ART. XXXVI.—*On the great Auroral Exhibition of Aug. 28th to Sept. 4th*, 1859, *and on Auroras generally*.—8TH ARTICLE; by ELIAS LOOMIS, Professor of Natural Philosophy and Astronomy in Yale College.

SINCE the publication of my seventh article on the great auroral exhibition of Aug. 28th to Sept. 4th, 1859, I have received from Prof. Hansteen a copy of the observations made at Christiania, Norway, corresponding to those made at Hobarton, as given in this Journal, vol. xxxii, p. 81. These observations are published in the Memoires de l'Academie de Belgique, tome xx, pp. 103–116, and Bulletins de l'Academie Royale de Belgique, tome xxi, pp. 284–298.

Observations of the Aurora at Christiania, Norway, lat. 59° 54′, long. 10° 43′ E. Magnetic dip in 1859, 71° 18′.

Day.		Hour.	Notices of Auroras.
1841.	March 15,	10^h	Aurora.
	March 22,		Rain.
	May 17,		Rain.
	July 20,		No aurora visible.
1842.	Feb. 18,	11-14	Aurora faint.
	April 11,	9-15	Slight aurora. Faint arch at 15^h.
	April 12,	9-14	Rays and flames extending to the zenith.
	April 13,	9-13	Rays and flames.
	April 15,	11-15	Flaming aurora.
	July 2,	10 and 12	The bifilar magnetometer was quite out of scale.
1844.	April 17,	9	Faint aurora. extending nearly to the zenith.
1846.	Sept. 22,	7-15	Vehement flames over three-fourths of the heavens. Reddish. Corona imperfect.
1847.	April 21,	11-14	Flaming and radiating aurora.
	Sept. 24,	7-10	Corona formed. Rays of a dark red color.
	Sept. 26,	10	Magnificent arc, radiating.
	Oct. 22,	10	Rain.
	Oct. 23,	6	High aurora, radiating behind clouds.
	Oct. 24,	5½-12	One of the most brilliant auroras we have observed. Corona formed. Vivid colors, red and yellow.
	Dec. 19,	10	Strong aurora, yellow rays, red masses without motion.
1848.	March 24,		Rain.
	April 5,	10	Faint aurora.
	April 7,	10	Arc radiating.
	Oct. 18,	7½-10	Vigorous radiation over the whole vault. Red color very intense.
	Nov. 19,	10	Aurora.
	Dec. 22,	10	Faint aurora.

We thus see that in twenty-one cases out of thirty-four, an aurora was recorded at Christiania within twenty-four hours of an aurora at Hobarton; and considering the number of auroras which must be rendered invisible by clouds and by day-light, we may safely conclude that almost every auroral exhibition at Hobarton is accompanied by a nearly simultaneous exhibition in Norway.

In successive numbers of this Journal, commencing with November, 1859, we have given a full report of observations upon the great auroral exhibition of August and September, 1859. This display was probably unsurpassed by any similar phenomenon on record, not only for its magnificence, but also for its geographical extent; and fortunately we have a greater amount of information respecting it, than was ever collected respecting any former aurora. These observations afford the materials for settling many questions which have hitherto been regarded as open to debate.

The aurora of Aug. 28th was witnessed throughout Oregon and California, longitude 124° W.; in Utah and New Mexico, longitude 111° W.; from Kansas, long. 95° W., to Maine, long. 70° W.; at Halifax, long. 63° W.; on the Atlantic Ocean in long. 45° W., 27° W., and 10° W.; and in Europe from longitude 2° W. to 18° E. Also in Asia from long. 60° E. to 119° E., the disturbance of the magnetic instruments was very remarkable, although being generally cloudy, no mention was made of the auroral light. It hence appears highly probable that this auroral display extended to every meridian of the northern hemisphere. The aurora of Sept. 2d was observed at the same stations as that of Aug. 28th, besides which we have learned that this aurora was witnessed at the Sandwich Islands in long. 157° W., and from Eastern to Western Asia the disturbance of the magnetic instruments was well nigh unprecedented for its violence, so that we cannot doubt that this display extended to every meridian of the northern hemisphere.

The auroral display in the southern hemisphere was cotemporaneous with that in the northern, and was perhaps equally remarkable. Both of these auroras were observed in South America and in Australia, in latitudes where such exhibitions are extremely rare.

The southern limit of these auroral displays was not the same upon all meridians. In North America, the aurora of Aug. 28th appeared in the zenith as far south as lat. 36° 40′; and it attracted general attention as far south as lat. 18°. In Central Europe, this aurora extended to the zenith of places as far south as about lat. 45°. It was brilliant at Rome in lat. 42°, but was not noticed at Athens in lat. 38°; neither was it seen in Western Asia in lat. 40°.

In North America, the aurora of Sept. 2d appeared in the zenith at places as far south as lat. 22½°, and attracted general attention in lat. 12°; and if the sky had been clear, some traces of the aurora might probably have been detected even at the equator. In Europe this aurora was noticed at Athens, in lat. 38°. Both of these auroras conformed to the general law of auroral distribution, as developed in this Jour., vol. xxx, pp. 89–94, the region of greatest auroral action being in America about 15° further south than in eastern Europe.

We have been able to collect sufficient materials for determining with tolerable precision the height of these auroral displays above the earth's surface. At the most southern stations, the aurora rose only a few degrees above the northern horizon; at more northern stations, the aurora rose higher in the heavens; at certain stations it just attained the zenith; at stations further north the aurora covered the entire northern heavens, as well as a portion of the southern; and at places further north the entire visible heavens, from the northern to the southern horizon, were overspread with the auroral light. The following table presents a summary of a few of the most definite observations on the aurora of Aug. 28th, 1859, at about $8^h 42^m$ P. M., New Haven time.

TABLE I.

Locality.	Latitude.	Extent of auroral display.	Authority.
North side of Jamaica,	18° 20′	Like the light of a fire.	A. J., v. 29, p. 265.
Inagua, Bahamas,	21 18	Remarkably brilliant.	" v. 29, p. 264.
Havanna, Cuba,	23 9	Rose 23° above the north horizon.	" v. 28, p. 404.
Key West, Florida,	24 33	Rose about 30° " "	" v. 30, p. 349.
Savannah, Georgia,	32 5	Rose some 45° " "	" v. 29, p. 262.

The following table presents a summary of observations of the same aurora, made at the same hour, at places where the auroral light covered the entire northern heavens as well as a portion of the southern.

