Report on the Discussion of the Electrical Observations at Kew.

By William Radcliff Birt.

The electrical observations made at the Observatory of the British Association at Kew from August 1, 1843, to August 8, 1848, are divisible into two portions, one occupying a period of seventeen months, viz. from August 1843 to December 1844 both inclusive, during which the readings were taken at sunrise, 9 A.M., 3 P.M. and sunset; the other, a period of three years and seven months, viz. from January 1844 to July 1848, also inclusive, during which the readings were taken at each even hour of Greenwich mean time as well as at sunrise and sunset. The last portion, which is by far the most complete, furnishes, from the observations of three complete years, the materials for deducing the diurnal and annual periods of the electrical tension. This has accordingly claimed our first attention and forms the first section of Part I., which is exclusively devoted to the examination of Positive Electricity.

The observations at sunrise and sunset, extending over the entire period of the five years, from the variability of the epoch of observation, require a separate discussion; they accordingly form the subject of the second section; and the third section is occupied with a discussion of the observations during the first seventeen months.

Scattered over the entire period of the five years we have several readings of negative electricity, and as they are evidently accompanied by meteorological phænomena of a peculiar and unmistakeable character which strongly indicate them to be the results of disturbances, rather than their forming any portion of a regular progression of the electric signs, they have also been separately discussed. Their discussion forms Part II. of this Report.

Part I.—POSITIVE ELECTRICITY.

Section 1.—*Discussion of Positive Readings during the Years* 1845, 1846 *and* 1847.

During the years 1845, 1846 and 1847, 10,526 observations were recorded in the Journal, including the indications of the night-registering apparatus. Of these—

10,176	were positive;
324	„ negative, and
26	„ not employed in the discussion;
10,526	

In the following table are recorded the twenty-six unemployed readings which were positive; they were in almost every case either preceded or succeeded by *negative* readings, from which it was concluded that they resulted more from a disturbance in the usual electrical condition of the atmosphere, than that they formed a part of its regular diurnal march: from these circumstances, connected with the high tensions mostly exhibited, it was apprehended the results would have been materially affected by employing them in the investigation.

In the following discussion, readings occasionally higher than some of those recorded below have been employed, but they have evidently formed either a part of a regular diurnal movement, or have occurred at such hours as are generally distinguished by exhibiting an increase of tension. It was consequently considered that a rejection of them would to a certain extent interfere with the development of the diurnal and annual curves. The values in the table, as well as throughout the discussion, are recorded in terms of Volta's electrometer No. 1. The observations were taken with Henley's instrument, 1 degree of which has been approximately considered to be equal to 100 divisions of Volta No. 1*.

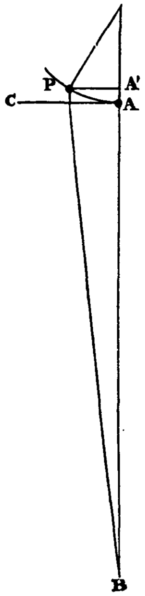
* On the 13th and 14th of July 1849, the reporter attended at the observatory for the purpose of comparing the electrometers, and especially determining the value of the readings of Henley's electrometer in terms of Volta's standard No. 1. The following are the results of the comparison. It appears from upwards of two hundred readings, the charge varying between 50 div. and 110 div. of Volta No. 1 as read from the scale of the No. 2 electrometer, that the mode of reading adopted by the observer at Kew, during the five years, was to bring the eye into such a position that the inner edge of the straw should coincide with the division read on the ivory arc of the instrument. By this mode of reading, 1° of Henley would very nearly equal in value 100 div. of Volta; this value has accordingly been retained, as most in accordance with the mode of reading adopted. It will be however evident that the true reading would be given, not by either *edge* of the straw, but by the *centre*: the diameter of the straw is equal to 2°; consequently when the inner edge coincides with 1°, the true reading must be 2°. From this it is clear that the values in the following discussion are relatively *too high*, but they will not interfere with the results further than by *expanding* the curves; the inflexions, points of maxima and minima, and the general form of the curves, will be the same, consequently the results derived from these curves will be unaffected. It would have been desirable to have applied a correction for this difference in the mode of reading, had not a greater difficulty presented itself in the dissimilarity of the construction of the two instruments, by which the values at different parts of the scale of Henley's instrument acquire different values in terms of Volta's instrument. The small extent of range common to both instruments renders it very difficult to express the higher readings of Henley at all accurately in terms of Volta. It is therefore considered best under the circumstances to retain the values as given in the tables, especially as the results are not materially interfered with; and endeavour to point out a mode by which the readings of Henley's instrument may be *accurately* expressed in terms of Volta, as well as to indicate a more precise method of observation.

The standard electrometer No. 1 of Volta is so constructed that a given electric force causes a pair of straws of a known weight to diverge. Their divergence is measured on a circular arc of the same radius as the length of the straws, which is so graduated as to indicate half the distance in arc between the extremities of the straws in half-Parisian lines, each of the divisions, which are at equal distances from each other, being equal to half a line. It is clear from this construction of instrument, that upon measuring the distance between the straws in a *right line, the sine of half the angle subtended by the extremities of the straws is proportional to the electric tension of the charge.*

The electrometer No. 2 is so constructed that each division is exactly equal to five of No. 1, and the circular arc is graduated to read at once the electric tension in terms of No. 1. The difference in the electrometers consists in the straws of No. 2 being heavier than those of No. 1, in such a proportion as to increase the value of the readings in the ratio above mentioned. As in No. 1 the sine of half the angle of divergence is proportional to the tension, so in No. 2 precisely the same value of the tension obtains, viz. the sine of half the angle of divergence, the linear value of the sine itself being proportional to its value in No. 1 for the same force: thus, a force that would diverge the straws in No. 1 to an angle of 30° would only open them in No. 2 to an angle of 6°, and in each instrument the sines of 15° and 3° respectively would represent the same force. There is however no necessity to employ such a determination of the force, the graduation of each instrument being amply sufficient for the purpose.

The Henley's electrometer is so constructed that the force is measured by a straw terminating in a pith-ball, which together constitute a pendulum that is inserted in a ball working by two fine steel pivots. This pendulum diverges by the electric force from the perpendicular, the angular amount of divergence being measured by a quadrant, graduated to degrees of the circle on an ivory scale. As it is thus used, the readings are not very readily comparable with those of the Volta's electrometers, in consequence of the Henley readings being in arc, while those of Volta are in linear measure. This difficulty may however be readily overcome by immediately measuring the *sine* of the angle of divergence, which in this instrument is a measure of the electric tension. Nothing further would be required than to place the electrometer in a convenient position for observation by a theodolite, which should be firmly fixed at a known distance from it. The centre of the azimuth circle should be in the precise vertical plane of the centre of the pith-ball when unelectrified, and should be at such a distance that the arc measured by it may be of sufficient range to determine the length of the sine with tolerable accuracy. The distance between the centres of the azimuth circle and pith-ball should, if possible, be of such a value in half-Parisian lines as to facilitate the formation of a table for obtaining the value of the sine in half-Parisian lines by inspection, so that a simple observation of the bisection of the right and left limbs of the pith-ball, which of course would be in arc, and the deduced divergence in arc of its centre from its plane of rest when unelectrified, would, with the assistance of the table, give at once the electric tension in half-Parisian lines; and these readings might readily be converted into terms of Volta's electrometer No. 1, by properly adjusting the straw, pith-ball, &c. to a definite value, so that a divergence of half a Parisian line may be equivalent to a certain number of divisions of Volta's standard electrometer. In this way, it is clear, the tensions might be expressed in terms of Volta's standard up to 90° of Henley without the necessity of applying corrections, unless such corrections should be rendered necessary from the effects of gravity on the pendulum.

Fig. 1.



The whole matter may be rendered plain by the annexed diagram (fig. 1). Let A represent the centre of the pith-ball when unelectrified, and B the centre of the azimuth circle of the theodolite. The distance B A will form the base of a right-angled triangle, of which the divergence of the pendulum P — A′ is the perpendicular. When the instrument is electrified, the pith-ball diverges in a plane at right angles to the plane passing through its centre when unelectrified, and that of the azimuth circle; or in other words, the plane of its motion passes vertically through the line A C, and is at right angles to the vertical plane passing through the line A B. If now the theodolite is so adjusted that the limbs of the pith-ball may be bisected, the azimuth circle will measure in arc the sine of the angle of divergence, and thus we have given the side and angles of a right-angled triangle from which the linear measure of the divergence may readily be deduced. The analogy is as follows:—Radius is to the tangent of the horizontal angle, as the distance between the centres of the pith-ball and azimuth circle is to the divergence.

Suppose the distance A B	=	500 half-lines;
The azimuthal angle......	=	6°;
Then Log A B	=	2·698970
„ Log tan 6°	=	9·021620
„ Log 52·55+	=	1·720590

Consequently the divergence is equal to 52·55 half-Parisian lines in a plane at right angles to the vertical plane passing through the above-mentioned centres.

N.B. The diagram is constructed in accordance with the above example.

It is not absolutely necessary to employ a theodolite. A telescope furnished with cross wires firmly fixed on a support having its centre of azimuthal motion at a known constant and invariable distance from the centre of the pith-ball when unelectrified, the angle being measured by an arm sufficiently extended to include the angle subtended by the pendulum when deflected from the perpendicular 90°, will be sufficient. A vertical motion should be given to the telescope by rackwork by which it can be raised to the level of the pith-ball when electrified, and it should be furnished with a level, &c. to ensure horizontality.

The above remarks have reference to the expression of the electric tension in the *linear* terms adopted by Volta, viz. *half-Paris lines*, and are principally applicable to the retention of Volta's notation so far as the measurement of the sine of the angle of divergence from the perpendicular is concerned; but Mr. Ronalds has suggested a much better mode of connecting the readings of the two instruments, viz. a conversion of the readings of Volta's electrometer (half Paris lines) into measures of *arc*, so that the readings of the three instruments, Volta No. 1, Volta No. 2, and Henley, and even of the discharger, may all be expressed in degrees of the circle, the sines of which are of course readily ascertainable.

TABLE I.

Unemployed positive readings.

Date.	Div. Volta No. 1.	Date.	Div. Volta No. 1.
1845. Feb. 23, 8 a.m.	2000	1846. June 25, 2 p.m.	4500
1845. May 20, 8 p.m.	3000	1846. Aug. 1, 4 p.m.	5500
1845. May 26, noon.	4500	1846. Aug. 1, 6 p.m.	5500
1845. June 4, 2 p.m.	3500	1846. Aug. 3, noon.	1500
1845. July 11, 2 p.m.	2000	1846. Aug. 5, 6 a.m.	3000
1845. Aug. 7, 2 p.m.	1000	1847. Mar. 10, 4 p.m.	2500
1845. Aug. 7, 4 p.m.	2000	1847. Apr. 29, 4 p.m.	2500
1846. Feb. 27, noon.	2000	1847. Apr. 29, 6 p.m.	1000
1846. Mar. 26, 6 p.m.	4500	1847. Apr. 30, 2 p.m.	2500
1846. Apr. 25, 2 p.m.	3000	1847. May 3, 2 p.m.	3000
1846. Apr. 26, 6 a.m.	2000	1847. July 17, 6 a.m.	2000
1846. May 6, 2 p.m.	4500	1847. July 17, 8 a.m.	3500
1846. May 20, 2 p.m.	5000	1847. Dec. 30, noon.	3000

DIURNAL PERIOD.

Diurnal period. Year.—In examining the results obtained from a discussion of the positive observations, it will be desirable to confine our attention first to the diurnal period of the electrical tension, or to those variations exhibited by the electrometers which have a day for the period in which they are completed, and which evidently depend on, or are connected with, the rotation of the earth on its axis.

The 10,176 observations upon which the mean diurnal period of the three years is based, are thus distributed among the twelve daily readings.

TABLE II.

Number of positive readings at each observation-hour in the three years 1845, 1846 and 1847.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Sums.
1845.	222	236	246	190	341	327	275	297	302	304	302	332	3374
1846.	234	257	269	190	353	338	288	278	287	281	286	338	3399
1847.	199	255	289	186	353	348	285	283	289	289	290	337	3403
Sums.	655	748	804	566	1047	1013	848	858	878	874	878	1007	10176

It will be remarked, that the greatest number of positive observations were recorded at 8 A.M., and the least number at 6 A.M. The numbers from noon to 8 P.M. do not vary materially in amount; but at 10 P.M. the number again increases. By consulting the following table of the distribution of negative observations, it will be seen that the greatest number occurred between 8 A.M. and 8 P.M. exclusive; this will to some little extent account for the difference; but the principal cause is, that on Sundays the observations were suspended between 10 A.M. and 10 P.M. exclusive. The small number of observations at 6 A.M. arises from the fact, that during the winter months, the *personal* observations were not commenced until 8 A.M., or more properly speaking until sunrise.

TABLE III.

Number of negative readings at each observation-hour in the three years 1845, 1846 and 1847.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Sums.
1845.	3	5	5	5	11	17	13	16	22	20	17	15	149
1846.	1	4	4	5	9	18	11	11	12	10	5	4	94
1847.	3	1	1	4	9	11	10	13	7	9	5	8	81
Sums.	7	10	10	14	29	46	34	40	41	39	27	27	324

The mode of discussion adopted has been, to arrange all the positive readings under the respective hours of observation, and then to divide their sums by the number of readings at each hour, so that the values recorded in the following tables are the arithmetical means of the readings at each observation-hour. The transcription from the Journal has been most carefully checked, and every precaution taken to ensure accuracy, both in ascertaining the number of observations and in calculating the means; in the latter case the arithmetical operations have been executed in duplicate. The results of these computations, as before mentioned, are expressed in terms of Volta's standard electrometer No. 1, all observations of tensions exceeding the range of this instrument having been reduced to its readings (see description of electrometers, 'Report,' 1844, p. 124, and the previous note on p. 114 of this Report).

On the 1st of January 1845, when the night-registering apparatus was first brought into use, a note occurs in the register which it is important to transcribe here. It is as follows:—

"The electric tensions at the hours 0, 2 and 4 are estimated by adding a quarter of a degree (of Volta) to the tensions exhibited by the three night-registering electrometers at sunrise, *for each hour which has elapsed between the time at which they were charged (by the clock) and the time of observing them (viz. sunrise).*

"The rate of loss by these electrometers begins to be inconstant after the tension has exceeded about 50° (of Volta): *vide* Experiments, 1844, p. ; if, therefore, the tension at sunrise of any such instrument shall exceed 50°, it is not noted in the Journal*."

TABLE IV.

Mean electrical tension at each observation-hour in the three years 1845, 1846 and 1847, with the mean diurnal period as deduced from the whole.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	19·8	17·8	18·3	28·6	64·7	84·4	67·9	59·9	59·2	71·1	98·9	117·2	63·1
1846.	24·3	21·2	21·4	35·4	61·1	76·7	69·6	65·5	63·5	85·0	96·3	87·2	61·3
1847.	23·7	21·1	21·5	38·7	78·7	102·5	88·4	89·4	85·0	99·1	112·0	107·9	76·3
Mean.	22·6	20·1	20·5	34·2	68·2	88·1	75·4	71·5	69·1	84·8	102·4	104·0	66·9

* For a full description of these night-registering electrometers, see 'Report,' 1844, p. 138, under the head of "Experiments on insulation by means of chloride of calcium."

Table V.

Excess or defect of the mean electrical tension at each observation-hour, as compared with the mean of the year, for the three years 1845, 1846 and 1847, and the mean diurnal period.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	− 43·3	− 45·3	− 44·8	− 34·5	+ 1·6	+ 21·3	+ 4·8	− 3·2	− 3·9	+ 8·0	+ 35·8	+ 54·1	63·1
1846.	− 37·0	− 40·1	− 39·9	− 25·9	− 0·2	+ 15·4	+ 8·3	+ 4·2	+ 2·2	+ 23·7	+ 35·0	+ 25·9	61·3
1847.	− 52·6	− 55·2	− 54·8	− 37·6	+ 2·4	+ 26·2	+ 12·1	+ 13·1	+ 8·7	+ 22·8	+ 35·7	+ 31·6	76·3
Mean.	− 44·3	− 46·8	− 46·4	− 32·7	+ 1·3	+ 21·2	+ 8·5	+ 4·6	+ 2·2	+ 17·9	+ 35·5	+ 37·1	66·9

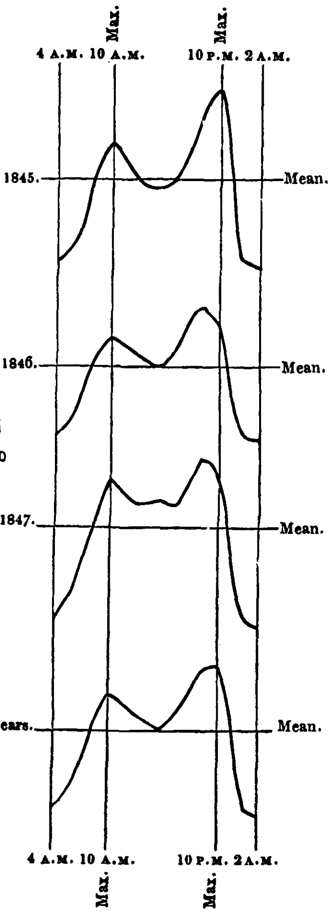
The above tables, which are based upon the numbers in Table II., clearly exhibit a double progression of the electrical tension during the twenty-four hours. The means of the first two years closely approximate, and in connexion with the general course of the numbers, give a proportional confidence, both with regard to the care manifested in making the observations and the faithfulness of the record. The third year exhibits upon the whole a higher tension, the means at midnight and 2 A.M. being the only values that are lower than those of the same hours in 1846. The mean of all the observations is 66·9 divisions of Volta's electrometer No. 1.

There are only three exceptions to the general fact, that from 8 A.M. to 10 P.M. the mean electrical tension is above the mean of the year. The mean diurnal period, as deduced from the three years, does not exhibit any depression *below* the mean of all the observations between the above-mentioned hours. The hours that exhibit a depression below the mean are midnight, 2, 4 and 6 A.M., and these are considerably in defect. The hour of minimum tension appears to be 2 A.M., a gradual rise taking place from that hour until 6 A.M. Between the hours of 6 and 8 A.M. a rapid rise occurs, the tension being nearly doubled; it then increases gradually until 10 A.M., when a maximum is passed, after which it gradually declines until 4 P.M., the epoch of the *diurnal* minimum as contradistinguished from the *nocturnal* minimum. The tension then rapidly increases until 8 P.M., and at 10 P.M. passes another maximum rather considerably above the maximum of 10 A.M. From 10 P.M to midnight (two hours) the diminution of the tension is enormous, 81·4 divisions of Volta No. 1. The midnight value is but slightly above the value at 2 A.M., the epoch of the minimum.

The diurnal march of the tension is rendered more apparent to the eye by the annexed curves (fig. 2). The general similarity of the movements in the three years, and the close agreement between the curves of these years, and that of the mean diurnal curve as deduced from them, is, to a certain extent, satisfactory. The forenoon maximum is well marked in each case, as well as the evening maximum: in 1846 and 1847 this occurred at 8 P.M., and it may be probable that 9 P.M. may be the hour at which it is most frequently exhibited.

The lower readings at midnight, 2, 4 and 6 A.M., demand particular attention. From the note above extracted (see page 117), we find that tensions at these hours, above 50 div. of Volta No. 1, do not enter into the discussion. It is not only highly probable, but the absence of records at these hours, when Henley's electrometer has ranged rather high, indicates that the conductor has possessed much higher charges than 50 div. at the hours of 0, 2 and 4.

Fig. 2.



Mean diurnal curves of the electrical tension for the years 1845, 1846 and 1847, with the mean curve of the three years.

The inference undoubtedly is, that the means at those hours are *too low*, and as a consequence, the mean of each year, as well as the mean of all the observations, is also *too low*. With regard to the hour of 6 A.M., the value appertains only to the summer, very few observations occurring at this hour in the winter. When we come to discuss the seasons, it will be seen that the higher tensions invariably occur in the winter; the value at 6 A.M., upon the whole year, is therefore also *too low*; consequently, were we in possession of either an uninterrupted series of *personal* observations during the day and night, or carefully executed photographic registers for the same period, we should doubtless have a curve which would exhibit neither so rapid a rise from 6 A.M. to 8 A.M., nor so great a fall from 10 P.M. to midnight, but would at these hours be more in accordance with its other portions. Of course it is important, in reference to this point, to bear in mind the circumstances under which the observations were made, the personal establishment not having enabled the observer to continue the observations during the night, and the uncertain diminution of the charges of the night-registering electrometers above 50 div. rendering it preferable *not* to record the indications of the instruments above 50 div., rather than insert numbers likely to vary from the truth, and for which there are no certain means of correction. From a consideration of the tables and curves, it will be apparent, that the hour most suitable for observing the mean electrical tension during the entire year is 8 A.M., the difference from the mean at this hour being 1·3 div. in excess.

Diurnal period. Summer.—The 10,176 observations from which the diurnal period having reference to the entire year has been deduced, are thus divided:—

Summer............	5,514
Winter	4,662
	10,176

The following table exhibits the distribution of the summer observations among the twelve daily readings: the months considered to constitute the summer half-year are, April, May, June, July, August and September:—

Table VI.

Number of positive readings at each observation-hour in the three summers of 1845, 1846 and 1847.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Sums.
1845.	135	135	147	176	174	167	135	146	149	152	158	171	1845
1846.	140	149	155	172	175	170	142	135	139	138	148	169	1832
1847.	125	148	163	177	178	173	139	137	141	140	147	169	1837
Sums.	400	432	465	525	527	510	416	418	429	430	453	509	5514

These numbers are more nearly equal in their amount than the yearly distribution.

Table VII.

Mean electrical tension at each observation-hour in the three summers of 1845, 1846 and 1847, with the mean diurnal period of summer.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	19·6	16·0	17·3	29·1	39·4	34·8	29·6	33·8	32·6	36·6	53·6	71·1	35·3
1846.	21·0	17·4	19·4	33·9	44·9	47·1	34·9	33·9	36·3	40·4	49·1	55·0	36·5
1847.	23·5	20·0	19·8	36·7	46·5	57·9	35·4	37·8	37·0	39·8	49·7	64·2	39·7
Mean.	21·3	17·8	18·9	33·2	43·6	46·7	33·4	35·1	35·2	38·9	50·8	63·4	37·2

Table VIII.

Excess or defect of the mean electrical tension at each observation-hour as compared with the mean of each summer in the years 1845, 1846 and 1847, and the mean of the three summers.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	− 15·7	− 19·3	− 18·0	− 6·2	+ 4·1	− 0·5	− 5·7	− 1·5	− 2·7	+ 1·3	+ 18·3	+ 35·8	35·3
1846.	− 15·5	− 19·1	− 17·1	− 2·6	+ 8·4	+ 10·6	− 1·6	− 2·6	− 0·2	+ 3·9	+ 12·6	+ 18·5	36·5
1847.	− 16·2	− 19·7	− 19·9	− 3·0	+ 6·8	+ 18·2	− 4·3	− 1·9	− 2·7	+ 0·1	+ 10·0	+ 24·5	39·7
Mean.	− 15·9	− 19·4	− 18·3	− 4·0	+ 6·4	+ 9·5	− 3·8	− 2·1	− 2·0	+ 1·7	+ 13·6	+ 26·2	37·2

In contrasting the numbers in Tables VII. and VIII. with those in Tables IV. and V. having reference to the entire year, we are struck with the greater uniformity that prevails among those appertaining to the summer. The means approximate more closely to each other, the general course of the numbers is more regular, and the rise during the morning hours more gentle, although there is still a considerable diminution of tension between 10 P.M. and midnight.

In contemplating the numbers in Table VIII., indicating the excess or defect in comparison with the mean, we see at a glance that the double progression is well exhibited: at noon, 2 and 4 P.M., the numbers are in defect, or lower than the mean, as well as at midnight, 2, 4 and 6 A.M. It may be proper to mention here, that during the summer months the tension seldom rises above 100 div. of Volta No. 1, except at particular hours; this will form a subject of discussion further on; in the meantime it enables us to gain some insight into the reason of the diurnal period during the summer months in each year being more in accordance with itself than that of the entire year. The defect of the early morning hours is not so great as the excess at 10 P.M.; consequently the mean line cuts the entire curve more equably, exhibiting the two maxima above, and the two minima below it. This doubtless arises from the very few tensions above 50 div. that occur during the summer nights, as well as from the observations at 6 A.M., which are generally low. We have therefore a period that differs but little, if any, from the natural progression of the electrical tension: 2 A.M. is the epoch of the principal minimum; the tension gradually rises from this hour until 10 A.M., the forenoon maximum; the succeeding minimum occurs at noon, the decline in the two hours being 13·3 div.; the rise is then very slow and gradual until 4 P.M., only 1·8 div.; at 6 P.M. the tension increases and mounts rapidly until 10 P.M., the principal maximum; the decline is then very considerable from 10 P.M. to midnight.

TABLE IX.

Comparison of the excess or defect from the mean of the diurnal periods deduced from all the observations, and from those made during the summer months.

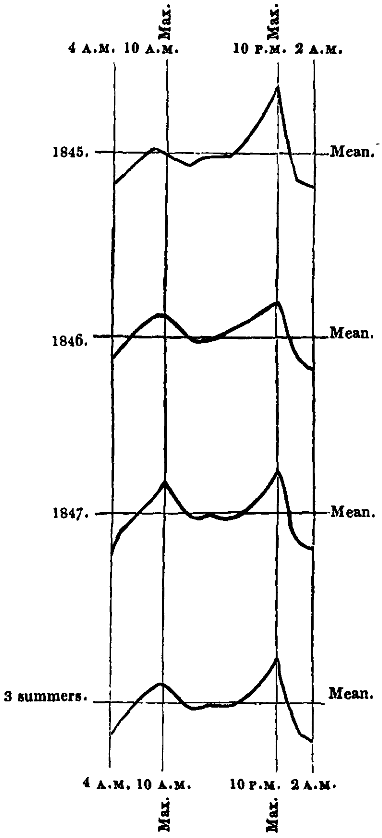
Season.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
Year . .	− 44·3	− 46·8	− 46·4	− 32·7	+ 1·3	+ 21·2	+ 8·5	+ 4·6	+ 2·2	+ 17·9	+ 35·5	+ 37·1	66·9
Summer.	− 15·9	− 19·4	− 18·3	− 4·0	+ 6·4	+ 9·5	− 3·8	− 2·1	− 2·0	+ 1·7	+ 13·6	+ 26·2	37·2

The above table places the diurnal period of the summer months in contrast with that of the entire year.

The annexed curves (fig. 3) exhibit the diurnal march of the tension during the summer months. The same similarity of movement is noticed as in the yearly curves; it is however worthy of remark, that the depression in or about the afternoon does not differ very essentially from that of the entire year, with the exception of the minimum occurring at noon. During the summer the evening maximum is 16·7 div. above the forenoon maximum, and during the entire year it is 15·9 div. The afternoon minimum is depressed below the evening maximum during the year 34·9 div., during the summer it is 30·0 div. This is in decided contrast with the lower branches of the curves, which exhibit a much greater difference. The difference of range in the two series of curves has not been exhibited, from the consideration that the nocturnal minimum of the entire year is probably too low.

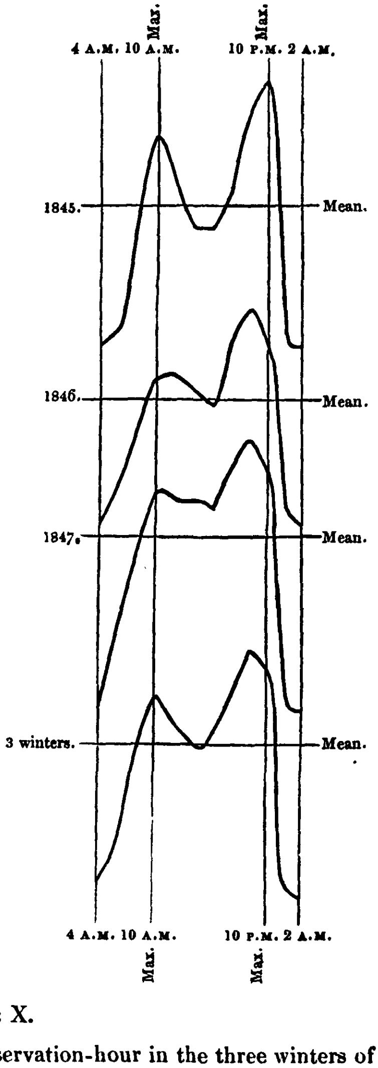
Diurnal period. Winter.—The months constituting the winter half-year are, October, November, December, January, February and March. In the tables that follow, the means are not of consecutive months, but of January, February and March at the commencement, and October, November and December at the end of each year.

Fig. 3.



Mean diurnal curves of the electrical tension for the summers of 1845 1846 and 1847, with the mean curve of the three summers.

Fig. 4.



Mean diurnal curves of the electrical tension for the winters of 1845, 1846 and 1847, with the mean curve of the three winters.

Table X.

Number of positive readings at each observation-hour in the three winters of 1845, 1846 and 1847.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Sums.
1845.	87	101	99	14	167	160	140	151	153	152	144	161	1529
1846.	94	108	114	18	178	168	146	143	148	143	138	169	1567
1847.	74	107	126	9	175	175	146	146	148	149	143	168	1566
Sums.	255	316	339	41	520	503	432	440	449	444	425	498	4662

Table XI.

Mean electrical tension at each observation-hour in the three winters of 1845, 1846 and 1847, with the mean diurnal period of winter.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	20·1	20·2	19·8	23·5	90·9	136·3	104·8	85·2	85·2	105·6	148·6	166·3	96·7
1846.	29·2	26·5	24·2	49·2	77·0	106·7	103·3	95·4	89·2	128·1	146·9	119·4	90·4
1847.	23·9	22·7	23·6	76·9	111·4	146·6	138·9	137·9	130·7	154·8	176·1	151·9	119·1
Mean.	24·5	23·2	22·7	46·5	93·1	130·0	115·8	106·0	101·5	129·4	157·3	145·5	102·1

Table XII.

Excess or defect of the mean electrical tension at each observation-hour as compared with the mean of each winter in the years 1845, 1846 and 1847, and the mean of the three winters.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	− 76·6	− 76·5	− 76·9	− 73·2	− 5·8	+ 39·6	+ 8·1	− 11·5	− 11·5	+ 8·9	+ 51·9	+ 69·6	96·7
1846.	− 61·2	− 63·9	− 66·2	− 41·2	− 13·4	+ 16·3	+ 12·9	+ 5·0	− 1·2	+ 37·7	+ 56·5	+ 29·0	90·4
1847.	− 95·2	− 96·4	− 95·5	− 42·2	− 7·7	+ 27·5	+ 19·8	+ 18·8	+ 11·6	+ 35·7	+ 57·0	+ 32·8	119·1
Mean.	− 77·6	− 78·9	− 79·4	− 55·6	− 9·0	+ 27·9	+ 13·7	+ 3·9	− 0·6	+ 27·3	+ 55·2	+ 43·4	102·1

Most of the remarks offered under the head of "*Diurnal period, Year*," will equally apply to the present tables. There is, however, one feature that is very striking, viz. the greater range as well as amount of tension during the winter months, and that independent of the low readings during the early morning hours. The double progression is even more decided than in either of the former cases. In tracing the diurnal march we find the minimum at 4 A.M., a comparatively gentle rise takes place at 6 A.M., after which the tension rapidly mounts until 10 A.M., the forenoon maximum; it then gradually declines until 4 P.M., the afternoon minimum, and from this hour the rise is very rapid until 8 P.M., the epoch of the evening maximum. A fall of 11·8 div. takes place between 8 and 10 P.M., and then the enormous fall occurs between 10 P.M. and midnight, which we noticed in the yearly curves. The elevation of the evening above the forenoon maximum equals 27·3 div., and the depression of the intermediate minimum is as great as 55·8 div. The recess of the nocturnal maxima and minima from each other is interesting. The above phænomena are very clearly apparent in the annexed curves (fig. 4).

On contrasting these curves with those of the summer half-year (fig. 3), and comparing both with the curves having reference to the entire year on p. 119, the influence of the winter curves on those of the year is readily seen: the yearly curves present precisely the same general features as the winter curves. Taking this circumstance in connexion with the greater number of higher readings in winter than in summer, it may be inferred that the higher tensions materially influence the general results. The influence of season in both instances, viz. the difference of tension and the form of curve, is very apparent from the series of summer and winter curves.

Table XIII.

Comparison of the excess or defect from the mean of the diurnal periods deduced from the observations in summer and winter.

Season.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
Summer.	− 15·9	− 19·4	− 18·3	− 4·0	+ 6·4	+ 9·5	− 3·8	− 2·1	− 2·0	+ 1·7	+ 13·6	+ 26·2	37·2
Winter.	− 77·6	− 78·9	− 79·4	− 55·6	− 9·0	+ 27·9	+ 13·7	+ 3·9	− 0·6	+ 27·3	+ 55·2	+ 43·4	102·1

In the above table the summer and winter diurnal periods are placed in contrast.

Table XIV.

Synopsis of the principal points in the summer, winter, and yearly curves.

Season.	Nocturnal Minimum.	Forenoon Maximum.	Afternoon Minimum.	Evening Maximum.	Even. Max. above Forenoon.	Aftern. Min. below Even. Max.
					div.	div.
Summer.	2 a.m.	10 a.m.	Noon.	10 p.m.	16·7	30·0
Winter ..	4 a.m.	10 a.m.	4 p.m.	8 p.m.	27·3	55·8
Year ...	2 a.m.	10 a.m.	4 p.m.	10 p.m.	15·9	34·9

The numbers in the last two columns clearly indicate a greater diurnal range of tension in winter than in summer; and this is very apparent from the curves, the upper portions of those of the winter being much bolder, and the depressions more distinctly marked, than the similar features of the summer curves. It is to be remarked, that although the diminution of tension between 10 P.M. and midnight is not so great in summer as in winter, the *precipitate* downward movement of the curve, which is so strikingly apparent in winter, does not in the summer disappear altogether, so as to give the curve that gentle depression to the nocturnal minimum which characterizes the rise from the afternoon minimum.

