

SPARK SPECTRA OF ZINC

by

FRANCIS GUTMANN
B.A., University of British Columbia, 1956

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in the Department

of

PHYSICS

We accept this thesis as conforming to the
required standard

THE UNIVERSITY OF BRITISH COLUMBIA

April, 1958

Abstract

The spectra of zinc have been photographed in the region between $2400\text{\AA}$ and $7000\text{\AA}$. Electrodeless discharge and Schuler tube were used as sources, and exposures were taken on a Hilger E-498 medium quartz spectrograph, a Hilger E-1 Littrow prism spectrograph and a 21 foot concave diffraction grating. There were 1200 lines measured in this region of which 110 were already classified.

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the Head of my Department or by his representative. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Physics

The University of British Columbia,
Vancouver 8, Canada.

Date April 16, 1958

ACKNOWLEDGEMENT

I am very grateful to Dr:A.M.Crooker for his devoted supervision. His inspiring discussions and interest were stimulating throughout this work. I am also indebted to Mr.J.Lees and Mr.A.Fraser for their helpful technical assistance.

TABLE OF CONTENTS

	Page
Abstract.....	iii
Acknowledgements.....	iv
Introduction.....	1
Experimental.....	3
Analysis and Results.....	7
List of Measured Zinc Lines.....	10
Bibliography.....	40

Illustrations

following p.6

- (a) Calibration Curve for Hand Spectroscope
- (b) Electrodeless Discharge
- (c) Electrodeless Discharge (Circuit Discharge),
Temperature Control
- (d) Schüller Tube
- (e) Schüller Tube (Circuit Diagram)

INTRODUCTION

During the time between the two world wars, there was a tremendous amount of work done in the field of optical spectra. The analysis of emission spectra yielded in a short time a large amount of information which was soon interpreted by people like Bohr, Catalan, Russell, Saunders, Hund, Pauli, Bowen, and Millikan. However, the interest in this field declined soon because there did not seem to be much more information one could obtain from any further analysis. At that stage the atomic theory was able to predict in a semi-quantitative way the structure of most spectra. However, although numerous theories have been put forward regarding prediction of atomic energy levels, none of them was adequately tested because of the many gaps in our knowledge of atomic spectra. Meggers (11) points out that out of 4278 theoretically possible spectra, 3800 were unknown in 1946, and also that ionization potentials of only 65 neutral atoms and 60 ions were known. The table of "Atomic Energy Levels" compiled by Mrs Moore-Sitterly show that there are still many gaps in the study of isoelectronic sequences and frequent unexplained irregularities in position of energy levels and energy level intervals. A large amount of work must still be done in the analysis of spectra of transuranic elements and rare earth elements and also in the second and third spark spectra of the first long period. Beside all the mentioned deficiencies,

wavelength values must frequently be changed when remeasured on modern improved instruments.

The object of this work was to obtain the best possible list of zinc spark lines. The arc spectrum of zinc, which was analysed mainly by Hetzler, Boreman, and Burns in 1935, is complete. Von Salis, Paschen, Lang, and Shenstone observed Zn II but the analysis is still not complete since a number of terms arising from $3d^9 4s n x$ are missing. The most complete list up to now of high excitation zinc lines was compiled by L. and E. Bloch in 1936. Mazumder used partly this list to obtain the twenty four terms he published. Laporte and Lang observed the spectrum in the vacuum ultraviolet and obtained 9 terms. Since Zn III is expected to have roughly the same number of terms as Cu II and Ni I, it is quite clear that only about one-third of the terms have been observed and that a large amount of work still has to be done to complete the analysis.

EXPERIMENTAL

In this analysis, the electrodeless discharge was adopted as the source, the main reasons being that the spectrum produced is nearly free of impurities, that the lines produced are sharp, and that the excitation and intensity are high.

A quartz tube containing a few grams of zinc metal was placed inside a furnace, which consisted of four electric heaters placed around the discharge tube as shown in the diagram. Wrapped around the tube was a copper coil, consisting of eight turns, that was connected through a spark gap to a mica condenser so as to form a closed loop. The coil had an inductance of about $2.6\mu H$ and the condenser had a capacitance of $.0038\mu f$, thus making the circuit resonant at 10^8 cycles per second. The high frequency oscillations were produced by placing the condensers across a 50 KV X-ray transformer. After evacuating the tube, the temperature was raised to about $500^\circ C$ to produce a .76 mm Hg zinc vapour pressure. In order to avoid conduction across the spark gap and thus increase the excitation, an electric fan was used to blow air across the spark gap. The air ventilation also prevented the condenser from becoming too hot. After running the discharge for a relatively short time, zinc would diffuse out of the furnace into the cool part of the discharge tube. This caused the quartz windows on either end of the tube to become coated with a film of zinc which reduced the intensity of the source and cut

down the amount of available zinc vapour. This was overcome by placing a gas flame at the end of the tube so as to keep it hotter than the remaining part. During every exposure, the changes in excitation (i.e. changes in intensity of known high excitation lines) were watched through one end of the tube using a Canadian Arsenal no.109 hand spectroscope. For the purpose of identifying some of the strong low excitation lines, the hand spectroscope was calibrated, using a mercury vapour lamp and a copper arc.

As an attempt to obtain an alternative low excitation source, a Schüller tube was used. It consisted of a hollow water-cooled cathode tube into which was placed a small zinc rod. The Schüller tube was connected through two liquid air traps to a mercury circulating pump to form a closed system. After evacuating the apparatus, a small amount of argon was let in. The Schüller tube was now connected across a condenser. The spark gap between the anode and the high potential terminal of the condenser served also to control the potential difference between the anode and the cathode. The circulating speed of the argon gas was controlled by a needle valve. It was found that the excitation was controlled mainly by varying the spark gap which was easier to change than in the case of electrodeless discharge.

Instruments used for exposures were a Hilger E-1 Littrow prism spectrograph, a Hilger E-498 medium quartz spectrograph, and a 21 foot concave diffraction grating with a Paschen-Runge mounting.

Exposures were taken on the medium quartz spectrograph

using the Schüller tube as a source. The exposures lasting about five minutes were taken on Ilford HP3 and Ilford Q- plates. The wavelength scale in the instrument was used for identification of lines instead of the usual iron standards. The current between the anode and the cathode remained roughly constant at about 35 m.a. during all exposures while the circulation speed and the potential difference between the anode and the cathode was varied. The same procedure was repeated using the Hilger E-1 spectrograph.

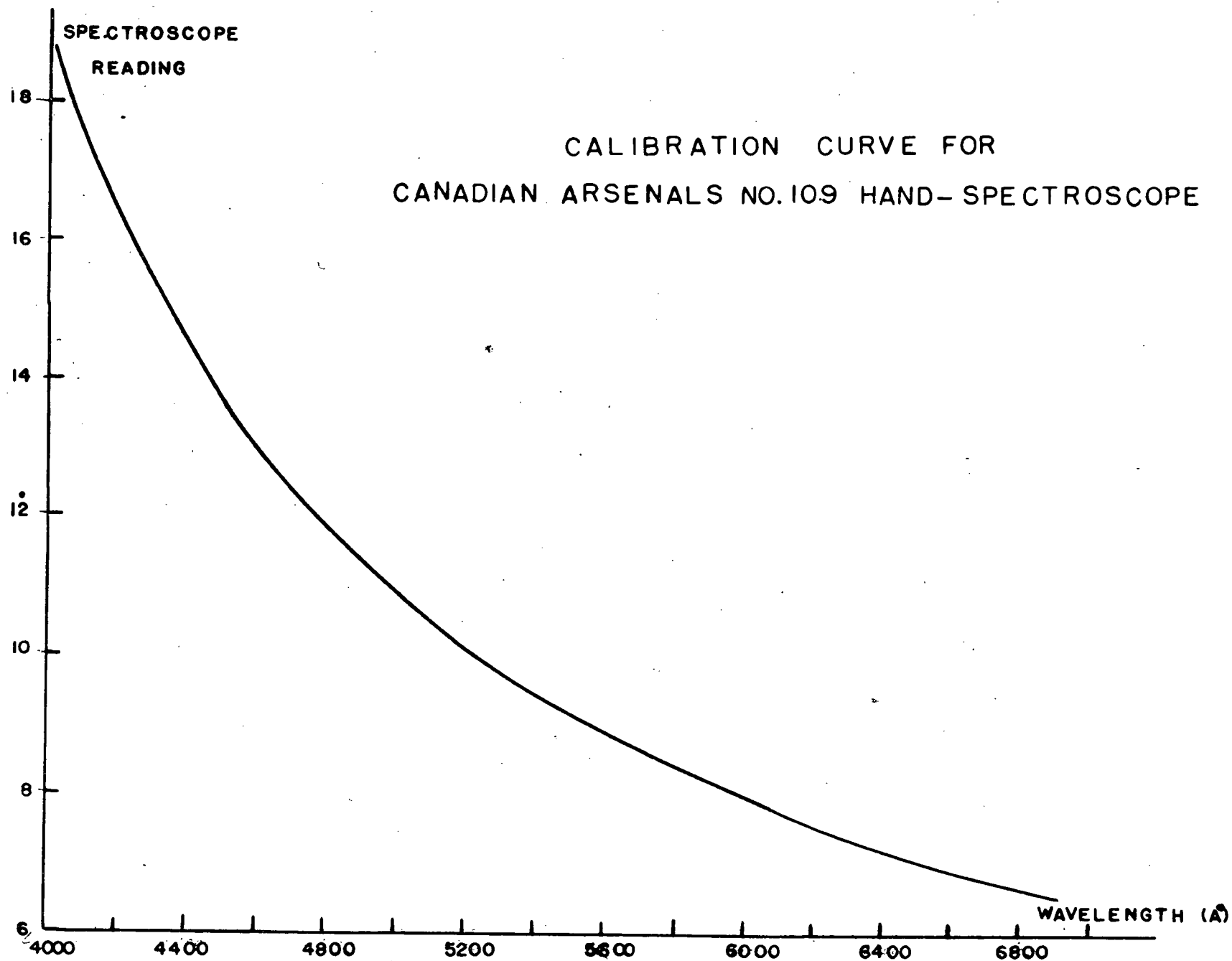
The electrodeless discharge was used first with the Hilger E-1 spectrograph. Two series of exposures were taken with Kodak F-11 and Ilford HP-3 plates in the visible and near-ultraviolet region, and Ilford Q-plates in the far-ultraviolet. After transferring the electrodeless discharge to the 21 foot grating, six three-hour exposures were taken. In five out of the six exposures, the instrument was fully loaded with plates. The distribution of the different types of plates along the plate holder is shown in the following table:

