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Compendium of the eight articles on the "Carrington Event" attributed to or written by Elias Loomis in the American Journal of Science, 1859–1861

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Abstract

The eight articles attributed to or written by Elias Loomis on the outstanding aurora and magnetic observations between 28 August and 5 September 1859 are assembled into one compilation for easy reference by contemporary researchers. The articles were originally published in the *American Journal of Science* between 1859 and 1861.
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Keywords: Carrington Event of 1859; Elias Loomis; Aurora; Geomagnetic disturbances

1. Introduction

Many of the authors in this issue of *Advances in Space Research* have referenced a series of articles on the auroral and magnetic observations between 28 August and 5 September 1859 published in the *American Journal of Science*. These eight publications have been assembled into one document and are appended to this article.

2. Authorship of the original articles

As detailed by Green et al. (2006), Boteler (2006) and others, the authorship of these eight articles has been attributed to various individuals. The first four articles contain individual reports on the outstanding observations during the events from 28 August to 5 September 1859 as apparently compiled by the editors of the American Journal of Science.[1] These articles are frequently referenced by either "The Editors" or "B. Silliman, Editor". The last four articles were written by Elias Loomis of Yale College, and are generally referenced as authored by Loomis.

The confusion is associated with the first four articles. The first "observation" given in the first article is from Elias Loomis who was near Lewiston, Maine on 28 August 1859. At the end of this article the editors suggest that "Observers may forward their communications either to the "editors of the Journal of Science, New Haven, Ct." or to Prof. Elias Loomis, New York City," who has consented to undertake the discussion of the phenomena.

The next three articles in the series are again observational reports all compiled by the editors who probably combined the information they received together with that received by Prof. Loomis. Each article refers back to the previous articles published in the Journal.

The fifth article and the first with the explicit authorship of Professor Loomis, starts with the words "Since the publication of our former articles on the great aurora..." indicating that Professor Loomis had a major part in the compilation of the first four articles. For this reason Elias Loomis is frequently cited as the author for all eight articles.

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[1] The cover page of this journal states the following: The American Journal of Science and Arts, conducted by Professors B. Silliman and B. Silliman, Jr. and James D. Dana in connection with Professors Asa Gray and Louis Agassiz of Cambridge, and Dr. Wolcott Gibbs of New York.

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Table 1 contains the original publication information for all eight articles included in the Appendices. Note that each article initially has an Article number (in Roman numerals) preceding the title; this is the sequence of the article in the specific publication. Additional auroral observations and a more complete description of the terms used to describe the aurora in the 1860s is contained in the Annual Report of the Smithsonian Institution (Loomis, 1866).

3. Alterations from the original text

The compilers have endeavored to maintain the style and structure of the original text as much as possible. The spelling, language and punctuation as well as the words originally placed in italics have been retained. Place names occasionally had two different spellings for the same location. It was interesting to note that names of individuals reporting various observations were all in capital letters. The headings for each session were primarily in italics except for numbers which were not italicized. There were also some inconsistencies in the style used for the different articles.

Several changes were found necessary to accommodate the present publication style. In the original articles specific times were given using the Astronomical format with the "h" for hours and the "m" for minutes as superscripts (e.g. $10^{h}\ 23^{m}$). We have elected to place the "h" and "m" on the same line as the numbers, primarily as a time saver since there are hundreds of times given in these documents. The original manuscripts were printed full-page width, and all the tables were incorporated within the text directly under the description of the table. For this present compilation each table was given a sequential number within the specific article and the table will be placed wherever the typesetters find appropriate. Some of the original tables contained "ditto" marks; these have been replaced and the full information inserted. Likewise the figures have been identified with separate figure numbers at the appropriate place.

Footnotes from the original publication have been identified as such; additional footnotes were added by the compilers as necessary. Another change was to put the heading of each observation in bold type. This was done to facilitate a search for observations from a specific place or location.