The three following tables exhibit the mean electrical tension at each observation-hour for each month in the years 1845, 1846 and 1847, with the monthly, seasonal, and yearly means. The characters of the monthly movements are exhibited to the eye in the sheets of curves illustrating this report.— See Plates VI. VII. and VIII.

TABLE XV.—Mean electrical tension at each observation-hour, as deduced from all the positive observations in the year 1845 arranged under the respective months, with the mean electrical tension of the summer, winter, and year.

Period.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Summer.	Winter.	Year.
Midnight..	14·5	22·2	22·0	22·3	19·4	16·7	16·0	21·4	22·3	19·1	....	28·1	19·6	20·1	19·8
2 a.m.......	12·3	19·5	27·6	17·7	16·6	16·5	14·6	14·4	17·1	21·6	....	26·2	16·0	20·2	17·8
4 a.m.......	18·2	18·9	21·6	18·0	18·2	20·3	15·5	15·8	16·4	16·2	....	27·2	17·3	19·8	18·3
6 a.m.......	....	....	....	37·7	45·5	21·7	24·8	18·6	27·1	....	....	....	29·1	23·5	28·6
8 a.m.......	113·8	197·4	51·5	56·5	50·4	32·4	22·1	25·1	49·6	46·9	71·5	69·6	39·4	90·9	64·7
10 a.m......	167·8	286·9	73·5	64·1	32·7	27·4	26·7	24·5	35·5	44·8	115·6	130·2	34·8	136·3	84·4
Noon	140·4	213·5	42·0	34·8	28·9	24·0	23·8	29·1	36·6	41·9	65·0	109·4	29·6	104·8	67·9
2 p.m.......	125·9	139·3	46·5	36·2	41·4	24·2	25·0	31·9	43·7	46·8	64·0	70·2	33·8	85·2	59·9
4 p.m.......	96·5	121·2	59·4	39·2	39·6	22·7	27·9	30·7	36·8	48·6	90·8	84·4	32·6	85·2	59·2
6 p.m.......	139·4	191·8	55·4	43·0	32·2	27·9	31·7	38·2	47·2	51·4	92·3	96·8	36·6	105·6	71·1
8 p.m.......	217·1	307·3	122·6	105·4	47·7	33·1	29·0	48·6	58·7	65·4	96·1	87·4	53·6	148·6	98·9
10 p.m......	136·8	395·6	153·0	143·7	78·8	39·5	49·6	61·7	57·3	94·4	112·1	108·2	71·1	166·3	117·2
Means......	109·3	190·3	64·5	56·1	38·7	26·0	25·9	29·9	37·5	46·2	83·9	84·2	35·3	96·7	63·1

TABLE XVI.—Mean electrical tension at each observation-hour, as deduced from all the positive observations in the year 1846 arranged under the respective months, with the mean electrical tension of the summer, winter, and year.

Period.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Summer.	Winter.	Year.
Midnight..	32·5	31·3	33·0	27·4	23·1	21·1	22·1	17·9	18·0	26·1	24·3	32·8	21·0	29·2	24·3
2 a.m.......	31·1	25·8	26·9	23·4	19·6	17·7	17·0	13·5	16·2	24·9	20·9	32·0	17·4	26·5	21·2
4 a.m.......	22·4	31·4	23·8	21·6	21·1	23·1	22·5	14·0	15·2	21·3	19·7	31·5	19·4	24·2	21·4
6 a.m.......	....	....	....	40·9	62·3	29·5	29·5	19·1	21·5	....	....	....	33·9	49·2	35·4
8 a.m.......	100·7	92·8	80·2	84·2	53·4	41·1	36·4	27·9	30·7	56·9	49·6	82·3	44·9	77·0	61·1
10 a.m......	123·4	131·1	93·4	96·6	42·7	51·4	34·3	30·2	30·0	68·0	66·9	159·0	47·1	106·7	76·7
Noon	82·4	77·7	66·2	40·8	63·9	28·1	28·9	22·9	23·7	122·5	69·8	189·2	34·9	103·3	69·6
2 p.m.......	101·6	69·1	66·1	38·3	42·3	23·0	30·3	44·8	25·0	59·1	59·2	205·0	33·9	95·4	65·5
4 p.m.......	79·2	72·4	61·1	69·5	33·3	26·8	28·1	29·5	32·3	62·2	60·1	188·0	36·3	89·2	63·5
6 p.m.......	143·4	133·3	83·7	73·1	36·9	37·8	34·1	31·9	33·7	77·4	58·8	270·3	40·4	128·1	85·0
8 p.m.......	145·3	168·4	210·8	89·4	43·5	41·9	46·0	34·7	38·9	83·4	56·4	219·6	49·1	146·9	96·3
10 p.m.	133·8	158·9	98·1	98·3	61·5	48·0	44·7	34·5	43·1	107·5	54·3	167·2	55·0	119·4	87·2
Means......	95·9	100·1	78·9	63·7	42·8	33·0	31·3	26·3	27·2	65·6	49·8	160·3	36·5	90·4	61·3

TABLE XVII.—Mean electrical tension at each observation-hour, as deduced from all the positive observations in the year 1847 arranged under the respective months, with the mean electrical tension of the summer, winter, and year.

Period.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Summer.	Winter.	Year.
Midnight..	29·3	32·5	35·5	31·1	19·3	25·2	30·4	20·6	20·2	17·6	19·7	24·5	23·5	23·9	23·7
2 a.m.	32·7	30·3	26·6	25·6	17·3	17·8	26·8	17·3	16·2	14·7	19·9	23·0	20·0	22·7	21·1
4 a.m.	34·1	26·8	22·3	22·8	15·6	23·4	25·0	17·4	15·7	19·2	18·8	27·6	19·8	23·6	21·5
6 a.m.	....	....	....	60·0	24·6	27·3	52·9	29·3	27·3	....	....	....	36·7	76·9	38·7
8 a.m.	185·2	160·0	135·1	76·7	35·5	29·6	56·9	40·0	39·2	62·3	70·9	52·4	46·5	111·4	78·7
10 a.m.	282·4	220·1	96·7	57·9	35·5	32·8	134·4	39·2	42·6	71·5	97·0	106·7	57·9	146·6	102·5
Noon	328·6	236·8	62·0	47·0	28·7	28·1	42·3	33·4	32·9	35·4	109·9	74·6	35·4	138·9	88·4
2 p.m.	331·0	266·9	48·2	55·5	34·9	28·5	47·3	29·6	32·0	33·4	91·1	83·3	37·8	137·9	89·4
4 p.m.	372·9	182·0	44·1	39·7	35·9	28·5	45·9	33·4	38·1	37·5	82·9	90·2	37·0	130·7	85·0
6 p.m.	333·8	229·3	77·2	46·4	38·5	27·0	47·1	37·2	42·0	43·9	140·8	116·8	39·8	154·8	99·1
8 p.m.	320·9	320·4	124·1	63·2	58·0	35·8	51·2	42·9	47·0	57·6	103·2	137·6	49·7	176·1	112·0
10 p.m.	263·6	259·9	133·6	72·5	42·6	41·9	126·2	42·3	55·9	50·2	88·7	127·0	64·2	151·9	107·9
Means......	258·8	206·6	79·6	52·2	32·3	28·8	59·7	31·9	34·3	41·0	78·7	84·3	39·7	119·1	76·3

TABLE XVIII.—Mean electrical tension at each observation-hour, as deduced from all the positive observations in the years 1845, 1846 and 1847, arranged under the respective months, with the mean electrical tension of the summer, winter, and year.

Period.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Summer.	Winter.	Year.
Midnight..	23·0	27·1	30·2	26·6	20·6	21·2	22·1	20·0	20·1	20·6	22·5	28·1	21·3	24·5	22·6
2 a.m.	23·2	24·3	27·0	22·6	17·9	17·4	19·3	15·1	16·5	20·0	20·2	26·8	17·8	23·2	20·1
4 a.m.	23·5	25·7	22·6	21·1	18·2	22·3	21·1	15·7	15·7	18·9	19·3	24·6	18·9	22·7	20·5
6 a.m.	....	....	52·9	46·3	44·3	26·2	35·6	22·3	25·3	29·0	....	....	33·2	46·5	34·2
8 a.m.	134·7	149·4	91·5	72·5	46·4	34·4	38·6	31·1	39·8	55·5	63·9	68·5	43·6	93·1	68·2
10 a.m.	194·8	213·8	89·3	72·6	36·9	37·5	66·4	31·3	36·1	61·4	93·4	132·3	46·7	130·0	88·1
Noon	182·4	179·3	58·2	40·7	41·3	26·8	31·8	28·5	31·0	65·1	80·5	126·3	33·4	115·8	75·4
2 p.m.	183·0	156·8	53·4	42·8	39·6	25·2	34·3	35·4	33·6	46·1	71·4	122·3	35·1	106·0	71·5
4 p.m.	172·0	126·4	54·6	49·6	36·4	25·9	34·1	31·3	35·7	49·4	77·9	121·3	35·2	101·5	69·1
6 p.m.	203·7	186·4	72·3	53·2	35·8	30·9	37·5	35·7	41·0	57·2	97·3	161·3	38·9	129·4	84·8
8 p.m.	227·2	266·2	152·5	87·4	49·8	36·8	41·7	42·3	48·6	68·1	84·4	147·2	50·8	157·3	102·4
10 p.m.	178·2	271·6	126·1	105·1	60·7	43·2	73·5	46·3	52·4	83·0	84·2	134·1	63·4	145·5	104·0
Means......	150·7	166·6	75·0	57·2	37·9	29·3	38·8	29·4	33·0	50·5	69·6	109·5	37·2	102·1	66·9

Table XVIII. exhibits the mean monthly electrical tension at each observation-hour deduced from the observations of *three* months, also the mean summer, winter, and yearly tensions deduced from the observations of *three* summers, winters, and years. The last line in the table to which the word "Means" is prefixed, exhibits the mean tension in each month as deduced from *all* the separate monthly observations; *i. e.* the mean tension of January, 150·7 div., is the result of all the January observations in the three years. The same thing holds good of the seasonal and yearly mean tensions.

The curves projected from these numbers will be found on Plate IX.

The tensions that enter into the preceding discussion range between 2 div. and 2000 div. in terms of Volta's standard electrometer No. 1. It has however been considered that tensions above 100 div. of this electrometer, or those measured by Henley's instrument, are not susceptible of that accuracy of determination which is requisite in the deduction of results, such as characterize those of modern science. In addition to this, it is apprehended that the electrical tension known more particularly as the tension of *serene weather*, seldom (if at all) rises above 100 div., although there may be movements indicated by Henley's instrument which partake of the character of those of serene weather.

In immediate reference to these points, and considerably elucidating them, remarks occur, either in the body of the Journal or in the notes and addenda accompanying it. In the description of the instruments at Kew published in the volume for 1844 (Reports, 1844, p. 124), the following occurs in reference to Henley's instrument:—

"This electrometer has seldom been observed until the Volta No. 2 had risen beyond 90° (in terms of the first, *i. e.* 18 lines × 5); and since the uncertainty and difficulty of measuring the higher tensions increase in a rapid ratio with the increments of tension owing to unavoidable and sometimes almost imperceptible 'spirtings,' and particularly to the falling of rain from the dish or funnel N (fig. 2), proportionably less confidence must, of course, be placed in our notations of such tensions by means of this instrument."

In the account of the experiments having reference to the employment of photographic methods for self-registering the indications of the instruments, which is appended to the volume of observations 1845 and 1846, we have the following remark relative to the objection of the Astronomer Royal as to the non-registry of the *kind* of electricity:—

"I had not of course overlooked the objection as to not registering the kind of electricity, but as every former observer of the periodical electricity of serene weather, (*i. e.*) that alone which is susceptible of exact measurement, and that which is by far the most important and interesting, had arrived at the same conclusion as myself, (viz.) that it is positive, and that the exceptions to this law are extremely rare, and always accompanied by an easily distinguished feature in meteorology."

In the above extracts we have clearly a restriction of the electricity of *serene weather* to a comparatively low tension, and that the higher tensions, although more difficult to measure accurately, are not near so important as those which characterize serene weather. In immediate connection with this comparatively low tension we have the following remark, recorded on June 23, 1844:—

"The weather of this day, considered as serene, has been rather remarkable. The signs a little after sunrise were the highest *for such weather* that we have had. The thermometer *at nine* stood at 75·5, the max. also, and the barometer at 29·938. The atmosphere quite clear; the clouds were light, rather fleecy, roundish and somewhat detached. Wind N.E. and E., its force about 500 grms. Daniell's hygrometer marked 20° of dryness."

At sunrise the electric tension was registered at 65 div. Volta No. 1. From this it appears that a tension of 65 div. at sunrise is considered as *high* for *serene weather*, and it might be inferred that tensions of a higher value indicated some other exciting cause than that which we contemplate as exciting the electricity of serene weather.

In the explanations and remarks concerning the Journal, &c. at Kew, published in the Report for 1844, p. 130, a serene day is defined as follows: "In the column N is pointed out (by the letter S) such days as generally occur when the positive charge rises after sunrise, falls early in the afternoon, and rises again in the evening, accompanied by what is commonly understood by the term 'fine weather;' but there are exceptions to this (rather vague) definition, which I believe require some habit, and an acquaintance with the observations of Monier and others, particularly Beccaria, to appreciate."

By glancing at the curves on pages 119 and 122, to which attention has been solicited, it will be seen that the movements, as deduced from the observations in individual years and seasons, as well as those from the entire number during the three years, are perfectly in accordance with the movements in serene weather, and it is only the restriction to which allusion has been made that suggests the probability of the higher tensions being due to a different exciting cause than that of the electricity of serene weather. In searching for such a cause among the records preserved in the Journal, we are struck with the fact, that in the majority of cases high tensions (*i. e.* those measured by Henley's electrometer) are accompanied by fog; and this suggests that it is not improbable that these high tensions may be more or less direct measures of the electricity, not of the atmosphere, but of the condensed aqueous vapour enveloping the collecting lanthorn. Of course the atmospheric electricity, as contradistinguished from that of the condensed aqueous vapour, will be mixed with it, and the conductor will be charged from two different sources, the atmospheric electricity exhibiting by far the smallest amount, and in cases of high charges forming probably but a very small proportion of the whole. There does not appear to be any direct means of separating these tensions; for if we take the *high* numbers, a small proportion, as we have already said, must appertain to "atmospheric electricity;" and if we take the *low* numbers as giving a more accurate measure of this element, on some occasions and especially at certain hours, the tensions exhibited may be those produced by the presence of aqueous vapour either in an invisible or condensed state, so that a degree of uncertainty as to the *true* forms of either of these diurnal curves must necessarily exist. Again, it is difficult to determine the point at which to separate the high from the low tensions; the uncertainty attendant on the readings of Henley's electrometer, combined with the electricity which alone is susceptible of exact measurement, tends greatly to place all readings of Henley's instrument in the category of *high* tensions. As a first attempt to separate the high from the low tensions, 1° of Henley equal to 100 div. of Volta No. 1 was regarded as the separating point; but it soon became apparent that readings lower than 100 div. had an equal claim to be regarded as high, indications being afforded that they were measures rather of the electricity of aqueous vapour than of the atmosphere. The observations of three or four months were discussed in this manner, but the curves of low tension presenting very anomalous characters, the mean readings increasing very considerably towards 8 P.M. led to their abandonment, and other separating points were tried from 50 div. and upwards. The result has been that the point 60 div. has been employed in the further discussions of the observations, all readings above and including it being regarded as high, and more or less measuring the electrical tension of aqueous vapour either invisible or condensed; and all readings below it being regarded as more or less measuring the tension of "atmospheric electricity." Of course this method is entirely tentative; the separating point 60 div. has been arbitrarily fixed, and, as before observed, it is not to be expected that the curves furnished will be true representatives of natural phænomena, when we come to contemplate the two different sources from which the conductor is supposed to be charged; nevertheless it may not be without its use in assisting us to devise some mode by which the two tensions may be effectually separated, either by some subsidiary observations and computations by which the electrical tension of the aqueous vapour may be disengaged from the aggregate tension as exhibited by the electrometers, or by directly observing the electrical tension of the vapour itself.

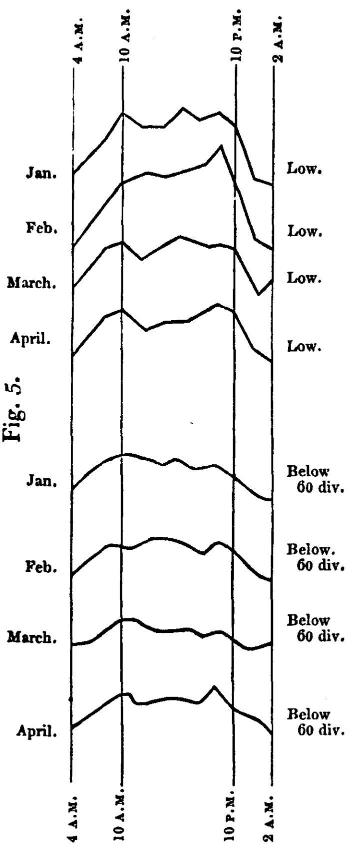


Fig. 5.

TABLE XIX.

Mean diurnal period of *low* tension for the months of January, February, March and April 1845.

Period.	Jan.	Feb.	March.	April.
Midnight ..	14·5	22·2	22·0	22·3
2 a.m.	11·4	19·5	30·6	17·7
4 a.m.	18·2	18·9	23·6	18·0
6 a.m.	......	......	......	28·0
8 a.m.	34·1	41·0	49·8	40·3
10 a.m. ...	49·5	52·4	50·6	44·0
Noon	41·1	58·6	42·0	32·6
2 p.m.	41·1	57·2	49·7	37·3
4 p.m.	53·0	59·7	52·4	39·2
6 p.m.	46·7	61·8	50·2	42·2
8 p.m.	51·0	72·9	50·5	47·4
10 p.m. ...	44·3	49·5	48·4	43·0
Means	34·3	45·6	43·7	35·1

The above table and curves are intended to illustrate the separation of the readings into those of high and low tensions. The table contains the diurnal periods for the first four months of the year 1845, and the four upper curves are the projections of these periods on the same scale as the curves deduced from all the observations. The four lower curves exhibit the diurnal period for the same months as deduced from the readings below 60 div. The greater uniformity of the lower curves, especially of January and February as compared with the upper, is very apparent. The curves appear naturally to divide themselves into two sets, the greater uniformity appertaining to January and February below 60 div., and to March and April, higher tensions than 60 div. entering as elements into the discussion of low tensions. This seems at once to indicate the *variability* of any point that may be fixed on for the purpose of separating the two. Uniformity of curve clearly points out uniformity of action, and in endeavouring to obtain a knowledge of the action of the electricity of serene weather on the conductor and electrometers, it is to be presumed that it is to a great extent uniform and regular, and that consequently the curves will exhibit such uniformity and regularity among themselves. This then, in the absence of some direct means of measuring either the electricity of serene weather or of aqueous vapour, must be our principal guide in endeavouring to separate them; and although on some occasions greater uniformity may be obtained by either including or excluding particular tensions, yet upon the whole great uncertainty must prevail, if we attempt to *vary* the point of separation without more conclusive data than the mere uniformity of curve.

Diurnal period below 60 *div., Year.*—The 10,176 observations at all tensions are thus divided :—

Below 60 div.	7,529
Above 60 div.	2,647
	10,176

Those below 60 div. are thus distributed among the twelve daily readings.

TABLE XX.

Number of positive readings below 60 div. at each observation-hour in the three years 1845, 1846 and 1847.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Sums.
1845.	222	236	243	172	249	224	202	222	215	197	172	168	2522
1846.	234	257	267	170	235	214	212	195	201	171	148	181	2485
1847.	199	255	286	160	229	222	213	210	209	193	161	185	2522
Sums.	655	748	796	502	713	660	627	627	625	561	481	534	7529

From a consideration of the above quantities, we find that the greatest number of low tensions occurred at the hours 2, 4 and 8 A.M.; 6 A.M. appears to be excepted; but we must bear in mind that the number 502 refers principally to the summer half-year; with this exception, the smallest number of low tensions occurred at 6, 8 and 10 P.M. It is to be remarked that these periods coincide, more or less, with the principal epochs of minimum and maximum, the whole of the observations being taken into account.

TABLE XXI.

Mean electrical tension below 60 div. at each observation-hour in the three years 1845, 1846 and 1847, with the mean diurnal period as deduced from the whole.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	19·8	17·8	17·5	19·4	26·6	28·7	29·7	31·4	30·5	30·5	31·6	30·8	25·9
1846.	24·3	21·2	21·0	25·0	30·5	32·4	31·3	30·5	32·0	34·3	35·0	36·0	28·8
1847.	23·7	21·1	20·9	27·1	32·1	36·0	35·5	33·9	35·0	37·5	38·0	39·2	31·1
Mean.	22·6	20·1	19·9	23·7	29·6	32·3	32·2	32·0	32·5	34·1	34·8	35·5	28·6

Table XXII.

Excess or defect of the mean electrical tension below 60 div. at each observation-hour, as compared with the mean of the year for the three years 1845, 1846 and 1847, and the mean diurnal period.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	− 6·1	− 8·1	− 8·4	− 6·5	+ 0·7	+ 2·8	+ 3·8	+ 5·5	+ 4·6	+ 4·6	+ 5·7	+ 4·9	25·9
1846.	− 4·5	− 7·6	− 7·8	− 3·8	+ 1·7	+ 3·6	+ 2·5	+ 1·7	+ 3·2	+ 5·5	+ 6·2	+ 7·2	28·8
1847.	− 7·4	− 10·0	− 10·2	− 4·0	+ 1·0	+ 4·9	+ 4·4	+ 2·8	+ 3·9	+ 6·4	+ 6·9	+ 8·1	31·1
Mean.	− 6·0	− 8·5	− 8·7	− 4·9	+ 1·0	+ 3·7	+ 3·6	+ 3·4	+ 3·9	+ 5·5	+ 6·2	+ 6·9	28·6

In the above tables the double progression, so apparent in the curves deduced from all the positive observations, is but slightly developed. The forenoon maximum at 10 A.M. rises very slightly above the afternoon minimum at 2 P.M.—only 0·3 div. The evening and principal maximum occurs at 10 P.M., presenting the highest mean reading of the series. The year 1847 is marked by an increase in the low as well as in the aggregate tension, this increase appearing after the hour of 4 A.M. If the separation of the high from the low tensions at the point of 60 div. be that which is most accordant with truth, and the above tables exhibit more accurately the movements during serene weather than those which form the preceding part of this discussion, it would appear that upon contemplating the movements as deduced from the three years, there exists a great tendency to soften down or even to obliterate the forenoon maximum in such movements, so as to exhibit an approach to a single progression. The departure from an exhibition of the *true* march of the electricity of serene weather by the numbers before us, has been alluded to, inasmuch as the same cause, viz. the presence of aqueous vapour, must influence the results as deduced from the lower as well as those from the higher readings, and it becomes a curious matter of inquiry as to how far both the subdued maximum of the forenoon and the more decidedly developed maximum of the evening, in the progression of the lower tension, may be due to the presence of such vapour. It is a matter worthy of remark, and certainly is not without great signification, that the curves already discussed agree in presenting a precipitous downward movement between 10 P.M. and midnight. The tables now under consideration present in a very decided manner the same feature: although the extent of the diminution of tension is not so great as in the aggregate curves, yet as compared with the other two-hourly movements, it is sufficiently large to constitute a marked contrast to them, and this is by no means to be confined to the tensions we have hitherto examined; it will be found as we proceed to be an invariable accompaniment to nearly the whole of the curves.

The mean of the 7529 observations below 60 div. is 28·6 div., or 38·3 div. lower than the mean of the 10,176 positive observations. The minimum occurs at 4 A.M., from which hour the tension gradually rises until 10 A.M.; a very slight depression of 0·3 div. then takes place, the turning-point being at 2 P.M., from which hour the rise is very gradual until 10 P.M., the principal maximum, which is immediately succeeded by the precipitous diminution above mentioned. These phænomena are rendered more apparent by the annexed curves, fig. 6.

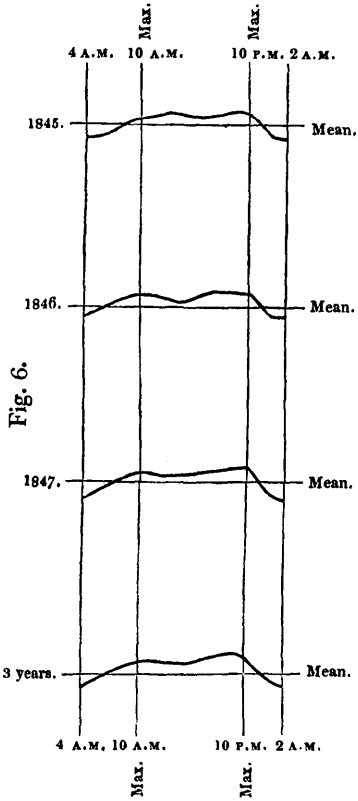


Fig. 6.

Mean diurnal curve of the electrical tension below 60 div. for the years 1845, 1846 and 1847, with the mean curve of the three years.

In the following table, the diurnal periods, as deduced from the aggregate observations and from those below 60 div., are placed in contrast.

TABLE XXIII.

Comparison of the excess or defect from the mean of the diurnal periods of the entire year, as deduced from the aggregate observations and from those below 60 div.

Value.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
Aggregate ...	− 44·3	− 46·8	− 46·4	− 32·7	+ 1·3	+ 21·2	+ 8·5	+ 4·6	+ 2·2	+ 17·9	+ 35·5	+ 37·1	66·9
Below 60 div.	− 6·0	− 8·5	− 8·7	− 4·9	+ 1·0	+ 3·7	+ 3·6	+ 3·4	+ 3·9	+ 5·5	+ 6·2	+ 6·9	28·6

Diurnal period below 60 *div.*, *Summer.*—The 7529 observations below 60 div. are thus distributed in the two half-years :—

Summer	4846
Winter	2683
	7529

The following table exhibits the distribution of the 4846 summer observations among the twelve daily readings :—

Table XXIV.

Number of positive readings below 60 div. at each observation-hour in the three summers of 1845, 1846 and 1847.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Sums.
1845.	135	135	144	160	148	148	126	139	136	128	116	103	1618
1846.	140	149	153	158	138	139	137	129	129	121	102	119	1614
1847.	125	148	160	154	134	138	133	131	131	127	112	121	1614
Sums.	400	432	457	472	420	425	396	399	396	376	330	343	4846

This table exhibits a more equable distribution of observations over the twenty-four hours than that which has reference to the entire year ; the greatest number occurs at 6 A.M., and the smallest at 8 P.M.

Table XXV.

Mean electrical tension below 60 div. at each observation-hour in the three summers of 1845, 1846 and 1847, with the mean diurnal period of summer.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	19.6	16·0	15·8	19·9	24·5	27·3	26·6	29·3	28·4	29·8	31·7	31·7	24·7
1846.	21·0	17·4	18·7	24·4	29·0	30·1	27·5	27·0	28·2	31·2	31·2	33·3	26·2
1847.	23·5	20·0	18·9	26·9	32·3	35·6	34·0	32·2	33·8	35·4	37·4	39·6	30·3
Mean.	21·3	17·8	17·8	23·7	28·5	30·9	29·4	29·5	30·1	32·1	33·5	35·0	27·1

Table XXVI.

Excess or defect of the mean electrical tension below 60 div. at each observation-hour, as compared with the mean of each summer in the years 1845, 1846 and 1847, and the mean of the three summers.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	− 5·1	− 8·7	− 8·9	− 4·8	− 0·2	+ 2·6	+ 1·9	+ 4·6	+ 3·7	+ 5·1	+ 7·0	+ 7·0	24·7
1846.	− 5·2	− 8·8	− 7·5	− 1·8	+ 2·8	+ 3·9	+ 1·3	+ 0·8	+ 2·0	+ 5·0	+ 5·0	+ 7·1	26·2
1847.	− 6·8	− 10·3	− 11·4	− 3·4	+ 2·0	+ 5·3	+ 3·7	+ 1·9	+ 3·5	+ 5·1	+ 7·1	+ 9·3	30·3
Mean.	− 5·8	− 9·3	− 9·3	− 3·4	+ 1·4	+ 3·8	+ 2·3	+ 2·4	+ 3·0	+ 5·0	+ 6·4	+ 7·9	27·1

In these tables we find the forenoon maximum developed in a greater degree than in those having reference to the entire year—a result to be expected if the notion be correct that both low and high tensions are influenced by the presence of aqueous vapour in the atmosphere. The number of observations on which these tables are based forms a very considerable portion of the whole of the summer observations—rather above seven-eighths. The entire number is 5514, from which deduct those below 60 div., and we have left 668, or nearly an eighth part of the whole, so that the probability of the forenoon and evening maxima resulting from the presence of aqueous vapour is rendered more apparent in the summer than during the entire year. It is important here to remark, that the results obtained by separating the summer observations from those of the entire year below 60 div. are of an opposite character to those obtained by dividing the aggregate observations into summer and winter series. In the case of the aggregate observations we found the summer curves representing the diurnal march, less in extent and less abrupt in their character than those of the entire year. On the contrary, we find the summer observations of low tension rather bolder in their character and of greater range than those of the entire year. In the former case, that of the aggregate observations, the summer readings were as a mass much lower than those of the winter; there were also a much greater number that would have especial reference to *serene weather* than of those in the winter, and these circumstances would *reduce* the summer curves to the form in which we find them. When however we contemplate the tensions below 60 div., there is nothing cut off in the summer from those furnishing the results of the year, the whole of the observations up to and including 59 div. finding entry at all seasons; but we have a much greater number of low tensions during the summer than in the winter, so that a greater portion of the entire phænomena is as it were compressed into the lower readings, and manifests itself by expanding the summer curves as compared with those of the entire year rather than contracting them.

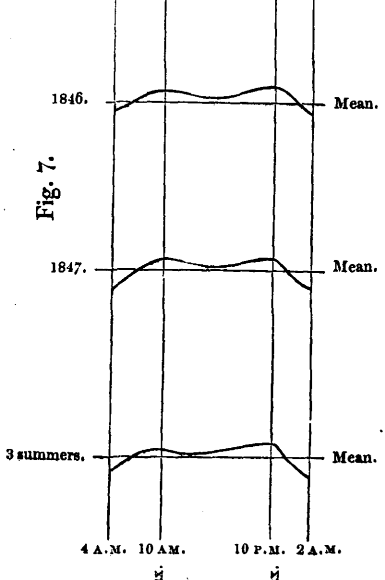


Fig. 7.

Mean diurnal curves of the electrical tension below 60 div. for the summers of 1845, 1846 and 1847, with the mean curve of the three summers.

In tracing the diurnal march of the tension below 60 div., we find the minimum occurring at 2 and 4 A.M.; after 4 A.M. the tension gradually rises until 10 A.M., the epoch of the forenoon maximum; a fall of 1·5 div. occurs between 10 A.M. and noon, after which a very gradual and regular rise takes place until 10 P.M., the epoch of the evening maximum, which is succeeded by the precipitous diminution of tension already alluded to. In the diurnal minimum occurring at noon, and its being followed by a gentle rise to the evening maximum, we have repeated to a certain extent the same feature which we noticed as characterizing the summer curve of the aggregate observations. There is however one important point of difference which strikingly exhibits the influence of the higher tensions on the curves: the hours of maxima and minima are nearly if not the same in both cases, and the gentle rise from noon to 4 P.M. in each instance possesses many features in common, the principal difference being a greater movement in the aggregate than in the low tensions. The point of difference to which we particularly solicit attention is the augmentation in the summer curves of low tension of the forenoon and evening maxima, and their contraction in the aggregate summer curves. This is very apparent on consulting the curves. In discussing the high tension during the summer months, this subject will be again referred to; in the mean time we may notice here, that upon the consideration of the high readings measuring the electrical tension of aqueous vapour, it appears probable that these maxima depend on the presence of aqueous vapour for their development.

TABLE XXVII.

Range of the diurnal curves of electric tension below 60 div. in the summers of 1845, 1846 and 1847, and also in each year.

Year.	Summer curve.	Yearly curve.
	div.	div.
1845.	15·9	14·1
1846.	15·9	15·0
1847.	20·7	18·3
Mean.	17·2	15·6

TABLE XXVIII.

Comparison of the excess or defect from the mean of the diurnal periods of summer, as deduced from the aggregate observations and from those below 60 div.

Value.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Means.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
Aggregate ...	− 15·9	− 19·4	− 18·3	− 4·0	+ 6·4	+ 9·5	− 3·8	− 2·1	− 2·0	+ 1·7	+ 13·6	+ 26·2	37·2
Below 60 div.	− 5·8	− 9·3	− 9·3	− 3·4	+ 1·4	+ 3·8	+ 2·3	+ 2·4	+ 3·0	+ 5·0	+ 6·4	+ 7·9	27·1

The above table places the aggregate and low tension summer diurnal periods in contrast.

Diurnal period below 60 *div., Winter.*—The following table exhibits the distribution of observations below 60 div. during the winter among the twelve daily readings.

TABLE XXIX.

Number of positive readings below 60 div. at each observation-hour in the three winters of 1845, 1846 and 1847.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Sums.
1845.	87	101	99	12	101	76	76	83	79	69	56	65	904
1846.	94	108	114	12	97	75	75	66	72	50	46	62	871
1847.	74	107	126	6	95	84	80	79	78	66	49	64	908
Sums.	255	316	339	30	293	235	231	228	229	185	151	191	2683

In this table, the greatest numoer of readings occur at 4 A.M., the epoch of the principal minimum, and the least number at 8 P.M., two hours after the evening maximum. It will be remarked, that the morning hours, viz. 2 and 4 A.M., exhibit the greatest number, and the evening hours, 6, 8 and 10 P.M., the least. The thirty readings at 6 A.M. are excepted, for the reason stated on page 130.

