the last four years has consisted in the elimination of the effects of impurities. I am therefore aware of the great necessity for caution in the spectroscopic examination of various substances. There is, however, a number of bodies which permit of the inquiry into their simple or complex nature being made in such a manner that the presence of impurities will be to a certain extent negligable. I have brought this subject before the Royal Society at its present stage in the hope that possibly others may be induced to aid inquiry in a region in which the work of one individual is as a drop in the ocean. If there is anything in what I have said, the spectra of all the elementary substances will require to be re-mapped—and re-mapped from a new standpoint; further, the arc must replace the spark, and photography must replace the eye. A glance at the red end of the spectrum of almost any substance incandescent in the voltaic arc in a spectroscope of large dispersion, and a glance at the maps prepared by such eminent observers as Huggins and Thalén, who have used the coil, will give an idea of the mass of facts which have yet to be recorded and reduced before much further progress can be made.

In conclusion, I would state that only a small part of the work to which I have drawn attention is my own. In some cases I have merely, as it were, codified the work done by other observers in other countries. With reference to that done in my own laboratory I may here repeat what I have said before on other occasions, that it is largely due to the skill, patience, and untiring zeal of those who have assisted me. The burthen of the final reduction, to which I have before referred, has fallen to Mr. Miller, my present assistant; while the mapping of the positions and intensities of the lines was done by Messrs. Friswell, Meldola, Ord and Starling, who have successively filled that post.

I have to thank Corporal Ewings, R.E., for preparing the various diagrams which I have submitted to the notice of this Society.

December 19, 1878.

W. SPOTTISWOODE, M.A., D.C.L., President, in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The following Papers were read:—

I. "Note of an Experiment on the Spectrum of the Electric Discharge." By the Hon. Sir W. R. GROVE, D.C.L., V.P.R.S. Communicated December 19, 1878.

The difference between the appearances at the positive and negative terminal which an electric discharge presents in vacuum tubes has struck many observers. The negative terminal is surrounded in what is called an air vacuum with a blue glow extending to a considerable distance from the platinum wire, and is generally bounded by a dark space separating it from the crimson light of the positive wire; it is affected by the magnet, the light following the direction of the magnetic curves, and a deposit of platinum on the glass tube appears in time in the vicinity of the negative which is absent at the positive terminal. I do not propose to enter more fully on these distinctions which have been largely experimented on by M. Gassiot, Professor Plücker, and to some extent by myself. The recent announcement of Mr. Norman Lockyer of observations on the spectra of bodies which were assumed to be elementary, but which showed lines seeming to denote that they were compound, led me to repeat some old experiments of mine on the spectrum of the electric discharge, one result of which I have ventured to communicate to the Royal Society. I had intended to mention them in the discussion of Mr. Lockyer's paper, but was not able to be present at it.

On November 24th last I examined, with a small spectroscope, by Browning, the electric discharge in some Geissler's air vacuum tubes, three of which I possessed. In these, which were of different shapes and sizes, the effects were the same. The globes into which the negative wire protruded were filled with a blue light more diffused as it became more distant from the wire. The rest of the tube was filled with a crimson light appearing to issue from the positive wire, and this light was striated in the narrow parts of the tubes.

The spectrum from what I will call the positive light presented a series of numerous and variously coloured bands not greatly differing in brightness, and showing what has been called the fluted or channelled spectrum. The spectrum of the negative light was extremely different. Four bright lines divided the spectrum, viz., yellow, green, blue, and violet respectively, the distance between them increasing towards the violet end. There was also a faint line at the extreme red, and the red end of the spectrum was divided into two different tints, terminating with the bright yellow line. In the positive spectrum there was a wide black band, apparently an absorption band, overlapping the yellow and a portion of the orange space.

On looking for a longer time at the spectrum of the negative light, my eye becoming more accustomed to it, I became able to detect other

bands between the bright lines, and on attaching a small prism (with which the spectroscope was provided) in front of the slit, so that the separate spectra of the positive and negative lights could be juxtaposed, I could trace several of the bands which appeared quite distinctly in the positive spectrum, into the negative one; but in the latter they were very faint, while the converse case obtained with the four bright lines I have mentioned, which were brilliant in the negative spectrum and faint or normal in the positive.

Although the four bright lines standing out in strong relief in the negative spectrum was the more striking phenomenon to the eye, yet the black band in the positive appearing in the space corresponding to the bright yellow light in the negative spectrum is equally or possibly more important.

The positive light, far the brightest to the eye, is diffused into a fluted spectrum of substantially equal intensity throughout, while the negative dim light is concentrated into brilliant lines of intense luminosity.

Another tube in which the vacuum was, I have no doubt, produced by the absorption of carbonic acid by potash, and which may be called a carbonic acid vacuum, gave a very different result from the three I have mentioned. In it the light throughout was striated and blue, or bluish, with a slight purple tinge pervading the negative glow. With this tube the spectra were strikingly different from those in the air vacuo. There were in the negative spectrum of this tube six bright lines, viz., extreme red, orange, greenish-yellow, green, greenish-blue, and violet. The same lines with one exception were visible and equally prominent throughout the whole of the tube. That exception, which was noticed by Dr. Frankland, to whom I showed my experiments, was the extreme red line which was apparent only in the spectrum from the negative glow.