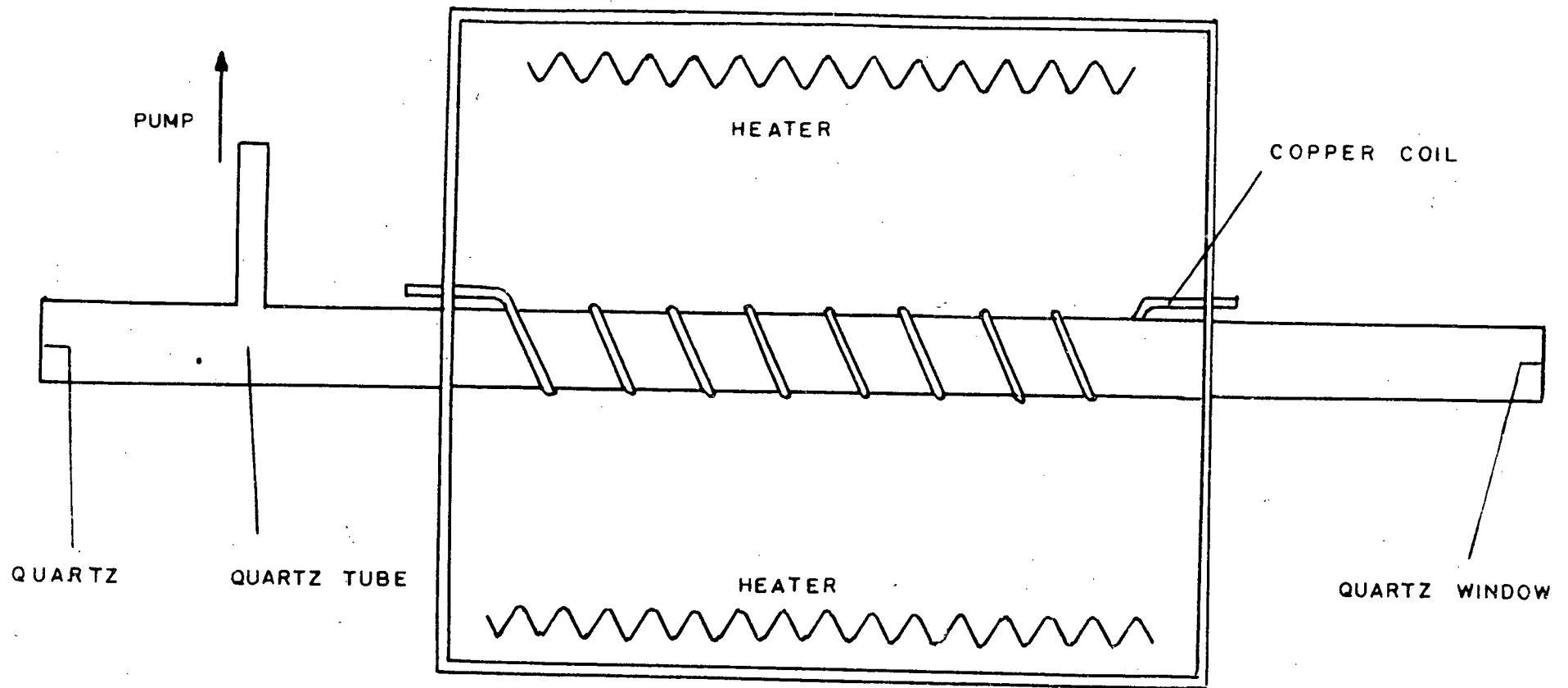
Run Number	slit								
	pl#8	pl#7	pl#6	pl#5		pl#4	pl#3	pl#2	pl#1
5710X	HP3	HP3	HP3	HP3		HP3	HP3	HP3	HP3
5720X	HP3	HP3	HP3	HP3		HP3	HP3	HP3	HP3
5730X	HP3	HP3	HP3	HP3		HP3	HP3	HP3	HP3
5740X		Q	Q				Q	Q	
5750X	HP3	HP3	Infrared	f.		L.R.	Q	HP3	HP3
5760X	HP3	HP3	L.R.			L.R.	HP3	HP3	Q

L.R. denotes Ilford Long-Range plate.

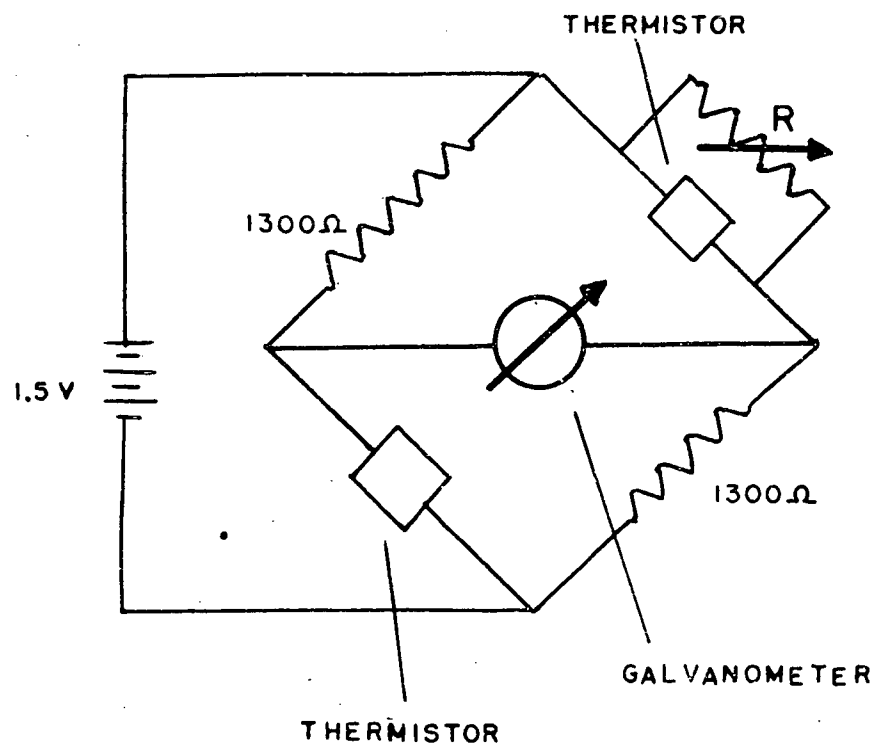
In order to prevent line broadening and shifting, the temperature of the immediate surroundings of the grating was kept constant to within $1/25^{\circ}\text{C}$ by heating the room to about 2°C above its normal temperature. A mercury column acting as a circuit switch controlled the heaters. The temperature changes were being watched outside the grating room by a bridge circuit connected as shown on the diagram. It was possible with this temperature-measuring device to note changes of about $1/1000^{\circ}\text{C}$, since an increase of about 3750Ω in R was equivalent to a 1°C drop in temperature.

All plates were measured on a Hilger comparator; however, the weak lines had to be measured with an eyepiece. Although the distances measured on the Hilger comparator could be read to $.001\text{ mm.}$, the readings were usually reproducible to about $.004\text{ mm.}$ depending upon the width of the line.