Table XXX.

Mean electrical tension below 60 div. at each observation-hour in the three winters of 1845, 1846 and 1847, with the mean diurnal period of winter.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	20·1	20·2	19·8	13·2	29·6	31·4	34·8	34·8	34·2	31·7	31·5	29·2	28·1
1846.	29·2	26·5	24·2	32·1	32·5	36·6	38·3	37·5	38·8	42·0	43·4	41·3	33·8
1847.	23·9	22·7	23·6	32·9	31·7	36·8	38·0	36·8	37·1	41·5	39·4	38·4	32·4
Mean.	24·5	23·2	22·7	24·7	31·2	35·0	37·1	36·3	36·6	38·0	37·7	36·2	31·4

Table XXXI.—Excess or defect of the mean electrical tension below 60 div. at each observation-hour, as compared with the mean of each winter in the years 1845, 1846 and 1847, and the mean of the three winters.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	− 8·0	− 7·9	− 8·3	− 14·9	+ 1·5	+ 3·3	+ 6·7	+ 6·7	+ 6·1	+ 3·6	+ 3·4	+ 1·1	28·1
1846.	− 4·6	− 7·3	− 9·6	− 1·7	− 1·3	+ 2·8	+ 4·5	+ 3·7	+ 5·0	+ 8·2	+ 9·6	+ 7·5	33·8
1847.	− 8·5	− 9·7	− 8·8	+ 0·5	− 0·7	+ 4·4	+ 5·6	+ 4·4	+ 4·7	+ 9·1	+ 7·0	+ 6·0	32·4
Mean.	− 6·9	− 8·2	− 8·7	− 6·7	− 0·2	+ 3·6	+ 5·7	+ 4·9	+ 5·2	+ 6·6	+ 6·3	+ 4·8	31·4

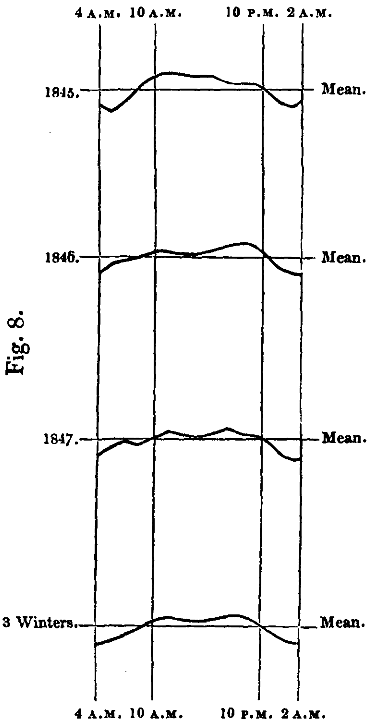


Fig. 8.

Mean diurnal curves of the electrical tension below 60 div. for the winters of 1845, 1846 and 1847, with the mean curve of the three winters.

In order to facilitate the comparison of the diurnal march of the low tensions during the individual winters, which present some striking features of interest, we shall at once introduce the curves to the notice of the reader. On contemplating them, it will be at once apparent that they present several interesting points of contrast. There appears to be a greater approach to a single progression, especially in the winter of 1845. In this curve the maximum occurs at noon and 2 P.M.; the precipitous diminution between 10 P.M. and midnight disappears, the curve taking a gently rounded course from 2 P.M. to midnight; there appears to be a slight check to this gradual diminution of tension at 8 P.M. The principal minimum occurs at 6 A.M., the rise from this hour to noon being of a bold, rounded character; it is probable that the true minimum occurs at 4 A.M., twelve observations only contributing to the determination of the value at 6 A.M. On contrasting this curve with those of the summer and entire year aggregate tension, we find the movements during the day reversed, the greatest development occurring about the middle of the day. A much greater number of observations of high tensions contribute to the production of the aggregate curve in winter than in summer, and as a consequence, the observations on which the winter curve of low tension is based are less numerous than those on which the summer curve rests. In the curve now before us, the double progression may be considered if not entirely, as almost disappearing; the removal of the higher tensions appears to be accompanied by a removal of the forenoon and evening maxima, which is replaced by a maximum near the middle of the day. This is extremely striking when we compare our curve with that of the winter, as deduced from all the positive readings (page 122); in this curve the forenoon and evening maxima are strongly developed, and the depression at 2 and 4 P.M. very distinctly marked. It would appear, on the supposition of the high readings being measures of the electrical tension of aqueous vapour, that in this particular winter (1845), very few measures of such tensions occurred below 60 div., so that in the great majority of instances, the readings below 60 div. were, more or less, measures of atmospheric electricity. The curve itself suggests the inquiry—Is the diurnal march of atmospheric electricity—viz. that which is uncombined with the electrical tension characterizing, or developed by, the presence of aqueous vapour—a single progression? In other words, does the electrical tension of dry air present a curve having simply an ascending and descending branch, the progression being in harmony with the temperature? We shall have occasion to refer again to this subject in a future part of this Report.

On turning our attention to the winter of 1846, we find a curve more or less in harmony with those of the summer and entire year, and strikingly in contrast with that of the winter of 1845. It is however to be remarked, that the depression at 2 P.M. is but slight, and very much less than the depression during the summer of this year; the slight check which is apparent in the forenoon rise, at 8 A.M., tends to give the curve an appearance of possessing three maxima; there is indeed a great tendency to assume somewhat of the form of 1845, which appears to be counteracted by the greater development of the evening maximum.

The winter curve of 1847 may be characterized as exhibiting considerable trepidation, and consisting of alternate but very subordinate maxima and minima, the principal of which occurs at 6 P.M. There is an evident tendency to a single progression, having its maximum about the early afternoon hours. This curve is in contrast with that of the winter of 1845, inasmuch as the most rounded portion of the curve is developed in the evening.

On directing our attention to the mean of the three winters, we find two maxima, noon and evening, well-developed, but of a subdued character. The evening maximum is the principal; it however rises only 0·9 div. above that at noon; the intermediate minimum occurs at 2 P.M., and is depressed 1·7 div. below the principal maximum.

TABLE XXXII.

Synopsis of the principal points in the summer, winter, and yearly curves below 60 div.

Season.	Forenoon Maximum.	Minimum.	Evening Maximum.	Nocturnal Minimum.	Even. Max. above Forenoon.	Aftern. Min. below Even. Max.
					div.	div.
Summer.	10 a.m.	Noon.	10 p.m.	2 & 4 a.m.	4·1	5·6
Winter...	Noon.	2 p.m.	6 p.m.	4 a.m.	0·9	1·7
Year	10 a.m.	2 p.m.	10 p.m.	4 a.m.	3·2	3·5

This subdued character of the two maxima, as well as the comparatively slight depression of the included minimum, is well seen in the above table; and when combined with the characters of the individual curves of each winter which have been noticed above, together with the approach of the epochs of maxima in the mean curve to each other, viz. from 10 A.M. to noon, and from 10 P.M. to 6 P.M., a strong probability is suggested, that were we able effectually to separate the high from the low tensions, *not at an arbitrary point*, but in such a manner that the high tensions of summer (in all probability lower than those of winter) should find entry in their respective department, the result would be, that the low tensions would exhibit a single progression in harmony with the temperature.

In the following table the diurnal periods for the winter, as deduced from the aggregate and low tensions, are placed in contrast.

TABLE XXXIII.

Comparison of the excess or defect from the mean of the diurnal periods of winter, as deduced from the aggregate observations and from those below 60 div.

Value.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
Aggregate ..	− 77·6	− 78·9	− 79·4	− 55·6	− 9·0	+ 27·9	+ 13·7	+ 3·9	− 0·6	+ 27·3	+ 55·2	+ 43·4	102·1
Below 60 div.	− 6·9	− 8·2	− 8·7	− 6·7	− 0·2	+ 3·6	+ 5·7	+ 4·9	+ 5·2	+ 6·6	+ 6·3	+ 4·8	31·4

Tables XXXIV., XXXV., XXXVI. exhibit the mean electrical tension at each observation-hour for each month in the three years 1845, 1846 and 1847, with the monthly seasonal and yearly means. The characters of the monthly movements are exhibited to the eye in the sheets of curves illustrating this report. See Plates VI. VII. and VIII.

Table XXXVII. exhibits the mean monthly electrical tension at each observation-hour deduced from the observations of *three* months, also the mean summer, winter, and yearly tension deduced from the observations of *three* summers, winters, and years. The last line in the table, to which the word "Means" is prefixed, exhibits the mean tension in each month as deduced from all the separate monthly observations, *i.e.* the mean tension of January, 31·5 div. is the result of all the January observations in the three years. The same thing holds good of the seasonal and yearly mean tensions.

The curves projected from these numbers will be found on Plate IX.

Previous to proceeding with the discussion of the high tensions, it will be advantageous to pause, for the purpose of recapitulating the principal points that have hitherto come under our notice, and of particularly directing our attention to those that stand out prominently from among the others.

1. We have seen that the discussion of the entire series of the positive observations for the three years furnishes us with series of curves, exhibiting in a most decided manner *a double progression*. The points of maxima and minima are well-marked, and in most cases they present a tolerable fixity of epoch.

2. The presence of *fog* mostly occurring on those occasions when *high* electrical tensions have been observed, combined with the opinion that the electricity of serene weather is mostly characterized by *low* tensions, has

TABLE XXXIV.—Mean electrical tension at each observation-hour, as deduced from all the positive observations *below* 60 div. in the year 1845, arranged under the respective months, with the mean electrical tension of the summer, winter, and year.

Period.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Summer.	Winter.	Year.
Midnight...	14·5	22·2	22·0	22·3	19·4	16·7	16·0	21·4	22·3	19·1	......	28·1	19·6	20·1	19·8
2 a.m.	12·3	19·5	27·6	17·7	16·6	16·5	14·6	14·4	17·1	21·6	......	26·2	16·0	20·2	17·8
4 a.m.	18·2	18·9	21·6	18·0	15·3	17·1	13·2	15·8	16·4	16·2	......	27·2	15·8	19·8	17·5
6 a.m.	......	......	......	22·0	21·2	15·7	19·0	18·6	23·2	......	......	......	19·9	13·2	19·4
8 a.m.	34·1	38·3	33·1	30·8	28·9	19·6	22·1	19·7	27·8	23·2	31·3	25·5	24·5	29·6	26·6
10 a.m.	37·7	34·9	38·1	37·4	29·1	22·1	25·5	22·5	31·5	28·4	34·5	20·9	27·3	31·4	28·7
Noon	38·2	40·8	31·3	29·9	27·1	19·7	23·8	25·6	32·8	33·0	40·0	27·8	26·6	34·8	29·7
2 p.m.	30·6	43·2	31·1	32·8	27·7	24·2	25·0	30·5	35·5	38·5	32·7	33·1	29·3	34·8	31·4
4 p.m.	34·4	40·7	32·7	33·7	26·1	22·7	27·9	30·7	31·0	33·9	36·9	28·2	28·4	34·2	30·5
6 p.m.	31·2	32·9	28·8	31·9	26·9	25·0	27·5	34·0	35·7	28·4	32·7	38·0	29·8	31·7	30·5
8 p.m.	32·0	41·9	32·8	41·4	38·3	28·9	25·1	29·1	33·4	23·4	31·4	35·0	31·7	31·5	31·6
10 p.m.	26·5	36·6	24·7	25·1	34·1	29·9	30·6	34·8	34·0	26·6	34·3	28·1	31·7	29·2	30·8
Means......	25·8	30·7	28·7	29·0	25·2	21·5	22·5	24·0	27·5	25·6	32·4	28·6	24·7	28·1	25·9

TABLE XXXV.—Mean electrical tension at each observation-hour, as deduced from all the positive observations *below* 60 div. in the year 1846, arranged under the respective months, with the mean electrical tension of the summer, winter, and year.

Period.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Summer.	Winter.	Year.
Midnight...	32·5	31·3	33·0	27·4	23·1	21·1	22·1	17·9	18·0	26·1	24·3	32·8	21·0	29·2	24·3
2 a.m.	31·1	25·8	26·9	23·4	19·6	17·7	17·0	13·5	16·2	24·9	20·9	32·0	17·4	26·5	21·2
4 a.m.	22·4	31·4	23·8	21·6	19·0	23·1	20·8	14·0	15·2	21·3	19·7	31·5	18·7	24·2	21·0
6 a.m.	......	......	......	26·0	27·6	27·4	27·8	19·1	19·6	......	......	......	24·4	32·1	25·0
8 a.m.	29·8	26·0	34·9	35·2	34·4	29·1	31·7	23·6	24·3	33·7	30·7	44·4	29·0	32·5	30·5
10 a.m. ...	31·4	34·2	41·1	36·6	32·7	33·1	30·9	26·2	24·7	39·6	31·7	44·4	30·1	36·6	32·4
Noon	43·3	36·7	40·5	37·2	25·9	28·1	28·9	22·9	23·7	37·5	34·2	34·4	27·5	38·3	31·3
2 p.m.	41·6	41·5	42·8	34·6	26·0	23·0	30·3	25·2	25·0	31·4	36·5	36·9	27·0	37·5	30·5
4 p.m.	40·5	37·1	41·9	28·7	31·4	24·1	28·1	27·7	29·6	37·1	34·2	44·2	28·2	38·8	32·0
6 p.m.	44·7	43·1	43·1	40·6	33·8	29·2	34·1	27·5	24·6	39·0	42·8	38·3	31·2	42·0	34·3
8 p.m.	43·1	47·5	38·7	37·9	30·2	31·1	37·7	24·9	28·8	45·7	39·4	52·5	31·2	43·4	35·0
10 p.m. ...	37·5	36·9	43·3	31·0	31·6	37·7	38·0	29·9	29·6	41·9	41·3	46·7	33·3	41·3	36·0
Means......	34·7	34·6	35·1	31·3	27·5	26·8	28·5	22·3	22·8	33·3	30·7	37·3	26·2	33·8	28·8

TABLE XXXVI.—Mean electrical tension at each observation-hour, as deduced from all the positive observations *below* 60 div. in the year 1847, arranged under the respective months, with the mean electrical tension of the summer, winter, and year.

Period.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Summer.	Winter.	Year.
Midnight...	29·3	32·5	35·5	31·1	19·3	25·2	30·4	20·6	20·2	17·6	19·7	24·5	23·5	23·9	23·7
2 a.m.	32·7	30·3	26·6	25·6	17·3	17·8	26·8	17·3	16·2	14·7	19·9	23·0	20·0	22·7	21·1
4 a.m.	34·1	26·8	22·3	22·8	15·6	20·1	22·6	17·4	15·7	19·2	18·8	27·6	18·9	23·6	20·9
6 a.m.	......	......	......	32·4	23·3	23·4	35·4	26·2	23·6	......	......	......	26·9	32·9	27·1
8 a.m.	38·7	32·9	31·5	34·5	28·3	28·4	42·0	32·9	31·0	25·9	35·5	29·8	32·3	31·7	32·1
10 a.m.	45·0	36·2	34·1	43·7	30·4	32·8	43·5	32·5	33·4	32·8	38·3	41·0	35·6	36·8	36·0
Noon	50·0	41·7	43·6	44·6	27·3	28·1	40·3	31·8	32·9	26·7	45·4	39·6	34·0	38·0	35·5
2 p.m.	43·7	41·7	40·9	41·2	31·6	28·5	33·2	28·0	32·0	27·7	38·7	39·4	32·2	36·8	33·9
4 p.m.	43·7	42·2	37·1	36·8	31·9	28·5	39·7	31·6	34·2	29·8	37·8	42·4	33·8	37·1	35·0
6 p.m.	49·4	45·8	44·8	39·8	35·8	27·0	39·8	35·0	36·4	34·8	41·8	44·0	35·4	41·5	37·5
8 p.m.	46·0	42·5	40·0	38·3	33·2	35·8	44·4	38·1	35·5	30·7	43·7	44·2	37·4	39·4	38·0
10 p.m.	44·5	39·2	45·8	43·2	38·7	37·7	42·7	38·4	39·9	34·7	34·2	42·7	39·6	38·4	39·2
Means......	38·8	36·2	35·2	35·3	27·4	27·6	36·4	28·7	28·5	26·2	31·8	35·0	30·3	32·4	31·1

TABLE XXXVII.—Mean electrical tension at each observation-hour, as deduced from all the positive observations *below* 60 div. in the years 1845, 1846 and 1847, arranged under the respective months, with the mean electrical tension of the summer, winter, and year.

Period.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Summer.	Winter.	Year.
Midnight...	23·0	27·1	30·2	26·6	20·6	21·2	22·1	20·0	20·1	20·6	22·5	28·1	21·3	24·5	22·6
2 a.m.	23·2	24·3	27·0	22·6	17·9	17·4	19·3	15·1	16·5	20·0	20·2	26·8	17·8	23·2	20·1
4 a.m.	23·5	25·7	22·6	21·1	16·6	20·2	19·0	15·7	15·7	18·9	19·3	24·6	17·8	22·7	19·9
6 a.m.	......	......	26·1	26·3	24·2	22·2	26·9	21·2	22·1	21·9	......	......	23·7	24·7	23·7
8 a.m.	33·6	31·9	33·3	33·1	30·3	25·7	30·9	25·3	27·6	27·3	32·6	30·2	28·5	31·2	29·6
10 a.m.	37·3	35·2	37·9	39·7	30·7	29·2	32·3	26·8	29·7	33·4	34·8	32·1	30·9	35·0	32·3
Noon	41·4	39·6	39·2	37·0	26·8	25·5	30·9	26·8	29·7	31·8	39·4	34·6	29·4	37·1	32·2
2 p.m.	36·0	42·2	38·1	36·3	28·3	25·2	29·4	28·0	30·7	32·2	35·9	36·8	29·5	36·3	32·0
4 p.m.	38·1	39·8	37·2	33·1	29·9	25·0	31·9	30·1	31·6	33·4	36·5	36·5	30·1	36·6	32·5
6 p.m.	38·7	41·3	38·1	36·9	32·2	27·0	33·7	32·1	32·2	33·7	39·6	40·3	32·1	38·0	34·1
8 p.m.	38·9	44·5	36·1	39·7	33·8	31·9	34·8	30·9	32·5	32·4	39·0	40·4	33·5	37·7	34·8
10 p.m.	33·0	37·1	38·2	32·3	35·5	35·2	36·9	34·3	34·3	35·3	37·2	36·5	35·0	36·2	35·5
Means......	31·5	33·7	33·1	31·8	26·8	25·4	28·8	25·0	26·2	28·1	31·5	32·9	27·1	31·4	28·6

suggested the probability that the forenoon and evening maxima result more or less from the presence of aqueous vapour, either in an invisible or condensed state.

3. With a view to submit this notion to the test of observation, an attempt has been made (it must be confessed of a very rough and arbitrary character) to separate the high from the low tensions; the point 60 div. of Volta's electrometer No. 1 has been provisionally assumed as the separating point, and all tensions above it have been regarded as high, those below it the converse. The result of this separation, so far as the low tensions are concerned, has been to exhibit series of curves, those of the summer and entire year being somewhat in harmony with the aggregate curves for the same periods; the forenoon and evening maxima however are greatly subdued, but still the evening holds the most prominent position. The curves of the entire year suggest the probability that a single progression would be obtained on the removal of the two maxima.

4. The winter curves of low tension strongly confirm this suggestion. The approach to a single progression is very apparent in the winters of 1845 and 1847; the mean curve however still presents the two maxima, although their altitudes are considerably more equal in value than any of the curves yet contemplated; their interval in time (6 hours) is also less than most of the others, especially the aggregate curves, the most usual interval of these being 12 hours.

5. The salient points characterizing the two series of curves (aggregate and low tension) are a decided development of the forenoon and evening maxima in the aggregate, and a considerable subduing of these features with an approach to a single progression in the low.

Diurnal period above 60 *div., Year.*—We are now prepared to enter on the discussion of the high tensions, with the expectation that the two maxima so prominently developed in the aggregate curves will form very decided features in those deduced from observations above 60 div. It is necessary to observe here, that the observations above 60 div. will not furnish the entire diurnal march of the high tensions, none being recorded at the hours of midnight and 2 A.M.; very few indeed are entered at 4 A.M.; and those finding entrance at 6 A.M. being mostly confined to the summer half-year, the diurnal march cannot be accurately said to commence until 8 A.M. In the following tables and curves, with the exception of those having reference to the summer half-year, the diurnal march is given between 8 A.M. and 10 P.M. inclusive; in the summer it commences two hours earlier.

The 2647 high readings during the three years are thus divided among the twelve observation-hours:—

TABLE XXXVIII.

Number of positive readings above 60 div. at each observation-hour in the three years 1845, 1846 and 1847.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Sums.
1845.	......	......	3	18	92	103	73	75	87	107	130	164	852
1846.	......	......	2	20	118	124	76	83	86	110	138	157	914
1847.	......	......	3	26	124	126	72	73	80	96	129	152	881
Sums.	......	......	8	64	334	353	221	231	253	313	397	473	2647

In connection with this table it will be observed that it furnishes two periods, each being marked by a greater number of readings than the intermediate period between them. Of these, the last, viz. that occurring at 6, 8 and 10 P.M., presents the greatest number of observations, and it is to be noticed, that both periods coincide with the epochs of the forenoon and evening maxima, as developed in the aggregate curves. This of itself indicates that the greatest number of high readings occur at those epochs, and that the maxima result more from a systematic occurrence of the high than the low readings. There is a difference between the greatest number, 473, at 10 P.M., and the smallest (excluding 4 and 6 A.M.), 221, at noon of 252.

TABLE XXXIX.

Mean electrical tension above 60 div. at each observation-hour in the three years 1845, 1846 and 1847, with the mean diurnal period as deduced from the whole.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
			div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	......	......	85·0	116·7	167·7	205·6	173·7	144·3	130·2	146·0	187·9	205·8	173·2
1846.	......	......	72·5	123·9	122·2	153·2	176·3	147·6	137·2	163·9	162·1	146·2	149·7
1847.	......	......	70·8	110·0	164·7	219·6	244·9	249·2	215·5	222·8	204·4	191·6	205·6
Mean.	......	......	76·6	116·2	150·5	192·2	197·8	178·6	159·6	175·8	184·3	181·5	175·9

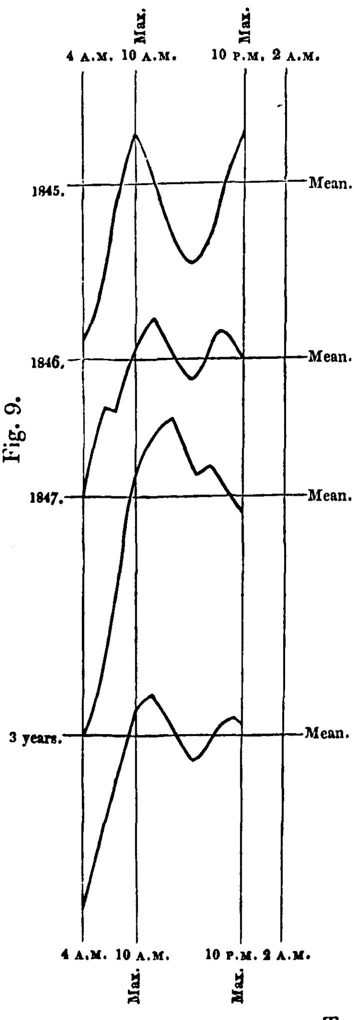
TABLE XL.

Excess or defect of the mean electrical tension above 60 div. at each observation-hour, as compared with the mean of the year for the three years 1845, 1846 and 1847, and the mean diurnal period.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
			div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	......	......	− 88·2	− 56·5	− 5·5	+ 32·4	+ 0·5	− 28·9	− 43·0	− 27·2	+ 14·7	+ 32·6	173·2
1846.	......	......	− 77·2	− 25·8	− 27·5	+ 3·5	+ 26·6	− 2·1	− 12·5	+ 14·2	+ 12·4	− 3·5	149·7
1847.	......	......	− 134·8	− 95·6	− 40·9	+ 14·0	+ 39·3	+ 43·6	+ 9·9	+ 17·2	− 1·2	− 14·0	205·6
Mean.	......	......	− 99·3	− 59·7	− 25·4	+ 16·3	+ 21·9	+ 2·7	− 16·3	− 0·1	+ 8·4	+ 5·6	175·9

Although the movements, as exhibited in the above tables, are decidedly *irregular*, yet the indications of a double progression are by no means deficient; they appear very prominently in the period for the year 1845. In this year the rise is very regular until 10 A.M., after which a fall, quite as regular, takes place between 10 A.M. and 4 P.M., and then the tension increases quite as regularly until 10 P.M. In 1846 and 1847 these movements are not so distinct, especially in the latter year, in which a great tendency to a single maximum about 2 P.M. occurs; there is however a subordinate maximum at 6 P.M. In 1846 the two maxima are developed, the forenoon being the principal. The mean curve of the three years exhibits a period of tolerable regularity, in which the two maxima are well-marked, that of the forenoon being the *highest*; the epochs are noon and 8 P.M.

Fig. 9.



Mean diurnal curve of the electrical tension above 60 div. for the years 1845, 1846 and 1847, with the mean curve of the three years.

Previous to examining the summer curves of high tension, it will be desirable to direct our attention to those of the winter; two circumstances contribute to this mode of proceeding. In discussing the curves of low tension, we found the greatest approach to a single progression occurring in the winter, and this would suggest that in the same season we ought to find the most decided development of the two maxima in the curves of high tension, which give to the aggregate curves the feature of a double progression. The great majority of readings during the summer being below 60 div., those above will be considerably less in number than the high readings in the winter, and it is consequently to be expected that the movements of the high tensions (simply considered as such) will be much more irregular in the summer than in the winter: in a word, if we can at all find any unequivocal indications of regularity of movement among the high tensions, we are much more likely to find them in the winter than in the summer.

Diurnal period above 60 *div., Winter.*—The entire number of high readings, 2647, is thus divided:—

Winter	1979
Summer	668
	2647

The following table exhibits the distribution of the winter observations over the twelve observation-hours:—

TABLE XLI.

Number of positive readings above 60 div. at each observation-hour in the three winters of 1845, 1846 and 1847.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Sums.
1845.	......	......	......	2	66	84	64	68	74	83	88	96	625
1846.	......	......	......	6	81	93	71	77	76	93	92	107	696
1847.	......	......	......	3	80	91	66	67	70	83	94	104	658
Sums.	......	......	......	11	227	268	201	212	220	259	274	307	1979

It will be seen from these numbers that the distribution of readings somewhat assimilates to that of the entire year, being more numerous about the epochs of the forenoon and evening maxima. It is however much more equable, the difference between the greatest and least numbers, excluding the 11 at 6 A.M., being only 106. A proportionate regularity in the diurnal march may consequently be expected.

TABLE XLII.

Mean electrical tension above 60 div. at each observation-hour in the three winters of 1845, 1846 and 1847, with the mean diurnal period of winter.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
				div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	......	......	......	85·0	184·8	231·1	188·0	146·6	139·6	167·0	223·1	259·1	196·0
1846.	......	......	......	83·3	130·4	163·2	171·9	145·0	136·9	174·5	198·7	164·7	161·1
1847.	......	......	......	165·0	206·0	248·0	261·1	257·1	235·0	244·8	247·4	221·8	238·7
Mean.	......	......	......	105·9	172·9	213·3	206·3	180·9	169·0	194·6	223·3	213·6	197·9

TABLE XLIII.

Excess or defect of the mean electrical tension above 60 div. at each observation-hour, as compared with the mean of each winter in the years 1845, 1846 and 1847, and the mean of the three winters.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
1845.	......	......	......	− 111·0	− 11·2	+ 35·1	− 8·0	− 49·4	− 56·4	− 29·0	+ 27·1	+ 63·1	196·0
1846.	......	......	......	− 77·8	− 30·7	+ 2·1	+ 10·8	− 16·1	− 24·2	+ 13·4	+ 37·6	+ 3·6	161·1
1847.	......	......	......	− 73·7	− 32·7	+ 9·3	+ 22·4	+ 18·4	− 3·7	+ 6·1	+ 8·7	− 16·9	238·7
Mean.	......	......	......	− 92·0	− 25·0	+ 15·4	+ 8·4	− 17·0	− 28·9	− 3·3	+ 25·4	+ 15·7	197·9

There can be no question that a much greater regularity of movement characterizes these periods than we found appertaining to those of the entire year. In each of them we find the two maxima well-developed; in the winter of 1847 the forenoon maximum was the highest, but in other respects they agree more or less closely with the aggregate winter curves. The diurnal march is well-traced: commencing at 8 A.M., we find the forenoon maximum attained at 10 A.M., then a well-marked fall until 4 P.M., the afternoon minimum, after which a regular and rather rapid rise until 8 P.M., the epoch of the evening maximum, which is followed by a diminution of tension at 10 P.M. The annexed curves (fig. 10), which may be well compared with those on page 143, exhibit all the winter phænomena of high tension with considerable distinctness. It may be remarked, that in 1845 the evening maximum occurred at 10 P.M., and that a close agreement, in this respect, obtains between the high tension and aggregate curves in the winter of 1845.

In our remarks on the winter curves of aggregate tension (see page 123), we noticed the influence which the winter curves exerted on those of the entire year, and suggested the probability that the *higher* tensions materially influence the general results. This is very strikingly illustrated by the comparison of the winter curves of high tension with those of the same season as deduced from the aggregate observations; the main features of the curves in both series are similar, the principal difference consisting in the values of the

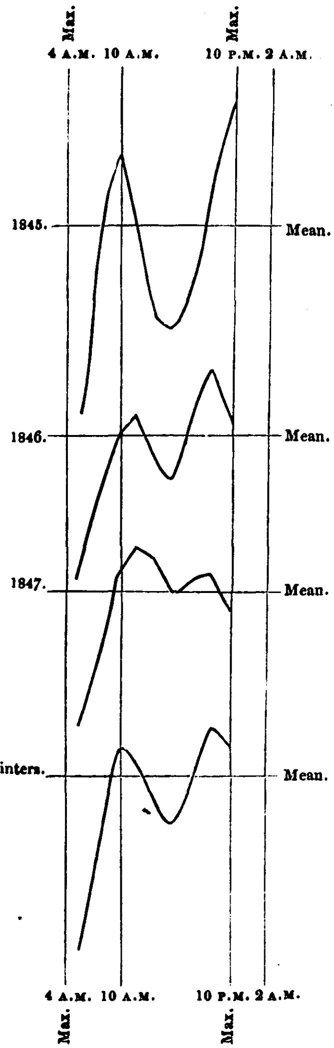


Fig. 10.

Mean diurnal curves of the electrical tension above 60 div. for the winters of 1845, 1846 and 1847, with the mean curve of the three winters.

maxima in the winter of 1847. We see at a glance how greatly the forms of the aggregate curves *depend* on the *higher* tensions. On comparing the two series with those of the entire year (aggregate tension), the influence of the *high* tensions upon the whole is readily traced. We see the winter curves of high tension strongly influencing the winter curves of aggregate tension, and these again the aggregate of the entire year, the three series of curves closely resembling each other. The influence of the high tension entire year on the curves of aggregate tension for the same period is not so striking; the summer readings modify the curves, and illustrate the remarks we have already offered on the *variability* of the point of separation.

Table XLIV.

Comparison of the excess or defect from the mean of the diurnal periods of winter, as deduced from the aggregate observations and from those above 60 div.

Value.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
Aggregate...	−77·6	−78·9	−79·4	−55·6	−9·0	+27·9	+13·7	+3·9	−0·6	+27·3	+55·2	+43·4	102·1
Above60div.	......	......	......	−92·0	−25·0	+15·4	+8·4	−17·0	−28·9	−3·3	+25·4	+15·7	197·9

In the above table the correspondence within certain limits as to excess and defect, in reference to the mean of each period, is well seen; also the striking development of the forenoon and evening maxima in each case. Upon the continuation of the observations of high tension at midnight, 2 and 4 A.M. in the winter, the mean line would be lowered and the correspondence rendered more complete.

During the day the movements do not very materially differ from those of the aggregate curves for the same periods; this is evident from the following table:—

Table XLV.

Synopsis of the principal points in the aggregate and high tension winter curves.

Value.	Forenoon Maximum above Minimum.	Evening Maximum above Minimum.	Evening Maximum above Forenoon.
	div.	div.	div.
Aggregate	28·5	55·8	27·3
Above 60 div..........	44·3	54·3	10·0

Diurnal period above 60 *div., Summer.*—The 668 readings upon which this period is based are thus distributed among the twelve observation-hours:—

Table XLVI.

Number of positive readings above 60 div. at each observation-hour in the three summers of 1845, 1846 and 1847.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Sums.
1845.	......	......	3	16	26	19	9	7	13	24	42	68	227
1846.	......	......	2	14	37	31	5	6	10	17	46	50	218
1847.	......	......	3	23	44	35	6	6	10	13	35	48	223
Sums.	......	......	8	53	107	85	20	19	33	54	123	166	668

It will be at once apparent that these readings are but unequally distributed. As in the former instances, the greatest numbers occur about the hours of the forenoon and evening maxima; but the numbers about noon and 2 P.M. are so small as to render it questionable whether we should regard the periods deduced from the observations as true representatives of natural phænomena: we shall however give them in the same form as the others, and in our remarks solicit particular attention to the maxima occurring in each summer, either at noon or 2 P.M.

Table XLVII.

Mean electrical tension above 60 div. at each observation-hour in the three summers of 1845, 1846 and 1847, with the mean diurnal period of summer.

