and *Rhytiphlœa Gomardii* are amongst the novelties. A large number of zoological and botanical specimens have been lost through my inability to attend to them in time without assistance. This has principally affected the number of duplicates; but in one instance it has led to the loss of a species—one of the Petrels, which was the commonest bird about here when we first arrived. Fortunately it is a well-known species.

The 1st of March is announced as the approximate date of our sailing from Kerguelen's Island. Five weeks later I hope to arrive at the Cape and to forward to you such of the specimens collected as require only ordinary care in their transmission. The more fragile things are likely to reach you in better condition if I keep them until my return to England, than they would if they were sent with the others.

I am, dear Sir,

Faithfully yours,

A. E. Eaton.

II. "Experiments to ascertain the Cause of Stratification in Electrical Discharges *in vacuo*." By Warren De La Rue, Hugo W. Müller, and William Spottiswoode. Received February 24, 1875.

Some results obtained in working with a chloride-of-silver battery of 1080 cells in connexion with vacuum-tubes appear to be of sufficient interest to induce us to communicate them to the Society, in anticipation of the more detailed account of an investigation which is now being prosecuted, and which it is intended to continue, shortly, with a battery of 5000 cells, and possibly with a far greater number.

The battery used up till now consists of 1080 cells, each being formed of a glass tube 6 inches (15·23 centims.) long and $\frac{3}{4}$ of an inch (1·9 centim.) internal diameter; these are closed with a vulcanized rubber stopper (cork), perforated eccentrically to permit the insertion of a zinc rod, carefully amalgamated, $\frac{3}{16}$ (0·48 centim.) of an inch in diameter and 4·5 inches (11·43 centims.) long. The other element consists of a flattened silver wire passing by the side of the cork to the bottom of the tube and covered, at the upper part above the chloride of silver and until it passes the stopper, with thin sheet gutta percha for insulation, and to protect it from the action of the sulphur in the vulcanized corks; these wires are $\frac{1}{16}$ of an inch (0·16 centim.) broad and 8 inches (20·32 centims.) long. In the bottom of the tube is placed 225·25 grains (14·59 grms.) chloride of silver in powder; this constitutes the electrolyte: above the chloride of silver is poured a solution of common salt containing 25 grammes chloride of sodium to 1 litre (1752 grains to 1 gallon) of water, to within about 1 inch (2·54 centims.) of the cork. The connexion between adjoining cells is made by passing a short piece of india-rubber tube

over the zinc rod of one cell, and drawing the silver wire of the next cell through it so as to press against the zinc. The closing of the cells by means of a cork prevents the evaporation of water, and not only avoids this serious inconvenience, but also contributes to the effectiveness of the insulation. The tubes are grouped in twenties in a sort of test-tube rack, having four short ebonite feet, and the whole placed in a cabinet 2 ft. 7 in. (78·74 centims.) high, 2 ft. 7 in. wide, and 2 ft. 7 in. deep, the top being covered with ebonite to facilitate working with the apparatus, which is thus placed on it as an insulated table.

The electromotive force of the battery, as compared with a Daniell's (gravity) battery, was found to be as 1·03 to 1*, its internal resistance 70 ohms per cell, and it evolved 0·214 cub. centim. (0·0131 cub. inches) mixed gas per minute when passed through a mixture of 1 volume of sulphuric acid and 8 volumes of water in a voltameter having a resistance of 11 ohms. The striking-distance of 1080 elements between copper wire terminals, one turned to a point, the other to a flat surface, in air is $\frac{1}{263}$ inch (0·096 millim.) to $\frac{1}{250}$ inch (0·1 millim.). The greatest distance through which the battery-current would pass continuously *in vacuo* was 12 inches (30·48 centims.) between the terminals in a carbonic acid residual vacuum. This battery has been working since the early part of November 1874, with, practically, a constant electromotive force.

Besides 2000 more cells like those just described, we are putting together 2000 cells, with the chloride of silver in the form of rods, which are cast on the flattened silver wires, as in a battery described by De La Rue and Müller †, but in other respects similar to the battery above described, the glass tubes being, however, somewhat larger in diameter; the rods of chloride of silver are enclosed in tubes open at the top and bottom, and formed of vegetable parchment, the object of these vegetable-parchment cases being to prevent contact between the zinc and chloride-of-silver rods. The internal resistance of batteries so constructed is only from 2 to 3 ohms per cell, according to the distance of the zinc and chloride-of-silver rods, and they evolve from 3 to 4·5 cub. centims. (0·18 to 0·27 cub. inch) per minute, in a voltameter having a resistance of 11 ohms. Their action is remarkably constant.

