XXXVII. *On Spectra of Electric Light, as modified by the Nature of the Electrodes and the Media of Discharge.* *By the Rev.* T. R. Robinson, *D.D., F.R.S., &c.*

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The important discovery of Wheatstone, that the spectra of electric sparks contain brilliant lines whose character depends on the nature of the electrodes, after being almost neglected for several years, has lately become an object of great interest; and much additional light has been thrown on it by several physicists, of whom Masson, Ångström, Plücker, and Kirchhoff are the most conspicuous. Ångström has announced as a general law that the lines in question are produced by the electric current igniting the medium in which the discharge takes place, or molecules of the electrodes which are torn off by its passage, that each of these actions produces its own spectrum, and that those spectra are simply superposed without any modification. The gases with which he worked were at the ordinary pressure. Plücker, on the other hand, used the well-known Geissler tubes, which contain minute proportions of highly rarefied gas or vapour. He attaches very little importance to the lines due to the electrodes (*metallic* lines), which he thinks are confined to those portions of the spark near the electrodes; and he maintains that in the centre of an exhausted tube of some length only gaseous lines are seen. He was embarrassed in several instances by the decomposition or absorption of the gaseous media; and there must always be some doubt as to the precise nature of these media, as the tubes are hermetically sealed. On the other hand, Kirchhoff seems to attach most importance to the metallic lines, whose influence he has exhibited to a wonderful extent by a spectrum-apparatus probably unrivalled. All hold the doctrine of an essential connexion between the character of the spectral lines and the chemical nature of the substances which are present in the track of the discharge; and the last, in conjunction with Bunsen, has based on this principle the new system of spectral analysis, which is rapidly becoming popular, and has applied it to explain the dark lines of the solar spectrum in a way which, if not absolutely certain, is singularly elegant. Yet it is impossible to overlook the fact that, in all this, much is assumed, not proved. Has it been established that these lines depend so absolutely on chemical character that none of them can be common to two or more different bodies? Has it been ascertained that, while *the chemical nature* of the bodies present remains unchanged, the lines never vary if the circumstances of mass, density, &c. are changed? And what evidence have we that spectra are superposed, so that we observe the full sum of the spectra which the

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* The continuation of the paper, from p. 974 to the end, was not received complete till September 1; but the conclusions therein contained are embodied in the abstract presented to the Society on June 19, 1862.

electrodes and medium would produce separately? Lastly, is it certain that electricity produces light merely by its heating power? and may not the same action which produces thermic vibrations, also (and independently) produce luminous?

Some of these questions I have endeavoured; to investigate and the attempt can scarcely fail to be of use, were it only to direct attention to the subject.

My attention was originally turned to it by observing, some years ago, that the discharge in carbonic oxide, which is white at common pressures, becomes bright green when the gas is highly rarefied. The spectra in these cases differed so much that I determined to examine them in various gases and metals; and I procured the apparatus which seemed necessary. That of STEINHEIL had not been contrived then; and my want of experience in such researches caused at first some mistakes, but by degrees I corrected them; and though my instrument is of comparatively limited power, the results are, I hope, not without importance; and I have given details sufficient to estimate the errors which may affect them.

The source of electricity in my experiments was an induction-machine. Till July 1860 I used one by HEARDER, having three miles of secondary wire; after that, one which I have described*, with the substitution of copper wire for iron. It has 9·5 miles, of which three are not lapped, merely varnished; and when excited by three Grove's, each of which has 49 square inches of platinum acting, it gives abundantly sparks 6·8 inches long. By a simple device its two coils can be in an instant made to act collaterally instead of consecutively, thus reducing the intensity but doubling the quantity. Then the sparks are only 2·5 inches, but very dense and luminous, and possessing a far higher power of ignition. A Leyden jar, each coating 1·25 foot, was normally connected with the terminals, as the spectrum of the simple spark is far more faint and unsteady: I have given one as a specimen in Table III. With this jar there is a continuous stream of discharge at 0·6 inch.

The discharges were made in the open air, or in tubes about 0·2 inch diameter and 6 inches long. With rarefied gases they would be more luminous if the tubes were capillary; but in that case it would be very difficult to clean them from the coatings of metal or oxide which are deposited, most densely near the negative electrode, but often on the whole interval. In some metals, of which the most notable are lead, cadmium, bismuth, antimony, arsenic, and above all tellurium, this deposit was so thick that at the close of an experiment it was difficult to see the fainter lines, and I found it necessary to employ for common density a tube 1 inch diameter. Even this was coated, but not so thickly as to give much trouble. The upper electrode (which was, in all cases but one, positive) was attached to platinum wire fused in the tube. It was sometimes soldered to it, at other times twisted with it; and when I could not procure the metal as wire or foil, a globule of it was fused by a gas-blowpipe, a platinum wire inserted in this, and the heat withdrawn. For nickel and cobalt, the blowpipe was oxyhydrogen. As the electric light does not spread over the positive electrode, it was unnecessary to insulate the platinum wire; but with the negative it is otherwise; and when I had not enough of

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* Philosophical Magazine, April 1859.

the body to give a length of some inches, it was inserted in a piece of quill tube, whose lower extremity was fused on platinum wire reaching up to it; and this was inserted in the discharge-tube. In tubes the distance of the electrodes was about 0·75, in open air 0·10. The discharge-tube was cemented in a cap screwed to the air-pump, or rather to a transfer piece. This is a cylinder of brass with a concave screw above, a stopcock below screwing to the air-pump, and a lateral one connected with a desiccator. The desiccator is a bottle 8 inches deep and 2 inches diameter, fitted with a ground stopper, in which are two apertures. In one of these is cemented a tube which is connected with the transfer; in the other, one descending to the bottom of the bottle, where it is drawn into a capillary point, its upper end being connected with either another desiccator or a gasometer. The desiccator is filled nearly with sulphuric acid. Supposing the transfer and the tube exhausted, shut off the air-pump cock and cautiously open that which connects the desiccator; gas bubbles up slowly through the acid and fills the transfer and tube. Shut off the desiccator, connect the pump, and exhaust. By repeating this process *ad libitum* all traces of air or any gas previously used are removed, and nothing is present but the subject of experiment. It is almost needless to say that every part of this apparatus, including the air-pump, must be *absolutely** air-tight. To ascertain whether this means of desiccation is sufficient, I used Kater's oat-beard hygrometer. In the air of the room it read at 60° 3·358 R. It was then placed under a receiver containing a capsule exposing 20 square inches of sulphuric acid for five hours at a pressure of 0·3 inch, when it read 0·455 R. The receiver was then filled with air drawn through the desiccator as rapidly as could be done without drawing acid into the pump. In 10^{m} it read 0·285 R. Admitting air and introducing a slip of bibulous paper moistened with water, in 40^{m} it was 8·480 R; and when left in the air of the room some hours it was again 3·258. It is therefore evident that in this respect nothing more can be desired. Sulphuric acid also absorbs sulphurous acid and nitric oxide; but when other acids might be present, a second desiccator was used filled with concentrated solution of potassa.

The gasometer was made of a Woulfe's bottle holding 75 cubic inches. In its central neck is cemented a siphon, one branch of which reaches to its bottom, the other to the bottom of a bottle of rather larger capacity; in the other two necks, stopcocks are cemented, one of which (A) is connected by elastic tube with the desiccator, the other (B) with any apparatus for generating gas. Suppose the Woulfe filled with water (or on a smaller scale with mercury). Let gas be supplied to B, the water will be displaced by it through the siphon into the bottle; then closing B and opening A, the transfer and its tube are filled. If the water has been boiled for a few hours and cooled without exposure to the air, I find that gas continues in this gasometer sensibly pure for a much longer period than the duration of a day's observations. For operating on vapours free from any mixture of permanent gas, I use a mercurial apparatus, consisting of a strong Woulfe's bottle in whose three necks are ground (1) a glass stopcock, (2) a tube in which

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* That which I use has kept for a month a vacuum of 0·1 inch without variation of 0·01.

a platinum wire is sealed long enough to dip in the mercury and serve as the negative electrode, (3) a tube also dipping in the mercury, and with a platinum electrode at top. If the bottle be filled one-third with pure mercury, and the stopcock be connected by a caoutchouc tube* with the transfer and the apparatus exhausted, the tube can be filled with mercury, which on erecting it falls, leaving a vacuum, through which discharges can be passed by the electrodes. If the tube has been *perfectly* cleaned by filling it with nitric acid and washing it with distilled water, dried by sulphuric acid in a vacuum, and finally wiped with a morsel of linen which has been boiled in distilled water, after being fastened to a flexible wire, on inclining the tube the mercury will fill it without leaving the least speck of air, and will often adhere with considerable force. It, however, always falls at the first discharge. In this case the space is filled with mercurial vapour alone. If a few drops of any volatile fluid be introduced into the tube, by filling it with mercury the excess is expelled, and the vacuum contains only its vapour highly rarefied. With phosphorus, the tube filled with water was warmed till it fused and adhered to the upper part; the water was removed, and the tube put in its place. The apparatus was then repeatedly filled with dry nitrogen till all traces of moisture disappeared. If a platinum wire of sufficient length be introduced below, both electrodes are platinum; and if the upper part be bent so that the descending branch remains full of mercury, both are of that metal.

Prisms.—For three-fourths of the observations I used a prism by MERZ, with an angle 45° 35′·4. By sets of from eight to twelve it gives, for the deviations of FRAUNHOFER'S lines,

	°	′	
A	32	20·00	μ 1·6230
B	32	32·04	1·6259
C	32	38·88	1·6285
D	32	56·50	1·6336
E	33	20·26	1·6405
F	33	41·67	1·6467
G	34	23·06	1·6587
H	35	0·06	1·6692

It is therefore nearly identical with FRAUNHOFER'S flint No. 2, but in dispersive power it is far inferior to those used by MASSON and PLÜCKER. After working with it a long time, I found that several bright but cloudy bands which it showed were resolved into two, three, or more by a prism of bisulphuret of carbon having an angle of 60°. The indices of this fluid change so much with temperature, that I did not venture to employ it; and I obtained from Mr. DUBOSCQ a prism of 60° 3′·54 angle, which, though nearly of the same density as the Merz, is more effective, in the proportion of 3 to 2. Determining with it FRAUNHOFER'S lines, and comparing with their deviations in Merz, I

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* This, with which I was supplied by Messrs. SILVER, is far superior to vulcanized tube, which always leaks. The glass apparatus was made with great precision and intelligence by Mr. CASELLA.

formed by interpolation a Table of reduction to the latter, by means of which all are given on the same scale. The two glasses are so nearly similar, that it was not necessary to go beyond second differences. Even this prism leaves several bands unresolved, though often giving a suspicion of their compound character, which in some recent instances I have verified by combining *two* 60°-prisms of the bisulphuret.

It is an object of great interest to ascertain whether there be any special relations between the wave-lengths of these luminous bands. In aid of this I subjoin a Table giving the value of λ for every five minutes of MERZ's deviations within the range of my observations. It has been computed by a very simple form of interpolation given by Professor STOKES*. Assuming $\mu = A + \frac{B}{\lambda^2}$, and taking μ and $\frac{1}{\lambda^2}$ for any two of FRAUNHOFER's lines, we get, for any intermediate μ, the $\frac{1}{\lambda^2}$ *simply by proportional parts.* This is so accurate, that it gives correctly one of the intermediate lines by taking the double interval, as D from C and E; even H from F and G.

φ.	λ.	Δλ.	Δ²λ.	φ.	λ.	Δλ.	Δ²λ.	φ.	λ.	Δλ.	Δ²λ.
32° 35′	2493	−88		33° 25′	1909	−37	+ 2	34° 15′	1620	−21	+ 1
40	2405	−79	+ 9	30	1872	−35	+ 2	20	1599	−19	+ 2
45	2326	−69	+10	35	1837	−32	+ 3	25	1580	−18	+ 1
50	2257	−63	+ 6	40	1805	−31	+ 1	30	1562	−18	+ 0
55	2194	−58	+ 5	45	1774	−29	+ 2	35	1544	−18	+ 0
33 0	2136	−53	+ 5	50	1745	−27	+ 2	40	1526	−17	+ 1
5	2083	−49	+ 4	55	1718	−26	+ 1	45	1509	−16	+ 1
10	2034	−45	+ 4	34 0	1692	−25	+ 1	50	1493	−15	+ 1
15	1989	−41	+ 4	5	1667	−24	+ 1	55	1478	−14	+ 1
20	1948	−39	+ 2	10	1643	−23	+ 1	35 0	1464		
25	1909		+ 2	15	1620		+ 1				

Theodolite.—For the use of this instrument I am indebted to Mr. GRUBB, who made it many years since to determine the μs of the glasses for his object-glasses. It is of simple and very firm construction. A strong brass disk, supported by three screws, has on its upper surface a circle 9·5 inches diameter graduated to half degrees, and carries laterally the supports of a collimating telescope 9·5 inches focus and 1 inch aperture, which is provided with an adjustable slit. Above the disk turns a brass plate bearing two verniers in the plane of the divisions (which read to minutes), and supporting the telescope, with a triple object-glass 7 inches focus and 0·9 inch aperture. Below the disk turns another circle, similarly divided on its cylindric surface; its axis rises through that of the upper plate, and carries a table 3 inches diameter, which bears the prism. The axis of the prism is adjusted by observing the images of the slit reflected from its surfaces, which also give its angle by means of the lower circle. Some of these matters require a few remarks.

1. The telescope (and the collimator also), though sensibly achromatic on a day-object

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* Report of the British Association, 1849, Trans. of Sections, p. 11.

or the moon (and very sharp), is over-corrected for G and the rays beyond it: as no provision was made for changing the distance of its object-glass from the system of wires, I at first had some difficulty from parallax at that end of the spectrum, till such an adjustment was applied. The eyepiece (positive, magnifying nine times) was also not achromatic, and had to be constantly focused. It was replaced by a microscope's objective about 0·4 inch focus, magnifying 14 with the prism. A higher power, and even a larger object-glass, avails little in comparison of an increase of the prism's dispersion. Thirdly, I found the cross of spider's lines useless, except for the brightest lines. In the spectra of rarefied gases, which are very faint, it is difficult to see them, and I substituted the point of a fine needle, carefully ground to be a sharp wedge. One can estimate very nicely the equality of the tongues of light on each side. These changes were not made till about fifty spectra had been measured, which, therefore, are not as well determined as the rest.

2. The collimator certainly possesses advantages over the simple slit which FRAUNHOFER and his predecessors used in studying the spectrum. It requires no correction for parallax, secures from any accidental shift of the theodolite, and brings the observer close to his work; but it has the great defect of diminishing the light. Unless the slit be very narrow, it is impossible to distinguish close and fine lines. I find that with the instrument which I am describing, and the Merz prism, I cannot see D double if the slit subtend more than 72″, which corresponds to a width of $\frac{1}{259}$ inch. If it be 3′ (the opening used by PLÜCKER) I cannot see any of FRAUNHOFER'S lines, and the finer parts of electric spectra are lost. Obviously the quantity of light must diminish with the slit, and the evil is made greater by the necessity of keeping the latter at some distance from the discharge. If it be nearer than 1·5 inch, or at most 1 inch, the inductive action of the spark *charges* the theodolite, and the observer, on applying his eye to the telescope, gets a stream of pungent sparks anything but pleasant. But in order that the whole object-glass may be illuminated, we must have this distance less than $\frac{f^2}{\mathrm{A\ cosecant}\ 72''-f}$, A and f being the aperture and focus. This limit in the present instance $=0{\cdot}03$ inch, from which it is obvious that a comparatively small portion of the light can reach the object-glass. I was led to this discussion by a fact which at first startled me a little. When obtaining the deviations of FRAUNHOFER'S lines, I was surprised to find that H was not visible to me, nor any line beyond *h*; though in 1838, with the same prism, but with a slit in the shutter 15 feet distant, I saw several beyond K. I concluded that my eyes had become insensible to rays of short wave-length (in analogy to WOLLASTON'S inaudible sounds), or that their humours had undergone some change by which they absorbed that part of the spectrum; but never suspected the collimator. However, last year, while examining a very fine Munich grating belonging to Mr. STOKES, I was surprised to find that it showed me the missing lines perfectly: here the aperture was a slit $\frac{1}{30}$ at 18 feet. He was so kind as to entrust me with the grating; and on my return home I found that with the collimator it behaved no better than the prisms had done, but that with

the plain slit it recovered its power: the same was the case with my prisms. That the sole cause of this was the narrowness of the slit, and not any peculiar action of the collimator, I verified by attaching to the stand of the theodolite a good object-glass of 8 feet focus, and placing it at that distance from the slit $(\frac{1}{30})$. This arrangement gave vision that was first-rate, and showed lines in an electric spectrum 14′ beyond the last of those that were visible in the usual mode of observing. It follows from these facts, that the collimator's focus should be as long as possible consistent with convenience; and I will suggest that it should be a cassegrain instead of an achromatic. The *equivalent* focus of this is from six to seven times that of the large mirror, and I find by a rough trial that the image is very sharp. If the mirrors of A were glass silvered on FOUCAULT'S plan, it would have as much light as the achromatic, and be free from all chromatic error. I have recently found that the brightness of faint lines is much improved by using a cylindric lens before the slit. The slit was generally one minute wide.

3. The precision of the angles measured depends, on the determination of the index-correction, on the precision of the bisection, and on the reading of the circle. The zero was obtained at the beginning, and also often at the end of each set, by bisecting the slit when illuminated by nearly homogeneous light. At first this was done by interposing a slip of red glass; latterly, in preference, by using the flame of a Bunsen burner in which chloride of sodium was present. The bisection is sometimes doubtful from the flicker of the discharges, more frequently from faintness of the lines, whether intrinsic or relative to the ground on which they are seen, and occasionally from want of sufficient light to see the point. The verniers read only to minutes; but the half minute is easily estimated, and so 0′·25 may be considered the uncertainty of reading. It is desirable to form some estimate of the probable amount of error due to the combined action of the three. This is done by observing twice over the same spectra, and comparing the differences of the observed lines; from which may be obtained the probable error, and the probabilities of given observed differences being errors of observation, or evidences of the lines not being identical. Unless the graduation were much finer than it is, this process would not be of any real value; and a much simpler one may serve. In this work 325 such differences were observed, of which number there were,

				Comp.
Equal to 0′	86		86	239
From 0′ to ±0′·5	131	Not exceeding 0′·5	217	108
From ±0′·5 to ±1′·0	89	Not exceeding 1′·0	306	19
From ±1′·0 to ±1′·5	15	Not above 1′·5	321	4
Above 1′·5	4			

We may reason thus: if the difference of the places of a certain line in two spectra exceed 0′·5, either the lines are identical and the difference is error, or they are distinct; the probability of the first happening $=\frac{108}{325}$, and therefore that of the other $=\frac{217}{325}$, or it is 2 to 1 they are not the same. If the difference exceed 1′·0, it is 16 to 1, if 1′·5, 80 to 1. Two things, however, must be remembered: these errors may be ±; and therefore, in comparing a series, the limit is nearly doubled; and further, these probabilities may be much modified by other circumstances. For instance, a line or band may be identified by some peculiarity, even if the difference be greater than the probable limit. In general I would fix the limit to $\pm 1'{\cdot}0$ from the mean.

I at first read both verniers; but found this consumed so much time, that I determined the excentricity of the upper circle and allowed for it. This correction for the vernier A $=0'{\cdot}75 \times \sin(160^\circ + \varphi)$.

The gases which I selected for experiment are—1, air; 2, nitrogen obtained by heating nitrite of potassa with saturated solution of sal-ammoniac; 3, oxygen; 4, hydrogen: these last two were obtained by electrolysis of *pure* oil of vitriol diluted with eight volumes of distilled water, in a voltameter of peculiar construction. A porous cell has a cover cemented on it with three tubulures; one for admitting the dilute acid; one for a strong platinum wire to which is soldered with gold a platinum sheet, exposing 19 square inches; the third carries away the evolved gas. Round this cell a larger platinum is rolled, and it is immersed in a jar filled with the same dilute acid. When connected with the three Grove's already mentioned, it gives 8 inches of hydrogen per minute. Both the gases I believe to be quite pure, except as to ozone, when thus obtained. 5. The carbonic oxide was got by heating sulphuric acid with ferrocyanide of potassium.

As to the metals, the platinum and silver were obtained from Messrs. JOHNSON and MATTHEY, the aluminium from Paris. I am indebted to the kindness of Dr. MATTHIESSEN for calcium, tellurium, and gold. The palladium was given to me by Dr. WOLLASTON; tin, lead, and bismuth reduced from oxides carefully prepared; zinc, iron, and antimony, deposited by electrolysis on platinum wires. Cadmium, nickel, cobalt, magnesium, sodium, and potassium were got from Messrs. JACKSON and TOWNSON.

The spectra at common pressure (C.P.) are in general magnificent objects. Their ground seems to be a continuous spectrum, of which, however, the brightness varies very much with different substances and at different parts. Sometimes, especially at the violet end, this ground is so faint that its presence might be questioned; but I believe it exists even there. On this are, as it were, superposed luminous lines of every degree of brightness, from a splendour almost insupportable, to a faintness such that (at least with my optical means) the least glimmer of diffused light in the telescope totally effaces them. Most of these lines are (as might be expected) as broad as the image of the slit: a few are much broader, even to six or seven times. Such are, I think, always cloudy and ill defined, giving the impression that they are groups of finer lines, which the optical power is insufficient to separate. In several instances this is shown to be the fact by the combination of two fluid prisms of 60° (2BS.C), of which the two most remarkable are those which I call ζ, in the green, and $\varkappa''$, at the beginning of the violet. The first was seen in the Merz prism as a broad bright band, but it is a crowd of very fine lines, of which the central one is much the brightest; and some of the others are developed in different spectra: the second (not resolved in Duboscq) consists of six bright and sharp lines. Even this power fails to decompose the remarkable blue-green and violet bands which characterize the hydrogen spectra C.P. Perhaps a third prism might, but there is no room for it on the theodolite.

A third class of lines is narrower than the slit, down to the finest hairbreadth; they are mostly sharp and well defined, sometimes very bright. Their occurrence is not easily explained; for in the ordinary conditions of these observations each ray illuminates the whole slit, and the image of the line due to it ought to be as broad as that slit. The only explanation which has yet been proposed (by PLÜCKER) is that they are caused by the overlapping of two images the distance of whose centres is less than the slit. It is, however, liable to two objections—that the brightness of such an overlap cannot exceed twice that of the ground on which it is seen, and that it would be often resolved by a prism of higher dispersion: the combination 2BS.C disperses seven times as much as the Merz, and ought surely to break up some of them. This is not, as far as I have examined, the case; and some of these lines are as intense as any in the spectrum. These narrow lines are sometimes very thickly crowded, as in the green and blue of iron spectra, and in those of carbonic oxide; and possibly they may compose the bright ground when so close as to be unresolvable. There is a seeming tendency in them to be grouped in two, three, or higher numbers, which, however, might disappear with more powerful prisms; but with those I use one can scarcely avoid thinking that there is some special connexion between the components of such groups; such are enclosed in brackets.

Some of the most brilliant are double, as the orange one γ, supposed to correspond with D (though its components seem to me more separated than those of that line), the splendid yellow δ, and the greens η and θ.

At that boundary of the spectrum which corresponds to the negative electrode (and in a much less degree at the positive) extremely intense lines are seen, especially in the green, which however are short: bismuth, zinc, lead, and arsenic are the best examples of this. These are generally supposed to be metallic lines, and to proceed from the intense dispersion of metal near the electrodes, especially the negative. It has even been proposed to consider this not crossing the entire breadth of the spectrum as a test of metallic origin, and to regard the others as gaseous. I, however, find that these very lines can be traced entirely across though sometimes very faint, except when the entire part is covered with a sort of bright haze, through or on which nothing can be seen which is not very bright. It seems to me that the existence of a line and its brightness depend on different causes; and I shall give instances when the *same* line assumes very different aspects as the media of discharge are changed. I may add that the sort of haze just mentioned does not occur at the negative electrode.

The spark discharge without a jar is so much fainter that none but the brightest lines can be seen. If the surface of the jar be increased (for the converse reason) more lines are visible, but I think no new ones are produced. One or two examples will be given, If the secondary coils be arranged for quantity, the red end is not changed, the violet is much brighter.

On rarefying the gas in which the discharges are made (R) there is at first no change, except perhaps a little diminution of brightness, till at a certain pressure (varying with the media and diameter of the tube) the spectrum fades away. Sometimes, as with CuO (*i. e.* copper electrodes in oxygen), *all vanishes* except a trace of the lines at 0·75 inch; in SbN all but a trace of δ; in NiN, at 2·8 inches, all but a suspicion of violet light, and sometimes perfectly dark bands take the place of bright lines. In others the change is not so striking. In Al, Air, at 1·2 inch, the chief violet lines remain tolerably conspicuous; δ can be seen, but η and κ vanish: in Pt, Air, tube ·1 inch diameter, at 6 inches the first half fades to a neutral-tinted haze with faint alternations of brightness, and the rest has eleven definite but faint bands. In general, however, it may be considered the rule that from 3 inches to 1 inch these spectra almost vanish. I will only mention another, PbH. In hydrogen spectra, at C.P. the most distinctive characters are a *very* bright red line (found in all spectra, but not so bright); a very bright and broad one at the confines of green and blue, and a similar one in the violet. Of these the last diappears at 5·3 inches; the red at 3·1 inches; the blue not totally till 0·15 inch; but this is doubtful, as it may have been confounded when waning with another which was near its place. It deserves notice that this disappearance of the peculiar hydrogen bands is also produced when the hydrogen is diluted with air. The electrodes were cobalt; 20 cubic inches of hydrogen were mixed with 10 of air, and the spectrum of the mixture examined; its volume was reduced to 20, 10 more of air added, and so on; the degree of dilution was easily found from the number of additions; and it was found that the violet band vanished when H is 0·2 of the mixture, the blue when 0·09. These correspond to hydrogen under the pressures 6 inches and 2·7 inches: the red could not be determined, as air has the same band.

