V. *Measurements of the Wave-lengths of Lines of High Refrangibility in the Spectra of Elementary Substances.*

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[Plates 4–6.]

Introduction.

In the Philosophical Transactions, Vol. 170, pp. 257–274, 1879, one of us has described, in conjunction with Mr. A. K. Huntington, the first use of dry gelatine films, sensitised with silver bromide, for photographing ultra-violet spectra; and the application of the almost continuous spectrum emitted by the metals iron, nickel, and copper to the purpose of examining the ultra-violet absorption spectra of organic compounds. These researches, up to the present* time, have been prosecuted under considerable disadvantages, owing to the impossibility of describing accurately either absorption or emission spectra, by reason of the data for calculating wave-lengths being unfortunately insufficient. The object of this work is to give an exact description of the photographed spectra of some sixteen elementary substances, and to place on record the wave-lengths of so large a number of well-defined metallic lines, together with such other measurements of spectra, that subsequent workers may experience no difficulty in constructing interpolation curves capable of yielding fairly accurate numbers representing wave-lengths. The first measurements of rays of high refrangibility made by means of photography were the determinations of the wave-lengths of the lines of cadmium by M. Mascart ('Annales de l'École Normale,' vol. iv., 1867). He made use of a Nobert's grating, a goniometer, and a photographic eye-piece. In addition to the splendid map of the ultra-violet portion of the solar spectrum given us by M. Cornu, we have wave-lengths most carefully calculated for a series of lines in the spectra of the metals cadmium, magnesium, aluminium, and zinc ('Annales de l'École

* Proc. Roy. Soc., xxxi., pp. 1–26. Journ. Chem. Soc., xxxix., pp. 57–60, and pp. 111–128; xxxvii., pp. 676–678, &c.

Normale,' vol. ix., 1880; and 'Archives des Sciences Physiques et Naturelles de Genéve,' (3), ii., pp. 119–126). Messrs. LIVEING and DEWAR, with an improved goniometer and a RUTHERFURD grating, have estimated the wave-lengths of the lines of carbon by a modification of MASCART'S method (Proc. Roy. Society, vol. xxxii., 1882). As each line must be discussed independently of the rest of the spectrum and photographed on a different plate, and as the relative positions of the lines on the photographs are varied by very slight alterations in focus and by the removal and replacement of the plates, we have been led to apprehend that there are grave objections to this method of manipulation. The process, moreover, appears to be a lengthy one. In accordance with these views, which are the result of long experience, we have preferred to employ a method similar to that of CORNU.*

As much of each spectrum as possible is photographed on one plate, and together with this a series of ideal lines or plain reflections of the slit, each corresponding to a measured angular deviation, from which a scale of wave-lengths may be calculated.

The instruments.—For the production of spectra we have used one of Mr. RUTHERFURD'S small diffraction gratings. This was mounted on a stand made six years ago by Mr. BROWNING, the telescope and collimator of which are fixed, and the grating movable. A tangent screw is used to give an angular motion to the grating, and measurements are made upon a divided arc of 9 inches radius. The position of the grating can be fixed at any required angle without the necessity of clamping. The original telescope and collimator fitted with glass lenses were removed from the stand, and replaced by a collimator and two lenses of 36 inches focus for the D lines. The material of the lenses was quartz, one of right- the other of left-handed rotation. Unless the lenses are approximately of the same thickness and correct one another, all fairly strong lines, whether produced by a prism or grating, are liable to be doubled, that is to say, accompanied by faint images resembling the "ghosts" that are seen when strong lines are viewed with a RUTHERFURD grating. The distance of the lenses from the grating was about 3 inches. Their considerable focal length gives an approximately flat field over a wide range of the spectra. Instead of a telescope, the photographic camera described in the Scientific Proceedings of the Royal Dublin Society, vol. iii. ("Description of the Instruments and Processes employed in Photographing Ultra-violet Spectra," 1881, W. N. HARTLEY) was altered and adjusted for use with the grating. The table upon which it was supported consisted of a large and massive slab of slate, immovably set upon solid stone foundations.

In taking photographs from metallic electrodes, it is of some importance that the spark be always in exactly the same position with regard to the slit, otherwise the relative positions of the lines are liable to variation; we have, therefore, always used an electrode of cadmium immovably fixed opposite to the slit, the other points of metal

* It may be mentioned that the best method for the determination of wave-lengths, and the precautions to be taken with regard to the accurate measuring of the positions of the lines, was the subject of several months' investigation by one of the authors, W. N. H.

being on the same stand below it, the arm by which they were held being capable of such motion that they could be renewed or replaced without disturbance of the fixed cadmium point. The image of the spark was projected on to the slit by a lens of 3 inches focus, which was also immoveably fixed. All lines photographed could be measured with reference to those in the spectrum of cadmium. The slit of the collimator, which was not more than $\frac{1}{1000}$th of an inch in width, was protected from dust by being covered with a thin plate of quartz. Photographs were taken of the first order, both to the right and to the left of the plain reflection of the slit. The average period of exposure was an hour to an hour and a half.

The spectrum of one order overlaps that of another, but this is of no consequence, because the lenses being uncorrected for chromatic aberration, and the spectra of different orders having different foci, only one image is visible on the developed plate.

The developer used was made with pyrogallic acid and potassium bromide.

Method of measuring the spectra.—When a series of photographs had been obtained, the distances between the lines of the various spectra were accurately measured by means of a microscope and a dividing engine with a screw 30 inches in length. The arrangement by which a forward motion only is given to the screw was thrown out of gear, and a divided wheel, 4 inches in diameter, with a handle attached, was placed at the opposite end of the screw. Each division on the wheel as it passed the pointer registered a longitudinal motion of the stage equal to $\frac{1}{5000}$th of an inch, and it was easy to read to $\frac{1}{10000}$th. The measurements were certainly accurate to $\frac{1}{20000}$th of an inch even when working on lines of different intensities. The microscope, which was placed on the stand of the machine, had a magnifying power of 25 diameters. Less than this is insufficient, and more is unsatisfactory, except in special cases.

A plate-glass stage was fitted to the carrier of the dividing engine, and by means of screw clamps the photographs were secured to this. The photographs must be so adjusted that a line passing from end to end of the spectrum and dividing it into two parts longitudinally lies parallel to the axis of the screw, otherwise the lines will not all occupy the same position with respect to the cross lines in the field of the microscope.

Again, it is necessary that the photographs be taken on patent plate-glass so as to present a perfectly flat surface, and the plates are more suitable if selected with regard to equality of thickness at each end. Such curvature as is ordinarily to be seen in flattened crown-glass would yield inaccurate measurements, and if the plates be not of the same thickness throughout, the two ends of the spectrum, when the plate was in position on the glass stage, would not be in the same horizontal plane, and so by the motion of the screw the lines of the spectrum would soon travel out of focus. Freedom from spherical aberration, which facilitates the measurement of the lines, is secured by using lenses of unusually long focus.

Three plates were taken for each spectrum, the first included all rays lying between the cadmium lines 6 and 12 (λ=4676·7 and 3249·5), the second included Cd 11 and

Cd 18 (λ=3402·9 and 2572·2), and the third Cd 16 and Cd 26 (λ=2836·1 and 2145·7). Between these limits all the lines were accurately focussed. It will be seen that these plates overlap, so that on one series of photographs a certain number of lines may be measured twice over if necessary. The accurately measured portions of the spectra were 4 to 5 inches in length on each plate, so that the whole spectrum extended from 12 to 15 inches, and each inch was easily divisible into 10,000 parts. The measurements of the lines were made when the cross wires coincided with or equally divided the ends of the lines. This is necessary, as many lines are extremely short and cannot be measured at any other point. Lines continuous from pole to pole are comparatively few in number. "Ghosts" of very strong lines appear in the photographs of diffraction spectra; they are generally easy of recognition, but should it happen that by reason of a crowd of lines they are not easily distinguishable, they may be eliminated by comparing the diffraction with the prism spectrum.

No metallic line which is not common to both spectra has been measured. It is difficult to identify the lines rendered by a prism spectroscope when the original photographs only are examined, on account of the necessity of employing the microscope, which enables one to view only a small portion of the spectrum at one time. For the convenience of identifying the lines and registering their wave-lengths two sets of enlargements have been used, each containing about eight spectra, 36 inches in length. For the purpose of registering the wave-lengths of the air-lines and the very numerous lines of iron, enlargements 8 feet in length have been made.

Determination of Wave-Lengths.

Method of Working.—The determination of the wave-lengths of the lines in any photograph becomes very simple if we know the value of their linear positions on the plates in terms of the scale of the goniometer, and so be in a position to find their deviations. M. Cornu has described a method by which he determined the deviation of some of the lines in his photographs of the ultra-violet solar spectrum. After photographing a spectrum he moved his plate so as to obtain an impression of the image of the slit on the sensitised film on each side, and very close to the line he wished to measure. The points on the arc to which the images corresponded being known, the deviation of the line could be determined from them, since the images were sufficiently close together for linear distances between them to be taken as proportional to angular distances. We have followed the principle of this method. As stated in the introduction to this paper, after photographing a spectrum, the grating was moved so as to reflect on to the sensitised film a series of images of the slit, corresponding to equi-distant fixed points on the arc of the goniometer. In this way the spectrum was obtained, together with a number of images of the slit, disposed at regular intervals along its length, the images serving as fiducial lines, the deviations of which were known with all the accuracy afforded by the scale of the goniometer.

The wave-lengths corresponding with these deviations were calculated, and those of the spectral lines were determined from them by interpolation.

Calculation of the wave-lengths corresponding to the fiducial lines.—For the convenience of future reference the photographs of the three portions of the spectrum for which the plates were focussed, will be designated by the numbers 6–12, 11–18, and 17–26. These numbers have been assigned to the prominent cadmium lines by MASCART, and they serve to fix the limits of the less and more refrangible ends respectively of each portion of the spectrum.

The grating was placed so that to get the three portions of the spectrum into focus it was only necessary to move the plate-carrier, without shifting either the lens of the camera or the grating itself. The calculations of the wave-lengths corresponding to the deviations of the fiducial lines were made from the formula

$$a\,(\sin i + \sin \delta) = n\lambda,$$

where n is positive for the diffracted rays on the same side of the reflected ray as the normal, and negative for those on the other side, δ_n is the deviation of the line reckoned from the normal to the grating, and positive when situated on the same side of the normal as the incident ray; i is the inclination of the normal of the grating to the incident ray. This is, of course, at once determined from the position of the grating, when its normal is parallel to the incident ray. This position was found in the following way. A piece of plate-glass was placed in the small mahogany box at the end of the collimator tube (for a description of which see the paper already referred to in the Scientific Proceedings of the Royal Dublin Society, p. 10) in such a way as to allow the light from the slit to pass through it to the grating, and to reflect upwards the image of the slit reflected back from the grating. The grating was moved about till the image coincided with the slit. A wide slit was used to ascertain approximately the position of the grating, the slit was then narrowed as far as necessary, and the grating accurately adjusted. After this adjustment neither slit nor grating was moved during the time the whole of the series of photographs were being taken.

The deviation δ_n is not measured directly. One measures $\frac{i-\delta}{2}$ or $\frac{\delta-i}{2}$ according as the spectrum observed is to the right or to the left of the regularly reflected image of the slit. The following calculation of the wave-lengths corresponding to the fiducial line I. for the spectra to the left will serve as an example.

Position of grating when the normal was parallel to the incident ray	51°	3′	18″
Position of grating when the spectrum was being photographed.	42°	22′	25″
Point on the arc corresponding to fiducial line I. . .	32°	43′	41″

$$51^\circ\ 3'\ 18'' - 42^\circ\ 22'\ 25'' = 8^\circ\ 40'\ 53'' = i$$

$$42^\circ\ 22'\ 25'' - 32^\circ\ 43'\ 41'' = 9^\circ\ 38'\ 44'' = \frac{\delta - i}{2}$$

whence $\delta = 27^\circ\ 58'\ 21''$

δ is negative and n is negative, $a = \cdot 00146859$

therefore $\lambda = 4671 \cdot 7$

The constant of the grating was determined by means of the sodium lines D_1 and D_2 of the first and second order of spectra on both sides of the regularly reflected rays, with the following result:—

	D_1.	D_2.
First order to the right	0·00146831	0·00146855
Second order.	0·00146858	0·00146861
First order to the left.	0·00146853	0·00146900
Second order.	0·00146861	0·00146855

Mean = 0·00146859

The following table gives the wave-lengths corresponding to all the fiducial lines, together with their angular measurements.

SPECTRA to the left.

Fiducial lines.	Angular measurements.	Corresponding wave-lengths.
	° ′ ″	
I.	32 43 41	4671·7
II.	33 4 21	4515·27
III.	33 25 1	4357·85
IV.	33 45 41	4199·49
V.	34 6 21	4040·2
VI.	34 27 1	3880·0
VII.	34 47 41	3718·93
VIII.	35 8 21	3557·00
IX.	35 29 1	3394·22
X.	35 49 41	3230·63
XI.	36 10 21	3066·27
XII.	36 31 1	2901·14
XIII.	36 51 41	2735·26
XIV.	37 12 21	2568·68
XV.	37 33 1	2401·41
XVI.	37 53 41	2233·46
XVII.	38 14 21	2064·87
XVIII.		

SPECTRA to the right.

Fiducial lines.	Angular measurements.	Corresponding wave-lengths.
	° ′ ″	
IX′.	37 33 1	3426·02
X′.	37 12 21	3250·71
XI′.	36 51 41	3075·71
XII′.	36 31 1	2901·00
XIII′.	36 10 21	2726·61
XIV′.	35 49 41	2552·57

The fiducial lines I. to X. inclusive, photographed on the spectra to the left of the regularly reflected image of the slit, were contained on Plates 6–12, IX. to XV. on Plates 11–18, and XII. to XVII. on Plates 17–26.

Photographs of the portion 11–18 only were taken of the spectrum to the right.

It will be seen from the table that the differences between consecutive readings to the left are the same as those to the right for the same part of the spectrum.

The reading on the goniometer when the spectra to the right were being photographed was 30° 39′ 38″.

Determinations of the wave-lengths of the spectral lines.—The linear positions, or as these will be hereafter termed the scale numbers of the fiducial lines, and spectral lines of each plate were carefully measured off by means of the dividing engine in hundredths of an inch and fractions thereof. Interpolation curves were constructed from the wave-lengths and the scale numbers of the fiducial lines. The wave-lengths of the metallic lines were determined from these curves.

The scale numbers of the fiducial lines of the various plates are given in the following tables.

TABLES giving in linear measurements the positions of the fiducial lines on the several spectra photographed.

Spectra to the left.

Portions 6–12. Measurements in hundredths of an inch.

(1)

Fiducial lines.	Indium.	Aluminium.	Thallium.	Copper.	Carbon.	Magnesium.	Arsenic.	Mean.
I.	0·000	0·060	..	..	..	..	..	0·030
II.	37·250	37·250	37·250	37·250	..	37·250	37·250	37·250
III.	74·305	74·185	74·365	74·260	74·300	74·375	74·380	74·300
IV.	111·585	111·505	111·575	111·575	111·595	..	111·54	111·575
V.	148·825	148·840	148·795	148·745	148·835	148·845	148·780	148·815
VI.	186·225	186·225	186·190	186·380	186·165	186·186	186·250	186·210
VII.	223·695	223·725	223·620	223·660	223·675	..	223·740	223·685
VIII.	261·400	261·365	261·295	261·455	261·335	261·240	261·450	261·350
IX.	299·155	299·175	299·09	299·135	299·110	299·110	..	299·145
X.	337·260	337·200	337·175	337·350	337·280	..	..	337·255

(2)

Fiducial lines.	Lead.	Tellurium.	Tin.	Mean.
I.				
II.	37·250	37·250	..	37·250
III.	74·555	74·440	74·345	74·500
IV.	111·700	111·750	111·660	111·700
V.	149·070	149·025	149·030	149·050
VI.	186·430	186·465	186·370	186·450
VII.	223·980	223·985	224·020	223·985
VIII.	261·700	261·660	261·695	261·680
IX.	299·570	299·585	299·540	299·575
X.	337·655	337·530	337·600	337·590

(3)

Fiducial lines.	Iron.	Nickel.	Mean.
I.			
II.	37·250	37·250	37·250
III.	74·350	74·240	74·295
IV.	111·485	111·440	111·465
V.	148·665	148·620	148·645
VI.	185·965	186·050	186·010
VII.	223·490	223·510	223·500
VIII.	261·110	261·265	261·190
IX.	298·885	299·100	298·995
X.	336·880	337·050	336·965

TABLES giving in linear measurements the positions of the fiducial lines on the several spectra photographed (continued).

Spectra to the left.

Portions 11–18. Measurements in hundredths of an inch.

(4)

Fiducial lines.*	Magnesium.	Silver.	Tin.	Iron.	Carbon.	Bismuth.	Mean.
XV.	0·000	0·000	0·000	0·000	0·000	0·000	0·000
XIV.	48·625	48·640	48·760	48·650	48·585	48·600	48·650
XIII.	98·345	98·035	98·260	98·305	98·180	98·350	98·275
XII.	148·925	148·965	149·040	148·965	148·895	149·150	148·965
XI.	200·750	200·590	200·795	200·665	200·860	200·710	200·730
X.	253·650	253·620	253·605	253·715	253·500	253·710	253·620
IX.	308·045	308·085	308·090	308·250	308·110	308·150	308·115

(5) (6)

Fiducial lines.*	Tellurium.	Arsenic.	Zinc.	Mean.	Lead.	Antimony.	Mean.
XV.	0·000	0·000	0·000	0·000	0·000	0·000	0·000
XIV.	48·815	48·705	48·750	48·757	48·685	48·805	48·745
XIII.	98·730	98·610	98·515	98·670	98·560	98·650	98·605
XII.	149·520	149·500	149·350	149·457	149·320	149·560	149·440
XI.	201·395	201·405	201·250	201·350	201·050	201·380	201·215
X.	254·515	254·365	254·450	254·443	254·360	254·250	254·305
IX.	308·975	308·880	308·865	308·907	308·815	308·715	308·765

(7) (8) (9)

Fiducial lines.*	Indium.	Thallium.	Mean.	Aluminium.	Copper.
XV.	0·000	0·000	0·000	0·000	0·000
XIV.	49·170	49·010	49·090	48·705	48·640
XIII.	99·055	99·160	99·108	98·310	98·180
XII.	150·205	150·230	150·218	149·065	148·780
XI.	202·320	202·500	202·410	200·970	200·640
X.	255·645	255·740	255·693	254·010	253·530
IX.	310·305	..	310·305	308·340	308·040

* These lines were measured in the reverse to the usual order.

TABLES giving in linear measurements the positions of the fiducial lines on the several spectra photographed (continued).

Spectra to the left.

Portions 17–26. Measurements in hundredths of an inch.

(10)

Fiducial lines.	Iron.	Antimony.	Mean.
XII.	0·000	0·000	0·000
XIII.	85·805	85·790	85·800
XIV.	168·005	168·020	168·010
XV.	246·635	246·700	246·700
XVI.	322·030	321·960	322·000
XVII.	394·570	394·150	394·000

(11) (12) (13)

Fiducial lines.	Tin.	Thallium.	Indium.
XII.	0·000	0·000	0·000
XIII.	85·725	85·685	85·625
XIV.	168·080	167·810	167·715
XV.	246·435	246·400	246·055
XVI.	321·800	321·615	321·310
XVII.	393·910	393·880	393·140

Spectra to the right.

Portions 11–18. Measurements in hundredths of an inch.

(1) (2) (3)

Fiducial lines.	Magnesium.	Thallium.	Zinc.
I.	0·000	0·000	0·000
II.	101·530	101·660	102·140
III.	198·000	198·630	198·965
IV.	289·540	290·175	290·220
V.	376·500	377·270	377·430
VI.	458·905	459·760	459·950

TABLE of means and numbers adopted as correct measurements of the fiducial lines on each plate.

Spectra to the left.

Portions 6–12. Measurements in hundredths of an inch.

(1)

Fiducial lines.	Mean measurements.	Adopted numbers.	Intervals.
I.	0·03	0·15	
			37·05
II.	37·25	37·20	
			37·10
III.	74·30	74·30	
			37·20
IV.	111·575	111·50	
			37·30
V.	148·815	148·80	
			37·40
VI.	186·21	186·20	
			37·50
VII.	223·685	223·70	
			37·65
VIII.	261·35	261·35	
			37·80
IX.	299·145	299·15	
			38·00
X.	337·255	337·15	

(2)

Fiducial lines.	Mean measurements.	Adopted numbers.	Intervals.
I.	..	..	
			..
II.	37·25	37·25	
			37·15
III.	74·50	74·40	
			37·25
IV.	111·70	111·65	
			37·35
V.	149·05	149·00	
			37·45
VI.	186·45	186·45	
			37·55
VII.	223·985	224·00	
			37·70
VIII.	261·68	261·70	
			37·85
IX.	299·575	299·55	
			38·05
X.	337·59	337·60	

TABLE of means and numbers adopted as correct measurements of the fiducial lines on each plate (continued).

Spectra to the left.

Portions 6–12 (continued). Measurements in hundredths of an inch.

(3)

Fiducial lines.	Mean measurements.	Adopted numbers.	Intervals.
I.	..	..	..
II.	37·25	37·20	37·075
III.	74·295	74·275	37·175
IV.	111·465	111·45	37·275
V.	148·645	148·725	37·375
VI.	186·01	186·10	37·475
VII.	223·50	223·575	37·625
VIII.	261·19	261·20	37·775
IX.	298·995	298·975	37·975
X.	336·965	336·95	

Portions 11–18. Measurements in hundredths of an inch.

(4)

Fiducial lines.	Mean measurements.	Adopted numbers.	Intervals.
XV.	0·000	0·000	48·65
XIV.	48·65	48·65	49·65
XIII.	98·275	98·30	50·65
XII.	148·965	148·95	51·75
XI.	200·73	200·70	53·00
X.	253·62	253·70	54·35
IX.	308·115	308·05	

TABLE of means and numbers adopted as correct measurements of the fiducial lines on each plate (continued).

Spectra to the left.

Portions 11–18 (continued). Measurements in hundredths of an inch.

(5)

Fiducial lines.	Mean measurements.	Adopted numbers.	Intervals.
XV.	0·000	0·000	
			48·80
XIV.	48·757	48·80	
			49·80
XIII.	98·67	98·60	
			50·80
XII.	149·457	149·40	
			51·90
XI.	201·35	201·30	
			53·15
X.	254·443	254·45	
			54·50
IX.	308·907	308·95	

(6)

Fiducial lines.	Mean measurements.	Adopted numbers.	Intervals.
XV.	0·000	0·000	
			48·775
XIV.	48·745	48·775	
			49·775
XIII.	98·605	98·55	
			50·775
XII.	149·44	149·325	
			51·825
XI.	201·215	201·20	
			53·125
X.	254·305	254·325	
			54·475
IX.	308·765	308·80	

TABLE of means and numbers adopted as correct measurements of the fiducial lines on each plate (continued).

Spectra to the left.

Portions 11–18 (continued). Measurements in hundredths of an inch.

(7)

Fiducial lines.	Mean measurements.	Adopted numbers.	Intervals.
XV.	0·000	0·000	
			49·05
XIV.	49·09	49·05	
			50·05
XIII.	99·108	99·10	
			51·05
XII.	150·218	150·15	
			52·15
XI.	202·410	202·30	
			53·40
X.	255·695	255·70	
			54·75
IX.	310·305	310·40	

(8) (9)

Fiducial lines.	Aluminium readings.	Adopted numbers.	Intervals.	Copper readings.	Adopted numbers.	Intervals.
XV.	0·000	0·000		0·000	0·000	
			48·70			48·625
XIV.	48·705	48·70		48·64	48·625	
			49·70			49·625
XIII.	98·31	98·40		98·18	98·25	
			50·70			50·625
XII.	149·065	149·01		148·78	148·875	
			51·80			51·725
XI.	200·97	200·90		200·64	200·60	
			53·05			52·975
X.	254·01	253·95		253·53	253·575	
			54·40			54·325
IX.	308·34	308·35		308·04	307·90	

TABLE of means and numbers adopted as correct measurements of the fiducial lines on each plate (continued).

Spectra to the left.

Portions 17–26. Measurements in hundredths of an inch.

(10)

Fiducial lines.	Mean measurements.	Adopted numbers.	Intervals.
XII.	0·000	0·000	
			85·80
XIII.	85·80	85·80	
			82·20
XIV.	168·01	168·00	
			78·70
XV.	246·67	246·70	
			75·30
XVI.	322·00	322·00	
			72·00
XVII.	394·36	394·00	

(11)

Tin measurements.	Adopted numbers.	Intervals.
0·000	0·000	
		85·75
85·725	85·75	
		82·15
168·08	167·90	
		78·65
246·435	246·55	
		75·25
321·80	321·80	
		71·95
393·91	393·75	

(12)

Fiducial lines.	Thallium measurements.	Adopted numbers.	Intervals.
XII.	0·000	0·000	
			85·70
XIII.	85·685	85·70	
			82·10
XIV.	167·81	167·80	
			78·60
XV.	246·40	246·40	
			75·20
XVI.	321·615	321·60	
			71·90
XVII.	393·88	393·50	

(13)

Indium measurements.	Adopted numbers.	Intervals.
0·000	0·000	
		85·625
85·625	85·625	
		82·025
167·715	167·65	
		78·525
246·055	246·175	
		75·125
321·31	321·30	
		71·825
393·14	393·125	

TABLE of means and numbers adopted as correct measurements of the fiducial lines on each plate (continued).

Spectra to the right.

Portions 11–18. Measurements in hundredths of an inch.

