THE USE OF SERIES INDUCTANCE IN VACUUM SPARK SPECTRA*

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Abstract

Examples are given which illustrate the effect of series inductance on the intensity and form of lines in the vacuum spark spectra of antimony and tin and its use as an aid in the identification of the lines in the spectra of these two elements.

While endeavoring to solve certain difficulties which arose in the identification of lines belonging to the spectrum of Sb IV it became necessary to have other criteria available than those which the ordinary methods of classification afford. Fowler[1] has utilized to some extent, inductance in series with ordinary sparks in air and refers to its usefulness in the case of spark spectra in vacuo. By investigating the effect of varying inductance on the spectra of several elements, Kimura and Nakamura[2] have been able to sort out lines in the visible and near ultra-violet regions belonging to various stages of ionization of the atom. Rao[3] has also made use of the effect of varying the inductance in the secondary circuit, in his study of the spectra of some of the elements. The authors have employed this same method in their study of the vacuum spark spectra of tin, antimony and tellurium in the region below 2600A.

By making several exposures on the same plate, and by making a careful study of the relative quality of the lines, it has been possible to sort the lines into groups representing five different stages of ionization. In general the use of inductance serves to strengthen lines arising from lower states of ionization and to weaken those from higher states. Although some detail has been lost in enlarging and reproducing portions of the original plates, nevertheless, the plates included in this report serve to bring out the essential differences in the spectra produced with and without inductance. Lines belonging to various stages of ionization are so indicated in the figures. In all the exposures reproduced in this paper, which are labelled "with series inductance," a coil 16.5 cm in length and 7.8 cm in diameter and consisting of a single layer of 71 turns of No. 18 copper wire was inserted in series with the spark gaps and condenser.

In identifying the lines belonging to Sb IV this method proved to be particularly useful. Fig. 1 B indicates the line at λ891.17A which Lang[4] had previously used for Sb V. As is apparent from the figure, this line, as well as

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[1] Fowler, Phil. Trans. Roy. Soc. **A225**, 1 (1925).

[2] Kimura and Nakamura, Jap. Jour. Physics **3**, 200 (1924).

[3] Rao, Phys. Soc. London Proc. **39**, 150, 161, 408 (1926–1927).

[4] Lang, Proc. Nat. Acad. Sci. **13**, 341 (1927).

others belonging to Sb IV, is weakened in the inductance spectrum, while certain other strong lines, presumably due to Sb V are entirely cut out by the self-inductance One seems justified then in definitely assigning this line to trebly ionized antimony.[5]

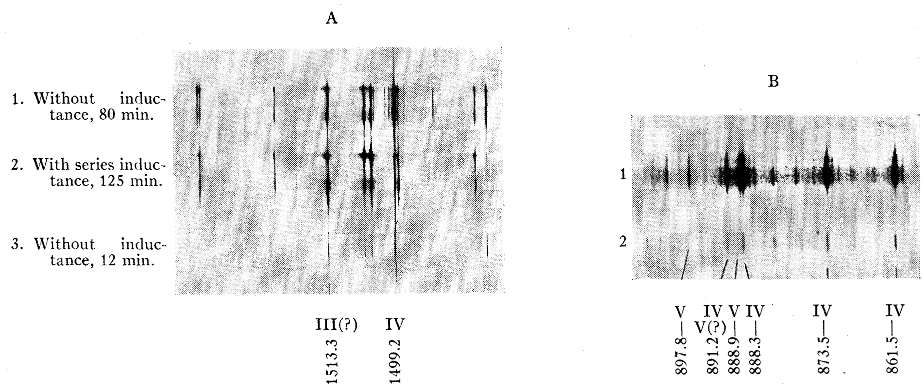


Fig. 1. Antimony

Fig. 2 shows some of the characteristic lines of Sb IV belonging to the $^3P-{}^3P'$ multiplet. The lines at λ1171.38A, 1099.33A and 1032.88A, which show the characteristic effects of self-induction for most of those lines already chosen for Sb IV, have been used in our selection of lines belonging to this multiplet. Those lines at λ1145.86A, 1120.43A and 1051.33A are the corresponding ones chosen by Green and Lang.[6] Observations indicate that of these