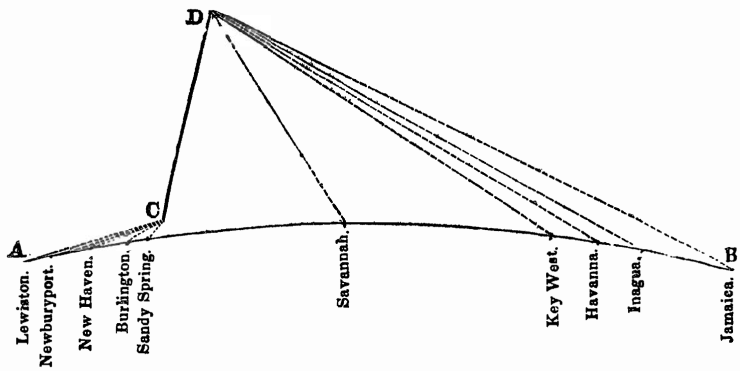
TABLE II.

Locality.	Latitude.	Extent of auroral display.	Authority.
Sandy Spring, Md.,	39° 9′	Extended to 51° from south horizon.	A. J., v. 29, p. 259.
Gettysburgh, Pa.,	39 49	" 30 " "	" v. 30, p. 345.
Philadelphia, Pa.,	39 57	" 22½ " "	" v. 29, p. 259.
Burlington, N. J.,	40 5	" 20 " "	" v. 29, p. 258.
New Haven, Conn.,	41 18	" 10½ " "	" v. 28, p. 391.
West Point, N. Y.,	41 23	" 12 " "	" v. 28, p. 394.
Newburyport, Mass.,	42 48	" 6 " "	" v. 29, p. 254.
Lewiston, Maine,	44 5	" 5 " "	" v. 28, p. 386.

If we combine the preceding observations in Table II. we shall find that *the lower limit* of the auroral light was elevated forty-six miles above the earth's surface, and that its southern margin was vertical over the parallel of 38° 50′ N. latitude in Virginia.

Now it is considered as established that the auroral streamers are luminous beams sensibly parallel to the direction of the dipping needle. But the dip of the needle in lat. 38° 50′ in Virginia is 71° 20′; and if we draw a line CD, figure 1, making an angle of 71° 20′ with the curve line AB which represents a portion of the earth's surface, we may assume that the line CD represents the southern boundary of the auroral illumination. If then we assume that the observations of Table I. were made upon the point D, we shall find that *the upper limit* of the auroral light was elevated 534 miles above the earth's surface, and that its southern margin was vertical over the parallel of 36° 40′ north latitude in Virginia.

Fig. 1.



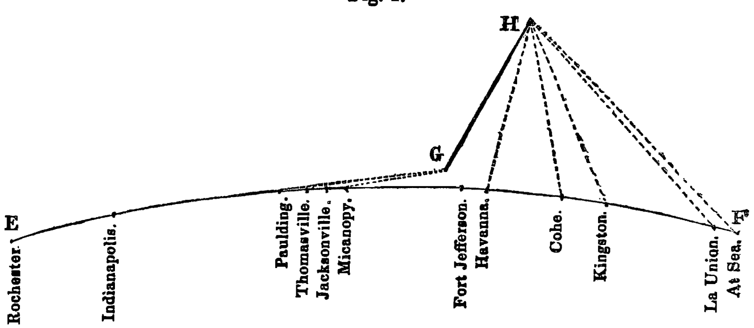
The following table presents a summary of the most definite observations of the aurora of Sept. 2, 1859, made generally about 2 A. M. Havanna time.

TABLE III.

Locality.	Latitude.	Longitude.	Hour.	Extent of auroral display.	Authority.
	° ′	° ′			
At Sea,	12 23	88 28	midnight	Sky lurid—wavy appearance.	A. J., v. 30, p. 361.
LaUnion,SanSalvador,	13 18	87 45	10–3 A.M.	About 30° above the North horizon.	v. 29, p. 265.
Salvador,	13 44	88 55		Same as at La Union.	v. 29, p. 266.
Kingston, Jamaica,	17 58	76 50	1–5 A.M.	Appeared like a colossal fire.	v. 29, p. 265.
Cohe, Cuba,	20 0	76 10		Extended upwards about 72°.	v. 29, p. 265.
Havanna, Cuba,	23 9	82 22	2 A. M.	More than 100° in height.	v. 28, p. 405.
Fort Jefferson, Fla.	24 37	82 52	2 A. M.	Extended beyond the zenith.	v. 30, p. 360.
Micanopy, Fla.	29 30	82 18	2·30 A.M.	Corona very distinct.	v. 30, p. 360.
Jacksonville, Fla.	30 15	82 0	3 A. M.	Extreme south in a red glow.	v. 30, p. 359.
Thomasville, Ga.	30 50	84 0	2 A. M.	Corona formed.	v. 30, p. 358.
Paulding, Miss.	32 20	89 20	2·10 A.M.	Whole visible heavens overspread.	v. 30, p. 357.
Indianapolis, Ind.	39 55	86 5		Down to south horizon.	v. 28, p. 398.
Rochester, N. Y.	43 8	77 51	2 A. M.	Down to south horizon.	v. 29, p. 253.

If we combine the last seven observations of the preceding Table, we shall find that *the lower limit* of the auroral light was elevated fifty miles above the earth's surface, and that its southern margin was vertical over the parallel of 25° 15′ north latitude in Florida. Now the dip of the magnetic needle in Florida in latitude 25° 15′ is 55° 40′; and if we draw GH, figure 2, making an angle of 55° 40′ with the curve line EF, which represents a portion of the earth's surface, and assume that the line GH represents the southern boundary of the auroral illumination, and that the first five observations of Table III. were made upon the point H, we shall find that *the upper limit* of the auroral light was elevated 495 miles above the earth's surface, and that its southern margin was vertical over the parallel of 22° 30′ N. latitude in Cuba.

Fig. 2.



We have thus discovered the geographical position of this auroral light. The aurora of Sept. 2d formed a belt of light encircling the northern hemisphere, extending southward in North America to lat. 22½°, and reaching to an unknown distance on the north; and it pervaded the entire interval between the elevations of 50 and 500 miles above the earth's surface. This illumination consisted chiefly of luminous beams or columns, everywhere parallel to the direction of a magnetic needle when freely suspended; that is, in the United States, these beams were nearly vertical, their upper extremities being inclined southward at angles varying from 15° to 30°. These beams were therefore about 500 miles in length; and their diameters varied from five to ten and twenty miles, and perhaps sometimes they were still greater.

These beams were simply illumined spaces, and the illumination was produced by a flow of electricity. That this illumination was produced by electricity is proved by the observations of the magnetic telegraph. During these auroral displays, there were developed on the telegraph wires electric currents of sufficient power to serve as a substitute for the ordinary voltaic battery. That the agent thus excited upon the telegraph wires was indeed electricity, is abundantly proved. Electricity produces various effects by which it may be distinguished from all other agents.