(1)

Fiducial lines.	Magnesium measurements.	Adopted numbers.	Intervals.
I.	0·000	0·000	
			101·475
II.	101·53	101·475	
			96·475
III.	198·00	197·95	
			91·625
IV.	289·54	289·575	
			86·925
V.	376·50	376·50	
			82·375
VI.	458·905	458·875	

(2) (3)

Fiducial lines.	Thallium measurements.	Adopted numbers.	Intervals.	Zinc measurements.	Adopted numbers.	Intervals.
I.	0·000	0·000		0·000	0·000	
			101·65			101·70
II.	101·66	101·65		102·14	101·70	
			96·65			96·70
III.	198·63	198·30		198·965	198·40	
			91·80			91·85
IV.	290·175	290·10		290·22	290·25	
			87·10			87·15
V.	377·27	377·20		377·43	377·40	
			82·55			82·60
VI.	459·76	459·75		459·95	460·00	

It will be observed that there are differences in the measurements of the fiducial lines which cannot be accounted for by errors of observation. These differences may be due to two causes: first, the difficulty of placing every photographic plate in exactly the same position in the camera; second, to the alteration in length of the screw of the dividing engine by change of temperature when the different plates were measured. That the temperature has some effect upon these measurements appears probable from the fact that the first dozen or so of photographs which were measured on consecutive days give those readings which agree most closely. The dividing engine could not be kept always in the same room, and on its removal it was probably subjected to small

changes of temperature such as would very nearly account for the discrepancy in the readings. Thus, taking the linear coefficient of expansion of wrought iron to be 0·0000122 for 1° C., the length of screw to be 20 inches, and the change of temperature 5°, the change in entire length would amount to 0·001 inch, or in 5 inches, which is about the measured length of each photograph, to 0·000305. From this must be deducted the coefficient of expansion of white glass, which amounts to 0·000215 inch, which reduces the error to 0·00019. The error is generally an increasing one as the distance from zero increases.

We have taken advantage of our numerous measurements to reduce the error to a minimum : first, by taking the mean of several readings ; secondly, by observing the intervals occurring between the lines and adopting numbers which, while they accord with the progressive increase in these intervals, closely approximate the numbers obtained by measurement. On comparison of the two sets of figures, it will be found that the mean of all readings and the mean of all adopted numbers agree. The greatest difference between any two series of mean adopted numbers and mean readings amounts to 0·0005 inch, the average error being 0·00023 inch. The value of these fractions in wave-length for any portion of the spectrum is not greater than 0·2 tenth-metre for the less refrangible, and probably as little as 0·05 for the more refrangible rays.

A difference in the linear measurements of the fiducial lines could occur by an unequal contraction of the gelatine film on drying. This was never the case with our plates for the reason that the central portion of each film only was used, the films were dry when the photographs were taken, and would presumably remain in the same position on the glass after developing unless some artificial mode of desiccation were employed, such as the elimination of water by steeping in alcohol. This latter method was never resorted to.

In the case of the photographs of the spectra to the right of the reflected image of the slit, one series of numbers, those of zinc, do not satisfactorily show the same relation between their intervals as can be traced between those of the other two plates, thallium and magnesium. The images on these photographs are not so sharp, and present consequently a greater difficulty in measurement than those on the spectra to the left. That the numbers adopted for the zinc plate are fairly correct is evident from the values determined for the cadmium lines.

The apparently greater dispersion of the portion 17–26 than of the portion 11–18, and of the latter than of 6–12, is due to the varying inclination of the plates to the axis of the camera lens. The plates, when in focus for the portion 6–12, were but slightly if at all inclined, while the plates including 11–18 and 17–26 were taken at a very considerable inclination ; the inclination for the latter being the greater. A screen of cardboard was placed in front of the upper half of the slit when photographing the fiducial lines, in order to prevent them obscuring the spectral lines below to which they referred. When the reflections of the slit were too diffuse it was found advan-

tageous to photograph four or five spectra on one plate, the photographs of the slit falling on the uppermost spectrum only, any error arising from adjustment of the plates for the reception of the different spectra being corrected by means of the cadmium lines.

The fiducial lines of the portions 6–12 were sufficiently close together for distances between any two of them to be taken as proportional to wave-lengths, with a maximum error of about 0·1 *tenth-metre*. Owing, however, to the inclination of the plates for the other two portions of the spectrum, the error in taking the distances as proportional to wave-lengths was too large ; three points were therefore interpolated between each pair of fiducial lines. This was easily accomplished, as the intervals between the reflections were simply related to one another. The maximum error of the curves constructed with the fiducial lines and the interpolated points was about 0·1 to 0·25 *tenth-metre* for the portions 11–18 and 17–26 respectively. Corrections were made for the latter error with the plates 17–26.

The curves were constructed on millimetre paper, 4 millims. were allowed for each difference of a *tenth-metre* of wave-length and 1 millim. for each two-thousandth of an inch of the scale numbers.

The wave-lengths of the cadmium lines.

As stated in the introduction to this paper, on taking photographs from metallic electrodes an electrode of cadmium was always used to furnish a spectrum in reference to which all other spectra could be measured. In the adjoining table will be found the values we have adopted for the wave-lengths of the cadmium lines, together with the numbers afforded by each plate employed in their determination. The latter numbers, it will be seen, do not give the true wave-lengths, but require a small correction, which will be found in the table. The correction for the numbers calculated for the lines 12, 17, 18, on the portion 11–18, from photographs of spectra on either side of the reflections of the slit, are shown by the table to be as nearly as possible 2·9 and 3·3 *tenth-metres*, of negative sign for the spectra to the right and positive sign for those to the left. Guided by these corrections, and owing to the fact that the lines 12α, β, γ occur also on the photographs of the portion 6–12, the lines 17 and 18 on the photographs of the portion 17–26, the corrections for the remaining lines have been deduced. Thus, for the portion 17–26 the corrections for the lines 17, 18 were found to be 3·6 and 3·8 respectively, and a correction of 4·0 was consequently made to remaining lines of this portion of the spectrum. In a like manner the corrections for the lines of the portion 6–12 were found. The explanation of the necessity of these corrections will be given later on, when considering the errors introduced by uncorrected lenses.

TABLE of the wave-lengths of the cadmium lines.

Spectra to the left of the regularly reflected image of the slit.

Portion of the spectrum 6–12.

No. of line of cadmium spectrum (MASCART'S notation).	Plates.					Corrections.	Wave-lengths adopted.
	Indium.	Thallium.	Aluminium.	Lead.	Mean.		
7	4411·4	4411·2	4411·4	4411·6	4411·5	+3·0	4414·5
8 (air)	3991·4	3990·99	3991·6	3991·4	3991·5	+3·0	3994·5
9	3608·7	3608·4	3609·0	3608·4	3608·6	+3·2	3611·8
	3606·4	3606·2	3606·6	3606·2	3606·4	+3·2	3609·6
10	3463·6	3463·5	3463·7	3463·4	3463·6	+3·2	3466·8
	3462·3	3461·6	3462·2	3461·9	3462·2	+3·2	3465·4
11	3399·9	3399·6	3399·8	3399·6	3399·7	+3·2	3402·9
12 α	3256·8	3256·8	3257·3	3257·2	3257·0	+3·2	3260·2
,, β	3248·6	3248·4	3248·8	3248·5	3248·6	+3·2	3251·8
,, γ	3246·4	3246·2	3246·6	3246·2	3246·4	+3·2	3249·6

Portion of the spectrum 11–18.

	Iron.	Thallium.	Magnesium.	Carbon.	Mean.
12 α	3257·23	3257·67	3257·03	3257·3	3257·31
,, γ	3246·63	3246·95	3246·4	3246·6	3246·65
17	2744·4	2745·0	2744·0	2744·15	2744·39
18	2568·8	2569·4	2568·5	2569·0	2568·92

Portion of the spectrum 17–26.

	Iron.	Thallium.	Tellurium.	Indium.	Mean.
17	2744·1	2744·1	2744·1	2744·1	2744·1
18	2568·2	2568·5	2568·2	2568·8	2568·4
22	2317·5	2318·0	2317·6	2317·7	2317·6
23	2309·6	2309·8	2309·6	2309·6	2309·6
Isolated ray (CORNU).	2284·8	2285·2	2284·8	2285·0	2284·9
24	2261·9	..	2261·9	2262·1	2261·9
25	2192·3	2192·5	2192·3	2193·0	2192·4

Spectra to the right of the regularly reflected image of the slit.

Portion of the spectrum 6–12.

No. of line of cadmium spectrum (MASCART'S notation).	Corrections.	Wave-lengths adopted.
	+3·0	4414·5
	+3·0	3994·5
	+3·2	3611·8
	+3·2	3609·6
	+3·2	3466·8
	+3·2	3465·4
	+3·2	3402·9
	+3·2	3260·2
	+3·2	3251·8
	+3·2	3249·6

Portion of the spectrum 11–18.

	Magnesium.	Thallium.	Zinc.	Mean.		
12 α	3263·23	3262·7	3262·7	3262·88	±2·9	3260·2
,, γ	3252·59	3252·0	3252·03	3252·21	±2·9	3249·5
17	2751·4	2751·0	2751·07	2751·16	±3·3	2747·7
18	2575·7	2575·2	2575·38	2575·43	±3·3	2572·2

Portion of the spectrum 17–26.

17	+3·6	2747·7
18	+3·8	2572·2
22	+4·0	2321·6
23	+4·0	2313·6
Isolated ray (CORNU).	+4·0	2288·9
24	+4·0	2265·9
25	+4·0	2196·4

When the corrections in the preceding tables are seen to vary slightly it is owing to small errors which are introduced by the re-adjustment of the grating. The corrections applicable to each spectrum are found by converting the values obtained for the cadmium lines given by the fixed electrode into the wave-lengths given above.

In the following tables the wave-lengths of a number of lines are compared with measurements of previous observers. That these numbers agree in a very satisfactory manner gives us some confidence in our method of working and in the probable accuracy of the wave-lengths we have adopted for the cadmium lines, as derived from our several measurements. With the exception of the lines 3402·9, 2196·4, and the triple group 3260·2, 3251·8, 3249·5, our numbers agree well with those of M. CORNU, but at these points the difference is considerable. We have carefully measured these lines directly and we are inclined to consider our numbers correct. M. CORNU did not directly measure these lines, but derived the numbers he has given from a comparison of his photographs with his map of the solar spectrum. But the reason why the wave-lengths we have given are probably the more correct lies in the fact that about this region there are many iron lines, and our measurements of iron agree with those of M. CORNU, while, if our cadmium lines departed from accuracy as far as they differ from those of M. CORNU, this difference would occur in the iron lines.

COMPARISON of the wave-lengths of lines from the spectrum of cadmium.

	MASCART.	CORNU.	HARTLEY and ADENEY.	LECOCQ.	THALÉN.
7	4414·5	..	4414·6	4414	
8	3985·6	..	3994·5	..	3995
9	3607·5	3609	3609·6		
10	3464·5	3465·5	3465·4		
11	3403·0	3401·5	3402·9		
12α	..	..	3260·2		
„ β	..	..	3251·8		
„ γ	3287·5	3247·0	3249·5		
17	2763·4	2747·7	2747·7		
18	2574·2	2572·3	2572·2		
23	2318·2	2313·5	2313·6		
24	2265·6	2265·5	2265·9		
25	2217·6	2194·5	2196·4		

No. 8 is an air line.

Nos. 9 and 10 we discovered to be doublets, but the numbers here given are those assigned to the more refrangible lines of each.

No. 12 is a triple group ; this fact was recognised by M. CORNU. The wave-lengths of two iron lines close to this group are the following :—

CORNU.	HARTLEY and ADENEY.
3246·2	3246·3
3242·7	3243 0

LINES of iron compared with those in the solar spectrum measured by MM. THALÉN and CORNU.

HARTLEY and ADENEY.	THALÉN.	CORNU.	HARTLEY and ADENEY.	CORNU.
4403·7	4404		3742·7	3743·0
4382·6	4383		3736·9	3736·5
4325·0			3734·7	3734·4
4307·1	4307		3719·7	3719·8
4298·3			3709·0	3709·0
4293·3	4294		3705·5	3705·6
4281·7			3687·3	3687·2
4271·0	4271		3679·5	3680·3
4259·9			3676·5	
4249·8	4250		3647·6	3647·0
4201·4	4201		3631·0	3630·9
4198·4	4198		3618·6	3617·8
4143·0	4143		3594·9	
4071·5	4071	4071·2	3586·3	3586·2
4063·0	4063	4062·9	3584·8	3584·9
4045·4	4045	4045·0	3581·1	3581·5 N
3968·7			3569·6	
3933·1	..	3932·9	3565·0	3564·2
3929·7	..	3929·7	3558·1	3558·2
3927·6	..	3927·2	3554·2	3554·0
3902·6	..	3902·0	3540·9	3541·4
3899·3			3525·9	3525·8
3895·1	..	3894·8	3520·7	3520·7
3888·1	..	3888·0	3513·3	3513·8
3885·7	..	3885·1	3443·3	3443·7
3878·1	..	3877·6		3443·1
		3877·3	3440·2	3440·0 O
3872·2	..	3871·4	3436·9	
		3871·2	3389·5	
3865·2	..	3864·8	3370·2	
		3865·2	3366·1	
		3865·5	3364·9	
3859·6			3358·7	3359·2 P
3856·1	..	3855·8	3353·3	
3849·1	..	3849·8	3305·4	3304·8
3840·3	..	3840·0	3291·5	3290·8
		3840·5	3288·8	3289·3
3834·0	..	3833·6	3285·4	3284·8 Q
3827·4	..	3827·7	3279·9	
3825·5	..	3825·2	3276·2	
3824·0	..	3824·1	3258·2	
3820·3	..	3819·8 L	3246·3	3246·2
3815·8	..	3815·3	3243·0	3242·7
3812·6	..	3812·7	3227·0	3226·6
3808·9			3221·5	3221·0
3804·4	..	3805·0	3212·7	3212·2
3798·4	..	3798·7	3209·5	
3794·6	..	3795·0	3204·6	3204·3
3767·0	..	3766·8	3199·9	3199·8
3765·3	..	3765·0	3195·7	3196·3
3763·3	..	3763·3	3192·7	
3757·9	..	3757·8	3186·2	
3749·4	..	3749·4	3182·3	
3745·4	..	3745·4	3179·1	3179·8 R

LINES of iron compared with those in the solar spectrum measured by MM. THALÉN and CORNU (continued).

HARTLEY and ADENEY.	CORNU.	HARTLEY and ADENEY.	CORNU.
3176·8		3066·6	
3153·6		3046·9	3046·5
3143·9	3144·1	3036·4	3036·1
	3144·4	3024·8	3025·2, 3024·8
3134·6			
3116·1		3020·1	3019·9 T
3113·4		3002·1	3002·0, 3002·3
3104·8			
3099·5	3099·8 S_2	2993·6	2994·3
3096·7		2964·0	
3082·8		2948·4	2947·8
3070·3		2946·9	

VARIOUS metallic lines measured by other observers compared with the new measurements.

	HARTLEY and ADENEY.	THALÉN.	CORNU.	LIVEING and DEWAR.	LECOCQ DE BOISBAUDRAN.	ÅNGSTRÖM and THALÉN.
Magnesium lines	4480	4481				
	3837·9	..	3837·7			
	3832·1	..	3831·6			
	3829·2	..	3829·0			
	3336·2	..	3334·0			
*	3331·8	..	3330·0			
	3329·1	..	3327·0			
	3096·1	..	3095·7			
	3091·9	..	3092·0			
	3090·0	..	3090·1			
	2935·7	..	2934·9			
	2928·0	..	2926·7			
	2913·7					
	2851·3	..	2850·3†			
	2848·0					
	2846·0					
	2801·6	..	2801·3			
	2796·9	..	2797·1			
	2794·1	..	2794·5			
	2789·6	..	2789·9			
	2781·8	..	..	2782·2		
	2780·2					
	2778·7	..	..	2779·5		
	2776·9					
	2775·5	..	..	2776·9		

* Our numbers here differ by about 2 *tenth-metres*, but an iron line in this part of the spectrum has given the following wave-lengths, 3358·7 (H. and A.) and 3359·2 (CORNU).

† Messrs. LIVEING and DEWAR give 2852·0 for this line. ("On the Disappearance of some Spectral Lines," Proc. Roy. Soc., vol. xxxiii., p. 429.)

VARIOUS metallic lines measured by other observers compared with the new measurements (continued).

	HARTLEY and ADENEY.	THALÉN.	CORNU.	LIVEING and DEWAR.	LECOCQ DE BOISBAUDRAN.	ÅNGSTRÖM and THALÉN.
Aluminium lines	4477·2	..	..	..	4478	
	3961·0	..	3960·7	..	3962	
	3943·4	..	3943·3	..	3943	
	3092·2	..	3091·6			
	3081·5	..	3081·7			
Indium lines . .	4510·2	4509	..	..	4511	
	4101·3	4101	..	..	4101	
Lead lines . . .	4386·4	4386	..	..	4386	
	4245·2	4246	..	..	4245	
	4061·5	4062				
	4057·5	4058	..	..	4056	
Bismuth lines .	4301·4	4302	..	..	4303	
	4259·1	4259	..	..	4259	
	4121·2	4119	..	..	4118	
Carbon lines . .	4266·3	..	..	..	..	4266
	3919·5	..	..	3919·3		
	3875·7	..	..	3876·5		
	2993·3	..	..	2995·0		
	2967·5	..	.	2968·0		
	2836·8	..	..	2837·2		
	2836·0	..	..	2836·3		
	2746·6	..	..	2746·5		
	2640·0	..	..	2640·7		
	2511·6	..	..	2511·9		
	2508·7	..	..	2509·0		
	2478·3	..	..	2478·3		
	2297·7	..	..	2296·5		

Errors.

There are four sources of error to which the measurements from our photographs are open. The total error is easily eliminated, but it is difficult to give precise values to the individual errors. They are :—

First—The lens of the collimator was uncorrected. It was focussed for white light, and the adjustment was unaltered during the photographing of the spectra. On this account the rays striking the grating would not be parallel to one another, but be slightly convergent. Further, the rays corresponding to the different fiducial lines would be, after reflection, diverging from points not in the axis of rotation of the grating. To this source of error is mainly due the correction we have to make in our measurements.

Second.—M. CORNU found during his researches on the "Ultra-Violet Solar Spectrum" (Annales Scientifiques de l'École Normals, iii., 1874, second series, p. 430), that in order to make his numbers obtained by direct vision and by photography

comparable one with the other, he had to make a correction of —1·0 *tenth-metre* to those obtained by the latter means. An explanation of this will be found in M. CORNU'S paper.

Third.—The error arising from the adjustment of the grating to its position for photographing the spectrum. This does not exceed 0·5 *tenth-metre*, and, it should be noted, appears in all the measurements of the plate. This may be eliminated by taking the mean of the measurements of the cadmium lines.

Fourth.—The error in the measurements arising from change of temperature affecting the dividing engine. This is within ± 0·2 for well defined lines, and it is always corrected by the cadmium lines. The errors of observation in the measuring of lines are also, for well-defined lines, at most ± 0·2.

The first and second errors are of opposite sign for the spectra, to the right and left of the regular reflection of the slit, and are therefore easily eliminated by taking the mean of the spectra on the two sides.

The wave-lengths given in the accompanying tables are all comparable with one another. If an error occurs in any of the values for the cadmium lines, it will be common to all the lines in that part of the spectrum in which the particular line occurs, and will be easily eliminated. If the wave-lengths assigned to the cadmium lines are correct, there are only two errors to which the wave-lengths in the tables that have been calculated from grating spectra are liable. These are that incurred in the measurement of the lines by the microscope and dividing engine, and that due to the interpolation curve. The errors of measurement mentioned above are, for well-defined lines, in no case greater than $\frac{1}{2000}$th of an inch; this, in terms of wave-length, equals 0·2, 0·17, and 0·12 *tenth-metres* for the portions 6–12, 11–18, and 17–26, respectively. The error of the interpolation curve is not more, we believe, than 0·1 *tenth-metre*. The maximum for well-defined lines probably does not exceed ± 0·3 *tenth-metre*. In the case of faint lines, the general error is larger, but it seldom rises to more than 0·5. Thus in the accompanying table of air lines, the wave-lengths of which were all determined directly by measuring diffraction spectra, two sets of numbers taken from different photographs are given, and the numbers for the following six, which are all very feeble and diffuse lines, and therefore difficult to measure, are the only ones differing by more than the general error :—

Aluminium plate. Portion 6–12.	Copper plate. Portion 6–12.
4402·0	4403·1
4215·9	4217·1
4025·9	4024·7
3851·0	3850·0
3842·2	3841·2
3325·3	3324·1

The subjoined lists give the numbers of some of the lines of tin, lead, indium, and copper that occur between the cadmium lines 11 and 12, and near the cadmium line 18. Each of these lines occurs therefore on two different plates, and has been twice measured.

Some Lines of Tin, Lead, Indium, and Copper, of which duplicate measurements have been made.

Copper.				Tin.			
Plate 6-12.	Plate 11-18.		Plate 17-26.	Plate 6-12.	Plate 11-18.		Plate 17-26.
3306·8	3307	2544·5	2544·6	3329·9	3329·6	2705·6	2705·9
3289·9	3289·9	2528·8	2528·9	3282·9	3282·9	2664·6	2665·2
3282·2	3282·1	2526·1	2526·3	3261·7	3261·5	2660·2	2660·6
3273·3	3273·2	2522·6	2522·7	3174·3	3174·1	2657·8	2658·1
3246·8	3246·9	2506·3	2506·2			2645·2	2645·7
		2491·1	2491·7			2643·0	2643·3
		2489·3	2489·0			2631·4	2631·5
		2485·5	2485·7			2617·9	2617·8
		2481·8	2481·9			2593·4	2593·9
		2477·9	2478·5			2570·6	2570·5
		2468·1	2468·7			2545·5	2545·7
						2488·1	2488·8
						2482·8	2482·9

Lead.				Indium.			
Plate 6-12.	Plate 11-18.		Plate 17-26.	Plate 6-12.	Plate 11-18.		Plate 17-26.
3277·9	3277·5	2716	2716·7	3236·5	3236·0	2713	2712·9
3242·4	3242·4	2697·8	2697·7	3246·5	3245·7	2709·1	2709·5
		2662·4	2662·6	3255·3	3255·8	2706·0	2707·0
		2650·0	2650·0	3257·7	3257·9	2630·6	2631·7
		2627·1	2627·8	3273·8	3274·0	2600·3	2600·3
		2613·2	2613·5			2559·6	2559·4
		2576·3	2576·5			2553·9	2554·3
		2566·8	2567·6			2527·2	2527·0
		2561·3	2561·8				
		2475·5	2476·0				

There is no distinction made in these tables between strong and weak or sharp and diffuse lines, and the numbers therefore represent the degree of accuracy common to our measurements of lines of different characters.

Determination of wave-lengths from prismatic spectra.—Owing to the large portion of the spectrum being focussed on one plate, and the very fine definition of the lines, it was advantageous to take measurements from grating spectra, and determine the wave-lengths by interpolation between the fiducial lines. Faint lines, and some of the weak ones that were indistinguishable under the microscope, were marked by a fine needle-point, and a drawing of the line and point, as seen under a hand lens, was

taken to serve as a guide when measuring with the microscope. In this way, very accurate measurements were obtained, even of lines that could not possibly have been measured otherwise. Nearly all lines given in the accompanying tables, up to and including a wave-length of 2265, have been measured from grating spectra. Between λ 2265 and λ 2145·7, the very well marked lines only were measured from the grating spectra. The numbers not obtained from grating spectra for the other lines given in the tables were determined by means of an interpolation curve, constructed from measurements taken from prism spectra.

The curve was laid down on millimetre paper, four millimetres being allowed for each difference of a *tenth-metre* in wave-length, and one millimetre for each $\frac{1}{2000}$th of an inch of difference in the scale numbers. The wave-lengths were taken as normals, and the scale numbers as abscissæ; the aggregate length of the curve from λ = 4800 to λ 2020 was about nine metres. The spectra were taken from one quartz prism of 60°, composed of two halves each of 30°, one of right-handed and the other of left-handed rotation. The prism was fixed for the minimum angle of deviation of the cadmium line 2747·7, and the photographs were similar to those published in the Journal of the Chemical Society (Transactions, vol. xii., p. 85, W. N. HARTLEY).

In the tables, besides the wave-lengths, the scale numbers from the prismatic spectra are in every case given. These numbers are expressed in hundredths of an inch and fractions thereof. The numbers for the various metals are strictly comparable with each other, since the measurements from each spectrum have been reduced to a standard spectrum of an alloy of tin and cadmium. This was accomplished in the following way. The spectrum of each metal was photographed with that of the tin-cadmium alloy. The same electrode of the alloy was employed for all the spectra, and was not moved during the time the whole series was being photographed. An alloy of tin-cadmium was used because it gives a large number of well-defined lines, equally distributed. Notwithstanding the care taken, and that twelve spectra were photographed on the same plate, in only four spectra are the tin and cadmium lines coincident in position. The mean of the readings for these four spectra was taken for the standard spectrum, and all others were reduced to it by finding the corrections for the tin and cadmium lines, and interpolating corrections for lines between them.

For the construction of the curve, 180 lines from the different spectra were employed. The whole of these lines were cut by the curve. A few lines were left a little to the one side or the other, but these are not included in the above number. The lines employed for the portion of the spectrum beyond the cadmium line 2146·8 were those of zinc, M. CORNU'S numbers for their wave-lengths being made use of. This portion of the curve was made as continuous as possible with the other. Not all the points were cut by it, and to this is owing the slight difference between some of the numbers in our table of the zinc lines and those of M. CORNU.

The curve is a very regular one, and might be drawn from a very few accurate points.

The value of the error of $\frac{1}{2000}$th of an inch in measurement for different parts of the curve for prism spectra, in terms of wave-length, is given in the following table :—

Portion of curve between the wave-lengths given.	Value of error in tenth-metres of $\frac{1}{2000}$th of an inch.
4780 to 4440	1·1 to 1·0
4440 to 3990	1·0 to 0·7
3990 to 3600	0·7 to 0·5
3600 to 3200	0·5 to 0·3
3200 to 2800	0·3 to 0·25
2800 to 2400	0·25 to 0·16
2400 to 2020	0·16 to 0·08

Well defined lines can with certainty be measured to $\frac{1}{2000}$th inch ; for weak and indistinct lines the error of measurement amounts to $\frac{1}{1000}$th, but even with this error most satisfactory determinations can be obtained from the curve.

Great care is necessary in measuring these prismatic spectra. It is difficult to accurately adjust the cross hairs to the lines, owing to the latter being somewhat, though very slightly, curved ; consequently the readings may not be quite true with reference to the tin and cadmium lines, but either a little too small or a little too large.

The danger of this error is reduced to a minimum if the photographs are taken with the electrodes rather close together, or where only strong lines are to be observed by making the spark cross the slit.