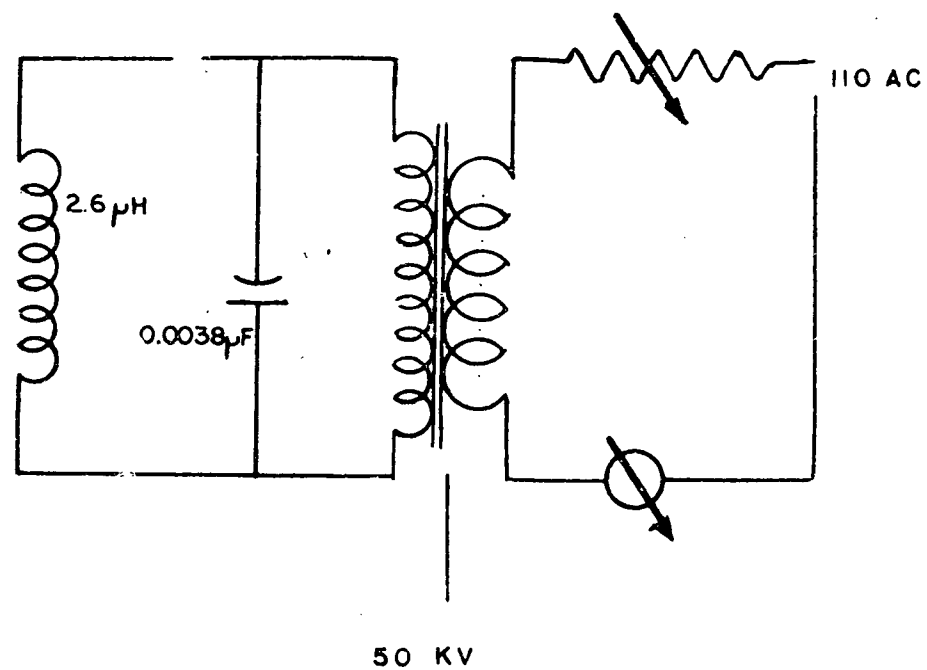




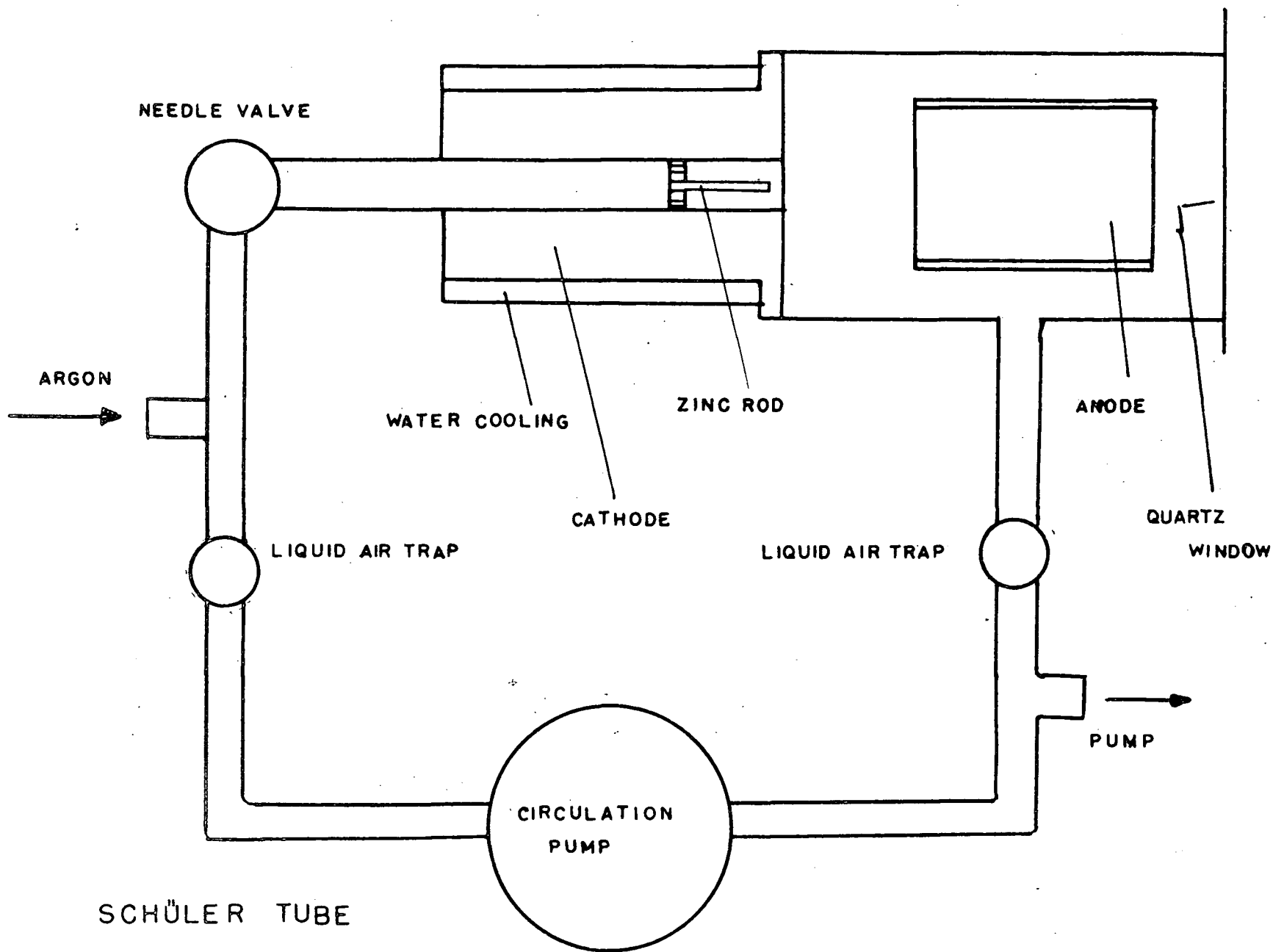
ELECTRODELESS DISCHARGE

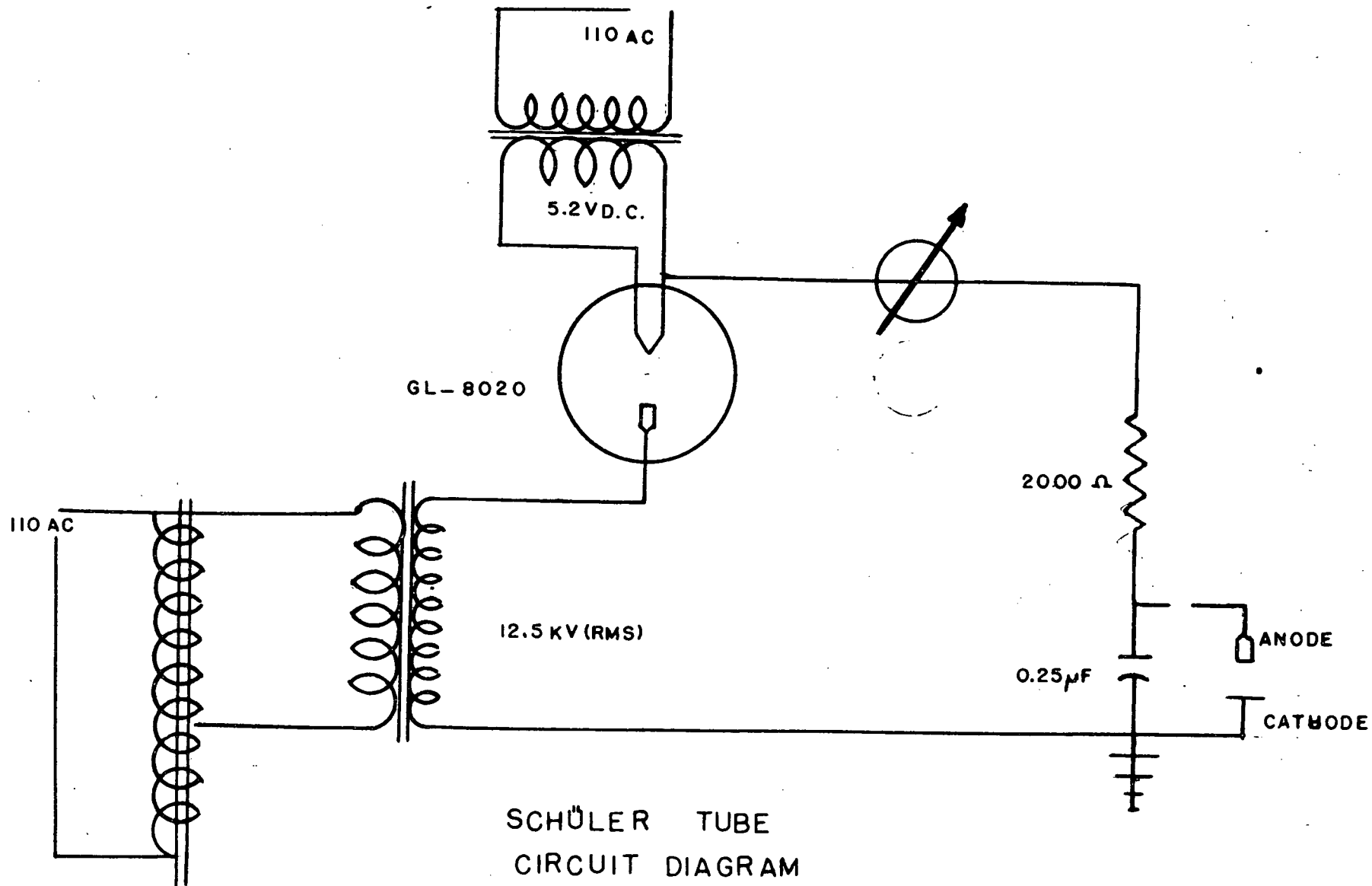


TEMPERATURE CONTROL



ELECTRODELESS DISCHARGE
CIRCUIT DIAGRAM





Analysis and Results

In the analysis of the plates obtained using the Schüller tube as source, mercury and argon lines had appreciable intensity. Hence it was decided not to analyse those plates in any great detail. The wavelength list compiled contains therefore only lines emitted by the electrodeless discharge.

The prism plates were reduced using the Hartmann dispersion formula and iron standards. The weak lines were determined by linear extrapolation from a known neighbouring zinc line, using the experimental dispersion curves which are roughly approximated by the following formulas:

- 1) $D = \lambda^{3/5.4}$ in A /mm for 3100A - 6500A
(Prism rotation at 17.00.)
- 2) $D = \lambda^{3/6.0}$ in A /mm for 2400A - 3100A
(Prism rotation at 13.30.)
- 3) $D = \lambda^{3/6.4}$ in A /mm for region below 2400A
(Prism rotation at 9.20.)

The prism wavelengths were later used to determine the order on the grating spectrograms.

By using the well-known strong Zn I and ZnII lines

and the theoretically-predicted dispersion, the iron standards were identified.

Since $b = \text{grating } 16.934\text{\AA}$
 $i = \text{angle of incidence} = 25^\circ$
 $R = \text{radius of curvature of the grating}$
 $= 642.214 \text{ cm.}$

it follows from the theory that the dispersion (in $\text{\AA} / \text{mm}$) is given by

$$D = 2.63687 \sqrt{1 - \left(\frac{m}{b}\right)^2 - \sin^2 i}$$

The D values were calculated and tabulated for increments of $100 \text{\AA}$ and lie between 2.61 and 1.96. The dispersion determined experimentally was found to agree very well with the tabulated values.

The order of the lines was determined mainly with the help of the prism plates. Rowland ghosts helped often to confirm the order of the stronger lines. Values for ghost spacing corresponding to any particular order and any $n\lambda$ were obtained from the thesis of R.E. Bedford. The actual Rowland ghost separations are given by-

$$ds = \frac{m \lambda}{D p} \quad \text{where } p = \text{number of grating lines / period} = 750$$

$m = \text{Rowland ghost order.}$

An appreciable number of lines were also identified because they reappeared in higher orders, and because their intensity on the plate varied depending upon the sensitivity of the plate in that particular wavelength region.

