VARIATION IN THE INTENSITIES OF MERCURY SPECTRUM LINES WITH PRESSURE OF THE VAPOR

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Abstract

The relative intensities of spectrum lines of Hg vapor in the d.c. arc and at a pressure of 10^{-3} mm in a high frequency electrodeless discharge have been measured for wave-lengths ranging from 7000 to 3000A. There is a decided increase in intensity, relative to the triplet line 5460, of the singlet members in the low pressure discharge, the sharp series showing the greatest increases. The relative intensity increases rapidly with ascending members of the series. Five new lines in the sharp singlet series were observed. Combination singlets appeared strong in the red in the low pressure discharge. The first members of the triplet series do not show much change but the higher members show an increasing intensity at low pressure. Combination lines also show decided increase in the low pressure discharge.

IN ORDER to investigate the behavior of the spectrum of mercury vapor under widely different conditions of pressure, the spectrum as produced in an ordinary d.c. arc has been compared with the spectrum in the vapor at a room temperature of 20°C. The pressure in the arc being in the neighborhood of one atmosphere and that in the vapor at 20°C being approximately 10^{-3} mm, these two conditions allow comparison of the spectra for a pressure ratio of approximately 10^6 to 1.

In order to secure a strong discharge in the vapor at 20°C or at lower temperatures that might be necessary to use in the research, it was decided to use an electrodeless discharge at frequencies of the order of 10^8 cycles per second. The success which Wood and Loomis[1] had already reported in obtaining strong discharges in tubes already evacuated to a high degree indicated that there should be no difficulty in securing a strong discharge in mercury vapor at pressures of 10^{-3} or 10^{-4} mm.

An ordinary horizontal quartz arc was used for the high pressure spectra. A Pyrex window was placed in front of the spectrograph slit in order to allow comparison with the spectrum from the high frequency discharge apparatus which was made entirely of Pyrex glass. The arc was operated on a current of 3 amperes and was allowed to run for half an hour before any photographs were taken of the spectra. The power for the high frequency discharge was obtained from two R.C.A. UX-852 tubes connected in "push-pull" manner. Oscillations of 3 meter wave-lengths were strongly produced in this type of circuit. A solenoid of copper wire was wound on the discharge tube and coupled to the helix of the oscillating circuit. When this solenoid had a natural period corresponding to the frequency of oscillation, strong dis-

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[1] Wood and Loomis, Nature **120,** 510 (1927).

charges were produced in the tube containing mercury vapor at room temperature. This discharge was viewed end-on through a plane glass window.

The arc spectrum was photographed for periods ranging from one second to 16 minutes while the spectrum of the high frequency discharge was taken for periods ranging from 5 seconds to 4 hours. The plates were developed together in a tank in which a developing solution was continuously stirred. The density of the lines of each spectrum was then measured on a microphotometer and the densities of a given line for different exposure-times were plotted against the logarithm of the time of exposure. Practically all these curves had a straight line characteristic for densities ranging from around 0.4 to 1.2. All the data used in calculating intensity values shown in the table were obtained for a line-density of one. If the plate were equally sensitive to all wave-lengths these lines would be parallel. However, in the panchromatic plates used in this work the curves in the yellow and red regions of the spectrum were very nearly parallel in their straight line sections, while the curves in the blue and violet regions exhibited similar parallelism but with different slope from those of the long wave-length lines. On account of the varying sensitivity of the plate the relative intensities of the lines in one exposure will not be the true values. However, the intensity of any line in the arc relative to the intensity of the same line in the low pressure discharge will be correct within the limits of experimental error.

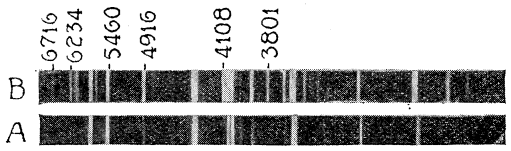

Fig. 1. Hg spectrum. *A*, d.c. arc; *B*, discharge at 10^3 mm.