4. Comments on interpreting old magnetometer observations

Several of the Loomis articles contain magnetic field measurements using a unifilar or a bifilar magnetometer. In a unifilar magnetometer a magnetized needle is suspended by a single (torsionless) thread so that the needle is free to rotate and to align itself in the magnetic meridian. In a bifilar magnetometer, the needle is suspended by two threads so that its movement is constrained. Both instruments can be used for measuring (absolute) horizontal intensity. The bifilar can also be used to measure horizontal field variations. The unifilar can also be used to record

Table 1
Articles on the "Carrington Event period" attributed to or written by Elias Loomis in the American Journal of Science and contained in the Appendices

Appendix A:	ART. XLII – The Great Auroral Exhibition of August 28th to September 4th 1859. American Journal of Science, Second Series, Vol. 28, No. 84, pp. 385–408, 1859.
Appendix B:	ART. XII. – The Great Auroral Exhibition of August 28th to September 4th, 1859. – (2d ARTICLE). American Journal of Science, Second Series, Vol. 29, No. 85, pp. 92–97, 1860.
Appendix C:	ART. XXIV. – The Great Auroral Exhibition of August 28th to September 4th, 1859. – 3D ARTICLE. American Journal of Science, Second Series, Vol. 29, No. 86, pp. 249–265, 1860.
Appendix D:	ART. XXXV. – The Great Auroral Exhibition of Aug. 28th to Sept. 4th, 1859. – 4TH ARTICLE. American Journal of Science, Second Series, Vol. 29, No. 87, pp. 386–397, 1860.
Appendix E:	ART. XI. – The Great Auroral Exhibition of Aug. 28th to Sept. 4th, 1859; and the Geographical Distribution of Auroras and Thunderstorms. – 5TH ARTICLE. American Journal of Science, Second Series, Vol. 30, No. 88, pp. 79–94, 1860.
Appendix F:	ART. XXXI. – The Great Auroral Exhibition of Aug. 28th to Sept. 4th, 1859. – 6TH ARTICLE. American Journal of Science, Second Series, Vol. 30, No. 90, pp. 339–361, 1860.
Appendix G:	ART. XII – The Great Auroral Exhibition of Aug. 28th to Sept. 4th 1859. – 7TH ARTICLE. American Journal of Science, Second Series, Vol. 32, No. 92, pp. 71–84, 1861.
Appendix H:	ART. XXXVI. – On the great Auroral Exhibition of Aug. 28th to Sept 4th 1859, and on Auroras generally. – 8TH ARTICLE. American Journal of Science, Second Series, Vol. 32, No. 96, pp. 318–335, 1861.

absolute or relative declination. Additional information can be found in Multhauf and Goode (1987).

Some of the tables are given in units of a scale division, denoted by the letter "d". Scale divisions would be dependent upon the station location and the magnitude of the total field.

5. Comments on interpreting reported times

Standardized time zones had not been implemented in 1859. Many of the times reported are the mean solar time for the longitude of the observation location. However, some observations are recorded in astronomical time which starts at noon local mean time. The purpose of this was to accommodate astronomers so that their observing night is not split between two days.

The Magnetic Union, started by Gauss at the Göttingen Observatory in 1835, was instrumental in standardizing the reporting of simultaneous magnetic observations, and thus many observatories adoped Göttingen mean time for their observations. Caution is advised whenever specific times are used for various interpretations of the phenomena associated with the reports in the Loomis articles.

6. Additional comments

In compiling and reviewing these eight articles the compilers were impressed by the richness of the descriptive text – something not generally found in publications today. Without the aid of fast photography (and without the extensive light pollution of the present day), these authors, all of whom had an extensive command of the English language, were able to give such detailed descriptions of their observations that it was possible to easily visualize the phenomena from the description. Some of the most vivid descriptions included the following:

"...portions of the luminous cloud broke off and floated for some minutes far away..."

"...wavy pencillings grew stronger and broader ... enveloped in a sheet of mellow flame."

"...spears and pencils of pale flickering light..."

"...darting forth palpitating rays towards the zenith..."

"...kindling up with greater brilliancy than before."

"...vehemently flaming with broad flames..."

"...the streamers from the arc meeting them and toothing in, appearing to alternate short and long ones."

Another observation was what would be considered, today, as an excessive use of punctuation marks. Abbreviations all had periods in the appropriate places; commas were liberally inserted, sometimes several in a single sentence.

7. Concluding remarks

While care has been taken to faithfully reproduce these original documents, it is possible that an occasional mistake has crept into the compilation. Should doubt of any of the numbers arise, readers are referred to the original publications in the *Journal of American Science*. The compilers hope that this compendium will be useful in future study of this remarkable event as well as a reference for events that may occur in the future.

