Between the first and second group Lecoq de Boisbaudran gives a line which was not noticed by us in the arc.

In the second group the two middle lines are very close, and Lecoq de Boisbaudran gives only their mean wave-length. Measuring the distances of the middle from the extreme lines of the group, the wave-lengths of this quartet are 5355, 5338, 5334·5, 5319. These are all about of equal brightness, but we have not seen the third (5334·5) reversed.

The third group consists of the lines 5112, 5098, 5095, 5081. Of these the second is not given by Lecoq de Boisbaudran, and only the first has been seen by us reversed.

Three lines given by Lecoq de Boisbaudran between the third and fourth groups are not seen in the arc, or at least are not nearly so conspicuous as the groups here described.

The fourth group consists of lines for which we find the wave-lengths about 4964, 4956, 4950, 4942. Of these the first and last only are given by Lecoq de Boisbaudran as 4963 and 4936.

The fifth group has lines of which we find the wave-lengths about 4870, 4863, 4856, 4850.

The sixth group has lines of about the wave-lengths 4808, 4803, 4796, 4788.

The seventh group is too faint and diffuse to be distinctly resolved. The wave-length of the least refrangible edge is about 4759.

None of these last three groups are seen by Lecoq de Boisbaudran, and they are too diffuse for exact measurement; on the other hand, he gives several other lines which are not noticed by us in the arc.

As in the case of sodium the repetition of these quartets of lines at decreasing intervals with decreasing brightness and sharpness as they proceed from the less to the more refrangible, gives the impression of a series of harmonics; but the wave-lengths do not seem to be in a simple harmonic progression, though simple harmonic relations may be found between some of the groups.

VI. "On the Reversal of the Lines of Metallic Vapours." No. VII. By G. D. Liveing, M.A., F.R.S., Professor of Chemistry, and J. Dewar, M.A., F.R.S., Jacksonian Professor, University of Cambridge. Received November 18, 1879.

The experiments of which the results are here given were all made in the Chemical Laboratory of the Royal Institution, with the powerful electric current from the Siemens dynamo-electric machine. Limestone crucibles similar to those before employed were in all cases used, but the opening through which the arc was observed was in general placed

horizontally, so that the axis of the collimator of the spectroscope was directed immediately on to the arc without the intervention of a mirror, and a small vertical opening was made for the introduction of the substances under observation, and was closed when not in use by a piece of lime.

With sodium carbonate the green pair wave-lengths 4983, 4982 were reversed, showing dark lines in the middle of the bright ones, the less refrangible of the two giving the stronger dark line. The sodium line given by Lecoq de Boisbaudran at wave-length 4670 showed as a diffuse blue band with a *pair* of fine dark lines in it, of which the stronger and more lasting was the less refrangible. The diffuse blue band resolved itself into *two* diffuse lines as the sodium carbonate evaporated, and the measurement of their positions in comparison with a conspicuous titanium line, which lies between them, and was made to show at the same time by introducing a fragment of titanic oxide into the crucible, gave for this sodium pair the wave-lengths 4667, 4664. The orange pair, wave-lengths 6160, 6154, were also seen reversed in like manner, but we failed to detect any difference in the strength or continuance of the dark lines in this case. These reversals of sodium lines were many times observed, and we noticed that the reversals of the other pairs continued after that of the red pair had ceased to be visible, that next after the disappearance of the dark lines in the red pair those in the diffuse blue pair ceased to be visible, then the dark lines in the green pair, and then those in the yellowish-green (5687, 5681). In some cases when a large quantity of sodium carbonate was put into the crucible a curious double reversal occurred. In the middle of an enormous dark expansion of D a bright yellow band appeared, which in turn had a narrower dark band, or a pair of dark lines, in its middle. A similar double reversal of the lithium blue line occurred so far as to show a bright line in the middle of the dark one. Of the two violet lines of potassium we observed that the more refrangible remained reversed longer than the other.

In addition to the reversals of calcium lines before observed by us, we have noticed the reversal of all the more conspicuous calcium lines of the G group, viz., those wave-lengths—4282, 4289, 4298, 4307, 4318, besides 4302 before noted, also that of 4379, and all three lines of a triplet 4585, 4581, 4578. The finer lines, wave-lengths 4434·3, 4454·5, slightly less refrangible than the strong lines 4434, 4454, were reversed, but only when one of the poles was a bar of iron, instead of carbon. The strong lines just mentioned were expanded so as to cover their neighbours, and all four lines were seen black against the bright background in the positions and of the same relative strengths as when bright.

When strontium chloride was put into the crucible the lines with the following wave-lengths, besides those before noted, were observed

reversed—4305, 4865, 4892, 5223, 5225, 5228, 5480, 5503, 5522, and momentarily only, 5155, 5238, 5256. Besides these, many dark bands were observed in the less refrangible part of the spectrum, of which three, with wave-lengths 5920, 6035, 6060, appear to be identical with bright bands ascribed to strontia, and one, with wave-length 6597, is identical with a bright line given by strontium chloride.

Manganese, introduced as sulphate, gave with facility the violet triplet, 4029, 4032, 4033 as dark lines on the continuous background. The bright blue lines of manganese were not, however, reversed until some metallic magnesium was introduced. This brought out the reversal of the lines, wave-lengths 4753, 4783, and 4823, the last being the most easily reversed of the three.

Lead introduced in the metallic state gave a reversal of the violet line, wave-length 4058, which Cornu had previously seen reversed, but this reversal was far better seen, becoming a wide black band, when the lead was introduced as an alloy with zinc. Probably the lead vapour was not so rapidly oxidised when mixed with zinc, and a thicker, if less dense, stratum interposed between the arc and the spectroscope. When lead ferrocyanide was used, not only the line above mentioned was reversed, but also much less strongly, a line near it, wave-length 4062.