The accuracy of the wavelength varies from $.005\text{\AA}$

around $2400\text{\AA}$ to about $.04\text{\AA}$ in the infra red region. The most complete list of high excitation lines up to now was compiled by L. and E. Bloch in 1934. Considering the fact that the dispersion they quote is at least ten times lower than the one used in this analysis, the agreement is quite good especially in the $5000\text{\AA}$ region. All the wavelength given by L. and E. Bloch are high by about $.02\text{\AA}$ - $.15\text{\AA}$ compared to the ones obtained here.

On most exposures Zn II and Zn III lines dominate the spectrum. In the region between $2400\text{\AA}$ and $6600\text{\AA}$ there are about 1200 lines recorded here, out of which, 110 are classified.

List of Measured Zinc Lines

P : intensity on E - 1 (prism

G : intensity on 21 foot grating

B : intensity observed by L. and E. Bloch

Note: Intensities are on a visual scale from 0 - 1000.

Intensity			Wavelength (air)	Wave Number (vac)	
B	P	G	A°	cm ⁻¹	Class
		1	6635.71	15065.85	
		0	6632.58	15074.07	
		5	6625.50	15089.04	
100	100	0	6601.53	15143.83	
		0	6595.60	15157.44	
10		50	6569.50	15217.66	
		1d	6545.24	15274.07	
		30	6499.69	15281.08	
		50	6498.14	15284.77	
500	500		6496.85	15287.83	
		20	6483.34	15419.89	11
		40	6483.10	15420.47	11
5		5	6399.20	15622.64	
		1	6396.98	15628.07	
500	1000		6362.32	15713.20	1
50		5	6300.15	15768.26	
		5	6268.94	15947.26	
500		10	6265.94	15954.90	
500		500	6214.61	16086.67	11
		5	6186.09	16160.84	
50		20	6149.29	16257.55	
100		30	6111.53	16358.00	11
500		500	6102.49	16381.96	11
50		50	6071.62	16465.52	
500		100	6053.15	16515.76	
		1	6046.42	16534.15	
		5	6045.49	16536.69	
		5	6044.69	16538.88	
500		500	6021.18	16603.45	11
5		10	5982.27	16711.43	

List (continued)

Intensity			Wavelength (air)	Wave Number (vac)	Class
B	P	G	A°	cm ⁻¹	
	50	5	5937.22	16838.24	
		5	5934.88	16845.82	
	50	5	5928.79	16862.19	
	100	15	5908.49	16920.12	
	500	100	5894.33	16960.77	
	50	15	5883.18	16992.91	
	10	5	5865.73	17043.46	
		1	5852.42	17082.22	
		5	5820.63	17175.52	
		5	5820.09	17177.12	
	500	50	5814.92	17192.39	
		5	5812.86	17198.84	
	10	1	5801.22	17232.99	
	500	200	5757.87	17362.73	
		10	5755.46	17370.00	
		100	5741.66	17411.75	
	50	2	5699.10	17541.77	
	500	200	5686.00	17582.19	
	10	15	5678.27	17606.12	
		10	5678.09	17606.71	
	15	15	5658.38	17668.01	
		10d	5623.58	17777.34	
	10	20	5620.01	17788.64	
			5610.31	17819.39	
	100	10	5586.04	17896.81	
	500	500	5578.81	17920.01	
	500	500	5563.79	17968.38	
		15	5563.38	17969.73	
		0	5550.48	18011.47	
		1	5528.61	18082.72	
		1	5525.21	18093.85	
		20	5522.09	18104.06	
	50	30	5520.12	18110.53	
		15	5519.80	18111.58	
		15	5516.84	18121.30	
		10	5513.23	18133.16	
		10	5512.12	18136.81	
	500	40	5510.62	18141.74	
		20	5510.32	18142.73	
		20	5509.49	18145.47	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
	10	15	5498.65	18181.24	
		15	5493.17	18199.38	
	10	100	5492.51	18201.57	
	10	15	5472.47	18268.22	
	500	100	5468.19	18282.52	
	5	30	5439.66	18378.41	
	10	10	5427.4	18420.1	
	50	50	5423.81	18432.18	
	100	100	5416.34	18457.53	
	50	10	5403.34	18501.94	
	50	10	5400.02	18513.45	
		1	5390.76	18545.12	
2		30	5389.32	18550.07	
2		30	5388.77	18551.97	
1		10	5387.07	18557.82	
3	500	1000	5386.27	18560.58	
1		20	5384.92	18565.23	
0		10	5380.96	18578.89	
2	100	50	5375.66	18597.21	
		30	5373.62	18604.27	
		15	5362.27	18643.65	I
		20	5359.05	18654.85	
		10d	5357.66	18659.69	
		20	5357.47	18660.38	
		1	5337.95	18728.59	
5	500	50	5336.88	18732.29	
0		1	5312.36	18819.23	
	10	2	5310.84	18824.19	
2	50	5	5290.56	18896.34	
		0	5288.26	18904.56	
1	50	5	5271.05	18966.29	
4	500	80	5249.68	19043.49	
3	100	30	5233.50	19102.37	
0	5	0	5217.83	19159.74	
0	20	1	5206.57	19201.17	
1	100	30	5192.33	19253.83	I
2	100	0	5181.97	19292.32	
		5d	5159.04	19378.07	
3	500	50	5157.61	19383.44	
	10	1	5145.6	19428.6	

Intensity			Wavelength (air)	Wave Number (vac.)	class
B	P	G	A°	cm ⁻¹	
		1	5122.11	19517.78	
2	500	40	5119.81	19526.55	
		5	5095.22	19620.78	
0		20	5085.05	19660.03	
3		500	5075.33	19697.68	
	50	10	5069.44	19720.56	I
2	500	100	5050.13	19795.96	
	10	5	5035.45	19853.68	
	10	10	4994.08	20018.14	
	5	1	4988.96	20038.18	
			4986.5	20048.5	
4	500	80	4970.78	20111.98	
	10	5	4960.42	20153.98	
		1	4940.70	20234.42	
7	500	500	4924.01	20303.00	II
8	500	1000	4911.63	20354.18	II
1		10	4910.45	20359.07	
		30	4879.92	20486.44	
5	500	80	4879.14	20489.71	
2	50	10	4874.23	20510.35	
6	100	50	4866.84	20541.49	
2	50	10	4850.26	20611.71	
4	100	30	4836.05	20672.27	
8	500	100	4818.91	20745.80	
10	500	50	4810.53	20781.94	I
		50	4806.06	20801.27	
10	500	500	4722.20	21170.67	I
		5d	4713.79	21208.43	
	5	2	4691.18	21310.65	
10	100	100	4680.12	21361.01	II
		1	4679.68	21363.02	
		2	4679.11	21365.62	
	10	20	4657.90	21462.91	
		5	4654.24	21479.79	
		5d	4650.29	21498.04	
2?		10d	4649.17	21503.22	
		1	4641.82	21537.26	
		1	4640.0	21545.8	
10	100	20	4629.80	21593.18	I
3	10	5	4609.19	21689.73	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
3	10	10	4605.58	21706.73	II
		15	4595.12	21756.14	
		50	4589.88	21780.98	
	10	40	4567.20	21889.00	
	50	5	4540.90	22015.91	
	50	5	4523.53	22100.45	
5	100	40	4510.19	22165.72	
		5	4505.79	22187.56	
3	100	5	4502.55	22203.43	
2	500	20	4487.66	22277.10	
4	20	20	4482.69	22301.80	
	10		4465.6	22387.3	
1	25	10d	4451.00	22460.58	
	5		4445.01	22490.84	
	20	5	4442.14	22505.39	
	10		4436.7	22533.0	
2	30	50	4431.43	22559.77	
3	40	80	4424.91	22593.01	
1		10	4424.01	22597.60	
1		20	4420.92	22613.40	
0		15	4419.68	22619.74	
4	40	100	4419.37	22621.33	
3		80	4417.51	22630.85	
3	60	500	4415.10	22643.21	
3		200	4413.86	22649.57	
2		40	4412.03	22658.96	
2		50	4407.41	22682.71	
4	80	500	4406.04	22689.77	
4		100	4405.56	22692.24	
2		50	4404.21	22699.19	
2	10	5	4402.72	22706.87	
		3	4402.25	22709.30	
2	20	50	4399.63	22722.82	
0		5	4398.10	22730.73	
1		30	4394.20	22750.90	
3	20	100	4392.18	22761.36	
1		20	4391.60	22764.37	
0		30	4385.75	22794.73	
3	40	80	4385.52	22795.93	
3	30	500	4381.15	22818.67	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
1		30	4380.80	22820.49	
		20	4370.76	22872.91	
4	30	100	4370.44	22874.59	
5	50	100	4361.30	22922.52	
		40	4359.66	22931.14	
5		100	4359.40	22932.51	
4	30	200	4351.70	22973.09	
4		100	4351.12	22976.15	
2		10d	4349.43	22985.08	
		1000	4347.98	22992.75	
1	10	5	4354.10	23007.98	
	50	80	4341.3	23028.03	
2	20	1	4334.97	23061.75	
		5	4329.30	23091.95	
4	50	5	4328.33	23097.13	
4		5	4327.06	23104.91	
		0	4322.36	23129.03	
	15	5	4320.66	23138.22	
		1	4316.65	23159.62	
3	30	1	4316.52	23160.34	
1		20	4314.10	23173.31	
		0	4312.90	23179.76	
	10		4305.3	23220.7	
1	20		4302.6	23235.1	
2	6	10	4298.34	23258.27	I
	10	1	4297.17	23264.61	
1	6	5	4292.89	23287.80	I
	4	0	4289.68	23305.23	
	15d	40	4282.91	23342.07	
		0	4280.96	23352.70	
		0	4280.83	23353.41	
	10d	80	4277.55	23371.31	
	4	8	4272.44	23399.26	
		1	4268.42	23421.30	
		0d	4267.07	23428.71	
	30	100	4266.53	23431.68	
2	20d		4261.1	23461.8	
3	10d		4258.8	23485.1	
	20d	5	4254.36	23498.71	
		0	4254.17	23499.75	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
	5		4249.6	23525.6	
2d	0		4243.5	23558.9	
	10	5	4239.38	23581.74	
2d		1	4239.14	23583.07	
		1	4238.71	23585.46	
	10	50	4228.18	23644.20	
	30	8	4222.45	23676.29	
		15	4222.24	23677.46	
4		5	4222.04	23678.59	II
1	6	20	4218.31	23699.52	
1	6	20	4214.27	23722.25	
	10d	10	4210.31	23746.55	
2		5	4209.62	23748.45	
2	10d	10	4205.66	23770.81	
3	15d	15	4200.89	23797.80	
		2	4195.64	23827.57	
3	20d	5	4195.41	23828.88	
	30d	5	4189.81	23860.72	
		5	4189.69	23861.41	
	20	10	4184.41	23891.64	
1		10	4183.95	23894.15	
2d	20d	10d	4178.36	23926.12	
3d	20d		4171.6	23964.7	
	30d		4167.6	23987.9	
		0	4164.73	24004.42	
	10d	15	4156.13	24054.09	
		10	4153.47	24069.48	
4	30	15	4148.61	24097.69	II
2	10		4145.4	24116.6	
	20		4137.8	24160.64	
	30		41337.7	24184.6	
		50	4131.77	24195.91	
6	40	40	4119.39	24268.62	II
3	10	10	4113.13	24305.55	
2	20d	10	4103.90	24360.21	
2	10	10	4094.64	24415.30	
0	5		4082.8	24485.7	
6	40	40	4078.14	24514.09	II
		30	4072.34	24549.00	
	5	50	4071.99	24551.11	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
0	5	10	4066.90	24581.84	
		1	4065.01	24593.26	
	8		4063.2	24604.0	
	10		4060.16	24619.9	
	10		4059.4	24627.2	
	10		4056.0	24647.7	
		20	4052.88	24666.87	
	10	20	4049.94	24685.26	
	2	100	4043.15	24726.23	
	20	20	4040.46	24742.81	
2		20	4039.89	24746.18	
		10	4039.17	24750.59	
0	10	10	4036.07	24769.60	
		10	4035.64	24772.24	
	20	2	4019.27	24873.13	
		10	4017.30	24885.33	
1	10	500	4013.85	24906.72	
		2	4011.20	24923.17	
			4009.4	24934.4	
		1	4007.25	24948.74	
			4005.9	24956.2	
0	20		4001.0	24986.7	II
0	10		3998.03	25005.27	
0	20	1	3995.01	25024.18	
4		50	3989.96	25055.84	
6	50	100	3988.96	25062.12	
		10	3974.80	25151.41	
1	10	15	3974.51	25153.25	
5	50	100	3971.44	25172.69	
	5	10d	3968.38	25192.10	
0		2	3963.45	25223.43	
		n 5	3962.84	25227.71	
		5	3960.41	25242.79	
		5	3958.05	25257.84	
		1	3944.27	25346.08	
2	40	30	3943.05	25353.92	
0	2	2	3940.44	25370.72	
1		10	3939.48	25376.90	
2	40	30	3938.44	25383.60	
3	50	80	3935.01	25405.73	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
	6	20	3928.64	25446.92	
	10	5	3924.63	25472.92	
	20d		3920.1	25502.0	
1	20	15	3914.87	25536.43	
3	80	100	3912.05	25554.84	
2	20	20	3909.09	25574.19	
1	10	10	3904.51	25604.18	
	5	10	3892.01	25686.41	
	5		3888.7	25708.0	
1	20	15	3886.13	25725.28	
1		15	3885.32	25730.64	
1	10	15	3882.15	25751.65	
2	20	30	3878.75	25774.22	
		15	3869.74	25834.23	
		15	3868.56	25842.11	
1	15	30	3865.58	25862.03	
3	40	20	3864.97	25866.11	
		20	3863.40	25876.63	
		0	3862.29	25884.06	
		0	3862.06	25886.41	
		10	3860.56	25895.66	
1	30	20	3859.74	25901.16	
1		15	3850.03	25966.49	
	20		3849.4	25970.7	
4	30	30	3842.21	26019.33	
8	80	500	3840.29	26032.34	II
		10	3837.24	26053.03	
		5	3833.49	26078.52	
		15	3831.69	26090.77	
4	30	200	3830.42	26099.42	
		2d	3827.04	26122.47	
		1	3826.83	26123.90	
3	50	100	3825.27	26134.56	
3	1	100	3824.44	26140.23	
2	20	30	3822.95	26150.42	
0		15	3814.60	26207.66	
4	50	500	3812.65	26221.06	
2	10	30	3810.57	26235.37	
		5	3809.47	26242.95	
		20	3809.02	26246.33	