On juxtaposing, by means of the prism, this spectrum with the spectrum of the negative light in an air vacuum tube, one only of the lines coincided, viz., the green line, the others were in entirely distinct parts of the spectrum; this was to be expected, as the one tube would give mainly a nitrogen spectrum, the other a carbonic oxide one.

I have long been convinced, and this is now, I believe, the prevalent opinion, that the light of the electric discharge is an incandescence of the intermedium through which it passes, and of the terminals themselves (see "Correlation of Physical Forces," 6th edit., pp. 75, *et seq.*).

If this be so, then, the above experiments, *i.e.*, those on the positive and negative spectra in the same tube, must be either different spectra of the same incandescent substances, or the attenuated gases must be differently decomposed or united in the different parts of the tube, or a different character of electric polarity must ensue in the positive

and negative portions of the gas. The first of the above conditions can only result from difference of heat, which is known to produce different spectra from the same gas. I do not think the effects are due to difference of temperature. It is true that the negative electrode is more heated than the positive in the electric discharge in vacuo, but the heat disseminated by it throughout the negative glow produces in its totality but a slight rise in temperature throughout the volume of the negative glow.

1st. If it be the effect of heat it must be what may be termed molecular heat, as the change in the character of the spectrum being comparatively sudden between the negative and positive light is against the phenomena being caused by change of temperature throughout.

2ndly. Is it caused by chemical decomposition? This is possible, but a different chemical effect pervading two definite portions of the electric discharge is a new effect and not to be hastily assumed. I have shown ("Phil. Trans.," 1852) that the electric discharge has an electro-chemical polarity when acting on attenuated gases, the positive terminal producing an oxidating, and the negative a deoxidating effect; but this effect in my experiments only manifested itself at the terminals, although it may molecularly pervade the gas.

3rdly. Is it due to electric polarity? I incline to think it is, but to a polarity so affecting the molecules of the gas, that, if not actually decomposed, they have something like a chemical polarity impressed upon them. This would to some extent favour Mr. Lockyer's view, though not supporting it to its full extent.

The results may help to explain the phenomena observed in some stars where one or more lines belonging to the spectrum of a given substance is observed, while others are wanting; and if stars have their atmospheres in a state of electric polarity, as is to some extent the case with this earth, or of electric discharge, as is the case with this earth when the Aurora Borealis or Australis is visible, the spectra would differ more or less from those normally observed here. If the spectrum of the negative light were examined through a series of prisms, there can, I think, be little doubt that the very faint intermediate lines would be obliterated by absorption in passing through the glasses, while the bright lines would remain, and thus the spectrum of a nebula would be presented; but it would be but a partial representation of the true spectrum, and the line spectrum seen in the nebulæ may thus be a partial spectrum.

P.S. December 23.

My attention has been called to Mr. De La Rue's paper recently printed in the "Phil. Trans.," which, although he kindly sent me a copy, I had not read when I made the above communication. He finds

in the spectra of hydrogen vacua a notable difference in the lines seen in the negative light, sometimes all and sometimes only one of the recognised lines of hydrogen being visible in that, and in many cases not visible in other parts of the tube. I had tried an experiment with a hydrogen vacuum tube of Geissler; but in that the difference was but slight between the positive and negative lights, though it was very great between the light in the narrow central part of the tube and in the wide portions on each side of it, the crimson light in the narrow tube giving a brilliant three-line spectrum, and the blue light, both on the positive and negative side, giving a comparatively dim fluted spectrum of many bands. The difference between the light of narrow and wide parts of the vacuum tubes has, I believe, been noticed; it is in this case the converse of the effects observed by me in the air vacuum.

II. "On the Precession of a Viscous Spheroid, and on the Remote History of the Earth." By George H. Darwin, M.A., Fellow of Trinity College, Cambridge. Communicated by J. W. L. Glaisher, F.R.S. Received July 22, 1878.

(Abstract.)

This paper is a continuation of a previous one on the bodily tides of homogeneous viscous spheroids (read on May 23rd), and it contains the investigation of the rotation of such a body as modified by the tides raised in it by external disturbing bodies. The earth is taken as the type of the rotating body, and the sun and moon as types of the disturbing ones; this plan not only affords a useful vocabulary, but permits an easy transition from questions of abstract dynamics to those of direct applicability to the physical history of the earth.

In the paper on tides it was shown that, if the disturbing influence be expressed as a potential, which is expanded as a series of solid harmonics, each multiplied by a simple time harmonic, then each such term in the expansion corresponds with a tide in a viscous or imperfectly elastic sphere, which is independent of the tides corresponding to all other terms. Also the height of every such tide is expressible as a fraction of the corresponding equilibrium tide of a perfectly fluid spheroid, and the tide is subject to a retardation which is a function of the frequency of the generating term, and of the constants expressive of the physical constitution of the distorted spheroid.

The case of the moon, supposed to move in a circular orbit in the ecliptic, is treated first. The tide generating potential of that body (of the type $\cos^2-\frac{1}{3}$*) has first to be expanded in the desired form;

* Terms of higher orders are shown to be negligeable.