Acknowledgements

We are grateful to David Boteler who provided information on the different times used in scientific data observations, and to Larry Newitt for details and calculations related to the magnetometer measurements.

Appendix A. ART. XLII – The Great Auroral Exhibition of August 28th to September 4th 1859*

On the evening of August 28th, 1859, was commenced an exhibition of Auroral or Polar light which continued with varying intensity at different localities in North America, so far as is now known, up to September 4th. This auroral display is one of the most remarkable ever recorded in the United States; remarkable not only for the great extent of territory over which it was observed, but also for its duration, for the intensity of the illumination as well as the brilliancy of the colors, and the extreme rapidity of the changes. It was also equally remarkable for the magnetic disturbances which accompanied it, especially on the 2d and 3d of September. These electrical perturbations were recorded not only by the usual magnetic instruments, but over the whole system of telegraphic wires, especially in New England and the Canadas, the magnetic induction either greatly interfered with or prevented the working of the lines by the usual voltaic current, while in more than one case the north and south lines were worked during the daytime of September 3rd solely by the atmospheric influence! This remarkable and novel phenomenon deserves and will receive special attention hereafter.

It appears from our own correspondence, and from the daily Journals, that the late display of the Aurora was witnessed from Cuba and Jamaica on the south, to an unknown distance beyond the Canadas on the north, and from Central Europe on the east, to California on the west. Doubtless we may expect to hear that it was seen over the entire northern hemisphere, and in some places as far south as lat. 20°.

Since the laws of this phenomenon are as yet but imperfectly understood, it is regarded as very important that the facts respecting the late grand exhibition should be carefully collected and placed on record, in the expectation that at some future day they may afford the basis for a complete and satisfactory theory of this meteor.

We now publish such original observations on this Aurora as have reached us in an authentic form, and we

* Originally compiled by the Editors and published in the American Journal of Science, Second Series, Vol. 28, No. 84, pp. 385–408, 1859.

hope in future numbers of this Journal to present many other important data of the same description from different and distant parts of this and the other continent. We intend to present in the first place the *facts* of this exhibition divested of all theoretical considerations; and when all the materials have been collected we shall give such explanation of them as we are able. At present we put on record observations of the aurora and its attendant phenomena made at Lewiston, Me.; at Toronto, Canada West; at New Haven, Conn.; at West Point, N. Y.; at Bloomington, Ind.; at Springhill, Ala.; at Jefferson Co., Miss.; at Havana, Cuba; and at San Francisco, California. All but one of these having been communicated to this Journal directly from their authors.

1. *Observations made at Lewiston, Maine*, lat. 44° 5′ N., long. 70° 15′ W.; by Prof. ELIAS LOOMIS.

Sunday, the 28th of August, I passed at Lewiston in the state of Maine. The day was throughout unusually cold and very windy. In the evening, the wind was less violent, but still fresh from the northwest, and so continued until midnight. At 10 P.M. the thermometer stood at 53° F, and the next morning at 5 o'clock it stood at 50° F.

At 8h 20m in the evening I first noticed some remarkable auroral indications. Long brushes of pale white light were shooting up from the west and also from the east, and were directed towards a point considerably south of the zenith; while in the northwest was a large mass of light tinged with a decided rosy hue.

At 8h 35m P.M. the light in the east and northeast had also assumed a rosy tint, while that in the northwest had acquired a deeper red color. At the same time a dark segment rested upon the southern horizon, its vertex having an altitude of about fifteen degrees above the horizon, and its convex edge was bordered throughout by a vivid light which was nearly white but with a decided tinge of emerald-green. In the north was also seen a dark bank similar to that in the south, but less sharply defined, and rising to an altitude of about 80°.

At 8h 45m P.M. in nearly every part of the heavens the light had become more intense, and the streamers were continually varying both in position and in the intensity of their light, presenting the appearance of undulations. From nearly every quarter of the heavens the streamers converged towards one point, but terminated about ten degrees before reaching that point. That point was nearly equidistant from the three stars *Lyra*, *Altair*, and α *Cygni*, but somewhat nearer to Lyra.

At 8h 55m P.M. the elevation of the bank resting on the southern horizon did not exceed five degrees.

At 9 P.M. the light had broken through nearly the entire dark bank in the north, so that there remained only a portion of this bank of very irregular shape, and its average height did not exceed ten degrees. The point of convergence of the streamers was now about equidistant from the three bright stars above named, but inclining a little to the north of that central point.