For the experiments detailed below, vacuum-tubes were generally used of about 1½ to 2 inches (3·8 to 5 centims.) in diameter, and from 6 to 8 inches (15·24 to 20·32 centims.) long; also prolate spheroidal vessels 6 inches by 3 inches (15·24 by 7·62 centims.). The terminals are of various forms, and from 4 inches to 6 inches (10·16 to 15·24 centims.) apart, and made of aluminium and occasionally of magnesium and of palladium,

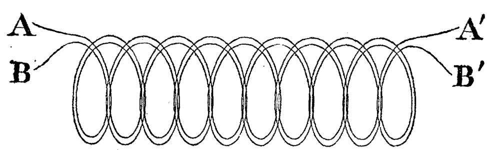
* Compared with a Daniell's battery, in which the zinc is immersed in dilute sulphuric acid in a porous cell, its electromotive force is about 3 per cent. less than the Daniell.

† Journal of the Chem. Soc., 2nd series, vol. vi. p. 488; Comptes Rendus, 1868, p. 794.

the latter showing some curious phenomena with a hydrogen residual vacuum, which will be described in a future paper. A tube which has given the most striking results is 8 inches (20·32 centims.) long, and has a series of six aluminium rings varying in diameter from $\frac{3}{8}$ of an inch to about $1\frac{1}{4}$ of an inch (0·95 to 3·17 centims.), the thickness of the wire being about $\frac{1}{16}$ (0·16 centim.) of an inch; the rings are a little more than 1 inch (2·54 centims.) apart; and connecting wires of platinum pass through the tube from each ring and permit of the length and other conditions of the discharge being varied.

At times the terminals of the battery were placed in connexion with accumulators of different kinds—for instance, two spheres of 18 inches (45·72 centims.) in diameter, presenting each a superficies of 7·07 square feet (65·68 square decims.), and cylinders of paper covered with tinfoil, each having a surface of 16 square feet (148·64 square decims.); the globe and cylinders were in all cases carefully insulated. Other accumulators were composed of coils of two copper wires $\frac{1}{16}$ of an inch (0·16 centim.) in diameter, covered with gutta percha, in two folds, $\frac{1}{32}$ of an inch (0·08 centim.) thick. One coil contains two wires, A A′ and B B′ (fig. 1), coiled side by side, each being 174 yards (159 metres) long, another with two wires each 350 yards (320 metres) long; of the latter we have two coils.

Fig. 1.



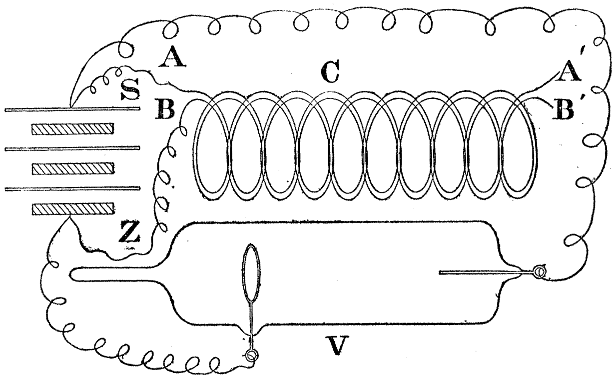
In addition to these accumulators we have several others formed of alternate plates of tinfoil and insulating material, such as paper saturated with paraffine, and also sheets of vulcanite. These are of various capacities and contain from 5 to several hundred square feet. The largest has a capacity of 47·5 microfarads; when it is discharged it gives a very bright short spark, accompanied by a loud snap; the charge deflagrates 8 inches (20·32 centims.) of platinum wire, ·005 inch (0·127 millim.) in diameter, when it is caused to passed through it. Each accumulator gives different results; but for the present we shall confine ourselves to a description of the experiments made with the coil-accumulators.

When the terminals of the battery are connected with the wires of a vacuum-tube which permits of the passage of the current, the wires (especially that connected with the zinc end) become surrounded with a soft nebulous light, in which several concentric layers of different degrees of brilliancy are seen; in most cases there is either no indication of stratification, or only a feeble ill-defined tendency to stratification: the tubes

selected for these experiments were those in which the stratification did not appear at all.