1. In passing from one conductor to another, electricity exhibits a spark of light. During the auroras of Aug. 28th and Sept. 2d, brilliant sparks were drawn from the telegraph wires, even when no battery was attached. At Springfield, Mass., a flash was seen about half the size of an ordinary jet of gas. (This Jour., xxix, 95). At Washington, D. C., a spark of fire jumped from the forehead of a telegraph operator when his forehead touched a ground wire. (This Jour., xxix, 97.) At Pittsburgh, Pa., streams of fire were seen when the telegraph circuit was broken. (Ib., xxix, 97.) At Boston, Mass., a flame of fire followed the pen of Bain's chemical telegraph. (Ib., xxix, 93.) On the telegraph lines of Norway, sparks and uninterrupted discharges were observed. (Ib., xxix, 388.) Bright sparks were noticed on the conductors of the telegraph lines to Bordeaux in France. (Ib., xxix, 392.)

2. In passing through poor conductors, electricity develops heat. During the auroras of Aug. 28th and Sept. 2d, paper and even wood were set on fire by the auroral influence alone. At Pittsburgh, Pa., the magnetic helices became so hot that the hand could not be kept on them. (Ib., xxix, 97.) At Springfield, Mass., the heat was sufficient to cause the smell of scorched wood and paint to be plainly perceptible. (Ib., xxix, 96.) At Boston, Mass., a flame of fire burned through a dozen thicknesses of paper. The paper was set on fire and produced considerable smoke. (Ib., xxix, 93.) On the telegraph lines of Norway, pieces of paper were set on fire by the sparks of the discharges from the wires; and the current was at times so strong that it was necessary to connect the lines with the earth in order to save the apparatus from destruction. (Ib., xxix, 388.)

3. When passed through the animal system, electricity communicates a shock which is quite peculiar and characteristic. During the auroras of Aug. 28th and Sept. 2d, some of the telegraph operators received severe shocks when they touched the telegraph wires. At Philadelphia, the current gave a severe shock. (Ib., xxix, 96.) At Washington, D. C., the telegraph operator received a severe shock which stunned him for an instant. (Ib., xxix, 97.)

4. A current of electricity develops magnetism in ferruginous bodies. The aurora of Sept. 2d developed magnetism so abundantly and so steadily that on several lines it was used as a substitute for a voltaic battery in the ordinary business of telegraphing. (Ib., xxix, 94, 96 and 97.) The intensity of this effect was estimated to have been at times equal to that of 200 cups of

Grove's battery. (Ib., xxix, 93.) In Switzerland, the currents were at least three fold the ordinary current employed in telegraphing. (Ib., xxix, 396.)

5. A current of electricity deflects a magnetic needle from its normal position. In England, the usual telegraph signal is made by a magnetic needle surrounded by a coil of copper wire, so that the needle is deflected by an electric current flowing through the wire. Similar deflections were caused by the auroras of Aug. 29th and Sept. 2d, and these deflections were frequently greater than those produced by the telegraph batteries. (Ib., xxxii, 74.)

6. A current of electricity produces chemical decompositions. During the display of Sept. 2d, the auroral influence produced the same marks upon chemical paper as are produced by an ordinary voltaic battery; that is, the auroral influence decomposed a chemical compound, the cyanid of potassium. (Ib., xxix, 95.) The same effect was produced by the aurora of Feb. 19, 1852. (Ib., xxix, 93.)

It is thus abundantly proved that the fluid developed by the Aurora on the telegraph wires was indeed electricity. This electricity may be supposed to have been derived from the Aurora either by transfer or by induction. If we adopt the former supposition, then the auroral light is certainly electric light. If we adopt the latter supposition, then we must enquire what known agent is capable of inducing electricity in a distant conductor. We know of but two such agents, Magnetism and Electricity. But the auroral fluid was luminous, while magnetism is not luminous. We seem then compelled to admit that the auroral light is electric light.

Admitting then that the Aurora is but an effect of electric currents, it is important to determine in what direction these currents flow, and what laws they observe. Do these currents move in a vertical, or horizontal direction, or in some intermediate direction? Is there any uniformity in the direction of these currents? Our most important means of information upon this subject are derived from the observations upon telegraph lines.

The observations published in this Journal, vol. xxix, pp. 92–97, show that on a large number of telegraph lines in the United States, the electric currents moved alternately to and fro. Such was the case upon the line from Boston to Portland running N. 24° E.; from Boston to Manchester running N. 25° W.; from Boston to Cambridge almost due West; from Boston to Springfield S. 79° W; from South Braintree to Fall River running S. 12° W; from Boston to New Bedford running S. 7° E.; from Springfield to Albany running N. 58° W.; from New York to Philadelphia running S. 49° W.; from Philadelphia to Pittsburgh running N. 82° W.; and from Washington to Richmond running S. 15° W.

Now whatever may be the direction of the current on the surface of the earth, it is evident that if this current travels on a telegraph wire, it must appear to move in the direction of the wire; and a current moving across the earth's surface in any fixed direction might be forced to travel over telegraph lines making various angles with this direction; but its efficiency would vary according to the inclination of the conducting wire to the direction of the current. The following table shows the effect of a current assumed to move from N. 45° E., to S. 45° W. Column first contains a list of the telegraph lines; column second shows their directions; column third shows the angle which the assumed current makes with each telegraphic line; and column fourth shows the fraction of the entire current which would be efficient upon such a line.

Telegraph lines.	Direction.	Inclination of current.	Efficient current.
Boston to Cambridge,	West.	45°	0·71
Philadelphia to Pittsburgh,	N. 82° W.	53	·60
Springfield to Albany,	N. 58 W.	77	·22
Boston to Manchester,	N. 25 W.	70	·34
New Bedford to Boston,	N. 7 W.	52	·62
Fall River to Braintree,	N. 12 E.	33	·84
Richmond to Washington,	N. 15 E.	30	·87
Boston to Portland,	N. 24 E.	21	·93
Philadelphia to New York,	N. 49 E.	4	·99
Springfield to Boston,	N. 79 E.	34	·83

We thus see that on one-half of these telegraph lines a current assumed to proceed from N. 45° E. would exert nearly its entire force; and on only two of them would so small a part as one half of its entire force be exerted. From Boston to Manchester, only one third of the entire current would be efficient, and this would perhaps be sufficient to explain the effects mentioned in vol. xxx, p. 95. From Springfield to Albany only one fourth of the entire current would be efficient. If this should be thought inadequate to explain the facts mentioned in vol. xxx, p. 95, it may be necessary for us to admit, that the direction of the electric current was subject to occasional fluctuations. If the force of the electric current upon each of the telegraph lines had been actually measured by a galvanometer, we should probably be able to determine whether the direction of the current was invariable, and what was its prevalent direction. At present we can only infer that all the facts reported are consistent with the supposition of electric currents moving to and fro on the earth's surface, whose average direction was from about N. 45° E. to S. 45° W.