At 9h 5m the illumination of the southern half of' the heavens was much greater than that of the northern; but at 9h l0m the illumination of the southern half had sensibly declined and the dark bank resting on the southern horizon had risen to a height of 15° or 18°.

At 9h 18m the point of convergence of the streamers was nearly equidistant from the stars above named, but somewhat nearer to α Cygni.

At 9h 23m the dark segment in the south was quite regular, and not more than ten degrees in height, and the bright border was very strongly illumined; while the dark segment in the north had almost entirely disappeared, and there was but little light in the northern portion of the heavens, nearer the north horizon than about forty degrees.

At 9h 33m a narrow beam of white light shot up from the west and another similar beam shot up from the east, which met at the magnetic zenith, forming a pretty well defined bow, and being nearly half of a great circle of the sphere. Throughout the entire portion of the heavens north of this arc, there was scarcely any trace of auroral light; while in the south the dark segment was complete, and the diffuse illumination above it was very strong; that is, the usual conditions of the aurora were entirely reversed, and it now appeared wholly on the south side of the zenith, with its base resting on the south horizon.

At 9h 49m P.M. the aurora was entirely confined to a region not rising more than 40° above the southern horizon, and it seemed as if the light was entirely disappearing, passing away towards the south, when very suddenly it increased in brightness, and rose higher in the heavens. Soon it became so bright that I could read with perfect ease the finest printed type. I took from my pocket a paper printed in *nonpareil*, (the finest type often used by printers,) and could read it by the light of the aurora with the same facility as at noonday. The streamers now converged to a point nearly midway between α *Delphini* and α *Cygni*. Soon they covered the entire heavens, reaching down almost to the north horizon. The light in many places, particularly in the south, at an elevation of about 45°, became of a brilliant crimson, and then commenced a succession of flashes like waves of light rolling up towards the magnetic zenith.

At 10 P.M. the point of convergence of the streamers was about equidistant from α *Delphini* and α *Cygni* and about three degrees east of the line joining those two stars. The flashes still continued, but the illumination was less intense.

At 10h 10m P.M. the light had become very pale and diffuse, particularly in the north.

At 10h 14m P.M. almost the entire heavens appeared of that dull slate color which usually characterizes the dark segment near the horizon; but at 10h 19m the whole heavens brightened up again with diffuse brushes of straw-colored light, all inclining towards the magnetic zenith.

At 10h 24m P.M. the point of convergence of the streamers was about equidistant from α *Delphini*, α *Cygni* and *Eta Pegasi*.

At 10h 30m P.M. the corona was very perfect, but the light was chiefly of a straw color, and much paler than it had been about ten o'clock.

At 10h 45m P.M. irregular streamers of pale light covered the entire heavens with the exception of a segment rising about thirty degrees above the southern horizon.

Soon after 11 o'clock I retired, but slept little during the night. The light of the aurora continued until day-light, and made my room nearly as light as a full moon would have done; and I frequently rose to observe the phenomenon from my window, which had a free northern exposure.

At 12 o'clock (midnight) the whole northern half of the heavens was covered with streamers of a diffuse yellow light, and whose borders were not sharply defined.

Aug. 29th at 2 A.M. the whole sky was covered with a haziness, while a number of light clouds of considerable extent were visible, and the whole was lighted up as by a full moon shining through them.

At 5 A.M. the sky seemed unusually clear with the exception of a few light clouds, mostly cirro-stratus, scattered irregularly over the heavens; but near the north horizon was a collection of cirro-stratus clouds forming together a bank rising to an elevation of about eight degrees, and similar to the dark segment observed last evening.

I subsequently ascertained that on the evening of Aug. 28th, snow and sleet were falling upon the summit of Mount Washington (the highest of the White Mountains in New Hampshire), and this snow remained unmelted for several days.

2. *Observations at Toronto, Canada West*, lat. 43° 39′ 35″ N., long. 79° 21′ 30″ W.; by Prof. G. P. KINGSTON, Director of the Magnetic Observatory. (In a letter to the Editors).

Magnetic Observatory, Toronto, Canada,
Sept. 24, 1859.