If in any case we rarefy beyond the limits of these *transition* spectra, bright lines reappear, but not all in the same places or with the same characters. Ordinarily the brilliant lines of the C.P. spectra are wanting, though sometimes lines which are faint in them assume this type in the others. The red, yellow, and green seem diffused in cloudy light; and the violet system is replaced by a set of broad cloudy bands nearly equidistant, and more conspicuous than the less refrangible ones. The red band, which almost always begins the C.P. spectra, is often wanting, and when it does occur is insulated in darkness, but at the other end both spectra are nearly of the same length. These R spectra are in general much less luminous, and show little distinction of colours unless the metal of the electrodes be easily vaporized. That of tellurium is very bright, containing thirteen brilliant lines; and under *every* circumstance of pressure or discharge, those of potassium and sodium show the dazzling orange bands.

As might be expected from their greater faintness, they contain fewer lines, or at least fewer are visible; but it is remarkable that of this number a considerable proportion *is not found* in the C.P. spectra. The percentage deduced from fifteen metals is

Air	0·39
Nitrogen	0·32
Oxygen	0·39
Hydrogen	0·66
Carbonic oxide	0·37

Of this, two explanations may be given. It may be said that these lines are not seen at C.P. because they are overpowered by the brightness of the ground on which they are seen. In some cases (of which examples are given hereafter), especially in hydrogen, this cause does act in some degree. In that gas the centre of the C.P. spectrum was at first observed, where, as I have stated, the finer lines are not easily seen with some metals; and then the percentage was very high; but at the negative boundary this bright haze does not interfere, and when observed *there*, the proportion is almost exactly that of the other gases. Besides, it occurs frequently that in the C.P. spectrum, on each side of the place where the missing line should be, faint and narrow lines are seen with perfect distinctness. The other solution is this, that these lines do not depend entirely on the chemical character of the media and electrodes, but also on their molecular condition. On any other supposition it seems hard to conceive the passage from the C.P. to the transition spectrum, and the increase of brightness from that to the R one, the same chemical elements being present in the three.

In presenting the measures of these spectra, there is a difficulty arising from the impossibility of giving, within any practicable limits, the distinctive characters of the phenomena, though they are of considerable importance. For instance, the orange band γ, which in the sodium spectrum is "intensely bright," is in Pt, CO "faint, scarcely visible." To tabulate them I must restrict myself to a few distinctive symbols. First, the lines which are far transcendent in brilliancy, and are not less broad than the image of the slit, I denote by a *. This implies merely that they surpass the others greatly; one in red or violet may fully deserve this symbol, though it would seem dull beside δ or θ. Not very frequently the same line has this mark in C.P. and R, but, except with sodium and potassium, less bright; and sometimes one which is faint in C.P. is a * in R. Then follow

Very bright, bright	vb, b
Conspicuous (from surrounding faintness rather than intense brightness)	c
Faint, very faint	f, vf
Narrower than slit	n
Very narrow, like a hair	vn
Wider than slit (the exponent expressing how many times as wide)	w^n
When they are on an obscure ground	o

The symbol R implies that the pressure $=0·2$ inch unless a different one is stated.

I shall commence with aluminium, which I selected as the type because, from its small dispersion at the negative electrode, it may be assumed that its influence on the spectrum bears a small proportion to that of the gas.

TABLE I.—Aluminium.

		Air.		Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.	
		C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
1.	32° α	39′ *	......	39 *	39·5 vf.	......	......	38·7 * o.	......	38·8 f.	......
2.	α′	40·7 c.	......	40·5 nc.	......	40·9 *	......	......	......	......	......
3.		43·6 f.	......	......	......	43·4 c.	......	43·6 f.	42·8 * o.	......	......
4.	β	46·8 f.	......	46 nf.	......	47·4 f.	......	45·5 f.	......	48 f.	......
5.	β′	48·8 *	......	48·5 *	......	49·4 *	......	......	......	49·8 f.	......
6.		......	51·5 f.	......	52 f.	......	......	......	51·3 f.	......	52 f.
7.	γ	55 *	56·5 vf.	55 *	......	56·4 b.	54 f.	......	......	55·5 b.	......
8.	32	57·7 vf.	......	......	......	......	......	57·7 f.	......	......	......
9.	33	0·3 vf.	1·3 vf.	......	59·5 nf.	......	1·5 f.	59·5 f.	59·3	1·7	......
10.		2·6 c.	......	2·5 nb.	......	......	......	3 f.	......	......	2·5 f.
11.	δ	4 *	......	3 *	......	3·4 vn.	......	3·3 b.	......	3·2 *	......
12.		......	......	......	......	5·4 bn.	......	6 c.	6·8 f.	5·5 f.	6·
13.		7·3 f.	7·5 wb.	......	7 wf.	7·9 vn.	7·5 b.	8 c.	......	then 4 vn.	......
14.	ε	9·4 vb.	......	8·5 b.	......	......	......	......	......	......	......
15.	ε′	11 b. 11·4 nf.	......	10 b.	......	10·4 f.	11 f.	10·4	......	......	......
16.	ε″	12 b	12·3 bn.	12 c.	13 nb.	13·4 b.	......	12·7 f.	......	12 f.	13·5 f.
17.		14 f.	......	......	......	......	15	......	......	then 3 vn.	......
18.	ζ	16 nb. 18 nb.	17 vf.	17·5 w².	16·5 wf.	17·4 b.	18 b.	18 f.	......	18 f. two.	......
19.		20 vf.	......	20 f.	20 f.	......	......	19·7 f.	......	21 f.	......
20.		22·7 vf.	......	......	......	23·4	......	22·1 f.	......	......	......
21.	η	24·4 *	24·2 *w. 1 f. here.	24·5 *	23·5 *	24·4	24 *	24·1 c.	23·3 b.	23 b.	23·5 b.
22.		27·4 vf.	......	......	......	26·4	......	26·4 f.	......	25·2 b.	28
23.		31·8 n.vb. 32·8 vn.	31 vf.	30·5 vnb.	29 w²f.	32·4 c.	30 b.	30·8 c.	......	30·2 b.	31 f.
24.	θ	34·1 *	......	33 *	35 f.	34·4 *	......	33·4 *	......	33 *	34 f.
25.		36·8 b.	......	37 b.	37·5 c.	37·4 c.	......	35·8 b.	36·8 b.vn.	35·7 c.	......
26.		39·4 b.	39·5 vf.	38·5 b.	......	......	39 c.	......	......	......	......
27.		41·4 b.	......	41·5 vb.	41 nc.	41·4 b.	42 c.	40·6 *	40·8 * n,	41·5	43
28.		45·4 bn.	44·2 wb.	45 *	44·5 bw$^{1·5}$	45·4 f.	45 b.	......	45·8 f.	45·8 f.	......
29.		47·4 bn.	......	46 *	......	......	......	......	......	......	......
30.		49·3 f.	......	49 f.	......	48·9 f.	......	......	......	......	49
31.		......	51·5 f.	50·5 f.	50·5 cn.	......	51 b.	......	49·8 f.	......	......
32.	ι	52·6 *	53·5 vf.	53·5 f.	......	52·4 *	......	52 c.	......	52 c.	53 b.
33.		54 vnc.	......	......	......	54·4 c.	......	54 c.	......	54·8 *	......
34.	κ	56·6 *	55·5 f.	55·5 *	55 b.	56·4 *	55 b.	56 double c.	55·3 f.	56·8 f.	......
35.	33 κ′	57·6 *	......	58 *	......	58·1 f.	......	58·5 b.	......	58·2 *	59 b.
36.	34 κ″	0 *	0·7 f.	......	......	59·4 *	1 b.	0·4 f.	59·8 f.	......	......
37.		2·6 nc.	......	1·5 f.	1·5 b.	......	......	1·7 f.	......	......	......
38.	λ	4·6 nb.	......	3·5 c.	......	......	......	3·6 c.	......	3 f.	......
40.		6·2 nc.	......	5·5 f.	......	......	......	4·9 c.	......	many here n.	6 b.
41.		......	8·5 wb.	......	7·5	8·9	9 b.	7·8 c.	7·3	......	......
42.	μ	10·5 *	......	10·5 b.	......	......	......	10·1 b.	......	10 f.	......
43.	μ′	12·4 b.	......	11·5 b.	......	11·4	......	10·8 c.	12·8 f.	......	......
44.	μ″	14 b.	13·5 f.	14 f.	14 b.	13·9 b.	......	13·4 c.	......	......	13 b.
45.		15·4 f. 18 f.	......	17 n.	......	16·9 c.	16 b.	16·7 f.	......	16·5 b.	......
46.	ν	20 vb.	19·7 wc.	20 c.	20 b.	19·4 *	......	19·3 *	19·8 c.	18·8 b.	18 b.
47.		21·9 f.	......	......	......	21·4 f.	21 b.	......	......	21 c.	......
48.		26·2 f.	27·9 f.	26·5	......	25·4 b.	......	25·8	26·3 f.	25·3 b.	25 c.
49.	ξ	30·1 *	......	30 *	28 b.	29·4 f.	28 b.	29·5	......	28·2 f.	......
50.		33 f.	......	34 f.	34 nc.	34·4 *	34 b.	32·4 f.	34·3 f.	34 f.	32 f.
51.	ο	36·3 wc.	36·6 vf.	36·5 c.	......	......	......			......	......
52.		38·2 vf.		40 f.	41 f.	......	40·5 f.	......	......	38 f.	38 f.
53.		41·6 vf.	......	43 f.		42·4 f.		......	......	43 f.	......
54.		44·9 f.	......	......	......	......	......	......	......	45 f.	......
55.		48·2 f.	......	48 f.	......	48·4 f.	......	......	......	47 c.	48 f.
56.		52·1 c.	......		......		......	......	......	51 f.	55 f.
57.		57·4 vf.	......	......	......	......	......	......	......	57 f.	69 f.

The first of these, air, C.P., was taken with Duboscq, and after the telescope had been improved; when first taken it showed only twenty-five lines, of which the groups ζ and λ were seen as broad bright bands. Air R. was taken at the same time, the others, except H, C.P. (which was taken with Duboscq, and at the negative boundary) were with Merz, but with the improved telescope. As first observed, and at the centre, this last showed only eight lines.

It will be remarked that all the lines in the C.P. of nitrogen, and all but one in that of oxygen, are found in air, as might be expected; often a line is common to the three, and then that in air is of intermediate character. But the same line is also often found in the other two gases. It is generally supposed that this indicates the metallic origin of that line; but it will be found that many occur, not only in all these gases, but with all or nearly all the electrodes which I have tried. I shall return to this at another time, now making a few remarks on those before us.

The pair α, α' are of almost universal occurrence at the origin of the spectrum; α has close before it a narrow but bright companion, whose place has sometimes been taken; but outside of that there are merely shadowy traces scarcely ever bright enough to be bisected. In a very few cases, however, one of them becomes predominant, *e.g.* silver and iron. In H (hydrogen) spectra, one of this pair acquires an intense brilliancy, which is peculiar to this gas, while the other fades away. It is to be noted that α is exactly in the place of the solar line C. These and β, β' are in the red. No. 7, γ is an orange band, nearly but, I think, not exactly in the place of D. When viewed with the combination 2BS.C, it is double in all cases which I have examined; but the distance of the centres of its components is fully twice that of the components of D. No. 11, δ is yellow, generally extremely brilliant, except in one; it is seen in 2BS.C double, the second one being about half the breadth of the preceding. Before it is a narrow orange line, and before that No. 10, which *seems to attend it constantly*. Nos. 14 ε, the origin of green, 15 ε' and 16 ε'' are of constant recurrence. With the higher prism-power the first and third are each double, and some between ε' and ε'', of which one (as here in air, C.P.) has been occasionally observed. No. 18, ζ was at first observed as a bright cloudy band; 2BS.C shows that the whole of that region is covered with close lines, of which one is more conspicuous than the rest. In CO many more are conspicuous. No. 21, η is very brilliant (except in oxygen and CO, when its following companion is the brightest). With 2BS.C it is close double of two equal*. This is also the case with No. 24, ϑ, at the boundary between green and blue, which is, as a rule, the most intensely bright in all the C.P. spectra, in many of which its light is almost blinding. In R it is always faint though present. It is preceded by two narrow ones of unequal brightness, which seem to form with it a system. Another system seems to be found from 32 to $\varkappa''$ 36, remarkable for its beauty and peculiar character; $\varkappa'$ is vivid blue, close double of equals, $\varkappa''$, broad and cloudy, begins the violet. With 2BS.C $\varkappa$ is composed of two further apart, and $\varkappa''$ of six. It is less developed in nitrogen and H; λ 37·40 was at first observed as a band; in CO the whole of its vicinity is covered with narrow violet lines. The pair 28, 29, and the triplet μ, μ', μ'', are also of very constant occurrence.

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* It has the deviation of b, and is double like it. No. 27 has that of F.

TABLE II.—Platinum.

		Air.		Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.		Mercury vapour.	Phosphorus.	Bisulph. carbon.
		C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.			
1.	3$\overset{\circ}{2}$	38·3 onc.	......	......	......	36·8 f.	......	37·5 * o.	......	37 fo.	......	......	......	Pressure. 0$^{\text{in}}$·45
2.	α α′	39·7 vb. 41·4 c.	....	39·5 * 41 vn.	......	40·8 f.	......	......	......	......	......	......	......	......
3.		42·4 f.	......	......	......	44·3 f.	......	......	......	......	......	......	......	......
4.	β	47·1 f.	......	48 f.	......	47·8 *	......	......	......	46 n.	......	......	......	......
5.	β′	48·9 vb.	......	......	......	48·8 nb.	......	......	......	......	......	49·4 f.	......	......
6.		50·2 f.	51·4 vf.	......	......	......	......	......	......	......	50·5 vf.	51·4 b.	50·1 f.	......
7.		52·8 f.	......	......	52 f.	......	52·8 b.	......	......	......	......	......	......	51·7 f.
8.	γ	55·2 *	......	55 *	55·5 f.	......	55·8 nf.	......	54 vf.	......	55·5 nf.	55·5 f.	......	......
9.		56·4 nf.	56·7 vf.	......	......	......	......	......	......	56 vn.	......	......	......	56·7 f.
10.	32	57·7 nf. 59·4 nf.	......	......	58 f.	......	58·8 nf.	......	......	57 f.	59·5 vf.	......	......	......
11.	33	0·7 n. 1·4 n.	......	......	......	......	......	......	......	......	......	0 *	0 f.	59·6 *
12.		2·7 nb.	2·3 nf.	2·2 n.	2·5 f.	......	......	......	......	3 b.	......	......	......	3·3
13.	δ	3·9 *	......	3 *	......	......	3·8 f.	3 f.	......	4 b.	3·5 vf,	3·4 c.	......	4 f.
14.		6·7 vf.	......	......	6 c.	......	6·8 b.	......	......	5·5 vn.	7 f.	6·7 *	......	6·7 *
15.	ε	9 vb.	......	9·6 vb.	......	......	......	......	......	many close and narrow here till	......	......	......	8 f.
16.	ε′	10·2 b.	10 f.	10 b.	......	......	......	......	......		......	......	......	8·7 f.
17.		11·1 bn. 11·8 vn.	very faint group here.	... ...	......	......	......	......	......		......	......	......	....
18.	ε″	12·4 b.		12 b. two f. here	12 vf.	12·3 wb.	......	......	......	......	......	11·7 *	11·4 *	12 *
19.		14·4 vf.	15·4 f.	......	15 vf.	14·8 cn.	15·3 w^{2}f.	......	......	......	15 w^{4}f.	14·7 f.	......	......
20.	ζ	16·4 vn. 17·4 vn. 18·8 b.	17·7 vf.	17 b.	......	16·8 b.	......	......	......	......	......	16·8 f.	19·7 c.	16 7 f.
21.		......	21·7 vf.	20·5 f.	20 f.	......	19·8 f.	......	......	21 vn.	19 vf.	20·7	20·1 f.	20·7 b.
22.		24·4 *	......	24 *	24 *	23·8 fn.	24·3 b.	23 vf.	22 vf.	23 vnc.	23 b.	24·1 *	24·1 f.	24·1 b.
23.		27·8 n.	26·1 vf.	......	......	......	......	......	......	11 or 12 here.	25 vf.	25·7 f.	......	......
24.		31·6 nb.	30·1 f.	30·3 nb.	29 f.	......	29·3 f.	......	......	30 vnc.	28 f.	30·1 f.	......	28·7 f.
25.		32·8 vn.	31·4 f.	32·3 *	33 vf.	32·3 f.	......	32·5 c.	......	32·5 *	......	......	......	31·8 f.
26.	θ	34 *	......	......	......	......	......	......	......	35 f.	35 vf.	34 f.	......	34·1 f.
27.		37·2 c.	35·8 nf.	37 wb.	......	36·8 bn.	......	......	36·5	......	......	36·1 f.	......	......
28.		39·5 c.	38·1 c.	......	38·5 f.	39·3 bn.	......	39·5 * w.	39·5 *?	......	......	37·5	38·1 c.	38·1 c.
29.		41·5 cw.	41 vf. rn.	40·7 *w^3.	......	41·8 b	40·8 nb.	......	......	40 w^{2}b.	38·5 f.	40·1 f.	42·1 f.	41·4 f.
30.		45·1 b.	44·7 b.	45 b.	45 *	......	43·8 b.	......	......	44 vn.	43 c.	44 *	44·1 f.	44·1 *
31.		46·6 b.	......	46 b.	......	......	......	......	......	45 f.	......	......	46·4 f.	......
32.		49·4 f.	48 vn. f.	50 c.	50 f.	......	......	......	...	48 vnf. 50 *	......	......	......	49
33.		51·9 vb. double.	51 f.	51 c.	......	51·8 *	52·3 vf.	......	......	51 f.	51·5 vf.	......	......	three f. here.
34.		53·8 nc.	......	53 c.	......	53·8 nc.	......	......	......	53 *	......	......	......	......
35.		56·1 *	55·3 c. double.	55 *	55 f.	55·8 *	......	......	......	56 f.	......	......	55 f.	55 b.
36.		57·1 *	......	56 *	......	......	......	56·5 nb.	......	57 *	......	......	......	......
37.	33	59·1 *	......	58 *	......	58·8 *	......	......	......	......	......	58·8 f.	57·6 c.	......
38.	33	......	1·1 cw.	......	0 f.	......	0·8 f.	......	......	0 f.	1 vf.	1 f.	......	......
39.		2·3 b.	......	2 b.?	......	......	......	......	......	2 f.	......	......	......	......
40.	λ	4·1 b.	......	3 b.?	......	......	......	......	......	4·5 f.	......	......	......	......
41.		5·6 b.	......	5 f.	5·5 f.	......	5·8 b.	......	......	5 f.	6 b.	......	......	......
42.		......	7·8 cw.	......	8 f.	8·8 b.	......	......	......	7 f.	......	6·5 *	6·2 f.	6·2 c.
42.	μ	10·8 *	......	11 b.	......	......	......	......	......	9 f.	......	9·1 vf.	......	......
43.	μ′	12·3 b.	......	12 b.	12 f.	12·8 b.	......	......	......	12·5 b.	......	12·4 f.	......	......
44.	μ″	13·6 b.	13·4 cw.	13·2 b.	14 f.	......	......	......	......	......	......	......	......	......
45.		15·4 f.	......	......	... ...	16·3 f.	14·8 b.	......	......	......	......	......	......	......
46.		17·7 c.	......	16·8 b. double.	16·5 f.	... ...	......	......	......	18 c.	17·7 w^5. seems triple.	16 vnc.	......	......
47.		19·3 b.	19·9 cw.	20 c.	20 b.	18·8 f.	18·8 f.	20 * w.	19·5 f.	19·5 f.	......	18·6 *	18·6 *	18·3 *
48.		22 n.	......	22·2 f.	......	21·8 f.	22·8 f.			......	......	......		23·2 c.
49.		25·9 n.	27·2 cw.	26 c.	27·5 c.	25·8	some f. seen here.	......	......	25 *	25 f.	......	......	24·5 f.
50.		30 vb.	30·1 vnf.	30 *	......	......	......	......	......	28 f.	......	30·1 f.	......	......
51.		33·3 n.	......	33 f.	34 f.	......	......	......	......	33 f.	33 f.	......	......	......
52.		35·1 vf.	35 nvf.	......	......	34·8 c.	......	......	......	34 f.	......	......	......	35 f.
53.		36·2 c.	......	36 f.	......	......	......	......	......	36 f.	......	......	......	......
54.		39·1 nc.	......	39 f.	......	......	......	......	......	38 f.	......	......	......	......
55.		41·7 nc.	......	......	42 vf.	......	41·8 f.	......	......	41 f.	41·5 f.	42·8 vf.	......	......
56.		45 nc.	......	45 f.		......		......	......	44 f.	......	......	......	......
57.		48·3 f.	49·5 vf.	48 f.	......	......	......	......	......	47 f.	48·5	46·9 fv.	......	46·7 f.
58.		51·5 f.		52·2 c.	......	......	......	......	......	50·5 f.	49·2 f.	50·9 fv.	......	50·8 f.
59.		58·2 vf.	......	56 f.	......	58·8 f.	......	......	......	56 f.			......	

In the air C.P. and R. were observed with Duboscq and are therefore comparable with the aluminium air spectra. So also were those of Hg, P, and S^2C. In the mercurial vapour the discharge was bright, greenish white, with very large cloudy strata; the spark discharge without the jar gave exactly the same spectrum. It has more *s than oxygen or carb. oxide; but the rest of it is very dark. In the phosphorus and bisulphuret the tubes were so darkened by deposit as to make observation difficult; the first was red, I suppose allotropic P, for nothing would remove it but strong nitric acid; the other is partly black (I suppose sulphuret of Hg), partly grey arranged in striæ (perhaps carbon). The P spectrum is so like that of Hg vapour, that I think it exerted very little influence, and in the other the metallic vapour seems also to predominate. I also tried olive oil in the same apparatus to ascertain whether its vapour (which may be present in air-pump experiments) could produce any effect. The flash of the discharge was bright green, as in the CO and S^2C tubes; but this probably came from the decomposition of a film of oil on the electrodes: the spectrum was identical with Hg vapour, except that it was very faint.

Table III.—Silver.

		Air.				Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.	
		Spark C.P.	J. C.P.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
1.	32°	37·4 vf.	36·5 * double.	......	......	......	36·5 o. double.	......	......	37 *	......	......	......
2.	α	......	......	38·8 * double.	......	......	......	38·5 *	......	......	......	......	......
3.	α′	......	40 b.	40·8 *	41 o.	40 *	......	41 f.	39·5 o.	......	......	40·5 *	......
4.		......	42·5 f.	......	......	41·5 f.	......	......	......	......	......	......	......
5.	β	......	46 f.	......	......	......	......	45·5 f.	......	......	......	......	......
6.	β′	......	49 b.	47·8 b.	......	49 f.	......	48 *	......	......	......	49·5 b.	......
7.		51·4 b.	......	......	51·5 f.	......	51·5	......	51 f.	......	50·5 f.	51·5 c.	52 *w$^{1\cdot5}$
8.	γ	......	56 *	55·8 *	......	55 *	56 f.	55 c.	......	......	......	56·5 f.	56 f.
9.	32	......	58 *	......	59 f.	......	59 f.	......	......	......	58·5 f.	57·5 *	......
10	33	......	......	......	......	......	......	......	......	......	......	0·5 f.	0 f.
11.		4·3 *	4 c.	3·8 c.	......	3 c.	3·5 f.	3 c.	3 f.	3 f.	......	......	......
12.	δ	......	5 *	4·8 *	......	4 *	......	......	......	......	......	5·5 b.	4 f.
13.		6·7 vf.	6 f.	......	6·5 *	......	......	......	6·5 *	......	7	7 f.	7 *
14.	ε	8·7 b.	9 b.	8·8 b.	......	......	8	8 f.	......	......	......	three	......
15.	ε′	......	11 c.	10·8 b.	......	10 b.	......	......	......	......	11 b.	9·5 f.	......
16.	ε″	not taken.	12 *	11·3 b.	......	12 b.	......	12·5 c. close pair	......	......	......	three	......
17.		......	14 b.	13·8 c.	14 b.	13 b.	13 c.	......	13 f.	......	......	14·5 f.	......
18.	ζ	......	18 f.	17·8 b.	......	15·5 c. 17·5 c.	17 b.	17 *	18·5 f.	......	......	three	16 f.
19.		20·7 b.	......	......	......	19 c.	......	......	......	......	......	19·5 f.	......
20.		......	22 b.	22·8 c.	......	23 vnc.	21 f.	22	......	......	22·5	21·5 c.	21·5 f.
21.	η	......	24	24·8 *	23·5 *	24 *	......	24·5	24 *	23 f.	23·5	24·5 c.	......
22.		......	......	......	......	......	25 *	26	......	......	......	26 *	25 *
23.		30·8 nb.	29	30·8 c.	29·5 f.	32 nc.	30	30 f.	29 b.	31·5 f.	......	30	30 f.
24.	θ	33·5 *	33·5 *	33·8 *	......	34·5 *	35 f.	33·5 b.	32 b. 34 b.	......	......	32·4 b. 34·5 b.	35 f.
25.		37 f.	35 c. 37 c.	36·8 f.	......	38 b.	39 b.	37 b.	38 b.	......	......	37·5 f.	36 f.
26.		41·4	41	40·8 f.	41 c.	40·5 f.	41·5 f.	41 *	40 b.	39 *	40 *	......	40 f.
27.		......	......	44·8 b.	42·5 *	43 b.	44·5 f.	......	44 b.	......	42 f.	42·5 b.	44 f.
28.		46 b.	47 c.	46·8 b.	......	46 b.	......	46 f.	......	......	......	......	......
29.		......	......	......	......	47·5 b.	......	......	......	......	......	48 c.	......
30.		50·7 b.	49 * double.	50·8 c.	51	50 f.	51	50 *	50 b.	......	......	50·5	......
31.	ι	......	......	......	......	52 b.	......	52·5 f.	......	52·5 c.	52 f.	52·5 *	53 f.
32.		......	54 b.	......	......	54·5 b.	55	55 *	53·5 b.	......	......	54·5 c.	......