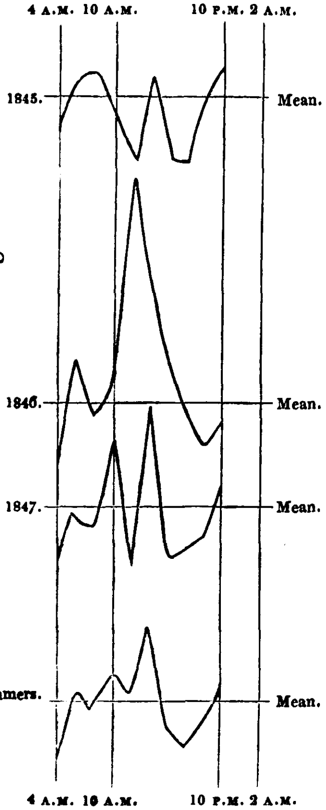
Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
			div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	......	......	85·0	120·7	124·3	92·8	72·2	122·1	76·5	73·1	114·0	130·6	110·6
1846.	......	......	72·5	141·2	104·3	123·3	238·0	181·2	139·7	105·9	88·7	106·6	113·3
1847.	......	......	70·8	102·8	89·7	145·8	66·7	161·2	79·5	82·3	88·9	126·0	107·7
Mean.	......	......	76·6	118·4	103·1	125·7	112·0	153·2	96·6	85·6	97·4	122·1	110·5

TABLE XLVIII.

Excess or defect of the mean electrical tension above 60 div. at each observation-hour, as compared with the mean of each summer in the years 1845, 1846 and 1847, and the mean of the three summers.

Year.	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
			div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	......	......	− 25·6	+ 10·1	+ 13·7	− 17·8	− 38·4	+ 11·5	− 34·1	− 37·5	+ 3·4	+ 20·0	110·6
1846.	......	......	− 40·8	+ 27·9	− 9·0	+ 10·0	+ 124·7	+ 67·9	+ 26·4	− 7·4	− 24·6	− 6·7	113·3
1847.	......	......	− 36·9	− 4·9	− 18·0	+ 38·1	− 41·0	+ 53·5	− 28·2	− 25·4	− 18·8	+ 18·3	107·7
Mean.	......	......	− 33·9	+ 7·9	− 7·4	+ 15·2	+ 1·5	+ 42·7	− 13·9	− 24·9	− 13·1	+ 11·6	110·5

Fig. 11.



Mean diurnal curves of the electrical tension above 60 div. for the summers of 1845, 1846 and 1847, with the mean curve of the three summers.

In the annexed curves (fig. 11), the general irregularity which is apparent in the tables is very distinctly marked. We have already alluded to the maxima at 2 P.M. or noon; with one exception they are the highest of each curve; but how far, from the small number of observations that contribute to their determination, they can be regarded as truly representing a mean increase of the electrical tension above 60 div. at this period of the day, must, we apprehend, be left for future observations to determine. It is however likely that even on a long series of years the number of high tensions at noon and 2 P.M. will always bear a very small proportion to those at other hours, especially near the epochs of the forenoon and evening maxima. In two of the aggregate summer curves, 1845 and 1847, we have small subordinate maxima at 2 P.M., which, when compared with the two principal, are scarcely apparent. Nothing of the kind appears in the winter curves, either aggregate or high tension, so that if the maximum about 2 P.M. in summer truly represent a natural phænomenon, it is one peculiar to the summer months. The close approximation of the values of the means of each summer is an interesting feature, which suggests considerable hesitation in deciding on the character of these irregular curves. The aggregate and low tension summer curves also agree in their means, differing but little from each other in value.

TABLE XLIX.—Mean electrical tension at each observation-hour, as deduced from all the positive observations *above* 60 div. in the year 1845, arranged under the respective months, with the mean electrical tension of the summer, winter and year.

Period.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Summer.	Winter.	Year.
Midnight...															
2 A.M.															
4 A.M.	....	....	....	....	90·0	95·0	70·0	....	....	....	....	....	85·0	....	85·0
6 A.M.	....	....	....	97·5	191·2	71·8	200·0	....	82·5	....	....	....	120·7	85·0	116·7
8 A.M.	293·4	276·9	77·2	110·8	190·0	109·4	....	71·7	137·1	121·1	111·7	196·2	124·3	184·8	167·7
10 A.M. ...	260·7	344·2	124·7	114·7	63·3	96·2	60·0	80·0	69·2	81·4	186·6	239·5	92·8	231·1	205·6
Noon	283·5	268 0	70·0	86·2	65·0	65·0	....	63·7	77·5	71·7	97·5	167·7	72·2	188·0	173·7
2 P.M.	273·2	211·4	71·6	65·0	200·0	....	....	65·0	130·0	68·2	103·9	92·5	122·1	146·6	144·3
4 P.M.	179·4	166·0	91·5	66·9	84·6	....	....	....	73·3	69·2	154·5	145·0	76·5	139·6	130·2
6 P.M.	226·0	229·6	86·9	73·2	70·8	62·5	67·5	63·3	85·4	88·2	134·8	160·4	73·1	167·0	146·0
8 P.M.	320·0	366·3	177·9	185·4	70·7	85·0	62·5	90·0	99·2	104·5	126·3	160·7	114·0	223·1	187·9
10 P.M. ...	232·4	546·8	217·2	203·1	107·8	73·3	125·8	132·2	87·9	138·2	169·2	188·4	130·6	259·1	205·8
Means......	258·5	303·5	127·1	138·8	110·8	82·1	98·3	94·4	95·3	98·5	138·3	167·1	110·6	196·0	173·2

TABLE L.—Mean electrical tension at each observation-hour, as deduced from all the positive observations *above* 60 div. in the year 1846, arranged under the respective months, with the mean electrical tension of the summer, winter and year.

Period.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Summer.	Winter.	Year.
Midnight...															
2 A.M.															
4 A.M.	....	....	....	....	75·0	....	70·0	....	....	....	....	....	72·5	....	72·5
6 A.M.	....	....	....	72·5	385·8	85·0	80·0	....	75·0	....	....	....	141·2	83·3	123·9
8 A.M.	207·1	136·0	142·9	129·8	113·2	77·1	80·0	88·7	72·5	101·0	111·8	96·1	104·3	130·4	122·2
10 A.M. ...	179·6	166·8	157·7	161·2	102·5	121·7	64·2	82·5	76·7	135·3	124·6	178·1	123·3	163·2	153·2
Noon	141·0	106·2	109·2	63·3	500·0	....	....	....	....	328·9	129·2	216·1	238·0	171·9	176·3
2 P.M.	152·3	92·1	79·5	70·0	400·0	....	....	182·5	....	164·0	80·2	255·4	181·2	145·0	147·6
4 P.M.	127·5	119·4	82·0	208·0	75·0	90·0	....	67·5	62·5	115·6	77·3	229·0	139·7	136·9	137·2
6 P.M.	196·0	195·8	91·9	149·2	65·0	132·5	....	80·0	70·0	115·8	79·1	301·9	105·9	174·5	163·9
8 P.M.	196·4	213·7	247·0	110·6	73·4	85 0	69·6	81·2	75·5	121·1	80·2	244·6	88·7	198·7	162·1
10 P.M. ...	160·1	201·6	132·6	130·1	107·7	85·8	71·2	72·5	102·5	219·0	74·3	181·7	106·6	164·7	146·2
Means......	171·5	160·0	132·7	127·7	145·3	94·6	71·3	97·6	78·4	155·7	92·0	211·0	113·3	161·1	149·7

TABLE LI.—Mean electrical tension at each observation-hour, as deduced from all the positive observations *above* 60 div. in the year 1847, arranged under the respective months, with the mean electrical tension of the summer, winter and year.

Period.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Summer.	Winter.	Year.
Midnight...															
2 A.M.......															
4 A.M.......	....	....	....	....	....	63·7	85·0	......	......	....	....	....	70·8	....	70·8
6 A.M.......	....	....	....	102·7	65·0	81·2	140·5	72·5	80·0	....	....	....	102·8	165·0	110·0
8 A.M.......	277·6	213·6	214·4	104·9	82·5	60·0	91·7	76·0	66·1	166·9	177·1	93·0	89·7	206·0	164·7
10 A.M. ...	365·0	293·6	148·2	89·4	67·5	....	316·2	71·0	72·9	265·0	187·7	159·2	145·8	248·0	219·6
Noon	354·0	353·8	112·1	70·0	60·0	....	65·0	70·0	......	140·0	195·8	119·1	66·7	261·1	244·9
2 P.M.......	388·5	372·0	67·9	183·7	67·5	....	400·0	65·0	......	65·0	157·7	140·2	161·2	257·1	249·2
4 P.M.......	442·2	271·8	78·7	65·0	63·3	....	200·0	75·0	66·7	68·0	124·8	131·2	79·5	235·0	215·5
6 P.M.......	390·7	290·4	121·4	66·0	100·0	....	135·0	90·0	70·0	80·0	218·6	165·3	82·3	244·8	222·8
8 P.M.......	393·3	378·9	140·1	80·4	162·5	....	70·7	75·0	76·4	105·6	152·7	204·3	88·9	247·4	204·4
10 P.M. ...	311·6	288·7	155·5	83·3	75·8	66·2	320·8	65·6	91·7	101·4	143·1	211·2	126·0	221·8	191·6
Means......	364·2	305·5	146·3	91·6	91·2	68·3	194·8	72·5	76·2	124·4	168·2	156·9	107·7	238·7	205·6

TABLE LII.—Mean electrical tension at each observation-hour, as deduced from all the positive observations *above* 60 div. in the years 1845, 1846 and 1847, arranged under the respective months, with the mean electrical tension of the summer, winter and year.

Period.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Summer.	Winter.	Year.
Midnight...															
2 A.M.......															
4 A.M.......	....	....	....	....	82·5	74·2	75·0	....	....	....	....	....	76·6	....	76·6
6 A.M.......	....	....	106·5	91·8	248·4	77·2	140·4	72·5	80·0	100·0	....	....	118·4	105·9	116·2
8 A.M.......	259·2	210·3	156·9	114·7	125·5	86·5	88·7	77·2	92·6	127·7	127·5	115·4	103·1	172·9	150·5
10 A.M. ...	277·8	272·4	146·0	126·8	79·1	115·3	243·9	75·0	72·9	142·7	168·9	189·0	125·7	213·3	192·2
Noon	286·5	250·6	100·8	71·8	281·2	65·0	65·0	65·8	77·5	200·8	139·3	179·7	112·0	206·3	197·8
2 P.M.......	289·9	234·1	74·5	106·2	187·0	....	400·0	135·5	130·0	97·3	112·0	175·5	153·2	180·9	178·6
4 P.M.......	281·0	191·9	85·3	130·7	77·2	90·0	200·0	71·2	68·1	85·1	115·2	177·8	96·6	169·0	159·6
6 P.M.......	282·9	242·2	98·3	96·5	73·7	97·5	94·5	73·3	76·2	99·0	149·2	225·5	85·6	194·6	175·8
8 P.M.......	309·0	324·8	187·7	122·6	94·7	85·0	68·8	84·7	86·6	110·1	122·4	212·7	97·4	223·3	184·3
10 P.M. ...	236·3	339·7	164·9	137·7	104·7	76·2	193·8	102·5	91·8	154·4	133·7	191·3	122·1	213·6	181·5
Means......	277·1	262·8	136·0	118·6	118·9	85·9	146·1	87·6	84·8	125·0	133·7	184·8	110·5	197·9	175·9

In addition to the principal results of the discussion of the aggregate and low tensions on pages 138 and 141, we find from that of the high, that the movements of the electrical tension above 60 div. in the *winter* are such as strongly to confirm the suggestion of the forenoon and evening maxima resulting from such high tensions.

Tables XLIX., L. and LI. exhibit the mean electrical tension above 60 div. at each observation-hour for each month in the three years 1845, 1846 and 1847, with the monthly, seasonal and yearly means.—The characters of the monthly movements are exhibited to the eye in the sheets of curves illustrating this report. See Plate X. and XI.

Table LII. exhibits the mean monthly electrical tension at each observation-hour, deduced from the observations of *three* months; also the mean summer, winter and yearly tensions, deduced from the observations of *three* summers, winters and years. The last line in the table, to which the word "Means" is prefixed, exhibits the mean tension in each month, as deduced from all the separate monthly observations; *i. e.* the mean tension of January, 277·1 div., is the result of all the January observations in the three years. The same thing holds good of the seasonal and yearly mean tensions.

The curves projected from these numbers will be found on Plate XI.

Annual Period.

Aggregate observations.—One of the principal results of the foregoing discussion has been to exhibit the march of the electrical tension during the twenty-four hours constituting the period of a day. This march has been found to present two well-defined maxima, in most instances removed from each other by an interval of twelve hours, the principal occurring at 10 P.M. and the inferior at 10 A.M. Two minima have also been ascertained, the principal at 4 A.M. and the subordinate at 4 P.M. At a particular season of the year, there have been indications of *a curve of low tension presenting considerable approximation to a single progression, more or less in harmony with the curve of temperature*; but the curve deduced from all the positive observations is not in harmony with the curve of temperature, inasmuch as neither of the maxima corresponds with either of its turning-points. We must not however forget, that the greatest development of electricity, so far as the diurnal period is concerned, takes place from sunrise to 10 P.M., and includes the period that the sun is above the horizon, and to this extent there is a connection between the temperature and the electrical tension. We now proceed to examine those changes of the electrical tension, the period of which is completed in the same time that the earth is occupied in making a revolution round the sun.

The following table contains the number of readings in each month of the three years which form the bases on which the results in the succeeding tables rest. It will be remarked, that the greatest number occur in the summer and the least in winter, the cause of which has been already referred to as resulting from the cessation of observations at 6 A.M. during the winter months.

Table LIII.

Number of positive readings in each month of the three years 1845, 1846 and 1847.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Sums.
1845.	287	258	228	280	305	299	330	313	318	287	220	249	3374
1846.	264	228	276	259	308	308	327	314	316	269	280	250	3399
1847.	244	226	278	271	313	300	320	315	318	298	265	255	3403
Sums.	795	712	782	810	926	907	977	942	952	854	765	754	10176

Table LIV.

Mean electrical tension of each month in the three years 1845, 1846 and 1847, with the mean annual period, as deduced from the whole.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	109·3	190·3	64·5	56·1	38·7	26·0	25·9	29·9	37·5	46·2	83·9	84·2	63·1
1846.	95·9	100·1	78·9	63·7	42·8	33·0	31·3	26·3	27·2	65·6	49·8	160·3	61·3
1847.	258·8	206·6	79·6	52·2	32·3	28·8	59·7	31·9	34·3	41·0	78·7	84·3	76·3
Mean.	150·7	166·6	75·0	57·2	37·9	29·3	38·8	29·4	33·0	50·5	69·6	109·5	66·9

Table LV.

Excess or defect of the mean electrical tension of each month, as compared with the mean of the year for the three years 1845, 1846 and 1847, and the mean annual period.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	+ 46·2	+ 127·2	+ 1·4	− 7·0	− 24·4	− 37·1	− 37·2	− 33·2	− 25·6	− 16·9	+ 20·8	+ 21·1	63·1
1846.	+ 34·6	+ 38·8	+ 17·6	+ 2·4	− 18·5	− 28·3	− 30·0	− 35·0	− 34·1	+ 4·3	− 11·5	+ 99·0	61·3
1847.	+ 182·5	+ 130·3	+ 3·3	− 24·1	− 44·0	− 47·5	− 16·6	− 44·4	− 42·0	− 35·3	+ 2·4	+ 8·0	76·3
Mean.	+ 83·8	+ 99·7	+ 8·1	− 9·7	− 29·0	− 37·6	− 28·1	− 37·5	− 33·9	− 16·4	+ 2·7	+ 42·6	66·9

An annual period in the electrical tension is not only very perceptible, but unquestionable. It is, with an exception hereafter to be noticed, a single progression having its turning-points in February and June. The exception alluded to consists in an increase of tension in July; but as this occurred only in one year (1847), it will form the subject of remark further on. From the mean of the three years, we find that June and August present nearly the same electrical tension, the difference being only 0·1 div. In September a small rise occurs which is increased in October; the augmentation becomes more rapid from November to January and then receives a check, the February increment being less than those of December and January. In February the maximum is attained, which is succeeded in March by a very rapid diminution of tension which continues through April and May, the decrements becoming less in value until June, the month presenting the lowest tension.

From this progression those of individual years differ to a greater or less extent: the turning-points do not occur in each year in the same months, and the range of tension differs materially. The year 1847, as we have already noticed, presents the highest tensions; this is very apparent from the following table of range.

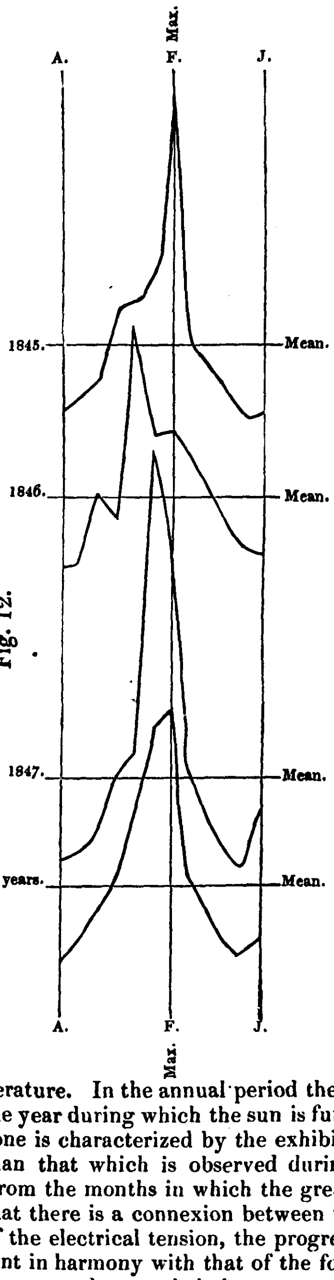


Fig. 12.

Mean annual curves of the electrical tension for the years 1845, 1846 and 1847, with the mean curve of the three years.

TABLE LVI.

Mean annual range of the electrical tension in the years 1845, 1846 and 1847, with the mean annual range of the three.

Year.	Range.
	div.
1845.	164·4
1846.	134·0
1847.	230·0
Mean.	137·3

The greater development of electricity in the year 1847 occurred in the month of January. The annexed curves (fig. 12) are projected on precisely the same scale as those of the diurnal periods, and are strictly comparable with them.

On contrasting the annual with the diurnal period, we find a marked difference which is not of an ordinary character. In the diurnal period we found an increase of tension towards the forenoon, succeeded by a diminution, the tension still continuing *high* in comparison with readings obtained after 10 P.M., at which hour the highest tension was most usually observed. The periods characterized by high and low tensions were those at which the sun was above and below the horizon (speaking in a general sense), the development of electricity appearing to be connected with the *increase* of temperature. In the annual period the reverse of this takes place: that portion of the year during which the sun is further removed from the northern temperate zone is characterized by the exhibition of electricity of much higher tension than that which is observed during the period when he is nearest thereto. From the months in which the greatest and least tensions occur, it appears that there is a connexion between the annual curve of temperature and that of the electrical tension, the progression of the latter being to a certain extent in harmony with that of the former, but inverse. It is well known that the same characteristic is presented by the annual curve of humidity, which is in inverse harmony with the annual curve of temperature, and this at once directly connects the annual period of the electrical tension with that of the humidity, and strongly confirms the suggestion already offered, that the high tensions at least measure the electrical tension of aqueous vapour. In order to illustrate this, the mean annual period of humidity, deduced from five years' observations at the Royal Observatory, Greenwich, is placed in connexion with the annual period of the electrical tension in the following table, in which the electrical tension is expressed in *entire* divisions of Volta's electrometer No. 1, and the humidity in the natural scale, in which complete saturation is reckoned as equal to 1000.

TABLE LVII.

Mean annual periods of electrical tension and humidity.

Period.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Electric..	151	167	75	57	38	29	39	29	33	51	70	109	67
Humid...	908	894	856	821	829	791	816	845	874	893	911	910	863

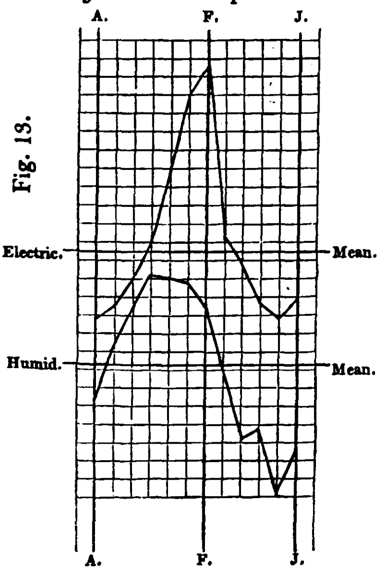
TABLE LVIII.

Comparison of the excess or defect from the mean of the electric and humid annual periods.

Period.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Electric..	+ 84	+ 100	+ 8	− 10	− 29	− 38	− 28	− 38	− 34	− 16	+ 3	+ 42	67
Humid...	+ 45	+ 31	− 7	− 42	− 34	− 72	− 47	− 18	+ 11	+ 30	+ 48	+ 47	863

The *general* correspondence as to the months exhibiting the greatest degree of humidity and the greatest electrical tension is very perceptible. It is however to be remarked, that the maximum of electrical tension does not occur in the same month as that of humidity. In Table LVIII., the later occurrence of the turning-points of the annual period of electricity as compared with that of humidity is very striking.

Fig. 13.



Mean annual curves of the electrical tension and humidity.

In the annexed curves (fig. 13), the points in which these periods correspond as well as those in which they differ are rendered very apparent to the eye. The curve of humidity is projected on a scale suitable for comparing it with that of the electrical tension, 100 divisions of the natural scale before mentioned, or one-tenth of the whole, being considered as equal to one inch.

Low tension.—In the following table, which exhibits the distribution of low readings in each month of the three years, the greater number during the summer is very apparent; it will be remarked that July presents the greatest number and February the least; the proportion is nearly as 3 to 1.

TABLE LIX.

Number of positive readings below 60 div. in each month of the three years 1845, 1846 and 1847.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Sums.
1845.	184	107	145	211	257	277	315	287	271	206	113	149	2522
1846.	146	109	152	172	268	280	306	297	291	198	193	73	2485
1847.	79	83	167	190	289	291	273	292	279	253	174	152	2522
Sums.	409	299	464	573	814	848	894	876	841	657	480	374	7529

TABLE LX.

Mean electrical tension below 60 div. of each month in the three years 1845, 1846 and 1847, with the mean annual period, as deduced from all the positive readings below 60 div.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	25·8	30·7	28·7	29·0	25·2	21·5	22·5	24·0	27·5	25·6	32·4	28·6	25·9
1846.	34·7	34·6	35·1	31·3	27·5	26·8	28·5	22·3	22·8	33·3	30·7	37·3	28·8
1847.	38·8	36·2	35·2	35·3	27·4	27·6	36·4	28·7	28·5	26·2	31·8	35·0	31·1
Mean.	31·5	33·7	33·1	31·8	26·8	25·4	28·8	25·0	26·2	28·1	31·5	32·9	28·6

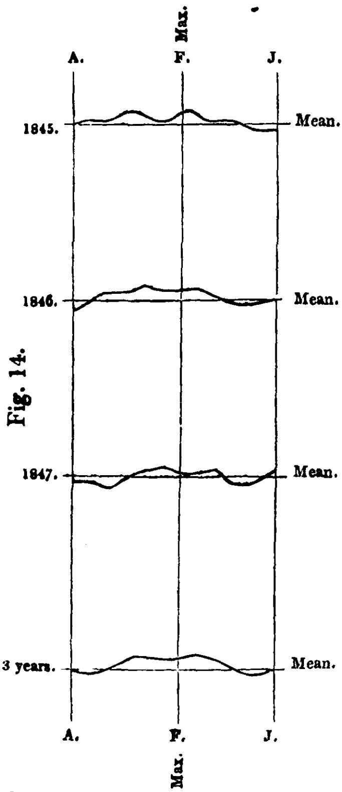
TABLE LXI.

Excess or defect of the mean electrical tension below 60 div. of each month, as compared with the mean of the years for the three years 1845, 1846 and 1847, and the mean annual period.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1845.	− 0·1	+ 4·8	+ 2·8	+ 3·1	− 0·7	− 4·4	− 3·4	− 1·9	+ 1·6	− 0·3	+ 6·5	+ 2·7	25·9
1846.	+ 5·9	+ 5·8	+ 6·3	+ 2·5	− 1·3	− 2·0	− 0·3	− 6·5	− 6·0	+ 4·5	+ 1·9	+ 8·5	28·8
1847.	+ 7·7	+ 5·1	+ 4·1	+ 4·2	− 3·7	− 3·5	+ 5·3	− 2·4	− 2·6	− 4·9	+ 0·7	+ 3·9	31·1
Mean.	+ 2·9	+ 5·1	+ 4·5	+ 3·2	− 1·8	− 3·2	+ 0·2	− 3·6	− 2·4	− 0·5	+ 2·9	+ 4·3	28·6

In the above tables we see an annual period nearly similar to that deduced from the entire series of positive observations during the three years. The main feature—that of an increase of electrical tension in the winter and a decrease in the summer—is the same in both periods; and from this circumstance the legitimate inference is, that the low tensions are affected by the presence of aqueous vapour as well as the high; consequently the arbitrary division at 60 div. fails *at all seasons* entirely to separate the electricity of aqueous vapour from that of the atmosphere, supposing the true march of the latter to be in harmony with that of the temperature. There are some minor differences between the two periods which it may be interesting to notice here. The progression is not single; it presents a depression at or near the period of the maximum, and an elevation at or near the period of the minimum. The maximum occurs in February and the minimum in August: commencing with the latter month, we have a gradual and uninterrupted rise until December of 7·9 div.; this is succeeded by a depression of 1·4 div. in January, and in February the maximum occurs, showing an increase on January of 2·2 div. The fall is then very gradual and uninterrupted until June—value 8·3 div. The elevation before spoken of occurs in July; it is as much as 3·4 div., and is succeeded by the minimum of August. The annual periods of single years partake of the same irregularity of movement which characterizes the annual periods deduced from all the positive observations.

Fig. 14.

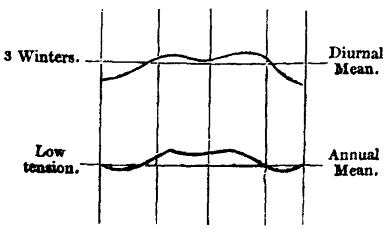


Mean annual curves of the electrical tension below 60 div. for the years 1845, 1846 and 1847, with the mean curve of the three years.

The symmetrical position of the elevation and depression interrupting the general march of the electrical tension at July and January, and their coincidence with the usual turning-points of the annual curve of temperature, suggest the idea that they may be more or less connected with that curve; *i. e.* it is not improbable that they may be the turning-points of the annual curve which depicts the annual progression of atmospheric electricity as distinguished from that of aqueous vapour, the latter being more strongly developed and consequently overpowering the former.

We have among the diurnal curves one that presents a striking similarity to that now under consideration; it is the curve of low tension for the mean of the three winters. In our examination of this curve, we considered that its peculiar form arose from the tendency in the readings to exhibit a single progression which was interrupted by the presence of aqueous vapour affecting the lower readings. It will be observed that the two curves (fig. 15), although to a great extent possessing *similarity* of form, are strikingly in contrast; they are to a great extent the converse of each other. In the winter we find the lower tensions struggling to maintain a single progression, which is overpowered, not by the maximum being depressed, but by the superposition of two maxima in all probability the effects of aqueous vapour,

Fig. 15.



and it is only after we have examined the yearly and summer curves that we find a tendency to a single progression in the winter. In the annual curve it is the aqueous vapour that produces the single progression; this is very apparent in the aggregate curves. When however we remove the tensions that appear more immediately to result from the presence of aqueous vapour, this single progression is interrupted at those points at which it is probable the influence of the vapour may be less than that of atmospheric electricity, and at these points only we have a corresponding elevation and depression. From the above considerations, both with regard to the diurnal and annual periods, we apprehend that it must be concluded, that a mere arbitrary division of the readings at any particular point will fail effectually to separate the electrical tension into its constituents, viz. that which is dependent on the solar action from that which results from the presence of aqueous vapour: nevertheless it appears, we apprehend, highly probable that the indications of a diurnal as well as an annual progression of atmospheric electricity, each having an ascending and descending branch, and consequently both being single progressions, are by no means of an uncertain character, and that the only requisite is a suitable mode of observation in order to apply *formulæ* capable of effecting such a separation, whereby all electrical tensions resulting directly from the presence of aqueous vapour may be ascertained and deducted from aggregate tensions as measured by the electrometers; that the curves both of atmospheric electricity and the electrical tension of aqueous vapour may be exhibited each freed from the influence of the other, so that their connexion or non-connexion with other meteorological elements may be readily ascertained.

High tension.—In the following table the great difference between the high readings in summer and winter is very apparent: February furnishes the greatest number (413) and June the least (59); the proportion is exactly 7 to 1.

TABLE LXII.

Number of positive readings above 60 div. in each month of the three years 1845, 1846 and 1847.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Sums.
1845.	103	151	83	69	48	22	15	26	47	81	107	100	852
1846.	118	119	124	87	40	28	21	17	25	71	87	177	914
1847.	165	143	111	81	24	9	47	23	39	45	91	103	881
Sums.	386	413	318	237	112	59	83	66	111	197	285	380	2647

TABLE LXIII.

Mean electrical tension above 60 div. of each month in the three years 1845, 1846 and 1847, with the mean annual period, as deduced from all the positive readings above 60 div.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1845.	258·5	303·5	127·1	138·8	110·8	82·1	98·3	94·4	95·3	98·5	138·3	167·1	173·2
1846.	171·5	160·0	132·7	127·7	145·3	94·6	71·3	97·6	78·4	155·7	92·0	211·0	149·7
1847.	364·2	305·5	146·3	91·6	91·2	68·3	194·8	72·5	76·2	124·4	168·2	156·9	205·6
Mean.	277·1	262·8	136·0	118·6	118·9	85·9	146·1	87·6	84·8	125·0	133·7	184·8	175·9

In the Tables LXII. LXIII. and LXIV. the annual period is very apparent, but it exhibits a much greater irregularity of movement, both in the individual years and in the mean of the three, than the annual period as deduced from all the observations. This irregularity of movement is well seen in the annexed curves (fig. 16), as well as the character which the high readings impart to the aggregate curves; for on comparing these with the aggregate curves on page 152, it will be observed that the latter present all the essential features of the curves of high tension, but so subdued that the movements appear more gentle and regular. In fact, throughout the series (excepting the summer months) the curves of high tension materially influence those as deduced from all the observations, and lead to the conclusion, that either throughout the year or during the winter, upon the supposition of high readings more directly measuring the electrical tension of aqueous vapour, the presence of such vapour materially affects the results. The same thing holds good with regard to the summer curves; for although the curves of high tension in the summer are very anomalous, yet the difference between the summer and winter curves of low tension, and the greater similarity between the aggregate and low tension summer curves, combined with the dissimilarity between the aggregate and low tension winter curves, strongly suggest that the summer low tension, as well as the aggregate curves, are materially influenced by the vapour, from the effects of which, as before observed, it is desirable the curves exhibiting the diurnal and annual march of electricity should be freed.

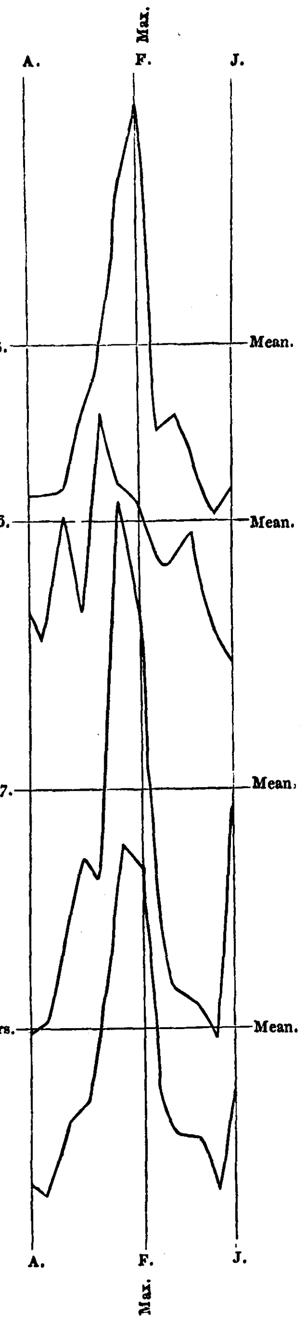


Fig. 16.

Mean annual curves of the electric tension above 60 div. for the years 1845, 1846 and 1847, with the mean curve of the three years.

TABLE LXIV.

Excess or defect of the mean electrical tension above 60 div. of each month, as compared with the mean of the year for the three years 1845, 1846 and 1847, and the mean annual period.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1845.	+85·3	+130·3	−46·1	−34·4	−62·4	−91·1	−74·9	−78·8	−77·9	−74·7	−34·9	−6·1	173·2
1846.	+21·8	+10·3	−17·0	−22·0	−4·4	−55·1	−78·4	−52·1	−71·3	+6·0	−57·7	+61·3	149·7
1847.	+158·6	+99·9	−59·3	−114·0	−114·4	−137·3	−10·8	−133·1	−129·4	−81·2	−37·4	−48·7	205·6
Mean.	+101·2	+86·9	−39·9	−57·3	−57·0	−90·0	−29·8	−88·3	−91·1	−50·9	−42·2	+8·9	175·9

SECTION 2.—*Discussion of Observations at Sunrise and Sunset.*

The observations made at sunrise and sunset furnish two series from which an interesting comparison with the mean annual period as deduced from three years' observations (see p. 151) may be derived. The epochs of observation of course are variable, coinciding in the summer with those points of the diurnal curve that are situated nearer the two *superior* turning-points, the principal extremes; while as regards the epochs of winter, that of sunrise approaches within two hours of the forenoon maximum, and that of sunset nearly coincides with the afternoon minimum. That this variability influences, no doubt to a considerable extent, the exhibition of electrical tension at the epochs of sunrise and sunset, there can be no question. Upon consulting Table V. (p. 118) it will be seen that the sunrise observations throughout the year, with the exception of those just about midwinter, fall in that portion of the diurnal curve that is *below* the mean of the whole year; while those at sunset appertain to a portion of the curve *above* the mean. We are therefore prepared to expect that the sunset observations throughout the year should present higher electrical tensions than those at sunrise, and such is the general fact—the tension at sunset is with but few exceptions higher than that at sunrise.