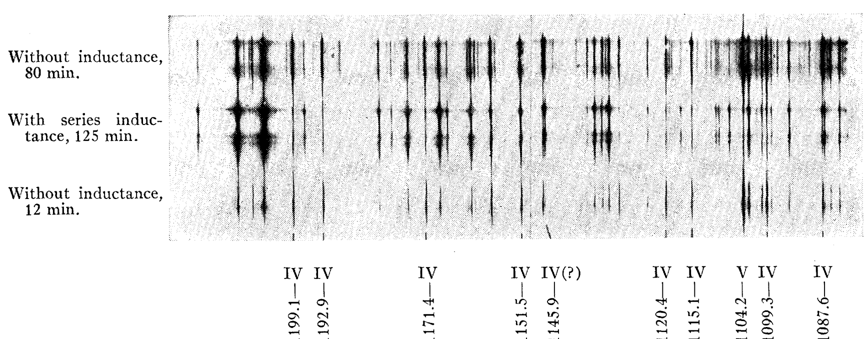


Fig. 2. Antimony

lines the first and last do not belong to Sb IV. We have identified the characteristic line at 1120.38A as $^3P_1-{}^1D_2$, as it is definitely associated with another similar line at 1199.1A, ($^3P_2-{}^1D_2$). The line chosen by them at 1513.34A as $^1S_0-{}^3P_1$ (Sb IV) appears to belong either to Sb II or Sb III, (Fig. 1A). The same figure shows the line at 1499.2A which is our choice for the same transition.

Fig. 3 serves nicely to bring out the different classes of lines for tin in various stages of ionization. The lines belonging to Sn II are increased considerably in intensity by the use of inductance while those of Sn III are not strengthened as much. Lines identified as Sn IV are decreased slightly

[5] Preceding paper.

[6] Green and Lang, Proc. Nat. Acad. Sci. **14,** 707 (1928).

in intensity, while those classified as Sn V appear considerably decreased in intensity, with only the ends of the lines evident. The lines in the vicinity of 1131A have been chosen by Lang[4] as possibly belonging to Sn IV. Evidence here indicates such a classification as incorrect. Gibbs and White[7] have classified the line at 1189.98A as belonging to Sn V. Figure 3 indicates that this line is incorrectly classified as belonging to quadruply ionized tin, unless there is present at the same wave-length a line belonging to a lower state of ionization, thus causing the presence of a stronger line in the inductance spectrum

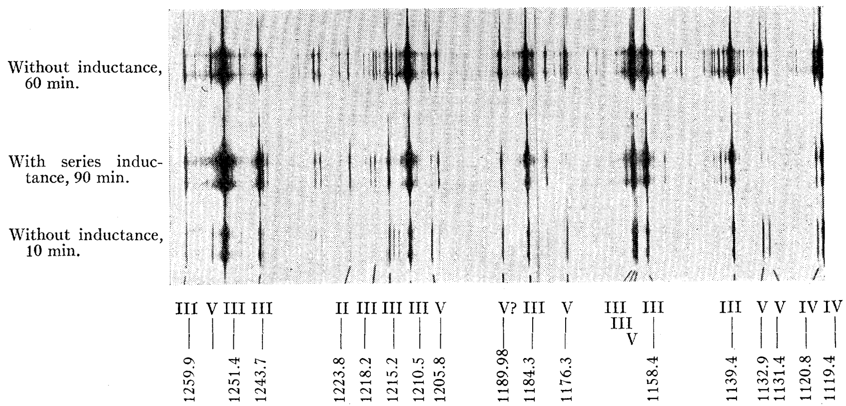
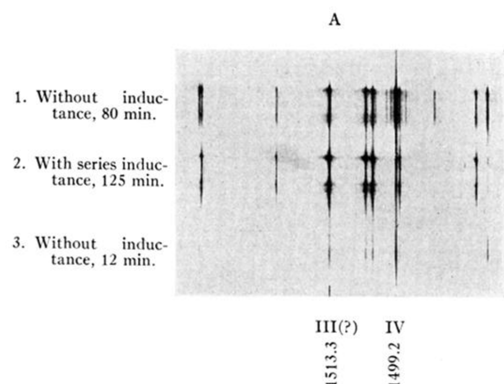


Fig. 3. Tin

than would be expected if only a Sn V line occupied that position. A line chosen by them at 1218.21A for Sn V belongs definitely to Sn III. Certain lines which Green and Loring[8] have picked for the spectrum of Sn III, but not completely identified belong to other states of ionization. Those at 1294.41A and at 1205.8A belong to Sn V.