List (continued)

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
0		20	3807.98	26253.22	II
8	50	200	3806.31	26264.73	
		30	3804.87	26274.68	
	50	20	3803.27	26285.73	
	30	10	3801.79	26295.96	
	30	100	3801.06	26301.01	
		10	3795.36	26340.51	
0		20	3789.21	26383.26	
1	30	20	3785.01	26412.54	
1		20	3778.35	26459.09	
1	10	30	3776.95	26468.90	I
0	30	10	3776.56	26471.63	
1		30	3775.65	26478.31	
3	20	50	3770.81	26512.00	
0		20	3766.56	26541.91	
		20	3765.28	26550.94	
2		50	3757.93	26602.86	
4	30	1000	3756.65	26611.93	
3		500	3755.04	26623.34	
4	30	100	3748.63	26668.86	
	20	20	3745.06	26694.28	
	30	100	3739.91	26731.04	
		10	3737.90	26745.41	
0	10	15	3732.64	26783.10	
2	20	50	3730.34	26799.61	
		50	3729.33	26806.81	
	10	15	3727.31	26821.40	
		15	3724.43	26842.14	
5	80	1000	3720.34	26871.65	
1	20	100	3717.52	26892.03	
4	40	1000	3713.68	26919.84	
1	20	100	3705.80	26977.08	
		30	3704.10	26989.46	
4	80	1000	3703.48	26993.98	
		20	3702.81	26998.86	
3	30	200	3695.17	27054.68	
5	50	500	3693.38	27067.80	
		10	3692.07	27077.40	
4	30	100	3687.93	27108.79	
	50	1000	3683.39	27140.47	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
		1	3682.54	27147.47	
2	30	300	3677.29	27186.23	
9	80	1000	3668.18	27253.75	
2	40	100	3661.70	27301.97	
1	25	80	3657.43	27333.84	
1	10	15	3653.60	27362.50	
4	80	500	3647.65	27407.13	
		1	3639.84	27465.94	
		50	3637.88	27480.74	
3	60	100	3635.53	27498.50	
7	60	1000	3631.96	27525.52	
1	10	100	3629.95	27540.77	
		1	3627.04	27562.86	
9	50	1000	3624.18	27584.61	
5	30	500	3620.36	27613.72	
3	40	100	3615.20	27653.13	
		100	3614.31	27659.94	
	1	5	3612.91	27670.66	
2	15	80	3612.07	27677.09	
2	5	100	3601.18	27760.79	
2	50	500	3598.88	27778.53	
2	10	10	3595.23	27806.73	
2	10	20	3587.43	27851.66	
	8	100	3588.44	27859.34	
0	10	10	3581.66	27912.08	
6	50	1000	3580.70	27919.56	
		100	3576.69	27950.08	
1	15	5	3575.89	27957.12	
	8d	20	3572.70	27982.08	
	8		3569.5	28007.6	
8	50	500	3562.46	28062.50	
0	10	10	3556.80	28107.16	
		5	3556.12	28112.54	
0	8	15	3555.32	28118.86	
3	20	1000	3553.19	28135.72	
	6	5	3547.92	28177.50	
0	8		3544.9	28201.2	
4	25	100	3539.09	28247.81	
5	50	200	3536.86	28265.62	
3		50	3531.16	28311.24	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
6	50	1000	3530.80	28314.13	
4		40	3529.39	28325.44	
		1	3528.91	28329.29	
	4	15d	3525.26	28358.62	
		10	3520.01	28400.92	
1	10	20	3519.69	28403.50	
1		8	3519.05	28408.67	
0		5	3515.99	28433.39	
	10d	10	3515.63	28436.30	
		30	3514.38	28446.42	
		30	3514.19	28447.95	II
0		20	3512.76	28459.53	
		10d	3511.68	28468.29	
	8	100	3511.16	28472.50	
0	2	0	3510.20	28480.29	
0	5	20	3508.84	28491.33	
	10	8	3507.35	28503.43	
	6d	50	3503.61	28534.02	
1	4	30	3499.23	28569.57	
0	10	15	3498.91	28572.16	
		5	3494.86	28605.29	
		1	3494.12	28611.35	
		15	3493.13	28619.46	
		20	3492.97	28620.77	
5	30	500	3492.41	28625.36	
2		50d	3490.74	28639.05	
1	6	20	3484.29	28692.07	
	6	40	3480.52	28723.15	
0		30	3478.95	28736.11	
		10	3478.49	28739.91	
		30	3476.76	28754.21	
		20	3476.33	28757.76	
		30	3475.18	28767.28	
0		20	3471.03	28801.67	
	8	5	3465.90	28844.30	
2	25	30	3462.26	28874.63	
		10	3461.42	28881.64	
0		10	3460.17	28892.07	
0		15	3459.12	28900.84	
0	2	25	3458.15	28908.95	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
		20	3456.47	28923.00	
	20	20	3455.77	28928.85	
	2	20	3454.35	28940.75	
		10	3454.12	28942.67	
		15d	3447.27	29000.18	
0		10	3446.54	29006.32	
0	8	15d	3446.21	29009.10	
		15	3445.01	29019.21	
	6	20	3444.74	29021.58	
		5	3444.63	29022.41	
0		0	3441.72	29046.94	
0	8d	5	3439.96	29061.81	
3	8d	20	3434.39	29108.94	
1		10d	3433.01	29120.64	
0	6	10	3428.81	29156.31	
2	12	30	3426.09	29179.45	
	8d	1	3423.42	29202.21	
	1 0d	1	3417.69	29251.15	
	5		3414.0	29282.8	
	5	10	3410.99	29308.62	
0	5		3405.7	29354.2	
		30	3404.31	29366.30	
	20	100	3403.85	29370.10	
	8	1	3394.42	29451.69	
		0	3393.00	29464.02	
	4	20	3389.81	29491.74	
2		1	3382.86	29552.33	
	10	15	3382.09	29559.06	
		5	3380.56	29572.44	
	15	10	3374.01	29629.84	
1		1	3373.74	29632.21	II
1		1	3363.54	29722.08	
1	5	10	3361.36	29741.35	
		50	3358.54	29766.32	
		5d	3355.24	29795.59	
		10d	3351.14	29732.04	
		15d	3350.95	29733.74	
3		50	3345.94	29778.41	I
6		100	3345.57	29782.07	I
8	500	300	3345.01	29886.71	I