The observations published in this Journal, vol. xxxii, pp. 74–96, give us more definite information respecting the strength of the currents as well as their direction. Between Ashford and Margate there were recorded 36 north currents and 31 south currents; from Ashford to Ramsgate 24 north currents and 19 south currents; and from Margate to Ramsgate nine north currents and five south currents; that is, currents from north to south were somewhat more frequent than currents from south to north. Between Ashford and Margate the northerly currents were on an average one degree stronger than the southerly; between Ashford and Ramsgate the southerly currents were on an average four degrees stronger than the northerly; while between Margate and Ramsgate the northerly currents were on an average six degrees stronger than the southerly. Mr. Charles V. Walker from a discussion of these and other similar observations has arrived at the conclusion that in the S.E. part of England, *there is a stream of electricity of indefinite width drifting across the country, moving to and fro along a line directed from N. 42° E. to S. 42° W.*

Now it is well known that an electric current has the power of deflecting a neighboring magnetic needle; the needle always tending to take up a position at right angles to the direction of the current; and if the direction of the current be reversed, the north pole of the magnetic needle will be deflected in a direction contrary to what it was in the first case. Mr. C. V. Walker has compared the magnetic observations made at Greenwich and Kew, and has discovered that the deflections of the magnets there observed were such as should be produced by the electric currents observed on the telegraph wires, (Proc. Roy. Soc., Feb. 14, 1861). We may then employ observations of the magnetic needle as indicating the direction and force of the electric currents near the earth's surface.

In the year 1835, there was formed in Germany a Magnetic Union, which included Philosophers from every part of Germany, and which in a few years spread over nearly every part of Europe. The object of this Association was to make simultaneous observations of the magnetic needle. The observations were all made in Göttingen mean time, at intervals of five minutes for a period of 24 hours on certain days of the year previously agreed upon. These observations were annually published in a volume entitled 'Resultate aus den Beobachtungen des magnetischen Vereins,' and afford the best materials we have for comparing the effect of electric currents over large portions of the earth's surface. These observations have been projected in curves which exhibit to the eye at a glance the movements of the magnetic needle at each station. On comparing these curves, we find a remarkable similarity at places widely separated from each other. From Göttingen to Munich (distant in a straight line more than 250 miles) the curves are ordinarily almost parallel to each other; and the changes take place sensibly at the same instant of absolute time, with this modification, that the extent of the deflections is generally somewhat greater at the more northerly stations. I have made a careful comparison of these observations for the purpose of determining whether these movements of the magnetic needles were strictly simultaneous. The following catalogue exhibits a list of those cases which afford the most satisfactory data for comparison, viz., when there was a well marked maximum or minimum value of the magnetic declination, and when this maximum or minimum value was of short duration. In the following list, all the dates are expressed in the mean time of Göttingen.

Observed deflections of the horizontal magnetic needle.

	d	*h m*	
1. 1836.	Aug. 17.	7 50,	Maximum at Upsala, Berlin, Göttingen, Leipsic and Munich.
		7 55,	Maximum at Hague.
2. 1836.	Aug. 17.	9 50,	Max. at Upsala, Berlin, Hague, Göttingen, Leipsic and Munich.
3. 1836.	Aug. 17.	10 10,	Minimum at Upsala, Leipsic and Munich.
		10 15,	Min. at Berlin, Hague and Göttingen.
4. 1836.	Aug. 17.	10 30,	Max. at Berlin, Leipsic and Munich.
		10 35,	Max. at Upsala, Hague and Göttingen.
5. 1836.	Sep. 24.	8 55,	Max. at Upsala, Berlin, Hague, Göttingen, Breslau, Leipsic, Marburg, Munich and Milan.
6. 1836.	Sep. 24.	11 0,	Min. at Hague.
		11 5,	Min. at Upsala, Berlin, Göttingen, Breslau, Leipsic, Marburg, Munich and Milan.
7. 1836.	Sep. 24.	18 40,	Max. at Upsala, Berlin, Hague, Göttingen, Breslau, Leipsic, Marburg, Munich and Milan.
8. 1836.	Sep. 24.	18 50,	Min. at Upsala, Berlin, Hague, Göttingen, Breslau, Leipsic, Marburg and Munich.
		18 55,	Min. at Milan.
9. 1836.	Sep. 24.	19 0,	Max. at Upsala, Berlin, Hague, Göttingen, Breslau, Leipsic, Marburg, Munich and Milan.
10. 1836.	Sep. 24.	21 10,	Max. at Upsala.
		21 15,	Max. at Berlin, Hague, Göttingen, Breslau, Leipsic, Marburg and Munich.
		21 20,	Max. at Milan.
11. 1837.	Jan. 28.	8 55,	Max. at Upsala, Altona, Berlin, Göttingen, Breslau, Freiberg, Augsburg, Munich and Milan.
12. 1837.	Jan. 28.	9 30,	Min. at Upsala, Altona, Berlin, Göttingen, Breslau, Leipsic, Freiberg, Marburg, Augsburg, Munich and Milan.
13. 1837.	Jan. 28.	12 30,	Max. at Upsala, Altona, Berlin, Breda, Göttingen, Leipsic, Breslau, Freiberg, Marburg, Augsburg. Munich and Milan.
14. 1837.	Jan. 28.	21 30,	Max. at Upsala, Altona, Berlin, Breda, Göttingen, Leipsic, Breslau, Freiberg, Marburg, Augsburg, Munich and Milan.
15. 1837.	May 28.	9 45,	Max. at Copenhagen.
		9 50,	Max. at Upsala, Berlin, Breda, Göttingen, Breslau and Marburg.
		9 55,	Max. at Munich and Milan.
		10 0,	Max. at Leipsic.
16. 1837.	July 29.	6 20,	Max. at Petersburgh.
		6 35,	Max. at Upsala and Copenhagen.
		6 40,	Max. at Berlin, Breda, Göttingen, Breslau, Leipsic, Freiberg, Marburg, Munich and Milan.
17. 1837.	July 29.	7 0,	Min. at Petersburgh.
		7 15,	Min. at Upsala, Copenhagen and Breslau.

d h m

1837. July 29. 7 20, Min. at Berlin, Breda, Göttingen, Freiberg, Leipsic, Marburg and Munich.

18. 1837. July 29. 8 55, Max. at Petersburgh.
9 0, Max. at Upsala, Copenhagen, Berlin and Breslau.
9 5, Max. at Göttingen, Leipsic, Freiberg, Marburg, Munich and Milan.

