Photographs of the spectra of Sr, Cu, and Mg, showing central thickening.

I. Sr, containing two lines, one Ba showing very little thickening, while the other true Sr line exists only at the centre as a broad, fluffly reversed line.

II. Cu, all the Cu lines in this photograph have their central portions expanded, and most of them to a greater extent on the less than on the more refrangible side. Some of the Fe lines have also their centres expanded, which is not the case with the Ca lines, the Ca lines in the blue being developed at their extremities.

III. Mg, showing line in the blue-green, with a central expansion on the less refrangible side, giving the line the appearance of a half spindle, *b* being quite normal.

Spectrum of Sn; showing lines of Ca and Fe; the former are expanded at their lower extremities, the Fe lines are not so expanded, but exist at a higher level than the Ca lines. The photograph shows that the line which is basic to Fe and Ca is carried up with the other Fe lines, and is also expanded at its lower extremity with the other Ca lines.

II. "Note on some Phenomena attending the Reversal of Lines." By J. Norman Lockyer, F.R.S. Received March 5, 1879.

In the "Phil. Trans." for 1873, page 253, I gave an account of an experiment devised by Dr. Frankland and myself, in which the absorption line of sodium was made to vary considerably in thickness, owing to the variation in the quantity of sodium vapour which was produced in a tube when a mass of metallic sodium was heated in an atmosphere of hydrogen.

In the "Phil. Trans." for 1874, vol. clxiv, Part II, p. 805, speaking of the photographs of arc spectra which I had then commenced to take, I stated, "it not unfrequently happens that a very thick line will reverse itself, a circumstance which greatly facilitates its comparison with confronted lines, since a thin dark line then runs down the centre of the thicker bright one," and I pointed out in a note that the absorption line does not always occupy the exact centre of the bright band. I gave examples of this from the spectra of calcium and aluminium, the examples being reproductions of photographs of the arc. These were published with the paper.

In other subsequent communications, I have referred to these reversals, and I have elsewhere made general statements with regard to them, and drawn attention to the distinction between those substances which give us winged lines in arc spectra and those which do not.

If the method of throwing an image of the arc upon the slit be employed, a method which I suggested and utilised in 1870,* for

* "Phil. Trans.," 1873, p. 254.

terrestrial substances, there is no difficulty in seeing the reversal of winged lines in the case of all spectra in which they exist, and such lines lying in the region between K and G have been photographed and exhibited to the Society on several occasions in connexion with one part or another of my researches. When a lamp of thirty cells, however, is used, although the various curious phenomena which these reversals present are easily visible, it is very difficult to photograph them.

The longer arc given us by the Siemens' machine to which I have referred in another communication has enabled me, however, to photograph several of the various aspects put on during the process of reversal; these photographs I exhibit to the Society; chief among these phenomena are the various thicknesses of the lines of reversal over the arc and poles, and the appearance of the bright line without reversal in some regions, and the reversal without bright line in others.

All the phenomena presented by the absorption of the D line to the eye are here in duplicate. It may be useful, perhaps, to state what phenomena are seen in the case of the D line, when a small image of the arc, carefully focussed for the yellow light, is thrown upon the slit and considerable dispersion is employed.

If the arc is observed before the introduction of the sodium on to the poles, with the poles slightly separated, the continuous spectrum of each pole will be bounded by a sharp line, and in the included region the exquisite flutings of the carbon vapour will be seen together with the lines due to any metallic substances present. The metallic lines will be thickest near one pole, and will overlap its continuous spectrum, while the carbon flutings will overlap the other. The D lines in the arc should occupy the centre of the field of view.

If now a piece of metallic sodium be placed on the lower pole, the whole of the light will be blotted out, if the field of view be small. Gradually the two ends of the spectrum of the arc will begin to appear on either side of the field, the sharp boundary lines to which reference has been made having disappeared, as the poles are no longer incandescent.

The absorption in its retreat to the central region will next take the appearance of a truncated cone, its base resting on that side of the arc formerly occupied by the carbon flutings. The intense blackness gradually changes into a misty veil through which, as it were, the D lines gradually make their appearance as enormous truncated cones with their bases turned in the opposite direction to that occupied by the original absorption.

The more refrangible line is twice as thick as the other, and is often contorted while the other is rigid. Gradually, as the quantity of sodium vapour is reduced, the poles regain their original incandescence,

and the one to which the carbon bands attach themselves will become more vividly incandescent than the other. Then begins a new set of phenomena—the absorption of the light of either pole. Generally on the more incandescent pole the absorption widens for a space, then narrows and finally puts on a trumpet appearance and is lost, as if the molecules to which the absorption is due were then, owing to the reduction of temperature, being reconstructed, thus increasing the quantity of available absorbing material of this particular kind.

Very often on the opposite pole the line is seen merely as a bright one, or again the absorption is reduced to its smallest proportions.

Having thus stated the phenomena with regard to the D line, it will be convenient to make some general statements supported by the various photographs which I now submit to the notice of the Society.

I. We have first a general absorption of the light of the arc over the region to be eventually occupied by the bright line.

II. Next the disappearance of this indefinite absorption and the formation of a truncated absorption of a symmetrical bright and wider line.

III. Next the parallelism of the boundaries of the bright and dark lines in the centre of the arc itself.

IV. Next the various absorption phenomena on the two poles.

V. Finally the extinction of the absorption line in the arc.

The other lines in the sodium spectrum are also good representatives of cases in which the absorption leads to different appearances, or in which absorption phenomena are entirely wanting. For instance, the double green line of sodium shows scarcely any trace of absorption when the lines are visible; but before the lines are produced out of a general brightness which fills the whole field the absorption is visible as line absorption, the less refrangible member being thicker and darker than the other, exactly the opposite to what holds with the D lines.