TABLE III. (continued).

		Air.				Nitrogen,		Oxygen.		Hydrogen.		Carb. oxide.	
		Spark C.P.	J. C.P.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
33.	°κ	55·3 b. double.	......	55·8 * double.	......	56 *	......	narrow one here.	......	......	......	55 5 * double.	......
34.	κ′	......	58 *	......	......	57 *	......	......	......	......	......	57 vn.	......
35.	33κ″	58·5 b.	......	59 *	......	59 *	......	58 *	0 b.	......	......	0 *	59
36.	34	1·1 vf.	......	......	......	......	1·5	2 b.	......	......	......	......	......
37.	λ	4·2 vf.	......	3·3 b.	......	3 b.	......	......	......	......	......	......	3 f.
38.		......	......	......	6	5 *	7·5	......	6	......	5 f.	......	......
39.		9·8 b.	8 b.	......	......	......	......	......	......	......		8 f. others	7 *
40.	μ	10·8 f.	9 b.	10·8 *	......	10·5 b.	......	9·5 f.	......	......	......	10·5 f.	......
41.	μ′	12·1 f.	11 b.	11·8 b.	......	12 b.	......	11·5 f.	......	......	......	......	......
42.	μ″	14·4 f.	14 f.	14 b.	14·5 f.	......	14·5	13·5 f.	13 b.	......	......	13·5 b.	......
43.		......	16 c.	17·8 b.	......	17 f.	......	16 c.	......	15·5 *	......	18·5 c.	17 f.
44.	ν	20 f.	19 f.	19·8 f.	......	19·5 c.	20·5	19 b.	19 b.		......	20·5 c.	
45.		some seen.	22 f.	......	22 f.	......	......	22 f.	......	......	......	23 c.	......
46.		......	25 b.	24·8 f.	......	26 f.	......	25 f.	25·5 b.	......	......	......	......
47.		29·1 f.	29 f.	27·8 b.	......	......	28 f.	......	......	......	......	27·5 *	......
48.	ξ	......	31 f.	......	......	30 b.	......	29·5 *	......	......	......	......	......
49.		......	......	33·3 f.	33·5 f.	33 f.	......	......	......	......	......	......	......
50.	34	36 vf.	......			37 c.	35 vf.	35 f.	......	......	......	36 c.	......
51.			41 f.	......	......		41 vf.		39·5	......	......	39·5 vf.	......
52.		......	......	......	......	......		......	......	......	......	43·5 vf.	......
53.		......	46·5 f.	......	......	......	......	......	......	......	......	48·5 vf.	......

These C.P. spectra are of very great splendour; the ground, especially the green part, is far brighter than the preceding, and the lines are dazzling. The R ones are on the whole faint. The first is a simple spark (without jar): it differs little except in brightness. The second, headed J, was obtained with two large jars having 8·5 feet of external coating; it was far more luminous, and showed eight more lines than the normal one, besides four at the violet end, which were measured, but not tabulated, as they were not seen in the other spectra. I was struck with the outline of this spectrum, which gives an idea that the red and violet rays are less abundant near the electrodes. [See p. 973.]

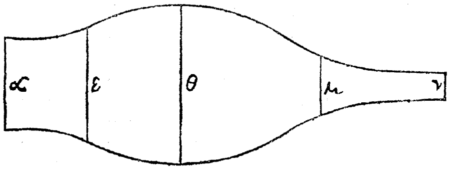

TABLE IV.—Copper.

		Air.		Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.	
		C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
1.	32°	37·1 nc.	......	36·5 *	......	......	......	......	......	......	......
2.	α	38·2 *	......	38·5 b.	......	38·3 b.	......	......	......	38·3 *	......
3.	α′	39·6 vb.	......	40·5 f.	......	41·3 f.	......	40 * o.	39·8 o.b.	......	......
4.		......	......	43·5 f.	......	......	......	......	......	......	......
5.	β	47·8 *	......	46 b.	......	48·3	......	......	......	47·8 f.	......
6.	β′	......	50 f.	......	49·5 f.	50·3 f.	50·3 f.	......	50·4 f.	49·5 *	51·5 c.
7.	γ	54·2 *	......	53 *	53·5 f.	54·8 vf.	......	......	......	55·5 c.	54·5 f.
8.		......	......	......	57·5 c.	......	......	......	......	56 *	......
9.	32	59 f. many here.	58·5 f.	59·5 c.	60·5 f.	......	......	......	59 c.	58·5 f.	58·5 f.
10.	33	1·5 f.	2 f.	1 *	......	......	1·8 f.	......	......	0·8 f. 2·6 f.	2·5 f.
11.		4·1 *	......	......	......	3·3 c.	......	......	3·5 c.	3·9 f.	......
12.		......	6 b.	6·5 b.	5 b.	......	6·8	......	7 b.	5·8	5·5 *
13.	ε	8·4 *	......	8·5 c.	......	8·3 f.	......	......	......	about 30 n here.	7·5 *

TABLE IV. (continued).

		Air.		Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.	
		C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
14.	°ε′	9·8 vb.	......	two.	......	......	......	......	......	......	......
15.	ε′′	11 vb. many.	11 c.	10·5 c.	10·5 c.	12·3 b.	......	......	12 f.	......	11 c.
16.		......	......	14·2 f.	14·5 f.	14·3 f.	14·8 f.	......	14·5 bw.	......	......
17.		......	......	......	......	16·3	......	......	......	......	15·5
18.	ζ	18·5 b.	......	......	19 f.	20·8	19·8 f.	......	20 c.	19·8 b.	19·5 f.
19.		21·7 vb.	23	22 *	......	......	22·8 b.	......	......	22·3 b.	23·5 f.
20.	η	24·3 *	23·5	......	24·5 *	23·3	......	......	24·6 b.	......	24·5 f.
21.		25 c.	......	25·5 f.	25·5 f.	25·3	......	......	......	26 *	......
22.		27 c.	......	28·5 c.	27 f.	......	28·8 f.	......	28·5 vnf.	26·5 c.	28·5 f.
23.		30·5 c.	......	30·5 *	31·5 f.	......	......	......	......	30·1 c.	......
24.	θ	32·9 *	......	......	......	32·8 b.	......	33·5 f.	32·8 f.	33·3 c.	33·5 f.
25.		35·5 b.	......	35·5 f.	......	... ...	......	......	......	35·8 b.	......
26.		36·8 b.	......	......	36 f.	36·3 b.	......	......	37·4 vf.	......	......
27.		38·1 b.	......	38·5 b.	......	... ...	......	......	......	......	38·5 f.
28.		40	......	42·5 b.	41·5	41·3 b.	39·8 c.	41·5 *	......	41 b.	......
29.		44 b.	43·5 b.	43·5 b.	......	......	43·8 c.	......	43·6 b.	......	43 * 44 f.
30.		46 b.	......	48·5 f.	47·5 f.	......	......	......	......	46·3 f. 48·9 f.	....
31.		51 b.	......	50·5 f.	51·5 f.	50·3 *	......	......	51·9 f.	50·3 *	......
32.	ι	......	......	52·5 c.	......	51·3 c.	......	......	......	52·3 c.	52 f.
33.		......	53 f.	53·5 *	......	53·8 *	......	......	......	... ...	......
34.	κ	55·4 *	......	55·5 *	......	......	......	55·5 vf.	......	54·5 *	......
35.	κ′	56·6 *	......	......	......	......	......	......	......	56·8 f.	......
36.	33κ′′	58·5 w*	......	59·5 c.	58 f.	57·3 *	......	......	59·8 f.	58·9 *	59·5 f.
37.	34	......	......	1·5 c. 2·5 f.	......	......	......	......	......	0·7 f. about 20 here.	......
38.	λ	3·5 b.	......	......	......	3·3 f.	4·8 f.	......	......		5·5 b.
39.		......	6·5 b.	8·5 *	6·5	8·3 f.	......	......	6·9 b.	8·5 f.	......
40.	μ	10·1 *	......	10·5 b.	10·5 f.	......	......	......	......	10·9	......
41.	μ′	11 b.	......	12·5 f.	12·5 f.	11·8 *	......	......	......	.. ...	......
42.	μ′′	13·4 vb.	......	14·5 f.	15·5 f.	15·3 f.	......	......	......	13·8 f.	14·5 f. about 20
43.		16·7 c.	17	16·5 f.	17·5 f.	17·3 f.	17·8	......	16·8 f.	16·3 f.	...... f.
44.		18·7 vb. two on each side.	some beyond.	......	......	19·3 f.		18·8 *w.	......	18·5 f.	18 f.
45.	ν	......	......	20 f.	......	......	......	......	......	20·5 f.	......
46.		22·6 w*	......	24·5 f.	24·5 b.	24·3 f.	......	......	22·3 b.	......	......
47.		25·8	......	......	25·5 b.	double.	......	......	......	25·5 *	......
48.	ξ	29 b.	......	27·5 *	......	......	......	......	......	......	......
49.		many here.	......	31·5 c.	31 f.	32·3 o.	......	......	......	32·5 c.	......
50.	ο	36 f.	......	34·5 c.	......	35·3 f.	......	......	......	37·5 f.	......
51.		......	......	......	40 f.	38·8 f.	......	......	38·8 vf.	37·5	......
52.		......	......	43 c.	......	41·3 f.	......	......		41·5 f.	42·5
53.		47·5 vf.	......	50·3 c.	46 vf.	45·8	......	45·3 vf.	......	45 f. 47·5 c.	......

In these the most remarkable thing is the comparative dullness of the red and yellow. In O, C.P., there seems no yellow, but the green ground is so intense that the lines there are scarcely visible. In O, R., the flash is green; in CO, C.P., is the same dullness of the red, but the faint ultra violet are visible in great numbers. In this also there are countless fine lines in the blue, and still more in the green.

TABLE V.—Nickel.

		Air.		Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.	
		C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
1.	32°	′	......	......	33·9 vf.	......	......	......	......	......	......
2.	α	39 *	......	38·4 *	......	38·5 *	38 vnfo.	39·7 *	......	38·5	......
3.	α′	40·6 nb.	......	40	......	......	......	......	......	......	......
4.		43 c.	......	43·6 f.	......	42 vf.	42 fo.	......	......	41·5 vf.	......
5.	β	46 f.	......	45·5 f.	......	45·5 vf.	46·5 fo.	......	......	46 vf.	......
6.	β′	49 *	......	48·1 *	......	48 *	......	......	......	48·5 *	48 ovf.
7.		......	......	......	50·4 vf.	49·5 nf.	51 f.	......	50·7 f.	50·5 vb.	......
					51·4 vf.						
8.		......	52·2 f.	52·7 vf.	52·7 vf.	......	......	......	......	......	52
9.	γ	55 *	......	55 *	54·3 vf.	55·5 f.	54 vf.	......	......	......	......
10.		56·5 nb.	......	......	56 vf.	......	......	......	......	56·5 *	57 f.
11.	32	......	60·2 vf.	......	58·3 vf.	59 vf.	59 f.	......	59·7 vf.	58· 8f.	60 f.
					59·3 vf.						
12.	33	2 nb.	......	2 nb.	1·3 vf.	3 bw^3.	2·5 f.	......	......	3 b.	......
13.	δ	4 *	......	4 *	......	......	5·5 *	3·7 n.	......	4·5 b.	5 f.
14.		6 f.	......	......	6 f.	6 cw.	6·5 n.	......	......	6·5 b.	......
15.	ε	8 b.	7·2 c.	8·7 vb.	7·3 f.	......	......	......	7·7 f.	8·5 b.	8 *
		9 n.									
16.		9·5 n.	......	......	9·7 f.	......	......	......	......	...... b.	9 n.
17.	ε′	10·5 nb.	......	10 b.	11 c.	10·5 c.	10 vf.	......	......	10·5 b.	......
18.	ε″	......	......	12 b.	12·7 f.	......	......	......	......	12·5 b.	12 vf.
19.		......	14·2 triple.	......	14·7 f.	15·5 c.	14 wf.	......	14·2 wf.	14·5 b.	......
					15·4 f.						
20.	ζ	16·2 bw^3.	......	17·2 bw^4.	17·4 f.	......	......	......	......	17·5 b.	17 w^4.
21.		19 bw.	......	......	18·7 nc.	19 c.	19 wf.	......	......	20·5 b.	21 f.
										both double.	
22.		23 *	......	......	......	21·5 *	23 *	......	......	22·5 b.	......
23.	η	25 vn.b.	24·7 c.	24·7 *	24·7 b.	25 *	......	......	......	......	......
24.		26 vn.b.	......	......	......	26 n.	......	......	......	......	......
25.		28 vn.b.	......	27·7 vf.	......	29 f.	28 vf.	......	29·2 n.	29·5 f.	......
26.		30 vn.b.	30·2 nb.	31·4 nb.	30·4 b.	......	31·5 vf.	......	......	31·5 vf.	31 w^{2}f.
27.	θ	32·5 *	......	32·1 nf.	32·8 b.	32 f.	......	32·2 n.	......	32 f.	......
28.		35 nb.	34·7 n.	33·4 *	36·1 b.	36 nb.	34 nf.	......	......	36·5	35 vf.
				36·4 f.		37 vn.					
29.		38 f.	39·2 n.	39·4 f.	39·4 b.	38·5	......	......	39·2 nb.	......	39 vf.
30.		40 w^2	......	......	......	40 b.	40 nb.	40·7 *w^4.	......	......	41 vf.
31.		......	......	41·7 b.	42·1 nf.	......	42 *	......	42·2	41·5 w^2.	42·5 *
32.		44 b.	......	45·4 b.	......	......	......	......	......	......	44·5 b.
33.		45 b.	45·2 b.	46·7 b.	45·4 b.	46 vf.	46 f.	......	......	46 n.	......
34.		48 f.	......	48·7 f.	......	48 n.	......	......	48·2 wc.	......	......
35.		50 b.	50·7 w.	50·7 vf.	50·7 b.	50 *	50 b.	......	......	49·5 nc.	49 vf.
36.	ι	......	......	52 vf.	......	53 nc.	......	......	52·2 wc.	51·5 *	......
37.	κ	54·5 *	......	54 nf.	54·7 b.	54·5 *	54 wb.	......	......	......	53·5 f.
38.	κ′	55·5 *	55·2 w.	56 *	55·9 b.	56·5 n.	......	55·2 nb.	......	56 * double.	......
39.	κ″	57 *w.	......	57 *	......	58 *	......	......	......	58 n.	......
40.	33	......	......	59 *	......	......	......	......	59·2 wc.	59·5 *	......
41.	34	1 b.	......	2·3 b.	1·7 b.	......	0·5 b.	......	......	......	......
42.	λ	3 c.	2·2	4·2 b.	......	......	5 b.	......	......	......	......
43.		4 c.	......	5·9 b.	......	......	6 b.	......	5·7 wc.	......	6·5 *
44.		8 f.	7·7 w.	8·2 f.	8·2 b.	7·5 nb.	......	......	......	......	......
45.	μ	10·5 b.	......	......	......	9·5 nb.	......	......	......	9 b.	......
46.	μ′	12 b.	......	11·1 *	......	12 *	......	......	12·7 wc.	11 b.	......
47.	μ″	13 b.	14·7 n.	14·7 f.	14·1 b.	16 c.	15 b.	......	......	13 *	......
48.		17 f.	......	17 f.	18·3 nb.	17·5 *	18 vb.	17·4 w^{9}f.	......	17 b.	17 b.
49.		19 nb.	......	19·3 f.	20 nb.	20 c.	21·5 nc.		18·7 wc.	19 vb.	......
50.	ν	22·7 f.	21·7 w.	22·6 vf.	......	23 vf.	......	.. ...	......	22 b.	22·5 vf.
51.		25 f.	......	25·5 vf.	......	25·5 *	25 b.	......	24·2 wc.	......	
52.		28·5 b.w^2.	......	27·5 vf.	27·2 b.	......	......	......	......	28 *	......
53.	ξ	......	29·7 w.	29·8 nb.	......	......	29 f.	......	......	......	......
54.		32·5 f.w^3.	......	33·7 b.	34·1 b.	33 b.	33 nf.	......	31·2 vf.	31·5 vf.	......
55.	ο	......	36·2 n.	36·3 b.	......	38 f.	......	......		36 b.	......
56.		42·5 f.		40·3 vf.	40·3 vf.	41 n.	40 nf.	......	......	42·5 c.	......
57.		......	......	44·9 c.	44·9 vf.	43·5 c.	......	......	......	45 c.	......
58.		47·5 f.	......	47·9	49·5 f.	47 b.	47 f.	......	......	49 vf.	......
59.		51·5 vf.	......	52·1 c.				......	......		......

Of these the spectra N were taken with Duboscq.

The group 23–26, in air, C.P., is notable. In N, R., the remarkable set 7–12 were first recognized; they are very faint, as broad as the slit, and spread over the orange and yellow. The groups 14–16 and 18–20 are peculiar. In O, C.P., there is scarcely any yellow, and the lines from seven to twenty-eight are very indistinct, from the brightness of the ground.

TABLE VI.—Palladium.

		Air.		Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.	
		C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
1.	$3\overset{\circ}{2}$ α	39* double	......	38·4 *	......	......	......	......	38·8 of.	......	......
2.	α'	......	......	39·7 b.	......	40·3 of.	......	39·5 o*	......	39·7 * very intense	39·5 ovf.
3.		41·8 vn.	......	41·6 f.	......	......	......	......	......	......	......
4.	β	......	......	45·2 f.	......	......	......	......	......	......	......
5.	β'	48·5 b.	......	47·5 *	......	48·3 f.	......	......	......	49·5 b.	48·5 ovf.
6.		......	50·3 vf.	......	51·4 f.	......	51·9 vf.	......	51·8 f.	51·5 b.	......
7.		......	......	54 *	53·7 f.	......	......	......	......	......	......
8.	32 γ	56·3 *	......	57·3 f.	56 f.	55·8 nb.	......	......	......	57 *	56 f.
9.	33	......	0·3 f.	59·6 f.	58 f.	......	0·4 vf.	......	58·8 f.	0 n.	1 f.
10.		3·3 nc.	......	1·6 b.	0 f.	......	......	3 nf. double	2·8 vf.	......	......
11.	δ	4·3 *	......	3 *	......	4·3 nb.	......	......	......	4 b.	......
12.		......	......	5·3 f.	......	......	......	6·5 nf.	......	6 b.	5 f.
13.		......	......	8·3 b.	7·3 b.	......	7·9 f.	......	7 c.	7·5 f.	8 b.
14.		9·3 vb.	......	10 b.	......	9·8 c.	......	9·5 nc.	......	10 f.	9
15.	ε'	10·8 b.	......	10·7 f.	......	... ...	......	......	......	not distinct f.	......
16.	ε''	12·3 b.	......	11·4 b.	11·7 f.	11·3 c.	......	......	......	...... f.	12 vf.
17.		......	13·3 c.	14 f.	......	13·8 c.	15·1 w^4.	15·6 vn.	13·8 f.	13 f.	......
18.	ζ	17·3 wb.	17 w^6.	16·7 b.	17 f.	17·3	......	18·5 nb.	17·8 vf.	16 f. 18 f.	16 wf.
19.		......	......	21·4 f.	......	......	......	21·5 fw.	......	19 f. 21 f.	21 n.
20.	η	24·8 *	......	24·1 *	24·7 b.	24·8 c.	25·4 b.	25·5 nc.	23 b.	24 c.	25 *
21.		......	27·3 wc.	27·4	......	......	......	28 nc.	28 nc.	26 * double	27 f.
22.		......	......	30·8 b.	30·4 b.	......	30·4 nc.	......	......	31 f.	......
23.		31·7 nvb.	......	31·4 b.	... b.	......	......	......	......	......	......
24.		......	......	32·8 *	32·8 b.	32·3 vnb.	......	......	......	......	......
25.	θ	33·8 *	33·3 f.	......	......	34·3 *	......	33·5 nb.	33 vf.	34 vf.	34·5 vf.
26.		36·8 f.	......	36·4	36·1	37·3 nvb.	38·4 nf.	......	37·5 nc.	37 c. many	......
27.		......	......	38·8	39·4 b.	......	......	......	......	39·5 nf.	40 vf.
28.		41·3 b.	41·3 f.	40·7	41·4 f.	41·8 w^3.	41·9 f.	41·2 *w^2.	41 b. 43 b.	42 *	......
29.		45·3 b.	......	44·7 b.	43·4 b.	......	......	......	45 b.	......	44·5 *
30.		46·3 b.	......	46 b.	45·4 b.	46·3 f. centreof3	......	......	......	......	...
31.		......	47·3 wc.	48·7 f.	......	......	......	......	......	47·5	47 *
32.		......	......	50 f.	......	......	50·4c.	......	50·2 nc.	50 nc.	50·5 vf.
33.	ι	51·3 b.	......	52 b.	51·3	51·8 nc.	......	......	......	52 *	......
34.		......	54·3	54 b.	......	......	54·4 c.	......	......	54 nb.	54 vf.
35.	κ	56·3 *	......	55·3 *	55·3	55·8 *	......	......	......	55·5 *	......
36.	κ'	double	......	56·3 *	56·3	56·3 *	......	......	56 w.	... ...	......
37.		......	......	57·2 f.	......	......	......	57·5 nf.	......	58 n.	......
38.	33κ''	58·3 *	58·3	58·5 *	......	59·3 *	......	......	......	59·5 *	......
39.	34	2·3 n.	......	1·7 b.	2·3 b.	2·8 vnc.	1·4 c.	......	......	many here very sharp	......
40.	λ	3·3 n.	......	3·6 b.	......	......	......	......	......	......	......
41.		4·3 n.	5·3	4·9 b.	......	4·3 nb.	......	4·5 nf.	......	......	4 f.
42.		......	......	7·2	8·8 b.	......	7·4 c.	......	8 w.	......	7 *
43.	μ	9·8 b.	......	10·1 *	......	10·3 c.	......	......	......	10 b.	......
44.	μ'	11·8 b.	10·8	11·4 *	......	11·8 c.	......	12·5	......	11·5 b.	......
45.	μ''	13·3 b.	......	13·4 f.	14·4 b.	14·3 c.	14·4 c.	......	14 w.	14 *	13 vf.
46.		16·3 c.	......	16 f.	......	......	......	......	......	15·5 vf.	......
47.		17·3 c.	17·3	......	......	17·3 nf.	......	......	......	......	......
48.		18·3 c.	......	18·6 f.	......	... ...	......	......	......	18 b.	18 f.
49.	ν	......	......	20·9 f.	20 b.	19·3 c.	19·4	20·5 *w^4.	20 w.	19 b.	19 f.
50.		......	......	23·2 f.	......	22·3 vf.	......		......	22 b.	......
51.		25·3 nf.	......	25·8 f.	......	25·3 f.	......	......	......	26·5 vnf.	......
52.		29·3 *w.	......	29·1 *	28·1	......	27·4 c.	......	28	27·5 * 28·5 c.	......
53.	ξ	......	31·3	32·4 f.	......	30·3 b.	......	......	......	31 vf.	......
54.		......	......	35·7 f.	34·4 b.	......	33·4 f.	......	......	35 nc.	......
55.	ο	37·3 vf.	38·8 vf.	......	......	37·3 vf.		......	36·5 f.	38·5 c.	......
56.				39·3 f.	40·3 f.		......	......	......	......	......
57.		......	......	43·6 c.	......	......	......	......	......	42 f.	......
58.		......	......	46·2 f.	45 b.	......	......	......	43 f.	45 f.	46 vf.
59.		......	......	50·5 c.	50·2 f.	......	......	......		48 f.	
60.	34	......	......	56·8 f.	58·1 f.	......	......	......	......		......
61.		......	......		3·4 f.	......	......	......	......	......	......
62.		......	......	......	6·5	......	......	......	......	......	......