The entire number of observations employed in the deduction of the following results is 3367; of these, 1712 were made at sunrise and 1655 at sunset. The following tables exhibit the distribution of these observations over the respective months of the five years during which they were made, and also the mean of each month as based upon these numbers.

TABLE LXV.

Number of positive readings of the electric tension at sunrise in each month from August 1843 to July 1848 inclusive.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Sums.
1843.	...	...	...	...	...	...	...	26	30	24	27	31	138
1844.	28	28	27	30	31	30	30	28	24	28	28	31	343
1845.	26	27	23	29	31	24	27	28	30	30	30	31	336
1846.	30	27	30	26	31	26	27	30	29	27	30	30	343
1847.	31	27	31	28	30	24	29	29	30	31	29	28	347
1848.	31	29	28	30	31	28	28	...	...	...	...	...	205
Sums.	146	138	139	143	154	132	141	141	143	140	144	151	1712

Table LXVI.

Mean electric tension at sunrise in each month from August 1843 to July 1848 inclusive, with the mean monthly electric tension deduced from them.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1843.	...	...	...	...	...	...	...	15·7	26·1	17·4	105·0	40·7	
1844.	127·0	93·9	23·6	42·0	11·1	12·7	17·3	25·8	19·3	24·9	59·3	116·5	48·0
1845.	105·3	93·3	29·0	31·2	26·9	20·2	16·2	18·5	21·9	30·5	62·3	69·2	43·7
1846.	99·4	67·3	53·4	35·5	33·9	19·0	24·3	19·3	21·0	32·4	33·3	81·6	43·8
1847.	176·9	92·6	54·8	43·6	19·1	20·8	36·3	22·0	22·9	30·5	40·3	48·2	51·3
1848.	80·9	40·5	88·7	44·3	46·5	21·3	31·2						
Mean.	118·3	77·1	51·0	39·4	27·5	18·6	25·1	20·3	22·4	27·5	59·3	71·6	46·8

Table LXVII.

Number of positive readings of the electric tension at sunset in each month from August 1843 to July 1848 inclusive.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Sums.
1843.	...	...	...	...	...	...	...	25	30	24	28	31	138
1844.	27	25	27	29	30	29	28	28	25	27	27	30	332
1845.	26	26	22	25	25	26	29	27	29	31	26	27	319
1846.	30	24	29	26	29	28	28	29	29	28	30	29	339
1847.	29	27	29	26	27	26	30	27	29	30	30	29	339
1848.	29	25	28	23	28	27	28		...	...	...	...	188
Sums.	141	127	135	129	139	136	143	136	142	140	141	146	1655

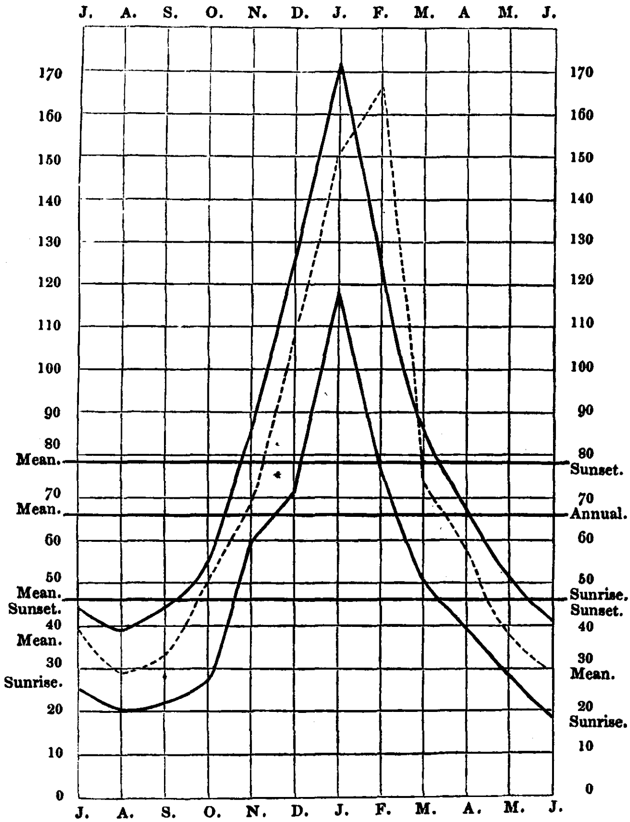
Table LXVIII.

Mean electric tension at sunset in each month from August 1843 to July 1848 inclusive, with the mean monthly electric tension deduced from them.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1843.	...	...	...	...	...	...	...	38·0	49·2	44·0	164·8	58·7	
1844.	173·1	156·5	48·7	39·3	32·1	34·6	38·3	40·1	46·3	56·8	58·6	225·0	79·0
1845.	90·2	151·2	60·6	61·3	43·5	34·2	29·8	43·4	50·7	57·2	74·4	84·4	64·6
1846.	86·5	78·1	162·1	75·1	41·5	44·0	46·8	35·6	34·4	72·9	60·1	181·2	76·7
1847.	342·2	170·5	66·5	50·7	58·4	37·0	54·9	39·4	42·7	42·2	78·3	86·3	89·6
1848.	158·6	61·3	81·7	124·1	82·0	61·2	50·0						
Mean.	171·2	124·8	85·6	68·2	51·3	42·2	44·0	39·3	44·6	54·8	87·1	127·4	78·4

The results of the five years' observations furnish the ordinates of two annual curves, viz. that exhibiting the annual period of the electrical tension at sunrise, and that exhibiting its annual period at sunset. As before remarked, the sunset curve is superior to that of sunrise. In fig. 17, these curves are projected on the same scale, so that the eye at once recognises the monthly differences between them. The annual curve, as deduced from the observations of 1845, 1846 and 1847, is also added for the sake of comparison. It will be observed that the three curves agree in presenting the slight increase of tension in July as compared with both June and August, which forms a secondary but very inferior maximum, and to which allusion has already been made. The minimum tension at sunset occurs in August (value 39·3 div.), and is succeeded in September and October by a gentle and regular increase. From October to January the increase is very rapid, but at the same time very regular, so that the curve possesses a bold flowing character, the ascending branch being free from interruptions arising from *sudden* starts in

Fig. 17.



Curves representing the annual period of the electrical tension at sunrise, sunset, and the mean from the observations of 1845, 1846 and 1847.

the movement, or from sudden and irregular increments of tension. The apex which occurs in January is well-marked and acuminated in its character, and the portion of the descending branch immediately succeeding it is to a great extent symmetrical with the corresponding portion of the ascending branch, and this symmetry obtains at least between the months of November and March. The entire diminution of tension from January to June presents precisely the same characteristics as the increase from August to January, viz. regularity of decrement, giving to the curve a flowing character, which in consequence of the large differences in the monthly tensions also possesses considerable boldness.

The mean annual curve derived from the observations of 1845, 1846 and 1847, differs from the curve just examined in two or three minor particulars.

It is not so gracefully flowing in its character, although based on a greater number of observations, thereby indicating a certain irregularity of movement in the monthly increase and decrease of tension, doubtless dependent on the *accidental* electrical character of each individual month contributing to the mean, which accidental character, it is highly probable, is derived from certain disturbing influences to be noticed in the next section, the effects of which have been eliminated in the sunset curve by employing five instead of three years' observations. The apex of the mean annual curve of 1845 to 1847 occurs a month later, but from the high tension in January it would probably appear that from a longer series of observations, January and February would present an equality of tension, or January would become the superior. As it is, there is at this point a marked difference between the curves, the later occurrence of the apex in the three years' curve destroying to a great extent the symmetry so observable in the sunset curve. With the exceptions just noticed, the two curves in their general course are similar, and this would suggest that the sunset curve presents to a certain extent an approximation to the mean annual curve of electrical tension, but in excess. The monthly differences between the two are as follows.

TABLE LXIX.

Monthly differences between the annual periods at sunset (five years) and the mean of the years 1845, 1846 and 1847.

Jan.	Feb.	Mar.	April.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
div. + 20·5	div. − 41·8	div. + 10·6	div. + 11·0	div. + 13·4	div. + 12·9	div. + 5·2	div. + 9·9	div. + 11·6	div. + 4·3	div. + 17·5	div. + 17·9	div. + 11·5

It will be observed that these differences upon the whole are greater in winter than in summer, particularly in the months of November, December and January. During these months the epoch of sunset is nearer to 4 P.M. than at any other period of the year, and at this hour the electrical tension differs only 2·2 div. from the mean, being in excess. If we take the curve of the three years as representing the mean tension, then it would appear that the mean tension at sunset increases upon the mean of all the observations at the twelve daily readings during the winter as compared with the summer, to the extent of about 16 div. The following numbers express the ratio of the mean tension derived from the observations at the twelve observation-hours to the mean tension at sunset.

TABLE LXX.

Ratio of the mean electrical tension, as derived from the observations of 1845, 1846 and 1847, to the mean electrical tension, as derived from five years' observations at sunset for each month in the year.

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
·880	1·334	·876	·838	·738	·694	·881	·748	·739	·921	·799	·859	·853

It will be observed that these ratios approach nearer to unity in the winter than in the summer, agreeing in this respect with the differences already noticed; but while the increasing differences denote divergence in the curves, the increasing ratios indicate a proportional convergence in the values of their ordinates. In winter the proportional value of the entire mean tension, as compared with the sunset mean tension, is nearly two-tenths more than it is in summer, *i. e.* in summer the value of the entire mean tension is about seven-tenths of the sunset mean tension, while in winter it is nearer nine-tenths: there is a greater *proportional* difference in summer than in winter. That this ought to obtain is evident from the consideration that the epoch of mean tension as before-mentioned is 4 P.M. In the summer the epoch of sunset is nearer 8 P.M., at which hour the tension is higher than at 4 P.M., consequently the differences of the two sets of mean tension should from this variability of the epoch of sunset be greater in summer than in winter; and although this is not apparent when we contemplate the differences only, because of the great increase of tension in the winter, yet upon ascertaining the ratios of the one series to the other it becomes apparent, the proportional differences as we have seen being greater in summer than in winter.

The irregularity of the curve of entire mean tension renders it doubtful whether these ratios ought to be regarded as at all sufficiently approximate to justify their employment in deducing from a series of sunset observations the entire mean tension. The month of July presents its usual anomalous character. October also presents a higher tension than the usual flexure of the curve would indicate as the mean, and the displacement of the apex renders it difficult to apply any correction at present to the February mean; nevertheless it is highly probable that a scale of corrections founded on the distance of the epoch of sunset from that of the mean tension of the entire year, and applied to the deductions from five or more years' observations, would furnish a tolerable approximation to the annual period of the entire mean tension.

The lowest curve in fig. 17 is that derived from the observations at sunrise; it partakes greatly of the character of the sunset curve, the flowing of the ascending branch only being interrupted by a greater increment of electrical tension in November than the mean monthly increment at this period of the year, and this would appear to be confined to November 1843 (see Table LXVI. on page 159). With this exception the sunrise curve follows the sunset very closely, the principal difference being in range, the range of the sunset exceeding that of sunrise by 32·2 div.

We now come to examine the *differences* between the annual periods of sunrise and sunset. These periods differ from each other not only in value, but, as we have just observed, in range; the consequence is an inequality of the monthly differences between them. We have already alluded to the approximation of the sunset curve to the mean annual curve derived from the observations of three years at the twelve observation-hours, the necessary corrections being comparatively small; it is however probable that the curves of sunrise and sunset approach much nearer in *form* to the true annual curve, which in value would come between them, and it is also likely that both curves may furnish true representatives of the annual period when certain corrections are applied, the value and range of the sunrise being necessarily lower than those of the sunset, from the observations contributing to its determination being made at a portion of the day characterized by a *feebler* development of the electrical tension. As the tension increases towards sunset in a certain ratio and according to a certain law which is most probably preserved during the annual progression of the electrical tension, the consequence would be that with increasing tensions at sunset we should have increasing differences from summer to winter and decreasing differences from winter to summer, and that from a sufficiently long series of observations either at sunset, sunrise, or any selected hour, the mean annual period might be deduced. The following are the differences between the two series.

TABLE LXXI.

Monthly differences between the annual periods at sunrise and sunset.

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
52·9	47·7	34·6	28·8	23·8	23·6	18·9	19·0	22·2	27·3	27·8	55·8	31·6

It will be remarked that these differences gradually decrease from December to July and gradually increase from July to December, but it should not be forgotten that the variability of the epochs of sunrise and sunset has a great tendency to produce a difference between the mean monthly values of the tensions of the two periods in the contrary direction, *i. e.* a greater difference in June and a less difference in December. In the summer, when we have the least difference in consequence of the general low tension of the season, the epochs of observation are the furthest removed from each other, that of sunrise nearly coinciding with or being but little removed from the epoch of the principal minimum, and that of sunset being brought within two hours of the epoch of the principal maximum: under these circumstances, and leaving out of consideration the effects of other movements, we ought to have the greatest difference between the tensions. On the other hand, in winter the epoch of sunrise occurs within two hours of the forenoon maximum, and that of sunset nearly coincides with the afternoon minimum; it is consequently manifest that the differences existing under these circumstances should be the least, and the entire series of monthly differences ought to enter as corrections in deducing the true annual period from observations at sunrise and sunset. It is however clear, from the series of differences before us, that this object cannot be attained by a mode of discussion which regards *them* only, the two opposite series of differences being mingled together in those presented to our notice; but if we compute the ratios of the sunrise to the sunset mean tensions, we shall probably discover the effects of the recess and approach of the epochs of observation according to the season of the year, the further they are removed from each other the lower the ratio—coincidence of value being considered as unity—and on the contrary the nearer they approach each other the higher the ratio, the proportional difference being less. The following numbers clearly exhibit these proportional differences.

TABLE LXXII.

Ratio of the mean electrical tension at sunrise to that at sunset, for each month of the year.

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
·691	·618	·596	·578	·536	·440	·570	·517	·502	·501	·680	·562	·596

In these ratios the effect of the variability of the epochs of observation is very apparent, the difference between June and January being as much as ·251, which is more than one-third of the ratio in January. In June the mean tension at sunrise is less than one-half of the mean tension at sunset; in January it is considerably more than in June, being very nearly seven-tenths of the sunset mean tension. There are two or three anomalies in the numbers, apparently arising from the sunrise observations, which must render a more extended series necessary before a correct scale of ratios between the two series can be computed.

SECTION 3.—*Discussion of Observations between August* 1, 1843, *and December* 31, 1844.

The entire number of observations selected from the seventeen months constituting the earlier portion of the five years is 1897; of these 551 were made in the last five months of 1843, and 1346 in the year 1844. It is quite improbable that from a series of this kind an annual period could be deduced. The only epochs of observation adopted in 1843 and 1844, and continued during the remainder of the five years, were sunrise and sunset; they accordingly, of all the observations, furnish an unbroken series during the whole period, and as such have been already examined. The epochs of the remaining observations, 9 A.M. and 3 P.M., having been discontinued at the end of 1844, the results furnished by them are necessarily very partial. In the discussion of 1843 and 1844 they have been incorporated with those of sunrise and sunset, and have been employed in the first instance in deducing the mean tensions in Table LXXIII., which are those of each day on which positive electricity *only* as a general rule has been observed.

TABLE LXXIII.

Mean electrical tension of each day from August 1, 1843, to December 31, 1844, on which positive electricity *only* was observed.

D.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
1	19·75	39·25	14·25	85·25	33·75	..	111·25	41·25	425·	38·75	11·	..	..	146·25	20·	44·25	43·12
2	..	29·	18·50	425·	77·50	154·75	375·	42·50	162·50	31·25	30·75	..	..	98·75	14·37	..	65·62
3	..	21·75	18·25	59·50	39·25	925·	372·50	27·50	66·25	27·12	31·	32·	..	30·37	6·25	..	30·62
4	..	14·50	12·75	158·75	8·50	600·	407·50	..	30·75	22·75	21·	..	16·37	19·62	34·12	49·37	65·62
5	18·75	34·25	33·25	31·	17·50	15·	450·	76·25	..	56·50	23·	..	48·12	18·37	3·87	160·62	450·
6	18·	62·25	..	34·75	42·25	20·75	425·	77·50	54·	64·75	5·25	21·87	20·37	25·	16·37	71·25	800·
7	27·75	58·	27·	22·	17·25	100·	..	38·75	68·12	27·50	8·	28·25	17·37	30·25	32·50	65·	216·25
8	22·75	62·50	18·	62·75	50·	51·25	55·	51·66	73·33	11·	25·50	37·50	12·50	52·87	57·50	..	71·25
9	35·50	39·25	..	158·75	63·75	40·	..	12·75	56·25	21·	13·25	25·	15·75	29·50	3·75	46·87	35·25
10	5·50	..	51·25	33·50	22·25	33·25	48·75	..	32·75	17·50	15·12	34·37	52·50	45·50	21·37	83·75	50·62
11	46·25	13·	..	345·	25·	52·50	66·25	..	43·50	30·75	23·	24·87	29·87	43·25	19·75	58·12	66·87
12	15·	46·25	..	447·50	168·75	..	68·75	..	33·87	23·12	23·87	30·50	29·87	32·75	39·12	16·5	76·87
13	48·75	62·25	27·50	428·75	225·	..	743·75	42·50	..	28·25	10·50	17·25	30·87	34·12	27·50	..	23·62
14	24·75	77·50	41·	233·75	175·	..	205·	40·62	15·75	21·50	10·25	26·	..	33·50	16·25	76·25	55·62
15	..	33·	51·25	245·	28·25	65·	9·75	28·	23·25	13·50	14·	20·62	20·87	4·50	..	12·50	195·
16	..	58·75	27·	43·75	17·50	375·	61·25	15·75	24·75	21·50	21·25	39·62	41·87	3·87	41·66	22·50	178·25
17	51·25	63·75	30·	116·25	112·50	300·	15·50	6·50	152·12	8·75	29·12	42·50	26·87	..	33·12	13·	575·
18	66·33	47·50	21·25	68·25	32·50	38·75	8·50	35·	25·75	16·75	..	30·87	26·62	30·87	39·75	20·75	108·75
19	36·25	39·25	107·50	198·75	77·50	42·50	26·75	24·	33·50	7·50	10·75	35·62	41·87	60·62	38·12	37·50	42·50
20	5·75	61·25	43·50	..	17·25	38·	36·25	36·66	12·	15·87	13·25	16·37	14·25	..	16·75	37·50	62·50
21	27·25	55·	..	10·75	13·	60·	..	72·50	28·25	15·	40·37	32·37	30·	15·33	17·83	192·50	57·50
22	..	37·75	38·75	53·33	7·75	400·	58·75	33·75	21·	14·75	25·75	41·25	20·62	..	39·	212·50	160·
23	25·	48·75	38·50	..	20·25	..	..	31·	38·75	15·	49·37	63·12	35·	..	..	162·50	68·75
24	7·75	24·25	20·75	300·	20·	203·75	37·50	17·25	12·50	16·37	21·25	51·62	35·87	..	55·83	97·50	58·75
25	28·	19·25	43·25	..	42·50	46·25	53·75	1·50	26·75	16·12	..	39·12	30·62	33·50	45·66	111·25	56·25
26	20·50	24·75	104·75	18·25	26·25	20·25	30·25	21·75	159·50	15·25	30·	12·75	18·87	60·	23·75	136·25	375·
27	48·75	15·25	65·	26·	49·50	42·	52·50	13·	22·	15·75	28·75	16·25	31·25	50·	59·37	180·62	650·
28	..	19·75	..	23·25	146·25	13·25	59·75	34·50	33·12	8·75	27·62	26·62	52·50	41·87	243·75	109·37	183·75
29	3·25	38·75	116·25	33·75	55·	28·75	83·75	76·25	38·75	11·	31·25	9·50	60·	6·75	71·25	41·50	18·33
30	36·	8·50	..	112·50	201·25	32·75	..	53·12	45·50	..	38·	21·16	55·62	39·37	66·25	49·37	408·12
31	28·75	..	..	..	58·75	..	..	51·50	..	19·75	..	19·87	27·50				

From this table has been formed Table LXXIV., which contains the greatest and least mean electrical tensions observed in each of the seventeen months, with their differences, and the days on which they occurred.

TABLE LXXIV.

Greatest and least mean daily electrical tension in each month, from August 1843 to December 1844, both inclusive, with their differences, and days of the month on which they occurred.

Month.	Mean daily electrical tension.		Difference.	Days of the month on which the mean electrical tension was	
1843 and 1844.	Greatest.	Least.		Greatest.	Least.
	div.	div.	div.		
August	66·33	3·25	63·08	18	29
September	77·50	8·50	69·00	14	30
October	116·25	12·75	103·50	29	4
November	447·50	10·75	436·75	12	21
December	225·00	7·75	217·25	13	22
January	925·00	13·25	911·75	3	28
February	743·75	8·50	735·25	13	18
March	77·50	1·50	76·00	6	25
April	425·00	12·00	413·00	1	20
May	64·75	7·50	57·25	6	19
June	49·37	5·25	44·12	23	6
July	63·12	9·50	53·62	23	29
August	60·00	12·50	47·50	29	8
September	146·25	3·87	142·38	1	16
October	243·75	3·75	240·00	28	9
November	212·50	12·50	200·00	22	15
December	800·00	18·33	781·66	6	29

The greatest mean daily electrical tension occurred in January 1844, and the least in March 1844: the difference (923·5 div.) is the *range* of the mean tensions during the seventeen months.

The numbers in this table bear testimony to the same general fact which we have already noticed in the discussion of the three years' observations, viz. the great increase of electric tension in winter; but from the nature of the quantities recorded, they are not comparable with the annual curves deduced from the observations of 1845, 1846 and 1847, and from those of sunrise and sunset during the five years.

From Table LXXV. we learn that in every month the electrical tension exceeded 79 div. of Volta's electrometer No. 1. In November 1843, January, February, March, April, and December 1844, the highest observed tensions at the four observation-epochs were between 1000 div. and 1500 div., or between 10° and 15° of Henley's instrument. In the remaining months, with the exception of August 1843 and June 1844, the highest tensions were between 100 div. and 500 div., or 1° and 5° of Henley, and in the two excepted months they were respectively 95 div. and 80 div. The effect of the annual progression is very apparent, the higher tensions being confined to the winter months.

During the seventeen months the electrical tension was never observed below 2 div. of Volta No. 1, except on one or two occasions on which the tension was too feeble materially to influence the instrument. The numbers in the column of least absolute tensions give the lowest observed tensions by Volta's instrument in the respective months.

Tables LXXVI. and LXXVII. exhibit the monthly distribution of all the observations at the four observation epochs, together with the value of the mean electrical tension at each observation-epoch in each of the seventeen months.

Table LXXV.

Greatest and least electrical tension observed in each month, from August 1843 to December 1844, both inclusive, with their differences, and the days of the month on which they occurred.

Month.	Absolute electrical tension in each month.		Difference.	Days of the month on which the electrical tension was	
1843 and 1844.	Greatest.	Least.		Greatest.	Least.
	div.	div.	div.		
August	95	2	93	17 9 a.m. 18 3 p.m.	29 3 p.m.
September	115	3	112	7 9 a.m. 16 9 a.m. 20 9 a.m. 21 9 a.m.	30 S.R.
October	300	3	297	19 9 a.m. 26 9 a.m.	1 S.R. 3 S.S. 4 S.R. 16 S.R.
November	1100	5	1095	12 S.S.	23 S.R. 29 S.R.
December	500	2	498	14 9 a.m.	4 3 p.m. S.S. 22 3 p.m.
January	1200	3	1197	4 9 a.m.	10 S.R.
February.........	1000	3	997	4 9 a.m.	17 S.R. 18 9 a.m.
March............	1500	3	1497	8 9 a.m.	9 S.R. 9 a.m. 17 S.R. 25 S.R. 9 a.m.
April	1000	3	997	1 9 a.m.	16 S.R.
May	200	2	198	5 S.S. 6 9 a.m.	17 S.R.
June	80	2	78	30 9 a.m.	22 S.S. 7 S.R.
July	100	5	95	23 S.S.	4 S.R. 6 S.S. 7 S.S. 26 S.R. 31 S.R.
August	105	4	101	29 9 a.m.	6 S.R.
September	400	3	397	1 9 a.m.	16 9 a.m. S.S.
October	400	2	398	28 S.S.	9 3 p.m.
November	500	4	496	27 9 a.m.	16 3 p.m.
December	1100	3	1097	6 3 p.m.	16 9 a.m.

Table LXXVI.

Number of positive readings at each observation-epoch in each month, from August 1843 to December 1844, both inclusive.

Epochs.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Sums.
Sunrise ..	26	30	24	27	31	28	28	27	30	31	30	30	28	24	28	28	31	481
9 a.m....	26	30	24	28	31	26	28	27	29	31	30	30	28	25	29	28	30	480
3 p.m....	25	29	23	28	31	28	28	26	29	30	27	26	27	25	27	27	30	466
Sunset ..	25	30	24	28	31	27	25	27	29	30	29	28	28	25	27	27	30	470
Sums....	102	119	95	111	124	109	109	107	117	122	116	114	111	99	111	110	121	1897

Table LXXVII.

Mean electrical tension at each observation-epoch in each month, from August 1843 to December 1844, both inclusive, with the mean annual period of 1844.

Epochs.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
Sunrise ..	15·7	26·1	17·4	105·0	40·7	127·0	93·9	23·6	42·0	11·1	12·7	17·3	25·8	19·3	24·9	59·3	116·5	46·1
9 a.m....	34·2	57·0	73·9	188·6	77·3	173·1	189·3	96·0	128·4	30·8	24·9	38·5	38·1	57·4	43·3	138·7	175·8	91·5
3 p.m....	18·0	26·9	29·5	86·6	64·8	142·6	151·5	35·8	33·8	12·0	18·1	20·3	23·8	35·1	38·4	66·1	204·8	60·9
Sunset ..	38·0	49·2	44·0	164·8	58·7	173·1	156·5	48·7	39·3	32·1	34·6	38·3	40·1	46·3	56·8	58·6	225·0	76·9
Mean....	26·4	39·9	41·3	136·5	60·4	153·4	147·5	51·2	60·7	21·5	22·6	28·8	32·0	39·7	40·7	81·0	180·0	68·9

The numbers expressing the mean electrical tension of each month exhibit very clearly a mean annual period, which may be advantageously compared with the annual periods already deduced; for this purpose the four annual periods derived from various sources are included in the following table.

Table LXXVIII.

Comparison of the annual periods of the electric tension derived from various sources.

Annual period.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
Sunset, 5 years	171·2	124·8	85·6	68·2	51·3	42·2	44 0	39·3	44·6	54 8	87·1	127·4	78·4
3 years, 1845 to 1847.	150·7	166·6	75·0	57·2	37·9	29·3	38·8	29·4	33·0	50·5	69·6	109·5	66·9
Sunrise, 5 years	118·3	77·1	51·0	39·4	27·5	18·6	25·1	20·3	22·4	27·5	59·3	71·6	46·8
The year 1844.........	153·4	147·5	51·2	60·7	21·5	22·6	28·8	32·0	39·7	40·7	81·0	180·0	71·8

Upon comparing the annual period deduced from the four daily readings, in the year 1844, with those recorded in Table LIV., we find the same irregularity of movement which characterized each of those deduced from the twelve daily readings in 1845, 1846 and 1847. The contrast in this respect with the smoothness and regularity in the general flowing of the curves, derived from five years' observations, appears to indicate that this is the shortest term in which the effects of accidental influences may be efficiently eliminated, so as to exhibit the annual progression of the electric tension, either in immediate connexion with, or following at some definite interval, the annual progression of the humidity of the atmosphere. We have already alluded to the protuberance on the upward branch of the sunrise curve, as resulting from a higher tension than ordinary in the month of November 1843 (see p. 162). The fifth column (Nov.) in Table LXXVII. exhibits the extraordinary character of this month, and shows that the electric tension was developed with increased force at each of the observation-epochs: this is very apparent from the comparison of this month with the remaining Novembers, and from it we may infer, that upon five years' observations, the tension of November being of the ordinary character, the annual curve is likely to present a smooth and gently flowing contour. In the table before us the features of the summit of the annual curve are well-marked: we have already alluded to the acuminated and symmetrical character of the summit of the sunset curve (see p. 160). This is amply borne out by the annual curve of the year 1844, and indeed by the others. Compared with the entire year, the three months, December, January and February, present by far the greatest electrical tension. In shorter intervals than five years, the months of maximum vary, sometimes occurring in the one or the other of the three months; but it appears from the entire series of five years, that the greatest tension is confined to the three months above-named.

The shortness of the period over which the observations at 9 A.M. and 3 P.M. extend, combined with the *irregularity* appertaining to the movements of a single year, render it impracticable to deduce the relation existing between the values at those fixed epochs. Nothing further than the general fact, confirmatory of the results deduced from the observations of 1845 to 1847, viz. that the tension in the forenoon hours is higher than that in the afternoon, is likely to be attained. This general result, which is very striking, is exhibited in Table LXXIX.

During the entire period the electric tension increased from sunrise to 9 A.M.; the mean value of this increase on the seventeen months is 45·4 div.: this, however, cannot be considered as of equal importance with the mean of the year, because the last five months of the year 1843 contribute to its determination. With only one exception, viz. December 1844, the tension declined from 9 A.M. to 3 P.M.—mean value as before, 30·6 div. It is not to be considered that the tension *actually* declines from 9 to 3, for we have already seen that 10 A.M. is the usual epoch of the forenoon maximum, but that the tension on an average is lower at 3 P.M. than at 9 A.M. The table shows an increase from 3 P.M. to sunset, with two exceptions: December 1843 and November 1844, mean value as before, 16·0 div., with the same limitation as to the character of the increase, 4 P.M. being the usual epoch of the afternoon minimum. These movements are further illustrated by the next table, which exhibits the excess or defect of the mean electrical tension above or below the mean of each month.

There are two or three numbers in the above columns that require a passing notice; most of them proceed very regularly, exhibiting a higher tension than the mean at 9 A.M. and sunset, and a lower tension at sunrise and 3 P.M. The first exception that we have to this order is in December 1843, the mean tension at 3 P.M. being in *excess*, while that at sunset is in *defect*. In this month the double progression disappears, the tension declining 18·6 div. from 9 A.M. to sunset. The second exception occurs in February 1844, when the tension at 3 P.M. was 4·0 div. *higher* than the mean; the usual order of progression was not interrupted; but from Table LXXVII. it would appear that the increase of tension giving rise to the anomaly just noticed, occurred principally between sunrise and 9 A.M., and was maintained afterwards. March and April 1844 present similar exceptions to each other in the tension at sunset being below the mean; the usual course of progression was not, however, interrupted in either case, as appears from Table LXXVII. The next exception occurs in November 1844, the tension at sunset being 22·4 div. below the mean: an inspection of Table LXXVII. indicates that the increase of tension, as in the former instances, took place between sunrise and 9 A.M., *but was not maintained afterwards*—in fact a diminution instead of an increase occurred at sunset; the increase between sunrise and 9 A.M. augmented the value of the monthly mean tension, and this, combined with the reversal of the usual movement at sunset, occasioned the depression of the mean at sunset below the mean of the month. In December 1844 there are no traces of the double progression, the tension increasing from sunrise to sunset: the epoch of mean tension for the month occurs between 9 A.M. and 3 P.M.; the signs of these mean quan-

TABLE LXXIX.—Differences between the mean electrical tensions at the four daily epochs from August 1843 to December 1844, both inclusive.

Epochs.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
Sunrise to 9 a.m.	+18·5	+30·9	+56·5	+83·6	+36·6	+46·1	+95·4	+72·4	+86·4	+19·7	+12·2	+21·2	+12·3	+38·1	+18·4	+79·4	+59·3	+45·4
9 a.m. to 3 p.m....	−16·2	−30·1	−44·4	−102·0	−12·5	−30·5	−37·8	−60·2	−94·6	−18·8	−6·8	−17·7	−14·3	−22·3	−4·9	−72·6	+29·0	−30·6
3 p.m. to sunset...	+20·0	+22·3	+14·5	+78·2	−6·1	+30·5	+5·0	+12·9	+5·5	+20·1	+16·5	+17·5	+16·3	+11·2	+18·4	−7·5	+20·2	+16·0

TABLE LXXX.—Excess or defect of the mean electrical tension at each observation-epoch, as compared with the mean of each month, from August 1843 to December 1844, both inclusive, and also with the mean of the seventeen months.

Epochs.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
Sunrise	−10·7	−13·8	−23·9	−31·5	−19·7	−26·4	−53·6	−27·6	−18·7	−10·4	−9·9	−11·5	−6·2	−20·4	−15·8	−21·7	−63·5	−22·8
9 a.m.	+7·8	+17·1	+32·6	+52·1	+16·9	+19·7	+41·8	+44·8	+67·7	+9·3	+2·3	+9·7	+6·1	+17·7	+2·6	+57·7	−4·2	+22·6
3 p.m...............	−8·4	−13·0	−11·8	−49·9	+4·4	−10·8	+4·0	−15·4	−26·9	−9·5	−4·5	−8·0	−8·2	−4·6	−2·3	−14·9	+24·8	−8·0
Sunset	+11·6	+9·3	+2·7	+28·3	−1·7	+19·7	+9·0	−2·5	−21·4	+10·6	+12·0	+9·5	+8·1	+6·6	+16·1	−22·4	+45·0	+8·0

tities are consequently reversed. It is worthy of remark that, while both the Decembers present *single* progressions, the points of maxima occur at different periods of the day. The very close approximation of the values of the means of the seventeen months, with opposite signs at sunrise and 9 A.M. and at 3 P.M. and sunset, is very interesting, and strongly indicates a symmetrical disposition of the epochs of mean tension, as deduced from these four daily readings with regard to them. We have, in fact, a tension at 9 A.M. as much above the mean as that at sunrise is below it, and the same thing occurs at 3 P.M. and sunset, the value being rather more than one-third of the movements in the morning. The great accordance which exists in this respect with the results already arrived at is interesting, and tends greatly to confirm the deductions that the movements are much greater in the morning and forenoon, that the depression in the afternoon is of a minor character, and that the principal maximum occurs in the evening; for although the mean tension at sunset is *lower* than that at 9 A.M. (see Table LXXVII.), yet the occurrence of two winters in the seventeen months tends to place the epoch of sunset *nearer* the afternoon minimum than it is upon the year. It should be borne in mind, that as the epochs of sunrise and sunset are variable, those of mean tension must be symmetrically disposed with regard to the *mean epochs of sunrise and sunset*, and 9 A.M. and 3 P.M.