With zinc, only the less refrangible two of the three blue lines, wave-lengths 4810, 4721, were seen reversed. The very bright lines, wave-lengths 4924, 4911, seen in the spark between zinc poles, were not seen by us at all in the arc, resembling in this respect the magnesium line, wave-length 4481, and the cadmium lines, wave-lengths 5377, 5336.

When cadmium was put into the crucible the lines, wave-length 5085, 4799, and 4677, were reversed, not the line, wave-length 4415. With a large dose of cadmium the red line, wave-length 6438, was once seen reversed for an instant only.

With silver, besides the reversals before observed by us, the line, wave-length 4053, showed a dark line in the middle of its expansion as noticed by Mr. Lockyer, but we could see no reversal of the line, wave-length 4208. Instead of the reversal of this line we observed that a second bright line came out close to it, rather diffuse, and about midway between the line 4208 and the calcium line 4215. By measuring the intervals and interpolating, we deduced 4211·3 for the wave-length of this silver line, which we could see, though it was fainter, in the less powerful current of a De Meritens' machine. This second line coming out near the other silver line gave the appearance of a reversal in the middle of a diffuse line, but besides the measurements made with a micrometer we assured ourselves of the fact of there being two lines by watching the fading of the second line as the silver evaporated. The use of an alloy of zinc with silver did not alter

the appearance of these two lines, or bring out a reversal of either of them. We failed to see any line of silver either bright or reversed with wave-length about 4240, as mentioned by Cornu, whether the silver were used pure or alloyed with zinc or with lead. With the carbons arranged vertically as shown in our last communication on this subject, p. 472 (vol. xxviii), and the light viewed through the perforated carbon, silver gave a channelled spectrum as described by Lockyer and Roberts. As this channelled spectrum was not seen with silver in any other arrangement of our crucibles, we are led to attribute it to a comparatively cool condition of the silver vapour ascending the carbon tube, a condition of near approach to a state of liquefaction.

Having observed that lines frequently came out with mixtures which were not visible when the separate ingredients were used, we tried a few amalgams. None of these showed any reversals of the mercury lines. But an amalgam of bismuth gave readily the reversal of the bismuth line, wave-length 4722, and with more difficulty that of the line, wave-length 4119.

Antimony did not appear to give any lines, or none easily distinguishable, in the arc.

With copper we observed the reversal of two lines only, wave-length 5105, 5153.

Iron introduced as metal, or as chloride, in the usual way, gave us no reversal; with an iron rod used as positive pole instead of one of the carbons, we succeeded in getting the reversal of one line, wave-length 4045, which expanded and showed a fine dark line in its middle; but by passing an iron wire into the arc through the positive carbon, which was perforated in the manner described in our last communication on this subject (p. 472), for the introduction of gases into the arc, and pushing in the wire slowly as the end burned away, we succeeded in reversing several of the brightest of the iron lines. The three violet lines, wave-lengths 4045, 4063, 4071, were the first to be reversed. They all expanded before showing reversal, and the order of reversal was that of refrangibility. Besides these the lines, wave-lengths 4957, 4920 (the stronger and less refrangible of a pair), 4404, 4383, 4325, 5040, 4307 (G) were reversed. These last two lines could not be certainly distinguished from calcium lines, as the last is almost if not quite coincident with a calcium line, and the other is too close to a calcium line to be distinguished without more exact measurement than the time during which it could be observed would allow, but we judged from their relative intensity that they were the iron lines. The line, wave-length 4415, was not seen reversed when the other bright lines near it were reversed.

Nickel, whether put into the crucible in the old way, or fed into the arc in small fragments filling a platinum tube which was passed through a perforated carbon pole, gave no definite reversal of any of

its lines; nor did cobalt, even when a bar of cobalt was used as the positive pole.

Tin, palladium, and platinum gave no reversals.

It is worthy of remark in regard to the difficulty of obtaining substances chemically pure, that we found that carbon poles which had been for some hours ignited in a current of chlorine and further intensely heated in the arc, while chlorine was passed through perforations down their axes, still showed in the arc, of course without any crucible being employed, a multitude of lines, amongst which the so-called carbon lines and those of calcium and iron were conspicuous.

December 1, 1879.

ANNIVERSARY MEETING.

THE PRESIDENT in the Chair.

Mr. Perkin, for the Auditors of the Treasurer's Accounts, on the part of the Society, reported that the total receipts during the past year, including a balance of £916 14*s.* 7*d.*, carried from the preceding year, amount to £9,048 5*s.* 1*d.*, and that the total expenditure in the same period, including purchase of stock, amounts to £7,783 18*s.* 5*d.*, leaving a balance at the Banker's of £1,222 12*s.*, and £41 14*s.* 8*d.* in the hands of the Treasurer.

The thanks of the Society were voted to the Treasurer and Auditors.

The Secretary read the following Lists:—

Fellows deceased since the last Anniversary.

On the Home List.

Peyton Blakiston, M.D.
Edward Blore, LL.D., F.S.A.
Charles Brooke, M.A., F.R.C.S.
John Allan Broun.
George William Callender, F.R.C.S.
James Robert Christie.
W. Kingdon Clifford, M.A.
George William Drory.
Isaac Fletcher, F.R.A.S.
William Froude, M.A., M.I.C.E.
A. H. Garrod, M.A.
John Benjamin, Baron Heath, F.S.A.
Sir Rowland Hill, K.C.B., D.C.L., F.R.A.S.
Rev. Philip Kelland, M.A., V.P.R.S.E., F.C.P.S.