List (continued)

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
		5	3344.76	29888.95	
	5	5	3339.57	29935.39	
	2	15	3336.83	29959.98	
3	30	100	3334.85	29977.76	
	5		3329.9	30022.2	
1		1	3326.50	30053.01	
	4	1	3320.07	30111.21	
2	20d	40	3317.15	30137.72	
		1	3316.95	30139.54	
		1	3316.45	30144.08	
		1	3316.18	30146.53	
	3	0	3314.25	30164.09	
	5	1000	3311.25	30191.42	
		0	3308.63	30215.32	
5	75	1000	3306.04	30288.99	II
		0	3304.14	30256.38	
5		50	3302.94	30267.37	I, II
5		200	3302.54	30271.04	I
	150	500	3301.86	30277.27	
		3d	3300.11	30293.51	
4	50	1000	3299.40	30299.85	II
0		10	3298.05	30312.25	
	5	0	3294.85	30341.69	
	5	0	3289.7	30389.2	
1	15	10d	3288.60	30399.35	
	5		3285.6	30427.1	
		40	3282.33	30457.42	I
	4	10	3279.72	30481.67	
3	20	20	3276.57	30510.98	II
	4		3274.9	30526.5	
	4d	1	3273.22	30542.18	
		0	3272.89	30545.26	
0		0d	3272.54	30548.53	
	10	5	3269.95	30572.73	
3	20	20d	3266.26	30607.26	
		15d	3265.33	30615.98	
1	15		3263.5	30633.2	
		10	3262.08	30646.48	
	6	1	3261.19	30654.94	
0		5d	3259.23	30673.28	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
		8	3259.12	30674.69	II
	10	10	3258.77	30677.61	
3	30	15	3255.58	30707.67	
1	20d	1	3252.98	30732.21	
	6	15	3249.84	30761.90	
		0	3249.61	30764.08	
		10	3249.45	30765.59	
3	5	30	3247.90	30780.28	
3	30	20	3245.07	30807.12	
		10	3243.73	30819.84	
3	15	15	3240.24	30853.04	
	10	5	3238.28	30871.71	
		0	3237.25	30881.53	
4	20	20	3233.98	30912.76	
1	20	10	3231.61	30935.43	
	3	5	3227.32	30976.55	
	2	3	3223.41	31014.12	
	2		3222.8	31020.0	
	2		3218.4	31062.4	
	3		3212.8	31116.5	
1	30d	1d	3209.90	31144.65	
		0	3209.55	31148.05	
0	30d		3205.7	31185.5	
	10d	10d	3200.79	31233.29	
		10	3197.12	31269.14	
7	300	20	3196.32	31276.97	II
	15d	10	3192.14	31317.92	
	15d	1	3188.97	31349.06	
1	30d	10	3185.92	31379.06	
		5	3185.76	31380.63	
		0	3185.51	31383.10	
	10d	3	3182.21	31415.64	
	5d	0	3180.62	31431.35	
	30	20	3178.59	31451.42	
1	15	5	3177.58	31461.42	
3	50	10	3175.84	31478.65	
8	100	15	3172.23	31516.46	
1	100	15	3171.45	31522.23	
	10		3168.7	31550.0	
	30	10	3165.50	31581.48	II?

List (continued)

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
		10	3165.35	31583.97	
	30		3158.9	31648.5	
	30d	5	3153.44	31702.25	
	10d	5	3149.18	31745.13	
	5d		3147.8	31759.0	
	10d		3141.7	31820.6	
0	30d		3138.7	31851.1	
	20d	0d	3134.68	31891.97	
	20d		3129.6	31943.2	
0	10d	5	3128.15	31958.54	
	20d		3125.7	31983.5	
	30	10	3121.58	32025.80	
	10d		3118.6	32056.4	II
1	20d		3111.3	32131.6	
	5d		3108.1	32164.7	
1	10d		3105.2	32194.7	II
1	40	2	3097.13	32278.62	
	20	20	3093.43	32317.22	
2	8		3091.7	32335.31	III
	30	15	3086.14	32393.56	
	6d		3079.7	32461.3	
	15	5	3078.14	32477.75	
5	100	50	3075.91	32501.29	
5	200	50	3072.7	32541.91	
		10	3064.74	32619.74	
	4	0	3063.39	32634.12	
2	15d	10d	3060.50	32664.93	III
	15		3059.1	32679.3	
	20	15	3054.76	32726.31	III?
		10	3054.58	32728.24	
0	8		3049.8	32779.5	
	4		3048.4	32794.6	
	30	1	3046.5	32819.88	
	30	1	3043.89	32843.17	
	10		3042.8	32854.4	
4	100	100	3035.73	32931.45	I
	8d		3031.8	32974.1	
	8d	15	3028.89	33005.81	
	6d		3027.0	33026.4	
1	50	70	3025.31	33044.87	III

