progressive development of the early stages of the living egg and the cinematographic record of the same over any other method is obvious. One has on the film a permanent record that can be examined repeatedly.

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DETECTION OF THE ISOTOPES OF LEAD BY THE BAND SPECTRUM METHOD

A FEW years ago Grebe and Konen[1] found that the lines near 4250 Ångstroms in the band spectrum emitted by an arc containing uranium lead were sharper than those from an ordinary lead arc, and were displaced .055 Ångstrom units towards shorter wave-lengths. A comparison of this nature is of interest, since it furnishes a direct experimental test of the isotope effect in band spectra.[2] In addition, if carried out with high resolving power, the experiment leads directly to a new method for the quantitative analysis of lead of radioactive origin. Such information has an important bearing on the problem of geologic time.[3] Consequently Dr. Mulliken suggested to the writer that he repeat Grebe and Konen's experiment, using improved experimental conditions.

The spectra were photographed in the second order of a twenty-one-foot Rowland grating first using an arc of ordinary lead (atomic weight 207.2), and then repeating with lead of atomic weight 206.1. This uranium lead, mined in the Belgian Congo, was a gift from the Wolcott Gibbs Memorial Laboratory of Harvard University. We are indebted to Dr. L. P. Hall for this material. The arc was struck between molten lead globules stuck to copper rods. The current carried was three amperes and was supplied at 220 volts. The exposure time was about fifteen hours.

A line for line comparison of our spectrograms, for instance, near the head of the strong 5678.3 Å. band where there is comparatively little overlapping of neighboring series, shows that each line in the band spectrum secured using uranium lead (Pb_{206}) corresponds to the long wave-length member of a group of three lines in the spectrum secured using ordinary lead ($Pb_{208, 207, 206}$ with relative abundance 7, 3, 4 respectively according to Aston's recent positive ray analysis).[4] Figure 1 makes this comparison

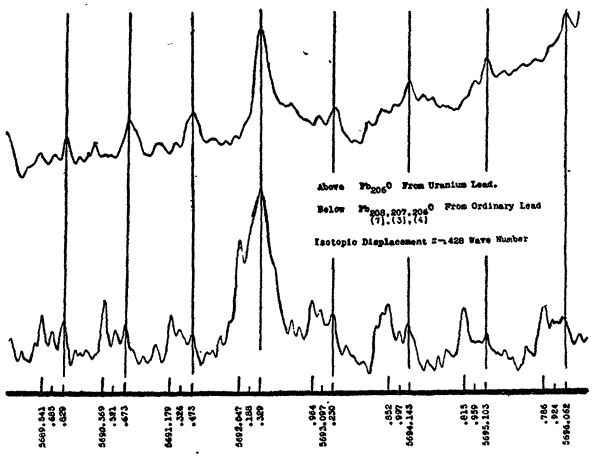

FIG. 1

clear. The upper curve is a microphotometer trace of the spectrum of this region taken with uranium lead in the arc. The lower is the corresponding curve with ordinary lead in the arc. These were secured with the Moll instrument which records automatically. The ordinates represent deflections of the beam of light reflected from the mirror of the galvanometer in the thermopile circuit. The strong peak in the middle of each curve is an arc line of lead and serves as a convenient reference line. The light, vertical lines identify the peaks in both spectra emitted by the molecules containing isotope 206. The series lines which we now find are due to oxides of isotopes 208 and 206 in ordinary lead were measured many years ago by Lamprecht,[5] who designated them by series I and III respectively in his tables of wave-lengths. The intermediate series which we find corresponding to 207 is not represented in Lamprecht's measurements since he used lower dispersion and resolving power than was employed in our experiment.

The results of this investigation are in good agreement with the theory on the basis of PbO as the emitter of these band spectra. The separation to be expected theoretically between the lines due to $Pb_{206}O$ and $Pb_{207}O$ near the head of the γ 5678.3 band is $-.37$ wave number. The average measured value was $-.43$ wave number. The negative sign indicates that the lines from the molecules containing the lighter isotope are displaced towards lower frequencies with respect to the radiations from the molecules containing the heavier isotope. Our method yields an analysis in agreement with that of Aston.

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[1] L. Grebe and H. Konen, *Phys. Zeit.*, 22: 546. 1921.

[2] *Cf.* R. S. Mulliken, *Phys. Rev.*, 25: 119. 1925.

[3] See an excellent summary by Dr. C. S. Piggot, of the Geophysical Laboratory of the Carnegie Institution of Washington, in the *Journal of the Washington Academy of Sciences*, vol. 18, no. 10, May 19, 1928.

[4] F. W. Aston, *Nature*, 120: 224. 1927.

[5] H. Lamprecht, *Zeit. f. Wiss. Phot.*, 10: 16, 33. 1912.