The deposit in the tube very dense. These spectra are notable for the indistinctness of the green lines, as compared with the remarkable sharpness of those in blue and violet. The number visible in the H pair also deserves notice. This metal seems to have great illuminating power.

TABLE VII.—Iron.

		Air.		Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.	
		C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
1.	32°	37·1 nf.	......	......	......	36·8 *	......	......	......	......	......
2.	α	38·4 *	......	38·4 *	......	......	......	......	......	38·4 vb.	38·7 vfo.
3.	α'	......	......	40 c.	40·3 of.	39·8 n.	......	39·7 *o.	......	39·7 vf.	......
4.		41·5 b.	......	42·3 c.	42·9 of.	......	......	......	......	42·7 vf.	43·3 vfo.
5.	β	......	......	45·5 c.	......	44·8 f.	......	......	......	44·9 vf.	......
6.	β'	48 *	......	47·5 *	47·5 of.	47·8 *	......	......	......	47·9 vb.	47·8 vfo.
7.		......	50·2 b.	50·1 f.	......	49 8 c.	49·8 f.	......	......	49·4 b.	50·7 *
8.		......	......	52·4 f.	51·1 f.	......	......	......	51·7 f.	51·4 f.	51·7 n.
9.		......	......	54·4 *	......	......	......	......	......	53·5 f.	......
10.	γ	55 *	......	57·3 vf.	55·3 c.	......	......	......	......	55·7 *	55·3 wb.
11.	32	......	59·7 f.	60·3 vf.	59·3 c.	0·8 c. many seen.	......	......	0·7 vn.	58 f.	58·6 b.
12.	33 δ	4·2 * double.	......	2 nb. 3·3 *	......	......	......	4·7	......	2·6 b. 5 b.	......
13.		......	......	......	6 *	5·8 nc.	......	......	6·2 bw.	6 b.	6 b.
14.		......	7·7	8·7 vb.	7 n	......	......	......	......	8 b.	......
15.		9·5 very many seen here.	......	10·4 b.	......	......	......	......	......	10 b.	......
16.		......	11·7	10·7 n. 11·4 b.	11·4 f.	11·8	......	......	11·7 nc.	12 b.	10·7 nb.
17.		14 vb.	......	14 f.	13·4 n.	......	......	......	......	... b.	13·7 nb.
18.		15 vb.	......	15·4 f.	15·4 n.	15·8 c.	14·8 w^2f.	......	......	14·7 b.	15·4 nb,
19.	ζ	17 vb.	16·7	18 f.	17·7 n.	......	......	......	......	16·7 b.	17·4 nb.
20.		20 vb.	19·2 f.	20 nf.	20 f.	21·8	......	......	......	20	......
21.		22·4 vb.	......	......	......	22·8 n.	22·8 c.	......	......	21·1	23·4
22.	η	24·8 *w^2.	24·7 *	24·1 *	23·7 *	25·3 n.	......	......	24·2 b.	25·4 *	24·7 *
23.		......	......	26·7 vf.	......	......	......	......	......	26·1 nb.	26·1 vf.
24.		......	......	28·7 vf.	29·4 f.	......	......	......	29·7 vf.	30·1 vb.	29·4 wb.
25.		31·5 f.	30·7 f.	30·8 b. 31·8 nvf.	32·8 vf.	32·3 vn.	......	32·7 c.	......	32·8 vb.	32·8 vf.
26.	θ	34 * double.	......	33·4 * double.	......	......	......	......	......	......	......
27.		......	......	35·5 f.	......	35·8 vb.	......	......	......	34·8 vn.	35·1 vf.
28.		36·5 c. many.	......	36·8 f.	37·5 vf. others seen.	......	......	......	36·2 vfn.	36·1 vb.	......
29.		39 c.	39·7 f.	39·4 f.	......	38·3 nf.	......	......	......	38·8 vn.	37·5 nf.
30.		40·5 c.	......	41·1 b.	40·8 nf.	40·8 b.	39·8 nc.	40·7 *w.	......	41·2 *w^5.	40·1 vf.
31.		......	44·7 b.	......	44·1 *	......	43·8 b.	......	43·7 nc.	44·1 f.	43·4 * 44·7 n.
32.		45·5 c. 46·5 c.	....	45 b. 46·7 b.	....	....	....	....	....	...... 46·7	....
33.		......	......	48·5 f.	48 vf.	......	......	......	......	......	......
34.		......	......	49·3 f.	......	......	......	......	......	49·1 nb.	49·3 nf.
35.		......	......	51·3 f.	......	50·3 *	......	......	50·7 vfw.	51·3 *	50·3 nf.
36.	ι	52·4 *	53·7 b.	53·6 f.	53·3 wb.	52·8 nc.	......	......	......	53·3 nb.	52·3 nf.
37.		55 b.	......	55·6 *	......	54·3 *	......	55·2 nc.	......	55·3 *	......
38.	κ	56·6 *	......	56·6 *	......	seen.	......	......	......	... ...	......
39.	κ'	57·3 *	......	57·2 vn.	......	57·8 *	......	......	......	57 nc.	......
40.	33κ''	59·3 *	......	58·5 *	......	......	......	......	......	58·8 *	......
41.	34	......	1·2 c.	1·7 b.	1·1 vf.	......	......	......	......	......	many.
42.	λ	4·5 c.	......	3·6 b.	......	3·8 n.	......	......	......	......	......
43.		......	......	5·2 b.	5·9 vb.	... ...	5·8 c.	......	5·7 c.	......	6·2 *
44.		......	8·7 b.	7·5 f.	......	7·3 n.	......	......	......	8·8 nb.	8·2 vf.
45.		......	......	10·1 *	......	9·8 n.	......	......	......	10·1 nb.	10·1 vf.
46.		12 * many.	......	11·4 *	......	12·8 *	......	......	......	12·7 *	12·4 vf.
47.		15·5 b.	......	14 f.	......	......	......	......	......	......	15·4 nc.
48.		16·8 *	......	16·3 f.	15·4 n.	......	16·8 wf.	......	......	16·7 b.	16·7 nc.
		......	18·7	18·6 f.	18 n.	17·3 n.		17·9 *w^7.	17·7 w.	18·6 *	18·6 nc.
	ν	20 vb.	......	20·9 f.	19·3 n.	18·8 c.	......				......
		21·9 vb.	......	... ...	......	21·8 nc.	......	......	......	21·3 b.	22·6 nc.
		23·7 vb.	......	23·9 f.	......	24·8 nb.	......	......	......	......	......
		26·5 vb.	28·2 f.	26·2 f.	26·5	27·3 nb.	......	......	......	25·8 *	......
	ξ	30·8 *w^3.	......	29·8 *	31·4 f.	......	......	......	......	......	30·4 f.
		32·5 b.	......	33·1 nc.	......	......	......	......	......	......	......
		......	34·7 f.	35·7 b.	34·4 f.	33·8 b.	......	......	......	34·4 c.	33·7 c.
	ο	37 f.		39 f.	39 f.	37·8 n.	......	......	......	37·7 c.	36 f.
		......	......	42·3 f.		40·8 f.	......	......	......	41·6 c.	42·3
		......	......	44·2 nc.	......	... ...	......	......	......	44·2 f.	......
		......	......	47·5	......	46·8 f.	......	......	......	47·3	......
		51·5	......	52·1	......		......	......	......	......	50·2
			......		......	......	......	......	......	......	

These are beautiful spectra, the red brilliant, the violet part specially so, but the yellow often feeble. In air and CO, C.P., the green has a very great number of close narrow lines. In CO, R., the bright lines are very brilliant, the others unusually faint. N and CO were taken with Duboscq.

TABLE VIII.—Cobalt.

		Air.		Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.	
		C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
1.											
2.	$\overset{\circ}{32}$ α	39 *	38·4 of.	39·1 *	34·5 ? vf.	39 *	......	38·4 *o.	38·4 ovf.	38 *	......
3.	α'	41 vn.	......	41·1 b.	......	41 nb.	......	......	......	41 vf.	......
4.		......	......	43·3 c.	......	43 c.	......	......	......	......	......
5.		45 f.	......	......	......	45 c.	......	......	......	45 vf.	......
6.	β	......	......	46·5 f.	......	......	......	......	47·5 of.	47 *	......
7.	β'	49 *	......	48·8 *	......	48·5 *	......	......	......	49 nb.	......
8.		......	......	50·7 vf.	50·7 vf.	......	......	......	......	......	......
9.		......	51·4 b.	......	... vf.	......	......	......	51·1 c.	......	51 c.
10.		......	52·4 b.	52·7 f.	52·7 vf.	......	52 vf.	......	......	......	......
11.	γ	54 *	55·7 nc.	55·3 *	55·3 vf.	......	......	......	53·7 c.	......	......
12.		......	......	......	56·7 vf.	56 f.	56 vf.	......	56·3 c.	56 *	56 f.
13.		......	......	58 vf.	58 vf.	... f.	......	58 f.	58 b.	58 nf.	... ...
14.	32	......	59·7 b.	60·6 vf.	60 vf.	59 f.	59·5 vf.	......	59·3 b.	......	59·5 f.
15.	33	3 vnb.	3 nc.	2·6 nb.	2 vf.	2 f.	......	......	2·6 fn.	2 n.	... ...
16.	δ	4·5 *	......	4 *	......	... f.	4 vf.	4 vf.	......	4 b. double.	3·5 f.
17.		......	6·7 vb.	......	6 f.	6·5 f.	......	......	6·7 b.	6 f.	6 *
18.		......	......	......	7·3 vf.	......	8 c.	......	......	8 f.	7·5 n.
19.	ε	9 b.	......	9·4 vb.	9·4 vf.	9 vf.	......	......	......	9·5 f.	......
20.		......	......	10·3 b.	......	10 *	......	......	......	... f.	......
21.	ε'	11 b.	11·4 vb.	11·4 bvn.	......	......	......	one nf.			
22.	ε''	12 b.	......	12 b.	12 vb.	......	12 nc.	11·7 nf. one nf.	11·7 b.	11 f.	11·5 bn.
23.		......	......	14·7 vf.	......	......	......	......	14·7 vf.	14 f.	14 vf.
24.		......	15·1 vf.	......	......	15 n.	16 vf.	......	......	15 f.	......
25.	ζ	17 bw².	......	17·2 w⁴.	......	17 *	......	16·7 c.	17·4 vf.	......	......
26.		20 f.	20 f.	......	20·7 f.	20 b.	20·5 vf.	19·4 f.	20 vf.	20 b.	20·5 vf.
27.		22 vn.	......	......	......	22·5 f.	......	22·4 nc.	......	22 b.	......
28.	η	24 *	23·4 *	24·7 *	25·1 wb.	24·5 f.	23·5 *	24·7 vf.	23·7 c.	25 * double vb.	......
29.		27 f.	26·1 f.	28·1 vf.	......	......	......	... ...	25·7 c.	26 nc.	26 nc.
30.		30 vnb.	29·4 f.	......	30·1 b.	30·5 w³.	29 vf.	28·7 vf.	29·4 c.	29·5 b.	......
31.	θ	32 *	32·4 c.	32·1 nb.	32·4 b.	......	......	......	......	......	......
32.		......	34·8 c.	33·4 *	... ...	......	34 vf.	......	33·1 c.	......	......
33.		36	......	36·8 f.	35·5 c.	37 *	37 vf.	......	35·5 c.	36 bn.	......
34.		40·5 nb.	38·1 c.	39·4 f.	......	39 f.	40·5 nc.	......	......	40 cw².	......
35.		42 c.	41·4 c.	42·1 bw².	41·7 b.	41 b.	......	41·4 *	41·4 b.	......	42·5 *
36.		44 b.	43·7 vb.	......	43·4 b.	......	......	......	43·4 b.	......	
37.		45·5 b.	......	46	44·7 b.	......	44 vb.	......	45·4 f.	46 n.	44·5 n.
38.		......	......	47·4	......	......	......	47·4 vf.	......	... ...	......
39.		......	......	49·3 nf.	......	49 vn.	......	......	......	48 n.	50 c.
40.	ι	51 b.	51·3 b.	......	51·3 b.	51 *	......	......	50·3 c.	50·5 *	one here
41.		53 f.	52·6 n.	52·6 c.	......	53 nc.	......	......	53·3 c.	52 nc.	53·5 c.
42.	κ	54 *	... ...	54·7 nb.	54·7 b.	... ...	......	......	......	54·5 *	......
43.	κ'	55 *	55·1 b.	......	...	55 *	......	......	......	... ...	55 vf.
44.		... ...	56·6 b.	56·3 *	55·9 b.	56·5 n.	......	56·6 vf.	56·9 b.	56·5 n.	......
45.	κ''	57 *	......	57·2 *	......	... ...	......	......	......	... ...	......
46.		......	......	58·2 n.	......	... ...	......	......	......	58 vb.	......
47.	33	60·5 c.	......	59·1 *	......	59 *	......	......	60·7 b.	......	......
48.	34 λ	2 c.	1 vf.	2·3 bn.	1 b.	......	......	......	1·7 n.	......	......
49.		4 c.	......	4·6 bn.	......	......	......	......	3·9 n.	......	3·5 vf.
50.		......	6·5 b.	6·2 bn.	......	6 nb.	6 f.	......	6·9 bw³.	5 f.	6·5 *
51.		......	7·5 f.	8·5 f.	8·2 b.	8 nb.	......	......	......	8 f.	......
52.	μ	9 b.	......	......	......	10 nb.	......	......	9·8 f.	10·5 f.	......
53.	μ'	11 b.	......	11·1 *	......	......	......	......	......	......	......
54.	μ''	12 b.	......	12·7 *	......	12·5 *	......	......	......	12 *	......
55.		......	13·4 nf.	14·7 f.	14 b.	......	......	......	13·4 f.	......	......
56.		16 f.	16·7 c.	... f.	......	16 b.	......	......	15·7 f.	16 vb.	15·5 c.
57.		18 b.	18·3 c.	17·3 f.	18·6 nb.	18 *	17 vfw⁶.	......	18·6 b.	18 vb.	17·5 c.
58.	ν	20·5 f.	20 c.	19·9 f.	20·6 nb.	21 b.		20 *w⁴.	20·3 n.	21 b.	......
59.		24 f.	23·2 nvf.	22·6 f.	......	25 c.	......	......	......	25 *	22·5 n.c.
60.		......	26·8 vb.	26·5 f.	......	26·5 c.	......	26·8 vf.	......	......	......
61.		28 *	27·8 c.	......	27·8 b.	......	......	......	27·5 f.	......	......
62.	ξ	......	30·8 f.	30·1 *	......	......	......	......	......	......	......
63.		......	32·1 f.	......	......	......	......	......	32·1 c.	......	......
64.	ο	34 fw.	34·1 c.	33·7 b.	34 b.	34 c.	......	35 vf.	33·7 c.	33 vnf.	......
65.		......	36·3 vf.	......	......	......	......	......	36·6 c.	......	......
66.		......	38·3 vf.	......	......	38·5 n.	......	......	37·7 c.	37 f.	......
67.		40 nc.	39·6vf.	41 vnf.	40·3 f.	41 n.	......	......	39·3 c. 40·6 c.	41 f.	42 vf.
68.		43·5 vf.	42·9vf.	......	......	43 n.	......	43·9 vf.	42·9 vf.	43 nf.	
69.			......	44·6 nc.	44·9 f.	......	......	......	......	47 vf.	......
70.		......	......	47·5 vn.	......	46·5 c.	......	......	......		......
		......	50·2 f.	......	50·5 f.		......	51·5 vf.	50·5 vf.	......	......
		......		54·1	......	......	......		57·4 vf.	......	......
		......	......	57·1	57·4 vf.	......	......	......		......	......
		......	......			......	......	......	......	......	......

The spectrum O, R., has very little light, and much of it is a mere shadow. In H, C.P., the lines are visible only near the negative electrode, except the ∗. Above they are lost in a grey haze. Exhausting, the ∗s and haze vanish, and the other lines stand out conspicuous. In H, R., sometimes the tube was filled with conical strata and the lines were faint; at other times it was filled with a uniform flash, and they were bright. In CO, C.P., the sets 17–24 seem to replace the multitude of close narrow lines that fill the green in this gas in most of its spectra; they are as wide as the slit. The two of CO, the C.P. of air and H, and the R. of O were observed with Merz, the others with Duboscq.

TABLE IX.—Lead.

		Air.		Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.	
		C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
1.	32°	36·5 b.	......	......	......	......	......	......	......	......	......
2.	α	38·5 b.	37·8 of.	39 ∗	......	38·3 ∗	......	39 ∗o.	......	37·5 ∗	......
3.	β'	48 f.	49·1 vf.	48 vf.	......	48·8 ∗	......	......	......	47·5 b.	......
4.		......	......	......	......	......	......	......	......	49·5 b.	49 fo.
5.		......	51 b.	......	51 f.	......	50·8 vf.	51·4 f.	51 f.	51·5 f.	52 b.
6.	γ	55 ∗	......	55 ∗	......	......	......	......	......	54 f. 54·5 vn.	....
7.		57 c.	......	......	......	......	57·8 vf.	57·7 c.	......	56 vbn.	56 f.
8.	32	......	58·5 fn.	......	59 f.	......	......	60 f.	59·5 n.	59·5 vf.	0 f.
9.	33	......	0·6 vf.	......	......	......	......	1 f.	......	......	... ...
10.		......	......	2 nc.	2·5 nf.	......	2·3 nf.	......	......	2·5 bw^2.	... ...
11.	δ	4 ∗	3 fn.	3·5 ∗	......	.. ...	......	3·3 f.	3·5 n.	......	3·5 f.
12.		7 ∗	6·5 b.	......	6·5 nb.	6·8 nb.	6·8 b.	6·5 ∗	6 b.	5·5 f.	7 ∗
13.	ε	8·5 b.	......	9 vb.	8·5 vf.	......	......	8·7 ∗	......	ten or twelve	....
14.	ε'	......	10·5 nb.	10 b.	......	......	......	......	......	here.	......
15.	ε''	......	......	12 b.	12 b.	12·8 nb.	......	11·7 f.	11 c.	... ...	11 nb.
16.	ζ	16 ∗	......	17·5 bw^3.	16 f.	16·8 b.	14·8 w.	16 ∗	......	17·5 f.	16·5 bw^3.
17.		......	20 f.	20 f.	......	......	19·8 nf.	19·7 f.	19·5 n.	20·5 c.	21 f.
18.		......	......	......	......	22·8 nb.	......	22·7 f.	......	22·5 c.	......
19.	η	24 ∗	24 ∗	24 ∗ intense.	24 ∗	24·8 bn.	23·8 b.	......	24 ∗	24·5 n∗	24·5 ∗ intense.
20.		......	......	......	25 f.	......	......	25·4 f.	......	25·5 ∗	......
21.		......	......	27·5 f.	28 f.	......	......	28·1 f.	......	......	......
22.		......	......	30·5 vbn.	......	......	29·8 nf.	30·1 fn.	29·5 f.	30·5 b.	30·5 f.
23.		31 b.	......	......	......	......	......	31·8 ∗	32 f.	......	......
24.	θ	33 ∗	......	33 ∗	32·5 vf.	......	33·8	33·8 nc.	......	32·5 nb.	34 vf.
25.		36 f.	......	36·5 fw.	......	36·8 b.	......	36·1	35 f.	35·6 b.	36·5 vf.
27.		......	......	......	37·5 f.	38·8 vn.	37·8 nf.	......	......	37·8 b.	......
28.		41 f.	40 n.	40·5 bw^3.	......	40·8 bw.	......	......	40 f.	40·5 bw^4.	40 vf.
29.		......	43 b.	......	43·5 ∗	......	43·8 c.	42 ∗w^6. intense.	42·5	......	43 ∗
30.		45 ∗	......	45 nc.	......	......	......	......	......	......	......
31.		......	......	46 nc.	......	......	......	46 bn.	......	46 f.	......
32.		48·5	......	......	......	......	......	48·3 bn.	......	48·5 vn.	......
33.		......	......	51 f.	50	50·8 ∗	......	......	51·5 f.	50·5 b.	......
34.	ι	52 b.	......	......	52	52·3 vn.	52·8 f.	......	......	52·5 nc.	52·5 fw^5.
35.		......	......	54 f.	54	54·3 ∗	......	......	......	54·5 ∗	......
36.	κκ'	56 ∗ double	......	55·5 ∗ 56 ∗	......	......	......	......	......	56·5 f.	......
37.	33κ''	58 ∗	......	58 vb.	......	58·8 ∗	......	......	59·5 f.	58·5 ∗	......
38.	34	......	......	1·5 nc.	0 b.	......	......	0·3 c.	......	......	0 fw.
39.	λ	4 w.	......	4 nc.	......	......	......	3·6 c.	......	......	......
40.		......	5 b.	5·5 nc.	......	4·8 fn.	......	......	5 b.	......	......
41.		......	......	......	6·5 b.	......	6·8 c.	6·5 f.n	......	7·5 vnb.	6·5 ∗
42.		......	......	......	9·5 n.	8·8 n.	......	......	......	9·5 vnb.	......
43.	μ	......	......	10·5 ∗	......	10·8 f.	......	......	......	......	......
44.	μ'	11·5 bn.	......	12 ∗	......	11·8 b.	......	......	......	12·5 ∗	......
45.	μ''	......	......	14 f.	14 f.	......	......	......	14·5 f.	14 nf.	14·5 nc.
46.		17 ∗	17 f.	16 f.	16 n.	15·8 n.	15·8 fw.	16 ∗		15·5 nf.	17 nc.
47.		......		19·5 f.	18 b.	19·3 b.		17·3 n.	......	......	19 nc.
48.	ν	20 nb.	......	......	20·5 n.	......	......	20·9 ∗w^7.	......	21·5 ∗	
50.		......	......	22·5 f.	22·5 f.	21·8 n.	......	......	......	......	......
51.		......	......	26 vf.	27 c.	24·8 bw^2.	......	26·5 f.	......	26·5 vf.	......
52.	ξ	30 bw.	......	29 ∗	......	......	......	29·5 ∗	......	......	......
53.		......	......	32 c.	......	32·8 nb.	......	31·8 nf.	......	33·5 vf.	......
54.	ο	35 fw.	......	35 b.	34 c.	36·8 nb.	......	35·7 vf.	......	36·5 vf.	......
55.		......	......	40 n.	40 vf.	39·3 vn.	......		......	42 vf.	......
56.		......	......	45 vf.		......	......	......	......	46·5 vf.	......
57.		50 vf.	......	51 f.	......	48·8 n.	......	......	......		......
			......		......		......	......	......	......	......

Some of these are peculiar. In air, C.P., No. 12 is the brightest of all, ζ is very brilliant, so is No. 46. The H, C.P., is also greatly developed. It was taken at the negative electrode only. Nos. 2, 29, and 48 reach quite across the spectrum; the others more or less, but on an average about one-third of the way from each electrode, being brightest at the negative. The deposit in the tubes was very considerable, but it does not seem to have cut off much of the spectra. To examine the effect of the diameter of tube, I took (with Duboscq) the air R. in a compound tube, of which the wider parts were 0·4 inch bore, and the narrower 0·04 and 1·5 long. The distance between the electrodes was 5 inches. The discharge was pretty bright in the narrow parts, and red, except on the negative wire, where it was blue. They are as follows:—

		Narrow.	Blue negative.	Red positive.
1.	32° α	38·1 f.	……	……
2.		49·1 vf.	……	……
3.	32	58 vf.	58 vf.	58 vf.
		many.		
4.	33	0·6 vf.	……	……
5.		5·3 n.	6 f.	……
6.		7·3 n.	……	7 vf.
7.	ε	9·4 vf.	……	……
8.		11 b.	10·7 c.	10·5 nb.
		others.		
9.		14 f.	……	……
		some.		
10.	ζ	16·4 f.	……	……
11.		20 f.	20·7 c.	……
12.		22·4 w.	23·4 c.	23 f.
13.		25·7 w.	25·7 c.	……
14.		28·4 nf.	29·4 f.	……
		one.		
15.		31·4 nf.	32·1 nc.	30·8 vf.
16.		34·4 c.	35·1 vf.	……
17.		37·5 c.	37·8 f.	37·8 nf.
18.		40·8 nb.	40·8 nc.	……
19.		44·1 w.	44·1 vf.	44·1 f.
20.		……	46·7 vf.	……
21.		50 b.	51·3 c.	49·3 vf.
22.	33	55·3 b.	54·7 f.	54·3 f.
23.	34	0·4 b.	0·1 f.	0·4 f.
24.		7·5 b.	6·9 f.	6·9 f.
25.		13·4 nb.	12·7 vf.	13·4 vf.
26.		18 c.	……	……
27.		……	18·6 f.	18·6 w.
28.		19·3 c.	……	……
29.		26·5 b.	25·8 c.	26·5 vf.
30.		33·1 c.		33·4 vf.
31.		39·6 c.	……	
32.		49·5 vf.	……	……
33.		57·8 vf.	……	……

The three evidently represent the same system of lines, for those missing in the second and third have been lost by their faintness. Nos. 12, 19 and 46, Table IX., are resolved by Duboscq into pairs. It also shows 17 which were not visible in the other. Nos. 5 and 11 of that again are not found in these: the first of these is almost peculiar to R. spectra; and its not being visible in the narrow tube here seems to argue that condensed discharge cannot show it.