Dear Sirs: – According to the promise conveyed to you in my note of yesterday I send you some facts relating to the Aurora of 28th August and following days. These facts you will notice are not given in a form suitable for publication, but must be considered only as materials for you to work up in the manner best adapted for your purpose.[1] (See Table 1.1.)

In the magnetical observations the readings of the instruments have been compared with the normal standard readings proper to the time of observation, and the excess or defect from the standard have been then expressed in arc for the declination and dip and in parts of the horizontal and vertical forces respectively for those components of the force. The times of observation are expressed in hours and minutes Göttingen astronomical time. By these means the tabulated numbers are independent of instrumental peculiarities and of local time, and are therefore comparable with results similarly obtained from other quarters. That the deviations given are extraordinarily great will be apparent when it is considered that according to the rule adopted by General Sabine a disturbance is reckoned *large* when the declination differs 5′ the dip 1′ the horizontal force 0.012 and the vertical force 0.0026 from their several normal values. Prior to the morning of Sept. 2, the instruments occasionally gave evidence of a disturbed condition of the magnetic elements but not to such an extent as to lead to any systematic reading of them excepting at the regular hours of observation. The Aurora first appeared about 7:40 P.M. of Sunday Aug. 28. From which time though the *whole night* the *whole sky* was covered with a brilliant mass of streamers, patches and luminous bands, which rose from all points of the horizon, the predominant color being yellow intermixed with patches of crimson.

At 8h 10m along the *south* horizon was seen a low bank of dark haze similar to that which is common on like occasions in the north horizon, and from which streamers occasionally issued extending towards the zenith and forming with streamers that converged from other points a corona about 16° south of the zenith.

At 8h 25m dense masses of red streamers extended in a band from N.W. to S.S.E., with an intermixture of crimson patches.

On the whole the aurora of Aug. 28 seems to have been characterized not so much by the activity of the phenomena as by the *extent* of the sky which it occupied, (the whole hemisphere,) and by the permanence; for there was little variation in the kind or intensity of the phenomena through the night.

On Aug. 29 – Faint auroral light from 8:30 in the night, being clear and favorable for observation.
Aug. 30 – Sky overcast.
Aug. 31 – Clear and unclouded but no aurora recorded.
Sept. 1 – Overcast till near midnight. When the sky cleared auroral light was seen accompanied by streamers. At 12h 30m a fine corona was formed round a point 28° S. of the zenith.
Sept. 2 – Generally overcast with auroral light occasionally visible through the clouds.
Sept. 3 – Aurora visible from sunset consisting of streamers with the formation occasionally of imperfect corona.
Sept. 4 – Auroral light with occasional streamers.
Sept. 5 – Unclouded, faint auroral light.

[1] Prof. Kingston's letter was accompanied by a copy of his magnetic records for the two days named – Sept. 2nd and 3rd – taken every fifteen or every five minutes and for a part of the time every two minutes during the hours of observation. These records are extremely interesting and will undoubtedly be presented in full in the records of the Observatory. We have condensed from them the brief table here given. (Footnote from original publication).

Table 1.1
Magnetic disturbance at Toronto, 2nd and 3rd Sept., 1859 giving the variation of the declination, inclination, horizontal and vertical forces from their respective normal values[a]