In the list of lines given in the tables for each metal, the greatest care has been taken to eliminate those due to foreign metals. This has been done as completely as possible by taking a large number of photographs of the spectra of several elements for the purpose of comparison. In cases of doubt, spectra of very strong solutions of the purest salts were taken. It has been found that lines due to impurities generally present a decidedly different character to any of the lines due to the metal under examination. This will be referred to again further on. The wave-length of every line identified with a given metal has been determined either from the grating or prismatic spectrum. In the present state of our knowledge this has been thought important. The short lines of cadmium and zinc, for instance, have not been measured by previous observers ; they are, however, a very characteristic feature in each spectrum.

Certain weak lines do not appear in the diffraction spectra, but are plainly visible in those obtained by means of a prism. Such lines have been measured with the interpolation curve, and are distinguished in the following tables by their wave-lengths being printed in italic figures.

It was originally intended that these spectra should be drawn on the same scale as CORNU'S map of the solar spectrum; this would have necessitated scales and drawings eight feet in length for each of the sixteen spectra. The work was actually commenced, but the mapping of every line proved too laborious; accordingly enlarged photographs of the prism spectra, about thirty-six inches in length, have been utilized by writing the wave-length over each line. These photographs are intended to serve for particular reference. In addition, each line has been carefully described, and its position on the photographed spectra has been very carefully determined and recorded in the scale numbers. For the purposes of chemical analysis, small maps and actual photographs, showing the characters of the lines, are of most value, and accordingly the principal lines have been drawn on the scale of wave-lengths on sheets of a size convenient for reference and comparison with a series of prism photographs ten inches in length. The scale numbers refer to spectra of about one-half these dimensions. Should it be found necessary at any time to rectify any of the wave-lengths given in this paper, this may be easily accomplished by the use of an interpolation curve, derived from the scale numbers and true wave-lengths.

In all cases where the wave-lengths on the maps differ from the numbers in the tables the latter must be considered as the more correct, the drawings being on too small a scale to admit of great accuracy, and moreover some of the numbers were slightly altered after the maps had been drawn.

DESCRIPTIONS OF SPECTRA AND TABLES OF WAVE-LENGTHS.

Full particulars concerning the method of producing the prism spectra, together with an account of the electrodes employed, have been already published in the Scientific Transactions of the Royal Dublin Society, and the characters of the various lines observed is there defined.

A peculiar feature of certain lines in the spectra of cadmium and indium has been observed, we believe, for the first time by us. The lines are continuous lines, but they do not extend from the point of one electrode to the other, but occupy only an intermediate position, commencing and terminating at some distance from the metallic points. A similar character is observable in certain air lines, when strong metallic lines occur in close proximity on either side. In both air lines and metallic lines the central portions become stronger, and the ends fade away as the temperature is increased. Lines which show this in a marked degree are those of indium with wave-lengths 2429·0, 2389·8, 2332·2, and that of cadmium with wave-length 2544·5. In a less remarkable manner the following lines represent this character in cadmium: 3080·2, 2868·0, 2832·3, 2774·5, 2763·1, 2658·5, 2635·3; in indium, 2956·1, 2709·3, 2602·5, and 2520·9. Air lines altered by the proximity of metallic lines are the following: 3408·0, 3329·3, 3007·0, and 2733·2.

The Spectrum of Air.

Scale-numbers.	Description of lines.	Electrodes employed.			Remarks.
		Copper.	Aluminium.	Mean.	
		Wave-lengths.	Wave-lengths.	Wave-lengths.	
7·97	Faint	4674·2	..	4674·2	The air lines being difficult to measure, we have taken the mean wave-lengths derived from two or three different photographs. *Thalén gives this line as double.
8·60	Faint	4660·2	..	4660·2	
9·08	Weak	4647·2	..	4647·2	
9·48	Weak	4641·2	..	4641·2*	
10·00	Strong	4629·0	4628·7	4628·9	
10·40	Weak	4619·9	..	4619·9	
10·74	Weak	4612·3	..	4612·3	
11·10	Weak	4605·6	..	4605·6	
11·40	Weak	4600·1	..	4600·1	
11·85	Weak	4595·0	..	4595·0	
11·89	Weak	4589·3	..	4589·3	
13·80	Faint nebulous band	4553·2	..	4553·2	
	Faint	4543·4	..	4543·4	
14·97	Weak band	4530·1	..	4530·1	
15·25	Faint, nebulous	4523·0	..	4523·0	
15·7	Weak, fine	4513·7	..	4513·7	
15·9	Weak	4506·6	..	4506·6	
16·96	Weak, fine	4476·6	..	4476·6	
17·48	Weak band	4466·1	..	4466·1	
18·23	Weak, fine	4458·7	..	4458·7	
19·25	Strong	4446·3	4445·8	4446·0	
20·03	Weak nebulous band	4433·0	4432·2	4432·6	
20·30	Weak, nebulous	4426·3	4425·5	4425·9	
20·89	Weak	..	..	4415·5	From the platinum plate.
21·01	Weak	..	..	4413·6	From the platinum plate.
21·80	Faint	4403·11	4402·0	4402·6	
21·93	Weak	4395·0	4394·8	4394·9	
22·5	Very faint	..	4386·3	4386·3	
22·83	Faint	4378·1	4377·9	4378·0	
23·61	Weak	4365·9	4365·7	4365·8	
24·16	Very faint, nebulous	..	4356·4	4356·4	
24·53	Weak, fine	4350·7	4350·2	4350·5	
24·67	Strong	4348·4	4348·0	4348·2	
24·83	Weak, fine	4343·8	4344·0	4343·9	
25·32	Faint	4336·0	4335·8	4335·9	
25·63	Faint	4330·9	4330·6	4330·8	
25·78	Faint	4327·2	4326·6	4326·9	
25·88	Faint	4324·6	4324·6	4324·6	
26·31	Weak	4319·0	4318·5	4318·7	
26·44	Weak	4316·3	4316·1	4316·2	
27·15	Very faint, nebulous	4306·1	4306·9	4306·5	
	Very faint	..	4302·0	4302·0	
27·16	Faint, nebulous	4290·3	4289·7	4290·0	
28·93	Faint, nebulous	..	4275·3	4275·3	
	Very faint, sharp	..	4274·3	4274·3	
29·49	Very faint	4265·8	4264·9	4265·4	
30·21	Faint	4253·4	4253·3	4253·4	
30·95	Strong, nebulous	4240·2	4241·0	4240·6	
31·21	Strong, nebulous	4236·7	4236·0	4236·4	
31·68	Fairly strong, nebulous	4229·1	4228·7	4228·9	
31·98	Faint, nebulous	4222·3	4222·8	4222·6	
32·38	Faint	4217·1	4215·9	4216·5	

The Spectrum of Air (continued).

Scale-numbers.	Description of lines.	Electrodes employed.			Remarks.
		Copper.	Aluminium.	Mean.	
		Wave-lengths.	Wave-lengths.	Wave-lengths.	
33·16	Faint, nebulous	4206·4	4206·2	4206·3	
33·63	Faint, nebulous	4197·5	4198·3	4197·9	
34·16	Weak, sharp	4189·3	4189·4	4189·3	
34·43	Weak, sharp	4185·2	4185·0	4185·1	
35·09	Weak, broad, nebulous	4176·4	4177·3	4176·8	
35·41	Weak, nebulous	4169·0	4169·5	4169·2	
35·97	Very faint, nebulous.	..	4157·9	4157·9	
36·47	Weak, fine	4152·8	4152·6	4152·7	
37·03	Fairly strong, fine	4145·4	4145·3	4145·4	
37·29	Fairly strong, fine	4132·8	4132·7	4132·8	
38·50	Faint, fine	4123·6	4123·7	4123·7	
38·73	Fairly strong, fine	4118·8	4119·1	4119·0	
39·23	Faint, fine	4110·5	4111·2	4110·9	
39·68	Fairly strong, fine	4103·6	4104·3	4104·3	
39·77	Fairly strong, fine		4102·6	4102·6	
40·25	Strong, fine.	4096·2	4096·7	4096·5	
40·36	Very faint, fine	..	4092·6	4092·6	
40·97	Faint, fine	4084·4	4085·3	4084·8	
41·68	Strong, fine.	4074·9	4075·3	4075·1	
41·98	Strong, fine.	4071·3	4071·5	4071·4	
42·13	Strong, fine.	4069·1	4069·2	4069·2	
42·58	Very faint, fine	..	4063·5	4063·5	
42·94	Very faint, fine	..	4057·2	4057·2	
44·09	Strong, broad, nebulous	4041·8	4041·5	4041·7	
44·55	Weak, nebulous	4034·3	4034·5	4034·4	
45·18	Faint, nebulous	4024·8	4025·9	4025·3	
47·33	Very strong, sharp	3994·6	3994·5	3994·5	
47·83	Very faint	..	3988·5	3988·5	
48·23	Faint, sharp, fine.	3982·9	3983·1	3983·0	
48·97	Strong, fine	3972·6	3972·4	3972·5	
49·33	Faint, fine	..	3967·3	3967·3	
50·30	Strong, fine	3954·8	3954·9	3954·8	
51·03	Faint, nebulous	3944·1	3945·0	3944·5	
51·43	Weak, nebulous	3939·0	3939·5	3939·2	
51·88	Very faint	3932·4	3933·5	3932·9	
52·13	Very faint	..	3929·0	3929·0	
53·03	Strong, fine.	3918·5	3918·4	3918·5	
53·57	Weak, fine	3911·8	3911·6	3911·7	
54·95	Very faint	..	3892·4	3892·4	
55·85	Weak, fine	3881·8	3882·0	3881·9	
57·27	Faint, fine	3864·2	3863·4	3863·8	
57·86	Weak, nebulous	3856·4	3856·1	3856·2	
58·43	Faint, fine	3850·0	3851·0	3850·0	
58·99	Faint, nebulous	3841·2	3842·2	3841·7	
59·20	Weak, nebulous	3839·5	3839·1	3839·3	
59·86	Weak, fine	3831·0	3831·1	3831·0	
60·46	Very faint	..	..	3824·0	An approximation.
61·97	Faint, fine	3803·7	3804·4	3804·0	
63·07	Faint, fine	3791·6	..	3791·6	
63·97	Faint, fine	3781·8	3782·4	3782·1	
64·92	Faint, fine	3771·6	3771·3	3771·5	
65·95	Faint, fine	3759·4	3759·4	3759·4	

The Spectrum of Air (continued).

Scale-numbers.	Description of lines.	Electrodes employed.			Remarks.
		Copper.	Aluminium.	Mean.	
		Wave-lengths.	Wave-lengths.	Wave-lengths.	
66·35	Faint, fine	3753·7	3753·7	3753·7	
66·85	Strong, fine	3749·0	3748·9	3749·0	
67·57	Very faint, fine	3739·3	3740·1	3739·7	
68·78	Strong, fine	3726·6	3726·6	3726·6	
70·01	Fairly strong, fine	3712·2	..	3712·2	
70·89	Very faint	..	..	3702·0	An approximation.
71·89	Faint, fine, sharp	..	3639·0	3639·0	
79·21	Faint, fine	..	3613·6	3613·6	
79·63	Weak, fine	..	3610·0	3610·0	
81·08	Weak, fine	3595·0	3594·9	3595·0	
81·62	Weak, fine	3589·6	3589·7	3589·6	
82·29	Weak, fine	3583·1	3584·3	3583·7	
82·90	Weak, fine	3575·9	3576·4	3576·2	
84·38	Weak, nebulous	3560·4	3560·9	3560·6	
85·10	Very faint	..	3550·3	3550·3	
85·93	Weak, nebulous	3545·6	3544·8	3545·2	
89·21	Very faint, fine	..	..	*3514·1*	
90·76	Very faint, fine	..	..	*3499·7*	
91·61	Weak, fine	..	..	3490·7	
93·05	Faint, fine	3478·2	3478·1	3478·1	
93·83	Weak, fine	..	3471·2	3471·2	
95·51	Very faint, fine	..	..	*3456·2*	
96·40	Very faint, fine	..	..	*3448·0*	
97·63	Strong, fine	3436·8	3437·1	3436·9	This line is much altered in the palladium spectrum by two strong neighbouring lines. It appears strong in the centre, thinning away towards each end.
100·96	Fairly strong, fine	3407·8	3408·2	3408·0	
103·08	Fairly strong, fine	3389·7	3390·0	3389·9	
104·51	Weak, fine	3376·6	3377·2	3376·9	
105·00	Faint, fine, sharp	..	3373·6	3373·6	
105·28	Faint, fine, sharp	3370·2	3370·4	3370·3	
105·65	Fairly strong, fine, sharp	3366·1	3366·4	3366·7	
105·77	Fairly strong, fine, sharp			3365·7	
107·28	Fairly strong, fine	3353·7	..	3353·7	
108·63	Very faint, nebulous	..	..	*3342·7*	
109·88	Strong, fine	3331·8	3331·2	3331·5	In the antimony spectrum only the central portion of this double line is visible, the two ends gradually thinning away. A metallic line fails near it.
110·23	Strong, fine	3329·1	3329·4	3329·3	
110·79	Faint, fine	3324·1	3325·3	3324·7	
111·49	Weak, fine	3320·1	3319·9	3320·0	
112·97	Very faint, fine	..	3313·3	3313·3	
113·07	Very faint, fine	..	3307·1	3307·1	
113·75	Very faint, fine	..	3301·1	3301·1	
115·13	Faint, nebulous, broad	..	3289·9	3289·9	Possibly a triplet.
117·26	Faint, nebulous	..	3274·6	3274·2	
118·33	Weak, fine	..	3265·2	3265·2	
119·05	Weak, fine	..	3259·9	3259·9	
124·57	Very faint	..	3219·7	3219·7	This and the following lines are from the indium and thallium plates, 11–18.
132·97	Very faint, fine	3157·4	..	3157·4	
135·61	Fairly strong, fine	3139·0	3139·6	3139·3	
136·51	Fairly strong, fine	3134·2	..	3134·2	
138·36	Very faint	3122·4	..	3122·4	
148·14	Very faint, fine	..	3058·4	3058·4	
150·00	Faint, fine	..	3046·3	3046·3	
150·73	Very faint, fine	..	3042·5	3042·5	

THE Spectrum of Air (continued).

Scale-numbers.	Description of lines.	Electrodes employed.			Remarks.
		Copper.	Aluminium.	Mean.	
		Wave-lengths.	Wave-lengths.	Wave-lengths.	
152·01	Faint, fine	..	3034·9	3034·9	
153·77	Weak, fine	..	3024·1	3024·1	
154·86	Faint, fine	..	3016·1	3016·1	
156·27	Strong, fine	3006·7	3007·4	3007·0	In the antimony and arsenic spectra a metallic line falls near this, and its character is altered. In other spectra it generally appears stronger, and in cadmium it is strong throughout its length, but in the case of the above spectra it is strongest in the centre.
160·45	Weak, fine	2983·0	2982·6	2982·8	
164·59	Faint, fine	2959·7	2959·3	2959·5	
178·35	Faint, fine, sharp. . . .	2884·6	..	2884·6	
178·87	Faint, fine, sharp. . . .	2880·4	..	2880·4	
189·975	Weak, nebulous	2822·8	2823·3	2823·1	
194·935	Faint, fine	2799·0	2800·0	2799·5	
205·615	Very faint, fine	2748·8	..	2748·8	This and following numbers from the indium, 17–26 plate.
208·955	Faint, fine	..	..	2733·2*	
213·875	Faint, broad, nebulous . .	..	..	2710·1	
241·375	Very faint	..	..	*2598·4*	*The line 2733·2 is strongest in the centre, thinning away at each end.
243·105	Faint, fine	..	..	*2591·8*	
246·175	Faint, fine	..	..	*2580·0*	
261·85	Weak, nebulous, broad . .	..	..	2522·1	
274·78	Weak, fine, sharp . . .	..	..	2478·1	
279·42	Very faint, nebulous. . .	..	..	2463·0	
282·29	Faint, fine	..	..	2453·8	
284·80	Fairly strong, fine . . .	..	..	2445·2	
288·56	Fairly, strong, fine . . .	..	..	2433·6	
291·58	Weak, nebulous	..	..	2423·8	
293·37	Faint, fine	..	..	2418·6	
294·15	Very faint, fine	..	..	*2416·2*	
295·60	Very faint, fine	..	..	*2411·7*	
296·95	Very faint, fine	..	..	*2407·7*	
299·975	Very faint, fine	..	..	*2398·3*	
302·555	Very faint, fine	..	..	*2390·7*	
322·86	Very faint, broad, nebulous	..	..	2332·2	
328·21	Fairly strong, broad . .	..	..	2318·1	
333·25	Very faint, fine, sharp . .	..	..	*2314·4*	
334·23	Faint, fine, sharp . . .	*2301·3*	*2301·8*	*2301·8*	From the zinc and bismuth prism spectra.
335·62	Faint, fine, sharp . . .	*2297·6*	*2298·0*	*2298·0*	
337·14	Faint, fine, sharp . . .	*2294·1*	*2294·2*	*2294·2*	
338·35	Very faint, fine, sharp . .	..	..	*2291·0*	
339·00	Very faint, fine, sharp . .	..	..	*2289·3*	
354·51	Very faint, nebulous . .	..	..	*2250·2*	
381·19	Very faint, nebulous . .	..	..	*2186·0*	An approximation.

THE Spectrum of Magnesium.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
17·46	VERY STRONG, discontinuous, broad, with nimbus	4480·1	All the strongest lines of magnesium are much extended and surrounded by a very strong nimbus. A nebulous air-line occurs at λ=3856·1.
54·72	Weak, short	*3896·0*	
55·03	Weak, short	*3892·0*	
57·90	Weak, short	*3855·5*	
58·58	Weak, short	*3849·5*	
59·30	STRONG, CONTINUOUS, extended	3837·9	A very strong nimbus is seen around these lines.
59·83	STRONG, CONTINUOUS, extended	3832·1	
60·07	STRONG, CONTINUOUS, extended	3829·2	
65·45	Faint, short, broad, nebulous	*3765·3*	
109·52	Weak, fine, continuous, extended, faint in centre	3336·3	
110·04	Weak, fine, continuous	3331·8	
110·36	Weak, fine, continuous	3329·1	
135·67	Faint, short	3139·3	
136·33	Faint, short	3134·3	
140·55	Weak, short, broad, nebulous	*3107·0*	
142·30	STRONG, CONTINUOUS, fine, extended	3096·2	A large nimbus is seen here.
142·85	Fairly strong, continuous, fine, extended	3091·9	
143·18	Fairly strong, continuous, fine, weak in centre	3089·9	
145·85	Weak, short, fine	3071·6	
150·09	Faint, short, fine	*3046·0*	
167·74	Faint, very fine, discontinuous	*2941·6*	
168·70	VERY STRONG, continuous, broad, with nimbus extended	2935·8	
170·18	VERY STRONG, continuous, broad, with nimbus extended	2928·1	
172·58	STRONG, FINE, short	2913·8	
178·25	Faint, short, broad, nebulous	*2884·3*	
184·63	VERY STRONG, continuous, broad, with nimbus, extended	2851·2	The first and third lines of this quadruple group are more persistent than the second and fourth, so that the former lines are visible in solutions too dilute to show the latter. The nimbus to this group of lines is remarkably strong.
185·23	Very faint, fine, continuous	*2847·9*	
185·61	Very faint, fine, continuous	*2845·9*	
191·72	Faint, discontinuous, nebulous	*2815·3*	
192·80	Faint, discontinuous, nebulous	*2810·0*	
194·55	VERY STRONG, continuous, fine, extended	2801·6	
195·39	VERY STRONG, continuous, fine, extended	2796·9	
195·95	VERY STRONG, continuous, fine, extended	2794·1	
196·92	VERY STRONG, continuous, fine, extended	2789·6	
198·64	*Fairly strong*, continuous, fine	2781·8	A nimbus surrounds the extremities of these lines.
198·96	*Fairly strong*, continuous, fine, weak in centre	2780·2	
199·30	*Strong*, continuous, fine	2778·7	
199·61	*Fairly strong*, continuous, fine, weak in centre	2776·9	
199·97	*Fairly strong*, continuous, fine	2775·5	
208·48	Faint, fine, discontinuous	*2736·0*	
208·80	Faint, fine, discontinuous	*2734·3*	
226·42	Short, weak, broad, nebulous	*2658·4*	

The Spectrum of Zinc.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
5·72	Faint, short, fine	*4725·0*	The lines of zinc are much extended.
7·72	Faint, short, fine	*4680·0*	
61·35	Very faint, short	*3813·5*	
61·53	Very faint, short	*3811·5*	
66·12	Faint, very short	*3757·5*	
69·34	Weak, very short	*3720·5*	
69·98	Weak, very short	*3713·5*	
70·79	Weak, very short	*3704·5*	
71·75	Weak, very short	*3694·0*	
72·75	Weak, very short	*3683·0*	
74·13	Weak, very short	*3668·0*	
76·01	Faint, very short	*3645·4*	
77·49	Weak, very short	*3632·2*	
78·25	Weak, very short	*3623·4*	
82·57	Faint, very short	*3578·2*	
84·35	Faint, very short	*3560·8*	
86·84	Very faint and short	*3536·8*	
87·56	Faint, very short	*3529·8*	
89·73	Very faint and short	*3509·2*	
91·61	Faint, very short	*3491·8*	
108·49	VERY STRONG, CONTINUOUS, broad, with nimbus, extended	3344·4	
113·75	VERY STRONG, CONTINUOUS, broad, with nimbus, extended	3301·7	
116·30	STRONG, CONTINUOUS, with nimbus, extended	3281·7	
119·53	Faint, very short	*3255·8*	
121·77	Faint, very short	*3238·7*	
122·30	Faint, very short	*3234·6*	
145·69	STRONG, CONTINUOUS, fine, sharp, extended	3075·6	
146·22	STRONG, DISCONTINUOUS, fine, extended	3071·7	
152·03	STRONG, DISCONTINUOUS, slightly extended	3035·4	
153·89	Faint, short	3024·1	Coincident with an air line.
154·85	Weak, discontinuous, fine, sharp	3017·5	
158·21	Faint, very short	2996·7	
164·86	Faint, very short	2959·5	Coincident with an air line.
177·86	Faint, very short	*2886·4*	
183·60	Faint, very short	*2856·3*	
194·98	STRONG, CONTINUOUS, fine, with a nimbus	2800·1	
198·54	Very faint, short	*2782·5*	
199·30	Faint, short	*2778·4*	
201·23	STRONG, CONTINUOUS, with a nimbus	2770·2	
204·37	*Fairly strong*, discontinuous	2754·5	
212·17	Faint, short	*2719·7*	
213·97	Faint, long	2711·5	
220·45	Faint, long	2683·8	
226·64	Faint, short	2657·0	
238·96	Weak, discontinuous, fine	2607·6	
242·97	Very faint and short	*2592·3*	
243·75	Very faint and short	*2589·3*	
244·84	Very faint and short	*2585·1*	
245·81	Weak, discontinuous, fine	*2581·4*	
247·58	Weak, short	*2574·8*	
249·01	Weak, short	*2569·4*	
252·31	VERY STRONG, CONTINUOUS, broad, with a nimbus much extended	2557·3	

THE Spectrum of Zinc (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
258·42	Faint, very short	*2535·0*	These lines appear as dots on the photographs.
259·17	Faint, very short	*2532·3*	
260·85	STRONG, very short	*2526·3*	
262·26	STRONG, very short	*2521·3*	
264·12	STRONG, very short	*2514·7*	
265·85	STRONG, very short	*2508·7*	
267·95	Very strong, broad, sharp, continuous, with a nimbus, extended	2501·5	
269·23	Very faint, short	*2497·0*	The lines more refrangible than this, described as very short, appear as dots on the photographs.
269·34	Very faint, short	*2496·5*	
271·10	STRONG, short, nebulous	*2490·4*	
272·44	STRONG, very short	*2485·9*	
272·70	Weak, very short	*2485·0*	
273·10	Faint, very short	*2483·7*	
274·43	Faint, very short	*2479·2*	
276·56	Weak, very short	*2472·2*	
277·70	Faint, very short	*2468·3*	
278·38	Weak, very short	*2465·9*	
279·40	Faint, very short	*2462·8*	
279·88	Weak, very short	*2461·3*	
280·37	Faint, very short	*2459·8*	
283·44	Weak, very short	*2450·0*	
286·02	Weak, very short	*2441·6*	
287·29	Weak, very short	*2437·7*	
288·51	Faint, very short	*2433·9*	
290·73	STRONG, very short	*2427·0*	
291·91	Weak, very short	*2423·3*	
292·75	Faint, very short	*2420·7*	
293·35	STRONG, very short	*2418·8*	
296·69	Weak, very short	*2408·4*	
297·71	Weak, very short	*2405·3*	
298·79	Very faint and short	*2401·9*	
299·81	Very faint and short	*2398·7*	
300·60	Very faint and short	*2396·4*	
301·68	Very faint and short	*2393·3*	
302·76	Very faint and fine, rather long	*2390·1*	
304·79	Very faint and short	*2384·2*	
305·30	Very faint, fine, discontinuous	*2382·8*	
309·10	Very faint, short	*2371·7*	
310·43	Very faint, short	*2367·8*	
317·10	Weak, very short	*2348·7*	
317·79	Very faint, fine, discontinuous	*2346·7*	
324·04	Very faint and short	*2329·3*	
329·30	Weak, very short	*2315·0*	
331·58	Weak, very short	*2308·8*	
347·76	Faint, very short, fine, sharp	*2267·0*	
352·62	Faint, very short, fine, sharp	*2255·0*	
402·91	Weak, continuous, nebulous	*2138·5*	
419·05	Faint, discontinuous, fine	*2104·2*	CORNU measured this quadruple group as a double line, λ of the more refrangible line =2098·8.
420·04	Faint, discontinuous, fine	*2102·0*	
421·51	Faint, continuous, nebulous	*2099·0*	
422·95	Very faint, discontinuous	*2095·9*	
428·02	Faint, short, nebulous	*2085·4*	CORNU did not measure these lines.
431·87	Faint, short, fine	*2077·6*	
436·50	Very faint, short	*2068·4*	
439·37	Faint, discontinuous, nebulous	*2062·8*	
440·35	Faint, continuous, nebulous	*2060·8*	
460·30	Faint, continuous, nebulous	*2024·2*	