TABLE X.—Zinc.

		Air.		Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.	
		C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
1.	32°	37·3 f.	......	......	......	......	......	......	......	......	38 o.
2.	α	38·7 *	......	38·4 *	38·7 *	39·4	......	39 *	39·6 *o.	......	......
3.	α	40·5 vb.	......	39·7 b.	......	41·4 n.	41·3 fo.	......	......	40 *	......
4.		43 *	......	42·9 f.	42·8 f.	44·4 n.	......	......	......	......	42·5 vfo.
5.	β	......	......	45·9 f.	45·9 vf.	46·4 n.	......	......	......	......	......
6.	β′	48·2 bn.	......	48·1 vb.	......	......	......	......	......	48·2 f.	......
7.		50·3 *	......	50·1 vf.	51·1 vf.	51·4 n.	......	......	......	50·5 f.	......
8.		52·1 vb.	......	52·1 f.	......	......	52·6 vf.	......	......	52 f.	52 vfo.
9.	γ	54·7 *	54·8 f.	54·4 *	53·7 vf.	54·4 n.	......	......	......	55 vf.	55 fo.
10.		......	......	......	56·3 nc.	......	......	56 vf.	......	57 vb.	......
11.		......	......	......	58·3 vn.	57·4 vn.	......	......	......	......	......
12.	32	60 b.	......	......	59·6 vb.	......	......	......	......	......	59·5 f.
13.	33	......	......	1·6 nb.	2·3 vnc.	......	......	......	......	......	......
14.	δ	3·7 *	4·5 f.	3·3 *	......	3·4 n.	3·8 vf.	4·5 f.	4·6 b.	......	4 nf.
15.		......	......	......	6 b.	7·4	6·8 c.	......	......	7 c.	7 c.
16.	ε	9·5 b.	......	8·3 b.	......	9·4 b.	......	9·5 vf.	......	9 c.	......
17.	ε′	10·8 b.	......	10·4 b.	......	......	10·8 nc.	......	......	......	......
18.		...	......	11 b.	11·7 *	......	......	......	......	11 f.	11·5 c.
19.	ε″	12·7 b.	13·5 f.	......	......	12·4 b.	......	......	......	13 f.	......
20.		......	...	......	......	......	14·8 fw^2.	......	......	15·5 f.	14·5 f.
21.	ζ	18 b.	16·3 f.	17 bw^4.	17·2 w^2.	......	......	......	......	17 f.	16 vf.
22.		......	......	......	......	20·4 f.	19·8 n.	......	......	19 f.	20·5 vf.
23.		......	......	......	23·7 b.	23·4 bn.	23·8 b. brightest.	......	......	21 c. 23 c.	....
24.	η	24·8 *	25·5 *	24·4 *	25·1 b.	24·4 bn.	......	25 vf.	......	25·5 *	25 *
25.		......	......	25·7 nf.	......	26·4 bn.	......	......	......	......	......
26.		......	......	27·1 nf.	27·1	......	......	......	......	27·5 n.	......
27.		......	......	29·1 nf.	29·1	......	28·8 w.	......	......	29 f.	......
28.		......	31·1 f.	31·1 vb.	31·1	30·4 f.	......	......	......	......	30 fw.
29.		32·4 n.	......	32·1 vn.	......	......	......	......	......	......	......
30.	θ	33·7 *	34·7 f.	33·5 *	33·1	34·4 bn.	......	34 c.	......	34 *	34 nf.
31.		......	......	36·1 f.	35·5	......	35·8 w.	......	......	......	......
32.		37·8 *w^2.	......	......	......	37·4 vb.	......	......	......	37 nb.	......
33.		......	......	......	......	38·4 vb.	......	38 vf.	......	......	38 f.
34.		......	40 f.	39·1 f.	39·1 f.	39·4 vb.	......	......	......	......	......
35.		......	42 f.	41·7 w.	41·7 *	42·4 w^2.	41·3 b.	42 *w^4.	......	41·5 *w^3.	42 *vb.
36.		44·7 *	......	......	43·7 b.	......	43·8 bw.	......	......	44·5 vfn.	44 b.
37.		......	45·8 c.	45·7 b.	45 b.	45·9 b.	......	......	45·6 b.	......	......
38.		......	......	46·4 b.	......	......	......	46 fn.	......	47 nc.	......
39.		49 *	......	48·7 nf.	......	......	47·8 n. a fine one	......	......	49·5 fn.	48 fn.
40.	ι	50·3 *	50·5 f.	50·3 vf.	50·3 c.	50·9 vn.	......	......	50·6 f.	... ...	50·5 f.
41.		......	......	52 f.	52·3 c.	......	......	52 vf.	......	52 *	......
42.		53 *	......	53·6 f.	... ...	52·9 *	......	......	53·6 vf.	53 c.	......
43.	κ	55·6 *	55 f.	55·9 *	55 c.	......	......	56 f.	......	... ...	56 f.
44.	κ′	56·8 *	......	57·2 *	56·6 c.	57·4 *w.	56·8 n.	......	......	57 n.	......
45.	33κ″	59 *	......	58·2	58·5 nf.	59·9 vn.	......	59 f.	......	59 b.	......
46.	34	......	1 f.	2 b.	1·1 bn.	0·4 *	1·8 vfw.	......	......	1 f.	1 f.
47.	λ	......	3·1 c.	3·9 b.	2·6 bn.	......	......	4 vfw.	......	3 f.	......
48.		5·8 b.	......	5·9 f.	5·9 nc.	......	......	......	......	... ...	......
49.		......	7 f.	......	7·2 vb.	6·4 f.	6·8 b.	......	......	6·5 f.	7 bw. double.
50.		......	9·1 f.	8·5 f.	8·5 nf.	......	......	......	......	8·5 f.	......
51.	μ	11·3 vb.	......	11·1 *	......	10·4 nb.	......	11 vf.	......	11 f.	......
52.	μ′	......	......	12·7 *	......	12·9 nb.	......	......	......	11·5 vf.	......
53.		......	......	......	13·7 b.	... ...	13·8 f.	......	......	13 *	13 n.
54.	μ″	14·2 b.	15·1 f.	14·4 f.	......	14·9 b.	a fine one	......	......	14 c.	14 vf.
55.		......	......	17·7 f.	18·3 b.	18·4 n.	......	......	......	17 b.	16·5 vf.
56.	ν	20 *	20 f.	20·3 f.	20·4 b.	20·9 n.	22·8 f.	21 *w^3.	21 c.	19 *	20 c.
57.		......	......	23·5 f.	23·2 nc.	23·9 n.	23·8 f.	......		22 b.	......
58.		......	......	... ...	24·9 n.	......	......	......	......	24 f.	24 c.
59.		......	......	... ...	25·5 vb.	......	......	......	......	... ...	......
60.		......	27 f.	26·8 ...	27·9 f.	28·2 bw^4.	27·8 f.	27 nc.	......	27 *	28 c.
61.	ξ	30 *	......	29·8 vb. 30·5 b.	29·5 nc.	......	......	......	......	29 n	....
62.		......	......	......	32·1 nc. 34·1 vb.	......	......	......	......	33 f.	......
63.		......	35 f.	36·7 vn.	35·4 nf.	......	35·8 f.	......	......	35·5 c.	35 f.
64.		......		......	36·7 nf.	36·4 c.		......	......	......	
65.		39 f.	......	......	38·6 nf.	......	......	......	......	......	......
66.			......	......	40·6 nf.	40·9 nf.	......	......	......	42·5 c.	......
67.		......	......	45·2 f.	45·9 nc.	44·4 nf.	......	44 fw.	......	......	......
68.		......	......	......	49·8 c.	49·4 f.	......		......	48	......
				52·5	56·1 vf.		......	......	......		......
						......	......	......	......	......	......

This is one of the most splendid spectra, especially at the violet end. N, R., is remarkable for its brightness and the number of its lines. CO, R., has the discharge lilac-coloured instead of green, as is generally the case in this gas.

TABLE XI.—Cadmium.

		Air.		Nitrogen.		Oxygen.		Hydrogen.			Carb. oxide.	
		C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R. 2·55.	R. 0·2.	C.P.	R.
1.	32°	35·5 o.	......	......	......	....	......	......	......	......	....	......
2.	α	38·5 *	......	39 *	38 f.	38·8 *	......	38·8 *o.	......	......	....	......
		double.										
3.	α′	41 double.	......	41 n.	......	39·8 f.	......	......	......	......	40·7 *	......
4.		....	......	......	......	44·8 f.	......	......	......	......	......	......
5.	β′	48·5 *	......	48 f.	49 f.	47·8 *	......	......	......	......	48·7 *	......
6.		....	......	......	... ...	49·8 n.	50·8 b.	......	......	50·5 vf.	50·7 b.	......
7.		....	52 o.	......	... ...	....	53·8 fn.	53·3 vf.	......	......	......	52·7 bw².
8.	γ	54·5 *	......	55 *	... ...	56·3 n.	......	......	......	......	55·2 n.	55·7 vf.
9.	32	59 n.	......	......	... ...	....	58·8 fn.	......	......	......	57·7 *	59·7 f.
10.	33 δ	3·5 *	4 fw.	3 vn.	3 f.	....	......	......	......	......	0·2 fn.	3·7 f.
				4 *	......	....	5·8 vb.	......	......	......	3·7 *	......
11.		....	7 c.	......	......	....	6·8 nb.	......	......	6 fw.	6·7	7·7 *
											three.	
12.	ε	10 b.	......	9 b.	......	....	......	......	......	......	9·7	......
											four.	
13.	ε′	11·5 b.	11 fn.	10·5 b.	......	11·3 bn.	10·8	......	......	......	......	......
14.	ε″	13 b.	13 vfn.	13 b.	12 b.	13·8 fn.	......	12·8 f.	14·5 vfw.	......	......	12·7 nb.
15.		16 *	......	15 *	......	16·3 bw.	14·8	17·3 f.	......	......	14·7	16·7 w³f.
											four.	
16.	ζ	17 *	17 f.	17 *	17 bw.	....	......	18·8 f.	......	......	......	......
17.		....	......	......	......	21·8 b.	......	......	......	......	20·7 c.	21·2 f.
						double.					23·7 c.	
18.	η	25·5 *	24 b.	24 *	24·5 bw³.	24·8 b.	23·8 *	......	24·5 vfn.	24 b.	25·7 *	24·7 vb.
			27 f.			double.						
19.		....	28·5 c.	......	29 c.	....	28·8 fw.	......	29 vf.	28·5 bn.	28·7 n.	28·7 bn.
20.		30 vbn.	......	29·5 nb.	......	30·3 fw.	......	30·8 bn.	......	......	30·7 f.	......
21.		32 vn.	......	31 nb.	......	....	......	......	......	......	......	......
22.	θ	33·5 *	......	33 *	33 c.	....	32·8 f.	......	......	......	......	34·2 vf.
23.		....	......	......	35 c.	36·3 b.	......	......	......	......	......	......
24.		37·5 f.	......	38 f.	......	....	......	......	......	......	37·2 f.	38·7 f.
25.		....	......	......	39 n.	39·8 w.	39·8 nb.	......	40 nf.	39·5 f.	......	......
26.		41 f.	42 c.	41 bw.	41·5 bn.	....	......	41·8 *w.	......	41·5 c.	......	41·7 nc.
					43·5 n.							
27.		45 *	44 bw.	45·5 *	45·5 bn.	....	43·8 vb.	45·8 nbw.	45 vfn.	44 c.	43·7 fw².	44·7 b.
28.		....	......	......	......	....	......	......	......	......	47·7 n.	......
29.	ι	51·5 n.	......	50 f.	50·5	49·8 *	......	......	51·5 vfvn.	......	51·7 *	......
30.		53 *	53 cw.	53 c.	52	51·8 n.	51·8 vf.	......		52·5 cn.	53·2 nc.	54·2 fw.
31.	κκ′	56 * double.	......	56 *	55	53·8 *	......	53·8 n.	......	......	54·7 *	......
											57·2 nf.	
32.	33κ″	59·5 *	......	58 *	......	57·8 *	58·8 vf.	......	......	......	59·2 *	......
33.	34	....	2 f.	2 bn.	1 f.	....	......	......	......	......	......	1·7 f.
34.	λ	3·5 cw.	......	3·5 bn.	......	....	......	......	......	......	......	......
35.		....	......	4·5 bn.	......	4·8 bn.	......	......	......	......	......	......
36.		....	7 cw.	......	7 f.	7·8 bn.	6·3 vb.	......	......	......	......	6·2 *
37.		....	......	......	......	8·8 bn.	......	......	......	......	9·7 vf.	......
38.	μ	11 vb.	......	......	......	....	......	......	......	......	......	......
39.	μ′	12 b.	......	11·5 w.	......	11·8 bw.	......	......	......	......	......	......
40.	μ″	13·5 b.	......	......	14·5 f.	....	13·8 vf.	13·3 vn.	......	......	13·7 b.	......
41.		....	......	......	......	15·8 n.	16·3 vf.	......	......	......	......	15·7 f.
42.		....	18 f.	......	......	17·8 c.	...	......	......	......	17·7 n.	...
43.	ν	19 vbn.	......	......	19·5 f.	19·8 f.	19·3 vf.	19·8 *w.	......	......	19·7 c.	18·7 f.
44.		....	......	......	......	....	......		......	......	21·7 n.	23·2 f.
45.		....	27·5	26 vfn.	27 f.	25·8 bw².	......	......	......	......	26·7 *	26·7 f.
46.	ξ	29·5 *	......	30 *	......	....	......	......	......	......	......	......
47.		....	34 f.	33·5 vf.	34 vf.	32·8 nc.	......	......	......	34·5 vfw.	34·7 f.	33·7 f.
48.	ο	35 fw.		36 c.	......	....	......	......	......		......	......
49.		....	......		......	37·8 f.	......	......	......	......	38·7 vf.	......
50.		....	......	......	41 f.	41·8 f.	40·8 vf.	......	......	......	......	......
51.		46 f.	......	......		45·8 c.		......	......	......	44·7 vf.	43·7 vf.
52.		50·5 vf.	......	......			......	......	......	......	47·7 vf.	45·7 vf.
53.		53·5 vf.	......	......		....	......	......	......	......		

I have given here the H transition spectrum. The lines are scarcely visible; they are all found in the other two H. These spectra are exceedingly beautiful, but troublesome in tubes of such small diameter from the dense and opake deposits.

TABLE XII.—Bismuth.

		Air.		Nitrogen.			Oxygen.		Hydrogen.		Carb. oxide.	
		C.P.	R.	C.P.	Ditto – end.	R.	C.P.	R.	C.P.	R.	C.P.	R.
1.	32°	32·7 fo.	......	......	......	33·5	......	......	......	......	......	......
2.	α	39·7 *	......	38·5 c.	......	......	39 *	......	......	......	39·2 *	......
3.	α′	41·7 b.	......	40·5 42·5 f.	......	......	42 f.	......	40·9 *o.	......	......	......
4.	β	......	......	46 f.	......	......	45 f.	......	......	......	......	......
5.	β′	48·7 b. double.	......	49 c.	......	......	49 *	......	......	48·9 vf.	47·5 *	......
6.		......	......	51 f.	......	50·5 vn.	50 f.	......	......	......	49·5 b.	......
7.		52·2 bn.	52·5 f.	53 f.	......	first of many.	......	......	......	......	......	52·5 f.
8.	γ	55·2 *	no other red.	55 *	......	......	......	......	56·4 vf.	......	55·5 vn. 56·5 *	56 f. vn.
9.	32	58·2 c. 58·7 n.	......	many close here.	......	60·5 vn.	......	......	......	......	59 f.	59·5 f. vn.
10.	33	2·2 vbn.	1·5 f.	2 nf.	......	......	......	......	......	......	2·5	......
11.	δ	3·7 *	......	4 *	......	......	......	4 fo.	......	......	3·5	4·5 vn.c.
12.		6·7 f.	......	7 vf.	......	5·5 b.	7 b.	8 f.	6·9 vfn.	......	5·5 vn.	7·5 *
13.		9·7 b.	9·5 f.	8·5	......	9·5 f.	......	......	......	8·4 bw.	four here.	9·5 nc.
14.	ι	......	......	10 c.	......	... ...	10 vf.	......	......	......	... ...	......
15.	ε′	10·7 b.	......	11 c.	......	11·5 vf.	......	......	......	11·4 n.	... ...	11·5 vf.
16.	ε″	13·2 b.	......	12 c.	......	......	13 fw.	12 vf.	......	......	12 vn.	......
17.		14·7 f.	......	15 nf.	......	......	......	......	......	15·4 fn.	four here.	15 f.
18.	ζ	15·7 f.	......	17 nf.	......	16·5 f.	17 w.	17 vf.	......	......	... ...	......
19.		19·7 vb.	18·5	18 nf.	......	......	......	......	......	......	18·5 vn.	......
20.		22·7 *	......	23 vb.	20 b.	......	21 f.	22 vf.	......	20·4 vf.	20·5 c.	20·5 f.
21.	η	24·2 f.	24·5 bw.	......	23 *	......	......	......	......	24·4 *	24·5 nb.	24·5 *
22.		25·7 *	......	......	25 vn. vb. 26 vb.	......	25	25 *	......	......	25·5 *	......
23.		27·2 *	......	27 vf.	27 vb.	......	......	27 n.	......	......	26·5 nb.	26 vnb.
24.		30·2 bn.	......	30 nb.	29 vb.	29·5 vb.	......	30 vf.	29·4 vfn.	......	......	......
25.		32·7 c.	31·5 c.	......	31 vb.	30·5 vb.	......	......	......	......	30·5 bn.	30 vf.
26.	θ	33·7 *	......	33 *	33·5 *	......	......	......	......	......	33·2 b.	......
27.		......	36·5 fn.	36·5 f.	......	......	36·5 vb.	35·5 vf.	36·4 vf.	......	35 n.	35·5 vf.
28.		37·7 f.	......	......	37·5	37·5 c.	38 n.	38 vf.	......	......	36·5 nb.	......
29.		40·7 f.	39·5 f.	39 nf.	......	39·5 vn.	39 n.	......	......	......	......	......
30.		40·7 f.	......	40	41 w.	......	41 f.	41 nc.	......	......	......	41 vf.
31.		......	44·5 w.	45 c.	45 bw. double.	43·5 b.	......	......	42·4 *w.	42·9 bw.	42·5 bw².	44·5 vb.
32.		45·2 cw.	......	46 c.		......	44·5 vf.	45 vb.	......	......	46·7 vn.	45·5 f.
33.		47·7 b.	......	48 f.	48 nvc.	48·5 b.	48 bn.	48 vfn.	......	......	......	......
34.		49·7 *	49·5 nc.	......	50 nvc.	......	......	......	......	......	49·2 vn.	50·5 f.
35.	ι	51·2 b.	......	51 f.	52 nvc.	......	52 *	50·5 vnc.	......	......	51 *	50·5 f.
36.		......	......	53·5 n.	......	53·5 b.	53 vbn.	......	......	......	53·5 vn.c.	52·5 f.
37.	κ	......	55 w.	55 *	......	......	55 *	......	......	......	54·5 *	54·5 f.
38.	κκ′	58·2 * double.	......	56 *	56 * double.	......	57 n.	......	......	......	57·6 vn.	......
39.	33κ″	58·7 c.	......	59·5 vb.	58·5 b.	59·5 b.	59 *	......	58·4 c.	......	58·5 *	......
40.	34	1·2 *	0·5 w.	......	2 b.	2 f.	......	......	......	......	......	2 vf.
41.		......	......	3 n.	......	......	......	......	......	......	......	......
42.	λ	4	......	4 n.	4 f.	......	......	......	......	......	......	......
43.		......	......	5·5 n.	5·5 vf.	6·5 b.	5 cn.	......	......	6·4 c.	......	6·5 vb.
44.		8·7 vf.	8·5 w.	......	......	......	8 cn.	8 fw.	......	......	7·5 nb.	......
45.		......	......	......	......	......	9·5 cn.		......	......	9 nb.	......
46.	μ	10·7	......	11	10 f.	......	......	......	......	......	10·5 nb.	......
47.	μ′	12·2	......	12	11 f.	12·5 bn.	......	......	......	......	11 nb.	......
48.	μ″	13·7	13·5 w.	14	seen. vf.	......	......	......	......	......	13·5 *	......
49.		......	......	16 f.	......	......	16·5 bn.	......	......	16·4 vf.	17·7 f.	17
50.		......	18·5 w.	19 vn. c.	19 fw.	18·5 b.	18 b.	......	......		19·2 c.	18·5
51.	ν	20·2 b.	......	......	......	......	21 f.	......	22·4 *w.	......	22 f.	20·5
52.		23·7 *	......	......	23 nc.	......	......	......	......	......	......	23·5 c.
53.		......	25·5 w.	25 vf.	27 nb.	25·5 b.	26 b.	......	......	......	26·8 *	
54.		28·2 vb. 29·7 vf.	....	29·5 b.	29 nc.	....	29·1 wb. 30 vb.	....	29·4 c.	....	....	....
55.	ξ	......	32·5 vf.	33·5	34·5 f.	33 vf.	34·5 bn.	......	......	......	34·2 f.	......
56.	ο	37·7 vfw.		36 f.				......	......	......	38·2 f.	......
57.		......	......		......	......	......	......	......	......	42 f.	......
58.		......	......	......	......	......	......	......	......	......	46·5 f.	......
59.		48·2 vf.	.....	......	......	......	......	......	......	......	48·1 f.	......

I have given N, C.P., at the negative boundary in part. It seemed identical with the central one till No. 20; so I did not take that part. In the green the lustre of the lines marked b. or vb. is fully that of θ, and they would be marked * if they were as wide as the slit. In the indigo and violet this spectrum has little, if any, superiority of brightness. In air, C.P., No. 20 is the brightest of the whole, and the companion of η is developed into first-rate brightness. In air, R., there is no red but the single line No. 7.

TABLE XIII.—Tin.

		Air.			Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.	
		C.P.	R. 2·18.	R. 0·2.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
1.	32°	......	......	......	......	34 vfo.	......	......	......	......	....	....
2.	32 α	38 * double.	......	......	38·5 * double.	39 fo.	39·5 *	......	37·5 *o.	......	39 b.	....
3.	32 α′	41·5 *	......	......	......	....	41·5 n.	......	......	......	....	....
4.	32 β	......	......	......	......	45 vf.	44 f.	......	......	......	....	....
5.	32 β′	48 b.	......	......	48 b.	47·5 f.	47·5 vf.	......	......	......	48	49 vf.
6.		......	......	51·5 c.	......	51 f.	50 * 51 bn.	51 f.	......	......	51	52 c.
7.	γ	54 *	53	......	53 *	....	54 f.	......	52·5 n.	......	....	....
8.		......	......	......	......	55 f.	......	55 f.	......	56 fw.	55·5 f.	55 f.
9.	32	58 b.	......	......	......	59 f.	......	...	......	......	57·5 c.	....
10.	33	1·5 vbn.	1	......	1 n.	....	0 f.	0 f.	1	......	....	0 f.
11.	δ	3 *	......	2·5 b.	3 *	....	4 f.	4 f.	......	......	....	....
12.		6 b.	......	......	......	5 c.	......	......	7	......	7 n.	7 *
13.		7·5 b.	......	......	8 b.	....	7·5 f.	8 *	......	......	many	8 *
14.	ε	9 b.	......	......	9·5 c.	....	......	9 n.	......	......	here.	....
15.	ε′	10 c.	......	10 c.	10	10 nb.	10 f.	......	......	10 b.	......	....
16.	ε″	11·5 c.	......	...	11	two	... ...	......	......	......	......	12 cn.
17.		......	......	14 c.	......	... ...	13 c.	13 cn.	......	......	......	....
18.	ζ	16 b.	......	16 c.	16	15 nb.	15·5 n.	......	15 fw.	......	......	16·5 triple.
19.		......	18·5	......	......	....	18 n.	17 f.	......	......	......	....
20.		21 n.	......	......	......	....	21 n.	21 f.	......	......	21·5 n.	21 nc.
21.	η	23 *	......	23 w.	23 *	24 b.	24 bn.	24·5 *	22·5 bn.	23·5 vf.	23 c.	24 *
22.		26·5 n. one here.	26·5	......	25 vf. 27 f.	24·5 n.	26 b.	26 n.	......	......	26 *	25 n.
23.		......	......	......	28 bn.	29	......	29 f.	......	......	....	....
24.		30·5 vn.	......	30·5 f.	faint.	31 nf.	31·5 f.	......	31 b.	......	31 c.	31 vf.
25.	θ	33 *	32 vfvn.	......	32 *	34 nf.	......	......	......	......	33·5 b.	....
26.		36 f.	......	......	35·5	....	......	35	......	......	....	36 nf.
27.		38 nf.	......	38 cn.	37·5 vf.	38 c.	37 bn. 38 cn.	......	......	37 vf.	37 c.	....
28.		......	40 vf.	......	39·5 f.	....	39 vf.	......	one n. 39 * one n.	......	....	....
29.		41 b.	......	......	42·5 f.	....	42	40·5 nc.	......	......	....	41 f.
30.		43·5 c.	......	44 n.	44 f.	43 b. compound.	......	44 *	......	......	44 b.	44 *
31.		45·5 c.	44·5 vf.	......	46 f.	....	......	one here.	......	......	....	46
32.		......	......	......	49	49 c.	49 f.	......	......	......	49 *	50 f.
33.	ι	50 b.	50 vf.	50 n.	......	......	52 *	52 f.	......	......	50·5 n.	52 f.
34.		53 c.	52 vf.	53 w.	......	54 c.	54 n.	......	53·5 f.	......	53·5 *	... ...
35.	κκ′	55 * double.	56 vf.	......	55 *	56 c.	56 *	......	...	......	55.5 n.	55 f.
36.	33κ″	58 * double.	......	......	57 b. double.	......	58 n.	......	57·5 f.	......	57·5 *	....
37.	34	......	......	0·5 cn.	......	59·5 c.	0 *	1 f.	......	......	....	....
38.		......	2 vfw.	......	2	......	......	......	......	......	1 n.	....
39.	λ	4	......	......	3	......	......	......	......	......	3·5 n.	....
40.		......	......	......	5	5 c. triple.	......	......	......	......	4·5 n.	....
41.		......	......	8 c.	......	......	6 cn.	7 *	......	......	7·5 b.	6 b.
42.	μ	10 b.	......	......	9·5 b.	......	9 cn.	......	......	......	9·5 b.	....
43.	μ′	11 c.	......	......	11·5 b.	......	10·5 cn.	11	......	......	11·5 b.	....
44.	μ″	13 c.	10 f. many n.	13 f.	......	12·5 c. double.	13 b.	......	......	......	12·5 b.	....
45.		17 vfn.	......	......	15 f.	......	17 f.	15·5	......	......	16·5 c.	15·5
46.	ν	19 c.	19 f.	19 bw.	18 f.	18 c.	20 c.	20·5 f.	19·6 *w.	......	18·5 b.	18
47.		......	......	......	22 f.	......	22 f.	......	......	21 vf.	21·5 c.	22
48.		24·5 vfn.	......	......	......	......	......	......	......		24·5 f.	....
49.		......	27 *w.	27 *w.	......	......	27 *	......	......	......	26·5 *	26 f.
50.		28·5 *w.	29 f. double.	......	29 vb.	......	......	......	......	......	29·5 f.	....
51.	ξ	33·5 vf.		34 vf.	33 f.	32 c.	31·5 f.	......	......	......	33·5 f.	....
52.	ο	......	......		35·5 f.	....	35 bn.	......	......	......	35·5 f.	36 fw[10].
53.		......	......	......	......	39 f.	38·5 cn.	......	......	......	39·5 f.	
54.		......	......	......	43·8 f.		43 cn.	......	......	......	42·5 f.	....
55.		......	......	......		....	45	......	......	......	45·5 f.	....
56.		47 vf.	......	......	......	....	48 b.	......	......	......		....