Göttingen time			Declination		Inclination		Horizonal force	Vertical force
Day	hr	Min	Deg	Min	Deg	Min		
02	00	00	0	09.5	0	07.7	−.0191	.0028
02	00	15	0	41.0	0	11.1	−.0129	.0039
02	00	30	0	52.2	0	17.4	−.0233	.0033
02	00	34	0	12.6	0	16.9	−.0171	.0019
02	00	42	−0	40.3	0	25.0	−.0256	.0012
02	00	48	0	16.6	0	26.1	−.0275	.0019
02	00	52	−0	40.3	0	08.6	Off Scale	−.0027
02	01	00	0	33.1	1	07.3	−.0611	.0001
02	01	04	−0	16.6	0	46.9	−.0393	.0027
02	01	06	0	28.7	1	04.9	−.0601	.0036
02	01	08	0	67.6	0	24.6	−.0672	.0036
02	01	10	−0	13.7	1	19.6	−.0647	.0027
02	01	12	2	06.7	1	20.5	Off Scale	−.0022
02	01	20	−0	02.9	1	37.3	−.0765	.0025
02	01	26	1	35.0	1	14.5	−.0717	.0056
02	01	36	1	41.2	1	42.5	−.0741	−.0013
02	01	40	0	54.4	1	16.9	Off Scale	−.0003
02	01	48	2	06.4	1	00.5	Off Scale	−.0031
02	01	50	0	11.2	Off Scale		−.0809	Off Scale
02	01	56	0	27.7	2	29.8	−.0857	−.0057
02	02	04	1	24.2	0	45.7	−.0566	.0000
02	02	06	0	51.8	0	51.7	−.0549	−.0006
02	02	16	−1	37.2	Off Scale		−.0583	−.0021
02	02	34	1	26.0	1	16.9	−.0748	−.0005
02	02	36	0	49.3	1	20.7	−.0724	−.0032
02	02	46	2	07.8	1	39.3	−.0630	−.0021
02	02	58	0	57.8	0	47.7	−.0501	.0006
02	03	08	−0	29.3	0	49.3	−.0472	−.0009
02	03	24	1	07.2	0	32.8	−.0406	.0003
02	03	36	−0	10.6	0	36.8	−.0360	.0000
02	03	40	−0	00.4	0	29.2	−.0275	.0013
02	04	00	0	32.8	0	22.8	−.0232	.0038
02	04	16	0	08.6	0	22.0	−.0204	.0031
02	04	24	0	22.3	0	21.6	−.0147	.0035
02	04	32	0	02.5	0	17.6	−.0154	.0041
02	04	42	0	23.8	0	08.4	−.0128	.0039
02	04	52	−0	01.4	0	12.4	−.0109	.0037
02	05	02	0	14.8	0	15.2	−.0147	.0038
02	05	18	−0	04.3	0	10.4	−.0080	.0038
02	05	45	0	15.1	0	05.2	−.0069	.0034
02	06	35	0	01.7	0	03.2	−.0043	.0027
02	07	10	0	09.0	0	01.2	−.0024	.0040
02	08	00	0	14.1	−0	02.8	.0024	.0039
02	09	00	0	11.3	−0	02.2	.0016	.0040
02	09	30	0	04.2	−0	04.0	.0045	.0047
02	10	20	0	33.3	−0	14.4	.0130	.0060
02	11	00	0	11.3	−0	09.6	.0095	.0047
02	11	10	−0	09.7	−0	10.8	.0113	.0050
02	13	00	0	06.6	−0	01.6	.0044	.0045
02	13	30	0	43.3	−0	18.8	.0268	.0089
02	14	00	0	08.3	0	03.2	−.0027	.0044
02	15	05	−0	31.3	0	13.2	−.0179	.0006
02	15	45	0	22.7	0	40.0	−.0064	.0021
02	16	00	−0	16.6	0	16.8	−.0174	.0031
02	16	15	1	04.9	0	24.8	−.0120	.0006
02	17	00	−0	06.3	0	03.6	−.0061	−.0014
02	17	45	−0	24.0	0	13.2	−.0015	−.0007
02	18	00	−0	10.4	0	09.2	−.0096	.0002
03	04	00	0	08.9	0	05.8	−.0056	.0021
03	04	10	0	01.2	0	04.6	−.0044	.0016
03	04	50	0	51.1	0	14.3	−.0146	.0026
03	05	25	0	18.0	0	15.6	−.0127	.0034

Table 1.1 (*continued*)

Göttingen time			Declination		Inclination		Horizonal force	Vertical force
Day	hr	Min	Deg	Min	Deg	Min		
03	05	30	0	40.3	0	17.2	−.0167	.0033
03	05	40	0	02.2	0	18.0	−.0168	.0037
03	06	00	−0	11.9	0	15.2	−.0104	.0041
03	06	15	−0	16.3	0	13.6	−.0081	.0040
03	07	00	−0	05.8	0	02.4	.0000	.0043
03	08	00	0	05.1	0	00.0	.0022	.0035
03	09	00	−0	04.2	0	07.2	−.0032	.0023
03	10	00	−0	14.5	0	08.4	−.0063	.0023
03	11	00	0	01.5	0	08.0	.0067	.0021
03	12	00	0	06.1	−0	00.8	.0028	.0037
03	13	00	0	31.0	−0	18.8	.0185	.0037
03	14	00	0	05.4	−0	00.4	.0006	.0024
03	14	05	0	01.1	0	01.6	.0011	.0023
03	14	35	0	17.1	−0	00.4	−.0014	.0012
03	14	50	−0	01.8	0	04.0	−.0025	.0012
03	15	10	−0	04.0	0	04.4	−.0022	.0025
03	15	35	0	29.0	0	04.4	−.0083	−.0012
03	15	45	−0	32.8	0	07.6	−.0090	−.0012
03	15	55	−0	16.2	0	09.6	−.9112	−.0012
03	16	15	−0	05.9	0	08.0	−.0080	−.0013
03	16	30	−0	19.6	0	07.2	−.0059	−.0012
03	17	00	−0	13.2	0	06.8	−.0064	.0060