High tensions.—Of the 1346 observations in the year 1844 that contribute to the results deduced for that year, 180 belong to the class of high tensions. The two following tables exhibit the distribution and limits of value of these readings.

TABLE LXXXI.

Number of positive readings (high, or above 60 div.) at each observation-epoch in each month of the year 1844.

Month.	Sunrise.	9 a.m.	3 p.m.	Sunset.	Sums.
January	8	6	8	7	29
February ..	11	9	5	6	31
March	4	3	...	1	8
April	5	5	1	...	11
May	...	1	...	1	2
June					
July					
August					
September ..	2	2	...	...	4
October	2	1	1	1	5
November ..	11	13	7	6	37
December ..	12	13	14	14	53
Sums	55	53	36	36	180

TABLE LXXXII.—Limits of value of the *high* readings at each observation-epoch in the year 1844.

At Sunrise.

Jan.

		div.		div.	
1	at	95.			
5	between	100	and	500	inclusive.
1	at			800.	
1	at			1000.	

Feb.

3	at	75.			
3	between	75	and	100.	
5	between	100	and	500	inclusive.

March.

4	between	75	and	90	inclusive.

April.

4	between	60	and	110	inclusive.
1	at			500.	

Sept.

2	between	70	and	75	inclusive.

Oct.

2	at	75.			

Nov.

9	between	65	and	100	inclusive.
2	between	200	and	300	inclusive.

Dec.

4	between	75	and	85	inclusive.
7	between	200	and	500	inclusive.
1	at			600.	

55

At 9 A.M.

Jan.

		div.		div.	
4	between	100	and	500	inclusive.
1	at			1000.	
1	at			1200.	

Feb.

6	between	120	and	500	inclusive.
2	at			700.	
1	at			1000.	

March.

1	at	90.			
1	at	110.			
1	at			1500.	

April.

4	between	115	and	500	inclusive.
1	at			1000.	

May.

1	at	200.			

Sept.

1	at	200.			
1	at			400.	

Oct.

1	at	200.			

Nov.

2	at	85.			
11	between	100	and	500	inclusive.

Dec.

5	between	55	and	95	inclusive.
6	between	200	and	500	inclusive.
1	at			700.	
1	at			900.	

53

At 3 P.M.

Jan.

		div.		div.	
7	between	100	and	500	inclusive.
1	at			900.	

Feb.

3	between	200	and	500	inclusive.
1	at			600.	
1	at			1300.	

April.

1	at	300.			

Oct.

1	at	300.			

Nov.

1	at	75.			
1	at	90.			
5	between	100	and	300	inclusive.

Dec.

3	between	70	and	100	inclusive.
8	between	200	and	500	inclusive.
1	at			600.	
1	at			900.	
1	at			1100.	

36

At Sunset.

Jan.

		div.		div.	
5	between	100	and	500	inclusive.
1	at			1000.	
1	at			1100.	

Feb.

4	between	300	and	500	inclusive.
1	at			600.	
1	at			900.	

March.

1	at			200.	

May.

1	at			200.	

Oct.

1	at			400.	

Nov.

4	between	50	and	95	inclusive.
2	at			200.	

Dec.

3	between	40	and	90	inclusive.
5	between	100	and	500	inclusive.
4	at			600.	
1	at			800.	
1	at			900.	

36

Upon consulting Table LXXXII. it will be seen that in most instances the months March to October inclusive present tensions considerably lower in value than those of the remaining four months, and in connexion with this, Table LXXXI. informs us that in June, July and August, all the tensions were low. The means have accordingly been taken for January, February, the eight months of low tension, November and December; they are exhibited in the following table.

Table LXXXIII.

Mean electrical tension (high, or above 60 div.) at each observation-epoch for the months specified in the year 1844.

Epoch.	January.	February.	Eight months.	November.	December.	Mean.
	div.	div.	div.	div.	div.	div.
Sunrise	386·9	198·6	108·8	110·7	251·7	198·8
9 a.m.........	616·7	480·0	426·2	243·8	337·3	390·4
3 p.m.........	389·4	620·0	300·0	137·9	375·0	361·9
Sunset	528·6	500·0	266·7	113·3	413·9	388·2
Mean	469·3	406·6	264·3	163·0	348·1	325·7

Table LXXXIV.

Differences between the mean electrical tension (high, or above 60 div.) at the four daily epochs for the months specified in the year 1844.

Epoch.	January.	February.	Eight months.	November.	December.	Mean.
	div.	div.	div.	div.	div.	div
Sunrise to 9 a.m.	+229·8	+281·4	+317·4	+133·1	+85·6	+191·6
9 a.m. to 3 p.m.	−227·3	+140·0	−126·2	−105·9	+37·7	− 28·5
3 p.m. to sunset.	+139·2	−120·0	− 33·3	− 24·6	+38·9	+ 26·3

Table LXXXV.

Excess or defect of the mean electrical tension (high, or above 60 div.) at each observation-epoch, as compared with the means of the winter months and also with the means of the eight months of low tension and of the entire year.

Epoch.	January.	February.	Eight months.	November.	December.	Mean.
	div.	div.	div.	div.	div.	div.
Sunrise...........	− 82·4	−208·0	−155·5	−52·3	−96·4	−126·9
9 a.m.	+147·4	+ 73·4	+161·9	+80·8	−10·8	+ 64·7
3 p.m.	− 79·9	+213·4	+ 35·7	−25·1	+26·9	+ 36·2
Sunset	+ 59·3	+ 93·4	+ 2·4	−49·7	+65·8	+ 62·5

These tables confirm the general result of the discussion of the high tensions in 1845, 1846 and 1847, viz. the *irregularity* of the movements above 60 div. In the four months specified the quantities are affected by precisely the same signs as those in Tables LXXIX. and LXXX., with only one exception, and thus we have additional evidence that the higher tensions materially influence the aggregate results.

Low tensions.—Upon omitting the high readings above specified, we obtain a series of numbers considerably in accordance with those recorded in Tables XXXIV. XXXV. XXXVI. and XXXVII.

The following table exhibits the distribution of the low readings in the year 1844, upon which the mean quantities in Table LXXXVII. are based.

TABLE LXXXVI.—Number of positive readings (low tension) at each observation-epoch in each month of the year 1844.

Epoch.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Sums.
Sunrise..	20	17	23	25	31	30	30	28	22	26	17	19	288
9 a.m....	20	19	24	24	30	30	30	28	23	28	15	17	288
3 p.m....	20	23	26	28	30	27	26	27	25	26	20	16	294
Sunset ..	20	19	26	29	29	29	28	28	25	26	21	16	296
Sums ...	80	78	99	106	120	116	114	111	95	106	73	68	1166

The numbers in this table are perfectly in accordance with those entering into the discussion of the low tensions of 1845, 1846 and 1847, in exhibiting the greatest quantity in the summer months.

TABLE LXXXVII.

Mean electrical tension (low, or below 60 div.) at each observation-epoch in each month of the year 1844, with the monthly and yearly mean tensions.

Epoch.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.	div.
Sunrise .	23·0	26·1	13·8	18·4	11·1	12·7	17·3	25·8	14·5	21·0	26·1	31·1	19·2
9 a.m....	40·1	51·6	37·2	54·5	23·2	24·9	38·5	38·1	37·7	37·7	47·5	52·4	38·9
3 p.m....	43·9	49·6	35·8	24·3	12·0	18·1	20·8	23 8	35·1	28·3	40·9	55·9	30·6
Sunset ..	48·7	48·0	42·9	39·3	26·3	34·6	38·3	40·1	46·3	43·6	42·9	59·7	41·4
Means...	38·9	44·6	32·9	33·9	18·5	22·6	28·8	32·0	33·5	32·7	39·4	49·0	32·6

TABLE LXXXVIII.—Differences between the mean electrical tension (low, or below 60 div.) at the four daily epochs in each month of the year 1844.

Epoch.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	div.	div.	div.	div.	div	div.	div.	div.	div.	div.	div.	div.	div.
S.R. to 9 a.m....	+ 17·1	+ 25·5	+ 23·4	+ 36·1	+ 12·1	+ 12·2	+ 21·2	+ 12·3	+ 23·2	+ 16·7	+ 21·4	+ 21·3	+ 19·7
9 a.m. to 3 p.m..	+ 3·8	− 2 0	− 1·4	− 30·2	− 11·2	− 6·8	− 17·7	− 14·3	− 2·6	− 9·4	− 6·6	+ 3·5	− 8·3
3 p.m. to S.S....	+ 4·8	− 1·6	+ 7·1	+ 15·0	+ 14·3	+ 16·5	+ 17·5	+ 16·3	+ 11·2	+ 15·3	+ 2·0	+ 3·8	+ 10·8

TABLE LXXXIX.—Excess or defect of the mean electrical tension (low, or below 60 div.) at each observation-epoch, as compared with the mean of each month and also with the mean of the year.

Epoch.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	div.	div.	div.	div.	div.	div.	div.	div.	div:	div.	div.	div.	div.
Sunrise .	− 15·9	− 18·5	− 19·1	− 15·5	− 7·4	− 9·9	− 11·5	− 6·2	− 19·0	− 11·7	− 13·3	− 17·9	− 13·4
9 a.m....	+ 1·2	+ 7·0	+ 4·3	+ 20·6	+ 4·7	+ 2·3	+ 9·7	+ 6·1	+ 4·2	+ 5·0	+ 8·1	+ 3·4	+ 6·3
3 p.m....	+ 5·0	+ 5·0	+ 2·9	− 9·6	− 6·5	− 4·5	− 8·0	− 8·2	+ 1·6	− 4·4	+ 1·5	+ 6·9	− 2·0
Sunset ..	+ 9·8	+ 3·4	+ 10·0	+ 5·4	+ 7·8	+ 12·0	+ 9·5	+ 8·1	+ 12·8	+ 10·9	+ 3·5	+ 10·7	+ 8·8

The double progression as a general rule is very apparent in the above tables. To the increase of tension from sunrise until 9 A.M. there are no exceptions; two only to the diminution of tension between 9 A.M. and 3 P.M., and one only to the increase from 3 P.M. to sunset. The numbers are greatly in harmony at least in this respect with the results obtained from the discussion of the low tensions in the years 1845, 1846 and 1847.

The exceptions to the double progression occurring as they do in the *winter* months, viz. January max. at sunset, February max. at 9 A.M., and December max. at sunset, are not without significance. In the discussion of the low tensions in the years 1845, 1846 and 1847, we adverted to the tendency exhibited by the winter curves to present a *single* progression; and while we noticed that the essential features of the *double* progression as exhibited in the aggregate curves were *compressed* as it were into the low tensions in the *summer* months, we also remarked that when the higher tensions—which were evidently more intimately connected with aqueous vapour, and were very much more numerous in the winter,—were withdrawn, the features of the double progression were withdrawn also, and suggested that upon a mode of directly observing the electrical tension of the aqueous vapour being devised, it might probably be practicable to separate it from the aggregate tension, and thus obtain a curve of a single progression representing the march of *atmospheric electricity*. The tables before us are strikingly confirmatory of the results obtained from the three years' observations. We see here, as there, the double progression most decided in the summer months; and the great tendency to a single progression in the winter is quite as conspicuous, if not more so than in those years. Upon the whole, the discussion of these seventeen months very strongly confirms the results already obtained.

One point only remains for our consideration; it is the annual period as exhibited by these numbers. It may probably be useful to particularize the annual period of each observation-epoch, and with this view the excess or defect as compared with the mean annual value of each epoch is given in the following table.

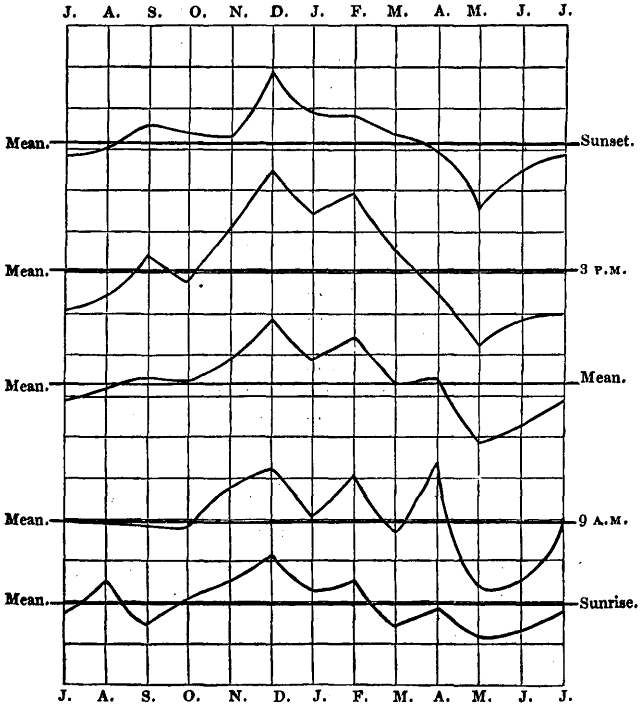
TABLE XC.

Excess or defect of the mean electrical tension (low, or below 60 div.) of each month in the year 1844, as compared with the mean annual value at each observation-epoch; also the excess or defect of the monthly mean tensions, as compared with the mean of the year.

	Sunrise.	9 A.M.	3 P.M.	Sunset.	Mean.
	div.	div.	div.	div.	div.
January	+ 3·8	+ 1·2	+13·3	+ 7·3	+ 6·3
February ..	+ 6·9	+12·7	+19·0	+ 6·6	+12·0
March	− 5·4	− 1·7	+ 5·2	+ 1·5	+ 0·3
April	− 0·8	+15·6	− 6·3	− 2·1	+ 1·3
May	− 8·1	−15·7	−18·6	−15·1	−14·1
June	− 6·5	−14·0	−12·5	− 6·8	−10·0
July	− 1·9	− 0·4	− 9·8	− 3·1	− 3·8
August	+ 6·6	− 0·8	− 6·8	− 1·3	− 0·6
September ..	− 4·7	− 1·2	+ 4·5	+ 4·9	+ 0·9
October	+ 1·8	− 1·2	− 2·3	+ 2·2	+ 0·1
November ..	+ 6·9	+ 8·6	+10·3	+ 1·5	+ 6·8
December ..	+11·9	+13·5	+25·3	+18·3	+16·4

In this table the depression of the summer readings below and elevation of the winter readings above the mean line at each epoch are very apparent. The differences however between the annual periods at each epoch and their approach to, or departure from, the mean is rendered more perceptible to the eye by the annexed curves (fig. 18).

Fig. 18.



Curves exhibiting the annual periods of the electrical tension (low) at the four observation-epochs for the year 1844.

It will be apparent from these curves that the *forenoon* and *afternoon* movements upon the annual period are strikingly different. There is considerable agreement between the curves of sunrise and 9 A.M., and also between those of 3 P.M. and sunset; the four curves forming two pairs, each pair presenting many features in common. The greatest difference between the curves is noticed at 9 A.M. and 3 P.M. There is more accordance between the sunrise and sunset curves, the principal difference occurring in the *opposite* movements in September. The sunrise curve is evidently modified by the movements at 9 A.M., as is that of sunset by the movements at 3 P.M. From this we may probably infer that the movements in the middle of the day, at least between 9 A.M. and 3 P.M., are much more irregular even in the low tensions than at any other period. The range (see Table XCI.), which is lowest at sunrise, increases rapidly between 9 A.M. and 3 P.M. the maximum; and this circumstance, taken in connexion with the cloudiness of the atmosphere (a subject to which we shall have occasion particularly to refer when treating on negative electricity), strongly indicates that the irregularity of movement in the middle of the day is more or less connected with the disturbing influences of clouds. The curve of cloudiness, as deduced from six years' observations at Greenwich, will be found on page 198. The approximation towards agreement in the sunrise and sunset curve is greatly in accordance with the phænomena already noticed in the same curves from five years' observations (see page 162); and the differences observable between those for the year 1844 strongly confirm the remark that has been offered, viz. that a series of five years' observations at least is necessary to eliminate the effects of irregular movements. It may be remarked, in immediate connexion with the curves of 1844, that the sunrise curve is much more in accordance with the sunset than that at 9 A.M. is with that at 3 P.M.

TABLE XCI.

Annual range of the electrical tension at the four observation-epochs in the year 1844.

Epoch.	Range.
	div.
Sunrise....	20·0
9 a.m.	31·3
3 p.m.	43·9
Sunset	33·4
Mean	30·5

PART II.—NEGATIVE ELECTRICITY.

The exhibition of negative electricity being confined within very narrow limits as compared with that of positive—the number of readings being extremely few—renders it exceedingly doubtful whether we can at all hope to find anything like a diurnal period manifested by it. The number of readings in the three years 1845 to 1847 amounted to 324, and it is not difficult to obtain the mean reading at each observation-hour from these records. In the seventeen months prior to 1845, great care was manifested in observing every and even the minutest change in the *kind* of electricity with which the conductor was charged. Not a shower appears to have occurred but it was minutely watched, the rapidity and extent of the changes assiduously observed, and the length of the sparks carefully measured; the whole being accompanied by notices of the weather at the time which appear to possess great accuracy of detail. As however the extremes of the charges are usually set down in some cases at the times they occurred, in others in a more general manner and *between certain epochs,* and not at such regular intervals, except on certain occasions, as would be useful in discussing them with a view to determine a diurnal period; such discussion, with regard to the negative observations previous to 1845, has not been attempted; but they have been carefully arranged in Table XCII. under the heads of "Limits of Time," "Extremes of Charge," "Maximum Length of Spark," and accompanying "Weather and Remarks." Under the last head are included the state of the weather with remarks by the observer at Kew; the clouds or other phænomena (likely to illustrate the Kew observations) recorded at or near the same epochs at the Royal Observatory, Greenwich, and occasional remarks by the writer. All remarks having reference to the Greenwich Observatory are placed within brackets.

In the succeeding table, the great majority of instances in which negative electricity has been exhibited, are characterized by *two* very interesting features. At Kew one of these features has been the *falling of rain*, in most instances *heavy*; and the other the great probability, from the almost constant record, at or near the same epochs at the Royal Observatory, Greenwich, of *cirro-stratus*, and occasionally *cumulo-stratus*, that these clouds have more or less not only accompanied, but contributed their quota to, the development of the electricity observed. On numerous occasions, *cirro-stratus* has been observed at Greenwich without the electrical instruments having been affected, and from this we may with great truth infer that *cirro-stratus* in its *ordinary* action does not occasion a disturbance of the regular diurnal march of the electrical tension. Most probably it is only when the conditions exist for the precipitation of rain, especially when the rain is formed very rapidly and in great quantities, that the electrical condition of the cloud is disturbed, and the conductor affected negatively. From the great constancy of the phænomena during a period of seventeen months, we are inclined to consider that to a certain extent they illustrate the remark relative to the *production of lightning by rain*, which occurs in the Report of the Committee of Physics, including Meteorology, approved by the President and Council of the Royal Society, pages 46 and 47. In speaking of thunder-storms, the writer, in alluding to one point to which the Committee wished some attention to be paid, says,—"It is the sudden gush of rain which is almost sure to succeed a violent detonation immediately over-head. Is this rain a *cause* or a *consequence* of the electric discharge? Opinion would seem to lean to the latter side, or rather, we are not aware that the former has been maintained or even suggested; yet it is very defensible. In the sudden agglomeration of many minute and feebly electrified globules into one raindrop, the quantity of electricity is increased in a greater proportion than the surface over which (according to the laws of electric distribution) it is spread. Its tension therefore is increased, and may attain the point when it is capable of separating from the *drop* to seek the surface of the cloud, or of the newly formed descending body of rain, which under such circumstances, and with electricity of such a tension, may be regarded as a conducting medium. Arrived at this surface, the tension for the same reason becomes enormous, and a flash escapes." In immediate reference to this remark, we apprehend the observations do not so much indicate the *actual electric tension of the rain falling on the conductor*, as the effect on the conductor of the *electric disturbance occasioned by the production of the rain*; this disturbance principally influencing the cloud from which the rain is precipitated, and through the cloud influencing the earth and bodies in its immediate neighbourhood. We shall have occasion again to refer to this subject in the *Notes* that are subjoined.

The exceptions to the general fact of heavy rain falling when the conductor has been negatively electrified are rare; only ten instances are recorded during the seventeen months; they are given in Table XCIII. p. 185; some of them are extremely interesting, and are calculated to throw great light on the subject to which we have just alluded: we shall notice them in their proper places in the Notes that follow.

TABLE XCII.

Observations of Negative Electricity made at the Observatory of the British Association at Kew, between Aug. 1, 1843, and December 31, 1844.

Date.	Observed limits of time.		Observed extremes of Charge.		Max. length of Spark.	Weather and Remarks.
1843.	h m	h m			in.	
Aug. 2.	1 30 p.m.	1 45 p.m.	....	N.	....	During a shower which began about $1^h 30^m$ P.M. the charge was negative for about 15 minutes; it changed to positive when the rain ceased. Showery from 10 A.M. and during the day. [Cirro-stratus and dark scud at Greenwich.—W. R. B.]
3.	11 0 a.m.	5 0 p.m.	P.	50^HN.	....	From 11 a.m. to 5 p.m. a continuation of heavy showers of rain at short intervals, the charge changing continually and rapidly during each shower. The negative charge 50^H was registered at 3 P.M. [Cumulo-stratus, cirro-stratus, nimbus and scud at Greenwich: a violent squall of rain from $9^h 50^m$ A.M. to $9^h 57^m$ A.M. which affected the galvanometer.—W. R. B.]
4.	0 45 p.m.	4 0 p.m.	90^HP.	N.	0·950	From about $0^h 45^m$ P.M. to $4^h 0^m$ P.M. continual heavy showers, during which the charges rose very high and changed rapidly from positive to negative. * * * Thunder was heard during the greater part of the afternoon and some lightning seen. One flash was accompanied by a discharge which resembled a luminous galvanic current; it lasted about half a second and was more than half an inch long ([a]).
8.	8 0 p.m.	8 30 p.m.	....	40^HN.	0·400	At about 8 P.M. some heavy drops of rain fell and the conductor became negative; it changed to positive about $8^h 30^m$ P.M. [Cirro-stratus and scud at Greenwich.—W. R. B.]
15.	4 20 p.m.	9 30 p.m.	....	30^HN.	0·200	This period commenced with a thick mist to windward (E. at 3 P.M.), Volta 125 div. N. Between $6^h 45^m$ P.M. and $8^h 45^m$ P.M. several claps of thunder and flashes of lightning were heard and seen. From 9 P.M. to $9^h 30^m$ P.M. heavy rain fell: the negative charge 30^H and the spark were registered at 9, and at the termination of the rain the charge became positive ([b]).
16.	6 0 a.m.	8 15 a.m.	....	30^HN.	0·500	At about 6 A.M. a heavy rain began, accompanied by thunder, lightning, and continual rapid changes of the charge from positive to negative. The negative charge 30^H was registered at $7^h 16^m$ A.M. Immediately before a clap of thunder (? time) a continued stream was observed to flow from the conductor to the discharger about ·5 inch long and lasting about 2 seconds. [This appears to have been a continuation of the same kind of weather observed on the previous evening.—W. R. B.] [At Greenwich cirro-stratus and scud with a low rumbling of thunder in the S.W. were registered at $7^h 20^m$ A.M.; it was first heard at $7^h 5^m$ A.M. and passed round by the N.W.—W. R. B.]
22.	5 15 p.m.	5 30 p.m.	....	100^VN.	....	Heavy rain from 11 A.M. to $5^h 30^m$ P.M. The charge during this rain was positive until the last quarter of an hour. It became again positive on the ceasing of the rain. [Cirro-stratus and scud at Greenwich.—W. R. B.]
23.	8 30 p.m.	9 15 p.m.	10^HP.	N.	....	Heavy rain from 3 P.M. The charge was positive but disturbed during this rain; the reading 10^HP. was registered at $3^h 15^m$ P.M. shortly after its commencement. The negative electricity did not appear until $8^h 30^m$ P.M. [The largest amount of rain recorded in 24 hours at Greenwich between October 1840 and April 1845; it was rather above 2 inches.—W. R. B.]

Sept. 10.	2 10 p.m.	2 47 p.m.	40^{H}P.	45^{H}N.	0·400	*Between* $2^h\ 10^m$ P.M. *and* $2^h\ 47^m$ P.M. *a thunder-cloud passed over the observatory from* S.W. *to* N.E., *during which passage four different changes in kind of charge took place. The tensions registered were the highest observed; they gradually diminished until the positive signs of serene weather returned* (c).
Oct. 2.	11 0 a.m.	11 10 a.m.	....	N.	....	This 10 minutes of negative charge (value not recorded) occurred during a *light rain* from 10 A.M. to $1^h\ 30^m$ P.M.; it was accompanied by *heavy rain*, so that this heavy rain might be considered as a distinct shower from the general light rain, the signs becoming positive upon its ceasing (d).
6.	11 30 a.m.	noon.	....	75^{V}N.	....	During a heavy shower. Other showers occurred during the afternoon, but although negative electricity was not exhibited, disturbance was manifested. [Cirro-stratus at Greenwich.—W. R. B.]
7.	0 30 p.m.	4 0 p.m.	10^{H}P.	30^{H}N.	0·200	During a shower in which the changes were frequent. [Cirro-stratus, cumulus, cumulo-stratus and scud registered at Greenwich.—W. R. B.]
9.	8 45 a.m.	9 0 a.m.	25^{V}P.	15^{H}N.	....	Heavy shower.
9.	5 20 p.m.	6 45 p.m.	25^{H}P.	20^{H}N.	0·200	During a shower. Weather between the showers dull and cloudy. [Cirro-stratus and scud at Greenwich.—W. R. B.]
11.	11 0 a.m.	11 15 a.m.	....	11^{V}N.	....	Several very heavy showers between 11 A.M. and 4 P.M. A negative charge characterized the first only for about a quarter of an hour. [Cirro-stratus and heavy rain at Greenwich.—W. R. B.]
12.	11 0 a.m.	2 45 p.m.	25^{V}P.	30^{H}N.	....	This period is divided into two portions: one of $2^h\ 15^m$ duration, characterized by heavy rain; the other $1^h\ 30^m$ *by fine weather accompanied with sunshine.* [I subjoin in the Notes the original entry. —W. R. B.] (e)
21.	1 15 p.m.	1 45 p.m.	....	5^{H}N.	....	During a heavy shower. [Cirro-stratus and scud at Greenwich.—W. R. B.]
28.	3 0 p.m.	3 10 p.m.	....	30^{H}N.	0·200	During a heavy shower of hail and rain (f).
31.	11 0 a.m.	8 0 p.m.	....	17^{H}N.	0·150	A general heavy rain began about $9^h\ 30^m$ A.M. which continued during the whole day and evening; the negative charge commenced at 11 A.M. and continued the whole day and evening. [Cirro-stratus and scud registered at Greenwich.—W. R. B.]
Nov. 8.	0 15 p.m.	0 40 p.m.	55^{H}P.	40^{H}N.	0·400	During a shower. [Cirro-stratus and scud were registered at Greenwich at $1^h\ 20^m$ P.M., and a squall of hail was observed there from $0^h\ 35^m$ P.M. to $0^h\ 45^m$, during which the galvanometer needle deviated to 45° towards A.—W. R. B.]
18.	2 0 p.m.	2 20 p.m.	40^{H}P.?	35^{H}N.	0·250	During a heavy shower of rain and hail. [This shower did not occur at Greenwich, but at the observations before and after its occurrence at Kew, *large white cumuli were observed at Greenwich, at first in every direction and afterwards in the* W. S. *and* E.—W. R. B.]
24.	0 0 nn.	1 30 p.m.	....	6^{H}N.	....	Heavy rain and fog during the first half-hour; *the negative charge continued an hour after the rain had ceased*, and half an hour after the maximum charge. [Cirro-stratus registered at Greenwich from $5^h\ 20^m$ A.M. to $1^h\ 20^m$ P.M.: rain occurred till within a few minutes of $1^h\ 20^m$ P.M.: a heavy rain is registered from $2^h\ 40^m$ P.M. to $3^h\ 5^m$ P.M., which did not appear to have affected the electrical instruments. *Cirro-stratus is not named.*—W. R. B.]
25.	9 0 a.m.	10 30 a.m.	20^{H}P.	25^{H}N.	0·150	Heavy rain. [Cirro-stratus registered at Greenwich.—W. R. B.]
Dec. 31.	3 0 p.m.	4 30 p.m.	75^{V}P.	100^{V}N.	....	Heavy rain. The negative charge commenced about sunset. [Cirro-stratus and scud registered this day at Greenwich.—W. R. B.]
1844. Jan. 1.	sunrise.	9 0 a.m.	20^{H}P.	16^{H}N.	....	Snow and rain. [Cirro-stratus and scud registered at Greenwich.—W. R. B.]

TABLE XCII. (*continued*).

Date.	Observed limits of time.		Observed extremes of Charge.		Max. length of Spark.	Weather and Remarks.
1844.	h m	h m			in.	
Jan. 5.	sunset.	4 15 p.m.	12^{V}P.	5^{HN}.	....	Heavy rain. [Cirro-stratus and scud registered at Greenwich.—W. R. B.]
5.	6 0 p.m.	6 45 p.m.	15^{V}P.	10^{HN}.	0·100	Heavy rain. [Cirro-stratus and scud registered at Greenwich.—W. R. B.]
13.	8 0 a.m.	8 20 a.m.	7^{V}P.	19^{HN}.	....	Heavy shower. [Negative electricity was registered at Greenwich between 11 P.M. of the 12th and $6^h\ 7^m$ A.M. of the 13th Maximum tension 40° single gold leaf of dry pile apparatus.—W. R. B.]
23.	9 0 a.m.	9 30 a.m.	....	6^{HN}.	....	A shower. [Cirro-stratus and thick fog registered at Greenwich at $9^h\ 20^m$ A.M., also positive electricity between 9 A.M. and 9 P.M. Max. tension 35° of dry pile.—W. R. B.]
30.	7 30 p.m.	....	....	80^{V}N.	....	Heavy rain. [Cirro-stratus and scud at Greenwich.—W. R. B.]
31.	8 45 a.m.	9 0 a.m.	45^{HP}.	90^{HN}.	1·000	Heavy storm of snow and hail.
31.	0 0 nn.	0 20 p.m.	50^{HP}.	90^{HN}.	1·500	Storm of snow and hail.
31.	1 40 p.m.	2 0 p.m.	60^{HP}.	90^{HN}.	0·700	Heavy shower of rain and hail (g).
Feb. 7.	4 30 p.m.	5 20 p.m.	....	20^{HN}.	0·150	Heavy rain. [Cirro-stratus at Greenwich.—W. R. B.]
7.	7 0 p.m.	11 0 p.m.	16^{HP}.	10^{HN}.	....	Heavy rain. [Cirro-stratus registered at Greenwich between $3^h\ 20^m$ A.M. and $9^h\ 20^m$ P.M.—W. R. B.]
8.	4 0 p.m.	4 15 p.m.	35^{HP}.	20^{HN}.	....	Heavy shower of rain and hail. [At $5^h\ 20^m$, more than an hour later, cirro-stratus and scud was registered at Greenwich, but at $3^h\ 50^m$ P.M. a squall of rain and hail was observed; the electrometer not affected, except by a sudden but slight start in the pith-balls shortly before the squall.—W. R. B.]
9.	4 30 p.m.	5 0 p.m.	60^{HP}.	70^{HN}.	1·000	Heavy storm of rain and snow. [Cirro-stratus and scud registered at Greenwich at $5^h\ 20^m$ P.M. At $5^h\ 5^m$ a shower of sleet and snow fell which ceased at $5^h\ 20^m$ P.M.—W. R. B.] (h)
19.	11 0 a.m.	11 15 a.m.	....	12^{HN}.	0·100	Heavy rain. [Cirro-stratus and scud registered at Greenwich from $11^h\ 20^m$ A.M. to $9^h\ 20^m$ P.M.; at $10^h\ 10^m$ A.M. a squall of heavy rain commenced; it continued until $11^h\ 45^m$ A.M., the electricity being negative during the last 45 minutes. Maximum tension 40 div. Volta (2).—W. R. B.]
21.	11 30 a.m.	....	95^{V}P.	20^{HN}.	0·150	Light rain with intermissions. [Cirro-stratus and scud registered at Greenwich from $5^h\ 20^m$ A.M.—W.R.B.]
23.	5 0 p.m.	....	....	20^{HN}.	0·150	Light rain and snow; heavy rain. [Cirro-stratus registered at Greenwich from $3^h\ 20^m$ P.M. to $7^h\ 20^m$ P.M. with thin rain, succeeded by squalls of heavy rain. Negative electricity from $4^h\ 50^m$ P.M. to $6^h\ 12^m$ P.M. Max. tension 45 div. Volta (2) at $5^h\ 33^m$ P.M. Max. length of spark 0·10 inch.—W. R. B.]
25.	2 40 p.m.	2 56 p.m.	60^{HP}.	25^{HN}.	0·500	Heavy rain. [Cirro-stratus and scud registered this day at Greenwich.—W. R. B.]
26.	10 45 a.m.	11 0 a.m.	55^{HP}.	25^{HN}.	0·500	Heavy shower. [Cirro-stratus and scud $9^h\ 20^m$ A.M. at Greenwich.—W. R. B.]
26.	0 5 p.m.	0 20 p.m.	5^{HP}.	15^{HN}.	....	Heavy shower. [Before $1^h\ 12^m$ P.M. a large *cumulo-stratus* approached the zenith of Greenwich, and all the instruments became at once affected; at $1^h\ 12^m$ a few heavy drops of rain fell. The electricity exhibited was negative. Max. tension 100 div. Volta (2). Sparks 0·15 inch in length. 1 in 10 seconds occurred at $1^h\ 22^m$ P.M.—W. R. B.] (i)
29.	7 0 p.m	10 0 p.m.	90^{V}P.	20^{HN}.	0·200	Light and heavy rain. [Cirro-stratus registered at Greenwich at $7^h\ 20^m$ P.M. At $9^h\ 20^m$ heavy rain. Between $9^h\ 55^m$ and $10^h\ 20^m$ P.M. negative electricity. Max. tension 23 div. Volta (1). The observer adds this note: "Rain is falling; during the continuance of previous heavy rain no effect was noticed."—W. R. B.]