The Spectrum of Cadmium.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
2·45	Faint, fine, discontinuous	*4799·0*	The strongest lines of cadmium are remarkable for being much extended, more so than those of zinc or even magnesium. The nimbus surrounding the electrodes is larger than that of zinc, but much less than that of the magnesium lines.
7·85	Weak, fine, discontinuous	4676·7	
20·93	Weak, fine, continuous, extended	4414·5	
32·53	Faint, very short	*4215·3*	
36·15	Faint, very short	*4158·0*	
37·29	Faint, very short	*4141·0*	
38·19	Faint, very short	*4127·4*	
39·01	Faint, very short	*4115·2*	
47·93	Faint, very short	*3987·6*	
48·75	Weak, very short	*3976·3*	
49·89	Weak, very short	*3974·5*	
51·39	Weak, very short	*3940·0*	
58·29	Faint, very short	*3851·0*	
61·64	Faint, very short	*3810·0*	
(72·59)	(Faint, fine)	(3682·6)	Line of doubtful origin. Like an impurity, as it proceeds from one electrode only.
79·37	STRONG, CONTINUOUS, greatly extended, with a nimbus	3611·8	A pair appearing like a single line.
79·68	VERY STRONG, continuous, much extended, with a nimbus	3609·6	
87·06	Weak, fine, discontinuous	3535·0	
90·88	Weak, short, nebulous	3498·2	
94·30	STRONG, continuous, much extended, with a nimbus	3466·8	A pair appearing like a single line.
94·50	VERY STRONG, continuous, much extended, with a nimbus	3465·4	
101·45	VERY STRONG, continuous, extended	3402·9	
103·56	Weak, very short	*3384·7*	These lines appear somewhat nebulous, being very short and crowded together.
115·76	Faint, very short	*3285·3*	
116·06	Weak, very short	*3282·9*	
116·87	Weak, very short	*3276·4*	
118·45	Weak, very short	*3264·1*	
119·00	STRONG, continuous, extended, fine	3260·2	
120·04	Weak, fine, continuous	3251·8	
120·42	STRONG, FINE, continuous, extended, weak in centre	3249·5	
122·21	Faint, very short	*3233·6*	
123·91	Faint, very short	*3222·6*	
124·30	Faint, very short	*3219·9*	
124·77	Weak, very short	3216·0	
125·39	Faint, very short	*3211·8*	
125·79	Weak, very short	3209·0	
126·91	Faint, very short	*3200·6*	
127·49	Weak, very short	*3196·8*	
127·78	Weak, very short	*3194·9*	
129·21	STRONG, very short	*3185·1*	
129·62	Faint, very short	*3181·5*	
130·13	Faint, very short	*3177·9*	
130·40	Faint, very short	*3176·1*	
130·87	STRONG, very short	*3172·9*	
132·60	STRONG, very short	*3161·0*	
133·30	Weak, very short	*3156·6*	
133·78	Faint, very short	*3152·7*	
136·80	Weak, continuous, fine	3132·5	

THE Spectrum of Cadmium (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
137·34	STRONG, very short	3129·4	
138·05	Weak, very short	3123·6	
138·47	Weak, very short	3120·9	
138·92	Fairly strong, very short	3117·8	
139·80	Weak, very short	*3112·0*	
142·38	STRONG, very short	3095·0	
143·05	Faint, very short	*3090·5*	
143·48	Faint, very short	*3087·7*	
144·10	STRONG, very short	3084·3	
144·60	Weak, continuous, fine	3080·2	This line appears strongest in the centre.
145·24	Weak, very short	*3076·7*	
145·78	Faint, very short	*3073·2*	
146·61	Fairly strong, very short	*3067·8*	
147·21	STRONG, very short	*3064·0*	
148·13	Fairly strong, very short	3058·4	Coincident with an air line.
149·10	Fairly strong, very short	3052·3	
149·75	Fairly strong, very short	3048·2	
151·88	Faint, very short	*3034·9*	
153·68	Faint, very short	*3023·8*	
154·93	Weak, very short	*3016·1*	
155·48	Faint, very short	*3013·8*	
157·18	Faint, very short	*3002·5*	
158·47	Weak, very short	*2994·8*	
159·93	Weak, very short	*2986·1*	
161·05	STRONG, CONTINUOUS, extended	2979·9	
162·70	Weak, very short	*2970·2*	
163·95	Faint, very short	2964·5	
165·96	Faint, very short	2951·4	
166·75	*Fairly strong*, short	2947·1	
173·50	Weak, very short	*2909·9*	
179·07	STRONG, CONTINUOUS, extended	2880·1	
181·37	Weak, continuous, fine	2868·0	In some photographs this line appears strongest in its central portion, more especially when the spark is strong and the electrodes near together. Though continuous it does not extend from pole to pole.
187·65	*Fairly strong*, continuous	2836·1	
188·22	Faint, short	*2833·0*	
188·30	Faint, fine, continuous	*2832·3*	Strongest in its central portion.
193·37	Faint, very short	*2807·3*	
194·01	Weak, very short	*2804·0*	
199·10	Faint, very short	*2779·8*	
200·18	Faint, continuous, fine	2774·5	Strongest in its central portion.
202·04	Weak, very short	2766·5	
202·58	Weak, fine, continuous	2763·1	Strongest in its central portion.
205·87	VERY STRONG, CONTINUOUS, broad, with a nimbus, and greatly extended	2747·7	
210·72	Weak, very short	2726·9	
215·34	Faint, very short, fine	2706·0	
222·05	Weak, continuous, fine	2677·2	
226·49	Very faint and short	*2658·5*	Strongest in its central portion.
228·67	Very faint and short	*2649·4*	
229·62	Very faint and short	*2645·4*	
231·05	Very faint and short	*2639·5*	
231·12	Weak, continuous, fine	2639·7	

THE Spectrum of Cadmium (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
232·09	Very faint and short	*2635·3*	Strongest in its central portion.
232·75	Very faint and short	*2632·7*	
232·84	Very faint, continuous, fine	*2632·3*	
233·45	Very faint and short	*2630·2*	
233·61	Very faint, continuous, fine	*2629·1*	
234·69	Very faint and short	*2624·8*	
236·35	Weak, very short	2618·0	
237·39	Faint, fine, continuous, sharp	*2614·0*	
238·13	Very faint and short	*2611·0*	
240·79	Very faint and short	*2600·8*	
241·30	Very faint and short	*2598·8*	
242·19	Very faint and short	*2595·3*	
243·08	Very faint and short	*2592·0*	
244·16	Very faint and short	*2587·8*	
244·86	Very faint and short	*2585·0*	
248·24	VERY STRONG, CONTINUOUS, broad, with a nimbus and greatly extended	2572·2	
250·70	Very faint and short	*2563·2*	
252·30	Very faint and short	*2557·4*	
252·96	Very faint and short	*2555·0*	
253·72	Weak, very short	2551·6	
255·08	Very faint and short	*2547·2*	
255·73	Faint, fine, continuous	2544·5	The central portion of the line only visible.
258·50	Weak, short	2499·6	
272·02	Weak, short	2488·2	
277·50	*Fairly strong*, fine, discontinuous	2469·3	
293·32	Weak, short, fine	2418·5	
307·11	Faint, very short, fine	*2377·3*	
307·75	Faint, very short, fine	*2376·6*	
323·80	STRONG, CONTINUOUS, weak in centre	2329·5	
326·80	VERY STRONG, CONTINUOUS, with a nimbus, weak in centre	2321·6	
329·85	VERY STRONG, CONTINUOUS, broad, with a strong nimbus, extended	2313·6	
332·22	STRONG, CONTINUOUS, fine, weak in centre	2307·0	
339·25	VERY STRONG, CONTINUOUS, broad	2288·9	
347·20	Weak, discontinuous	2268·6	
348·15	VERY STRONG, continuous, broad, with a nimbus and slightly extended	2265·9	
354·60	Weak, short	2249·2	
358·35	*Fairly strong*, discontinuous, fine	2241·4	
364·73	Weak, short	2227·0	
373·55	Weak, continuous	2206·2	
377·48	STRONG, BROAD, continuous, nebulous, weak in centre	2196·4	
400·20	STRONG, BROAD, continuous, nebulous	2146·8	
415·60	Faint, very short, nebulous	*2111·5*	

Five lines of zinc appear in the photographs, which proceed from one electrode only, their wave-lengths are 3344·7, 3302·1, 3282·0, 2557·3, 2501·5.

The Spectrum of Aluminium.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
15·5	Strong, short	4511·0	A comparison of the map with the photograph of this spectrum will show that most of the short lines photographed are due to iron or other impurities.
15·85	Strong, short	4518·3	
17·66	Strong, very short	4477·2	
19·42	Strong, very short	4445·2	
49·85	Very strong, continuous, sharp, extended	3960·9	
51·16	Very strong, continuous, sharp, extended	3943·4	
70·02	Strong, short	3713·4	
71·03	*Fairly strong*, short	3701·5	
79·17	A triplet, very strong	3612·4	
80·50	The lines are short and extended, the	3601·1	
82·07	most refrangible being the strongest and most extended	3584·4	
142·86	Very strong, continuous, sharp, extended	3091·9	
144·5	Very strong, continuous, sharp, extended	3081·2	
147·10	*Fairly strong*, short, fine	*3065·0*	
147·40	*Fairly strong*, short, fine	*3062·8*	
148·12	*Fairly strong*, short, fine	*3058·5*	
148·50	Strong, short, fine, sharp, slightly extended	3056·4	
148·90	*Fairly strong*, short, fine	*3053·6*	
149·60	*Fairly strong*, short, fine	*3049·1*	
179·00	Strong, fine, discontinuous, slightly extended	2879·9	
191·76	Very strong, discontinuous, broad, sharp, much extended	2815·3	
226·30	*Fairly strong*, discontinuous, fine . .	2659·3	
228·26	*Fairly strong*, discontinuous, fine . .	2651·2	
233·25	Very strong, short, broad, with a nimbus, extended	2630·6	
247·75	Strong, discontinuous, extended. . .	2574·1	
249·66	Strong, discontinuous, extended. . .	2566·9	
308·55	Strong, discontinuous, nebulous. . .	*2373·3*	
309·00	Strong, short, nebulous	*2372·0*	
309·60	Weak, short, fine.	*2370·2*	
309·94	Weak, short, fine.	*2367·2*	
310·62	Strong, discontinuous, nebulous. . .	*2364·5*	

This spectrum was from carbon electrodes, kept moistened with a strong solution of pure aluminium chloride.

The photographs show faintly at one pole the two lines of copper, wave-lengths 3273·2 and 3246·9. A number of iron lines also appear; their wave-lengths have not been determined.

The Spectrum of Indium.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
7·60	Strong, short, fine	4681·5	
8·83	Strong, short, fine	4655·2	
9·58	Strong, short, fine	4637·0	
15·88	Very strong, continuous, fine, extended	4510·2	
30·10	Strong, and very short	4253·1	
39·91	Very strong, similar to line 4510·2	4101·3	
41·84	Very strong, very short	4071·6	
42·53	Weak, very short	*4063·5*	
44·61	Very strong, very short	4032·7	
45·20	*Fairly strong*, very short	*4025·6*	
58·10	Very strong, short	3852·8	
	Fairly strong, short	3840·5	
59·53	Very strong, short	3834·7	
62·92	Faint, short, nebulous	*3794·8*	
106·56	Faint, short	*3359·5*	
119·31	Very strong, continuous, fine, sharp, extended	3257·8	
119·68	Stronger, continuous, broader, more extended, with a nimbus	3255·5	
120·74	Weak, continuous, fine	3246·1	
122·15	Weak, short, fine, sharp	3236·2	
129·02	Weak, discontinuous, fine	3186·2	
130·72	Faint, very fine in centre, thins away at each end	3174·1	Appears to be a tin line.
132·81	Weak, short nebulous	3159·7	
134·26	Weak, short nebulous	3148·6	
149·97	Weak, discontinuous, fine	3047·0	Appears to be a tin line.
151·35	Very strong, continuous, broad, extended	3038·7	
156·38	Very strong, short, broad, with a nimbus	3008·0	
160·70	Very strong, short, broad, with a nimbus	2982·3	
165·115	Faint, continuous, very fine	2956·1	The central portion of this line only is visible.
168·00	Very strong, continuous, broad, extended, fine in the centre	2940·8	
169·56	Strong, continuous, fine, extended	2932·3	
177·34	Very strong, discontinuous, sharp, extended	2889·8	
183·50	Faint, continuous, very fine	2857·1	
187·00	Very faint and fine, continuous	2839·2	
187·70	Weak, fine, continuous	2836·0	
188·38	Very faint and fine, continuous	2832·1	Between these two lines two or three broad nebulous dots occur. They are too faint to measure.
204·94	*Fairly strong*, continuous, fine	2752·8	
205·34	Weak, short, nebulous	2750·7	
208·01	Faint, short, fine	*2738·1*	
210·56	Faint, short, broad, nebulous	*2727·0*	
213·70	Weak, continuous, fine	2712·9	
214·56	Strong, sharp, continuous, extended	2709·3	In some photographs this line is strongest in its central portion.
215·32	Very faint and fine, continuous	2706·4	
233·27	Weak, short, nebulous	2631·2	
238·21	Very faint and fine, continuous	*2610·8*	
240·74	Weak, fine, continuous	2602·5	Strongest in its central portion.
241·34	Weak, fine, short	2600·2	
243·32	Weak, fine, short	2591·0	
244·42	Weak, fine, short	2586·6	
250·32	Weak, discontinuous, fine	2564·7	
251·76	Strong, continuous, fine, extended	2559·5	
253·30	Weak, short, fine	2554·1	

THE Spectrum of Indium (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
255·78	Weak, short	2545·8	
260·74	STRONG, very short	2527·1	
262·45	Weak, fine, continuous	2520·9	Strongest in the central portion.
270·93	Faint, short.	2492·7	
272·65	Faint, short, very fine	2485·5	
272·90	Faint, short, very fine	2485·1	
274·67	A very faint nebulous dot	2478·3	
277·34	*Fairly strong*, fine, discontinuous	2470·2	
278·00	Weak, very fine, sharp, only visible in central portion	2468·4	
279·68	Faint, very short dot	2462·5	
280·30	*Fairly strong*, continuous	2460·8	
280·42	Faint, very short dot	2460·3	Appears to be nearly coincident with previous line.
284·25	Faint, very short dot	*2447·4*	
285·40	Faint, very short dot	*2443·7*	
288·63	Weak, very short dot	2433·6	
289·43	Weak, very short dot	*2431·0*	
289·89	Very faint and fine, continuous	2429·0	*The central portion only of this line is visible.
290·18	Weak, discontinuous, fine	2428·6	
291·99	Weak, fine, sharp, discontinuous	2423·2	
292·11	Weak, fine, sharp, discontinuous	2422·8	
294·16	Weak, very short.	*2416·3*	
298·25	Weak, very short.	*2403·5*	
300·21	Weak, very short.	*2397·6*	
302·86	Faint, very fine, continuous	*2389·8*	The central portion only of this line is visible.
303·50	Faint, short	*2388·0*	
304·54	Weak, very short	*2385·9*	
305·87	Weak, very short	*2381·0*	
309·44	Weak, short, very fine, one half stronger than the other	*2370·7*	
314·24	Faint, very short.	*2357·0*	
314·65	Very faint and fine, continuous	*2355·8*	
314·75	Faint, very short.	*2355·4*	
315·30	Faint, very short.	*2353·8*	
316·12	STRONG, discontinuous	2351·3	
322·96	Faint, very fine, continuous	*2332·2*	The central portion only of this line is visible.
332·20	VERY STRONG, sharp, continuous, extended.	2306·9	
338·96	Faint, short	*2289·3*	
339·65	Faint, short	*2287·8*	
(343·44)	Weak, fine, sharp, half line	(*2278·0*)	This is probably an impurity.
348·82	Weak, short, fine, sharp	*2264·4*	
349·06	Weak, very short, nebulous	*2263·8*	
354·93	Weak, short, fine, sharp	*2249·2*	
356·74	Weak, short, fine, sharp	*2245·7*	
(361·82)	Faint, short, fine, sharp, half line	*2232·2*	These are probably due to impurities.
(362·32)	Faint, short, fine, sharp, half line	*2231·0*	
(366·80)	Weak, short, fine, sharp, one half stronger than the other	*2220·2*	These are probably due to an impurity.
(370·04)	Weak, short, fine, sharp, one half stronger than the other	*2212·4*	
372·92	Faint, discontinuous, fine	*2205·5*	
374·44	Faint, short, nebulous	*2202·0*	
377·82	Weak, fine, short.	*2194·0*	
378·94	Weak, fine, short.	*2191·2*	
383·42	Weak, short, fine, sharp	*2181·0*	
394·81	Faint, very short, nebulous	*2155·8*	
403·20	Faint, short, fine	*2137·8*	
431·61	Faint, discontinuous, broad, nebulous	*2078·1*	

The Spectrum of Thallium.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
5·09	Faint, short	*4740·0*	Very great extension is characteristic of some of the strongest lines in this spectrum.
29·18	Weak, very short	4270·5	
36·43	Weak, very short	*4152·7*	Coincident with an air line.
39·36	Strong, very short	4109·4	
42·92	Weak, discontinuous, fine, sharp	4057·2	Coincident with an air line.
46·38	Weak, very short	*4009·2*	
51·90	Strong, very short	3932·7	
63·37	Weak, very short	*3790·0*	
64·55	Very strong, continuous, sharp, very much extended	3775·6	
72·80	Weak, very short	*3682·2*	
73·50	Weak, very short	*3674·6*	
74·95	Faint, very short	*3658·9*	
75·50	Faint, very short	*3652·9*	
87·75	Very strong, fine, continuous, extended	3528·8	
88·70	Very strong, broad, continuous, sharp, very much extended, with a nimbus on more refrangible side	3518·6	
89·44	Weak, very short	3512·7	
89·90	Weak, very short	*3507·8*	
95·55	Strong, short	3455·8	
104·03	Strong, short, fine	3381·3	
105·44	Very faint and short	*3369·1*	
108·06	Weak, very short	*3347·4*	
113·95	Faint, very short	*3299·6*	
114·72	Faint, very short	*3293·6*	
115·34	Very faint and short	*3288·6*	
117·45	Faint, very short	*3271·6*	
120·74	Faint, fine, sharp, discontinuous	*3246·6*	
123·22	Strong, continuous, fine, sharp, extended	3229·0	
125·06	Weak, short	*3214·2*	
127·59	Faint, short	*3195·6*	
128·87	Faint, short, broad, nebulous	*3186·6*	
132·43	Strong, short	3162·6	
134·68	Faint, short	*3146·7*	
138·72	Faint, short	*3119·4*	
139·90	Faint, short	*3111·4*	
140·73	Faint, short	*3105·7*	
143·02	Very strong, continuous, sharp, weak in the centre	3091·0	
171·50	Strong, continuous, fine, sharp	2920·8	
172·21	Very strong, continuous, broad, extended	2917·7	
176·49	Very faint, fine, continuous	*2893·9*	
185·06	Faint, short, nebulous	*2848·6*	
187·43	Faint, short	*2836·7*	
189·73	Weak, continuous, sharp, fine	2825·4	
192·32	Faint, short, nebulous	*2812·5*	
201·87	Very strong, broad, with faint nimbus, much extended	2767·1	
214·63	Faint, continuous, fine	*2709·4*	
214·89	Strong, continuous, fine	2708·6	
217·72	Faint, short	2700·1	
224·075	Faint, short	2669·1	

THE Spectrum of Thallium (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
224·98	Weak, continuous, fine, sharp . . .	2665·0	
237·82	Weak, continuous, nebulous	2608·7	
246·30	STRONG, CONTINUOUS, fine, sharp . . .	2579·7	
253·80	Faint, long, fine	2551·6	
259·86	STRONG, long, with faint nimbus . . .	2530·0	
274·93	Weak, fine, continuous	2477·7	
277·63	*Fairly strong*, short	2468·9	
282·85	STRONG, short	2451·9	
301·30	*Fairly strong*, short	2394·8	
306·18	STRONG, CONTINUOUS, with faint nimbus	2380·0	
311·27	*Fairly strong*, short	2364·8	
319·32	Faint, short, nebulous	2343·1	
328·61	Weak, discontinuous, fine, sharp . .	*2257·0*	
335·27	STRONG, LONG, fine, with faint nimbus .	2299·3	
351·77	Faint, short	*2257·0*	
357·10	Faint, short	*2243·7*	
359·05	Faint, continuous.	*2239·0*	
368·36	Faint, short	*2217·0*	
371·08	Faint, short	*2210·0*	Coincident with a tin line.
373·80	Weak, short	*2203·5*	
402·75	Faint, short	*2139·0*	

THE Spectrum of Copper.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
	Weak, short	4274·2	No scale number was recorded for this line.
80·63	Weak, short	*3598·9*	
80·85	Weak, short	*3596·6*	
88·21	Faint, short	*3523·6*	
89·51	Faint, short	*3510·4*	
92·55	Faint, short	*3483·2*	
93·02	Faint, short	*3478·8*	
93·81	Faint, short	*3471·6*	
95·56	Faint, short	*3455·8*	
96·17	Faint, short	*3450·1*	
(104·01)	Very faint, short, half line	(*3381·0*)	Probably a silver line with wave-length 3382·1.
113·10	*Fairly strong*, short	3306·8	
115·10	*Fairly strong*, short	3289·9	
116·10	Weak, about one half scarcely visible.	3282·1	
(116·41)	Faint, one half only visible	(3280·1)	Probably the silver line with wave-length 3280·1.
117·25	VERY STRONG, SHARP, continuous, much extended	3273·2	
118·38	Weak, short	3265·2	Coincident with an air line.
119·05	Faint, short	3260·2	Coincident with an air line.
120·705	A LITTLE STRONGER, more extended than line 3273·2 ; in other respects similar	3246·9	
(121·10)	Faint, short, half line	(*3243·9*)	Probably an impurity.
(122·35)	Faint, short, half line	(*3233·4*)	Probably an impurity.

The Spectrum of Copper (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
135·63	Faint, short	3139·7	There are five faint half lines slightly less refrangible than this, too faint to be measured.
136·40	Faint, short	3134·2	
138·08	Weak, short	*3123·7*	Approximations.
139·28	Faint, short	*3115·7*	
140·48	Weak, short	*3107·4*	
141·92	Faint, short	*3097·8*	
151·35	Faint, short	3035·6	
153·90	Faint, short	3023·4	
164·53	Weak, discontinuous	2959·6	
178·55	Faint, short	2882·4	
179·56	Weak, short	2877·4	
187·55	Weak, short	2836·5	
190·13	Weak, short	2823·2	
201·36	STRONG, SHORT, sharp	2769·1	
201·81	Weak, short	2766·2	
206·35	Weak, short	2745·9	
211·80	A TRIPLET of short fine lines, the least refrangible weak, the other two STRONG	2721·2	
212·55		2718·4	
213·71		2713·1	
216·10	STRONG, SHORT, fine line	2702·7	
216·58	STRONG, SHORT, fine line	2700·5	
219·37	STRONG, SHORT, fine line	2688·8	
224·70	Weak, short	2666·0	
230·31	Very faint and short	2643·5	
236·45	Weak, fine, discontinuous, fine	2617·8	
238·87	Faint, short, fine	2608·9	
241·10	STRONG, SHORT, fine line	2599·7	
241·58	STRONG, SHORT, fine line	2598·3	
243·66	Weak, short, fine	2590·1	
248·00	Very faint, short, nebulous	*2573·0*	There are two or three very faint lines similar in character to this line, less refrangible, too faint to be measured.
248·28	Very faint, short, nebulous	*2572·0*	
248·61	Faint, short	2570·9	
250·11	Faint, short, nebulous	*2565·3*	
253·29	Very faint, short, nebulous	*2553·7*	
253·70	Faint, short, nebulous	*2552·2*	
255·94	VERY STRONG, discontinuous	2544·6	
257·65	Faint, very short, nebulous	2538·2	Approximations.
258·53	Faint, very short, nebulous	2533·9	
259·25	Faint, very short, nebulous	2531·4	
260·25	A PAIR OF STRONG short lines, the more refrangible line slightly weaker	2528·8	
261·00		2526·2	
261·95	Very faint and short, nebulous	2522·7	Approximations.
262·21	Very faint and short, nebulous	2522·1	
263·22	Very faint and short, nebulous	2518·3	
263·79	Very faint and short, nebulous	2517·5	
264·79	Very faint and short, nebulous	2513·2	
265·33	Very faint and short, nebulous	2512·2	Approximations.
266·20	Weak, very short	2508·7	
266·77	STRONG, SHORT, sharp	2506·2	
269·29	Very faint and short, fine	2497·4	
269·71	Very faint and short, fine	2495·9	
270·91	Weak, very fine, sharp, long line	2491·4	
271·65	STRONG, SHARP, short, fine line	2489·1	
272·72	SHORT, STRONG line	2485·6	
273·74	Weak, very fine, and short	2481·8	

THE Spectrum of Copper (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
274·89	Faint, very fine and short	2478·2	
275·87	Very faint, short	2475·1	
276·45	*Fairly strong* short line	2473·2	
277·88	Weak short line	2468·4	
278·57	Very short, nebulous	*2465·2*	
279·81	Very short, nebulous	*2461·5*	
280·85	Very short, nebulous	*2458·2*	
282·63	Very short, nebulous	*2452·5*	
284·45	Very short, nebulous	*2446·7*	
285·31	Weak, very short	2444·1	An approximation.
286·15	Weak, very fine, discontinuous	2441·6	
286·63	Very faint and short	*2439·8*	
287·93	Very faint and short	*2435·7*	
289·63	Very faint and short	*2430·3*	
290·35	Very faint and short	*2428·2*	
291·51	Weak, short, fine	2425·1	
292·33	Very faint, short	*2422·0*	
295·51	Weak, very short, fine	2412·2	
297·68	Weak, very short, fine	2404·8	
298·31	STRONG, SHORT, fine line	2403·3	
299·40	STRONG, SHORT, fine line	2400·1	
301·90	Very faint, fine	2393·0	
302·21	Very faint and fine, very short	2392·2	
304·39	Very faint, short, fine	2385·2	
307·35	Weak, short, sharp, fine	2376·7	
309·17	Faint, fine, short	2371·6	
309·57	VERY STRONG, LONG, broad	2370·1	
310·13	Faint, fine, short line	2368·7	
314·07	Fairly strong, short	2357·2	
314·59	Faint, short	2355·0	
316·83	Faint, fine, short	2348·8	
317·79	Faint, fine, short	2346·2	
321·25	Weak, short	*2336·6*	
333·46	Very faint, short, and very fine	*2303·8*	
334·7	Very faint, short	*2300·5*	
335·88	Very faint, short	*2297·5*	
336·80	STRONG, SHARP, FINE, discontinuous, extended	2295·0	
336·98	Weak, sharp, fine, discontinuous, less extended	2294·6	
338·02	Weak, short, fine	2291·4	
339·66	Weak, short, fine	2286·7	
342·87	Faint, short, fine	*2279·6*	
343·67	STRONG, FINE, discontinuous, extended, somewhat nebulous on more refrangible side	2277·0	
347·92	Faint, short line	2265·8	
348·55	Weak, fine, short, nebulous	2263·9	
348·78	Weak, fine, short, nebulous	2263·2	
352·05	Faint, short	2257·7	
354·41	Faint, short	2250·0	
355·27	A PAIR of double lines, each consisting of a rather long, VERY STRONG, sharp, fine, and extended line, and a weak, discontinuous, nebulous line	2248·2	
355·50		2247·7	
357·10		2244·0	
357·32		2243·5	