We might go on citing other cases in these spectra in which the use of series inductance has made it reasonable to reject some lines in a given region and definitely to select certain others, as belonging to a particular multiplet. If one may then successfully apply the ordinary methods employed in classifying lines to the particular lines thus selected, he has more assurance that the identifications made in this way are correct. While the use of inductance in series with a vacuum spark furnishes useful evidence for classifying lines according to the stages of ionization of the atoms from which they come, it should not be concluded without further experimental verification that all lines arising from a given stage of ionization of an element are similarly modified by this change in the discharge circuit. Certain electronic transformations may be more sensitive to this change than others, or the lines of a given multiplet may show effects that are more marked than those of other multiplets. It is even conceivable, although not likely, that the lines of any one multiplet may thus be unequally affected. It is hoped that some of these questions may be answered by a more systematic study of the effect of series inductance upon many lines in various spectra, particularly upon those lines whose identification has been reliably determined by other criteria.

[7] Gibbs and White, Proc. Nat. Acad. Sci. **14**, 345 (1928).
[8] Green and Loring, Phys. Rev. **30**, 574 (1927).



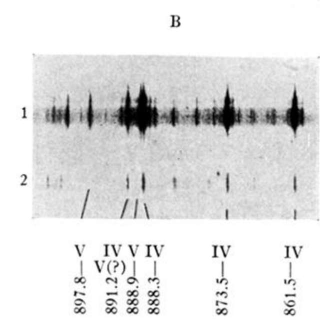


Fig. 1. Antimony

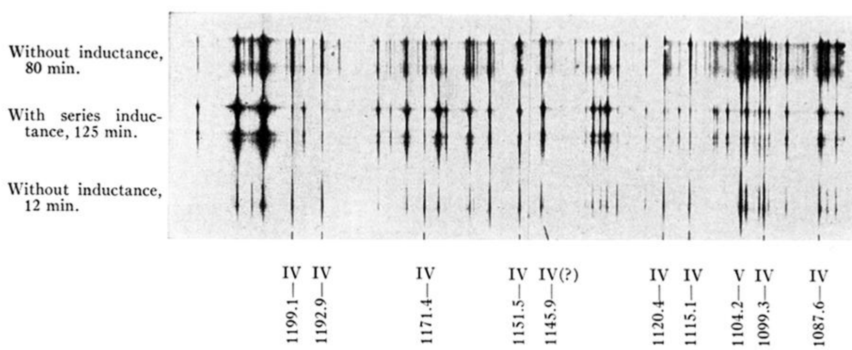
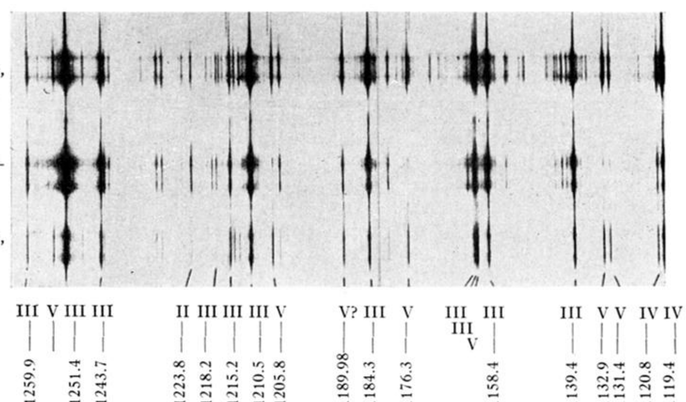


Fig. 2. Antimony



Without inductance, 60 min.
With series inductance, 90 min.
Without inductance, 10 min.
III V III III
II III III III V
V? III V
III III V III
III V V IV IV
1259.9
1251.4
1243.7
1223.8
1218.2
1215.2
1210.5
1205.8
1189.98
1184.3
1176.3
1158.4
1139.4
1132.9
1131.4
1120.8
1119.4

Fig. 3. Tin