I have given the transition spectrum for air. In it No. 7 is the beginning of light. No. 10 is the beginning of a band almost entirely dark, which occupies the place of δ. Another dark interval at No. 19 seems to replace the bright group ζ, and a third at No. 22 stands for η. No. 25, which, though very faint, is the brightest among them, is the residue of θ. The lines at the violet end are relatively less faded, but are all very obscure.

TABLE XIV.—Antimony.

		Air.		Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.	
		C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
1.	32̊ α	38 f.	......	39 *	39·3 vfo.	38 8 *o.	39·3 o.	39·4 *o.	......	38·7 *	......
2.	α′	41 c.	......	41 vnf.	......	......	......	......	41·4 c.	....	......
3.	β	45 f. double.	......	......	......	......	......	......	......	47·7 *	......
4.	β′	49 *	......	49 nf.	......	48·3 *	......	......	......	49·7 b.	......
5.		50 c.	......	......	......	50·3 n.	51·3 f.	......	......	....	......
6.		53 b.	52·2	......	52·5	......	......	......	......	....	52·2 *
7.	γ	55 *	......	55 *	55·5 f.	54·8 bn.	......	......	......	54·7 *	55·7 f.
		56 *	......	......	60 c.	......	......	......	......	55·7 *	
8.	32	59 fw.	59·2 n.	......	......	......	......	60·4 f.	59·4	....	58·7 c.
9.	33	....	......	3 vbn.	......	2·8 n.	1·8 vn.	......	......	2·7 vnc.	......
10.	δ	3·5 *	4·2	4 *	4 f.	......	......	3·9 n.	......	3·2 *	3·2 f.
11.		5 b. 7 bn.	7·2 b. double.	......	7·5	......	6·8 *	7·4 n.	7·4 c.	7·2 many.	7·2 *
12.	ε	8 n.	......	9 b.	......	8·8 f.	......	......	......	8·7	8·7 vf.
13.	ε′	10 nf.	......	10·5 b.	......	......	......	......	......	many.	......
14.	ε″	11 c.	12·2	12 b.	......	11·8 nb.	......	......	12·4	......	......
15.		13·5 b.	......	13 b.	13 b.	13·8 n.	......	......	......	13·7	......
16.	ζ	15·5 b.	......	......	16·5 vf.	16·8 *	15·3 w^7.	......	......	17·7	15·7 fw.
17.		20 c.	......	19 bw^4.	21 vf.	19·8 fn.	19·8 n.	20·9 vn.	......	20·2 c.	20·7 f.
18.		23 *	......	23 f.	......	21·8 n.	22·3 *	......	......	22·7 n.	22·7 *
19.	η	24·5 bn.	24·7 bw.	25 *	24 b.	24·8 *	......	24·5	......	23·7 nb.	24·2 * many b. and vn.
20.		26 n.	......	......	25·5 many n.	......	......	......	25·4	25·7 *w^2.	......
21.		30·5 w. some here.	30·2 vf.	......	30 cw^3.	29·8 w^2.	......	......	......	30·7 nb.	28·7 c.
22.	θ	32·5 *	......	32 vbn.	......	......	......	33 nb.	......	32·7 *	...
23.		36 f.	......	34·5 *	.....	35·8 b.	......	......	......	35·7 nb. double.	34·2 c.
24.		39	......	37·5 f.	......	39·8 b.	38·8 vb.	......	......	......	......
25.		41 c.	41·2 bn.	41 cw^3.	42 nb.	......	41·8 b.	40·4 *w.	......	41·2 bw^2.	40·7 nb.
26.		44·5 b. one.	43·7 c. double.	45 b.	44·5 bw^2.	......	44·3 f.	......	43·4 bn.	....	43·7 *
27.		46 b.	......	46 b.	......	45·8 f.	......	......	......	45·2 bw^2. multiple.	......
28.		48·5 b. double.	......	......	......	......	48·3 c.	......	.....	49·2 vnc.	48·7 n.
29.		......	50·2 f.	51 nf.	50·5 vf.	49·8 *	50·3 n.	......	......	50·7 *	49·7 n.
30.	ι	......	...	52 nf.	52 vf.	51·8 bn.	52·3 n.	......	......	52·7 n.	51·2 n.
31.		54 * double.	...	53·5 nf.	54 vf.	53·8 *	......	53·6 vn.	53·4 fw.	54·7 *	53·2 n.
32.	κ′	....	56·2 f.	56 *	......	56·8 n.	......	56·4 vf.	......	56·2 vnf.	......
33.	33κ″	57·5 bw.	......	57 *	......	57·8 *	......	...	......	58·2 *	......
34.	34	....	1·2 c.	59 vb.	1 b.	......	......	1·4 vf.	......	0·7 n. three.	......
35.	λ	3·5 fw. others.	......	2·5 n. 3·5 n.	......	......	......	......	......	......	......
36.		....	......	5 n.	......	......	48 b.	......	......	5·7 n.	......
37.		6·5 vb.	7·2 bw.	......	7 cw.	6·8 bn.	......	......	7·4 bw.	8·7 n.	6·2 b.
38.		11 b.	......	11 *	......	8·8 n. others.	......	......	......	10·7 nc.	......
39.		13 b.	......	13·5 *	......	12·8 *	......	......	......	13·7 *	......
40.		16 b.	......	16 vn.	16 nc.	16·8 nc.	14·8 c.	......	. ...	16·2 nb.	15·2 nf.
41.		19 c.	......	18 f.	19 c.	17·8 c.	......	......	18·4 f.	19·7 nb.	17·7 nb.
42.		....	21·7 vf.	20·5 f.	......	19·8 f.	20·8 bn.	21·4 *w.	......	21·2 f.	......
43.		23 n.	......	24 vf.	23 f.	......	......		......	......	22·7 c.
44.		26·5 *	28·2 f.	27 f.	27 f.	25·8 *	......	......	25·4 f.	26·7 *	25·7 vf.
45.	ξ	32 fw.	......	30 *	......	......	......	......	......	30·7 vf.	31·7 f.
46.			......	33·5 n.	34 vf.	34·3 vn.	......	......	......	35·2 vf.	......
47.		....	36·7 cw.	36·5 c.		37·8 vf.	......	......	37·4 cw.	38·7 vf.	36·7 vf.
48.		....		42 vf.	......	41·8 vf.	40·8	......		43·7 vf.	41·7 vf.
50.		....	......	45 nc.	......	46·3 f.		......	......	47·7 vf.	
51.		....	......		......		......	......	......		......

The deposit on the tubes very troublesome: this is especially the case with metals of this group. In air, exhausting to 0·86 inch, No. 8 is replaced by a narrow *black* band, but reappears on further exhaustion.

TABLE XV.—Magnesium.

		Air.		Nitrogen.		Oxygen.		Hydrogen.		Carb. oxide.	
		C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.	C.P.	R.
1.	32° α	39 *	39 vfo.	38·5 * 39·5 nf.	......	38 f.	37·5 vfo.	39·5 *vb.	38·5 vfo.	38·2 *	......
2.	α′	41 n.	....	42 vf.	......	41 f.	......	......	......	....	......
3.		....	....	......	......	43 f.	......	......	......	....	......
4.	β	....	....	45 vf.	......	46 f.	45·3 vfo.	......	......	....	......
5.	β′	49 b.	....	47·5 f.	......	49 vb.	......	......	......	48·2 f.	......
6.		....	51 fo.	......	......	50·5 vf.	50 nf.	......	......	49·7 f.	51·2 nf.
7.		....	54 fo.	......	......	53·5 vf.	......	......	52 f.	53·2 vn.	52·7 vfn.
8.	32 γ	55	56 fo.	54 *	......	55·5 *	......	......	......	55·7 f.	57·2 vnf.
9.	33	....	0	1 nc.	1 f.	......	......	......	1 vf.	59·2 f.	......
10.		2 nc.	3	2·5 * double.	3 vf.	2·5 vnc.	2 f.	......	......	3·2 c.	2·7 vnf.
11.	δ	4 * one follows.	....	......	6 n.	3·5 *	......	4·5 f.	5 vf.	....	......
12.		....	7 vb. one n.	7·5 b.	7 f.	.....	6·5	......	......	6·2	6·2 c.
13.	ε	9 b.	......	9 c. one.	......	9 b.	9·5 vfn.	......	......	many here.	7·2 n.
14.	ε′	10 nb. 11 nf.	....	10·5 c.	10	10 b. one.	......	......	10 vf.	......	11·2 vn.
15.	ε″	13 nb.	12 bn.	......	12 vf.	12 b.	12 vfn.	......	13 c.	......	......
16.	ζ	17 w^{2}b.	15 f.	16 w^4. quadr.	16 vf.	16·7 w^4. triple.	15 vf.	......	17 vf.	18·2	15·7 f.
17.		....	20 f.	......	19 vf.	......	18·5 c.	......	20 vf.	19·2	20·2 f.
18.		....	....	......	......	23 vn.	......	......	......	22·2 f.	23·2 *
19.	η	24 *	24 * one in cont.	23	24	24·5 *	24·3 bw^3.	24 c.	25 vb.	24·2 vn. 25·2 *	23·7 f.
20.		27 vf.	....	26 f.	......	28 f.	......	27 vf.	26·5 f.	27·2	28·2 f.
21.		....	29·5 vf.	29 n. one.	30 f.	......	29·5 f.	......	......	29·2	...
22.		31 nvb.	....	31 * doublevb.	31 f.	31 nc.	31·5 f.	31 vf.	31 f.	....	...
23.	θ	33 *	....	......	34 f.	33 *	33·5 c.	34 nb.	......	32·7 b.	32·2 f.
24.		36 nb.	34·5 vf.	36·5	......	37 c.	35·5 c.	......	......	35·2 vn.	35·2 f.
25.		39 f.	38 f.	39·5 cw^5. triple.	38 b.	39 f.	39 c.	38 vf.	39 f.	36·2 bn.	......
26.		41 w.	....	......	......	41 c. double.	41 nc.	41·7 *w^3.	......	40·2 bw^4.	......
27.		44 n.	43 * one close.	43	44 b.	......	......	......	43 vn.	....	42·2 vb.
28.		45 n.	....	44·5	......	44·5 c.	45 bw. one.	......	......	....	......
29.		46 n.	....	......	46 vn.	46 c.	......	46 vf.	45·5 c.	....	......
30.		....	48·5 f.	......	......	48 nc.	47 fvn.	47·5 f.	48 f.	48·2 fvn.	......
31.	ι	51 c.	50 nb.	50 vf.	49 b.	51 *	......	......	......	50·2 vb.	50·7 vf.
32.		....	....	......	......	......	......	52 nc.	52	52·2 nc.	52·2 f.
33.		54 vnc.	....	54·5 v. double.	54 c.	53·5 nb.	54·5 cw. double.	.....	......	53·7 *	......
34.	κ	55·5 *	55 c. double.	......	......	55 *	......	......	......	... ...	......
35.	κ′	56·5 *	....	......	......	56 * 57 vn.	......	56 b. double.	56 double.	56·2 nf.	......
36.	33κ″	59 b. compound.	....	57 bw^2. quadr.	......	58 *	......	59 f.	......	58·2 b.	59·2 f.
37.	34	1 n.	....	0 1	0·5 c.	1 f.	1 c.	......	......	many n. ones here.	......
38.	λ	3 n.	....	3	......	2·5 vn. 3·3 vn.	......	4 vf.	2 c.	....	......
39.		5·5 n.	....	6 c.	......	5 vn.	......	......	......	....	4·2
40.		8 nc.	7·5 double.	......	7 c.	......	7 c.	8 vb.	......	8·2 c. many.	......
41.		....	....	9 *	......	9 f.	......	......	9	....	......
42.	μ	10 b.	....	...	......	10·5 c.	......	......	......	....	......
43.	μ′	11·5 b.	....	11 b.	......	11·5 c.	......	......	......	....	......
44.	μ″	13 b.	14 n.	......	13 c.	13 c.	13·5 c.	14 vn.	......	13·2	13·7
45.		....	....	16 vn.	......	15·5 f.	......	......	15 nb.	15·2 vfn.	......
46.		16·5	....	17 fn.	......	17 nb.	......	......	......	16·2 nb.	17·2 f.
47.	ν	19 nb.	19·5 c. double.	......	19 c.	19 b.	20 c. mult.	20 *w^5.	......	18·7 nb.	20·2 f.
48.		22 vf.	....	22 vf.	......	22 nc.	......	......	21 double.	21·2 nb.	......
49.		26·5 c.	27 f.	25 nf.	27 c.	26 nc.	......	27 nc.	......	25·7 *	24·7 f.
50.		29·5 vb.	....	28 b.	......	29 cw^2.	27·5 c. mult.		28 b.	....	......
51.	ξ	....	....	31 f.	......	......	......	......	......	....	32·2 f.
52.		33 c.	....	34 f.	34 n.	......	34 c.	......	34·5	33·2 cvn.	
53.	ο	36 f.	35 f.	......	......	......	......	......	......	....	......
54.		....		......	39 f.	38·5 nf.	40 vf.	......	......	37·7 f.	......
55.		....	....	43 f.		42 f.	......	......	42 vf.	41·7 vf.	......
56.		44·5 f.	....	......	......	45 f.	45 vf.	......		....	......
		47 vf.	....	49·5 f.	......	47 c.	......	......	......	48·2 vf.	......

The discharges with this metal were extremely brilliant, so much so in O, that at first I thought the wires were in combustion. The light at the negative electrode was a dazzling green. The deposit was almost as small as that of aluminium, and intercepted very little light. In air, C.P., the comparative dulness of the κ group is peculiar; ν and ξ are scarcely perceptible.

Table XVI.—Tellurium.

		Nitrogen.		Hydrogen.			Nitrogen.		Hydrogen.
		C.P.	R.	C.P.			C.P.	R.	C.P.
1.	$\overset{\circ}{32}$	37·4 f.	....	....	35.	°	....	38·4 *	38·1 f.
2.	α	....	38·1 b.	39 *	36.		41·4 *w^{6}.	41·1 b.	41·4 *
3.	α′	39·7 f.	41 f.	....	37.		44·7 } n.	44·7 *	....
4.		42 b.	43·3 f.	....	38.		46·4 } b.	....	....
5.		44·2 f.	45·5 f.	....	39.		48·7 f.	....	....
6.	β	47·5 c.	....	....	40.		....	50·7 *	51 f.
7.	β′	49·4 f.	48·8 f.	....	41.		51·6 b.	....	....
8.		....	50·7	....	42.	ι	53·3 b.	53·6 b.	....
9.		52·1 f.	52·7	....	43.		55·3 *	55·3 *	55·9 f.
10.		54 *	54·4	....	44.	κ	56·6 *	....	....
11.	γ	....	56·3	....	45.	κ′	....	....	....
12.		57 f.	58	....	46.	33 κ″	58·5 *	....	....
13.	32	59·3 f.	59·6	....	47.	34	1 } c.	0·7 *	....
14.	33	1·3 } b.	1·3 b.	....	48.		...... }	....	....
15.		2·6 } *	....	....	49.	λ	3·6 } b.	....	....
16.	δ	....	4 c.	3·6 f.	50.		4·9 } c.	....	....
17.		....	6·7 b.	....	51.		7·5 f.	7·2 *	....
18.	ε	8 *	....	....	52.	μ	10·8 } *	....	....
19.	ε′	9·7	....	10·4 f.	53.	μ′	11·4 } b.	....	....
		fine set.			54.	μ″	13·4 f.	13·4 *	....
20.	ε″	11 b.	11·7 b.	....	55.		16·7 c.	18 } b.	....
21.		....	....	....	56.	ν	19·3 b.	19·9 } *	20 *w.
22.		14 f.	....	....	57.		21·3 f.	....	....
23.	ζ	16·5 b.	17·7 b.	....	58.		23·9 f.	....	....
24.		19 f.	....	....	59.		26·5 f.	27·2 *	27·2 f.
25.		21·4 f.	....	....	60.	ξ	29·1 *	30·4 f.	....
26.		....	....	....	61.		33·1 } b.	33·7 *	....
27.	η	24·1 *	24·1 *	....	62.	ο	36·3 } b.	....	....
28.		....	25·4 b.	....	63.		39 f.	39·6 b.	....
29.		27·4 f.	....	....	64.		41·6 f.	....	....
30.		30·8 b.	29·8 *	29·4 f.	65.		46·2 f.	44·6	46·9 f.
31.		32·8 *	32·1 *	....			....	49·2 b.	
32.	θ	....	....	33·4 b.			52·5 f.	....	....
33.		....	34·8 b.	....				56·8 f.	....
34.		36·8	....	....					

TABLE XVII.—Arsenic.

		Nitrogen.		Hydrogen.
		C.P.	R.	C.P.
1.	32°	37·7 f.	....	....
2.	α	....	....	38·7 *
3.	α'	40·7 f.	....	....
4.		43·6 f.	42	....
5.		45·5 f.	....	....
6.	β	47·5 b.	....	46·2 f.
7.	β'	....	....	48·2 b.
8.		....	51·1 f.	50·1 } b.
9.		....	five follow.	50·8 } b.
10.		54·7 *	....	54·7 b.
11.	γ	....	....	....
12.		....	....	57·3 b.
13.	32	....	....	58 c.
14.	33	....	1·3 f.	....
15.		....	....	....
16.	δ	4 *	....	4·6 *
17.		....	....	....
18.	ε	9 b.	8	8·7 *
19.	ε'	10·7 } b.	....	10·7 *
		one. }		
20.	ε''	11·7 } b.	11·4 } f.	....
21.		....	...... }	13·7 } f.
22.		13·7 f.	14 } f.	14·7 } f.
23.	ζ	17·4 b.	16·7 } f.	17 *
24.		....	18·7 c.	....
25.		20·4 f.	....	19·4 f.
26.		23 f.	22·7 f.	22·1 b.
27.	η	24·7 *	24·1 b.	....
28.		26·7 b.	25·7 f.	25·4 c.
29.		28·1 b.	29·4 c.	28·1 *
30.		30·1	30·8 f.	30·1 f.
31.		31·4 } b.	32·8 c.	32·1 f.
32.	θ	33·2 } *	....	....
33.		34·8 } *	....	34·8 vb.
34.		37·1 f.	....	....
35.		39·8 f.	39·1 b.	....
36.		42·7 f.	....	41·7 *w^7.
37.		44·7	44·7 b.	....
38.		46 b.	....	45·4 f.
39.		....	47·7	....
40.		50·3 } f.	....	50 } b.
41.		52·3 } f.	51·3 b.	52 } b.
42.	ι	54 } f.	54·7 } b.	54 c.
43.		....	55·9 } b.	....
44.	κ	56·6 *	....	56·9 } *
45.	κ'	....	....	...... }
46.	33 κ''	59 *	....	58·5 } *
47.	34	....	1·7 b.	....
48.		2·3 } c.	....	....
49.	λ	3·9 } c.	....	2·9 b.
				double.
50.		5·2 } c.	....	....
51.		....	8·2 b.	6·9 b.
52.	μ	....	....	9·5 b.
				double.
53.	μ'	11·1 } *	....	12·4 }
54.	μ''	13·1 } *	14 b.	14 }
55.		....	....	....
56.	ν	20·6 c.	20·3	....
57.		....	....	22·2 *
58.		....	....	....
59.		27·2 f.	27·8 b.	....
60.	ξ	29·8 *	....	29·1 } f.
				31·1 } f.
61.		33·7 f.	34·4 b.	32·7 } f.
				33·7 } f.
62.	ο	37 f.	.. ..	35 f.
63.			....	....
64.		....	42·3 f.	....
65.		....	....	45·9 f.
		....	....	49·5 f.
		....	51·5 f.	52·1 f.
		....		55·4 f.

TABLE XVIII.—Potassium.

		Air.	Hydrogen.	
		C.P.	C.P.	R.
1.	32°	....	....	....
2.	α	38·4 *	38·7 *	....
3.	α'	39·7 b.	41·6 f.	....
4.		42·6	....	....
5.		45·5	....	....
6.	β	....	46·2 f.	46·2 f.
7.	β'	48·5 vb.	....	....
8.		50·1 vb.	49·8 f.	....
9.		52·7 f.	....	51·4 f.
10.		55 } *	53·4 f.	54·7
11.	γ	56·7 } *	56·3 *	56·7 *
12.		57·3 w^2b.	....	....
13.	32	....	....	59 f.
14.	33	....	....	....
15.		2 c.	2·6 c.	2
16.	δ	4·3 *	....	4
17.		....	....	6·7 b.
18.	ε	8·7 *	....	7·7 f.
19.	ε'	10·7 } b.	....	....
20.	ε''	11·4 } f.	....	....
21.		12 } b.	....	12·7 f.
22.		14 f.	....	....
23.	ζ	15·4 } n.	16	16 f.
24.		18 } n.	....	....
25.		19·4 f.	....	20·7 f.
26.		22·1 f.	....	....
27.	η	24·4 *	....	24·1 } b.
28.		....	26·1 c.	26·1 } b.
29.		28·1 b.	....	....
30.		31·4 } bn.	....	30·1 f.
31.		32·8 } n.	32·8 nb.	32·8 f.
32.	θ	33·4 } *	....	....
33.		....	....	34·8 f.
34.		36·4 c.	37·5 f.	37·8 f.
35.		39·1 c.	....	....
36.		41·4 w^2b.	42·1 *	40·8 f.
37.		44·1 c.	....	44·4 b.
38.		44·7 } b. 46·7 } b.	....	....
39.		....	....	....
40.		....	....	50·7 } n.
41.		52·3	....	five or six. }
42.	ι	54 f.	....	.... }
43.		....	....	.... }
44.	κ	56·3 *	55·9 n.	.... }
45.	κ'	57·2 *	....	57·2 } n.
46.	33 κ''	58·8 *	59·1 c.	....
47.	34	1·7 } f.	....	1·7 f.
48.		...... }	....	....
49.	λ	4·2 } f.	....	....
50.		6·2 } f.	6·5	....
51.		9·1 f.	....	7·8 c.
52.	μ	10·8 }	....	....
53.	μ'	12·1 } n.	....	....
54.	μ''	13·5 b.	....	....
55.		16·3 f.	16·7 f.	....
56.	ν	17·3 f.	20 6 *	20·3 f.
		19·6 b.		
57.		....	....	....
58.		23·2 b.	24·2 f.	23·9 f.
59.		25·2 f.	....	....
		27·2 c.		
60.	ξ	29·8 b.	28·5 n.	28·2 f.
61.		....	31·8 c.	....
62.	ο	35 b.	36·7 n.	....
63.		40 f.	....	....
64.		....	42·3 f.	....
65.		44·9 f.	....	
		48·9 f.	....	....
		51·5 c.	....	....
		55·1 f.	54·8	....

