February 13, 1862.

Major-General SABINE, President, in the Chair.

The following communication was read:—

"On Magnetic Calms and Earth-Currents." By CHARLES V. WALKER, Esq., F.R.S., F.R.A.S. &c. Received February 3, 1862.

(Abstract.)

The author uses the word "calm" in a negative sense, "not storm", and states that very few notable earth-currents have attracted attention since the date of his original communication to the Royal Society, which was read on February 14, 1861.

Referring to that communication, he calls attention to the London, Tonbridge, and Dover–London lines of telegraph, making an angle of direction with each other of 149°, and by means of which a few groups of observations were made, from which the prevailing direction of earth-currents was determined to be approximately N.E. or S.W. He wished to multiply these observations and to modify them, which he was well able to do from the circumstance that the Dover–London telegraph wires enter his own private office at Tonbridge, where, by means of the necessary apparatus, he is able at any moment, when the wires are not occupied by telegrams, to obtain possession of the whole wire from end to end, Dover–London; or either section, London–Tonbridge, or Dover–Tonbridge,—the two former being the limiting lines, or those making the greatest available angle with each other, and the last, which is intermediate, being useful in confirmation of the observations made on the other two.

The telegraph needles have been rarely affected of late, the earth-currents which form the subject of the present communication being feeble. In order to their examination it was therefore necessary to prepare a delicate galvanometer, which is properly connected with the telegraph wire, and furnished with the simplest possible apparatus for bringing it into action whenever occasion serves. It is within arm's length of the author when in his office. The pressing-down of a spring allows any earth-current that may be present to enter the galvanometer; a brass plug, placed in holes 1, 2, and 3, gives

possession of the whole line, or either of its sections. The needle is deflected on the side marked "up" or "down," according as the current collected is moving up or down the line; and in all the Tables given in this communication the letters "*u*" or "*d*," placed beside the degrees of deflection, give the direction of the current in the above popular terms. The galvanometer, with its appliances, accompanies this communication, and is placed on the table as *in situ*, and will at a glance give an idea of the arrangement, of which also the author gives a plan.

A Table is given of earth-currents collected at Tonbridge, in October 1861, on the lines in question, together with the Meteorological Register of the month. An analysis of these observations follows, included with which is an analysis of all observations of a like character that were made in the subsequent month of November.

A few cases are recorded in which the earth gave no sign of current. No stress is laid on this, because a closer investigation with more delicate instruments might have given positive results.

The contents of the Table are divided into *Normal*, *Abnormal*, and *Exceptional*. Out of a total of 276 observations, 230 gave *normal* results, confirming the conclusion already arrived at, that the prevailing direction of earth-currents was approximately N.E. or S.W. Whether one or other of these directions prevailed more or less at different periods of the day did not appear, the observations not being sufficiently consecutive. Father Secchi's views of the relation between metereological phenomena and magnetic variation are referred to. The author has reason to conceive that sunshine or cloud, heat or cold, influence the relative values of the current collected from different parts of the same district; in connexion with which he refers to a group of night observations, which form part of the series made in October, and also to the want of consistency in the relation between two derived currents collected at the same time from different parts of the same plane. He gives a few extracts from the Table, showing how very variable are the relations; for instance, 15° : 15°; 15° : 30°; 15° : 35°; 13° : 38°; 18° : 21°; and so on.

Professor Loomis's "Eighth Article" on the subject is referred to; and the correspondence between the results at which he arrives by other processes, and those to which Mr. Walker arrives by the methods herein described, are given.

In addition to the currents whose direction has been already noted, 42 cases occurred of currents which, for distinction sake, are called *Abnormal*, and which were equally definite in character. They are found in the S.E. and N.W. quadrants; but the probable place in these quadrants could not be determined with any approach to accuracy from the lack of other lines of telegraph immediately at command. Four diagrams are given in illustration of the *normals* and *abnormals*.

The author mentions that the South-Eastern Railway Company have cordially entertained the proposition, to which he has previously referred, of the Astronomer Royal; and that he is now preparing to erect wires for Mr. Airy, terminating respectively near Dartford and Croydon, and which by combination will give an angle of 36° or 107°, the former, however, being without the range of normal direction. The consecutive observations to be made on these wires promise to be very instructive. The porcelain-ebonite insulator that will be used is described; a specimen is on the table.