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
2		15	3024.45	33054.27	III
1		40	3023.96	33059.59	
	10	15	3023.53	33064.33	I
4	60	50	3018.34	33121.17	
	10d		3009.7	33215.9	
	30	50	3002.64	33294.35	
2	100d		2997.8	33348.1	
0	50	5	2992.16	33410.96	
	15	5	2990.68	33427.49	
	8d	20	2988.80	33448.51	
	20	5	2987.64	33461.50	
	20		2986.4	33475.4	
	30	1	2983.78	33504.79	
	10d		2979.1	33557.4	
	5		2977.2	33578.8	
0	10d		2964.3	33725.0	
	20d		2962.8	33742.0	
2	10d	15	2960.25	33771.09	
3	40	10	2956.69	33811.74	
		5	2956.54	33813.47	
	10	15	2953.87	33844.03	
		15	2953.18	33851.94	
0	20	10	2952.79	33856.41	
0	20	5	2750.43	33883.49	
	5		2945.6	33938.5	
	5		2944.8	33948.3	
	10	10	2942.92	33969.95	
3	30	20	2942.26	33977.57	
	5		2939.8	34006.0	
3	40	30	2935.34	34057.67	
	6		2934.2	34070.3	
	4	5	2932.87	34086.35	
	30	5	2930.15	34116.82	
	15d	2d	2926.01	34166.26	
	40	10	2916.55	34177.07	
2	40	10	2916.11	34282.25	III
	30	0d	2912.95	34319.43	
4	100	15	2902.30	34345.36	
	30		2899.4	34379.8	
	10d	15	2892.81	34458.24	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
		10	2892.02	34467.80	
	10d		2891.6	34473.4	
	50d	10	2887.67	34619.87	
	10	5	2885.49	34646.02	
	40	15	2884.50	34657.91	
		10	2884.23	34551.16	
		5	2883.92	34664.88	
3	50	10	2882.16	34686.05	
	20	10d	2881.19	34697.73	
3	30	15	2879.83	34714.11	
		10d	2879.31	34720.38	
	10		2878.7	34727.7	
	10	1	2877.25	34745.24	
		10	2876.10	34759.13	
4	100	15	2875.68	34764.21	
		15	2875.53	34766.02	
1	25	5	2872.18	34806.57	
		5	2871.87	34810.32	
	10		2871.2	34818.4	
	20		2868.6	34850.0	
	10		2867.2	34867.0	
0	30d	10	2866.16	34879.67	
		10	2865.67	34885.64	
1	20	5	2864.35	34901.71	
0	10		2862.6	34923.7	
	10		2861.8	34932.2	
0	10		2860.1	34953.0	III
	25	1	2859.60	34959.68	
	50d	10	2857.59	34984.27	
	15	10	2855.32	35012.08	
	20	15	2853.84	35030.33	
	40	15	2853.04	35040.06	
	20	5	2852.09	35051.73	
4	100	30	2849.22	35087.04	
		20	2848.96	35090.24	
	25	1d	2845.08	35138.09	
		1d	2844.86	35140.80	
	8		2842.9	35164.4	
0	10d	5	2841.57	35181.49	
3	50	15	2838.66	35217.56	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
4	20	100d	2837.61	35230.59	III
4	20	500d	2836.70	35241.89	
2	30	10d	2832.50	35294.14	
	8		2829.7	35328.4	III?
	10	5	2826.57	35368.18	
	4	2	2824.63	35392.47	
0	20	15	2821.09	35435.63	
	10	15d	2816.07	35500.05	
	15	1	2815.35	35509.13	
	30	10d	2809.44	35583.82	
	20	2	2804.72	35643.70	II
4	200	50	2801.94	35679.07	I
		15	2801.05	35690.40	II
6	200	50	2800.86	35692.82	II
		20	2800.74	35694.35	I
	10		2798.6	35721.6	
	10	5	2796.66	35746.42	
0	10d		2793.3	35789.4	
	10	10	2788.82	35846.91	
		5	2788.67	35848.84	
1	20	10	2786.14	35881.38	III
	5	1	2784.41	35903.68	
		10	2783.53	35915.03	
2	30	30	2782.81	35924.32	II
	4	10	2782.16	35932.72	
		1	2781.69	35938.79	
		5	2781.55	35940.60	
		30	2781.26	35944.34	
			2779.0	35973.3	
2	15		2775.24	36022.30	
	5	5			
		20	2770.98	36077.88	I
3	100	30	2770.86	36079.25	I
1		10d	2768.49	36110.13	II
	15d	15	2767.66	36120.96	
1	5	15	2766.72	36133.23	
0	30	10	2763.96	38169.31	
	15	1	2762.18	36192.62	
1	10	15	2761.29	36204.28	
0	20	10	2758.85	36236.30	
	2	1	2757.60	36252.72	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A	cm ⁻¹	
2	40	50	2756.46	36267.72	I
1	40	20	2755.15	36284.96	
	30	30	2753.93	36301.03	
	6	1	2751.82	36328.87	I
0	10	10	2751.31	36335.60	
	10		2747.0	36392.6	
1	10		2746.5	36399.2	
	5		2746.4	36400.6	
	4d		2745.2	36416.5	
1	10d	10	2740.94	36473.06	
		5	2738.46	36506.09	
	30	10	2738.32	36507.96	
	2d	1	2737.78	36315.16	
	5		2737.4	36520.2	
	1		2736.3	36534.9	
	10		2735.6	36544.3	
2	30d	10d	2733.99	36565.78	
	5		2732.9	36580.4	
	1		2732.0	36592.4	
	10		2729.8	36621.9	
	15	10	2727.56	36651.97	
3	15	20	2727.12	36657.88	
	10		2724.6	36690.8	
	10		2722.3	36722.8	
		20	2721.27	36736.68	
5	50	50	2720.76	36743.57	III
0	10		2719.7	36757.9	
	10	15	2718.64	36772.22	
	2		2717.9	36782.9	
	5		2716.9	36795.8	
	2		2716.2	36805.3	
0	5d	0	2715.50	36814.74	
	100	20	2712.83	36850.97	I
0		15	2712.48	36855.72	
	5	10	2711.65	36867.00	
3	30	15	2709.59	36895.03	III
		5	2708.76	36906.43	
3	40	10	2708.64	36909.06	
		10	2706.92	36031.42	
1	20	10	2706.72	36934.15	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
		10	2705.68	36948.35	
2	20	20	2705.52	35950.53	
	15	15	2704.42	36965.56	
	2d		2703.5	36978.1	
	10		2702.6	36990.5	
	5		2701.6	37004.1	
2	20	10	2701.16	37010.17	
	10	0	2700.19	37023.46	
4	50	10	2699.42	37034.02	
	5	5	2698.70	37043.90	
	5		2697.4	37061.8	
		10	2696.08	37079.90	
3	50	20	2695.96	37081.68	III
	20	20	2694.53	37101.23	
4	30	50d	2693.89	37110.04	
		10	2692.75	37125.75	
3	40	20	2692.59	37127.36	
	5		2692.1	37134.7	
	2		2691.2	37147.1	
	2		2690.6	37155.4	
0	10	0	2689.83	37166.05	
0	15	10	2688.31	37187.06	
1	10		2687.8	37194.1	III
	5		2686.0	37219.0	
	2		2685.5	37226.7	
0	10	10d	2684.95	37233.60	III
		5	2684.18	37244.28	
	50	30	2683.99	37246.92	
	20	50	2683.33	37256.08	
	20	50	2682.81	37263.30	
	15		2681.2	37285.7	
2	20	10	2680.59	37294.16	
1	15		2679.4	37310.7	
1	15	1d	2678.46	37323.81	
	15		2675.9	37359.5	
1	15	20	2675.30	37367.90	
		10	2674.72	37376.00	
	2	20	2674.19	37383.40	
	5		2673.9	37387.5	
3	20	15	2673.12	37398.37	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	$\text{\AA}$	cm^{-1}	
	5	5	2672.45	37407.74	I
	10		2671.7	37418.2	
1	50	30	2670.56	37434.22	
0	10		2669.4	37450.5	
2	50	200	2668.25	37465.62	
		10	2667.89	37471.68	
	10	40	2666.67	37488.82	
	20	15	2666.22	37494.30	
		5	2665.75	37501.72	
2	30		2664.91	37513.58	
2	20	30	2663.54	37532.69	
	10	15	2662.78	37543.58	
	5d	15	2661.85	37556.70	
0		5	2661.66	37559.38	
	10	20	2661.49	37561.78	
	10	15	2660.68	37573.21	III
3	40	100	2659.68	37587.34	
	15	50	2658.65	37601.90	
		10	2658.46	37604.59	
5		15	2658.28	37607.13	
	30	30	2658.15	37608.97	II
		1	2657.65	37616.04	
	5d	1	2657.40	37619.59	
		1	2657.26	37621.57	
	10	0	2657.08	37624.12	
3	30	20	2655.16	37651.32	
		10	2655.10	37652.17	
	10	15	2654.41	37661.96	
0	10d	35	2653.16	37679.70	
		10	2652.94	37682.83	
	1	5	2652.25	37692.63	
	10	50	2651.54	37702.72	
4	30	100	2651.08	37709.26	
		15	2650.60	37716.09	
		20	2650.45	37718.23	
	50	50	2650.05	37723.92	
4		30	2649.83	37727.05	
	5	8	2649.49	37731.89	
0	10	15	2647.79	37756.12	
		10	2647.44		

Intensity			wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
0	10	1	2646.68	37771.95	
0	15	40	2645.59	37787.51	
1	15	50	2644.58	37801.94	
	1	1d	2643.34	37819.68	
2	10	5	2641.91	37840.14	
		30	2641.70	37843.15	
	15	5	2641.42	37847.16	
3	50	500	2640.34	37862.64	
	2	10	2638.48	37889.33	
1	5	20	2637.92	37897.37	
	10	30	2637.39	37904.99	
		5	2636.93	37911.60	
		10d	2636.34	37920.08	
1	30	50	2636.22	37921.81	
0	2		2633.5	37961.0	
0	5	20	2632.93	37969.20	
	10	50	2632.36	37977.41	
0		1	2630.88	37998.78	
	10d	15	2630.73	38000.96	
0	15	20	2630.05	38010.77	
		15d	2629.66	38016.40	II
		20	2629.38	38020.45	
	20	40	2629.09	38024.66	
0	10	15d	2628.36	38035.21	
		20	2627.40	38049.10	
2	30	20	2627.19	38052.14	
	10d	15	2626.29	38065.18	
		10	2625.94	38070.26	
		5	2625.82	38072.00	
	15		2624.7	38088.2	
	1d	1	2623.04	38112.35	
		5	2622.80	38115.83	
	15	30	2622.17	38124.99	
	15	15	2621.97	38127.86	
3d		10	2621.82	38130.08	
	15	40	2621.65	38132.55	
	10	10d	2621.20	38139.10	
	15		2619.6	38162.4	
	15	20	2619.10	38169.67	
		20	2618.96	38171.62	

List (continued)

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
5d	15	50	2618.66	38176.08	
	10		2617.9	38187.2	
3v	15	10	2617.40	38194.46	
	30	30	2615.84	38217.25	
		15	2615.72	38219.00	
	15	20	2614.47	38237.27	
	10	20	2613.41	38252.77	
		20	2613.22	38255.56	
2d		10	2612.93	38259.80	
	20	30	2612.80	38261.70	
	5	15	2612.21	38270.34	
	15	15	2611.68	38278.01	
		1	2611.33	38283.24	
	30	50	2610.62	38293.65	
2		10	2608.64	38322.71	
1d	300	20	2608.54	38324.18	I
1	20	10	2607.10	38345.35	
	15	5	2606.21	38358.44	
0	15d	30	2605.67	38366.39	
		10	2605.37	38370.81	III
1		5	2604.15	38388.78	
	30	20	2603.99	38391.14	
		20	2603.79	38394.09	
	10	5	2603.19	38402.94	
		5	2602.28	38416.37	
3	50	100	2600.94	38436.16	I
		20	2600.66	38439.11	
	10	10	2600.47	38443.11	
	10	10	2599.88	38451.83	
	10	5	2599.22	38461.59	
	50	30	2597.06	38493.58	III
0	10	10	2595.91	38510.63	
1	10d	15	2593.91	38540.32	
5	50	500	2592.93	38554.89	
	10d	10	2592.25	38565.00	
	20	50	2591.16	38581.23	
1	30	80	2590.39	38592.69	
2	20	80	2589.91	38599.84	
1	15	15	2588.40	38622.36	
	10	10d	2587.78	38631.61	

List (continued)

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
1	10	30	2586.84	38646.65	I
	50	80	2586.08	38657.01	
		10	2585.57	38664.63	
0	10d	20	2585.22	38669.86	
3		15	2582.49	38710.74	
0	300	30	2582.43	38711.64	I
		30	2582.14	38715.99	
	10	10	2580.43	38714.64	
	10	5	2579.87	38750.05	
	20	10d	2578.78	38766.43	
	10	5d	2577.61	38784.02	
	5	10	2577.20	38790.19	
7	500	500	2575.79	38811.43	
		200	2575.36	38817.91	
	1		2572.0	38867.9	
	30	20	2571.28	38879.49	II
1	30	30	2570.66	38888.87	
2	50	20	2569.87	38900.83	I
	50	30	2567.98	38929.45	II
2	50	10	2567.79	38932.33	
		20	2566.70	38948.87	II
	30	30	2564.46	38982.89	
		10	2562.61	39011.20	I
		20	2558.46	39074.30	II
6	1000	1000	2557.94	39082.24	
		30	2556.23	39108.34	II
		5	2554.96	39127.82	
2	50	20	2554.28	39138.24	
	10		2553.4	39151.7	II
3	50	20	2552.54	39164.92	
	10d	30	2551.39	39182.57	II
	1	1	2549.91	39205.31	
1	50	10	2547.47	39242.86	
	1	10d	2546.09	39264.13	II
1	20	20	2545.52	39272.92	
	5		2545.0	39280.9	I
	10	5	2544.21	39293.14	
2	50	10	2542.39	39321.27	
		5	2542.26	39323.28	
	50	30d	2541.68	39332.25	