THE Spectrum of Copper (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
361·52	A group of six fine sharp lines, *the third and fourth, fairly strong*, rather long and extended, are the strongest and longest of the group. A faint nimbus about the central portion of the group	*2233·0*	
361·82		*2232·2*	
362·23		*2231·2*	
362·76		*2230·0*	
363·12		*2229·1*	
363·52		*2228·1*	
364·00	Very faint, short, and very fine line	*2227·0*	
364·37	Very faint, short, and very fine line	*2226·0*	
367·20	STRONG, FINE, sharp, discontinuous	*2219·3*	
367·50	Weak, nebulous, discontinuous	*2218·5*	
368·34	Weak, short, nebulous	*2216·5*	
368·62	Faint, short, fine	*2215·8*	
369·34	Faint, short, fine	*2214·1*	
370·47	STRONG, FINE, sharp, discontinuous	*2211·3*	
370·74	Weak, nebulous, discontinuous	*2210·8*	
374·56	Faint, very short	*2208·8*	
375·06	Weak, short, fine	*2200·3*	
375·28	Very faint, short, nebulous	*2199·8*	
376·68	Weak, short	*2196·5*	
378·67	*A pair* of double lines, each consisting of a STRONG, short, fine, sharp, extended, and a weak, short, nebulous line	*2192·0*	
378·96		*2191·2*	
379·61		*2189·6*	
380·12		*2188·5*	
383·37	A very faint, short line	*2181·0*	
384·30	*Rather strong*, short line	*2179·0*	
384·68	Weak, nebulous, short line	*2178·0*	
386·29	Weak, short, fine	*2174·5*	
398·07	Weak, short, fine	*2148·8*	
404·18	Weak, short, fine	*2135·8*	
404·93	Faint, short, nebulous	*2134·2*	
409·08	A pair of double lines, each consisting of a weak, fine, short, and a faint, nebulous, short line	*2124·4*	
409·29		*2124·0*	
410·63		*2122·1*	
410·92		*2121·5*	
413·45	Very faint, short, fine	*2116·0*	
416·07	Very faint, short, fine	*2110·5*	Possibly a double line.
419·61	Very faint, short, fine	*2103·9*	

The Spectrum of Silver.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
86·39	Faint, short	*3541·3*	
101·42	Faint, short	3404·2	
103·06	Faint, short	3398·7	
103·94	VERY STRONG, sharp, continuous, much extended	3382·3	
107·49	Faint, short, nebulous	3351·8	Coincident with Sn. 3351·8
112·47	Faint, short	*3311·6*	
113·15	Faint, short	*3306·1*	
113·85	Double, two similar lines, faint and short	*3300·6*	
114·05		*3299·0*	
114·89	Faint, short, nebulous	*3292·3*	
115·35	Faint, short, nebulous	*3288·6*	
116·45	VERY STRONG, forming a pair with previous strong line, with which it is similar in character but a little stronger	3280·1	
117·30	Faint, short, nebulous	*3272·8*	
118·47	Faint, short, nebulous	3265·2	
119·03	Faint, short, nebulous	3260·2	
120·05	Faint, short, nebulous	*3251·8*	
121·10	Weak, short	*3243·8*	
122·69	Faint, short, nebulous	*3231·8*	
123·13	Faint, short, nebulous	*3228·6*	
123·95	Faint, rather longer than foregoing, nebulous	*3222·3*	
124·81	Faint, short, nebulous	*3216·0*	
125·89	Faint, short, nebulous	*3208·1*	
127·16	Faint, short, nebulous	*3198·8*	
128·30	Faint, short, nebulous	*3190·6*	
129·30	Faint, short, nebulous	*3183·7*	All the foregoing short lines except the first really form a group of lines remarkably similar in character, and for the most part equi-distant from one another.
129·96	Faint, short, nebulous	*3179·2*	
130·70	Faint, short, nebulous	3174·3	
136·40	Very faint, short	*3134·9*	
137·25	Very faint, short	*3129·2*	
168·50	*A triplet* of short lines, the least refrangible being weak, the other *two fairly strong*	2937·4	
169·30		2933·5	
170·17		2928·2	
171·75	Weak, short	2919·1	
175·025	*A pair* of *fairly strong* short lines	2901·6	
176·075		2895·6	
180·44	*Fairly strong*, short	2872·7	
191·82	*Fairly strong*, short	2814·5	There are 7 or 8 very faint nebulous dots between these lines too faint to be measured.
195·03	*Fairly strong*, short	2798·9	
201·81	STRONG, SHORT, sharp, fine, much extended	2766·4	
204·20	STRONG, FINE, shorter and less extended	2755·5	
207·06	Faint, very fine, short	2742·9	
211·96	Very faint, short, very fine	*2720·6*	
214·22	STRONG, SHORT, broad, much extended	2711·3	
221·20	*Fairly strong*, short	2680·5	
226·27	STRONG, SHORT, extended, fine, sharp	2659·6	
227·08	Weak, short, fine	2656·2	
234·10	*Pair* of short fine lines	2627·3	
234·77		2625·2	

THE Spectrum of Silver (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
237·57	Pair of weak, fine, short lines . .	2613·7	
239·75		2605·4	
241·43	Very faint, short, fine	*2598·2*	
242·38	Faint, short, fine	*2594·7*	
246·30	STRONG, SHORT, fine	2579·9	
249·98	Faint, short, nebulous	*2565·8*	
250·70	Faint, short, nebulous	*2563·2*	
251·16	Stronger but shorter, fine	*2561·5*	
253·73	Very faint, short, fine	*2552·0*	
258·73	STRONG, SHORT, extended, very fine, sharp	2534·5	
268·81	STRONG, SHORT, extended, sharp . . .	2506·0	
267·50	Weak, short, fine	2503·6	
272·63	Faint, short, fine	2486·4	
272·87	Weak, short, fine	2485·4	
274·52	*Fairly strong*, short, fine	2479·9	
275·41	*A little stronger*, short fine	2476·8	
276·41	STRONGER, LONGER, and extended, fine on less, but nebulous on more refrangible side	2473·3	
277·69	Faint, very fine, sharp	*2469·0*	
279·92	*A pair of fairly* strong, short lines .	2462·2	
280·52		2459·8	
282·60	STRONG, short	2453·0	
284·38	VERY STRONG, discontinuous, extended, sharp	2447·4	
284·79	Weak, fine, short	*2445·7*	
285·41	Fairly strong, short	2443·9	
287·46	VERY STRONG, continuous, broad, extended, forming a pair with line 2447·4	2437·3	
290·00	VERY STRONG, sharp, extended . . .	2429·8	
290·14	Weak, short, fine	2428·8	
292·18	Faint, short, very fine	2422·8	
293·08	STRONG, short, fine	2419·9	
294·72	Very faint, short	*2414·5*	
295·35	VERY STRONG, continuous, extended, broad, nebulous on more refrangible side, sharp on less	2413·3	
295·94	Discontinuous, broad, less strong, and extended, otherwise similar in character	2411·3	
296·41	Very faint, short	*2409·3*	
297·94	Faint, short, fine	2406·4	
298·85	Faint, short, fine	2404·5	
301·10	Faint, short, fine	2395·7	
301·92	Very faint, short, fine	2393·3	
302·74	*Fairly strong*, short, fine	2390·8	
304·07	Faint, short, fine	2386·7	
304·20	Faint, short, fine	2386·2	
305·25	Faint, short, fine	2383·6	
307·94	*Fairly strong*, short, broad, nebulous .	2375·5	
311·05	Weak, short, fine	2365·8	
311·70	*Fairly strong*, fine	2364·3	
312·34	*Fairly strong*, fine	2362·3	
313·47	*Fairly strong*, short, fine, slightly extended	2359·2	

THE Spectrum of Silver (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
313·88	STRONG, SHORT, extended, fine. . . .	2358·1	
318·93	Very faint, fine, short	*2343·7*	
319·42	Very faint, fine, short	*2342·1*	
320·47	Very faint, fine, short	*2339·2*	
322·81	Very faint and short, fine	*2332·5*	
323·35	VERY STRONG, discontinuous, broad, much extended, sharp on less refrangible edge, and *nebulous on more refrangible side*	2331·7	
325·53	DOUBLE, consisting of a STRONG broad NEBULOUS, and a VERY STRONG FINE	2325·8	
325·73	line, *nebulous on more refrangible side*, but discontinuous and much extended	2325·3	
326·65	Weak, short, fine	2322·3	
327·37	VERY STRONG, discontinuous, broad, much extended, fine sharp on less, and *nebulous on more refrangible side*	2320·6	
328·05	Faint, short, very fine	2319·5	
328·59	VERY STRONG, discontinuous, much extended, broad, sharp on less, and *nebulous on more refrangible side* .	2317·4	
331·27	Weak, fine, short.	2310·1	
336·13	Faint, very short, fine	*2296·8*	
340·04	Very faint, short, fine	*2286·7*	
342·55	VERY STRONG, broad, short, sharp on less, and *nebulous on more refrangible side*	2280·7	
343·50	Faint, very short, fine	*2277·8*	
344·40	Faint, very short, fine	*2275·3*	
352·96	Weak, short, very fine	2254·1	
354·95	PAIR OF STRONG, BROAD, short lines,	2249·9	
355·90	sharp on less, and *nebulous on more refrangible side.*	2247·6	
362·86	*Fairly strong*, broad, short, sharp on less, and *nebulous on more refrangible side*	2230·6	
372·73	A pair of very faint and short fine	*2206·0*	
374·44	lines	*2202·0*	
381·21	Weak, short, fine on less, and *nebulous on more refrangible side*	*2186·0*	
390·33	Faint, short	*2165·8*	
392·33	Very faint, and very short.	*2161·3*	
399·65	Weak, short, fine on less, and *nebulous on more refrangible side*	*2145·4*	
412·05	Very faint, short, nebulous	*2119·0*	
415·38	Very faint, short, nebulous	*2112·0*	

The strong lines of silver described as nebulous on the more refrangible side may be double, like those of copper, to which they are perfectly similar in character. There is, however, no appearance of their being double with the dispersion we have employed.

THE Spectrum of Carbon.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
29·47	VERY STRONG, short, slightly extended .	4266·3	
52·93	STRONG, very short	3919·5	
55·85	Weak, discontinuous, extended . . .	3881·9	This line is not given by Messrs. LIVEING and DEWAR. Coincident with an air line.
56·32	*Fairly strong*, very short	3875·7	
56·70	Weak, fine, discontinuous	3870·7	These lines are not given by Messrs. LIVEING and DEWAR.
81·57	Weak, short	3589·9	
82·05	Weak, fine, discontinuous	3584·8	
82·28	Weak, fine, discontinuous	3583·3	
131·65	Weak, very short	3167·7	
131·91	Weak, very short	3166·0	
158·70	Weak, very short, broad, nebulous . .	2993·1	
163·23	Weak, very short	2967·3	
187·43	STRONG, SHORT, extended	2836·7	
187·65	STRONG, SHORT, extended	2835·9	
206·20	*Fairly strong*, very short, *nebulous* . .	2746·6	
230·34	Weak, very short, nebulous	2640·0	
264·84	STRONG, SHORT, fine, extended . . .	2511·6	
265·88	STRONG, SHORT, fine, extended . . .	2508·7	
274·78	Sharp, fine, barely discontinuous, extended	2478·3	This line is all but continuous.
335·89	STRONG, short, with a nimbus . . .	2297·7	It is the longest line in this spectrum.

This spectrum was taken from a piece of very pure Ceylon graphite, which contains only traces of iron and of magnesium as determined by an analysis of the ash. No iron lines appear in this spectrum, and only four lines of magnesium, namely, those with wave-lengths 2801·6, 2796·9, 2794·1, and 2789·6.* There are certain lines in Messrs. LIVEING and DEWAR'S spectra which are absent from ours, viz. : those with wave-lengths 2733·2, 2541·5, 2528·2, 2523·6, 2518·7, 2515·8, 2514·0, and 2506·6.

* These have since been shown to belong to the spectrum of silicon. See "Line Spectra of Boron and Silicon," Proc. Roy. Soc., vol. xxxv., p. 301; also report presented to the British Association, Chemical News, vol. xlviii., p. 1 (W. N. HARTLEY, Nov. 1, 1883). Of the lines attributed to the arc spectrum of carbon by Messrs. LIVEING and DEWAR that to which they assign a wave-length of 2478·3 is the only line belonging to this element. Their measurement is identical with that which we have obtained from the longest line in the spark.

The Spectrum of Tin.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
12·20	Strong, very short	4584·3	The lines 3351·8 and 3282·9 are short and very broad, with a strong nimbus, so that they have a somewhat nebulous appearance. In a less degree this remark also applies to the lines 2657·9, 2643·2, and 2631·5, and to several other lines in this spectrum described as very short.
15·18	Weak, discontinuous, fine	4524·0	
25·93	Weak, very short	4324·6	
32·50	Weak, very short	4215·3	
42·93	Weak, short, fine	*4057·0*	
49·75	*Fairly strong*, very short	3961·8	
50·88	Weak, discontinuous	*3947·0*	
53·92	Strong, very short	3906·6	
57·62	Strong, very short	3859·0	
62·40	Strong, continuous, extended, fine	3800·3	
63·80	Strong, very short	3783·4	
64·29	Strong, very short	3779·0	
65·55	*Fairly strong*, very short	3763·9	
67·15	Very strong, very short	3745·1	
68·10	Strong, very short	3734·4	
68·40	*Fairly strong*, very short	3727·0	
70·50	Strong, very short	3707·6	
72·36	Weak, very short	3686·7	
74·15	Weak, very short	3667·6	
75·23	Weak, discontinuous, fine	3655·5	
78·19	Faint, very short	3623·9	
78·90	Faint, very short	3616·9	
79·80	Strong, very short	3609·3	
80·60	*Very strong*, very short	3598·3	
83·12	Strong, very short	3574·0	
85·50	Fairly strong, very short	3549·7	
86·57	Faint, very short	*3539·3*	
89·13	Faint, very short	*3514·8*	
92·08	Faint, very short, fine	*3487·3*	
93·83	Weak, very short	3471·1	
100·35	Strong, short	3412·7	
102·88	Faint, very short	3390·4	
107·51	Very strong, short, extended, broad, with a nimbus	3351·8	A very characteristic group. These lines with those at 3174·3, 3033·1, 3007·9, are the principal lines in this spectrum.
110·25	Very strong, continuous, fine	3330·0	
112·21	Weak, short	3314·6	
116·03	Very strong, short, broad, with a nimbus extended	3282·9	
118·83	Very strong, continuous, extended, fine	3261·6	
120·89	Weak, very short	3245·0	
124·14	Faint, very short	3219·6	
124·62	Faint, discontinuous	3218·0	
130·70	Very strong, continuous, extended, fine	3174·3	
135·50	Weak, discontinuous, fine	3140·6	
138·24	Weak, very short	3122·3	
139·50	Faint, very short	3131·0	
142·31	Faint, very short	3095·2	
146·12	Strong, very short	3070·6	
150·06	Weak, discontinuous	3046·5	
152·18	Very strong, continuous, extended, fine	3033·1	
156·29	Very strong, continuous, extended, fine	3007·9	
173·05	Weak, continuous, faint in centre	2911·9	
176·18	Strong, very short	2895·0	
177·80	Strong, very short	2886·9	
179·50	Weak, very short	2877·4	
180·07	Faint, very short	*2874·7*	

The Spectrum of Tin (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
182·47	Very strong, continuous, extended, fine	2862·1	
184·99	Strong, continuous, extended, fine . .	2849·3	
185·45	Strong, very short	2847·6	
187·01	Very strong, continuous, extended, sharp	2838·9	
192·30	Strong, continuous	2812·5	
192·40	Faint, discontinuous, fine	2811·5	
197·61	Faint, discontinuous	2787·3	
198·28	Fairly strong, continuous, weak in centre	2784·0	
199·34	Strong, continuous, extended . . .	2778·8	
202·23	Faint, long, continuous	*2765·0*	
204·52	Faint, short	*2754·0*	
205·01	Faint, short	*2751·8*	
205·70	Faint, short	2749·0	
206·24	Faint, short	2746·0	
207·94	Faint, short	*2738·4*	
209·17	Faint, long	*2733·0*	
215·35	Very strong, continuous, extended, sharp	2705·8	
224·95	Strong, very short	2664·9	
225·98	Strong, continuous, fine	2660·2	
226·56	Very strong, short, nebulous . . .	2657·9	
229·67	Strong, very short	2645·4	
230·23	Very strong, short, nebulous . . .	2643·2	
233·17	Very strong, short, nebulous . . .	2631·5	
236·40	Strong, very short	2617·9	
237·47	Faint, very short	2613·8	
238·18	Faint, short	*2611·0*	
239·38	Faint, short	*2606·3*	
241·31	Faint, short	2598·5	
242·65	*Fairly strong, continuous*	2593·6	
243·10	*Fairly strong*, short	2591·7	
248·70	Strong, continuous, extended . . .	2570·5	
250·70	Faint, very short, nebulous	*2563·2*	
252·20	Faint, continuous, fine	*2557·7*	
255·45	Strong, continuous, extended . . .	2545·6	
259·59	Faint, discontinuous, fine	*2530·8*	
261·57	Weak, discontinuous, fine	2523·4	
264·35	Faint, very short	*2514·0*	
266·61	Faint, very short	*2506·0*	
268·55	Faint, very short	*2499·3*	
269·80	Strong, continuous, extended . . .	2495·0	This is a characteristic group, which is repeated, but with a lesser intensity, in the three lines immediately following.
271·85	Strong, short, broad, nebulous . . .	2488·0	
273·40	Strong, continuous, extended . . .	2482·9	
281·83	Weak, discontinuous	2455·5	
283·37	*Fairly strong*, short, *nebulous*	2449·4	
284·82	Weak, continuous	2445·2	
287·55	Strong, very short	2436·4	
288·65	Faint, short	2433·3	
289·95	Very strong, continuous, extended .	2429·3	
292·37	Very strong, continuous, extended .	2421·8	
296·80	Weak, discontinuous, fine	2408·0	
300·82	Faint, short	*2395·8*	
301·54	Faint, short	*2393·7*	
305·40	Faint, short	*2382·3*	

The Spectrum of Tin (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
305·84	Weak, discontinuous	*2381·1*	
310·11	Strong, discontinuous	2368·3	
314·85	Very strong, continuous, extended	2355·0	
321·94	Strong, discontinuous	2335·3	
328·34	Strong, continuous, *nebulous*	2317·9	
339·65	*Fairly strong*, discontinuous	2288·1	
346·58	Strong, discontinuous, *nebulous*	2270·0	
347·25	Faint, short	2268·6	
347·63	Weak, short	2267·1	
355·83	Strong, discontinuous	2247·0	
361·43	Faint, discontinuous, fine	*2233·2*	
362·92	Strong, very short	*2229·6*	
366·29	Strong, very short	*2221·5*	
368·88	Weak, very short	*2215·2*	
371·01	*Fairly strong*, discontinuous	*2210·1*	
375·50	Weak, short	*2199·2*	
377·48	Weak, short	2195·0	
396·95	Weak, short	*2151·2*	
411·70	Faint, short	*2119·2*	
414·65	Faint, discontinuous	*2113·6*	
430·84	Faint, short	*2079·3*	
437·64	Faint, short	*2066·1*	

The Spectrum of Lead.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
21·76	Faint, short	4399·4	The very short lines in this spectrum, which are also strong, are surrounded by a nimbus which gives them a somewhat nebulous appearance. There are several nebulous lines, as for instance those with wave-lengths 3591·9, 3555·9, 3278·5, 3016·5, 2949·2, 2650, and a broad nebula extending from 2540 to 2523·4.
22·50	Very strong, short, sharp, extended	4386·4	
29·12	Weak, very short	4271·4	
30·71	Very strong, discontinuous, broad, sharp, extended	4245·3	
34·68	Faint, short	4180·9	
42·63	Weak, discontinuous, fine	4061·5	
42·93	Strong, continuous, extended, sharp	4057·5	
45·58	Faint, discontinuous, very fine	*4020·5*	
49·72	Faint, very short	*3961·5*	
50·47	Weak, very short	3951·7	
51·84	Faint, very short	3934·0	
52·29	Faint, very short	3927·5	
53·60	Weak, short	3910·4	
58·13	Strong, very short	3853·2	
58·97	Strong, very short	3842·9	
59·77	Strong, very short	3832·5	
60·18	Weak, very short	3827·5	
63·61	Strong, short	3785·9	
67·61	Strong, continuous, fine, extended	3738·9	
68·15	Faint, very short	*3734·3*	
69·67	Weak, short, broad, nebulous	*3717·0*	
70·38	Faint, short, nebulous	*3709·0*	

The Spectrum of Lead (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
72·13	Weak, very short	3688·8	
72·69	Strong, continuous, fine, extended	3682·9	
73·75	Strong, continuous, fine, with a nimbus at ends	3671·0	
75·23	Strong, very short	3656·1	
76·80	Strong, continuous, extended, fine	3639·2	
81·35	*Fairly strong*, very short	3591·9	
81·77	*Fairly strong*, very short	3590·5	
83·31	Strong, continuous, extended, fine	3572·6	
94·11	Weak, very short	3563·9	
94·47	Weak, very short	3562·2	
92·41	Weak, very short	3484·3	
95·66	Weak, short, nebulous	3455·9	
112·74	Faint, very short	3308·9	
114·04	Weak, very short	3296·8	
116·60	*Fairly strong*, very short	3278·5	
116·98	*Fairly strong*, very short	3276·9	
121·38	*Fairly strong*, short	3242·4	
122·22	Weak, continuous, with a nimbus at the ends	3219·9	
130·46	Very strong, short, with a nimbus	3176·0	
136·09	Strong, short, with a nimbus	3137·3	
143·45	Weak, very short	3088·5	
143·68	Weak, very short	3086·7	
149·20	Weak, very short	3051·1	
150·52	Strong, short, with a nimbus	3043·3	
152·56	Weak, very short	3030·2	
154·78	Weak, discontinuous, nebulous	3016·5	
161·27	Faint, very short	2978·8	
166·33	Weak, short, nebulous	2949·2	
170·45	Strong, continuous, fine, extended	2872·2	
181·06	Faint, very short, fine	2867·8	
182·25	Strong, very short	2863·2	
188·37	Strong, continuous, fine, extended	2832·2	
190·30	Strong, continuous, fine, extended	2822·1	
194·67	Very strong, continuous, fine, extended, with a nimbus	2801·4	
212·87	Weak, short	2716·3	
217·26	Weak, short	2697·2	
225·41	Strong, continuous, extended, fine	2662·5	
228·47	*Fairly strong, nebulous*, short	2650·0	
231·54	Faint, very short	*2637·5*	
233·91	Faint, short, fine	2627·4	
237·48	Very strong, continuous, extended, with a nimbus	2613·4	
247·08	Strong, continuous, fine	2576·4	
249·44	Weak, very short	2567·2	
251·01	Strong, very short, with a nimbus	2561·6	
259·11	Weak, short, broad, and *nebulous band*	2539·9 2523·4	These measurements are taken on each side of the band. This band is a remarkable peculiarity of the lead spectrum.
269·85	Faint, short, nebulous	2496·0	
275·39	Strong, continuous	2475·7	
279·41	Faint, very short, nebulous	*2462·8*	
284·61	Weak, discontinuous	2445·7	
285·29	Weak, continuous, fine, faint in the centre	2443·6	

THE Spectrum of Lead (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
288·61	Faint, short	2432·3	
289·89	Faint, short	2427·8	
295·49	Faint, discontinuous, fine	2411·2	
298·73	Weak, discontinuous, fine	2402·1	
301·43	STRONG, CONTINUOUS	2393·7	
302·53	Faint, fine, short	*2390·8*	
303·15	Faint, fine, short	*2389·0*	
322·60	Faint, fine, discontinuous	*2333·3*	
335·82	Faint, short	*2297·7*	
355·32	STRONG, CONTINUOUS	2247·9	
359·40	Faint, continuous	*2238·2*	
373·43	STRONG, CONTINUOUS, somewhat *nebulous*, with a nimbus	2204·3	
388·35	Weak, discontinuous	*2170·0*	

THE Spectrum of Tellurium.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
6·48	Faint, short	*4707·5*	There is a nimbus throughout the whole extent of this spectrum where the points of the electrodes have made an impression upon the plate, but it may be remarked that the continuous lines show no distinct nimbus, neither are they, as a rule, nebulous. The large number of short lines in this spectrum is remarkable. But few of the lines are extended, they are those with wave-lengths 3382·4, 3280·0, 3273·4, 2413·3, 2386·3, 2383·8, 2247·3, and 2243·3.
7·12	Faint, short	*4593·0*	
11·31	Weak, short	*4602·0*	
17·10	Weak, short	*4487·0*	
17·51	Weak, short	*4480·0*	
19·88	Weak, short	*4436·0*	
21·76	Weak, short	*4400·0*	
22·94	Weak, fine, short	4378·0	
23·69	Weak, short	4364·5	
24·33	Weak, short	*4353·0*	
25·94	Faint, short	4324·6	
27·32	*Fairly strong*, short	4301·5	
27·78	Faint, short	4292·7	
28·10	Faint, short	4287·3	
28·94	*Fairly strong*, short	4274·4	
29·72	*Fairly strong*, short	4259·8	
32·18	*Fairly strong*, short	4221·1	
34·70	Weak, short	*4180·7*	
35·36	Faint, short	*4170·3*	
38·70	Faint, short	4119·7	
41·83	Weak, short	4072·7	
42·64	*Fairly strong*, short	4061·3	
43·10	Fairly strong, short	4054·2	
43·60	Faint, short	4048·3	
46·60	STRONG, short	4006·0	
48·20	*Fairly strong*, short	3983·8	
49·30	*Fairly strong*, short	3968·6	
50·80	*Fairly strong*, short	*3948·0*	
51·96	Weak, short	*3932·5*	
53·76	Weak, short, nebulous	*3908·7*	