19. 1837. July 29. 11 40, Max. at Upsala, Berlin, Breda, Göttingen, Breslau, Leipsic, Freiberg, Marburg, Munich and Milan.

20. 1837. July 29. 12 10, Min. at Petersburgh, Copenhagen, Berlin, Breda, Göttingen, Breslau, Leipsic, Marburg, Munich and Milan.

21. 1837. July 29. 14 25, Min. at Breda.
14 25 to 30, Min. at Göttingen.
14 30, Min. at Petersburgh, Berlin, Breslau, Leipsic, Marburg, Munich and Milan.

22. 1837. Aug. 31. 6 35, Max. at Upsala, Berlin, Göttingen, Breslau, Leipsic, Marburg, Munich and Milan.
6 45, Max. at Dublin.

23. 1837. Aug. 31. 8 55, Min. at Upsala.
9 0, Min. at Berlin, Göttingen, Breslau, Leipsic, Marburg, Munich and Milan.
9 5, Min. at Dublin.

24. 1837. Aug. 31. 9 20, Max. at Upsala.
9 25, Max. at Berlin, Göttingen, Breslau, Leipsic, Marburg, Munich and Milan.
9 30, Max. at Dublin.

25. 1837. Aug. 31. 9 50, Min. at Upsala, Berlin, Göttingen, Breslau, Leipsic, Marburg and Munich.
9 55, Min. at Dublin and Milan.

26. 1837. Aug. 31. 10 25, Max. at Upsala, Berlin, Göttingen, Breslau and Leipsic.
10 30, Max. at Dublin, Marburg, Munich and Milan.

27. 1837. Aug. 31. 17 45, Max. at Upsala, Berlin, Göttingen, Breslau, Leipsic, Marburg, Munich and Milan.
17 50, Max. at Dublin.

28. 1837. Aug. 31. 19 5, Max. at Upsala.
19 10, Max. at Berlin, Göttingen, Breslau, Leipsic, Marburg and Munich.
19 15, Max. at Dublin and Milan.

29. 1837. Sep. 30. 3 50, Max. at Upsala, Copenhagen, Berlin, Göttingen, Breslau, Leipsic, Marburg and Milan.

30. 1837. Sep. 30. 7 30, Max. at Upsala, Copenhagen, Berlin, Göttingen, Breslau, Leipsic, Marburg and Milan.
7 35, Max. at Breda.

31. 1837. Sep. 30. 10 45, Min. at Upsala, Copenhagen, Berlin, Breda, Göttingen, Breslau, Marburg and Milan.

32. 1837. Sep. 30. 12 35, Min. at Upsala, Copenhagen, Berlin, Breda, Göttingen, Breslau, Leipsic, Marburg and Milan.

33. 1837, Sep. 30. 14 10, Max. at Upsala, Copenhagen, Berlin, Breda, Göttingen, Leipsic, Marburg and Milan.

34. 1837. Nov. 13. 6 25, Max. at Petersburgh, Upsala, Stockholm, Copenhagen, Berlin, Göttingen, Breslau, Leipsic, Freiberg and Marburg.
6 35, Max. at Munich.
6 40, Max. at Dublin.

35. 1837. Nov. 13. 8 50, Min. at Petersburgh, Upsala and Stockholm.
9 5, Min. at Copenhagen, Berlin, Breda, Göttingen, Breslau, Freiberg, Leipsic and Marburg.
9 10, Min. at Milan.
9 15, Min. at Dublin and Munich.

36. 1837. Nov. 13. 9 20, Max. at Petersburgh, Upsala and Stockholm.
9 25, Max. at Copenhagen, Berlin, Breda, Göttingen, Breslau, Freiberg, Leipsic and Marburg.
9 30, Max. at Dublin.
9 35, Max. at Munich.

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37. 1837. Nov. 13. 10 25, Max. at Upsala, Stockholm, Copenhagen, Berlin, Breda, Göttingen, Leipsic, Breslau, Freiberg, Marburg and Milan.
10 30, Max. at Dublin.
10 35, Max. at Munich.
10 35 to 40, Max. at Petersburgh.

38. 1837. Nov. 13. 11 25, Min. at Breda.
11 25–30, Min. at Dublin.
11 35, Min. at Berlin, Göttingen, Freiberg, Leipsic and Milan.
11 40, Min. at Upsala.
11 45, Min. at Petersburgh, Stockholm, Copenhagen and Munich.

39. 1838. Jan. 27. 7 35, Max. at Upsala, Copenhagen, Berlin, Breda, Göttingen, Breslau, Leipsic and Milan.
7 40, Max. at Marburg and Munich.

40. 1838. Mar. 31. 23 20, Min. at Upsala, Copenhagen, Berlin, Breda, Göttingen, Breslau, Marburg, Munich and Milan.

41. 1838. Nov. 24. 7 35, Min. at Upsala, Berlin, Göttingen, Breslau, Leipsic and Milan.
7 40, Min. at Breda and Munich.

42. 1838. Nov. 24. 8 5, Max. at Upsala and Breslau.
8 10, Max. at Seeburg, Breda, Göttingen, Leipsic, Marburg, Munich and Milan.

43. 1839. Feb. 22. 13 45 to 50, Min. at Breda.
13 50, Min. at Greenwich and Munich.
13 55, Min. at Berlin, Göttingen, Marburg and Milan.
14 0, Min. at Breslau, Leipsic and Heidelberg.
14 5, Min. at Upsala.

44. 1839. Aug. 30. 10 20, Min. at Upsala, Copenhagen, Berlin, Breda, Göttingen, Breslau, Leipsic, Marburg, Prague, Kremsmunster, Munich and Milan.

45. 1839. Aug. 30. 10 35, Max. at Upsala.
10 35 to 40, Max. at Breda.
10 40, Max. at Copenhagen, Berlin, Breslau, Leipsic, Prague, Kremsmunster and Munich.
10 45, Max. at Göttingen, Marburg and Milan.

46. 1839. Aug. 30. 10 55, Min. at Upsala.
11 0, Min. at Copenhagen, Berlin, Breda and Breslau.
11 5, Min. at Göttingen, Leipsic, Marburg, Prague, Kremsmunster, Munich and Milan.

47. 1839. Aug. 30. 11 20, Max. at Upsala.
11 20 to 25, Max. at Breda.
11 25, Max. at Copenhagen, Berlin, Göttingen, Breslau, Leipsic, Marburg, Prague, Kremsmunster, Munich and Milan.