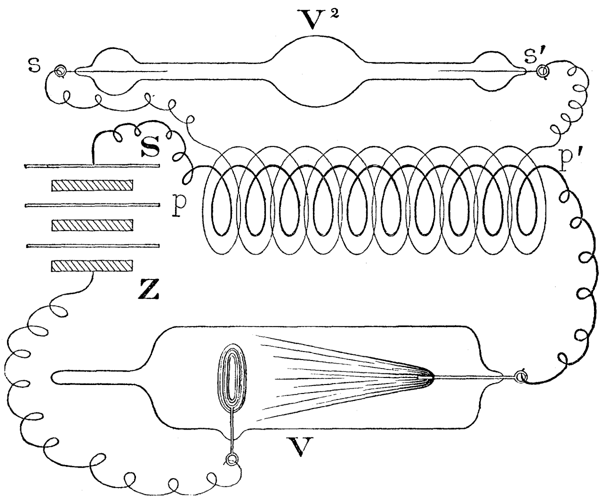
When the battery, already in connexion with the vacuum-tube, was also joined, as in fig. 2, on to one or more coil-condensers (coupled to introduce a greater length of wire) in the following manner, then immediately well-defined stratifications appeared in the vacuum-tube.

Fig. 2.



S Z represents the battery, V the vacuum-tube, C the coil-condenser; one terminal is connected with the end A of the wire A A′, and the other terminal with the end B of the second wire B B′; connexions are also led to the wires of the vacuum-tube. The ends A′ and B′ are left free; and it is clear that the coil forms a sort of Leyden jar when thus used: an interval, however short it may be, must elapse in accumulating a charge which at intervals discharges itself and causes a *greater flow* in the vacuum-tube in addition to that which passes continuously. It may be stated that the capacity of the accumulator has to be carefully adjusted to prevent any cessation of the current, to avoid, in fact, a snapping discharge at distant intervals. The periodic overflows, so to speak, which increase the current from time to time, would seem to have a tendency to cause an interference of the current-waves, and to produce nodes of greater resistance in the medium, as evinced by the stratification which becomes apparent. To the eye no pulsation in the current is apparent; and in order to convince ourselves whether or not there was really any fluctuation in the current when the apparatus was thus coupled up with the battery, we made several experiments, and ultimately hit upon the following arrangement (fig. 3):—

Fig. 3.



The primary wire p p′ of a small induction-coil, both with and without the iron core, was introduced into the circuit as well as the vacuum-tube V ; to the secondary wire s s′ of the induction-coil was connected a second vacuum-tube, V^2. Under these circumstances there was no change in the appearance of the discharge in V, in consequence of the introduction of the induction-coil, the terminals being still surrounded by the soft nebulous light before spoken of: no luminosity appeared in the second vacuum-tube V^2 in connexion with the secondary wire of the induction-coil, except on making and breaking the connexion with the battery. At other times there was evidently no fluctuation in the continuous discharge, no periodic increase or diminution of flow, and consequently no induced current in the secondary wire s s′ of the induction-coil.

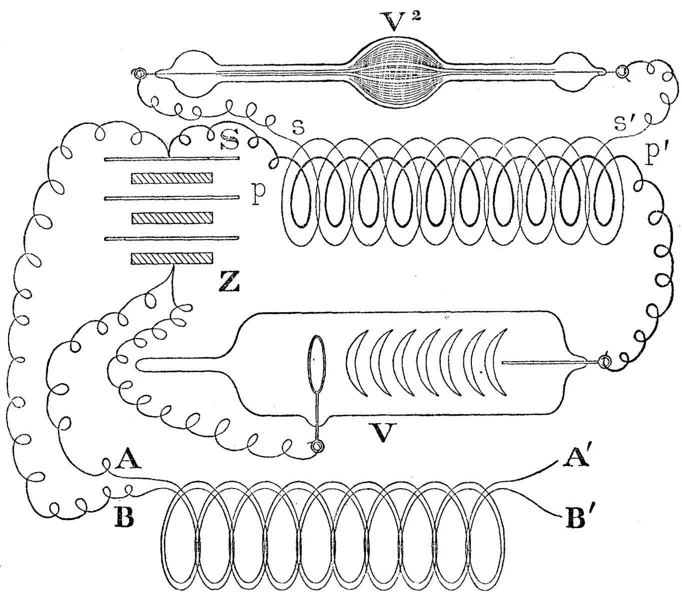
In the second experiment wires were also led from the terminals of the battery (all other things remaining as before) to the coil-accumulator as in fig. 4; then immediately the discharge in V became stratified and the secondary vacuum-tube V^2 lighted up, clearly showing that under these circumstances a fluctuation in the discharge really occurs on the appearance of stratification.

The brilliancy of the discharge in V^2 (the induced current passes through complicated vacuum-tubes through which the primary current cannot pass) depends greatly on the quality and quantity of the discharge in the primary vacuum-tube V. Under some circumstances the secondary discharge is extremely feeble, and the illumination in V^2 barely visible; under others it is very brilliant.

Preparations are being made to render evident induced currents in the

secondary wire of the coil too feeble to produce any illumination. Pending the further development of our investigation, we have ventured to give an account of our progress in elucidating some points in the theory of the vacuum-discharge, without any wish to ascribe to our results more weight than they deserve.