The spectrum of Hg vapor under these two conditions is shown in photographs of Fig. 1. The red lines which occur so faintly in the arc are very prominent in the low pressure spectrum. The lines 4916 and 4108 appear very prominently at low pressure but are very faint in the arc. In addition to these very obvious changes in intensity of these lines one will observe many lines in the low pressure spectrum that do not appear at all in the arc or are so weak that they only appear very faintly in long exposures.

Referring to Table I it will be noticed that if we assign an arbitrary intensity of 100 to the line 5460 in each spectrum the intensity of the second member of this triplet series, 3341A, is increased nearly twentyfold in the low pressure discharge. The most marked increase of intensities is found in the sharp series of singlets, the intensity ratio for the line 4916 being 250 and increasing to 360 for the line 4108. These observations are in general qualitative agreement with the work of Hodges and Michels[2] of this laboratory who

[2] Hodges and Michels, Phys. Rev. **32,** 913 (1928).

report a similar increase in relative intensity of the singlets in the helium spectrum at low pressures.

In the diffuse series the first member, 5790A, is almost twice as strong at the low pressure as it is in the arc. It will be observed, however, that the

TABLE I. *Ratio of intensities of lines in the mercury spectrum in the d.c., arc and in the high frequency discharge at low pressure.*

Line	Designation	Low pressure discharge (10^{-3} mm)	d.c. Arc	Intensity Ratio
6716.45	7^1S-8^1P	2.8	—	∞
6234.35	7^1S-9^1P	18	—	∞
4916.04	6^1P-8^1S	50	0.2	250
4108.08	6^1P-9^1S	62	0.10	620
3801.67	6^1P-10^1S	14	0.01	1400
3558.60	6^1P-12^1S	1.2	—	∞
5790.66	6^1P-6^1D	50	26	1.9
3906.40	6^1P-8^1D	100	1.9	52
3704.22	6^1P-9^1D	20	.1	200
3592.97	6^1P-10^1D	0.5	—	∞
3524.27	6^1P-11^1D	1.5	—	∞
3478.98	6^1P-12^1D	0.7	—	∞
3447.22	6^1P-13^1D	0.1		
5460.74	$6^3P_2-7^3S$	100	100	1
3341.48	$6^3P_2-8^3S$	104	5.4	19.2
4358.34	$6^3P_2-7^3S$	3000	500	6.0
4347.50	$6^1P_1-7^1D$			
4046.56	$6^3P_0-7^3S$	750	405	1.8
3663.28	$6^3P_2-6^1D$			
3662.88	$6^3P_2-6^3D_{1,2,3}$	875	292	3.0
3654.83				
3650.15				
3131.84	$6^3P_1-6^1D$			
3131.56	$6^3P_1-6^3D_{1,2}$	925	5	185.0
3125.66				
6072.63	7^3S-8^1P	8	—	∞
5675.86	7^3S-9^1P	6.3	—	∞
4077.83	$6^3P_1-7^1S$	428	48	8.9
3027.48	$6^3P_2-7^1D$	13	—	∞
3025.62	$6^3P_2-7^3D_{1,2,3}$			
3023.47				
3021.50				
6123.		8	—	∞
4797.		1	—	∞
3984.		0.05	0.2	0.25

fourth member of this series, 3704A, is 200 times stronger at low pressure. The intensity ratio of the line 4347, the second member of the diffuse series, could not be measured as it could not be separated by the microphotometer from the triplet line 4358. The combination lines which could be resolved

showed increase in intensity in the low pressure discharge. However, the two strong combination lines 3663 and 3131 could not be resolved sufficiently as they have practically the same wave-lengths as two strong members of the diffuse triplet series. In addition to the increase in strength of the higher members of the singlet series several new members of the sharp singlet series, were observed. Five lines of shorter wave-length than the 3801 line, which is the last member of the series listed by Fowler[3] were observed on plates exposed to the low pressure discharge.

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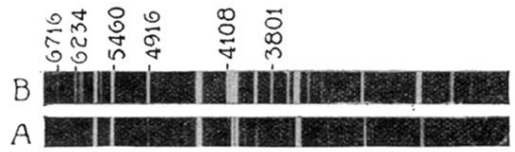
[3] Fowler, "Report on Series in Line Spectra" (1922).



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