These spectra are in some respects peculiar, those of tellurium most so. In N, C.P., No. 36 is so like the distinctive band of hydrogen that at first I suspected the presence of that gas. The only difference I can find between them is that at the negative electrode it separates into two sharp and bright lines. Still one can scarcely see it, without thinking that there is some close connexion between Te and H.

I have already noticed the extreme brilliancy of its R. spectrum. It is very difficult to work with from its rapid dissipation at the negative electrode, which is so great that a wire 0·01 in diameter disappears in a few minutes; and the deposit is of extreme opacity. In H few lines were seen; for I was obliged to take them at a distance from the electrode, as it became invisible in a few seconds. With arsenic, H, C.P., I was more successful; the centre of the spectrum was a bright cloud, in which only the three bright bands and two or three others were visible. But at the negative boundary I got the largest number of lines, and the brightest that I ever met in H. The arsenic of course soon lined the tube (0·5 inch diameter) with a dark mirror, through which the flash seemed crimson; but an ellipse opposite the plates which form the slit remained quite clear. I suppose the induction of the brass on the tube caused this.

The potassium (air) is of great beauty; the double orange * is of as great intensity as with sodium. No. 7 is an odd-looking olive band. In H, C.P., only the second orange * remains, but it is very bright; the first one is entirely wanting, but reappears in H, R. On exhausting, the second retains its brightness when the rest have vanished.

TABLE XIX.—Sodium.

		Air.		Nitrogen.	
		C.P.	R.	C.P.	R.
1.	32°	......	......	36·5 vf.	......
2.		......	......	37·1 f.	......
3.		40·5 *	......	......	......
4.		41·5 n.	......	......	......
5.		49·5 *	......	48·1 c.	......
6.		......	......	......	53·4 *
7.		55·5 n.	56·3 *	55·3 vb.	......
8.	32	57·5 * vb.	......	......	......
9.	33	......	......	2·6 bn.	......
10.		3·5 n.	3 vf.	4 *	3·3 c.
11.		5·5 *	......	......	......
12.		8 n.	......	......	......
13.		10 n.	......	10·7 } c.	......
14.		11·5 n.	11·7 c.	12·4 } f.	12·4 nb.
15.		16·5 w.	......	17·7	15·7 f.
16.		......	21·7 } vf.	......	......
17.	η	24·5 *	25·4 } f.	25·4 *	26·1 c.
18.		......	......	28·1 vf.	......
19.		30·5 bn.	30·4 vf.	31·8 nb.	31·1 f.
20.	θ	33·5 *	33·4 f.	34·1 *	35·5 f.
21.		......	38·1 nf.	37·5 vf.	38·4 c.
22.		......	......	40·1 vf.	......
23.		41·5 w.	41·1 nf.	41·4 f.	41·7 c.
24.	33	45·5 } nc.	45·1	45·4 } c.	45·4 b.
25.		46·5 } nc.	......	47 } c.	......
26.	33°	51·5 nb.	51·3 c.	51·6 vf.	51·3 c. double.
27.		......	......	......	52 double.
28.		......	......	54 f.	......
29.		56·5 *	55·9 c.	56·6 f.	......
30.	33	57·5 *	......	57·2 b.	......
31.	34	0·5 *	1·1 f.	59·1 b.	......
32.		......	......	2·9 } nc.	......
33.		......	......	4·6 } nf.	......
34.		......	......	5·2 } nc.	......
35.		......	8·2 vf.	......	7·8 c.
36.	μ	10·5 c.	......	11·3 n.	......
37.	μ′	12·5 nf.	......	one here.	
38.	μ″	13·5 c.	13·4 vf.	13·1 nb. many here.	14·4 c.
39.		17·5 f.	......	......	......
40.		19·5 c.	19·3 vf.	......	20·3 c.
41.		28·5 bw.	26·8 c.	......	27·8 c.
42.				30·1 bn.	31 nf.
43.		......	......	33·1 f.	34·7 nf.
44.		......	......	37·3 f.	
45.		......	......	39·6 nf.	......
46.		......	......	45·6 f.	......
47.		......	......	52·8	......

The flash of the discharge is white, with a dense yellow atmosphere, to which I think the sodium line No. 8 is due. The Air, R. spectrum is, with the exception of this line, very faint.

Table XX.—Graphite.

		Air.	Nitrogen.	Oxygen.	Carb. oxide.	
		C.P.	C.P.	C.P.	C.P.	R.
1.	32°	......	......	......	33·9 o.	......
2.		......	36·3 n.	......	......	35·8 fo.
3.		39 *	39·8 f.	37·7 c.	38·4 *	38·4 fo.
4.		......	41·8	......	40·3 f.	......
5.		44	......	43·3 f.	42·9 f.	44·2 fo.
6.		......	45·6 vf.	46·2 f.	45·5 f.	......
7.		......	48·1 *	48·5 *	48·1 f.	......
8.		50	......	......	50·1 c.	51·1 c.
9.		......	52·5 nf.	52·7 n.	......	......
10.		56 *	54·2 *	55·3 *	56 b.	56 c.
11.	32	......	......	......	58·3 nc.	59·3 c.
12.	33	......	1·8 vn.	2·3 bvn.	2·6 b.	2·6 c.
13.		5 *	4·9 *	4 *	3·6 b.	......
14.		......	6·1 f.	6·7 c.	6 nf.	6 n.
15.		......	......	......	......	7·3 *
16.		......	8·7 vb.	9 vb.	8·3 f.	8·7 f.
17.		10 b.	10·2 b.	10·4 c.	10·4 f.	10·7 f.
18.		11 b.	......	......	11·4 f.	11·7 nc.
19.		13 b.	12 b.	12 c.	12·7 f.	......
20.		......	14·6 vf.	15	15 n.	14·7 f.
21.		......	16·4 vf.	...	......	......
22.		18·5	18·1 vf.	18·4	18 f.	......
23.		......	19·9 vf.	20·7	20 nc.	21 f.
24.		......	22·8 vf.	23·4 b.	22·7 nc.	......
25.	„	......	24·6 *	25·1 b.	......	24·1
26.		26 *	......	26·7 f.	26·1 *	25·4 *
27.		......	......	......	27·1	27·1
28.		......	30·2	29·4 vf.	30·8 c.	......
29.		31·5	......	32·1 nb.	......	......
30.		34 *	33·3 *	34·1 *	35·8 f.	......
31.		......	36·5 f.	37·5 nb.	36·3 nb.	......
32.		......	39 vf.	38·1 f.	37·5 n.	......
				38·8 f.		
33.	33	42	41·4 bw.	41·4 bw.	41·4 b.	......
34.	33°	45 *	45·2 b.	45·4 b.	......	......
35.		......	46·2 b.	46·7 b.	46·7 n.	46·7
36.		......	49·1 f.	49·3 f.	......	47·9 nc.
37.		......	51·6 c.	52·6 n.	51·3 *	51·3 nc.
38.		53·5 f.	54·2 c.	54·3 n.	53·6 nc.	52 b.
39.		56 *	55·9 *	56·3 * double.	55·3 *	......
40.		......	57·2 *	58·2 fn.	57 c.	57·9
41.	33	58·5 *	59·1 vb.	59·8 *	59·1 *	......
42.	34	......	2 nc.	......	......	......
43.		3·5 com- pound.	3·8 nc.	......	......	......
44.		......	5·7 nc.	......	......	6·5
45.	μ	9	......	9·5 vn.	9·1 c.	......
46.	μ′	... ...	10·7 nvb.	11·8 vn.	10·1 c.	......
47.	μ″	13	12·4 nb.	13·4 vb.	13·1 *	......
48.		......	seen.	......	14·7 f.	15 f.
49.		......	16·7 f.	16 vf.	17 b.	17·3 f.
50.		......	19·6 f.	18 n.	19 b.	18·6 f.
51.		......	......	19·9 vb.	20·6 n.	......
52.		......	22·3 f.	21·9 n.	21·9 b.	23·2 f.
53.		......	24·3 f.	......	......	
54.		......	27 f.	25·8	27·2 *	......
55.		......	30·3 b.	29·8 c.	......	......
56.		......	33·5 nc.	......	35 c.	......
57.		36·5	36·7 nc.	35 b.	36·3 n.	......
58.			38·9 vf.	39 doubtful.	38·3 n.	......
59.		......	41·9 vf.	42·3 n.	42·3 nc.	......
60.		......	44·8 nc.	......	44·6 n.	......
61.		......	......	45·6 n.	45·6 fn.	......
62.		......	47·5 vf.	48·9 b.	47·5	......
63.		......	51·4 vf.			......

The electrodes were two of Mordan's "leads," and must have been nearly pure; for fragments of them burnt before a gas blowpipe without leaving any sensible residue. The discharge was white except in CO, R. Air, C.P., was taken with Merz, and at an early period.

The next spectra were taken in hopes of obtaining an easy mode of determining the lines due to gases. In the first, electrodes of mercury send the discharge through the vapour of that metal; its lines therefore belong to Hg *exclusively*. Then filling the same apparatus with any gas, the new lines which appear must belong to *it* exclusively; or if (as in the case of platinum, Table II.) the electrode be of a metal on which Hg does not act, *its* lines can be insulated; this, however, assumes that the lines of electrodes and media are independent.

TABLE XXI.—Mercury.

			Mercury vapour.	Nitrogen.		Hydrogen.	Carb. oxide.	
				C.P.	R.	C.P.	C.P.	R.
1.	32°		....	36·5 vfo.	....	....	....	....
2.		α	38·4 fo.	....	....	38·5 *o.	38·1 f.	....
3.		β′	48·1 f.	49·1 c.	....	48·8 b.	48·5 *	....
4.			50·9 f.	....	50·7 vf.	50·7 f.	49·8 cn.	....
5.			....	....	52·1 vf.	....	52·7 f.	52·7 vf.
6.			53·2 f.	....	....	....	53·7 f.	....
7.			54 f.	....	....	54 n.	....	....
8.		γ	....	55·7 } b.	55·3 vf.	....	56·3 b.	56 f.
9.			56·9 f.	57·3 } b.	....	....	....	....
10.			58·6 } *	....	58·6	58 c.	58·6 } *	58·6 f.
11.	32		59·7 } *	60 } *	....	59·6 *	59·3 } *	....
12.	33		2·6 nc.	0·6 } *	....	....	3 b.	2 c.
13.		δ	3·3 c.	....	....	3·3 *	....	....
14.			....	4·6 b.	....	....	4·6 nb.	....
15.			6 c.	....	6 vfn.	6 } n.	....	5·6
16.			....	7·3 f.	....	7·3 } n.	6·7 nb.	....
17.		ε	8·7 vn.	8·7 fw.	....	8·7 } f.	8·3 nb.	....
18.			....	....	10·7 *	....	10·7 vn.	10·7 f.
19.		ε′	11·5 *	....	....	11·4 *	11·4 *	....
20.		ε″	....	12·7 *	....	13 b.	12·7 nc.	13·4 b.
21.			14 vf.	14 nc.	14·7 vfw.	....	....	....
22.		ζ	....	17·4 nf.	....	16 f.	15·4 f.	17 n.
23.			19·2 vf.	18·7 nf.	19·4 f.	19·4 b.	18·7 f.	....
24.			....	20·7 nf.	....	20·7 f.	....	21·4 nf.
25.			23·3 vf.	23·4 f.	22·7 } f. several. }	22·4 b.	22·1 f.	....
26.		η	24·7 b.	....	...... }	24·7 f.	24·7 b.	....
27.			26·4 c.	26·1 b.	25·4 } f.	26·4 b.	26·1 b.	26·1 vb.
28.			27·9 c.	28·4 f.	28·1 } group. }	28·1 n.	....	....
29.			29·9 f.	....	.... }	29·8 } b.	30·1 b.	....
30.			31·1 f.	32·1 f.	32·1 }	30·8 } b.	....	31·4 vf.
31.		θ	33·2 f.	33·4 *	....	32·8 n.	....	....
32.			35·6 f.	....	34·8 vf.	35·5 b.	35·1 nb.	....
33.			....	36·8 vf.	....	....	37·1 nb.	....
34.			38·3 c.	....	38·4 c.	38·5 f.	37·8 nb.	....
35.			41·1 vb.	40·4 vf.	....	41·2 $*w^{5}$.	40·8 vf.	41·4 vf.
36.			43·5 b.	....	43·4 c.	....	43·1 f.	....
37.			45·4 fn.	45·4 c. double.	....	....	45 c.	....
38.			47 vf.	....	....	....	47·4 nc.	46·4 *
39.			49·3 fn.	....	....	....	49·3 } *	....
40.			50·3 vn.	50 vf.	50 fn.	....	50·7 } *	....
41.		ι	52·1 f.	....	....	....	52·6 } *	....
42.			53·1 f.	53 f.	....	....	...... }	....
43.		κ	55·3 vf.	....	54·7 w.	55·1 vf.	55·6 } *	54·1 f. many.
44.		κ′	56·9 f.	56·6 vb. double.	....	....	....	....
45.	33		....	58·5 b.	....	....	57·9 n.	....
46.	34	κ″	0·5 f.	1·7 } bn.	1 c.	....	59·1 c.	....
47.		λ	5 } c.	4·2 } bn.	....	....	4·2 vf.	....
48.			6·2 } c.	5·9 } bn.	6·9 c.	7·5 vf.	....	....
49.		μ	9·5 vf.	10·1 } b.	....	....	9·5 vf.	8·5 w.
50.		μ′	12·2 vf.	12·1 } b.	....	....	10·8 vf.	....
51.		μ″	....	....	13·1 vfn.	14 vfn.	13·4 nc.	13·7 vf.
52.			15·7 nf.	....	....	....	....	....
53.			18·2 *	18 *	17·7 *	18·3 *	18 *	18 nc.
54.		ν	22·9 nc.	....	20 f.	20·7 $*w^{7}$.	21·6 b.	21·3 f.
55.			25·9 f.	....	26·8 f.	....	25·8 b.	
56.			28·5 f.	29·1 vb.	....	....		....
57.		ξ	33·5 f.	33·1 nc.	34·1 f.	31·8 vf.	....	....
58.			....	36 c.		....	....	....
59.			42·9 vf.	....	....	43·6 vf.	....	....
60.			47·4 nf.	....	....	....	....	....
61.			50·9 c.	51·5 f.	....	51·5 vf.	....	....

I failed totally in getting the O spectra; for at the very first discharge the mercury was so rapidly oxidated that not a glimmer could pass the thick deposit on the tube. This singular energy is probably due to the presence of ozone in the electrolytic oxygen (though it was passed through a tube filled with silver-leaf). I shall repeat the experiment, passing it through a red-hot tube. This fact may explain the absorption of oxygen in Geissler tubes, which was observed by PLÜCKER; for Hg vapour must be present in them, as they are exhausted by a mercurial air pump. The deposit in CO was black below, grey above: the first was dissolved by nitric acid, the other not; it was probably some form of carbon from the decomposition of the gas; of that, however, there was a large residue present. The spectrum of Hg vapour has a few very brilliant lines, but the rest are narrow and faint on a very dark ground. I had expected by comparing it with Pt, Hg vapour, Table II., to obtain at once the lines of platinum, which I supposed would be *superadded* to those of Hg; but, to my great surprise, that spectrum has *fewer lines* (28, while the other has 48), and only three occur in it which the other wants. A similar deficiency occurs in the gas spectra of Table XXI.: N, C.P., wants 22 mercurial lines; N, R., 25; H, C.P., 20; CO, C.P., 12; and CO, R., 30. These observations, it must be remarked, are strictly comparable; they were all made with the Duboscq prism, nearly at the same time, and with the apparatus in precisely the same condition.

From this may be inferred, either that mercury gives different lines from its vapour, or that the gaseous media have lines which interfere with those of the electrodes so as to destroy each other.

I must reserve for a second communication the complete discussion of these and the other spectra, as it would, I fear, swell this one beyond all reasonable limits.

[P.S. (See page 954.) A more probable explanation of this peculiar form of the spectrum was suggested to me by Mr. STOKES, which is as follows:—

The aperture of the collimator was 1 inch, and its focal length 9·5 inches. The distance of the spark from the slit was probably less than 1·5 inch, say 1·25. Hence if we assume for simplicity that all the light emerging from the collimator entered the object-glass of the observing telescope, which was nearly true, each element of the slit would be capable of being illuminated by rays from a length $l=\frac{1\cdot25}{9\cdot5}\times1=\frac{1}{7\cdot6}$ inch of the spark, provided the spark reached so far, the centre of that line being in a prolongation of the line joining the centre of the object-glass with the element in question. If the length of the spark were very great compared with l, the central parts and those near the electrodes would illuminate widely separated elements of the slit, and the variations of brightness in a vertical direction would nearly correspond with the real variations of brightness of the different parts of the spark—though of course there would be a "ragged edge" above and below, where the spectrum was formed by partial pencils. If, on the other hand, the length of the spark were infinitely small compared with l, each illuminated element of the slit would receive rays from the whole spark, and the spectrum would be a band of uniform brightness in a vertical direction, and terminating abruptly above and below. In the actual experiment the length of the spark was $\frac{1}{16}$ inch, a quantity comparable with l, being a little less. Hence the spectrum would consist of a central stripe of uniform brightness, corresponding to the small portion of the slit illuminated by the whole of the spark, accompanied above and below by a ragged edge in which the illumination fades away, as more and more of the spark is cut off, till nothing is left but the rays coming from its very extremity. The distance from the central stripe to which the illumination would be perceived to extend would depend on the intrinsic brightness of the part of the spectrum regarded; and, bearing in mind the relative brightness of different parts as laid down by FRAUNHOFER for the solar spectrum, we should get for the visible boundary a curve similar to that represented in the figure. —March 1863.]

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On comparing these Tables, it is seen that the *places* of a very large proportion of these lines are identical, or at least differ only within the limits of observation, although they may be very unlike in brilliancy and magnitude. Such lines must be considered the same; for the essence of a ray is its wave's length, and the difference of intensity is but an accident depending on extrinsic causes. That this comparison may be more easily made, I have given in the following Table the mean places of those whose identity is probable: except in the spectra of iron, copper, and many of carbonic oxide, such are the great majority of what I have observed. For the conspicuous ones, which I have denoted by Greek letters, and which are recognized by peculiar characters, as also for some others which stand in definite relation to them, the means were taken without strict reference to probable errors; for the rest those limits were taken which I have already mentioned. It is possible that in several of the latter class one or two of the outliers may not belong to them; but the general agreement of each is so close as to preclude doubt. I include in the Table none beyond FRAUNHOFER'S H, though several were observed, and also omit the very faint red lines which were visible in some spectra outside the bright part*. It gives for each the mean place, the extreme deviations from that mean, the number of C.P. spectra in which it is found, in how many of these it is a *, and the same data for the R. spectra.

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* Especially in manganese, A, C.P. This splendid spectrum, which had 74 lines, is not given, as it was not taken in R. or other gases.

TABLE XXII.

No.	Place.	Diff.	C.P.	*	R.	*	
	° ′						
1.	32 33·80	−1·10 +0·70	3	0	4	0	All the R.s in N.
2.	32 37·43	−0·92 +0·27	17	5	5	0	
3 α.	32 38·68	−1·18 +1·02	76	55	19	2	6 metals show it in all the gases, A has all in N and O.
4 α′.	32 40·62	−0·90 +0·98	55	10	7	0	Often seen, but overpowered by α.
5.	32 42·36	−0·86 +0·54	16	1	7	1	
6.	32 43·34	−0·34 +0·56	14	1	2	0	
7.	32 44·96	−0·96 +0·46	24	0	4	0	O predominates, 5 of N and 9 O wanting in A.
8	32 45·72	−0·72 +0·78	31	0	5	0	
9 β.	32 47·63	−0·55 +0·57	31	11	5	0	In this and the three preceding A has no R.
10 β′.	32 48·78	−0·78 +1·52	60	19	10	0	Rose-red. In C.P., A has all the metals' except β.
11.	32 50·35	−0·33 +0·57	24	2	21	1	10 of N and O wanting in A.
12.	32 51·43	−0·63 +0·57	13	2	43	1	Notable predominance of R.; has few common to C.P.
13.	32 52·56	−0·57 +0·43	22	2	20	4	
14.	32 53·48	−1·48 +0·52	6	0	5	0	Very faint; the companion of γ, always seen with S^2C prisms.
15 γ.	32 55·08	−2·08 +1·62	69	46	38	3	Orange; in 16 cases it was resolved in the glass prism.
16.	32 56·21	−0·51 +0·79	20	7	20	1	
17.	32 57·60	−0·70 +0·40	28	1	11	1	No A in N, or N in A.
18.	32 59·02	−0·72 +0·68	24	4	39	2	6 of A not in N or O; 7 of them not in it.
19.	33 0·36	−0·76 +0·64	22	2	26	2	Similar discordance.
20.	33 1·66	−0·66 +0·34	20	0	13	0	Mostly N; 8 of it wanting in A.
21.	33 2·85	−0·60 +0·20	37	5	20	0	Companion of δ, generally vn but vb; always I believe present.
22 δ.	33 3·55	−0·95 +1·45	77	44	35	0	Pure yellow, with 5 metals in all the gases; in A and N with all the metals.
23.	33 6·16	−0·66 +0·54	30	2	34	6	Most frequent in CO.
24.	33 7·09	−0·29 +0·81	22	2	41	9	Many fine lines shown in this region by the S^2C prisms.
25.	33 8·37	−0·37 +0·33	25	1	15	3	
26 ε.	33 9·21	−0·91 +0·79	51	5	16	2	Bright green, well characterized.
27 ε′.	33 10·29	−0·49 +0·41	50	2	12	1	Separated from ε by a dark interval.
28.	33 11·23	−0·53 +0·27	32	2	23	2	More frequent in A than N; often too faint to be surely bisected.
29 ε″.	33 12·12	−0·42 +0·68	40	0	30	2	In CO many very fine lines here.
30.	33 13·28	−0·28 +0·52	22	0	14	0	The green ground bright, especially in CO.
31.	33 14·55	−0·85 +0·45	30	1	31	0	
32.	33 15·61	−0·61 +1·09	33	3	29	0	These three are chief in a group which was at first observed as a bright band, and named ζ. The whole ground seems covered with lines, of which 33 is chief.
33.	33 17·17	−0·67 +0·85	52	6	25	0	
34.	33 18·65	−0·65 +0·35	21	1	11	0	
35.	33 19·81	−0·61 +0·39	25	1	23	0	
36.	33 20·93	−0·80 +0·60	31	0	23	0	Most common in CO.

TABLE XXII. (continued).

No.	Place.	Diff.	C.P.	*	R.	*	
37.	33° 22′·74	−0·74 +1·26	52	8	29	6	
38 η.	33 24·52	−1·02 +0·78	63	32	63	25	One of the brightest and most common. With five metals it occurs in every gas.
39.	33 25·82	−0·42 +0·88	45	13	30	3	
40.	33 27·84	−0·84 +0·96	30	1	24	0	
41.	33 29·71	−1·01 +0·79	31	2	43	1	
42.	33 30·93	−0·53 +1·37	65	0	31	1	vb, but n; all the metals in A, all but two in N.
43.	33 32·13	−1·03 +0·67	19	0	11	1	This and the preceding are evidently connected with θ.
44 θ.	33 33·48	−1·48 +1·52	72	50	42	1	Generally brightest of all, bluish green perfectly characterized.
45.	33 35·59	−0·79 +0·41	27	0	25	0	First of blue, overpowered by glare of θ.
46.	33 36·62	−0·52 +0·78	42	1	16	0	Sb is wanting in this and the next.
47.	33 38·00	−0·99 +1·00	37	0	29	1	
48.	33 39·49	−0·49 +1·01	37	3	33	1	
49.	33 41·25	−0·75 +0·85	69	18	48	3	C.P., Al, Pd, Fe have it in all the gases. It is the H blue band.
50.	33 42·86	−0·86 +0·64	11	3	19	10	Well marked; specially bright in R.
51 ϛ.	33 44·49	−0·99 +1·31	55	7	69	0	First of a well-marked pair, universal in A and N, C.P.; frequent in R. with all.
52 ϛ′.	33 46·30	−1·30 +2·30	63	2	20	3	The two extremes very faint; Cd absent in C.P.
53.	33 48·73	−0·73 +1·77	55	9	28	0	Seems connected with the next.
54 ι.	33 51·09	−1·09 +1·59	82	28	52	1	With S^2C prisms multiple; perhaps the components are sometimes unequally developed.
55.	33 53·38	−1·18 +1·32	66	8	42	0	Generally like a hair, vb, a faint one follows.
56 κ.	33 55·33	−1·33 +1·27	77	58	38	1	These are often very intense in C.P.; they are brilliant blue.
57 κ′.	33 56·58	−0·58 +1·12	46	42	7	0	
58.	33 57·32	−1·30 +1·48	30	1	2	0	vn; I think always present; the * is with Na.
59 κ″.	33 59·08	−2·08 +1·92	81	57	26	0	Beginning of violet.
60.	34 1·12	−1·12 +0·88	28	1	34	1	
61 λ.	34 2·72	−0·72 +0·88	38	1	8	0	These were at first seen as one band before the apparatus was complete. In the C.P. spectra of CO, the ground is covered with fine lines.
62 λ′.	34 4·15	−0·65 +0·85	44	1	8	0	
63 λ″.	34 5·82	−0·92 +0·68	39	1	36	7	
64.	34 7·31	−0·51 +0·49	17	0	29	2	
65.	34 8·46	−0·46 +0·64	34	1	18	0	
66 μ.	34 10·31	−1·31 +0·99	67	13	8	0	A well-marked group in C.P., distinct in almost all the metals and the gases except H. Its parts are all found in R. but in different spectra. The * in μ″ R. belongs to Te.
67 μ′.	34 11·93	−1·03 +0·97	57	14	10	0	
68 μ″.	34 13·71	−0·91 +1·19	64	10	43	1	
69.	34 15·75?	−1·75 +1·05	42	3	22	0	With C.P., Ni, Co; and R., Cu, in all the gases.
70.	34 17·40	−1·20 +0·80	58	9	33	3	
71.	34 19·03	−0·73 +0·87	50	5	35	2	Some of these, especially in H, probably belong to No. 72.
72 ν.	34 20·78	−1·28 +2·02	64	13	35	1	In H it is developed into the violet band, whose cloudiness and width explain the range of the measure.