List (continued)

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A ^o	cm ⁻¹	
	10	20	2540.40	39352.07	
	50	50	2539.25	39369.89	
	10	10	2537.93	39390.36	
		3	2536.01	39420.18	
	100	100	2535.73	39424.54	
1	100	40	2534.58	39442.42	
	10	20d	2533.77	39455.05	
3d	100	50	2533.16	39464.53	
2	100	50	2531.96	39483.23	
	15	20d	2530.18	39511.00	I?
		10	2529.82	39516.63	
	20	20	2528.49	39537.41	
	50	15	2527.83	39547.74	
		5	2527.57	39551.80	
5	100	40	2526.85	39563.07	
	20	10	2526.25	39572.46	
		10	2526.02	39576.07	
	10		2525.4	39585.8	
	2		2525.0	39592.1	
5	100d	100	2522.06	39638.20	
		25	2521.99	39639.3	
	30	15	2520.57	39661.63	
2		10	2520.41	39664.15	
	10d	10	2519.14	39684.15	
	5d		2518.2	39699.0	
		40	2515.93	39734.77	
4		100	2515.77	39737.30	I
2	100	50	2515.03	39748.99	
		8	2514.70	39754.21	
	10	10d	2513.28	39776.67	
	30	100d	2512.06	39795.99	
		40	2509.78	39832.13	
7	1000	80	2509.03	39844.08	
1		15	2508.19	39857.38	
	50	50	2508.09	39858.97	
	10	5	2506.69	39881.23	
	1		2506.1	39890.6	
	15	1	2504.93	39909.25	
	5		2504.5	39916.1	
		20	2504.22	39920.57	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
6	15	30	2504.11	39922.32	II
	20	50	2503.28	39935.55	
	1000	1000	2501.98	39956.30	
		15	2501.66	39961.41	
		10	2501.54	39963.33	
1 0 2	10	10	2498.33	40014.68	
	50	50	2497.82	40022.85	
	50	50	2497.13	40035.51	
	50	100	2496.18	40049.14	
	15	20	2495.39	40061.82	
3	1		2494.2	40080.9	I
	20	1	2493.46	40092.82	
		500	2492.05	40115.51	
		20dd	2491.57	40122.91	
4	1000	1000	2491.20	40129.19	
5	5		2489.8	40151.8	
	5	3	2488.88	40166.60	
	5	0	2488.05	40167.08	
	10		2487.3	40192.1	
	100	200	2486.87	40199.05	
3	100	100	2486.16	40210.53	II
	5	5	2485.03	40228.82	
4	100	100	2484.53	40236.91	
		30	2484.36	40239.67	
	15	15	2484.06	40244.53	
5	1d		2483.2	40258.5	I
	15	10	2480.72	40298.71	
	1000	100	2479.80	40313.66	
	25	10	2478.70	40331.55	
		10	2478.55	40333.98	
2	1d		2477.3	40354.3	
	5		2476.5	40367.4	
	10	5	2476.08	40374.22	
	20	50	2473.82	40411.10	
	50	100	2473.28	40419.93	
2	50	100	2472.63	40430.55	
1?	15	15	2472.46	40433.33	
	10	5	2470.25	40469.50	
		3	2469.98	40473.92	
	20	5	2469.50		

List (continued)

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
3	50	500	2468.87	40492.12	I
		5	2467.70	40511.31	
	5		2467.5	40514.6	
	100	1000	2467.05	40521.99	
	2	0d	2465.04	40555.02	
5	1000	80	2463.65	40577.90	
		10d	2463.52	40580.05	
		100	2463.30	40583.67	
		30	2462.56	40595.86	
		50	2462.01	40604.93	
3	50	10	2460.92	40632.95	I
		50	2460.42	40631.17	
		10	2458.00	40671.17	
		20	2456.01	40704.12	
		1	2455.51	40712.41	
2	50	1d	2454.92	40722.19	
		2	2454.4	40730.8	
		0	2454.03	40736.96	
		5	2454.39	40747.59	
		5	2452.97	40754.56	
6	500	10	2452.02	40770.35	I
		2	2451.90	40772.35	
		10	2451.22	40783.66	
		500	2450.27	40800.47	
		20d	2449.72	40808.63	
1	40	15	2449.44	40813.29	
		30	2448.17	40834.47	
		10	2447.76	40841.30	
		20	2447.53	40845.14	
		5d	2447.04	40853.32	
4	50	5	2446.16	40868.04	I
		10	2445.5	40879.0	
		100	2444.93	40888.57	
		0d	2443.52	40910.49	
		5	2442.64	40926.90	
7	100	5	2442.54	40928.48	
		100	2441.96	40938.30	
		10d	2440.19	40967.99	
		15	2439.5	40979.6	
		20	2438.72	40992.68	

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
5	50	50	2438.17	41001.93	II
4	50	80	2437.48	41013.54	
	10	20	2436.92	41022.96	
2	15	10	2435.80	41041.82	
2	10	40	2435.45	41047.72	
		20	2434.51	41063.56	II
4	100	100	2434.27	41067.61	
	5	1	2433.20	41085.67	
0	10	5	2432.74	41093.44	
0	30	10d	2431.09	41121.33	
	5	10dd	2429.46	41148.91	
	20	20	2429.07	41155.52	
		0	2428.90	41158.40	
		10	2427.50	41182.14	
		10	2427.13	41188.41	
10	500	500	2426.94	41191.64	I
		10	2426.79	41194.18	
	15d	10d	2426.31	41202.33	
	10	1	2425.47	41216.60	
	10	8	2422.79	41228.16	
	10		2424.3	41236.5	
	20	100	2423.97	41242.11	
	10	10	2423.54	41249.42	
6	50	500	2423.33	41253.00	
	20	6	2422.92	41259.98	
		3	2422.74	41263.04	I
	15	5	2421.94	41276.67	
1	50	100	2420.73	41297.30	
	10		2419.9	41411.5	
10	300	1000	2418.73	41331.54	
	2		2417.7	41349.0	
	2		2416.9	41362.7	
	2	3	2416.30	41373.01	
		1	2416.00	41378.14	
		6	2415.87	41380.37	
	100	10	2415.66	41383.87	I
		2	2415.49	41386.88	
	2	5	2415.07	41394.08	
	15	10	2413.22	41425.81	
	5	5	2411.79	41450.37	

List (continued)

Intensity			Wavelength (air)	Wave Number (vac.)	Class
B	P	G	A°	cm ⁻¹	
		4	2411.09	41462.40	
	20	15	2411.01	41463.78	
		10	2410.86	41466.36	
	15	5	2409.10	41496.65	I
6	100	100	2408.45	41507.85	
	5	1	2408.11	41513.71	I
4	50	15	2405.21	41563.75	
		10	2405.01	41567.21	
	30	20	2404.61	41574.12	
	0	2	2403.86	41587.09	
	1	5	2403.40	41595.05	
	2	1d	2402.87	41604.23	I?
	10	20	2402.45	41611.50	
	50	50	2401.49	41628.14	
	2dd?		2400.3	41648.8	
	15	10	2399.22	41669.25	I
	50	50	2398.82	41674.46	
	1	8	2398.35	41683.62	
	15d		2397.1	41704.4	I
2	50	25	2396.55	41713.93	
	15	3	2395.67	41729.26	
	2		2395.5	41732.2	
	10d		2393.8	41761.8	
4	50	80	2393.03	41775.29	
1	20	30	2391.59	41800.44	
0	20	30	2390.04	41827.54	
0	20	30	2390.87	41813.02	
	10	10	2387.22	41876.95	
	5		2387.0	41880.8	
	10		2386.7	41886.1	
	2		2386.1	41896.6	
	30		2383.6	41940.5	
	2	2	2383.27	41945.35	
0	2		2382.7	41956.4	

BIBLIOGRAPHY

1. H. Beutler, K. Gugenheimer, Zeit. f. Phys., 87, 176, 1933
2. L. Bloch, E. Bloch, J. Phys. et Radium, (7) 5, 289, 1934
3. W. Grotrian, O. Laporte, E.A. Milne, K. Wurm, "Grundlagen der Astrophysik", J. Springer, Berlin, 1930
4. G.R. Harrison, "M.I.T. Wavelength Tables", John Wiley and Sons, New York, 1939
5. G. Herzberg, "Atomic Spectra and Atomic Structure", Dover Publications, New York, 1944
6. C.W. Hetzler, R.W. Boreman, K. Burns, Phys. Rev. 48, 656, 1935
7. P.N. Kalia, Ind. J. Phys., 10, 463, 1936
8. H. Kayser, "Tabelle der Hauptlinien der Linienspektren aller Elemente", J. Springer, Berlin, 1939
9. O. Laporte, R.J. Lang, Phys. Rev. 30, 378, 1927
10. K.C. Mazumder, Ind. J. Phys. 10, 171, 1936
11. W.F. Meggers, J. Opt. Soc. Am. 36, 1946
12. C.E. Moore, "Atomic Energy Levels", V.1, (1949) and V.2, (1952), National Bureau of Standards.
13. C.R. Nisenwanger, J.R. Holmes, G.L. Weissler, J. Opt. Soc. Am. 36, 581, 1946
14. F. Paschen, R. Ritschl, Ann. der Phys. (5), 18, 890, 1933
15. G.V. Salis, Ann. der Phys. (4), 16, 145, 1925
16. R.A. Sawyer, "Experimental Spectroscopy", Prentice-Hall, New York, 1946
17. (a) H. Schuler, Zeit. f. Phys. 35, 323, 1926
(b) H. Schuler, Zeit. f. Phys. 59, 149, 1929
18. H. Schuler, H. Gollnow, Zeit. f. Phys. (5) 93, 621, 1935
19. Y. Takahashi, Ann. der Phys. (5) 3, 27, 1929
20. H.E. White, "Introduction to Atomic Spectra", McGraw-Hill, New York, 1934