Mar. 2.	4 15 p.m.	4 30 p.m.	45^{HP}.	35^{HN}.	0·400	Heavy shower. [The clouds registered at Greenwich about this time were cumuli and scud.—W. R. B.]
3.	2 30 p.m.	2 35 p.m.	60^{HP}.	60^{HN}.	0·500	During the passage of a very heavy cloud from which fell a little hail. [This was most probably a cumulo-stratus, that cloud with nimbi and scud being observed at Greenwich in the forenoon.—W. R. B.]
4.	sunrise.	5 0 p.m.	....	35^{HN}.	0·300	Heavy and light rain. [Cirro-stratus was registered at Greenwich from $5^h 20^m$ A.M. to $11^h 20^m$. Between $6^h 25^m$ A.M. and 8 A.M. negative electricity was observed. Max. tension Volta (2) 150 div., rain falling heavily at the time. Also between $11^h 20^m$ A.M. and 1 P.M. max. tension Volta (2) 50 div., rain falling heavily.—W. R. B.]
10.	sunrise.	1 0 p.m.	....	10^{HN}.	0·100	Heavy rain, during which the charge was always negative.
13.	2 0 p.m.	2 20 p.m.	60^{HP}.	35^{HN}.	0·600	Heavy shower of rain and hail. [At $3^h 20^m$ P.M. dense cumulo-stratus covered the sky in the N. and N.E. at Greenwich.—W. R. B.]
14.	7 0 p.m.	9 0 p.m.	....	20^{HN}.	0·400	General heavy rain. [Cirro-stratus registered at Greenwich from $3^h 20^m$ A.M. Negative electricity was also observed between 10 A.M. and $0^h 26^m$ P.M. Max. tension Volta (2) 150 div., and sparks occurred 0·07 inch in length, 1 in 25 seconds, and 2 in 101 seconds.—W. R. B.]
15.	7 0 a.m.	7 30 a.m.	....	10^{HN}.	0·100	Heavy rain. [Cirro-stratus at Greenwich.—W. R. B.]
20.	1 0 p.m.	1 30 p.m.	20^{HP}.	45^{HN}.	0·400	Heavy shower. [Cirro-stratus and scud with squalls of rain at Greenwich. At $0^h 48^m$ P.M. to $0^h 50^m$ P.M. a squall occurred, in which negative electricity, tension 15 div. Volta (2), was exhibited; at $1^h 23^m$ P.M. dark clouds came up from the W.; at $1^h 32^m$ P.M. heavy rain commenced falling, after which a squall occurred; the electricity was pos. and neg. between $1^h 23^m$ and $1^h 58^m$, tension 100 Volta (2); sparks purple and white, 0·16 inch in length.—W. R. B.]
Apr. 5.	9 0 a.m.	....	....	15^{HN}.	....	Heavy rain. [Nimbi and cirro-stratus at Greenwich at $9^h 20^m$ A.M.—W. R. B.]
5.	0 20 p.m.	0 40 p.m.	....	19^{HN}.	0·175	Heavy shower of rain.
13.	3 0 p.m.	....	....	25^{HN}.	0·200	Heavy shower of rain. [Cirro-stratus at Greenwich.—W. R. B.]
14.	5 0 p.m.	5 20 p.m.	10^{HP}.	$35^{V}N$.	0·900	Heavy shower of rain. [Cirro-stratus and scud at Greenwich.—W. R. B.]
May 4.	11 30 a.m.	....	....	$65^{V}N$.	....	Light rain. [Cirro-stratus and scud at Greenwich.—W. R. B.]
17.	11 0 a.m.	....	....	$35^{V}N$.	....	Very dull and overcast from 11 A.M. to 3 P.M.; a little rain fell at noon which charged the rod negatively. [Cirro-stratus and scud at Greenwich.—W. R. B.]
18.	11 15 a.m.	....	10^{HP}.	22^{HN}.	0·100	A shower of rain. [At $10^h 50^m$ A.M. there were a few fleecy clouds in the zenith of Greenwich; the remainder of the sky was covered with cirro-stratus; small quantities of sleet fell shortly before noon, after which it was generally clear. Positive and negative electricity exhibited between $10^h 50^m$ A.M. and $4^h 30^m$ P.M., max. tension 200 div. Volta (2); numerous sparks, max. length 0·28 inch.—W. R. B.]
18.	1 0 p.m.	....	55^{HP}.	30^{HN}.	0·450	Heavy shower of rain and hail; the sparks were obtained from positive electricity.
18.	2 10 p.m.	....	50^{HP}.	....	....	Heavy shower of rain (^{k}).
27.	10 0 a.m.	10 15 a.m.	....	20^{HN}.	....	Heavy shower of rain. [During the continuance of these observations cirro-stratus, scud, and cumulo-stratus were registered at Greenwich; electrical changes were observed between $11^h 0^m$ A.M. and $4^h 5^m$ P.M., max. tension 100 div. Volta (2), hail and rain falling. It will be remarked that the phænomena were more or less similar at both stations.—W. R. B.]
27.	10 30 a.m.	10 40 a.m.	....	30^{HN}.	....	Heavy shower of rain.
27.	11 5 a.m.	11 15 a.m.	35^{HP}.	40^{HN}.	0·400	Heavy shower of rain.
27.	2 25 p.m.	2 45 p.m.	....	55^{HN}.	....	Heavy shower of rain.
27.	4 30 p.m.	4 45 p.m.	....	80^{HN}.	1·200	Heavy shower of rain.
29.	10 0 p.m.	....	....	$90^{V}N$.	....	Heavy rain. [Cirro-stratus with continued rain at Greenwich.—W. R. B.]

TABLE XCII. (*continued*).

Date.	Observed limits of time.		Observed extremes of Charge.		Max. length of Spark.	Weather and Remarks.
1844.	h m	h m			in.	
June 10.	1 0 p.m.	1 20 p.m.	90HP.	55HN.	1·950	Heavy shower (l).
18.	3 40 p.m.	5 50 p.m.	65HP.	60HN.	0·400	Thunder-storm (m).
19.	5 15 p.m.	5 25 p.m.	....	9vN.	....	A light shower of rain. [Cirro-stratus and scud registered at Greenwich; also at 5^h 20^m P.M. a shower of hail which lasted but three minutes; heavy clouds were observed in every direction.—W. R. B.]
25.	8 0 a.m.	7 0 p.m.	49vP.	29HN.	0·350	General rain, occasionally heavy, during which the charge varied both in kind and intensity several times. [Cirro-stratus registered at Greenwich nearly the whole day, and rain from 5^h 35^m A.M. of the 25th until 3^h 20^m A.M. of the 26th. Electrical changes occurred between 9^h 10^m A.M. and 11^h 25^m A.M. of the 25th, maximum tension 20° of Henley; sparks very numerous, in one instance in a volley, but not longer at any time than 0·10 inch; on one occasion 15 occurred in 8 seconds; the electricity was positive till 9^h 23^m A.M., when it suddenly changed to negative; at 9^h 36^m a rumbling of thunder was heard in the S.W.; at 9^h 55^m there was a slight galvanic current, the point of the needle moving towards B.—W. R. B.]
27.	5 0 a.m.	11 0 a.m.	40vP.	30vN.	....	Light rain with intermissions.
July 1.	5 30 p.m.	7 50 p.m.	60HP.	70HN.	0·550	Thunder-storm (n).
2.	9 0 a.m.	....	....	77·5vN.	....	Heavy rain.
2.	7 30 p.m.	7 45 p.m.	....	N.	....	Heavy shower of rain. [Cumulo-stratus and dark heavy scud very near the earth, registered at Greenwich.—W. R. B.]
2.	sunset.	....	....	15vN.	....	*Dull and cloudy.*
4.	3 0 p.m.	3 5 p.m.	20HP.	15HN.	....	Heavy rain. [Cirro-stratus and scud at Greenwich.—W. R. B.]
5.	3 0 p.m.	5 0 p.m.	....	25HN.	....	Heavy and light rain with intermission; the maximum charge occurred at 3^h 45^m P.M. just after heavy rain, but when it had ceased. [Cirro-stratus and scud at Greenwich; heavy rain between 3^h 55^m P.M. and 5 P.M.—W. R. B.] (o)
6.	4 0 p.m.	5 0 p.m.	3vN.	10vN.	....	*Dull and cloudy.*
12.	1 25 p.m.	1 30 p.m.	....	35HN.	....	Light rain.
12.	1 35 p.m.	2 0 p.m.	....	N.	....	*Fine but cloudy*; charge high.
12.	4 15 p.m.	4 25 p.m.	55HP.	40HN.	0·450	Heavy and lighter rain. [Cirro-stratus, cumulo-stratus, nimbi, and dark scud registered at Greenwich from 1^h 20^m P.M., also negative electricity from 5^h 20^m P.M. to 5^h 25^m P.M.; maximum tension Volta (1) 12 div.: negative electricity had been previously observed between 11^h 12^m A.M. and 1^h 4^m P.M., max. tension Volta (2) 50 div.; max. length of sparks 0·11 inch, 20 in 20 seconds.—W. R. B.]
13.	2 0 p.m.	9 30 p.m.	35vP.	5vN.	....	General rain; the negative charge was registered at 2 P.M. [Dark cumuli, cirro-stratus, and scud registered at Greenwich just previous to the commencement of the rain, which continued almost without intermission until 9^h 20^m P.M.—W. R. B.]
16.	11 0 a.m.	0 50 p.m.	90vP.	40HN.	0·350	Light and heavy rain. [Cirro-stratus and scud at Greenwich.—W. R. B.]
18.	4 0 p.m.	5 0 p.m.	45HP.	60HN.	0·500	Light rain. [Cumuli and cirri registered at Greenwich.—W. R. B.]
18.	6 20 p.m.	6 30 p.m.	....	50HN.	....	*Distant rain and storm*; *sunshine at Kew.* [There are no indications of this rain having been observed at Greenwich.—W. R. B.]

July 19.	11 3 a.m.	....	45^{H}P.	3^{H}N.	0·400	**Heavy shower.** At the beginning of this shower the Henley rose to 45° pos. in three minutes, afterwards Volta was at 60° neg., in three more minutes it rose to 3° Henley neg., then declined, and the charge changed to positive as usual. [Cumulo-stratus and haze, registered at Greenwich at 11^{h} 20^{m} A.M.—W. R. B.]
19.	3 20 p.m.	4 47 p.m.	65^{H}P.	60^{H}N.	....	Violent storm of thunder, hail and rain; it was considered to be the most violent that had occurred. [The phænomena, which are recorded at page 134 of the volume for 1844, Storm-paper No. 3, may be divided into two portions: one characterized by the discharges and *hail*, duration 17 minutes; the other by heavy and light rain, duration 1 hour; mean tension of the first period 53° Henley, mean tension of the second 42° of Henley. We have here another instance of higher tensions accompanying discharges (see notes on Table XCII.). The production of the hail in the apparent axis of the storm is not without interest. At Greenwich cirro-stratus and scud, with heavy cumulo-strati, from which, at intervals, emanated a rumbling of thunder, were registered at 3^{h} 20^{m} P.M., and from 1^{h} 59^{m} P.M. to 5^{h} 24^{m} negative electricity was observed; maximum tension 200 div. of Volta (2), max. length of spark 0·10, rain generally falling during the time; thunder occasionally heard; at 3^{h} 34^{m} the rain ceased.—W. R. B.]
30.	3 25 p.m.	3 56 p.m.	10^{H}P.	90^{H}N.	0·300	Heavy rain. [The details of this shower may be found on page 134 of the volume for 1844. Cirro-stratus and scud, registered at Greenwich, also numerous heavy showers of rain between 3^{h} 20^{m} P.M. and 5^{h} 20^{m} P.M.—W. R. B.]
31.	3 30 p.m.	4 4 p.m.	40^{H}P.	40^{H}N.	0·400	Heavy and light rain. [Cirro-stratus at Greenwich.—W. R. B.]
Aug. 1.	3 0 p.m.	....	....	5^{V}N.	....	General rain.
2.	1 45 p.m.	4 0 p.m.	60^{H}P.	55^{H}N.	0·700	Two heavy showers within this period. [Nimbi, cumulo-strati, and scud registered at Greenwich: the observer describes the sky as very wild; frequent sparks were observed of 0·13 inch; electricity positive and negative.—W. R. B.]
3.	7 35 a.m.	....	55^{H}P.	70^{H}N.	0·800	Heavy shower of rain. [Cirro-stratus and scud at Greenwich, also negative electricity between 11^{h} 0^{m} A.M. and 11^{h} 14^{m} A.M.; max. tension 3° of Henley; sparks 0·10 inch; a sudden charge of electricity; the charge was again negative at 1^{h} 53^{m} P.M. to 2^{h} 0^{m} P.M.; max. tension 7° of Henley; max. length of spark 0·10 inch, occurred at 1^{h} 56^{m}, 40 in 20 seconds.—W. R. B.]
6.	4 0 p.m.	....	....	5^{H}N.	....	A heavy dark cloud passed to the eastward. [At Greenwich nimbi near the horizon, and rather dense cumuli of a loose texture scattered in other parts of the sky were registered at 3^{h} 20^{m} P.M.—W. R. B.]
7.	11 0 a.m.	0 20 p.m.	75^{H}P.	60^{H}N.	1·700	Rain. [Nimbi, cumuli, and scud at Greenwich. From 11^{h} 8^{m} A.M. to 0^{h} 47^{m} P.M. negative electricity was observed; max. tension 12° of Henley; numerous sparks; max. length 0·18 inch; heavy clouds passing over the zenith.—W. R. B.]
8.	1 26 p.m.	....	....	50^{H}N.	0·500	*Fine rain at a distance*; *sunshine*. [Cumuli, cumulo-strati, and scud at Greenwich; a shower of rain at 1^{h} 35^{m} P.M.; electricity during this shower negative; maximum tension 100 div. Volta (2).—W. R. B.] (P)
11.	6 0 p.m.	....	....	50^{V}N.	....	General heavy rain. [Heavy rain at Greenwich from 7 P.M.—W. R. B.]
12.	10 22 a.m.	....	....	15^{H}N.	0·150	Light rain. [At Greenwich the rain was falling heavily at 11^{h} 30^{m} A.M.; the electricity was negative; max. tension 10 div. Volta (2).—W. R. B.]
14.	9 0 a.m.	4 0 p.m.	10^{H}P.	$62·5^{V}$N.	0·500	General light rain with intermissions. [At Greenwich heavy showers, cirro-stratus, and scud registered. The electrical instruments were affected between 11^{h} 30^{m} A.M. and 11^{h} 53^{m}, both negatively and positively; max. tension 7° of Henley; sparks abundant, 0·10 inch; at 11^{h} 45^{m} A.M. the electricity changed suddenly from positive to negative.—W. R. B.]

TABLE XCII. (*continued*).

Date.	Observed limits of time.		Observed extremes of Charge.		Max. length of Spark.	Weather and Remarks.
1844.	h m	h m			in.	
Aug. 15.	4 0 p.m.	....	....	4^{H}N.	....	Light rain. [At Greenwich we have the following record:—"Since 3^h 15^m Göttingen time, 2^h 35^m Greenwich time, there have been several dashing showers of rain; scud has passed quickly from the N.; at present (3^h 20^m P.M.) it is squally and the sky is covered with so dark a cloud as to cause a great gloom." "Immediately after the observation at 4^h (3^h 20^m P.M.), a heavy shower of rain fell and continued for about fifteen minutes; since that time no rain has fallen." From 3^h 50^m to 4^h 35^m P.M., a large cloud in the zenith, rain falling, gloomy; there were several changes from negative to positive electricity; max. tension 40 div. Volta (2).—W. R. B.]
Sept. 5.	10 0 a.m.	....	....	5^{H}N.	....	*Dull and cloudy.* [Cirro-stratus and scud at Greenwich.—W. R. B.]
8.	9 0 p.m.	....	....	45^{H}N.	0·400	Heavy rain; several flashes of lightning seen, and distant thunder heard. [At Greenwich we have the following record:—"5^h 20^m P.M.; the sky is nearly covered with thin cirro-stratus; after this time the sky became overcast, and at 6^h 30^m P.M. the clouds in the S. became black, and shortly afterwards several flashes of lightning emanated from them; lightning continued at intervals of about two minutes till 8^h 15^m; at that time thunder was heard, and lightning continued as before till midnight; heavy rain commenced falling about 8 P.M." The electrical instruments were not affected. Lightning had been prevalent more or less during the three previous nights. It would appear that the lightning was either not observed or not visible at Kew. On this evening it appeared to have been more prevalent at Greenwich than at Kew.—W. R. B.]
17.	3 0 p.m.	4 0 p.m.	....	5^{H}N.	....	*Fine but cloudy, with sunshine.* [At Greenwich cumulo-stratus towards the N., and cirro-stratus and scud in different directions.—W. R. B.]
18.	0 0 nn.	2 0 p.m.	....	....	0·100	Heavy and light rain. [Cirro-stratus and scud at Greenwich.—W. R. B.]
Oct. 13.	7 15 p.m.	7 45 p.m.	....	50^{H}N.	0·450	Heavy shower of rain. [Cumulo-strati and scud had been previously registered at Greenwich.—W. R. B.]
14.	11 5 a.m.	0 44 p.m.	....	40^{H}N.	0·400	Heavy shower of rain. [Cirro-stratus and scud at Greenwich, heavy rain falling between 11^h 43^m A.M. and 11^h 46^m A.M.; at 11^h 44^m A.M. there was a sudden change from negative to positive electricity; max. tension 40 div. Volta (2).—W. R. B.].
16.	sunrise.	....	....	20^{H}N.	....	Heavy rain. [Cirro-stratus and scud at Greenwich.—W. R. B.]
21.	sunset.	10 0 p.m.	50^{V}P.	20^{H}N.	0·175	General heavy rain. [Cirro-stratus and scud with heavy rain at Greenwich. Negative electricity between 5^h 42^m P.M. and 6^h 50^m P.M., max. tension 80 div. Volta (2).—W. R. B.]
24.	11 0 a.m.	....	....	10^{H}N.	0·100	General rain. [Overcast and heavy rain at Greenwich at 11^h 20^m A.M.; at 10^h 33^m to 10^h 49^m, negative electricity; max. tension 15 div. Volta (2).—W. R. B.]
24.	sunset.	9 30 p.m.	....	5^{H}N.	....	General heavy rain, during which the electricity was always negative.
Nov. 2.	sunrise.	1 0 p.m.	....	30^{H}N.	0·300	General rain. [Cirro-stratus and scud with heavy rain at Greenwich, also negative electricity between 11^h 30^m A.M. and 11^h 35^m A.M.; tension 2 div. Volta (1).—W. R. B.]
3.	sunrise.	....	....	15^{V}N.	....	Light rain.
8.	0 45 p.m.	....	....	30^{H}N.	0·300	Heavy shower of rain.
8.	3 0 p.m.	....	....	5^{H}N.	....	Heavy shower of rain. [Cirro-stratus and scud at Greenwich.—W. R. B.]
10.	1 0 p.m.	....	....	25^{H}N.	0·200	General heavy rain.
13.	sunrise.	9 0 a.m.	....	40^{V}N.	....	Heavy rain.
Dec. 29.	sunset.	....	....	55^{V}N.	....	General heavy rain.

TABLE XCIII.—Instances of negative electricity *without rain.*

Date.	Observed limits of time.		Observed extremes of charge.		Max. length of spark.
1843 and 1844.	h m	h m			in.
Sept. 10.	2 10 p.m.	2 47 p.m.	40ᴮP.	45ᴮN.	0·400
Oct. 12.	1 15 p.m.	2 45 p.m.	....	N.	
Nov. 24.	0 30 p.m.	1 30 p.m.	....	6ᴮN.	
July 2.	Sunset.	....	....	15ᵛN.	
„ 6.	4 0 p.m.	5 0 p.m.	3ᵛN.	10ᵛN.	
„ 12.	1 35 p.m.	2 0 p.m.	....	N*.	
„ 18.	6 20 p.m.	6 30 p.m.	....	50ᴮN.	
Aug. 8.	1 26 p.m.	....	....	50ᴮN.	0·500
Sept. 5.	10 0 a.m.	....	....	5ᴮN.	
„ 17.	3 0 p.m.	4 0 p.m.	....	5ᴮN.	

* Charge high.

Notes on TABLE XCII.

([a]) *August* 4, 1843.—This thunder-storm was observed at Greenwich: *cumulo-stratus* and *scud* were registered there at $3^h\ 20^m$ P.M. with occasional showers, soon after which the sky assumed a very stormy appearance, more particularly in the N. and N.W.; at $3^h\ 45^m$ P.M. a low muttering of distant thunder was heard from dark clouds in the N.W., and thunder has been heard at intervals to the present time, $5^h\ 20^m$ P.M.: at $4^h\ 40^m$ P.M. rain began to fall, and it has continued: at $4^h\ 0^m$ P.M. a fine double rainbow was visible in the E.N.E., and at $5^h\ 20^m$ P.M. another very perfect one, also double in the E.: at present, $5^h\ 20^m$ P.M., a large clear break is near the horizon in the W., and it is the only part of the sky which is not covered with a dense cirro-stratus. At $7^h\ 20^m$ large loose fragments of scud were passing from the S.W., the portions of the sky without cloud being remarkably clear; the rain which commenced at $4^h\ 40^m$ P.M. ceased at $5^h\ 30^m$ P.M.; the last clap of thunder was heard at $5^h\ 35^m$; it proceeded from dark clouds in the E.: *no lightning was seen during the whole time.* The galvanometer was affected, the needle moving towards A.

([b]) *August* 15, 1843.—The thunder-storm was observed at Greenwich. At $3^h\ 20^m$ P.M. *cumuli* and *cumulo-strati* were seen; weather hazy. At $5^h\ 20^m$ P.M. the same clouds were registered, and the observer thus writes: "Deep mutterings of thunder are heard, proceeding from dark *cumulo-strati* towards the N.E.: the weather is unusually sultry for this time of the day; temperature now at its maximum." At $7^h\ 20^m$ "massive *cumulo-strati* and *nimbi* in all directions: at $5^h\ 40^m$ P.M. a loud clap of thunder was heard from the S.E., and from that time to $6^h\ 10^m$ P.M. a constant succession of claps took place; no lightning was seen: between $5^h\ 50^m$ P.M. and $6^h\ 5^m$ P.M. the rain fell very heavily: distant thunder has been heard to the present time." "At $9^h\ 20^m$ overcast: at $7^h\ 40^m$ a vivid flash of lightning was seen in the N.E. which was followed by many others, chiefly forked, and accompanied by a heavy rolling of thunder, all from the N.E.: at present distant thunder is heard, and occasionally faint flashes of lightning from the N.W.: during the time the storm was in the N.E. the zenith was clear." Between $5^h\ 42^m$ P.M. and $6^h\ 12^m$ P.M., the galvanometer was affected; maximum deviation towards A 50° at $5^h\ 49^m\ 3^s$, and towards B 65° at the same time. This, the greatest oscillation, occurred on the occasion of a loud clap of thunder; numerous other oscillations occurred with thunder, and rain falling in torrents.

([c]) *September* 10, 1843.—We have here a well-marked instance of the regular diurnal march being interrupted by *the passage of a cloud* in the immediate neighbourhood of the observatory. No rain appears to have fallen, yet the instruments were thrown into a state of oscillation, positive to negative, which gradually diminished as the cloud passed off; a spark or sparks 0·4 inch in length were registered. This cloud appears to have been a *cumulo-stratus*; for at Greenwich at 3 P.M. *cumulo-stratus* is registered, and during the succeeding twenty minutes *a very heavy shower of rain accompanied with thunder* is recorded. The electrical instruments were not affected.

([d]) *October* 2, 1843.—The connexion in this instance between the *heavy rain* and *negative charge* is very apparent, and would, combined with the observation of September 10, greatly tend to refer the production of the charge to the particular cloud by the agency of which the rain was precipitated, rather than to the rain itself. Cirro-stratus was registered at Greenwich from 9^h 20^m A.M. to 5^h 20^m P.M. The violent squall of rain occurred there at 5 minutes before 11 A.M.

([e]) *October* 12, 1843.—"From sunrise until about 11 A.M. dull and cloudy. At about 11 A.M. a heavy rain began and continued until about 1^h 15^m P.M. At its commencement Volta stood at 25° pos.: immediately afterwards the charge became negative, the maximum of which was 30° of Henley, and a negative state continued until about 2^h 45^m P.M. The positive charge then remained during the rest of the day. The negative state existed about 1 hour and 30 minutes after the rain had ceased; and the weather during this period was fine and accompanied with sunshine. The duration of the negative state of the conductor, viz. about 3 hours 45 minutes, from about 11 A.M. to 2^h 45^m P.M., one hour and a half of which time elapsed without rain, is I believe a rare occurrence, and one which I do not recollect to have observed in my former experiments.—[F. R.]"

The negative state of the conductor during the three half-hours is remarkable. It appears the sun was shining and the weather fine; but the register does not inform us whether clouds were present or not. On turning to the Greenwich observations we find rain recorded at 11^h 20^m A.M., and at 1^h 20^m P.M. thin rain falling; the rain appears to have ceased earlier than this at Kew. From 9^h 20^m A.M. until 7^h 20^m P.M. *cirro-stratus* was registered at Greenwich; and as this cloud frequently manifests itself in the form of *a thin but very extensive stratum*, it is not unlikely that it was the source of the negative charge observed.—[W. R. B.]

([f]) *October* 28, 1843.—At 3^h 20^m P.M. this squall was observed at Greenwich *without the hail*. The observer thus writes: "At present there is a violent squall: the rain is falling in large drops: the sky is covered with a nimbus: a few minutes since a cumulo-stratus with coloured edges was in the west, and scud was passing quickly from the west with a fine blue sky between." The head of the galvanometer needle deviated towards A 5°.

([g]) *January* 31, 1844.—The electrical phænomena of this day being particularly interesting, and well-marked both at Kew and Greenwich, we cannot do better than present the reader with the records at both observatories.

KEW.

First Storm.—At sunrise fine, but cloudy. At 8^h 45^m A.M. a heavy storm of snow and hail began, when Volta stood at $35^{div.}$ pos. The charge immediately changed to neg., in the maximum of which charge the Henley vibrated above 90°, and a stream of fire one inch long flowed from the conductor to the discharger for at least four or five minutes during the time that the storm was at its height. At about 9 the storm had ceased, when the charge returned to pos. maximum 45° of Henley.

Second Storm.—At noon another storm of snow and hail began, when Volta stood at $105^{\text{div.}}$ pos.; but the charge immediately changed to neg., and the Henley again vibrated above 90°, sparks $1\frac{5}{10}$ inch. The positive maximum was about 50° of Henley, sparks $\frac{4}{10}$ inch.

Third Storm.—At $1^h\ 40^m$ P.M. a third heavy shower consisting of *rain* and hail began, when Volta stood at $10^{\text{div.}}$ pos., but the charge immediately changed to neg., when the Henley vibrated between 60° and 90°, sparks $\frac{7}{10}$ inch. The positive maximum during this shower was about 60° of Henley. At 2 P.M. very stormy with heavy rain. At 3 P.M. dull and cloudy. At 4 P.M. heavy snow. From sunset to 10 P.M. dull and cloudy.

Greenwich.

First Storm.—At the nearest observation, Jan. $30^d\ 22^h$ (Göttingen $9^h\ 20^m$ A.M. Greenwich time), the observer records: "A few clouds only here and there: at $8^h\ 5^m$ A.M. rain and sleet began falling; and about $8^h\ 40^m$ A.M. snow fell thickly, soon covering the ground; it ceased about $9^h\ 20^m$, when the clouds broke: wind in gusts to 2, with prolonged lulls." Negative electricity was observed between 7 and 9 A.M. very weak. Wind N.W., force $\frac{1}{4}$ to 7 lbs., rain falling occasionally.

Second Storm.—Jan. $31^d\ 0^h$, Göttingen $11^h\ 20^m$ A.M. Greenwich. Cirro-stratus and scud; wind in heavy gusts to $2\frac{1}{2}$ and 3. At $11^h\ 30^m$ A.M. sparks occurred from 0·05 inch to 0·13 inch in length, 2 in a second. Wind N.W., force 12 lbs. At this time a sudden squall of hail, wind and rain occurred; in an instant the gold leaf of the dry pile apparatus was destroyed, and in removing it the observer received a severe shock.

Third Storm.—At $1^h\ 20^m$ P.M. Greenwich time. Cirro-stratus; wind in heavy gusts; squalls of hail and snow are frequent; occasionally, also, a few breaks occur: very dark and gloomy; snow mingled with sleet has again begun to fall. Wind N.W., force 0 to 5 lbs. No electricity appears to have been observed.

Between 6 and 9 P.M. negative electricity was observed at Greenwich. Wind W.N.W., force 0 to 2 lbs. Sleet occasionally falling in small quantities: strong gusts of wind.

(h) *February* 9, 1844.—*Cirro-stratus* was registered at Greenwich from $9^h\ 20^m$ P.M. to $5^h\ 20^m$ A.M. of the following morning; two snow-showers occurred during this period, one at 11 P.M., the other at $4^h\ 10^m$ A.M., the electrometer-bell ringing during their continuance. Electrical observations were made between the undermentioned times:

	d h m		h m								in.
Feb.	9 10 55	to	11 35 P.M.	max. tension	50	Volta	(2)	neg.,	sparks		0·10
„	9 11 40	„	11 54 P.M.	„ „	50	„	(1)	„	„		0·10
„	10 4 10	„	4 26 A.M.	„ „	50	„	(1)	„	„		0·10

(i) *February* 26, 1844.—We have in the case before us another instance (see Sept. 10, 1843) of the electrometers being affected by the approach of a *cumulo-stratus*, and on the present occasion *previous to the falling of rain*. It would appear from the ordinary meteorological observations at Greenwich that the few drops of rain recorded in the electrometer observations at $1^h\ 12^m$ P.M. were succeeded by a heavy squall of rain, which commenced at $1^h\ 15^m$ P.M. and continued 10 minutes; the negative charge continued until

$1^h\ 55^m$ P.M. It is worthy of remark, that *the approach of the cloud to the zenith, the formation of the heavy rain-drops, and the affection of the instruments, the charge being negative, were apparently simultaneous*, and succeeded by the sudden gusts of rain constituting the heavy squall.

(k) *May* 18, 1844.—The *contrast* between the observations at Kew and Greenwich is interesting: it furnishes us with another instance (and perhaps the most striking of the three) of the affections of the instruments by the proximity of cloud, most probably *cirro-stratus*, which was prevalent at Greenwich, at least before noon. During the changes that occurred there in the electrical charges, *small quantities of sleet only fell*, and these not in any degree measurable, for we find on May 18, 22 hours Göttingen time, the same records of the rain-gauges as on May 17, 22 hours; but at Kew the period marked by the affections of the instruments at Greenwich is characterized by three showers, two of which are recorded as *heavy*, the electrical changes being considerable. It is to be remarked, that at Greenwich the tension was *higher* than had been observed previously in the course of the year. These phænomena appear to point to a common origin of the electricity noticed at the two observatories, viz. the presence of a particular kind of cloud. It cannot in this instance at least be immediately connected with the rain, for although *the changes were manifested at Kew during the continuance of the showers, yet electricity of a greater tension than any that had been observed during the former part of the year was recorded at Greenwich; the same action was going on at Greenwich without the rain as at Kew with it*: the only difference appears to have been, the absence at Greenwich of those particular conditions necessary to the production of the sudden gush of rain most frequently characterizing the exhibition of negative electricity, or rather the oscillation of the electrical condition between positive and negative. The instance before us presents a very instructive comparison with the passage of the cloud over the Kew Observatory on September 10, 1843, when the conditions for the production of rain did not appear to have existed at Kew, while they did at Greenwich; yet the electrical instruments at Kew *were affected*, while those at Greenwich *were not*.

(l) *June* 10, 1844.—The records of this shower at both observatories were as under:—

KEW.

Previous to the fall of any rain upon the conductor, the Henley rose to 90° pos., sparks $1\frac{19}{20}$ inch*. At one time of this high positive charge (before the rain), the Leyden jar, of about 56 square inches coating, on being applied to the conductor, became charged to the intensity of the rod in about 20 seconds. The charge changed to negative shortly after the rain began, max. 55° of the Henley, sparks $\frac{9}{20}$ inch. These high signs lasted about a quarter of an hour, and spirtings occurred from the little ball above the discharger. The negative charge remained a considerable time after the rain had ceased, gradually diminishing.

Nothing remarkable in the appearance of the clouds; they were rather fleecy or plumose, and not low, but large.