TABLE XXII. (continued).

No.	Place.	Diff.	C.P.	*	R.	*	
73.	34° 22′·99	−1·19 +1·51	33	1	23	0	None in H, C.P.; four in H, R.
74.	34 25·56	−1·36 +0·94	55	9	22	0	Frequent in N and O.
75.	34 27·45	−0·95 +0·75	38	13	37	2	Only one metal wanting in N, R.
76 *ξ*.	34 30·09	−0·92 +2·01	63	20	18	0	N, C.P. with all.
77.	34 33·43	−1·63 +1·27	51	1	38	1	The two *s are Al, O; Te, N.
78 *ο*.	34 35·83	−0·83 +1·67	53	1	19	0	All with Pb, C.P.; the * is Ca, H.
79.	34 39·03	−1·53 +1·27	43	0	19	0	None in H, C.P. These far-violet are ill defined and hard to bisect.
80.	34 41·85	−1·85 +1·85	42	0	28	0	Few in H and A.
81.	34 44·80	−1·85 +1·85	51	0	12	0	With Co, C.P., in all the gases.
82.	34 47·73	−1·22 +1·77	42	0	13	0	Most frequent in CO.
83.	34 51·35	−2·15 +1·45	30	0	14	0	O has only Zn in C.P. and Mg in R.
84.	34 55·81	−2·31 +1·89	15	0	6	0	None in O, C.P.
85.	34 59·34	−2·24 +1·66	10	0	8	0	

Among the most notable of these are,—

No. 3 *α*. It is one of the three brilliant bands in H, C.P., and is more intense in that gas than in any other. Its mean from 22 of H, C.P., is 32° 38′·52, almost identical with the general mean. It is also extremely intense in other gases, *e. g.* A, with silver and iron; at other times dull or even faint. In H it is generally separated by a dark space from the rest of the spectrum, as if the other red rays were condensed into it. It seems to have a fine line preceding it, which in many cases is separated enough to be bisected. In R. it is of much less importance; its place is that of FRAUNHOFER'S C.

No. 12 is remarkable for its much greater display in R. than in C.P.; the same occurs, though in a less degree, in Nos. 18, 24, and 64.

No. 15 *γ*. This beautiful band is nearly, but not exactly, in the place of D, and like it is double, though my glass prisms often fail to divide it fairly. With the two prisms of S^2C the components are generally equal, but I think further apart than those of D with the same prisms. In K, A, they are seen separate as intense *s; in CO the second is often the brightest. In O it is often dull and sometimes wanting (and the same may be said of the orange and yellow lines generally).

No. 16 coincides with the yellow band of sodium. In the A spectrum of this metal, No. 15 *γ* is only nb; in N it is a *, but No. 16 is far more brilliant; it retains its brightness during exhaustion and with the spark discharge. It is exactly in the place of D.

Nos. 18 and 19 are intense orange *s in mercury vapour with electrodes of mercury.

No. 22 *δ* is another beautiful band of common occurrence. In C.P. five metals have it in all the gases; A and N have it with all the metals, though of very unequal brightness; O with 11, H with 12, and CO with 19. It seems to be connected with No. 21, the ordinary character of which is bn. When examined with the S^2C prisms it is triple, the first being very narrow but bright, with a slight tinge of orange, the second and third pure yellow, the second broader than the third, and both sharply defined.

Nos. 26 to 29 form a very conspicuous group. The first, ε (which begins the green), is marked by the very obscure interval which separates it from the others; it as well as ε'' are double, and the S^2C prisms show many fine lines in their neighbourhood. With iron, copper, and in many of the CO spectra, the number of these is very great; it may be that the bright green from this to No. 44 is composed of such lines too close to be resolved; but I think it is continuous.

No. 36 is nearly in the place of E.

No. 38 η is very conspicuous on this bright ground; it is often intensely brilliant, sometimes more so than θ, and it occurs more frequently. No. 37 seems to belong to it; with the S^2C prisms, and sometimes with the glass one, it is double of two equal. Its brightness is scarcely developed in O, C.P., very much in N, but quite as much in O, R., as in N, R. CO, R. exceeds them both, though it has only 2 *s in C.P. With platinum, CO, C.P., it is replaced by a bright bluish-green band of singular appearance; this by careful focusing shows eleven or twelve fine lines, of which No. 37 is the first and No. 42 the last. In this spectrum the group ε, ε'' is also replaced by some twenty-five very fine lines from No. 23 to No. 36. The place of η is identical with the centre of the double line of *b*.

No. 44 θ, with its companions 42 and 43, is very common, though the latter, 43 especially, are hard to see in the blinding glare of the first, which is often most intense. They are always seen with S^2C prisms, which also show θ double (as Duboscq does occasionally). The components are generally, but not always, equal*. Though frequent in R. it is seldom bright. In C.P., N brings it out best; it is wanting in 8 of O, 8 of H, 5 of CO; and of its 50 * O has but 4, H 1, and CO 3; one belongs to mercury in mercury vapour. It ends the green.

No. 49 is remarkable, not only from its being in the place of F, but also from its being (or being in) the characteristic blue band of H, C.P. In the other gases and vapours it is scarcely ever a *, and often faint; here it is of great brightness and great breadth, often 6' or 7'. It has a cloudy but irresolvable look, and its edges are not sharply defined. Even with 2 S^2C prisms I cannot resolve it; and it gives me the impression that it consists of light whose wave-length varies continuously. Its mean by 22H, C.P., is $33^\circ\ 41'\cdot18$, corresponding to a wave length 1798. It is singular that the N, C.P., spectrum of tellurium has a band possessing this peculiar type so decidedly that one who saw it without knowing its origin would undoubtingly assert the presence of H; and my first idea was that this gas must be a component of the metal. If, however,

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* In this, as in similar instances, I suspect that an unequal development of the components may disturb the measures. I may at the same time notice another cause of disturbance, the flicker of the light. It might be supposed that the collimator must give an object absolutely fixed, but this is not the case. The discharge being narrower than the slit and at some distance from it, and the want of perfect achromatism in the object-glass, are capable of producing considerable unsteadiness.

the eye be directed to the negative boundary of the spectrum, two brilliant points are seen there not found in the ordinary H band. At the same time they may be due to the grosser metallic vapour which abounds there; for Te volatilizes under the discharge more than any other metal which I have tried. Iron in N, if the pressure be diminished a few inches, shows a similar band, though the other characters of the C.P. spectrum and discharge are unchanged. Zinc in CO, C.P., has one of the same sort 3′ broad.

Nos. 51 and 52 are a well-marked pair; but a much more remarkable group is that from No. 54 *ι* to No. 59 *κ″*. Of these, 55 and 58 are very narrow, and, though bright, are often overpowered by the splendour of their neighbours; the first has a still fainter follower seen in the S^2C prisms, which also show each of the brilliant ones to be compound, *ι* and *κ* double, *κ″* (which begins the violet) to consist of six fine bright lines. In thirty-two cases *κ* and *κ′* were observed as one, or as close double. When taken separately, their distance was found 0′·96; and hence the place of *κ* should be increased, and that of *κ′* diminished by 0′·14. H is unfavourable to this group, which is most splendid in O and CO, except in Cu, CO, C.P., when it is but a shadow of itself.

The ground is covered with very fine lines from No. 61 to No. 68 in the CO, C.P., spectra of Cu, Pd, Fe, Bi, Sb, and Mg.

No. 72 *ν*, besides being important in the spectra of other gases, is apparently developed in H, C.P., to the broad violet band, the third of the three brilliant ones of that gas; 22 of H, C.P., give its place 34° 19′·82. It is not nearly so luminous as No. 49 is in H, but is quite as broad and even more undefined. Unlike other violet bands, this is the first to disappear on rarefying the gas. I have occasionally seen fine lines in it, which, however, do not seem to belong to it.

No. 73 is in the place of G, and No. 85 very nearly in that of H.

If the individual spectra be compared with this Table, the result will, I think, throw some light on the questions which I mentioned at the beginning of this paper.

1. As to the *essential* connexion of each line of a spectrum with the chemical nature of some one metal, or some one gaseous medium, I think these observations are against it. For instance, if any line, say No. 22 *δ*, be found with electrodes of aluminium in all the gases which we have examined, our first inference might be that it is an aluminium line. But when we find the same thing is true of nickel, palladium, antimony, and magnesium, and that all the other metals have it in some of their spectra, we must conclude that it does not belong *exclusively* to any metal; nor can it be considered a gas line. In N it is indeed found with all the twenty-two electrodes; but it also occurs nine times in O, fourteen in H, as well as in the vapours of mercury, phosphorus, and bisulphuret of carbon. There are many similar cases; and though in general the lines of this Table are not seen with all the metals, yet it will be found that, with respect to gases (omitting No. 1, which on account of its bright neighbours is seldom seen), out of the whole eighty-five only Nos. 5, 6, 9, 73, 79, and 85 are wanting* in H, C.P.; only No. 6 in CO, and that of these all but No. 5 are found in the R. spectra, and *none* are wanting in A, N,

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* That is, are not visible with my means of observing.

and O. As to metals, the lowest number, 12, occurs in No. 85; but the average is far above this.

These facts may be explained in two ways. We may suppose that the action of the electric discharge on the molecules which transmit it has in itself intermittences which *tend* to produce maxima of light recurring at intervals, and which are effective in doing so when the forces inherent in these molecules are in accordance with them. If that accord be perfect, the development of light will be intense; but if imperfect or wanting, the corresponding light will be feeble or will vanish. Or it may be supposed that our metals and gases are compounds of unknown elements which are separated by the discharge, and exhibit their appropriate lines. This hypothesis is tempting, for if true it would at once lead to analysis of many of our supposed simple substances; and the facts which have been stated respecting the band No. 49 give some countenance to it. I however think the first view of the matter more probable, for reasons which I shall soon state. According to it, the existence of a luminous line merely indicates the presence of *matter* in the circuit; but its intensity depends on the nature of that matter, which may either make it extremely bright or obscure it, even to invisibility. It is generally supposed that the presence of a metal gives brilliant lines, and that those due to a gas or vapour are less bright; but as the two are always simultaneously present it is not easy to separate their influences. A promising plan of effecting this has been proposed by PLÜCKER. Two balls connected by a capillary tube were filled with any gas and then exhausted; the balls were coated with tinfoil, and when they were connected with the terminals of an induction machine *reciprocating* discharges took place, which, though very faint in the globes, were bright enough when condensed in the capillary part to give a spectrum. Here nothing but glass is in contact with the rarefied gas, and therefore he expected to obtain only gas lines. I repeated this experiment, adding a glass stopcock to one of the balls, that I might use the *same* glass with different gases. The spectra observed were the R. of N, O, and H; the first had 13, the second 23, and the last 13, besides several in each too faint to be taken. Of these were—

Common to three.	In N and O.	In O and H.	In O.	In N.	In H.
Nos. 18	Nos. 27	Nos. 49	Nos. 16	Nos. 14	Nos. 5
39	68	75	24	76	13
46			33	84	82
57			36		
61			41		
65			42		
78			44		
			48		
			52		
			54		
			72		

No. 5 is not in any other H spectrum; No. 82 only in Te, A and As, H; No. 16 only in PbO. None of these gas lines is peculiar to that one gas; thus No. 16 is found in N with nine metals and in H with five; this method therefore fails to give the true gas lines. Most of those that are common to two gases will be found in the spectra of sodium, potassium, calcium, and lead, all of which are ingredients of glass; it is hence evident that even reciprocating discharges disintegrate the surface of glass.

A plan of mine seemed more promising. With an apparatus which I have already described, I took the spectrum in mercury vapour with mercury electrodes; then filling the tube with a gas, I took the new spectrum. I tried N, O, H, and CO. O failed from its extraordinary action on the mercury, which in a few seconds blackened the tube, so that not a ray from the flash was visible. I expected that the gas lines would be thus easily obtained, but was disappointed.

Hg Hg	has 48 lines		
Hg, N, C.P.,	has 36 lines	N, C.P.,	has 10 not in Hg Hg
Hg, N, R.,	has 23 lines	Of these N, R.,	has 4
Hg, H, C.P.,	has 33 lines	H, C.P.,	has 7
Hg, CO, C.P.,	has 41 lines	CO, C.P.,	has 10
Hg, CO, R.,	has 18 lines	CO, R.,	has 8

Of these last Nos. 2, 46, 59, and 78 are found in N only (that is with Hg electrodes, for with other metals they occur in *all* the gases). Nos. 13 and 32 belong to CO, the rest are common to the three gases. It deserves notice that many of the lines of Hg Hg are wanting in the gases, the lowest number being 13 in CO, C.P., the highest (29) in CO, R. This may partly arise from mercury and its vapour having different sets of lines, the latter of which are displaced by those of the gas, fewer in number Were this the sole cause, the same lines would be missing in each gas spectrum; and the difference of the numbers shows that the presence of a gas actually *prevents* the development of some mercurial lines. Corresponding facts occur in other spectra, those of H especially.

The effect of a metal is most perceptible near the negative boundary of a spectrum, where some lines are brilliant for a short distance and then continue with much less brightness. The contrast is so great that, without measurement, one could scarcely believe the line to be the same. That its existence in the faint state is due to that metal which causes its partial splendour, is disproved by its occurring with other metals. In illustration I refer to the spectrum of bismuth (N) at the negative edge as compared to that of the centre (Table XII.), where it is seen that though lines (especially in the green) which are scarcely visible in the latter are intensely bright in the former, and faint single lines are seen as two, yet no decidedly new one appears. This is most remarkable with the volatile metals. Thus As, H, C.P., shows at the negative edge forty-four lines, of which ten are ∗s and eleven more are "bright." These retain their lustre for 10′ or 11′, and then (except the three hydrogen bands) can scarcely be traced across.

None of these, however, are peculiar, except that Nos. 11, 17, and 54* appear as double.

That the presence of a new body in the circuit developes oftener than originates lines, is further shown by moistening the electrodes with a solution of some salt; for instance, chloride of barium†. In trying it, platinum electrodes (carefully washed with nitric acid and distilled water) were lapped with *clean* cotton thread to retain the fluid, which, however, soon evaporates by the heat of the discharge. The change of the spectrum is almost startling from the instantaneous and intense development of many lines, and the increased lustre of some which before had been noted as *s. The most conspicuous are—

	°	′
α. Very bright	32	38·1
α′. * very intense		40·0
β′. * dazzling		49·1
γ. Very bright		54·7
No. 16. Orange intense		56·3
No. 17. Very bright		57·7
No. 34. * very intense	33	18·4

Nothing striking till θ, then

No. 47. * brighter than θ		37·4
No. 48. Almost *		39·4
λ. * of exceeding intensity	34	2·3
λ′. Very bright		4·6
No. 80. Extremely bright		40·6

All these are found in the platinum air spectrum, though in most cases with a totally different aspect; so that the barium makes no change in the place of the lines, but only in their brightness.

2. That the peculiar character of a line is modified by other circumstances than the chemical nature of the bodies engaged in producing it, appears from the difference between the spectrum at common-pressure, the transition spectrum, and that in rarefied gases, to which I have already referred. The chemical conditions are unchanged; but at first sight nothing is more dissimilar than the three; the first with its numerous bright *s; the second a shadow rather than a spectrum, with a bare suspicion of a few lines; and the R. one much brighter, but with a seeming discrepancy of lines that marks it as peculiar. The R. has, on an average, 0·53 of the C.P. lines; it extends as far in the violet, but is cut off in the red part. There, especially in N, are often found a set of equal bands reaching from No. 11 to No. 19 inclusive; there is also another set, that

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* This line is always double with S^2C prisms.

† It is desirable to ascertain whether this process gives a spectrum always identical with that given by electrodes of the metal contained in the salt. The difference of aggregation and the presence of water may modify it considerably.

looks like a row of luminous pillars, from No. 53 to No. 77. In general the R. spectra are much fainter than the C.P.; the brilliant No. 3 α, 15 γ, 22 δ, 44 θ, and the κ group are inconspicuous, though often present. On the other hand, some are occasionally brilliant; thus 38 η occurs as * twenty-five times; 23 and 24 have more *s in R. than C.P.; and the R. spectrum, Te, N, is positively splendid with thirteen *s. But I think there is no instance of a line† occurring in any R. which is not found in some C.P., or *vice versâ*. These differences may be attributed to three causes. First, the discharge which at C.P. passes in a flash of, probably, evanescent section, must be very much brighter than when diffused in a tube of 0·2 inch diameter, which it fills completely. This would account for the lines being fainter, but not for the difference of character. In a compound tube of two pieces, 0·5 inch diameter connected by one 0·05 inch, with lead electrodes, A., R., the spectrum in the narrow part had more lines than in either of the wider, as being brighter; but it contained all theirs, and was quite distinct from the C.P. Secondly, it may be thought that the air is less heated, because of the less resistance and the greater heat-capacity of rarefied gas. Were this the principal cause, the R. ought *never* to contain more lines than the corresponding C.P., much less have any as a * which is faint in the other; the transition-spectrum, too, should be more luminous than the R. Thirdly, the mere increased distance of the gas molecules *may* modify the light-vibrations. This is mere guess; but so is much more of our speculation on this mysterious subject, and it may at least point out the road for future research. Experiments at pressures greater than the atmospheric, produced by mechanical force or heat, and with electrodes in various states of aggregation, would probably throw light on the subject. One thing must be remembered: in these R. discharges the light, when viewed in a revolving mirror, has a certain permanence; but in the C.P. it is, so to say, instantaneous.

3. It is generally believed that each of the bodies present in the track of a discharge has its own independent spectrum, coexisting with those of the others and in nowise interfering with them. This is not universally true, as will be seen by comparing the spectra of air, both C.P. and R., with those of its components N and O. Without going through the entire series, but taking the first twenty-five numbers of the Table, and the last, I find that out of

353	lines found in	A., C.P.,	there are neither in N nor O .	71
156	„	A., R.,	„ „	62
404	„	N, C.P.,	there are wanting in A . .	186
226	„	N, R.,	„ „	124
314	„	O, C.P.,	there are wanting in N and A.	133
133	„	O, R.,	„ „	52

Many of those wanting in A are found both in N and O. From these numbers it is

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† Of course I mean the lines of this Table, without including in the statement those of special character and peculiar origin.

evident both that the spectrum of air is not formed by the mere superposition of those of N and O, and that certain electrodes can excite lines in a mixture of two gases which are not visible in either of those gases taken separately, or cannot excite them in the mixture, though they can in either or both of the components. This unexpected fact is illustrated by an attempt which I made to obtain the lines of platinum, by comparing its spectrum in mercury vapour with that of mercury. I expected, as I had done in the cases already mentioned of gases with Hg electrodes, that I should get the spectrum of Pt+that of Hg; but the result was otherwise. Hg Hg had forty-eight lines, Pt Hg only twenty-five, so that the presence of Pt instead of Hg as electrodes *put out* twenty-three. It however brought out four new ones, of which No. 15 γ is found with *every solid* metal, Nos. 33, 59 κ'', and 76 ξ with most of them. There is here no superposition, but, instead, either an antagonism of platinum and mercury, or the curious fact that the fluid electrodes act differently from the solid. It would be interesting to compare the spectra of tin in these two states.

The case is the same with a chemical compound as with a mixture. On the principle of superposition, the spectrum of CO should be merely the sum of those of C and O. To avoid all uncertainty about metallic lines, I used electrodes of graphite in the two gases. In each case nothing but C and O were present, and I expected to get the same spectrum in both. They were, however, very unlike. Of the lines which they had in common,

No. 3 α is nc. in . . O, but is a * in . . . . CO
No. 10 β' is a * in . O, but only c. in . . . . CO
No. 15 γ is a * in . O, but only b. in . . . . CO
No. 22 δ is intense * in O, but only b. in . . . . . CO
No. 26 ε is wvb. in . O, but one of many very fine in CO
No. 39 is faint in . O, but a * as bright as η in . CO

The κ group is not nearly so bright in O as in CO.

Besides these differences, O has ten wanting in CO, among which are No. 38 η, very bright, and No. 44 θ, in all its brilliancy; while CO has eight wanting in O, of which No. 75 is a *; the difference being greater than I have sometimes found with much less chemical agreement.

The only conclusion which such facts permit is, that the spectrum is a simple resultant of all the actions present, some of which may combine to produce an exalted effect, while others may be antagonistic in any degree.

4. As to the manner in which electricity produces the rays of these lines, whether by merely heating the medium, or by some luminiferous action analogous to its heating, nothing is really established. Heat is known to produce some brilliant lines when metallic vapours are introduced into flames; and it is possible that a temperature far above that of our hottest flame might bring out all those which I have enumerated, and the multitude of others which I did not attempt to measure. But is the temperature of the elec-

tric discharge so immensely superior to all others? and are there no means of estimating its real amount? Two of the facts which I have noted respecting these discharges may at least direct attention to this subject. In general the spectra of the simple spark of an induction machine are much fainter than when a jar, however small, is connected with it; and those with a small jar than those with a large. Thus, with silver electrodes in air, the spark gave twenty-three lines, of which δ and θ were "very bright;" a jar of 0·5 foot coating gave also twenty-three, but differently placed, more at the red, fewer at the violet, but seven of them *s; the normal one of 1·25 foot gave thirty-one, with nine *s; and two large of 8·5 feet gave thirty-six, with ten *s and many others "very bright." In these cases, were one to judge from first appearances, the spark heats air much more than the jar-discharge, for it has much greater power to burn anything which it encounters; but its section is larger, because much of it is *conducted* by the air which surrounds it; and besides, from the diminished resistance, the amount of heat produced *may* be less, as well as less concentrated. We cannot say it *must* be; we know too little of the nature of induction discharge to estimate the effect of changing resistance, for if it be increased it is possible that part of the electricity may be discharged through the coil itself. It must also be kept in mind, that while the jar-discharge is almost instantaneous, the other, at least in part, has a sensible duration. It could, however, be easily decided by experiment whether more heat is evolved in the C.P. or R. discharge.

Secondly. My induction machine, as I have already stated, can be used collaterally; in this case the quantity is double, and should have a fourfold heating power. In fact, its discharge (or rather the air which that discharge heats) fuses a piece of platinum wire, which the consecutive arrangement only reddens. Now, if the lines were produced by mere heat, the spectrum of the former discharge should be far the brightest: it is not so in the red and green; in the violet there is a difference, but I think an unpractised observer would scarcely notice it. I however saw the lines beyond H more easily and further. Unless the temperature is sufficiently raised by a weaker discharge than either of these to bring out all the lines (which seems inconsistent with the effects obtained by enlarging the jar), we might expect here, from the heat theory, a greater change. It is, I think, worth pushing the trial further, and I intend to repeat the experiment with an induction machine of much greater quantity, and at the same time to ascertain if intensity also have any influence.

These observations, on the whole, incline me to refer the origin of the lines to some yet undiscovered relation between matter in general and the transfer of electric action. According to the special properties of the molecules which are present, the brightness of these lines will be modified through a range from great intensity down to a faintness which may elude our most powerful means of observation. If several sorts of molecules be simultaneously present, there may be expected interferences which will produce alternations of brilliancy or obscurity to any extent; and if any of these be chemically united, analogy leads us to expect that such compound molecules will act with an influence of their own different from that of their elements. In even a simple mixture like air, I have shown that its spectrum, with a given metal, cannot certainly be deduced from those of its parts, and it is probable that this rule may be widely extended.

The bearing of this on electro-spectral analysis is obvious; for if the presence of one substance can be shown in any instance to disguise or transform the spectrum of another, or if the state of density, solution, alloyage, &c. have influence, it becomes necessary to eliminate such effects before we yield implicit confidence to this powerful guide. This implies a wide range of experiment and of cautious study; in fact, a complete system of spectral research through the whole range of our chemical elements *and their compounds*, conducted with strict inductive logic, and with the highest appliances of chemistry and optics. Whatever shall be so effected will be "an everlasting gift" to science, because, taking nothing for granted, it will be a real fact.