I have observed no absorption in the case of the blue line, but the radiation phenomena are extremely curious taken in connexion with the other lines. While the D lines put on the appearance of black truncated cones, while the green lines widen at their bases towards the red and not at all towards the more refrangible side, the blue lines are only widely developed in the centre of the arc, and are least developed in that portion of it where the phenomena of the other lines are seen in their strongest intensity; thereby affording a striking instance of the irregular absorption and radiation of the molecules of the same element in the same sectional plane of the arc.

The red double line of sodium I have never seen reversed nor irregularly widened.

When a Siemens' lamp is employed, the absorption phenomena of the flame referred to in another communication merit a most careful

study. The lines which reverse themselves most readily in the arc are generally those, the absorption of which is most developed in the flame; thus the manganese triplet in the violet is magnificently reversed in the flame, and the blue calcium line is thus often seen widened, H and K being not only not absorbed, but entirely invisible.

LIST OF PHOTOGRAPHS EXHIBITED.

Photographs showing passage from truncation to parallelism.

I. Spectrum of Sr, showing two reversed lines (wave-lengths 4078·5 and 4215·3) gradually broadening towards one end.

II. Spectrum of Ca, showing reversal of the blue line, and of H and K. While the blue line presents the appearance of a cone, through the centre of which is the absorption line bounded by parallel sides, the H and K lines are almost normal in their appearance, showing, however, a slight widening at one extremity.

III. Spectrum of Mn, showing blue Ca line tapering to a point at one extremity and enlarging spindle-shape towards the other end; the reversal of this line does not extend through its whole length, but merely through the bulging portion, tapering gradually to a point.

IV. Spectrum of Sr, showing the two lines (4078·5 and 4215·3) which this time present an appearance very similar to the blue Ca line in the last photograph. In the more refrangible line, however, the reversal retaining its tapering form extends through the whole length of the line.

Two photographs of the spectrum of Ca, in which not only the blue line but also the H and K lines present the appearance of truncated cones.

Spectrum of Mn, showing the absorption of its triplet (at wave-length about 4030) without its radiation.

Spectrum of Mn, in which the triplet is again reversed. Here the triplet, together with its two included bright lines, looks exactly like a group of eight radiation lines, each reversed line giving the appearance of two bright lines.

Photographs showing non-symmetrical lines.

I. Spectrum showing two Ag lines at about wave-lengths 4054·3 and 4210·0. Both lines are fluffy and reversed; the less refrangible line is much more strongly expanded on its more refrangible side, and is carried up to a much greater height as a radiation line than its other side. The more refrangible line is more symmetrical, but presents the same phenomena to some extent, only in the opposite direction, its less refrangible side being the most developed.

II. Spectrum of Rb, showing line at wave-length 4202. Here the two ends of the line are produced by radiation alone, the central portion showing absorption on its more refrangible side with fluffy shading on its less refrangible side.

Spectra of Sr and Cs, showing the absorption of light due to the poles.

Photographs showing the trumpeting of lines.

I. Spectrum of Ca, in which the reversal is seen to widen as we approach the faint end produced by the cooler external region of the arc, thus showing absorption increasing with reduction of temperature.

II. Another spectrum of Ca, showing the same thing again.

III. Spectrum of Pb, showing that the Pb line at wave-length 4058 also trumpets.

IV. Spectrum showing the Ba line at 4553·4 trumpeting. Here the line, after proceeding to a considerable distance from the hottest region of the arc as a fine reversed line, gradually expands towards its extremity.

Flame-spectrum of Mn, showing the reversal of the triplet in the arc-flame.

Flame-spectra of Ca, showing the gradual extinction first of K and then of H as the flame recedes farthest from the arc.

III. Discussion of "Young's List of Chromospheric Lines." (Note I.) By J. NORMAN LOCKYER, F.R.S. Received March 5, 1879.

[PLATE 9.]

In my paper read on the 12th December, 1878, I called attention to the fact that, in the case of the metals discussed in that paper, with the exception of hydrogen, there was a considerable discrepancy between the intensities of the lines seen in our laboratories and the number of times the lines had been seen by Young in his careful researches on the chromosphere.

In a preliminary note "On the Substances which produce the Chromospheric Lines" I pointed out that the lines visible in the spectrum of the chromosphere when a metallic prominence is observed are for the most part basic lines, that is to say, with few exceptions, the longest and brightest lines visible in the spectra of the so-called elements are conspicuously absent; instead of them we find fainter lines, which Thalén has, in many instances, mapped as common to two elements.

Since these papers were communicated to the Society I have continued this line of inquiry, and I now propose to state what I have thus far done:—

1. The maps of the spectra of calcium, barium, iron, and manganese, submitted to the Society in an incomplete state when the preliminary note was read, have been completed. In these the lengths of the lines in the spectra of the metallic elements represent the intensities given by Thalén, whose lines and wave-lengths I have followed in all cases, while those of the lines visible in solar storms, represent the number of times each line has been seen in the spectrum of the chromosphere by Professor Young, to whose important work I have drawn special attention in my last two communications. An inspection of these maps is sufficient to show that there is no connexion whatever beyond that of wave-length between the spectra; it will be gathered from the maps how the long lines seen in our laboratories are suppressed and the feeble lines exalted in the spectrum of the chromosphere, see Plate 9. The Mn map has been omitted on account of its excessive complication.

2. I have discussed the coincidences recorded in Ångström's map and Thalén tables in the sheets of the "Spectre Normal," comprising