* These were the *longest sparks* which we have yet observed; but on the 31st of January the *continuous stream* of fire from the conductor to the discharger was much more lasting. If the ball attached to the conductor and above the discharger were placed nearer or at the end of the cross-arm, the sparks would be longer; also if it were smaller. But it is, I fear, in vain to attempt to measure these very high tensions accurately by ordinary electrometers and dischargers. Our Henley was in this instance evidently useless. The shock of the spark reached the elbow without a jar. [Observer at Kew.]

GREENWICH.

June 10^{d} 2^{h} Göttingen time, 1^{h} 20^{m} Greenwich time. Cumuli, cumulo-strati, and dark scud; within the last three minutes the temperature has fallen 3°, the reading just before the observation having been $74^{\circ}\cdot5$, and there was a sudden exhibition of negative electricity; a large dark cloud was at the time passing over from the N.W.: at 1^{h} 27^{m} P.M. a fine shower of rain began falling; at 1^{h} 29^{m} the temperature was $62^{\circ}\cdot0$; and at 1^{h} 46^{m} it was $59^{\circ}\cdot5$.

Negative electricity recorded between 1^{h} 16^{m} and 1^{h} 44^{m} P.M., max. tension 20° Volta (2). Wind W., force 0 to 1 lb., rain falling.

By means of these records we obtain a further insight into the conditions necessary for the exhibition of the phænomena detailed. Cloud being the origin of the electrical oscillations, appears very evident from the affections of the instruments at Kew *previous to the fall of any rain upon the conductor*; and the very *high* charge communicated to the conductor under these circumstances is highly instructive. The usual march of the electrical tension was evidently disturbed by the approach of the cloud, although it exhibited *nothing remarkable*. This disturbance did not manifest itself at Greenwich until the cessation of the rain at Kew. It appears that at this time the observer at Greenwich noticed *a large dark cloud passing over from the north-west*, which was attended by two very remarkable phænomena:—*a sudden diminution of temperature, with as sudden an exhibition of negative electricity*. This appears to have occurred at least *seven* minutes before the fall of any rain. The presence of the cloud, the diminution of temperature, and the exhibition of negative electricity, appear to be closely and intimately connected, and to indicate either that the cloud itself underwent a remarkable physical change, which materially influenced bodies in its vicinity; or, which is the most probable, that it existed in such a condition as to produce great physical changes in such bodies, so far as electricity is concerned. It is easy to conceive, that if by any means the temperature of the cloud should be diminished; by coming into a colder portion of air, for instance, a sudden agglomeration of its vapour-particles might take place; its electrical condition be suddenly and extensively disturbed by the enormous tension which these newly formed rain-drops might acquire in consequence of the rapidity of their formation, in some cases the diminution of temperature being so great as actually to *freeze* them and thus produce hail, which at some seasons is not an unfrequent phænomenon accompanying the exhibitions of negative electricity. The electrical influence of the cloud thus circumstanced may not be confined to the mere strip of country over which the rain or hail may fall, but may extend to some little distance beyond its circumference, and thus the signs may be changed without the actual fall of rain in such localities, or the negative state continue after the precipitating portion has left the place of observation. Nor does it follow that rain must necessarily fall from *every* portion of the under-surface of a cloud; there may be an axis characterized by the *lowest* temperature; around this may exist a zone having a *higher* temperature, and another *still higher*, the skirts exhibiting the *highest*.

It is well known that in showery weather the masses of cumulus present the appearance of *highly heaped or vastly piled-up clouds* towering *high* in the atmosphere, and on many occasions these cumular bodies are surmounted by sheets of cirro-stratus, through which their summits frequently penetrate, giving rise to that modification of cloud termed by meteorologists cumulo-stratus. By carefully noticing their mode of formation the idea will be suggested of vapour rising from the earth by evaporation *with considerable force*, and which upon passing the vapour-plane is immediately condensed. The supply continuing from below, and the condensation going on above, produce the heaping, piling-up, and general outline of the cloud—which is particularly characterized by its *crenated* edges, and to which it owes its picturesque appearance—just as steam, which, issuing in an invisible state from the funnel of a locomotive, meets with a stratum of air sufficiently cold to condense it *rapidly*, by which it assumes in a very decided manner the characters of the highly-heaped cumular clouds. It has been suggested, that the immense masses of these clouds, so commonly met with in the calm latitudes between the trades, may possess some such an arrangement as above-mentioned—at least in the temperature of the rain that falls from them—by their more *elevated* portions being precipitated by the colder air with which they come in contact; and as it is likely the most elevated part of the cloud would most probably be situated near its centre, the precipitated rain would fall along the axis, and bring with it to a greater or less extent the temperature which contributed to its formation. The other portions of the cloud not being so elevated as the central would produce rain of a higher temperature, the rain falling from the skirts of the cloud being the warmest.

One such cloud appears to have come under the writer's notice, at least if the *difference* in the *precipitations* may be regarded as indicating differences of *temperature*, or of *elevation* of certain portions of the cloud. The cloud was considered to extend over a diameter of about six miles; near the *axis* a fall of *snow* occurred which was *surrounded* by a precipitation of *hail*, and from the portions near the *skirts*, *rain* fell. It would appear that the temperature in the centre or axis was sufficiently low, or that the summit of the cloud was sufficiently elevated to *freeze the vapour-particles before they had run into drops* in the usual manner in which snow is formed; but in the zone characterized by the *fall of hail*, a different process appears to have contributed to its production. Upon the first formation of the drops, the temperature appears to have been *above* the freezing-point, and it is possible that the relative diminution of temperature in this zone might have been greater than in either the axis or skirts. If so, we have all the conditions for a very rapid formation of rain-drops, which, from their proximity to the snow on the one hand, and the continued diminution of temperature on the other, might soon become *frozen*. There can be no question but that so rapid a conversion of aqueous vapour from the aëriform to the solid state, must have been accompanied by electrical phænomena more or less striking; the electrical condition of the cloud itself, as before observed, must have been materially influenced, and this as it travelled onwards again influenced bodies in its more immediate neighbourhood as it passed them. In the observations more immediately before us, as well as in numerous others, we find that shortly after the *rain began* the charge became *negative*. That the *cloud* disturbed the usual electrical condition of the conductor is very evident from the observations, and it is to be presumed that, at the time the high positive charge was communicated to the conductor, *the heavy rain was falling, although it had not arrived at the observatory*;—in other words, that portion of the cloud in which the diminution of temperature was so great as to occasion the rapid formation of rain, and thus alter the electrical condition of the cloud itself, was yet at some distance from the observatory. There might possibly have been at this moment *two* bodies reciprocally acting on each other electrically—the body of falling rain and the cloud; and it may not be at all improbable that it is the actions of these bodies, the one on the other, that influence our conductors, and give rise to the sudden and extensive changes often recorded on the occurrence of squalls of rain, hail and snow. The diminution of temperature in the present instance at Greenwich was 15° in 26 minutes, but nothing further than the fall of *a fine shower of rain* occurred; probably the path of the *heavy rain* did not cross the Greenwich Observatory, although the instruments there were influenced.

([m]) *June* 18, 1844.—This thunder-storm, which exhibited very interesting phænomena at Kew, did not extend eastward so far as Greenwich; neither thunder, lightning, rain, nor any affections of the electrical instruments were observed there; the only record at all bearing on the subject is one that indicates the presence of *cirro-stratus*. During the whole time the sky was completely overcast at Greenwich. As illustrating the rapid succession of phænomena on these occasions, as well as some of the suggestions in the preceding note, it may not be uninteresting to subjoin the entire record of the observations at Kew.

TABLE XCIV.

Phænomena of a Thunder-storm observed at Kew on June 18th, 1844.

Time.	Phænomena.	Tension.	Spark.	Wind.
h m		°	in.	
3 40 p.m.*	Rain beginning	Henley 22 P.		S.
3 45 p.m.		Henley 40 P.	0·300	S.
3 46 p.m.		Henley 50 P.	0·400	S.
3 55 p.m.	Distant thunder	Henley 25 P.		S.S.E.
4 0 p.m.	Distant thunder	Henley 5 N.		S.S.E.
4 2 p.m.	A flash	Henley 60 N. (*a*)		S.S.E.
4 4 p.m.	Distant thunder; no rain	Henley 65 P. (*b*)		S.
4 8 p.m.	Distant thunder; no rain	Henley 60 N.		S.
4 10 p.m.	A few drops of rain	Henley 59 N.		S.
4 13 p.m.	A flash †	Henley (*c*).		
4 15 p.m.	A flash ‡	Henley 60 N. (*d*).		
4 21 p.m.	Distant thunder; a little rain	Charge gradually falling.		
4 24 p.m.	A flash	No effect on electrometer.		S.S.W.
4 27 p.m.	Rain increasing	Volta 10 P.		S.
4 34 p.m.	Heavy rain	Henley 35 P. (*e*)	0·300	S.
4 35 p.m.	Heavy rain	Henley 40 P.	0·350	
4 47 p.m.	Sudden fall and gradual rise of electrometer.			
4 51 p.m.	Heavy rain	Volta 7 N.		S.S.W.
5 0 p.m.	Heavy rain	Henley 5 N.		S.S.W.
5 4 p.m.	Heavy rain and distant thunder	Henley 20 N. (*f*).		
5 15 p.m.	No rain	Henley 17 N.		S.E.
5 30 p.m.	No rain	Henley 15 N.		S.E.
5 37 p.m.	No rain	Volta 90 N.		S.E.
5 50 p.m.	No rain	Volta 6 P.		S.E.

The following notes by the writer of this report may probably assist in more distinctly particularizing the principal features of the above-recorded phænomena. The references are in letters of the italic alphabet.

(*a*) The occurrence of the flash and the increase of the negative tension may indicate the approach of the cloud as well as the formation of rain. It would appear that from $3^h 40^m$ to this time, 22 minutes, rain had been falling, but not such as to lead the observer to record it as heavy.

(*b*) The maximum tension; rain had ceased, but great oscillation of the charges existed.

(*c*) This flash appeared to exert a momentary influence on the conductor; the tension was slightly declining, but increased after its occurrence.

* At $3^h 35^m$ P.M. distant thunder and lightning, Volta at 50° pos. Distant thunder was heard at 3 P.M.

† Henley fell from 55° to 20°, and quickly rose again.

‡ No effect on the electrometer.

(*d*) This flash *appeared* to have no effect on the electrometer.

(*e*) The "gush of rain" *arrived* at the observatory. It may be remarked that after this, thunder was heard but once, and in all the records it is described as *distant*. From the time thunder was last heard, 4^h 21^m P.M., the charge had gradually fallen to Volta 10 div. P. The highest tensions were observed, not when the rain was heaviest, but when the discharges (at a distance) took place more frequently. It is probable that after the cessation of these discharges the "gush of rain" came travelling on, being still accompanied by the causes of its production, and a corresponding oscillation of the tension occurred.

(*f*) The increase of tension on the occurrence of the discharge is very apparent, as well as the *gradual* decline afterwards, notwithstanding the cessation of rain which occurred within the next 11 minutes.

(^{n}) *July* 1, 1844.—As the records of this storm have already appeared in the volume of Reports for 1844, page 134, we shall not further introduce them to the reader. On a careful consideration of the record it will be found that the storm may very naturally be divided into three sections, viz. the period of heavy rain *previous* to the electrical discharges; the period of the discharges themselves; and the period of rain *succeeding* the discharges, a portion of which was *heavy*. The times are as follows:—first period 5^h 30^m P.M. to 5^h 55^m P.M. inclusive=25 minutes; second period 5^h 56^m P.M. to 6^h 24^m P.M. inclusive=29 minutes; third period 6^h 25^m P.M. to 7^h 50^m P.M. inclusive=1 hour 26 minutes. We have in the first period a decided instance of heavy rain, characterized on one occasion as *very* heavy, being in advance of the actual thunder-storm. During the second period neither *thunder* nor *heavy rain*, except on one occasion, appear to have been noted: it is however to be presumed, as we shall have occasion hereafter to notice, that from the frequency and character of the flashes they were accompanied by both, and the probability is, that during the exhibition of the lightning the rain that fell was much heavier than that in either the preceding or succeeding period. In the third period the heavy rain continued about half an hour. The values of the tensions having reference to these periods are interesting. The mean of the tensions recorded during the first, without having regard to kind, is 32° of Henley; that of the second 48° of Henley; and that of the third 27° of Henley, or during the heavy rain only, 33° of Henley. The connexion between the high tensions and the electrical discharges from the cloud is very apparent; also the mean values of the tensions during each period of the heavy rain indicate a certain relation between them. The entire phænomena strongly suggest the existence of an axis characterized by the active development of strong electric action; the tension of the cloud and probably that of the rain being so enormous that frequent discharges took place to restore the equilibrium. This axis occupied about half an hour in passing the observatory. It is probable the strong action going on in the centre was communicated to a zone of nearly the same breadth in all its parts, in which the principal phænomenon was *the rapid formation of rain* unaccompanied by electric discharges. In connexion with this it may be remarked that the third period may be subdivided into two, the first characterized by heavy and the last by light rain; the duration of the first was, as we have already noticed, 30 minutes, namely from 6^h 25^m P.M. to 6^h 55^m P.M. inclusive, and this may probably be regarded as the true termination of the storm. The three periods,—viz. preceding heavy rain; actual thunder-storm; and succeeding heavy rain—do not differ very considerably in duration from each other. The first = 25 minutes, the second =29 minutes, and the third = 30 minutes. It is also to be remarked, that at the commencement and termination of the second, oscillations in the *kind* of tension occurred, the tension at the occurrence of the first flash being positive 60° of Henley, and that at the last also positive 50° of Henley: the intermediate tensions were negative. Oscillations also occurred during the periods of heavy rain.

At Greenwich the same storm was observed, the clouds recorded being cirro-stratus and scud. It appears to have commenced at 5^h 49^m P.M., at least so far as the affection of the instruments is concerned; the record is as follows:—["This storm first rose in the N.W.; it then passed round to the north, and afterwards to the east, as also did the wind; at 5^h 50^m there was a vivid flash of lightning, followed by thunder at the interval of seven seconds; at 5^h 55^m there was another very bright flash, and thunder followed at an interval of two seconds; this was a long peal, the crackling continuing from 45^s to 59^s. Several flashes of lightning took place between 6^h and 6^h 15^m, followed by thunder at intervals of one, two and three seconds. Between 6^h and 6^h 20^m, 0·78 inch of rain fell at Mr. Glaisher's residence; after this time the lightning ceased; the rain however continued, but not so heavily."—G.]

From this record it may be gathered that the first flash of lightning occurred at 5^h 50^m P.M., being six minutes earlier than the occurrence of the first flash at Kew; it is described as very vivid, and followed by thunder at the interval of seven seconds. The second flash, which was very bright, occurred at 5^h 55^m P.M., one minute earlier than the first at Kew; it was evidently much nearer than the first observed at Greenwich, the interval being two seconds. Between 6^h and 6^h 15^m P.M. several flashes are recorded, the point of discharge being upon the whole nearest to the observatory during this quarter of an hour. During the same period six flashes were registered at Kew, from four of which sparks were obtained, the longest being 0·4 inch; it occurred at 6^h 5^m P.M. This quarter of an hour was evidently the period in which the focus of the storm passed *both* observatories, and during the twenty minutes between 6^h and 6^h 20^m Mr. Glaisher registered 0·78 inch of rain at Blackheath. It is this circumstance to which we wish to refer in connexion with the *axis* of the storm, it being evidently accompanied at Blackheath by a great precipitation of rain. Less rain appears to have fallen at Greenwich, about half an inch having been registered during the twenty-four hours from 9^h 20^m A.M. of July 1 to 9^h 20^m A.M. of July 2. During the storm changes of tension occurred, the maximum tension being 30° of Henley and the longest spark 0·23 inch.

(°) *July* 5, 1844.—Between 11^h 18^m A.M. and 1^h 15^m P.M. a thunder-shower passed over the observatory at Greenwich. Positive and negative electricity were exhibited; heavy cumulo-strati covered the sky until 11^h 55^m A.M., when heavy rain began to fall and thunder was heard in the N.W.; max. tension 10° of Henley; sparks max. length 0·13 inch. During this time the weather at Kew is registered "fine but cloudy," but at 1^h to 1^h 5^m P.M. a heavy shower of rain is recorded, which does not appear materially to have affected the instruments.

Between 4^h 0^m P.M. and 4^h 46^m P.M. changes are again recorded at Greenwich with rain falling; the electricity was negative until 4^h 12^m P.M., when it suddenly became positive, max. tension observed 120 div. Volta (2). During the whole of this time the charge was negative at Kew.

(p) *August* 8, 1844.—There can be but little doubt that the fine rain at a distance observed at Kew at 1^h 26^m P.M. is the same shower that fell at Greenwich at 1^h 35^m P.M.; the only link in the chain of evidence required to identify it is the *direction* in which the fine rain was seen from Kew; both conductors were affected almost simultaneously. If the shower *seen* at Kew and the one that *fell* at Greenwich be the same, we have another instance of the cloud being the common origin of the electricity exhibited at the two observatories*.

It has already been remarked, that one of the most prominent results of the arrangement constituting Table XCII. is the almost constant accompaniment of *rain in a falling state* when the conductor exhibits a negative charge, and it is to be particularly noticed that this is in striking contrast with the condition of the atmosphere surrounding the conductor when *high charges of positive electricity are exhibited, the tension not being in a state of oscillation.* In both cases the conductor may be said to be surrounded by moisture, but the conditions of this moisture are extremely different. In the case of high positive tension such as we have described, the moisture *is not in the liquid state*; and even if it may be said to be in contact with the surface of the conductor, yet it has not passed beyond the form in which it exists as cloud; *the conductor under such circumstances may be considered as penetrating the cloud*; *and bringing to us the electricity of the cloud itself.* In the case of falling rain, the conductor is situated *below* the cloud, the drops impinge on it, and it is evidently a matter of question whether its indications are those of the electricity of the rain, or of a state induced in the conductor by the proximity of the cloud. A note appended to the description of instruments at Kew (Report 1844, page 124), relative to Henley's electrometer, appears to lead to the conclusion that the latter is the case:—"The oscillations of the index between the 30th and 35th degrees, sometimes during a heavy shower, plainly show that the electricity of the conductor is washed off, as it were, as fast as brought." By the electricity of the conductor being *washed off*, as it were, it would appear that the electric state induced in the conductor was momentarily conveyed *from it* by the falling rain. In connexion with this, we must bear in mind that *all* rain is not accompanied by negative electricity, nor on the other hand is the negative charge *always* accompanied by rain. In those instances in which negative electricity has been observed without rain, the state of the weather is printed in italics in Table XCII., and in such cases the presence of cloud *alone* has been the accompanying phænomenon at the Kew Observatory; nevertheless on some of these occasions heavy rain has fallen at Greenwich. If therefore negative electricity should be, as it appears to be, connected with cloudiness, it ought to present a

* It is a remarkable circumstance and one demanding further attention, that most of the *thunder-storms* recorded in the foregoing pages passed more or less to the *north-west* of the Royal Observatory at Greenwich. We give the following as illustrative of this remark:—

August 4, 1843.......	N. and N.W.	August 15, 1843.	N.E., S.E., N.W.
June 10, 1844.	N.W.	July 1, 1844............	N.W., N., E.
July 5, 1844.........	N.W.		

To these instances we may add that of the remarkable thunder-storm which passed over London on July 26, 1849. In the meteorological observations furnished by the Astronomer Royal, and published in the weekly report of the Registrar-General, it is thus noticed:—"From 1^h till 4^h P.M. a violent thunder-storm, *chiefly situated to the north*; the flashes of lightning were vivid and in quick succession, followed by loud thunder at intervals of 15 to 20 seconds generally." The storm passed over London from S.W. to N.E., striking several buildings in its passage. During the continuance of the storm at Greenwich the electrical tension was strongly *positive* for a period of two hours and a half, viz. from 1^h to $3^h\ 30^m$ *while the storm raged in London*; at other times, the observer writes, the tension was strongly negative, with frequent constant volleys of sparks and galvanic currents.

From the above it may be inferred that London is more particularly exposed to the effects of thunder-storms, most of them passing over the immediate neighbourhood of the metropolis.

diurnal period more or less in harmony with it. We have already remarked, that the record of negative exhibitions does not furnish us with sufficient data previous to 1845 to determine the diurnal period; nevertheless a synoptical arrangement of the hours included in the entries under the head "Limits of Time," furnishes us with an approximation to such a period—at least so far as the *time* of occurrence of negative charges is concerned. The following table, which is deduced immediately from Table XCII., exhibits the number of times negative charges (more or less) were observed between August 1843 and December 1844, both inclusive, between the hours specified, making in the whole 231.

TABLE XCV.

Number of readings of negative electricity between the hours specified, from August 1843 to December 1844.

Between																		
5 & 6 a.m.	6 & 7 a.m.	7 & 8 a.m.	8 & 9 a.m.	9 & 10 a.m.	10 & 11 a.m.	11 & Noon.	Noon & 1 p.m.	1 & 2 p.m.	2 & 3 p.m.	3 & 4 p.m.	4 & 5 p.m.	5 & 6 p.m.	6 & 7 p.m.	7 & 8 p.m.	8 & 9 p.m.	9 & 10 p.m.	10 & 11 p.m.	Sum.
1	5	9	11	10	11	22	21	21	17	23	22	14	12	13	10	7	2	231

It appears from this table that during the seventeen months negative electricity was not observed earlier than 5 A.M.: at the commencement of the series the numbers are small, but they increase gradually until 11 A.M., immediately after which hour they are doubled as compared with the preceding three hours. This value slightly decreases until between 2 and 3 P.M., and is again augmented between 3 and 4 P.M. A sudden diminution occurs between 5 and 6 P.M. The numbers from 5 P.M. to 8 P.M. are rather higher than those from 8 A.M. to 11 A.M., and late in the evening they are again few as at the commencement. The period of the day between 11 A.M. and 5 P.M. is particularly characterized by the more frequent exhibition of negative electricity than either the forenoon or evening, and the ratio as compared with these periods is very considerable. It is remarkable that so close a correspondence as regards the development of negative electricity in the middle of the day should obtain in the series of negative readings previous to 1845 and during the three succeeding years (see Table III. page 117). It is perfectly clear that the greatest number of negative readings occurs about the middle of the day, and this of itself would suggest the great probability of the existence of a diurnal period in the exhibition of negative electricity.

TABLE XCVI.

Mean amount of cloud at each observation-hour, Göttingen mean time, as deduced from the observations of six years at the Royal Observatory, Greenwich, and expressed in parts of the natural scale,—a sky completely covered with clouds being represented by 100.

Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Mean.
61	65	67	69	70	71	71	71	69	66	62	60	67

Table XCVII.

Comparison of the negative readings at Kew previous to 1845, with those also at Kew from January 1845 to July 1848 inclusive, and both with the mean amount of cloud at Greenwich from 1841 to 1846 inclusive, at hourly and two-hourly intervals.

	A.M.													P.M.											
	M.	1	2	3	4	5	6	7	8	9	10	11	N.	1	2	3	4	5	6	7	8	9	10	11
Neg....	...	...	...	...	...	1	5	9	11	10	11	22	21	21	17	23	22	14	12	13	10	7	2	...
Neg....	8	...	12	...	12	...	18	...	34	...	56	...	46	...	52	...	55	...	60	...	38	...	33	...
Cloud.	...	65	...	67	...	69	...	70	...	71	...	71	...	71	...	69	...	56	...	62	...	60	...	61

The numbers in these tables agree, so far as the general fact is concerned, in exhibiting a greater quantity of negative readings during a portion of the day which is distinguished by a greater prevalence of cloud. Dividing the day into two periods, viz. from 8 A.M. to 8 P.M. and from 8 P.M. to 8 A.M., we find that the *occurrence* of negative electricity is very considerable in the day as compared with the night. In the three years 1845 to 1847 (including also the first seven months of 1848), which furnish a comparable scale of numbers with regard to the cloudiness, the proportion of night to day negative readings is as 2 to 5 very nearly. The same portion of the day, viz. from 8 A.M. to 8 P.M., gives, as compared with the remaining twelve hours, the greatest prevalence of cloud, the mean amount being about 68 hundredths of the whole sky: during the night the mean amount is 65 hundredths, or about three hundredths less. In connexion with this, it may be remarked that the greater prevalence of cloud is rather in advance of the development of negative electricity: the period from 7 A.M. to 7 P.M., and *vice versâ,* gives double the difference between the day and night cloudiness; the mean amount in this case for the day being very nearly 7 tenths, while that for the night is 64 hundredths, or about 6 hundredths less. The proportion of the negative readings is the same. From Table XCII. it may be inferred that on most occasions when negative electricity occurred, *the sky was entirely covered with clouds*; and this might suggest that it is not so much the general existence of cloudiness in the atmosphere that may be connected with negative electricity, as the presence of certain clouds—*cumulo-stratus* for instance, or more probably *cirro-stratus,* from its almost constant occurrence with negative electricity. The remarkable changes that frequently occur from one kind of electricity to the other, often very suddenly, and at the same time very considerable in intensity, clearly show that at the time disturbances of no ordinary character prevail, and it may readily be conceived (in addition to the suggestion already offered) that different strata of cloud in different electrical states, operating on each other and on the earth, may very violently disturb the ordinary march either of the electricity of serene weather or of the aqueous vapour; and although these disturbances (taking them singly and considering the great uncertainty of their occurrence) may be regarded as purely accidental and obeying no recognized law of periodicity, yet should they result from causes which in themselves are not subject to mere accidental manifestations, but are the results of forces operating on the earth's atmosphere in a definite manner—producing for instance a greater accumulation of cloud at one period of the day rather than at another, and giving rise to a well-defined march in the manifestation of the cloudiness of the atmosphere, within small limits it is true, but yet sufficient, from six years' careful observation, to characterize the curve as that of a single progression having an ascending and descending branch, the maximum occurring about 40 minutes before noon, and the minimum between 9 and 10 at night—then they must necessarily exhibit somewhat of the same subjection to the laws of periodicity which is characteristic of the causes themselves. That the *diurnal occurrence* of negative electricity is of a periodical character, the observations of five years, viz. from August 1843 to August 1848, testify in a very unequivocal manner; and although its connexion with the general cloudiness of the atmosphere may not be satisfactorily made out, yet it by no means follows that it may not be more immediately connected with certain classes of cloud; for as we have determined a diurnal period in the cloudiness generally, it is not unlikely that certain clouds, the *cirro-stratus* for instance, may likewise exhibit a diurnal period, being much more frequent in its occurrence at one portion of the day rather than at another. Upon the whole, the negative readings are obvious indications of considerable disturbances, and their occurrence in much greater frequency at a particular period of the day renders it highly probable that the disturbances themselves are of a systematic character and subject to well-defined laws of diurnal periodicity.

Negative readings from January 1845 *to July* 1848 *inclusive.*—During this period 424 negative charges of the conductor were observed. Their distribution among the twelve observation-hours is seen in the following table, which also includes the mean value of the negative tension at each observation-hour, and the excess or defect of such mean as compared with the mean of the whole.

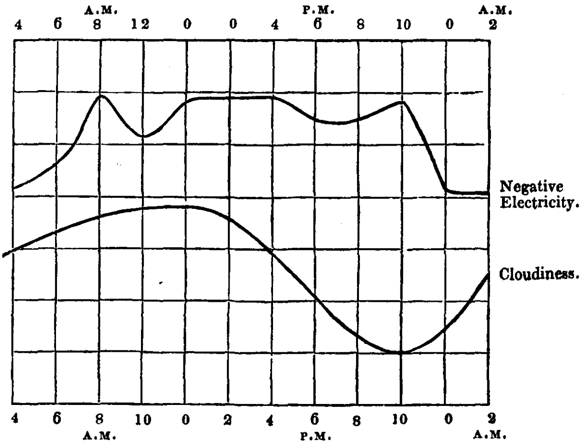
TABLE XCVIII.

Number of readings, mean tension, and excess or defect above or below the mean of all the negative observations from January 1845 to July 1848, as referred to the twelve observation-hours.

	Mid.	2 a.m.	4 a.m.	6 a.m.	8 a.m.	10 a.m.	Noon.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Sums and Means.
Readings	8	12	12	18	34	56	46	52	55	60	38	33	424
Tensions.	div. 36·0	div. 24·8	div. 109·4	div. 316·3	div. 938·6	div. 566·2	div. 871·7	div. 891·3	div. 907·6	div. 729·9	div. 721·9	div. 870·2	div. 725·3
Excess or Defect.	− 689·3	− 700·5	− 615·9	− 409·0	+ 213·3	− 159·1	+ 146·4	+ 166·0	+ 182·3	+ 4·6	− 3·4	+ 144·9	725·3

We have already alluded to the greater frequency of the occurrence of negative electricity in the middle of the day, and have remarked that the period under consideration agrees with the previous seventeen months in this particular. The line of mean tensions in the above table, in addition to the greater frequency of occurrence in the middle of the day, exhibits upon the whole period a corresponding increase of tension, particularly from 8 A.M. to 4 P.M., a portion of the day characterized by the greater prevalence of cloud (see Table XCVI.). The maximum occurs at 8 A.M., but from the close approximation in the values of the mean tensions at noon, 2 and 4 P.M., it can hardly be considered as the true maximum of the diurnal period: it is to be remarked that only 34 observations contribute to its determination, and until a more extended series can be obtained, it must remain a matter of question. The mean tensions at noon, 2 and 4 P.M., taken in connexion with those at 10 A.M. and 6 P.M., present a well-rounded and very regular portion of a curve, which in the absence of further observations may probably be considered as representing at least approximately the portion of the diurnal period of negative electricity from 10 A.M. to 6 P.M. At 8 P.M. the diminution is so exceedingly slight as almost to indicate a tendency to rise at that hour, and at 10 P.M. we have a decided increase: but in connexion with this, it should be borne in mind, that at one of the 33 observations contributing to its determination, the Henley's electrometer read 70°; and it is easily seen that this high tension very materially influences the result, for if we abstract it, the mean tension is lower than that at 8 P.M. With regard to the mean tensions at midnight and 2 A.M., the same remarks apply which we offered relative to the positive tensions at these hours (see pages 118, 119); they are for the same reason probably lower than the truth, and indeed more particularly so in the case of negative electricity; for it is likely that when such electricity has been indicated by the conductor on other occasions than the eight and twelve recorded, it has exhibited much higher tensions than 50 div. of Volta No. 1. The remarkable difference between the values of the mean of all the positive observations for three years (66·9 div.) and of all the negative during 43 months (725·3 div.) is exceedingly interesting, as indicating at once the character of the movements giving rise to the negative exhibitions, viz. *disturbances*.

Fig. 19.



Diurnal Curves of Negative Electricity and Cloudiness.

The annexed curves (fig. 19) exhibit to the eye the principal *diurnal* phænomena of negative electricity and cloudiness: 1000 divisions of Volta's electrometer No. 1 are considered equal to two vertical divisions of the scale on which the negative tensions are projected; eight hundredths of the scale of cloudiness being also considered equal to two of the same divisions. The points of the curve of cloudiness are placed about one-third of each horizontal division from the vertical or hour lines, the determination being at even hours of Göttingen mean time. The greater prevalence of cloud being in advance of the exhibition of negative electricity, which we noticed when treating of the frequency of its occurrence in the middle of the day, is very striking in the curves before us, which show that the same phænomena obtain in the comparison of the two, whether we regard the *occurrence* or the *value of the tension* of negative electricity. There is also another feature which ought not by any means to be overlooked; it is the similarity in this respect that exists between the curves of negative electricity and cloudiness, and those of the annual period of positive electricity and humidity (see page 153). In both instances the cloudiness and humidity precede the electricity, and strongly indicate that whatever relation may exist between the development of positive electricity and humidity on the one hand, and that of negative electricity and cloudiness on the other, such relations are not only likely to be of a very constant character, but that a similarity exists between the two sets of phænomena which goes far to show that the nature of their connexion, if any, is also similar; the one, viz. positive, principally indicating, as we have before remarked, the electric tension of aqueous vapour; the other, viz. negative, the electrical disturbances produced by the sudden precipitation of this vapour when existing as cloud.

It would greatly contribute to our knowledge of this part of our inquiry, if systematic and comparative observations were instituted at different observatories, on occasions of electrical disturbances, of a somewhat similar character, but of course considerably varied in their details, to those adopted on the occasions of magnetic disturbances. A principal feature in such observations should be *the observation of the electrometers at regular but small intervals of time during the continuance of the disturbance*, so that curves of the variations of the instruments might be readily projected at any time afterwards. Provision should also be made for noting the *precise* instants at which particular and striking phænomena occurred, such as *lightning*, *thunder*, *a change in the kind of electricity*, *the commencement of rain*, *the commencement of heavy rain*, *the termination of rain either light or heavy*, *also the same phænomena as regards hail or snow*. A rain-gauge should also be *kept for these particular phænomena*; it should be of such a construction as to admit of its being frequently read during the continuance of the disturbance; and its indications should be noted at sufficiently short intervals to afford data from which a curve could be constructed by which the eye could readily judge of the lightness or heaviness of the rain by the *amount precipitated* within the interval fixed on. Observations of the kind just alluded to should by no means be confined to the more striking exhibition of electrical phænomena, such as thunder-storms, &c., but upon the slightest indication of a disturbance they should be immediately resorted to; even on the positive tensions ranging higher than usual, the shorter intervals of observation may with great propriety be adopted, if it should be only for the purpose of securing on such extraordinary occasions the epoch of maximum; and in all instances that it may be deemed advisable to resort to them, they should be continued while there is the least indication, either from the appearance of the sky or from the instruments, of the existence of the disturbance, and in fact until the observer is perfectly satisfied that it has ceased. It may be well to remark, that electrical disturbances appear to be very *confined* in their effects, extending over but a comparatively small portion of the earth's surface.

Mr. Mallet's Report On the Facts of Earthquakes does not appear, as intended, in the present Volume, in consequence of the manuscript having been delayed by the author, pending his researches in foreign libraries, until too late for the period fixed for publication.

The Report will appear in the Volume for next year.