48. 1839. Aug. 30. 16 45, Min. at Breda.
16 50, Min. at Upsala, Copenhagen, Berlin, Prague and Munich.
16 50 to 55, Min. at Göttingen.
16 55, Min. at Leipsic, Breslau and Marburg.

49. 1839. Aug. 30. 17 5 to 10, Max. at Breda.
17 15, Max. at Upsala, Berlin, Göttingen, Breslau, Leipsic, Prague, Marburg, Munich and Milan.

50. 1839. Aug. 30. 18 30, Min. at Breda.
18 35, Min. at Munich.
18 40, Min. at Upsala, Copenhagen, Berlin, Göttingen, Breslau, Leipsic, Prague, Kremsmunster and Milan.
18 45, Min. at Marburg.

51. 1839. Aug. 30. 20 0, Max. at Breda.
20 5, Max. at Munich.
20 10, Max. at Upsala, Copenhagen, Berlin, Göttingen, Leipsic, Breslau, Marburg, Prague, Kremsmunster and Milan.

52. 1839. Aug. 31. 8 20, Max. at Breda.
8 25, Max. at Upsala.

		d	h m	
	1839.	Aug. 31.	8 30,	Max. at Copenhagen, Berlin, Göttingen, Leipsic, Breslau, Marburg, Prague, Kremsmunster, Munich and Milan.
53.	1839.	Nov. 30.	6 25,	Min. at Upsala.
			6 30,	Min. at Copenhagen, Seeburg, Berlin, Göttingen, Breslau, Leipsic, Marburg, Prague, Kremsmunster and Milan.
			6 35,	Min. at Dublin.
			6 40,	Min. at Breda.
54.	1840.	May 29.	10 20,	Min. at Upsala.
			10 25,	Min. at Copenhagen, Berlin, Breda, Göttingen, Leipsic, Breslau, Brussels, Cracow, Kremsmunster, Marburg and Milan.
			10 30,	Min. at Petersburgh and Prague.
55.	1840.	May 29.	11 10,	Min. at Petersburgh.
			11 20,	Min. at Upsala.
			11 25,	Min. at Copenhagen, Berlin, Breda, Göttingen, Leipsic, Breslau, Marburg, Cracow, Kremsmunster and Milan.
			11 30,	Min. at Greenwich, Brussels and Prague.
56.	1840.	May 29.	11 30,	Max. at Petersburgh.
			11 40,	Max. at Copenhagen, Breslau and Cracow.
			11 40 to 45,	Max. at Breda.
			11 45,	Max. at Göttingen, Leipsic, Brussels, Kremsmunster, Marburg and Milan.
			11 50,	Max. at Greenwich.
57.	1840.	May 29.	13 30,	Max. at Petersburgh.
			13 30 to 35,	Max. at Breda.
			13 35,	Max. at Upsala, Copenhagen, Göttingen, Breslau and Cracow.
			13 35 to 40,	Max. at Leipsic.
			13 40,	Max. at Berlin, Greenwich, Brussels, Prague, Kremsmunster and Milan.
58.	1840.	May 29.	16 10 to 15,	Max. at Breda.
			16 15,	Max. at Upsala, Copenhagen, Berlin, Göttingen, Leipsic, Breslau, Brussels, Cracow, Kremsmunster, Marburg and Milan.
			16 20,	Max. at Petersburgh.
59.	1840.	May 29.	16 45,	Min. at Petersburgh, Copenhagen and Breda.
			16 45-50,	Min. at Brussels.
			16 50,	Min. at Berlin, Greenwich, Göttingen, Leipsic, Breslau, Cracow and Kremsmunster.
			16 55,	Min. at Prague.
60.	1840.	Aug. 28.	10 30,	Min. at Petersburgh, Upsala, Copenhagen, Berlin, Göttingen, Breslau, Kremsmunster and Milan.
			10 30 to 35,	Min. at Leipsic and Prague.
			10 40,	Min. at Dublin, Breda and Brussels.
			10 45,	Min. at Greenwich.
61.	1840.	Aug. 28.	14 25,	Min. at Petersburgh and Upsala.
			14 40,	Min. at Copenhagen.
			14 45,	Min. at Greenwich, Göttingen, Leipsic, Brussels, Marburg, Breslau, Prague, Cracow and Milan.
			14 50,	Min. at Breda.
			15 0,	Min. at Dublin.
62.	1840.	Aug. 28.	17 10,	Max. at Dublin.
			17 20,	Max. at Greenwich, Brussels, Marburg and Kremsmunster.
			17 20-30,	Max. at Göttingen and Prague.
			17 25,	Max. at Breda.
			17 30,	Max. at Petersburgh, Copenhagen, Berlin, Leipsic, Breslau, Cracow and Milan.
			17 30-35,	Max. at Upsala.
63.	1840.	Aug. 28.	18 55,	Min. at Petersburgh, Upsala, Berlin, Göttingen, Breslau, Cracow, Marburg and Kremsmunster.
			19 0,	Min. at Dublin, Greenwich, Copenhagen, Breda, Leipsic, Brussels, Prague and Milan.