The Spectrum of Tellurium (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
59·04	Strong, short	3841·3	
62·04	Faint, short	3803·0	
62·75	Weak, short	3796·9	
63·40	Faint, short	*3789·0*	
64·54	Faint, short	*3776·0*	
64·96	Faint, short, fine	*3771·0*	
65·48	Faint, short, fine	*3765·0*	
65·96	Faint, short, fine	*3759·0*	
66·42	Faint, short, fine	*3754·0*	
68·00	Strong, short	3735·5	
68·89	Strong, short	3726·2	
69·74	Faint, short	*3716·0*	
71·30	Faint, short	*3698·7*	
72·70	Faint, short	*3683·3*	
73·30	Faint, short	*3676·7*	
73·98	Faint, short	*3670·4*	
75·28	Faint, short	*3656·4*	
75·84	*Fairly strong*, short	3649·2	
76·30	*Fairly strong*, short	3644·3	
77·04	Faint, short	*3636·3*	
77·98	Faint, short	3626·7	
78·88	*Fairly strong*, short	3617·0	
79·45	Faint, short	3611·0	
80·37	Faint, fine, short	3601·7	
80·66	Faint, fine, short	3599·6	
81·35	Faint, short	3594·5	
82·19	Faint, short	3589·4	
85·32	Strong, short	3551·6	
86·32	Very faint, short	*3541·8*	
87·22	Very faint, short	*3533·1*	
88·55	Strong, short	3520·3	
89·57	Weak, short	*3510·8*	
91·18	Strong, short	3496·3	
92·48	Weak, short	3483·7	
92·81	Faint, short	*3480·8*	
93·50	Weak, short	*3474·4*	
94·46	Faint, short	3465·5	
95·52	Strong, short	*3456·0*	
96·14	Weak, short	*3450·4*	
97·07	Strong, short	3441·2	
99·26	Faint, short	*3422·2*	
100·04	Faint, short	*3415·3*	
100·95	Strong, short	3407·5	
103·90	Very strong, continuous, extended, sharp	3382·4	The principal lines in this spectrum are 3382·4, 3307·1, 3280·0, 3273·4, and 3246·8; there are also two others, 2386·3 and 2383·8.
104·83	Faint, short	*3374·1*	
106·27	Strong, short	3362·4	
107·50	*Fairly strong*, short	3352·1	
110·35	*Fairly strong*, short	3329·0	
111·09	Faint, short	*3322·7*	
111·95	Faint, short	*3315·8*	
113·05	Strong, continuous	3307·1	
115·16	Weak, continuous	3289·6	
116·43	Very strong, continuous, extended, sharp	3280·0	
117·35	Very strong, continuous, extended, sharp	3273·4	

THE Spectrum of Tellurium (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
118·09	Weak, short	3267·4	
118·35	Weak, short	3264·6	
119·55	STRONG, short	3256·3	
120·10	Faint, short	3250·8	
120·77	VERY STRONG, CONTINUOUS, extended, sharp	3246·8	
121·33	Faint, fine, short	*3242·1*	
122·36	Faint, short	*3234·2*	
123·02	Weak, short	*3229·4*	
124·03	Faint, short	*3221·8*	
124·61	Faint, short	*3217·6*	
125·19	Faint, short	*3213·3*	
125·63	Weak, short	3210·4	
128·09	Faint, fine, continuous	*3192·2*	
128·69	Faint, short	*3188·1*	
129·33	Weak, short	*3183·7*	
130·75	Weak, fine, continuous	3174·4	
131·50	Faint, short	*3168·5*	
132·95	Weak, short	*3158·4*	
133·60	Faint, short	*3154·1*	
134·81	Faint, short	*3145·7*	
136·90	Weak, short	*3131·7*	
137·89	Weak, short	*3124·7*	
138·70	Faint, nebulous, short	*3119·5*	
140·46	*Fairly strong*, discontinuous	3107·5	
141·80	Faint, fine, short	*3098·7*	
142·28	Faint, short	*3095·5*	
143·43	Faint, short	*3088·0*	
145·85	*Fairly strong*, short	3072·7	
147·50	Weak, short	3063·2	
149·03	Weak, short	*3052·8*	
150·00	STRONG, CONTINUOUS, *nebulous*, weak in the centre	3046·0	
153·86	Weak, short	3022·1	
154·78	STRONG, short	3016·6	
155·68	Faint, short	*3012·1*	
156·91	Faint, short	*3004·1*	
158·18	Faint, short	*2996·4*	
159·49	Faint, short	*2988·8*	
161·70	Faint, short	2976·2	
161·78	Faint, short	2975·5	
162·26	Weak, short	2973·1	
163·36	STRONG, short	2966·1	
164·40	Weak, fine, continuous	2960·3	
165·14	Faint, short	*2956·3*	
166·14	Faint, short	*2950·6*	
166·46	Faint, short	*2948·8*	
167·10	Faint, short	*2945·3*	
167·82	STRONG, short	2940·8	
168·44	Faint, short	*2937·7*	
169·08	Faint, short	2932·5	
170·00	Weak, short	2928·1	
171·00	Faint, short	*2923·4*	
171·75	Weak, short	2918·9	
174·27	Weak, short	2905·9	
174·96	Faint, short	*2901·9*	

The Spectrum of Tellurium (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
176·24	Strong, discontinuous, *nebulous*	2894·3	
176·44	*Fairly strong*, short, *nebulous*	2893·3	
179·54	Very faint and fine, short	*2877·4*	
180·28	Very faint and fine, short	*2873·6*	
181·25	Strong, discontinuous, *nebulous*	2867·7	
182·78	*Fairly strong*, fine, discontinuous	2859·9	
183·40	Strong, discontinuous, *nebulous*	2857·0	
185·62	*Fairly strong*, short, fine	2844·9	
186·72	*Fairly strong*, short, fine	2840·0	
187·42	Very faint and fine, short	*2836·9*	
187·90	Very faint and fine, short	*2834·4*	
190·02	*Fairly strong*, continuous, fine, short	2823·2	
191·74	Very faint and fine, short	*2815·3*	
192·18	Very faint and fine, short	*2813·0*	
194·96	Faint, very fine, short	2799·1	
195·52	Faint, very fine, short	2795·5	
196·40	Strong, discontinuous, nebulous	2791·9	
201·32	*Fairly strong*, continuous, fine, sharp	2768·6	
201·85	*Fairly strong*, short, fine, sharp	2766·5	
202·00	Faint, very fine, continuous, sharp	2766·0	
204·12	Weak, fine, sharp, short	*2756·0*	
205·08	Very faint, short, nebulous	*2751·5*	
206·45	Faint, short, fine	*2745·0*	
206·90	Faint, short, fine	*2743·0*	
207·70	Faint, short	*2739·5*	
208·06	Faint, short	*2738·0*	
211·36	Weak, short, nebulous	*2723·2*	
211·94	Weak, short, fine	*2720·7*	
212·54	Weak, short, fine	*2718·0*	
213·67	Weak, fine, short	*2713·0*	
214·23	Strong, short, nebulous	2710·2	
216·10	Weak, fine, short	2702·3	
216·58	Weak, fine, short	2700·3	
217·36	*Fairly strong*, short, nebulous	2696·6	
217·98	*Fairly strong*, short, nebulous	2694·1	
218·83	Weak, fine, short	2690·2	
219·40	Weak, fine, short	2688·2	
220·50	Weak, short, nebulous	2683·2	
221·35	Weak, short, nebulous	2679·8	
222·55	Weak, continuous, fine, sharp	2674·6	
224·68	Faint, short, fine	*2666·0*	
226·13	Weak, short, fine, with a nimbus on the less refrangible side	2659·4	
226·85	Faint, short, nebulous	*2657·1*	
228·75	Weak, short, nebulous, fine	2648·7	
229·15	Weak, short, nebulous, fine	2647·0	
230·37	Very faint, short, nebulous	*2642·3*	
231·67	Weak, very short	*2637·0*	
232·20	*Fairly strong*, short, *nebulous*	2634·7	
233·30	Weak, short, nebulous	2630·5	
233·94	Faint, short, fine	*2627·8*	
234·83	Faint, short, fine	*2624·3*	
235·54	Faint, short, fine	*2621·4*	
236·56	Weak, fine, continuous, sharp	2617·4	
237·46	Faint, fine, short	*2613·7*	
238·07	Faint, fine, short	*2611·3*	

THE Spectrum of Tellurium (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
239·86	Weak, short, nebulous	2604·4	
241·13	Weak, short, fine	2599·4	
241·48	Weak, short, fine	2598·1	
242·56	Very faint, short	*2594·0*	
243·56	Weak, short, nebulous	2590·1	
244·88	Weak, short, nebulous	*2585·0*	
246·16	Weak, short, nebulous	*2580·1*	
246·69	Weak, short, nebulous	*2578·0*	
247·58	Faint, fine, short	*2574·8*	
248·24	Faint, short, nebulous	2572·4	
249·44	Very faint, short, nebulous	*2567·8*	
250·44	Very faint, short, nebulous	*2564·1*	
251·93	Very faint, short, nebulous	*2558·7*	
254·40	Weak, short, nebulous	*2549·7*	
255·96	*Fairly strong*, fine short	2543·7	
257·90	Weak, short, broad, nebulous	2536·8	
258·71	Weak, fine, sharp, short	2533·8	
260·00	STRONG, CONTINUOUS, fine, sharp	2529·4	
260·28	Weak, short, fine, nebulous	*2528·3*	
261·03	Weak, short, fine, nebulous	*2525·6*	
266·84	*Fairly strong*, short, fine, sharp	2505·2	
267·56	Very faint and short, fine, sharp	*2502·7*	
268·74	*Fairly strong*, short, nebulous	2498·6	
270·83	Weak, continuous, fine	2491·3	The next line, which is nebulous, appears to overlap this, which is a fine line.
270·90	Weak, short nebulous	2490·8	
271·60	Weak, short, fine, sharp	*2488·7*	
272·60	Weak, short, nebulous	*2485·3*	
273·92	Faint, short, fine	*2480·9*	
274·30	Faint, short, fine, nebulous	*2479·6*	
275·16	Faint, short, nebulous	*2476·7*	
276·26	*Fairly strong*, short, sharp	2473·2	
277·53	Weak, short, nebulous	*2469·0*	
279·69	Faint, short, fine, nebulous	*2462·0*	
280·25	Faint, short, fine, nebulous	*2460·2*	
282·43	Weak, short, nebulous	*2452·8*	
284·15	*Fairly strong*, discontinuous, sharp	2447·8	
285·21	Faint, short, nebulous	*2444·3*	
286·05	Faint, fine, continuous, sharp	*2441·7*	
287·30	STRONG, CONTINUOUS, slightly extended with a *faint nimbus*	2438·0	
289·10	Weak, fine, slightly continuous, nebulous	*2432·0*	
289·86	Weak, short, nebulous	*2429·7*	
290·33	Weak, fine, continuous, sharp	*2428·2*	
290·80	Weak, short, nebulous	*2426·7*	
291·36	Faint, short, nebulous	*2425·0*	
292·88	Weak, short, nebulous	*2420·3*	
293·44	Faint, short, nebulous	*2418·5*	
295·08	STRONG, CONTINUOUS, slightly extended	2413·3	
295·66	*Fairly strong*, slightly continuous and extended	2411·4	
298·20	*Fairly strong*, broad, nebulous, short	*2403·7*	
299·36	*Fairly strong*, fine, short	*2400·0*	
301·83	Faint, short, fine, nebulous	*2392·8*	
302·58	Faint, short, fine, nebulous	*2390·7*	

THE Spectrum of Tellurium (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
304·10	VERY STRONG, CONTINUOUS, extended, with a nimbus	2386·3	
304·92	VERY STRONG, CONTINUOUS, extended, with a nimbus	2383·8	
307·26	Weak, short, nebulous	*2377·0*	
307·84	Weak, short, nebulous	*2375·3*	
309·54	STRONG, SLIGHTLY continuous and extended, sharp	2370·3	
311·50	Faint, short, fine, nebulous	*2364·7*	
312·18	Faint, short, fine, nebulous	*2362·8*	
313·22	Faint, fine, short, nebulous	*2359·8*	
313·68	*Fairly strong*, fine, short	2358·6	
314·16	Faint, fine, short, nebulous	*2357·0*	
316·08	Weak, a broad nebulous dot	*2351·7*	
318·64	Faint, a rather broad nebulous dot	*2344·3*	
320·06	Faint, short, nebulous	*2340·3*	
321·32	Weak, short, nebulous	*2336·8*	
323·10	STRONG, short, slightly extended, sharp	2332·0	
325·50	STRONG, SHORT, slightly extended, sharp	2325·5	
327·17	STRONG, SHORT, slightly extended, sharp	2321·0	
328·32	STRONG, SHORT, slightly extended, sharp	2317·8	
331·08	Weak, short, nebulous	*2310·1*	
333·52	Faint, short, nebulous	*2303·7*	
334·48	Faint, short, nebulous	*2301·1*	
335·89	Very faint, short, nebulous	*2297·5*	
336·84	*Fairly strong*, continuous, nebulous	*2295·0*	
338·01	Very faint, short, nebulous	*2291·8*	
339·24	Faint, a broad nebulous dot	2288·6	
342·34	*Fairly strong*, short, nebulous.	*2280·6*	
343·74	*Fairly strong*, short, nebulous.	*2277·2*	
340·40	*Fairly strong*, a rather broad nebulous dot	*2285·7*	
348·09	*Fairly strong*, continuous, nebulous	2266·2	
348·90	Faint, short, nebulous	*2264·2*	
350·50	*Fairly strong*, continuous, nebulous	*2260·4*	
351·93	*Fairly strong*, continuous, nebulous	*2256·6*	
354·60	*Fairly strong*, short, fine, nebulous	*2250·0*	
355·18	*A pair of fairly strong, very fine, continuous lines, with a fairly broad nimbus on the more refrangible portion of the pair.*	2248·0	
355·36		2247·3	
357·18	*Fairly strong, rather long, nebulous on more and sharp on less refrangible side.*	2243·3	
358·34	Faint, very short, broad, nebulous	*2240·7*	
362·20	*A triplet of weak slightly continuous, fine, nebulous lines with a nimbus, making them appear one broad nebulous line*	*2231·3*	
362·21		*2230·3*	
363·20		*2229·0*	
364·08	Weak, short, nebulous	*2226·8*	
365·58	Faint, very short, broad nebulous	*2223·2*	
367·42	*Fairly strong*, continuous, nebulous on more refrangible side	*2219·3*	
368·58	Weak, continuous, nebulous	*2216·0*	
370·53	*Fairly strong*, discontinuous, nebulous	*2211·2*	
371·22	*Fairly strong*, continuous, nebulous	*2209·5*	

THE Spectrum of Tellurium (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
374·08	Very faint, very short, nebulous . .	*2202·8*	
375·16	Weak, continuous, nebulous	*2200·1*	
376·67	Very faint, short, nebulous	*2196·5*	
378·53	*Fairly strong, continuous*, broad, nebulous	*2192·2*	
379·60	*Fairly strong*, discontinuous, broad, nebulous	*2189·7*	
380·82	Weak, broad, very short, nebulous . .	*2186·9*	
382·95	Faint, short, nebulous	*2182·0*	
384·18	*Fairly strong, continuous*, broad, nebulous	*2179·2*	
385·90	Faint, very short, nebulous	*2175·3*	
389·60	Faint, very short, nebulous	*2167·2*	
390·31	Faint, very short, nebulous	*2165·7*	
393·05	Faint, short, nebulous	*2159·7*	
397·64	Weak, short, nebulous	*2149·7*	
398·54	Weak, continuous, nebulous	*2147·8*	
399·07	Weak, short, nebulous	*2146·7*	
400·83	Weak, continuous, broad, nebulous .	*2142·7*	
403·81	Weak, short, nebulous	*2136·5*	
404·56	Weak, short, nebulous	*2135·0*	
409·06	Weak, short, nebulous	*2125·5*	
410·46	Weak, short, nebulous	*2122·5*	
412·04	Very faint, very short, nebulous . .	*2119·0*	
413·34	Very faint, very short, nebulous . .	*2116·3*	
414·75	Weak, short, nebulous	*2113·3*	
416·02	Weak, short, nebulous	*2110·5*	
417·42	Faint, very short, nebulous	*2108·4*	
419·34	Faint, very short, nebulous	*2103·6*	
420·91	Very faint, very short, broad, nebulous	*2100·2*	
431·43	Weak, short, broad, nebulous . . .	*2078·5*	
445·45	Weak, short, broad, nebulous . . .	*2050·8*	
451·60	Weak, short, broad, nebulous . . .	*2039·2*	
455·40	Weak, short, broad, nebulous . . .	*2032·7*	

A certain number of lines of copper are coincident with those in tellurium. They are given in the table of coincidences, two of these lines are strong both in copper and tellurium.

The Spectrum of Arsenic.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
13·90	Weak, very short, fine	*4550·0*	There are several lines in this spectrum which are continuous and nebulous. Most of the strong lines have a nimbus.
14·48	Weak, very short, fine	*4538·4*	
16·73	STRONG, discontinuous	4494·3	
	Strong, short	*4474·0*	
	Strong, discontinuous	*4466·3*	
	Strong, discontinuous	*4458·7*	
20·14	STRONG, discontinuous	*4431·0*	
20·95	Weak, discontinuous	*4415·0*	
23·45	Weak, discontinuous	*4368·7*	
24·54	Weak, discontinuous	*4349·0*	
25·34	Weak, discontinuous	*4335·2*	
26·52	Weak, discontinuous	*4315·2*	
	Weak, discontinuous	*4301·0*	An approximation.
30·79	Weak, discontinuous	*4244·0*	
31·66	Weak, discontinuous	*4229·3*	
33·02	Weak, discontinuous	4207·3	
33·68	*Fairly strong*, discontinuous	4197·7	
34·19	Weak, discontinuous	*4188·9*	
38·70	Weak, short	*4120·0*	
41·15	*Fairly strong*, discontinuous	4081·8	
42·49	Weak, short	4064·3	
44·50	STRONG, short	4036·0	
46·54	Weak, short	*4007·0*	
48·13	Faint, short	*3985·0*	
50·80	*Fairly strong*, discontinuous	3948·5	
52·07	*Fairly strong*, discontinuous	3930·7	
52·88	STRONG, discontinuous	3921·6	
58·99	STRONG, discontinuous	3842·5	
62·50	Faint, discontinuous	3800·7	
63·62	*Fairly strong*, discontinuous	3784·4	
64·86	Faint, discontinuous	*3772·0*	
73·82	Weak, discontinuous	3671·2	
78·34	Faint, very short	*3622·4*	
81·32	Weak, very short	*3591·9*	
85·38	Weak, discontinuous	3551·6	
85·88	Weak, discontinuous	3545·8	
89·54	Faint, short	*3510·8*	
93·78	Weak, discontinuous	3471·1	
118·98	Faint, very short	*3260·1*	
119·46	Weak, short	3256·2	
128·70	Faint, short	*3187·7*	
129·60	Faint, short.	*3181·7*	
137·66	Faint, continuous, fine, very faint in centre	3125·4	
138·86	STRONG, fine, continuous, with a nimbus	3119·2	
139·34	STRONG, fine, continuous, with a nimbus	3116·1	
140·42	Faint, short, nebulous	*3107·7*	
145·56	Fairly strong, continuous, fine	3075·0	
148·40	STRONG, CONTINUOUS, fine, weak in centre, with a nimbus	3057·3	
149·10	STRONG, CONTINUOUS, fine, weak in centre, with a nimbus	3052·6	
152·38	STRONG, CONTINUOUS, sharp	3032·2	
157·12	Weak, continuous, faint in centre	3003·2	
159·22	*Fairly strong*, fine, continuous	2990·2	

The Spectrum of Arsenic (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
160·80	Weak, continuous, nebulous, weak in centre	2981·1	
164·82	Very strong, with a nimbus, discontinuous	2958·7	
170·67	Weak, discontinuous	2925·6	
175·75	Strong, continuous, extended	2898·2	
177·22	Weak, continuous, faint in centre	2889·1	
178·40	Weak, continuous	2884·2	
183·04	Very strong, extended, continuous	2859·7	The strong lines here form a characteristic group.
185·37	Faint, discontinuous	2843·6	
187·01	Faint, discontinuous	2836·9	
188·81	Strong, continuous, nebulous	2829·8	
196·93	Faint, discontinuous	2788·5	
199·22	Very strong, continuous, extended, with a nimbus	2779·5	
201·07	Faint, discontinuous	2770·4	
206·77	Very strong, continuous, extended	2744·1	
218·85	Faint, discontinuous	*2690·5*	
222·01	Faint, discontinuous	*2677·0*	
222·80	Faint, discontinuous	*2673·8*	
223·79	Faint, discontinuous	*2669·5*	
225·10	Faint, discontinuous	*2663·5*	
228·14	Faint, fine, discontinuous	*2651·5*	
233·33	Faint, fine, discontinuous	*2630·2*	
238·14	Faint, fine, discontinuous	*2611·2*	
240·68	Strong, continuous, *nebulous*	2600·8	
241·67	Weak, fine, continuous	2597·1	
241·96	Faint, continuous	2593·9	
247·90	Faint, discontinuous	2576·0	
248·38	Faint, discontinuous	2571·6	
250·98	Weak, discontinuous	2559·5	
260·37	Strong, continuous	2527·9	
265·68	Strong, continuous	2526·0	
269·02	Weak, continuous	2496·9	
270·65	Strong, continuous, extended	2491·9	
271·28	Weak, discontinuous	2489·1	
278·92	Weak, continuous, nebulous, faint in centre	2464·1	
279·94	Weak, continuous, nebulous, faint in centre	2461·0	
281·58	Strong, continuous, extended, sharp	2456·2	
287·58	Strong, continuous, extended, sharp	2436·9	
287·93	Weak, nebulous, discontinuous	2435·0	
288·65	Weak, continuous, fine	2432·5	
293·89	Weak, very short, nebulous	2415·8	
297·52	Weak, short, nebulous	2403·4	
297·82	Weak, short, nebulous	2402·6	
305·77	Strong, continuous	2381·0	
309·32	Strong, continuous, with a nimbus	2370·8	
309·74	Strong, continuous, with a nimbus	2369·7	
311·99	Weak, continuous, fine	2362·8	
316·60	Very strong, continuous, extended, with a nimbus	2350·1	These strong lines form a characteristic group.
318·66	Strong, continuous, extended, sharp	2344·3	
330·40	Weak, continuous, fine	*2320·7*	
339·14	Very strong, nebulous, with a nimbus, and slightly *nebulous*, extended	2288·9	

THE Spectrum of Arsenic (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
343·00	Faint, short, nebulous, broad. . . .	*2279·0*	
345·66	*Fairly strong*, continuous	*2272·3*	
347·54	Weak, discontinuous	*2267·5*	
362·80	*Fairly strong*, continuous, nebulous .	*2230·0*	
372·30	Weak, discontinuous	*2207·0*	
382·74	Weak, discontinuous	*2182·5*	
385·24	Weak, discontinuous	*2176·8*	
390·40	STRONG, CONTINUOUS, broad, nebulous .	*2165·4*	
394·44	STRONG, SHORT	*2156·7*	
397·06	STRONG, SHORT	*2151·0*	
398·64	STRONG, SHORT	*2147·8*	
400·13	STRONG, CONTINUOUS, broad, nebulous .	*2144·5*	
404·75	STRONG, discontinuous, broad, nebulous	*2135·2*	
415·22	STRONG, continuous, broad, nebulous, weak in the centre	*2112·2*	

THE Spectrum of Antimony.