Fig. 4.



Batteries of this description may be had from Messrs. Tisley and Spiller, Brompton Road. Their cost, in large numbers, is about one shilling per cell, exclusive of the charge of chloride of silver, which costs about two shillings per cell. The latter, either in the form of powder or of rods cast upon flattened silver wire, may be obtained from Messrs. Johnson and Matthey, Hatton Garden. When the battery is exhausted the reduced silver may be readily reconverted into chloride, with scarcely any loss.

April 15, 1875.

JOSEPH DALTON HOOKER, C.B., President, in the Chair.

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

The following Papers were read:—

Fig. 3.

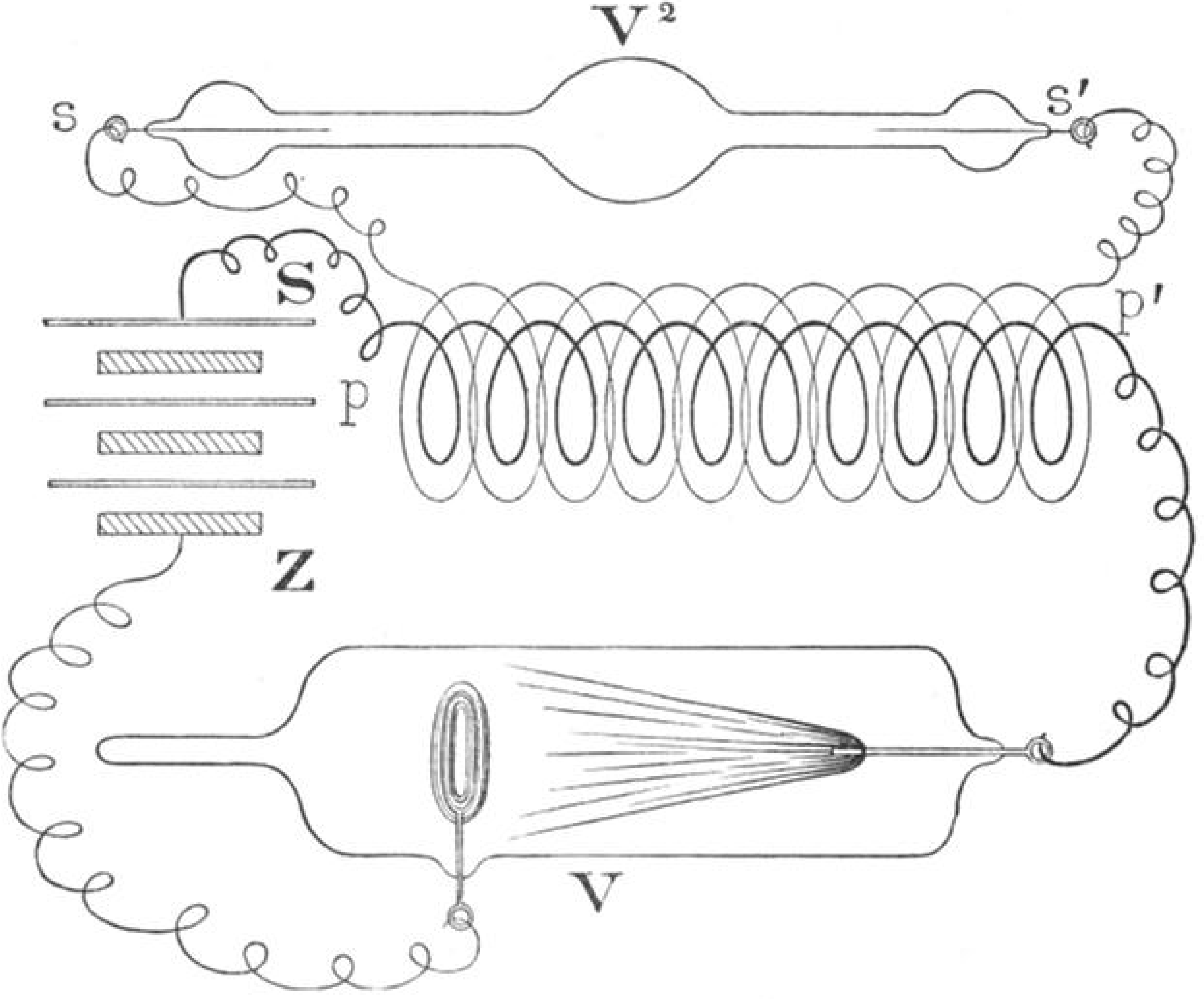


Fig. 4.