Among the 276 October–November observations, four cases occurred which are exceptional and do not admit of similar discussion. Subsequent observations may explain these.

Next follows a survey of the N. and S. boundaries of a plane, the mean dimensions of which are 56 miles × 20 miles, bounded on the N. by the Thames, and on the S. by the Dover–Tonbridge line of railway. This was accomplished by aid of the earth-plates at Ramsgate and London, to the former of which access was had at Tonbridge, when required, by means of a switch at Ashford Junction. A Table is given of observations made during November and December, which show that the plane of the current is at least 20 miles wide, and the direction is consistent at either limit of the plane.

Tonbridge being very nearly midway on a line joining London and Hastings, gave the opportunity of making observations on the whole or on either half of a same line of country. The results collected in November and December are given in a Table, and show a conformity in direction in the whole and in both halves, but a marked excess in value in the London–Tonbridge as compared with the Hastings–Tonbridge section. These differences are considered by the author as probably due to the different geological conditions of the country on either side of Tonbridge. Sections kindly furnished

by Mr. Robert Hunt are referred to. These differences indicate the influence of local conditions, as the differences previously mentioned point at the interference of meteorological variations.

In order to satisfy himself that he was dealing with currents collected *bonâ fide* from the earth, and in no way from the atmosphere, arrangements were made with the clerks at Ashford to detach the observing wire from the earth there when required. A considerable number of observations were made during October, November, and December, the results of which are tabulated. Whether the current, as shown by the galvanometer, was weak or strong, it in every instance entirely ceased when the wire at Ashford was detached from the earth and held insulated; so that no portion of the result was derived from any other source than the earth. These observations were made at all periods of the day and night, and in all weathers.

Powerful artificial currents were repeatedly made to flow into the earth by the earth-plates, in order to see whether any effects of polarization were produced; but the value of the earth-current, as observed before any such experiment, remained unchanged.

That the currents collected are in no way due to the electromotive power of the earth-plates themselves, is shown by the absence of any sign of a tendency for one or other direction. They are independent in character and in value of all such influences. To prevent misconception, a list of the earth-connexions used at the several stations that enter into the present investigation is given.

The author considers it may be premature to regard the subject as tolerably exhausted, as far as the means at his command are concerned; but at this moment he does not notice any other salient point within his reach. When the proposed special wires are ready for Mr. Airy, and consecutive observations are made and compared with the march of the magnetometers, the subject will be within the reach of the able hands of Mr. Airy; and we may be well assured that the various questions connected with it will be ably discussed by him.

The results comprehended in this and the previous communication are briefly summed up as follows:—

1st. That currents of electricity are at all times moving in definite directions in the earth.

2nd. That their direction is not determined by local causes.

3rd. That there is no apparent difference, except in degree, between the currents collected in times of great magnetic disturbance and those collected during the ordinary calm periods.

4th. That the prevailing directions of earth-currents, or the currents of most frequent occurrence, are approximately N.E. and S.W. respectively.

5th. That there is no marked difference in frequency, duration, or value, between the N.E. and the S.W. currents.

6th. That (at least during calm periods) there are definite currents of less frequency from some place in the S.E. and N.W. quadrants respectively.

7th. That the direction of a current in one part of a plane on the earth's surface (at least as far as the S.E. district of England is concerned) coincides with the direction in another part of the plane; and if the direction changes in one part, it changes in all parts of the plane.

8th. That the relation in value between currents in a given part of the plane and currents in another given part is not constant, but is influenced by local meteorological conditions, and varies from time to time.

9th. That the value of the current of a given length, moving in a given line of direction, is not necessarily the same as of a current of the same length on the same line of direction produced, and that their relative value depends on the physical character of the earth interposed between the respective points of observation, and is tolerably constant.

10th. That the currents which have formed the basis of these investigations are derived currents from true and proper earth-currents, and neither in whole nor in any appreciable part have been collected from the atmosphere, nor are due either in whole or in any appreciable part to polarization imparted to earth-plates by the previous passage of earth-currents or of powerful telegraphic currents; nor are they due to any electromotive force in the earth-plates themselves.

11th. That the earth-currents in question (at least the powerful currents present at all times of great magnetic disturbance) exercise a *direct* action upon magnetometers, just as artificial currents confined to a wire exercise a direct action upon a magnet.