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
6·23	Weak, discontinuous	*4714·0*	There are very many strong and nebulous lines in this spectrum. Two of the longest and strongest lines which are not nebulous are those with wave-lengths 2597·2 and 2527·6.
7·15	Weak, short	*4692·5*	
11·46	Weak, fine, discontinuous	*4599·0*	
11·90	Weak, short	*4590·0*	
16·09	Weak, fine, discontinuous	*4506·5*	
18·75	Weak, short	*4457·0*	
20·33	Faint, short	*4427·5*	
23·10	Weak, short	*4375·0*	
24·55	STRONG, short	4351·5	
26·62	Weak, short	4316·1	
29·57	STRONG, short	4264·4	
32·37	Weak, short	4218·5	
33·86	Weak, short	4194·5	
35·38	Faint, short	*4170·0*	
37·33	Faint, short	4140·2	
37·82	Weak, short	4132·8	
45·17	Faint, short	*4026·0*	
46·05	Weak, short	3984·9	
49·31	Faint, short	*3968·4*	
49·53	Faint, short	3964·1	
49·87	Faint, short	3960·3	
51·86	Weak, short	3933·2	
53·85	Faint, very short	3907·5	
58·38	*Fairly strong*, short	3849·7	
59·07	*Fairly strong*, short	3840·2	
60·37	Faint, short	*3825·0*	
64·78	Faint, short	*3771·0*	
67·63	VERY STRONG, short	3739·0	
69·10	Weak, fine, continuous	3722·4	

The Spectrum of Antimony (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
69·35	Faint, short, fine	3720·5	
72·39	Strong, very short	3686·0	
75·57	Strong, very short	3651·6	
76·92	Strong, continuous, fine	3637·5	
77·65	Strong, short, fine	3629·4	
80·74	Very strong, *nebulous*, discontinuous	3597·8	
81·81	Strong, nebulous, short	3566·0	
84·64	Strong, nebulous, short	3559·1	
87·13	*Fairly strong*, very short	3533·7	These form a remarkable group of lines.
88·65	*Fairly strong*, very short	3520·3	
90·21	Strong, *nebulous*, short	3504·6	
90·92	Strong, *nebulous*, discontinuous	3498·3	
93·55	Strong, *nebulous*, discontinuous	3473·9	
95·19	Faint, short	*3459·0*	
96·05	Faint, short	*3451·1*	
98·97	Strong, very short	3425·9	
100·13	Faint, short	*3414·7*	
101·45	Weak, very short	3403·0	
102·03	Weak, short	*3397·9*	
103·87	Weak, continuous, fine	(3382·0)	Apparently a tellurium line.
109·36	Very strong, short	3336·4	
113·47	Strong, short	3303·2	
116·47	Weak, continuous, fine	3279·7	Apparently tellurium lines in antimony.
117·38	Strong, continuous, fine	3273·0	
118·21	Strong, continuous, fine	3266·6	
120·80	Strong, continuous, fine	(3246·6)	Apparently a tellurium line.
121·65	Very strong, nebulous, discontinuous	3240·5	
122·87	Strong, continuous, fine	3231·6	
127·48	Faint, short	*3195·6*	
128·86	Faint, short	*3186·1*	
131·65	Faint, short	*3166·7*	
143·75	Faint, short	*3085·2*	
151·03	Strong, nebulous, discontinuous	3039·8	
152·91	Strong, fine, continuous	3029·0	
153·57	Weak, short	3023·7	
153·99	*Fairly strong*, short	3021·1	
155·83	*Fairly strong*, short	3010·4	
161·03	Strong, discontinuous, nebulous	2979·8	
163·56	Strong, discontinuous, nebulous	2965·2	
171·15	Weak, discontinuous	2921·6	
173·00	Strong, short	2912·6	
177·07	Strong, discontinuous, nebulous	2890·3	
179·62	Week, short	2878·3	
179·29	Strong, continuous, extended, fine	2877·1	
182·43	Weak, short	2861·9	
183·63	*Fairly strong*, very short	2855·3	
184·82	Weak, continuous, fine	2849·9	
187·50	Weak, short	2836·0	
189·55	Weak, continuous	2824·7	
195·43	Weak, short	2796·9	
197·05	Very strong, short, *nebulous*	2789·6	
198·03	*Fairly strong*, short	2788·5	
200·07	*Fairly strong*, short	2785·3	
200·1	Weak, short	2775·7	
201·29	Strong, continuous, extended, fine	2768·9	
202·37	Weak, short	2763·2	

THE Spectrum of Antimony (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
203·11	Weak, very short	2760·8	
204·45	Weak, very short	2754·9	
207·64	STRONG, very short	2740·1	
210·62	*Fairly strong*, continuous, fine	2726·1	
212·57	STRONG, CONTINUOUS, fine	2717·9	
213·39	Faint, short	2714·0	
216·09	Faint, short	*2702·6*	
216·65	Faint, short	*2700·2*	
218·67	*Fairly strong*, fine, continuous	2691·3	
219·91	Weak, short	2685·5	
220·83	STRONG, CONTINUOUS, fine	2681·7	
222·77	Faint, discontinuous	2674·0	
223·70	STRONG, CONTINUOUS, fine	2668·9	
223·97	Strong, short, nebulous	2668·3	
226·87	*Fairly strong*, nebulous, discontinuous	2656·3	
228·07	STRONG, CONTINUOUS, fine	2651·7	
233·07	STRONG, very short	2631·2	
236·73	STRONG, short	2616·3	
237·40	Faint, fine, continuous	2613·7	
238·05	STRONG, CONTINUOUS, fine	2611·3	
241·65	VERY STRONG, CONTINUOUS, extended, sharp	2597·2	
243·63	VERY STRONG, short	2589·4	
248·01	*Fairly strong*, continuous, fine	2572·7	
248·65	*Fairly strong*, discontinuous	2570·1	
249·64	*Fairly strong*, fine, discontinuous	2566·7	
250·18	STRONG, CONTINUOUS, nebulous, weak in centre	2564·6	
251·97	Faint, nebulous, short	2557·4	
252·32	Faint, short	2556·6	
253·13	Weak, fine, continuous	2553·3	
253·93	Faint, short	2549·8	
256·05	STRONG, discontinuous	2542·9	
260·33	VERY STRONG, CONTINUOUS, extended, sharp	2527·6	
262·75	Very faint, fine, continuous	2519·5	
263·02	Weak, short, nebulous	2518·8	
264·28	Weak, short, nebulous	2514·5	
265·45	Weak, fine, continuous	2509·5	
266·28	STRONG, short	2506·5	
268·20	Faint, short, nebulous	*2500·2*	
270·75	Faint, short, fine	*2490·7*	
271·50	Faint, short, fine	*2489·2*	
272·53	Faint, short	*2485·7*	
273·87	Faint, fine, continuous	2480·4	
274·31	Weak, fine, continuous	2479·4	
274·90	STRONG, CONTINUOUS, fine	2477·3	
275·21	Faint, short, nebulous	2476·7	
276·015	Faint, fine, continuous	2473·4	
277·14	Faint, short, nebulous	*2470·2*	
278·94	Faint, short, nebulous	*2464·4*	
279·66	Faint, short, nebulous	*2462·0*	
280·68	Faint, short, nebulous	*2458·8*	
282·09	Faint, short, nebulous	2454·5	
284·20	Faint, short, nebulous	2445·7	
284·90	STRONG, CONTINUOUS, fine	2444·8	

THE Spectrum of Antimony (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
287·35	Fine, discontinuous	2438·0	
290·92	Weak, continuous, fine	2425·7	
291·68	Faint, discontinuous, nebulous	2423·0	
292·40	Weak, continuous, fine	2421·5	
295·71	Faint, short	*2410·3*	
	Faint, short	*2408·3*	
297·71	Weak, short, nebulous	*2405·3*	
298·17	Faint, short	*2403·8*	
299·44	Faint, short	*2399·9*	
301·00	Weak, discontinuous	*2395·3*	
304·90	STRONG, CONTINUOUS	2383·2	
308·28	STRONG, CONTINUOUS	2374·3	
309·61	STRONG, short	2370·0	
312·72	STRONG, short, nebulous	*2361·3*	Appears single, but is seen to be double when very highly magnified.
312·93	Weak, fine, continuous	*2360·7*	
315·60	Faint, discontinuous	*2353·0*	
316·46	Faint, discontinuous	*2350·6*	
322·41	Weak, very short, nebulous	2334·2	
323·14	Faint, short, nebulous	*2331·8*	
323·90	Faint, short, nebulous	*2329·7*	
325·46	Faint, short, nebulous	*2325·3*	
327·00	Faint, short, nebulous	*2322·1*	
328·75	Weak, discontinuous	*2316·4*	
330·37	STRONG, CONTINUOUS, short	2311·8	
332·25	*Fairly strong*, continuous, sharp	3306·8	
336·05	*Fairly strong*, short	*2297·0*	
337·17	*Fairly strong*, continuous	*2294·0*	
339·18	*Fairly strong*, continuous	*2288·8*	
342·28	Faint, very short	*2280·8*	
343·25	Faint, very short	*2278·3*	
343·77	Faint, short	*2277·1*	
346·11	Faint, short	*2271·1*	
349·15	STRONG, CONTINUOUS	*2263·5*	
355·38	STRONG, CONTINUOUS, weak in the centre	*2248·0*	
357·25	STRONG, CONTINUOUS, weak in the centre	*2243·5*	
360·93	Faint, short	*2234·5*	
362·22	Faint, short	*2231·3*	
362·64	Faint, short	*2230·3*	
363·15	Faint, short	*2229·0*	
364·53	Weak, nebulous, continuous, weak in the centre	*2226·3*	
365·45	Faint, discontinuous	*2223·5*	
366·29	Weak, nebulous, continuous	*2221·5*	
367·46	Weak, nebulous, discontinuous	*2218·7*	
368·39	Weak, nebulous, short	*2216·3*	
370·48	Faint, short	*2211·3*	
371·50	Weak, nebulous, continuous	*2209·0*	
373·61	Faint, short	*2203·8*	
374·31	Weak, continuous	*2202·2*	
375·05	Faint, short	*2200·3*	
378·35	Weak, discontinuous	*2192·6*	
378·76	Weak, short	*2191·6*	
379·70	Faint, short	*2189·3*	
384·24	STRONG, CONTINUOUS, broad	*2179·0*	
385·71	STRONG, CONTINUOUS, broad	*2175·8*	
388·35	STRONG, short	*2170·1*	

The Spectrum of Antimony (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
393·19	Faint, continuous	*2159·4*	
394·79	Faint, short	*2156·0*	
398·07	Faint, short	*2148·8*	
400·12	Weak, continuous, nebulous	*2144·4*	
401·31	Faint, continuous, very faint in the centre	*2142·0*	
402·53	Weak, continuous, very weak in the centre	*2139·3*	
404·23	Weak, discontinuous	*2135·7*	
408·73	Faint, discontinuous	*2126·1*	
410·43	Faint, discontinuous	*2122·5*	
412·60	Faint, discontinuous	*2118·0*	
416·10	Faint, discontinuous	*2110·4*	
419·01	Faint, short	*2104·2*	
422·70	Faint, continuous	*2096·4*	
427·61	Very faint, very short	*2086·3*	
433·02	Very faint, very short	*2075.3*	
438·30	Weak, continuous, broad	*2064·8*	
445·62	Faint, discontinuous	*2050·5*	
448·25	Faint, discontinuous	*2045·3*	

The Spectrum of Bismuth.

Scale-numbers.	Descripton of lines.	Wave-lengths.	Remarks.
5·74	Weak, fine, continuous	*4724·5*	The very short, strong, and nebulous rays which abound in the less refrangible region of this spectrum resemble those in the spectrum of antimony.
6·49	Weak, short	*4707·0*	
13·41	Strong, short, extended	*4560·0*	
17·64	Weak, short	*4477·0*	
22·25	Weak, short	*4391·0*	
25·10	*Fairly strong*, short	4339·4	
25·72	*Fairly strong*, short	4328·7	
27·31	Very strong, discontinuous, broad	4301·5	
29·03	Strong, short	4271·3	
29·85	Very strong, discontinuous	4259·2	
38·63	Strong, continuous, fine	4121·2	
41·43	Strong, discontinuous	4079·0	
57·25	Strong, discontinuous	3863·7	
58·51	*Fairly strong*, short	3848·5	
58·72	Weak, short, fine	3845·4	
61·10	Strong, discontinuous	3815·9	
61·58	*Fairly strong*, fine, discontinuous	3810·5	
63·10	Very strong, *nebulous, continuous*	3792·7	
64·15	*Fairly strong*, discontinuous	3780·6	
66·16	Strong, discontinuous	3757·0	
68·26	Weak, short	*3732·7*	
69·38	Weak, fine, short	3711·0	
70·30	*Fairly strong*, very short	3704·0	
71·63	Very strong, short, nebulous	3695·3	
72·91	Very weak, short	3684·5	
75·36	Strong, fine, discontinuous	3653·9	
76·41	Faint, very short	3647·4	

THE Spectrum of Bismuth (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
77·29	Weak, very short	3631·9	
79·21	Very strong, nebulous, short	3613·8	
80·99	STRONG, FINE, CONTINUOUS	3595·7	
86·40	STRONG, short	3541·5	
87·91	*Fairly strong*, very short	3527·9	
88·97	Faint, short, nebulous	3517·9	
89·69	STRONG, FINE, CONTINUOUS	3510·5	
92·37	STRONG, short, nebulous	3485·0	
93·65	STRONG, short, nebulous	3473·5	
95·59	Weak, discontinuous, fine	3454·8	
96·12	STRONG, short	3450·7	
98·40	STRONG, discontinuous	3430·9	
102·25	STRONG, CONTINUOUS, SHARP	3396·7	
102·81	Weak, short, nebulous	3393·2	
103·91	Weak, fine, continuous	(*3381·9*)	A tellurium line probably.
112·03	Faint, very short	*3315·3*	
114·03	Weak, short	3297·9	
115·29	Weak, discontinuous, nebulous	3287·4	
116·45	Weak, fine, continuous	(3279·9)	A tellurium line probably.
119·58	Faint, nebulous, short	*3255·4*	
122·03	Weak, short	*3236·8*	
128·75	Faint, nebulous, short	*3187·7*	
131·28	Faint, short	*3170·0*	
132·73	Faint, short	*3160·0*	
137·01	Faint, short	*3130·8*	
139·42	STRONG, nebulous, short	3114·8	
140·11	Weak, discontinuous, fine	3110·4	
145·42	*Fairly strong*, fine, continuous	3075·7	
146·85	VERY STRONG, BROAD, CONTINUOUS, extended, sharp	3067·1	
150·75	Weak, short	3041·3	
151·91	STRONG, short	3038·0	
152·49	STRONG, FINE CONTINUOUS, SHARP	3034·5	
153·75	VERY STRONG, EXTENDED, CONTINUOUS, SHARP	3023·8	
156·02	Weak, short, nebulous	3009·0	
157·27	Faint, short	3001·2	
158·98	STRONG, CONTINUOUS, sharp	2992·2	
159·67	STRONG, CONTINUOUS, slightly extended, sharp	2988·1	
160·51	Weak, continuous, sharp	*2982·9*	The strong lines in this portion of the spectrum form a characteristic group.
162·68	Short, faint	2973·4	
163·27	Short, faint	2968·9	
166·08	Weak, discontinuous, nebulous	2951·0	
167·29	Faint, very short	2942·4	
168·52	VERY STRONG, CONTINUOUS, extended, sharp	2942·4 2937·5	
169·46	Weak, very short	2931·4	
171·03	Faint, very short	*2923·2*	
172·10	Weak, very short	2917·5	
175·85	VERY STRONG, CONTINUOUS, extended, sharp	2897·2	
182·45	*Long, fine*	2862·5	
183·91	VERY STRONG, short, nebulous	2854·8	
185·49	*Fairly strong*, short	2846·1	
186·61	Weak, very short	2840·1	
187·90	Faint, very short	2832·8	

THE Spectrum of Bismuth (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
190·33	*Fairly strong*, very short	2822·2	
191·47	*Fairly strong*, discontinuous	2816·3	
193·03	STRONG, fine, continuous	2808·4	
193·61	Faint, discontinuous	2805·4	
194·29	STRONG, CONTINUOUS	2802·6	
195·29	Weak, fine, continuous	*2798·0*	
198·15	STRONG, very short	2784·0	
199·08	STRONG, CONTINUOUS, extended, sharp	2779·3	
200·15	Weak, very short	2773·5	
200·55	Weak, very short	2772·5	
202·00	STRONG, very short	2766·3	
203·85	Faint, very short	*2757·3*	
206·24	Weak, discontinuous, fine	2746·0	
209·07	Faint, very short	2733·2	
209·89	STRONG, FINE, CONTINUOUS	2729·3	
210·45	Faint, very short	2727·1	
213·53	Weak, nebulous, discontinuous	2713·1	
217·57	STRONG, FINE, CONTINUOUS	2695·6	
218·09	Faint, nebulous, short	2693·2	
221·31	Faint, nebulous, very short	2679·5	
222·15	Faint, nebulous, very short	*2676·6*	
225·24	Very faint, very short, nebulous	*2663·6*	
227·91	STRONG, very short	2651·8	
230·08	Faint, very short, nebulous	2641·4	
233·75	Weak, short	2628·3	
234·05	STRONG, CONTINUOUS, sharp	2627·0	A prominent line.
245·29	Very faint, short	2583·5	
245·64	Weak, fine, continuous	2581·5	
247·40	Very weak, short, nebulous	2575·5	
255·84	Weak, nebulous, discontinuous	2543·3	
259·20	Weak, nebulous, discontinuous	2531·9	
259·87	Weak, discontinuous	2529·7	
261·47	STRONG, FINE, CONTINUOUS	2523·5	
264·01	Weak, fine, continuous	2514·3	
267·38	Weak, short, nebulous	2503·9	
268·22	SHORT, faint	2500·6	
268·67	Faint, fine, continuous	2499·1	
271·65	Weak, nebulous, continuous	2489·1	
274·30	Weak, short, fine	2479·1	
284·08	Weak, continuous, fine	2447·2	
287·37	Weak, short	2437·5	
289·95	Faint, continuous, fine	2429·3	
294·66	VERY STRONG, short, with a large nimbus	2414·8	A prominent line.
295·11	Faint, short, fine	2412·7	
299·21	STRONG, CONTINUOUS, sharp	2400·7	A prominent line.
306·87	Faint, very short, nebulous, broad	*2378·0*	
310·36	STRONG, CONTINUOUS, sharp	2368·0	
317·73	Faint, short, broad, nebulous	*2347·0*	
323·11	Faint, short, fine	*2331·8*	
324·79	Faint, short, broad	*2327·0*	
325·43	Faint, short, fine	*2325·4*	
326·78	Weak, short, fine	2321·7	
328·30	Faint, short, fine	2317·4	
329·83	Faint, short, broad, nebulous	*2313·7*	
330·91	Faint, long, broad, nebulous	*2310·5*	

THE Spectrum of Bismuth (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
334·40	Weak, continuous, fine	*2301·3*	
335·83	Weak, continuous, fine	*2297·6*	
337·13	Weak, continuous, fine	*2294·1*	
338·09	Very faint, short, nebulous	*2291·6*	
342·20	Short, faint	*2281·0*	
343·73	STRONG, CONTINUOUS, sharp	2276·9	
353·59	Faint, short, nebulous	*2252·5*	
354·41	Weak, short	*2250·5*	
355·78	Weak, short	*2247·0*	
362·20	VERY STRONG, CONTINUOUS, somewhat nebulous	2231·4	Prominent lines.
363·10	VERY STRONG, CONTINUOUS, somewhat nebulous	2229·1	
369·05	STRONG, CONTINUOUS	*2214·8*	
373·83	STRONG, CONTINUOUS, nebulous . . .	*2203·3*	
379·29	Faint, nebulous, continuous	*2190·4*	
380·78	STRONG, CONTINUOUS, nebulous . . .	*2187·0*	
385·35	Very faint, nebulous, short	*2176·6*	
395·00	Very weak, continuous, broad, nebulous	*2168·5*	
400·16	Weak, discontinuous, nebulous . . .	*2144·3*	
405·17	Weak, continuous, broad, nebulous .	*2133·8*	
416·40	Faint, continuous, nebulous	*2109·8*	
435·60	Faint, short	*2070·2*	
441·69	Faint, continuous, nebulous	*2058·2*	

Coincidences of lines real or apparent.

Those lines the wave-lengths of which are approximately the same have been tabulated, and a close examination of photographs taken from electrodes of such metals as appear to have coincident lines has been made. The instances where lines appear to coincide are extremely rare. One particular case may be referred to, it is that of the two lines 2307 cadmium, and 2306·9 indium. The latter line is the stronger, which points to the occurrence of indium in cadmium, assuming the difference in the numbers to be accidental. An electrode of the one metal was opposed to the other, and a spectrum photographed with the diffraction spectroscope shows that the indium line is distinctly more refrangible than that of cadmium. Many air lines are coincident with metallic lines: this arises not only from their great numbers, but from their breadth and band-like character. In many parts of the spectrum some of our photographs show a continuous background to the metallic lines, which is formed of what to all appearance are finely and very closely ruled lines, these belong to the spectrum of air.

TABLE of approximate and identical wave-lengths of lines belonging to the spectra of the following elements, viz. :— Copper, Silver, Thallium, Indium, Tin, Lead, Tellurium, Aluminium, Cadmium, Arsenic, Antimony, and Bismuth; together with observations on some apparent coincidences.

Cu.	Ag.	Tl.	In.	Sn.	Pb.	Te.	Al.	Cd.	Observations.
3306·8	..	..	..	..	..	3307·1	..	..	A series of coincidences occurs here. The two strongest and longest lines of copper
3289·9	..	..	..	..	..	3289·6	..	..	are apparently identical with two of the strongest and longest lines of tellurium. The
3280·1	..	..	..	..	..	3280·0	..	..	lines are of the same character in both spectra. The two weak lines of copper coincide
3273·2	..	..	..	..	..	3273·4	..	..	with two weak lines of tellurium, and in length, strength, and other features they are
3246·9	..	..	..	..	..	3246·8	..	..	precisely the same in both spectra.
..	..	..	3174·1	3174·3	..	..	..	..	The two least refrangible of these lines appear to be due to tin. The other lines in
..	..	..	3047·0	3046·5	..	..	..	..	the spectrum of indium, approximately coincident with those of tin, are of a totally
..	..	..	3008·0	3007·9	..	..	..	..	different character.
..	..	..	2956·1	..	..	2956·3	..	..	Lines with a different origin and different wave-lengths.
..	..	..	2940·7	..	..	2940·8	..	..	Possibly coincident lines.
..	..	..	2932·2	..	..	2932·5	..	..	Exceedingly faint in tellurium. Very doubtful.
..	..	..	..	..	..	..	2879·9	2880·1	Both fairly strong lines of a similar character. Possibly coincident.
..	..	..	2836·0	..	..	..	..	2836·1	Lines of different characters. The indium very sharp, the cadmium nebulous. Different lines.
..	..	..	2832·3	..	2832·2	..	..	..	The indium line very weak and nebulous, the lead very sharp and strong. Different lines.
2766·2	2766·4	..	..	..	..	..	..	2766·5	Very doubtful. Line strong and long in silver, very faint and long in copper, exceedingly short and rather strong in cadmium.
..	..	..	2631·7	2631·5	..	..	..	..	Lines with different wave-lengths.
..	2579·9	2579·7	..	..	..	..	..	..	Lines with different wave-lengths.
..	2561·5	..	..	..	2561·6	..	..	..	Very doubtful. Probably lines with different wave-lengths.
..	..	2551·6	..	..	..	..	..	2551·6	Both very faint lines. Doubtful.
..	..	..	2545·8	2545·6	..	..	..	..	Very doubtful. The indium line feeble.
2506·2	2506·0	..	..	..	..	..	..	..	Lines with different wave-lengths.
2485·6	2485·4	..	..	..	..	..	..	..	Faint and very doubtful.
..	.	2477·7	2478·1	..	..	..	..	..	Faint and very doubtful.
2473·2	2473·3	..	..	..	..	..	..	..	Doubtful. Probably a very close approximation.
..	2469·0	2468·9	2468·4	..	..	..	..	..	The silver line very faint. The thallium and indium have different wave-lengths.
..	2445·7	..	..	..	2445·7	..	..	..	Very doubtful. The silver line is very weak and short.
..	2411·3	..	..	..	2411·2	..	..	..	The silver line strong, the lead weak and of a totally different character. These lines are not coincident.
..	..	..	2429·1	2429·3	..	..	..	..	The indium line exceedingly faint. Very doubtful.
..	2393·3	..	..	..	2393·7	..	..	..	The silver line exceedingly faint, the lead very strong. Lines of a totally different character.
..	2364·3	2364·8	..	..	..	..	..	..	Lines not coincident. Very faint in the thallium.
..	..	..	2306·9	..	..	..	..	2307·0	These lines are not coincident, the indium is the more refrangible.
2265·8	..	..	..	..	..	..	..	2265·8	Extremely feeble in copper, but very strong in cadmium. Doubtful.
..	2247·6	..	..	..	2247·9	..	..	..	Lines of similar character. Doubtful.

TABLE of approximate and identical wave-lengths of lines belonging to the spectra of the following elements, viz.:—Copper, Silver, Thallium, Indium, Tin, Lead, Tellurium, Aluminium, Cadmium, Arsenic, Antimony, and Bismuth; together with observations on some apparent coincidences (continued).

Sn.	Pb.	Te.	As.	Sb.	Bi.	Observations.
4324·6	..	4324·6	..	..	..	Very faint lines. Doubtful.
3961·8	3961·5	..	..	..	..	Both very short and weak lines. Doubtful.
..	3842·9	..	3842·5	..	..	Lines totally differing in character. Lines with different wave-lengths.
3800·3	..	..	3800·7	..	..	Lines totally differing in character, that in arsenic probably an air-line.
3471·1	..	..	3471·1	..	..	Lines of a similar character, that of tin the stronger.
..	..	3280·0	..	3279·7	3279·9	A line of tellurium in antimony and bismuth.
..	..	3273·4	..	3273·0	..	A line of tellurium in antimony.
..	..	3256·3	3256·2	..	..	Lines with different characters; strong in tellurium, weak in arsenic.
..	..	3246·8	..	3246·6	..	A line of tellurium in antimony.
3219·6	3219·9	..	..	..	..	Lines with totally different characters, that of lead the stronger. Probably different lines.
3174·3	..	3174·4	..	..	..	Lines of the same character, that of tin much the stronger.
..	3016·5	3016·6	..	..	..	Lines of the same character, that of tellurium much the stronger. Probably different lines.
2877·4	..	..	..	2877·1	..	Different lines with totally different characters, that of antimony being the strongest.
..	..	2859·9	2859·7	..	..	The arsenic line is very strong, the tellurium line very strong. Totally different lines.
..	..	2840·0	..	..	2840·1	Both lines weak and nebulous. The tellurium long, and the bismuth short. Doubtful.
..	2822·1	..	..	..	2822·2	Lines of a totally different character; that of lead strong, bismuth very weak.
..	..	..	2779·5	..	2779·3	Both lines of the same character, that of arsenic the stronger.
..	..	2768·6	..	2768·9		A line of tellurium in antimony.
..	..	..	..	2651·3	2651·8	Lines of the same character, that of antimony the stronger.
..	..	..	2597·1	2597·2	..	Similar lines; that of antimony very strong, of arsenic very weak.
..	2576·4	..	2576·0	..	..	Lines with totally different characters, and with different wave-lengths.
..	..	2543·7	..	..	2543·3	Lines of similar character, that of bismuth (the weaker) is nebulous. Probably lines with different wave-lengths, as the numbers indicate.
..	..	2529·4	..	..	2529·7	A line of tellurium in bismuth probably.
2523·4	..	..	..	..	2523·5	Very similar lines, that of bismuth the stronger.
..	..	..	2489·1	..	2489·1	These measurements are not comparable; that for bismuth is the centre of a nebulous band.
..	..	..	..	2479·4	2479·1	Similar lines, that of antimony the less weak.
..	..	2473·2	..	2473·4	..	Tellurium in antimony.
..	..	2438·0	..	2438·0	..	Tellurium in antimony.
..	2411·2	2411·4	..	..	..	Similar lines, that of tellurium the less faint. Doubtful.
..	..	2370·3	..	2370·0	..	Tellurium in antimony.
2368·3	..	..	..	..	2368·0	Lines of the same character, but stronger and longer in bismuth. Different lines.
2317·9	..	2317·8	..	..	2317·4	The lines of tin and tellurium are of similar character, but differing in length and strength, those of tellurium being the stronger. The bismuth line is of quite a different nature.
2247·0	..	2247·3	..	..	..	