		d h m	
64. 1840.	Nov. 28.	0 50,	Min. at Upsala, Stockholm, Copenhagen, Dublin, Greenwich, Berlin, Breda, Brussels, Göttingen, Leipsic, Breslau, Prague, Marburg, Kremsmunster, Cracow and Milan.
		0 55,	Min. at Petersburgh.
65. 1840.	Nov. 28.	2 55,	Min. at Petersburgh.
		3 10,	Min. at Upsala, Stockholm, Copenhagen and Breslau.
		3 15,	Min. at Dublin, Greenwich, Berlin, Breda, Brussels, Göttingen, Leipsic, Marburg, Kremsmunster and Milan.
66. 1840.	Nov. 28.	6 40,	Max. at Petersburgh, Stockholm and Copenhagen.
		6 45,	Max. at Berlin, Breda, Göttingen, Leipsic, Breslau, Prague, Cracow, Kremsmunster, and Milan.
		6 50,	Max. at Dublin, Greenwich and Marburg.
67. 1840.	Nov. 28.	9 45,	Min. at Petersburg, Upsala, Stockholm, Copenhagen, Dublin, Berlin, Greenwich, Breda, Brussels, Göttingen, Leipsic, Breslau, Prague, Marburg, Kremsmunster, Cracow and Milan.
68. 1841.	Feb. 26.	12 45,	Min. at Petersburgh.
		12 50,	Min. at Upsala, Stockholm and Copenhagen.
		12 50 to 13 0,	Min. at Göttingen.
		13 0,	Min. at Breda, Leipsic, Berlin, Marburg, Prague, Kremsmunster and Milan.
		13 5,	Min. at Breslau, Brussels and Geneva.
69. 1841.	Feb. 26.	13 25,	Max. at Upsala and Stockholm.
		13 30,	Max. at Copenhagen.
		13 35,	Max. at Berlin, Breda, Göttingen, Leipsic, Marburg, Prague and Cracow.
		13 40,	Max. at Breslau, Brussels and Geneva.
		13 45,	Max. at Milan.
70. 1841.	Feb. 26.	15 35 to 40,	Min. at Breda.
		15 40 to 45,	Min. at Göttingen, Geneva and Milan.
		15 45,	Min. at Petersburgh, Upsala, Stockholm, Copenhagen, Brussels, Berlin, Leipsic, Breslau, Marburgh, Prague, Kremsmunster and Cracow.
71. 1841.	Feb. 27.	5 15,	Max. at Petersburgh.
		5 25,	Max. at Upsala.
		5 30,	Max. at Copenhagen, Berlin, Göttingen, Leipsic, Breslau and Prague.
		5 35,	Max. at Breda, Brussels, Geneva and Milan.
72. 1841.	May 28.	14 5 to 10,	Max. at Breda and Kremsmunster.
		14 10,	Max. at Upsala, Stockholm, Christiania, Copenhagen, Dublin, Göttingen, Leipsic, Breslau, Brussels, Prague, Marburg, Cracow and Milan.
73. 1841.	Aug. 27.	10 45,	Max. at Petersburgh.
		10 55,	Max. at Stockholm.
		11 0,	Max. at Upsala and Christiania.
		11 5,	Max. at Copenhagen, Breda, Berlin, Göttingen, Leipsic, Breslau, Prague, Cracow, Kremsmunster, Geneva and Milan.
74. 1841.	Aug. 27.	12 40,	Min. at Christiania.
		12 45,	Min. at Upsala, Stockholm, and Copenhagen.
		12 50,	Min. at Petersburgh, Berlin, Göttingen, Leipsic, Breslau and Cracow.
		12 55,	Min. at Makerstoun, Breda, Prague and Kremsmunster.
75. 1841.	Aug. 27.	13 10,	Max. at Petersburgh, Upsala, Stockholm, Christiania, Copenhagen, Makerstoun, Berlin, Breda, Göttingen, Leipsic, Breslau, Prague, Cracow, Geneva and Milan.
76. 1841.	Nov. 27.	8 40,	Max. at Petersburgh and Stockholm.
		8 45,	Max. at Upsala, Christiania, Berlin, Breda, Göttingen, Leipsic, Breslau, Prague and Cracow.
		8 50,	Max. at Makerstoun and Brussels.

The following table shows the latitude and longitude of the places mentioned in the preceding catalogue.

Station.	Latitude.	Longitude from Greenwich.	Station	Latitude.	Longitude from Greenwich.
Petersburgh,	59° 56′	30° 18′ E.	Leipsic,	51° 20′	12° 22′ E.
Christiania,	59 54	10 44	Breslau,	51 6	17 2
Upsala,	59 51	17 38	Freiberg,	50 55	13 20
Stockholm,	59 20	18 4	Brussels,	50 51	4 22
Copenhagen,	55 40	12 35 E.	Marburg,	50 48	8 41
Makerstoun,	55 36	2 31 W.	Prague,	50 5	14 25
Seeburg,	53 56	20 45 E.	Cracow,	50 3	19 58
Altona,	53 32	9 56 E.	Heidelberg,	49 28	8 42
Dublin,	53 23	6 20 W.	Augsburg,	48 21	10 53
Berlin,	52 30	13 24 E.	Munich,	48 8	11 37
Hague,	52 4	4 19	Kremsmünster,	48 3	14 8
Breda,	51 35	4 47	Geneva,	46 11	6 9
Göttingen,	51 31	9 57	Milan,	45 28	9 12 E.
Greenwich,	51 28	0 0			

The following table shows for each station in how many cases the maximum deviation of the magnetic needle occurred earlier than at Göttingen; in how many cases it occurred at the same instant as at Göttingen; and in how many cases it occurred later than at Göttingen.

Maximum deviation of the magnetic needle.

	Earlier.	Simultaneous.	Later.		Earlier.	Simultaneous.	Later.
Petersburgh,	9	3	2	Munich,	3	20	6
Christiania,	1	3	0	Kremsmunster,	1	9	1
Upsala,	13	27	1	Hague,	0	6	1
Stockholm,	5	4	0	Breda,	4	21	2
Copenhagen,	7	17	0	Brussels,	0	4	4
Seeburg,	0	1	0	Marburg,	0	31	3
Altona,	0	3	0	Augsburg,	0	3	0
Berlin,	3	36	1	Geneva,	0	2	2
Leipsic,	2	39	1	Milan,	0	30	7
Breslau,	4	34	1	Makerstoun,	0	1	1
Freiberg,	0	9	0	Dublin,	1	1	9
Cracow,	1	9	0	Greenwich,	0	1	3
Prague,	1	12	1				

From this table we perceive that at most of the stations, the maximum deviation generally occurred simultaneously; that is, within a period of five minutes, for this is the interval of time between the observations. But at some of the stations the maximum generally occurred earlier than at Göttingen, while at others it generally occurred later than at Göttingen. If we draw through Göttingen a great circle of the earth running from N. 60° W. to S. 60° E., it will divide the stations in such a manner, that at all those on the N.E. side of this line, the maximum occurs earlier more frequently than later; while at all those on the S.W. side of it, the maximum occurs later more frequently than earlier. We may then conclude that the maximum deviation of the magnetic needle advances progressively like a wave over the earth's surface; and that the direction of its motion is nearly from N.E. to S.W.

The following table shows for each station in how many cases the minimum deviation of the magnetic needle occurred earlier than at Göttingen; in how many cases it occurred at the same instant as at Göttingen; and in how many cases it occurred later than at Göttingen.

Minimum deviation of the magnetic needle.

	Earlier.	Simultaneous.	Later.		Earlier.	Simultaneous.	Later.
Petersburgh,	7	7	3	Heidelberg,	0	0	1
Christiania,	1	0	0	Munich,	3	12	3
Upsala,	11	17	2	Kremsmunster,	0	14	1
Stockholm,	3	4	1	Hague,	1	2	0
Copenhagen,	6	16	2	Breda,	5	15	6
Seeburg,	0	1	0	Brussels,	0	7	4
Altona,	0	1	0	Marburg,	0	26	1
Berlin,	1	31	0	Augsburg,	0	1	0
Leipsic,	1	28	2	Geneva,	0	1	1
Breslau,	3	26	2	Milan,	0	24	4
Freiberg,	0	4	0	Makerstoun,	0	0	1
Cracow,	0	9	0	Dublin,	1	3	7
Prague,	0	11	5	Greenwich,	1	5	3

We perceive from these observations that the progress of the magnetic minima was nearly in the same direction as that of the magnetic maxima. We may draw a great circle through Göttingen in such a manner that at every station on the N.E. side of this line, the minimum occurs earlier more frequently than later; while at all those on the S.W. side of this line (without any important exception), the minimum occurs later more frequently than earlier. This line runs from N. 62° W. to S. 62° E., indicating progress in a direction from N. 28° E. to S. 28° W.

