(1^1S) + \mathrm{He}(n^3D)$$

occurring outside the electron beam where the energy differences between the $n^1P$ and $n^3D$ states are of the order of the thermal energy. For mercury, similar atomic collisions resulting in a change from $n^1P_1$ to $n^3D_{1,2,3}$ states may be possible. Transitions of this kind to populate the $2^3S_1$ state from any of the $n^1P_1$ levels will be very unlikely on account of the large energy differences involved.

Randall and Webb[5] have measured the mean life of the $2^3S_1$ state of mercury by using the lines $2^3P_2 - 2^3S_1$ (5461A), $2^3P_1 - 2^3S_1$ (4358A) and $2^3P_0 - 2^3S_1$ (4047A) and found that the lines 4358A and 4047A gave the mean life of $5.75 \times 10^{-8}$ sec. while the line 5461A gave an entirely different value of $2.37 \times 10^{-7}$ sec. In this connection it is very interesting to notice from Table I that the line 5461A which gave the greater mean life shows no lengthening while on the other hand the other two lines 4358A and 4047A have prominent spreading. This shows that outside of the electron beam there are atoms in the $2^3S_1$ state which will give rise to transitions to the $2^3P_0$ and $2^3P_1$ levels but with practically the exclusion of transitions to the $2^3P_2$ state. This undoubtedly means that the fine structure of the $2^3S_1$ level plays an important part in the radiation phenomena, in support of the conclusion arrived at by Randall and Webb to account for the dis-

[3] Maxwell, Phys. Rev. **31**, 711 (1928); see also for instance, for absorption of excited states: Turner, and Compton, Phys. Rev. **25**, 606 (1925); Wood, Phil. Mag. **50**, 774 (1925); *ibid.* **4**, 466 (1927).

[4] Lees, Proc. Roy. Soc. **137A**, 173 (1932); Lees and Skinner, reference 2; Maxwell, Early issue of Jour. Frank. Inst.

[5] Randalls and Webb, Phys. Rev. **35**, 665. 1161 (1930); see also Richter, Ann. d. Physik, **7**, 293 (1930).

crepancies found for the mean life of this state.[6]

There exists the possibility that the photograph plate characteristics may vary for the triplet lines in such a manner as to weaken the spread of the line 5461A in comparison with the lines 4047A and 4358A, since the green line is nearer to the less sensitive portion of the plate. Exact intensity measurements were not obtained, however the difference in shape of the line 5461A in comparison with the other lines of this triplet appears too great to be accounted for by errors of this kind.

This work was done in the laboratory of the Bartol Research Foundation.

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[6] For further discussions see; Morozoroski, Zeits. f. Physik **68,** 278 (1931); Frisch and Pringsheim, Zeits. f. Physik **67,** 169 (1931).

## The Disintegration of Lithium by Swiftly-Moving Protons

We have recently carried through preliminary experiments on the disintegration of lithium by swiftly-moving protons and have obtained results in confirmation of those of Cockcroft and Walton (Proc. Roy. Soc. **A137,** 229–242, 1932).

Using the apparatus of Lawrence and Livingston (Phys. Rev. **40,** 19–35, 1932) as the source of high-speed protons, we have bombarded a crystal of lithium fluoride with protons having energies of 360,000, 510,000, and 710,000 volts. Radiations emanating from the crystal were detected by a Geiger point counter with a mica window (stopping power 2.2 cm of air) adjacent to the crystal, subtending a solid angle of $\pi/10$. Counts were ob-

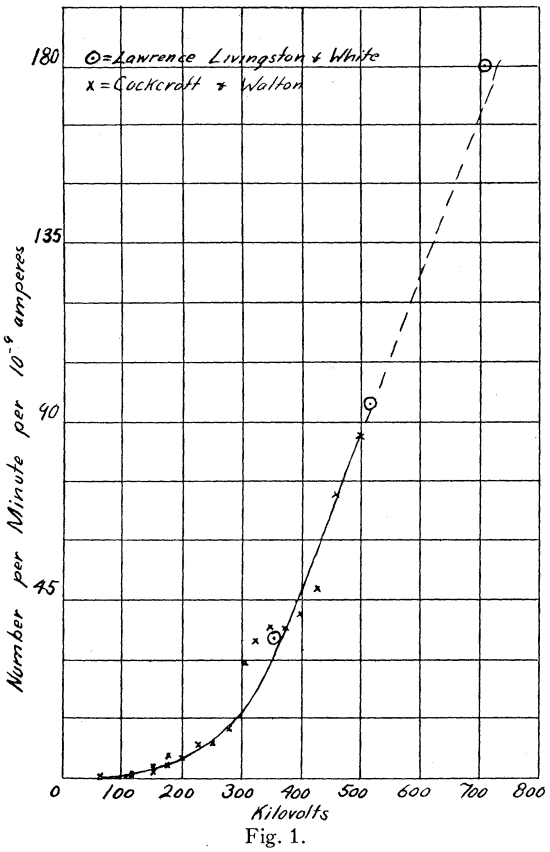


Fig. 1.

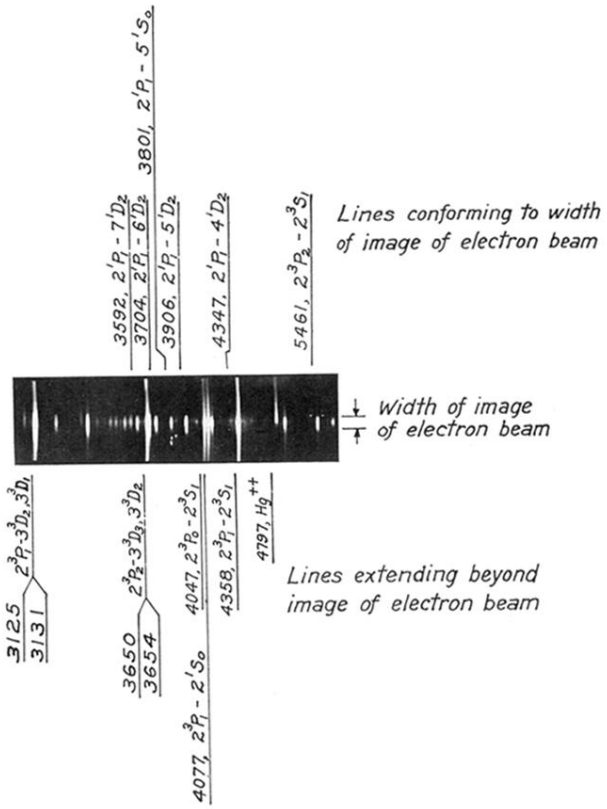


Fig. 1. A portion of the mercury spectrum illustrating the lengthening of lines beyond the image of electron beam.