The Spectrum of Mercury.

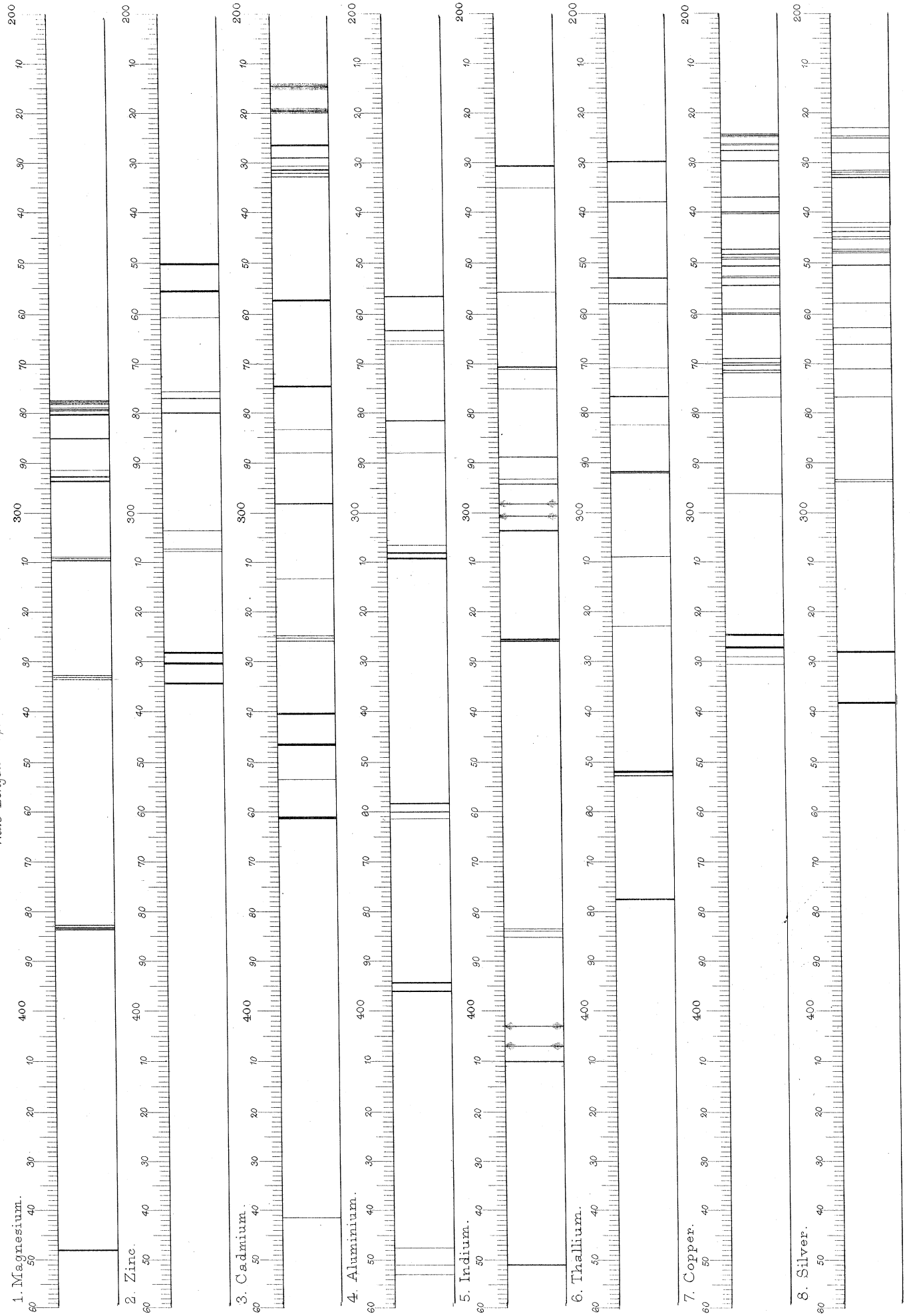
Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
24·05	VERY STRONG, CONTINUOUS, much extended, sharp	*4358·0*	All the lines in this spectrum were measured from a prism photograph, and are therefore printed in Italics.
24·61	Faint, continuous, fine	*4348·0*	
25·03	Faint, continuous, fine	*4341·0*	
41·56	Weak, continuous, fine	*4077·5*	
43·76	VERY STRONG, CONTINUOUS, much extended, sharp	*4046·5*	Several lines due to tin are visible in the photographs, but they are not recorded here.
48·19	VERY STRONG, CONTINUOUS, much extended, sharp	*3984·0*	
57·65	Weak, continuous, nebulous	*3859·0*	
60·85	Weak, continuous, nebulous	*3820·0*	
61·90	Faint, continuous	*3807·0*	
62·45	Faint, continuous	*3800·0*	
63·31	STRONG, continuous	*3790·0*	
65·04	Weak, continuous	*3770·0*	
66·34	Faint, fine, continuous	*3754·7*	
66·65	Strong, continuous	*3751·0*	
72·82	Weak, continuous, nebulous	*3681·9*	
74·60	A triplet of fairly strong, continuous, sharp, much extended lines, with a nimbus, the most refrangible line being the strongest and most extended	*3662·9*	
75·37		*3654·4*	
77·37		*3632·9*	
84·47	STRONG, CONTINUOUS, fine	*3560·1*	
86·27	STRONG, CONTINUOUS, fine	*3542·3*	
91·52	Very faint, short	*3492·6*	
93·60	Very faint, short	*3473·4*	
96·04	Very faint, short	*3451·4*	
103·00	STRONG, CONTINUOUS, somewhat nebulous, extended	*3389·5*	
105·84	Faint, discontinuous, fine	*3365·5*	
107·58	Weak, nebulous, continuous	*3351·2*	
108·79	STRONG, CONTINUOUS, extended	*3341·2*	
123·40	Faint, short fine	*3226·4*	
126·02	Weak, continuous, fine, faint in the centre	*3207·1*	
137·08	A PAIR OF VERY STRONG, continuous, much extended lines, with a nimbus	*3130·4*	
137·95		*3124·5*	
142·50	Faint, fine, continuous	(*3094·0*)	Possibly due to an impurity.
154·12	STRONG, CONTINUOUS, with a nimbus, extended	*3021·0*	
163·37	VERY STRONG, BROAD, with a nimbus, extended	*2966·4*	
166·86	STRONG, CONTINUOUS, fine, extended	*2946·6*	
168·84	Weak, discontinuous, fine	*2935·5*	
170·70	Weak, continuous, fine	*2925·2*	
172·50	Weak, continuous, fine, faint in centre.	*2915·3*	
176·63	STRONG, CONTINUOUS, sharp, extended	*2892·9*	
185·45	VERY STRONG, CONTINUOUS, broad, somewhat nebulous, extended	*2846·8*	
188·34	Faint, continuous, fine	*2832·1*	
191·04	STRONG, CONTINUOUS, nebulous	*2819·7*	
192·80	Faint, discontinuous, nebulous	*2810·0*	
193·90	Fairly strong, continuous, fine, weak in centre	*2804·5*	

The Spectrum of Mercury (continued).

Scale-numbers.	Description of lines.	Wave-lengths.	Remarks.
195·17	Weak, continuous, nebulous, faint in centre	*2798·5*	
196·96	Weak, continuous, fine, faint in centre	*2790·0*	
200·48	Faint, discontinuous, nebulous	*2773·2*	
203·09	Weak, fine, discontinuous	*2760·8*	
205·06	Fairly strong, fine, continuous	*2751·5*	
216·26	Faint, nebulous, discontinuous	*2702·0*	
226·66	Weak, discontinuous, nebulous	*2657·6*	
227·97	STRONG, VERY BROAD, nebulous	*2652·2*	
229·79	Faint, nebulous, discontinuous	*2644·6*	
230·77	Faint, broad, nebulous, discontinuous	*2640·6*	
240·37	Fairly strong, fine, discontinuous	*2602·3*	
245·21	Faint, discontinuous, fine	*2584·2*	
247·46	Faint, continuous, nebulous	*2575·3*	
258·20	Very strong, sharp, continuous, extended	*2535·8*	
258·75	STRONG, nebulous, continuous	*2533·8*	
261·88	Very faint, discontinuous, nebulous	*2522·7*	
264·20	Very faint, discontinuous, nebulous	*2514·3*	
270·83	STRONG, FINE, continuous, weak in centre	*2491·4*	
273·64	Faint, continuous, broad, nebulous	*2484·2*	
274·85	Very faint, discontinuous, nebulous	*2477·7*	
277·85	Faint, discontinuous, nebulous	*2468·0*	
278·16	Faint, discontinuous, nebulous	*2467·0*	
279·15	Faint, discontinuous, nebulous	*2463·7*	
280·53	Very faint, discontinuous, nebulous	*2459·3*	
294·79	STRONG, CONTINUOUS, fine, weak in centre	*2414·3*	
297·07	STRONG, CONTINUOUS, fine, weak in centre	*2407·3*	
302·78	Very faint, continuous, nebulous	*2390·0*	
314·84	Weak, continuous, nebulous	*2355·2*	
319·38	Very faint, continuous, nebulous	*2342·2*	
320·20	Very faint, discontinuous, nebulous	*2340·0*	
329·21	Very faint, continuous, nebulous	*2315·2*	
336·25	Very faint, continuous, fine	*2296·5*	
337·74	Very faint, continuous, nebulous	*2292·6*	
348·65	Fairly strong, continuous, fine, weak in centre	*2264·2*	
349·27	Fairly strong, continuous, fine, weak in centre	*2263·3*	
350·00	STRONG, NEBULOUS, continuous	*2261·4*	
353·00	STRONG, FINE, continuous	*2254·0*	
362·28	Very faint, fine, continuous	*2231·0*	
364·51	STRONG, BROAD, nebulous, continuous	*2225·7*	
379·09	Very faint, fine, continuous	*2190·9*	
398·45	Very faint, fine, continuous	*2148·0*	

NORMAL SPECTRA.

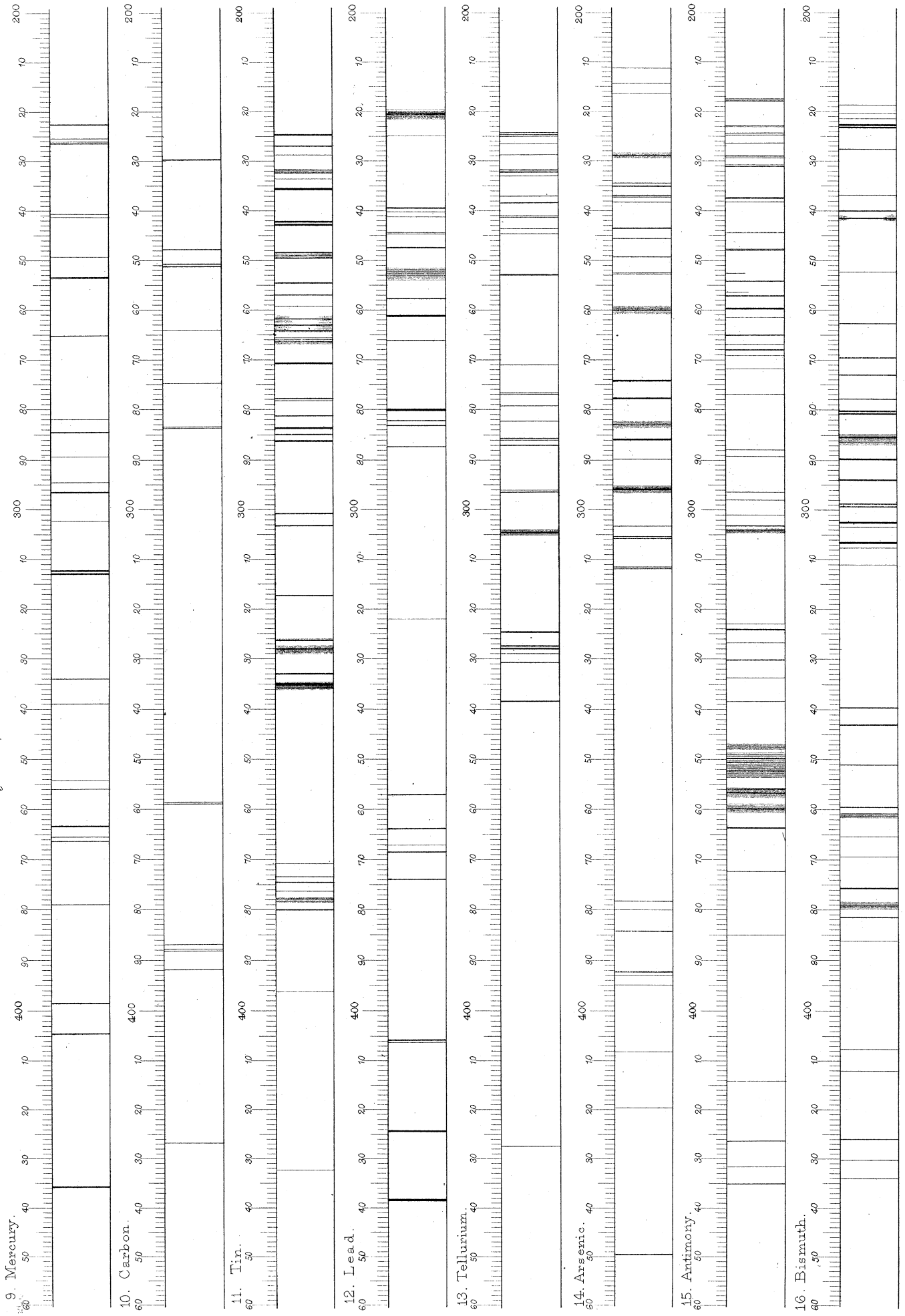
Wave-Lengths Expressed in Millionths of a Millimetre.



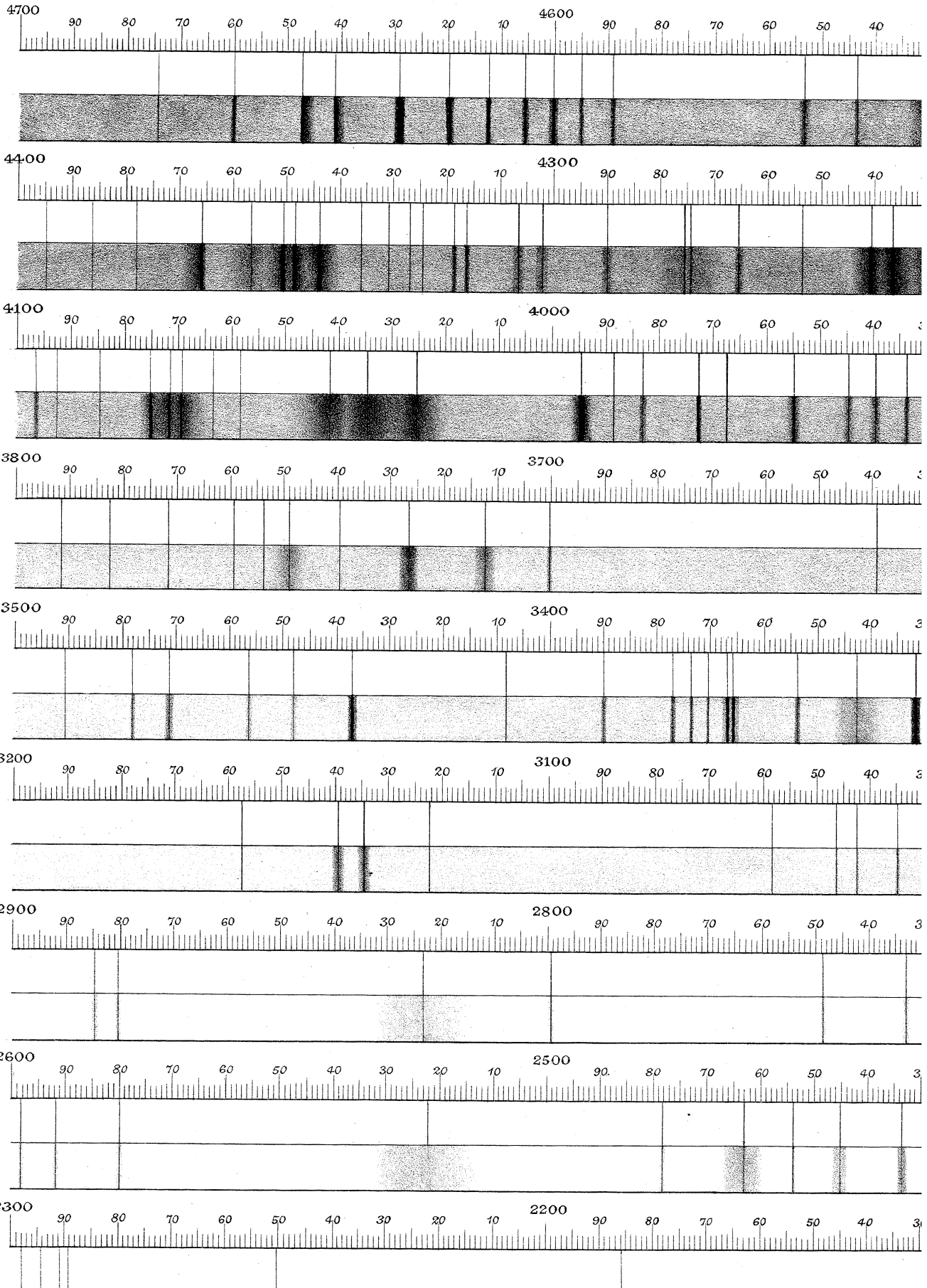
West, Newman & Co. lith.

NORMAL SPECTRA.

Wave-Lengths Expressed in Millionths of a Millimetre.



West Newman & Co lith.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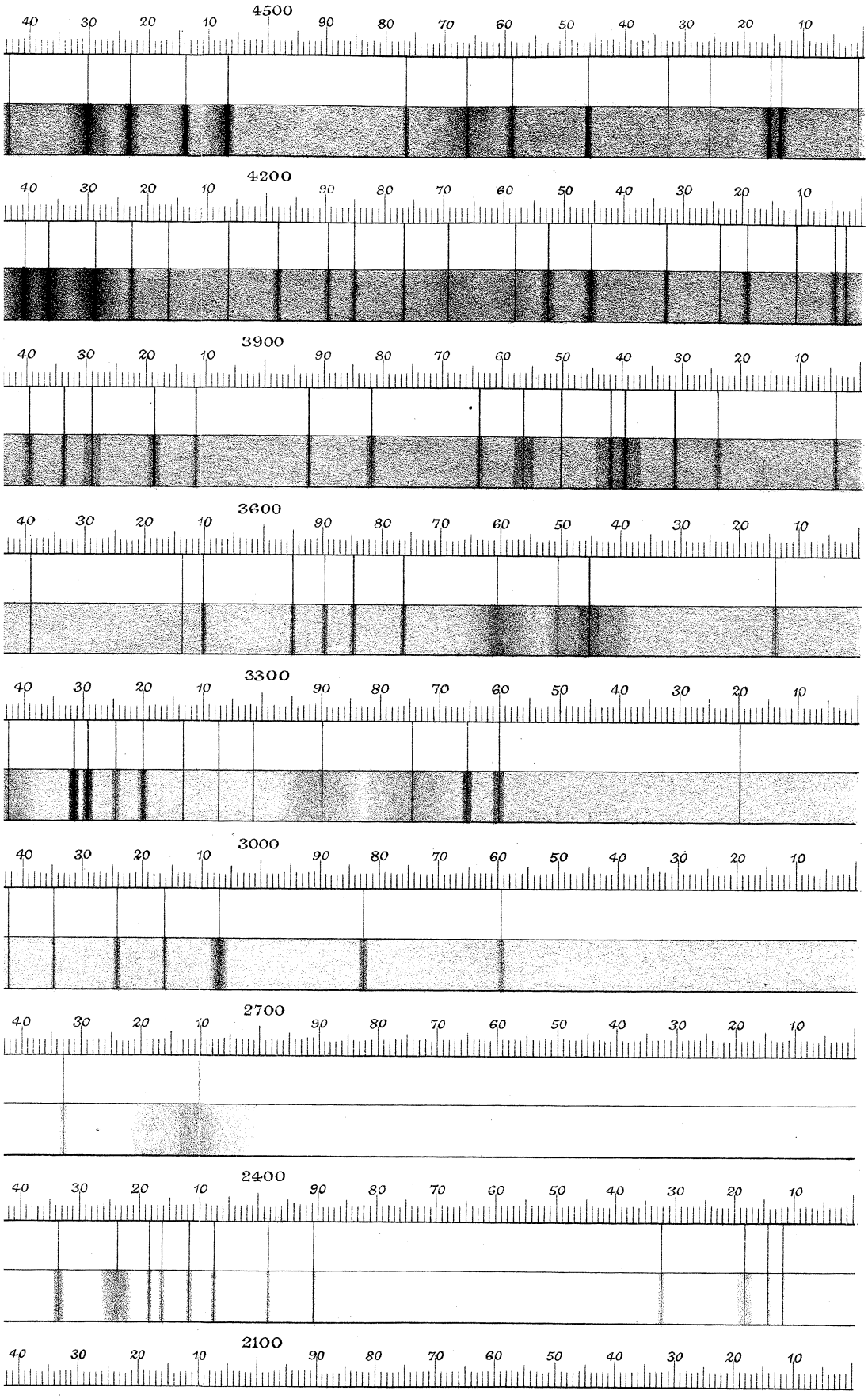
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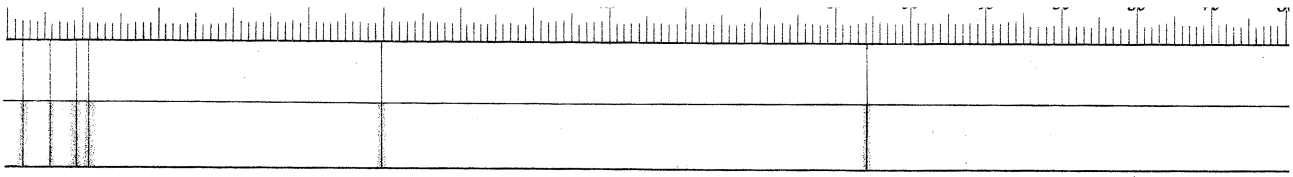

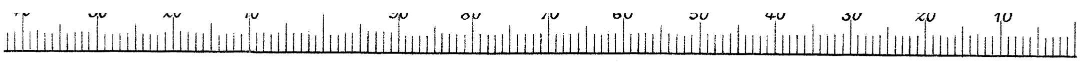

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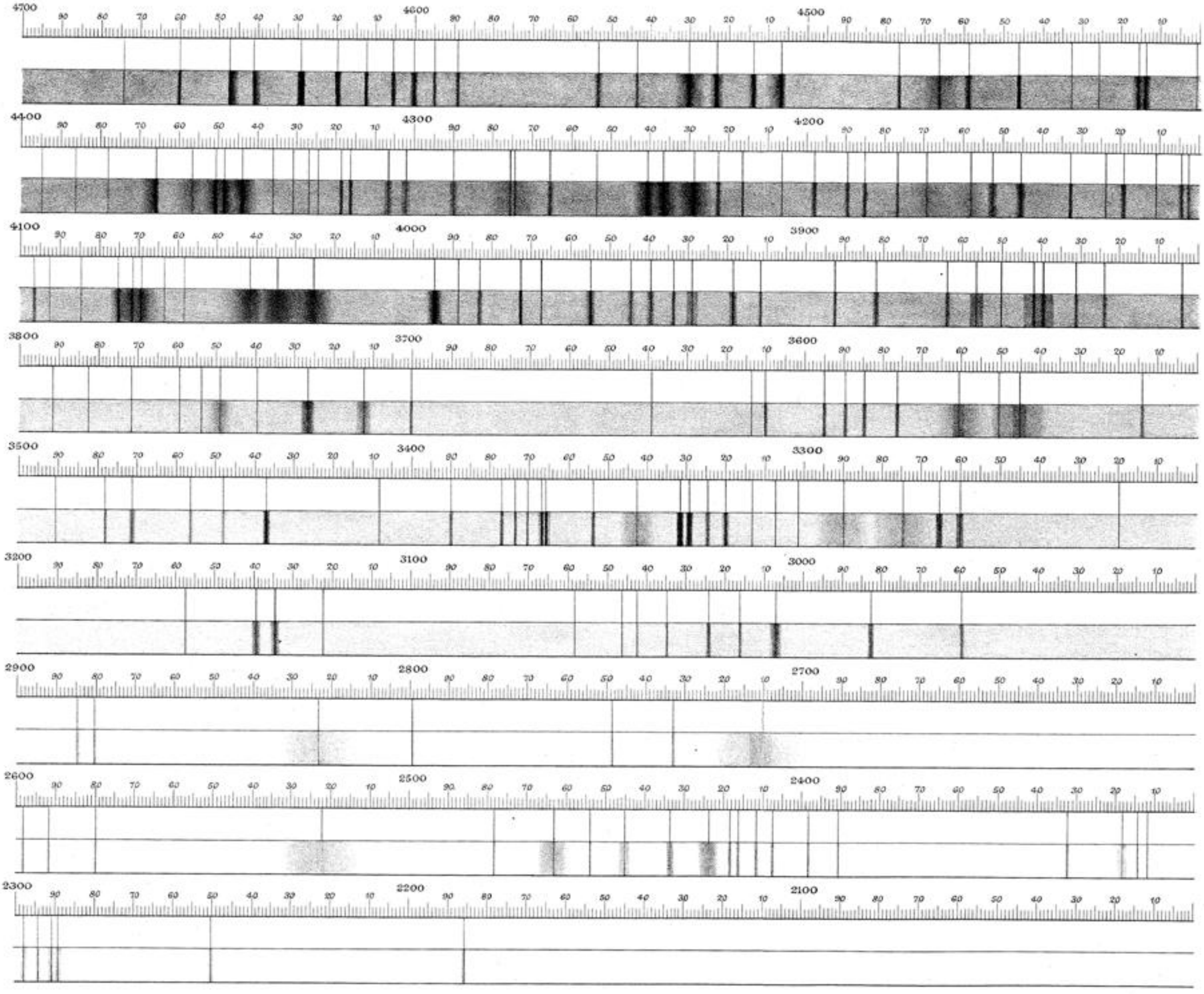

West, Newman & Co. lith.