We thus see that the average progress of the maxima and minima was very nearly in the same direction; and if the average direction for either of these classes of waves is constant, it is probably the same for both of them. We may therefore combine both maxima and minima in the same table, and we shall obtain the following result.

Extreme deviations of the magnetic needle.

	Earlier.	Simultaneous.	Later.		Earlier.	Simultaneous.	Later.
Petersburgh,	16	10	5	Heidelberg,	0	0	1
Christiania,	2	3	0	Munich,	6	32	9
Upsala,	24	44	3	Kremsmunster,	1	23	2
Stockholm,	8	8	1	Hague,	1	8	1
Copenhagen,	13	33	2	Breda,	9	36	8
Seeburg,	0	2	0	Brussels,	0	11	8
Altona,	0	4	0	Marburg,	0	57	4
Berlin,	4	67	1	Augsburg,	0	4	0
Leipsic,	3	67	3	Geneva,	0	3	3
Breslau,	7	60	3	Milan,	0	54	11
Freiberg,	0	13	0	Makerstoun,	0	1	2
Cracow,	1	18	0	Dublin,	2	4	16
Prague,	1	23	6	Greenwich,	1	6	6

It is not improbable that the line which divides the stations at which the extreme deviations of the magnetic needle generally occurred earlier than at Göttingen, from those stations at which the extremes generally occurred later than at Göttingen, differs considerably from a great circle of the earth; but if we regard it as an arc of a great circle, then its direction must be from about N. 62° W. to S. 62° E., indicating a progress of the electric wave from N. 28° E. to S. 28° W.

It was stated on page 326 that Mr. C. V. Walker, from a discussion of the observations on the lines of telegraph in England, has arrived at the conclusion that in the S.E. part of England there is a stream of electricity drifting across the country from N. 42° E. to S. 42° W. We have now found that the irregular deflections of the magnetic needle, which are so remarkable during auroral displays, do not occur everywhere simultaneously, but are generally propagated over the surface of Europe in a direction from N. 28° E. to S. 28° W. It is possible that a more extended series of observations would show that these two directions are identically the same; but it is not improbable that the direction in England is somewhat different from that in Central Europe.

The time of greatest and least deflection at Dublin is on an average five minutes later than at Göttingen. Now Dublin is situated 222 miles from the great circle above mentioned, passing through Göttingen, indicating a progress of the electric wave of about 2700 miles per hour. The time of the extreme deviations at Upsala is on an average three and one-third minutes earlier than at Göttingen; while Upsala is situated 644 miles from the great circle above mentioned, indicating a progress of the electric wave equal to 11,000 miles per hour. If we make a like comparison for each of the other stations, we shall obtain velocities very unequal in amount. We thus perceive the difficulty of determining the average rate of progress of the electric wave. Sometimes the observations may be explained by supposing a single broad current of electricity flowing over Europe from N.E. to S.W. as in the case of Nos. 10, 23, 24, 26, 28, 36, 46, 65, 69, 71, etc. Occasionally the progress appears to be mainly from S.W. to N.E., as in the case of Nos. 58 and 70.

At other times the effect takes place simultaneously from Upsala to Milan, or at least within a period of five minutes, as in the case of Nos. 5, 7, 9, 11, 12, 13, 14, 19, 20, 29, 31, etc.

At other times it seems necessary to admit the existence of several currents moving in different directions, and probably with unequal velocities, as in the case of Nos. 15, 37, 38, 43, 45, 50, 51, 54, 57, 62, 74, etc.

Of the seventy-six cases of magnetic disturbance contained in the preceding catalogue, thirty-three occurred on days when an aurora was recorded at some one of the stations. Some of the deflections of the magnetic needle here recorded, were caused by the electric currents which prevail during the presence of auroras; while others occurred when no aurora was noticed. During the presence of an aurora, the magnetic deflections are greater than when there is no aurora; but they all seem to follow the same law of progress, with perhaps this exception, that during auroras there is an unusual number of cases in which there is the appearance of several currents moving simultaneously in different directions. The following is the list of auroras corresponding to dates in the catalogue.

1837. Aug. 31. 10^h P.M. Christiania. Slight aurora.
1837. Nov. 12. $6\frac{1}{4}^h$. England. Bright aurora with streamers reaching to the zenith.
Nov. 12–13. Brilliant aurora of a reddish color seen throughout France.
Nov. 13. England. Rain.
Nov. 14. England. Broad patches and streamers of a fiery red color.
Nov. 14. $11\frac{1}{2}^h$–$12\frac{1}{2}^h$. Christiania. Aurora of an intense crimson color.
1838. Jan. 28. $6\frac{1}{2}^h$–10^h. St. Petersburgh. Aurora.
1838. March 30. $9\frac{1}{2}^h$–10^h. St. Petersburgh. Aurora.
1838. Nov. 24. 10^h. Christiania. A flaming auroral arch about 10° altitude.
1839. Feb. 21. $6\frac{1}{4}^h$. Christiania. Aurora radiating towards the zenith.
1839. Aug. 30. 8^h–9^h. St. Petersburgh. Aurora.
1840. Aug. 28. 10^h. Christiania. Slight aurora.
1841. Aug. 27. 9^h–12^h. Christiania. Slight aurora.

During the aurora of Sept. 2, 1859, the disturbance of the magnetic needle was very great at Toronto, Greenwich, Brussels, Paris, Rome, Christiania, St. Petersburg, Catherinenburg, Nertchinsk, and Barnaul, but the observations are not reported with sufficient frequency to enable us to trace satisfactorily the progress of any single wave.

At Rome the greatest easterly deflection of the needle is said to have taken place Sept. 1st, at $7^h\ 20^m$ A. M. Göttingen time. At Petersburgh it took place at $7^h\ 48^m$ A. M. Göttingen time; and at Catherinenburg, Nertchinsk and Barnaul, it certainly took place within an hour of the same instant; it being impossible to determine the coincidence more closely, for the observations at these three places are only given at intervals of one hour.

New Haven, September, 1861.