[a] The symbol − denotes a westerly deviation or increase of westerly declination and a decrease of dip and of force.

Table 1.1 lists the variation of the declination, inclination, horizontal and vertical forces, from the respective normal values as recorded at Toronto on 2nd and 3rd Sept., 1859. The variations of the declination and inclination are expressed in minutes of arc, and those of the horizontal and vertical forces in parts of the horizontal and vertical forces respectively. The symbol — denotes a westerly deviation or increase of westerly declination and a decrease of dip and of force.

3. *Observations at New Haven* (lat. 41° 18′ 27″), by Prof. C.S. LYMAN of Yale College.

The Auroral display of Aug. 28th, attracted attention at New Haven before the disappearance of daylight; and at 7h 40m mean time, when first seen by the writer, the whole northern quarter of the heavens was covered with a diffused, hazy light, rapidly changing its appearance, often of a crimson or yellowish hue, with occasional streamers, and with a denser mass of light, as usual, above the northern horizon. At 7h 45m this light reached the zenith; at 7h 55m it had passed 25° or 30° further south, and the marginal portion formed for a few minutes, an irregular belt or zone made up of evanescent fragments of arches, intermingled with streaks and patches of auroral light. No distinct bow, however, was at any time formed. At 8h 15m this portion had nearly vanished, and the southern edge was only 3 or 4 degrees below *alpha Lyræ* then near the meridian. Eight minutes later the edge touched *alpha Aquilæ* and in three minutes more was about 10° south of it. This southern margin was at times quite definite, and as it moved gradually towards the south the following notes were made of it at the time – the altitudes (near the meridian) being measured with a pocket quadrant, and probably in error less than half a degree. (The notes from Professor Lyman are given in Table 1.2.)

Table 1.2
Observations made at Yale College, New Haven, Conn., USA on the evening of 28 August 1859

Time	Altitude of edge	Observational Remarks
8h 27m	28°	
8h 29m	20° 30′	Bright and regularly arched
8h 30m 30s	17° 15′	Bright
8h 31m 20s	15° 45′	Bright, broad, edge well defined
8h 33m 15s	14° 00′	At star Epsilon Sagittarii
8h 34m 30s	14° 00′	Bright, and well defined
8h 35m 30s	12° 30′	Bright, and very well defined
8h 37m 40s	11° 20′	Edge, well defined
8h 38m 30s	10° 40′	Nearly the minimum alt
8h 40m 15s	12° 45′	Receding, 30′ or 40′ below star Epsilon Sagittarii
8h 42m 0s	10° 30′	Second arch, first 4° or 5° above
8h 47m 0s	12° 30′	Bright, edge well defined – at star ε
8h 49m 30s	12° 30′	Edge at same star

The times are local time.

At this time a small bright horizontal cloud of light some 2° wide and 5° or 6° in length, and pointed at each end, formed rapidly, near the meridian, in the open sky just below the arch at an altitude of 9° 50′, and moved slowly to the west parallel to the arch, through a distance of 15° or 20° till it was lost to view behind trees, about a minute, by estimate, after its formation. This cloud appears to have been identical with one seen by Prof. A.C. Twining at West Point.

The star *epsilon Sagittarii*, referred to in Table 1.2, is found by computation to have had an altitude at 8h 33m of 13° 36′, being then 45m past the meridian. Its altitude at 8h 50m was 12° 58′. When on the meridian at 7h 48m it was 14° 18′.

At 8h 52m, arch at the south growing fainter and breaking up. In a few minutes that quarter of the sky was nearly free from light.

At 8:54 an imperfect corona formed at an altitude of 69°. At 8:56 a better one with bright wisp at its center, alt. 72°. At 8:58½, corona 72½° apparently in vertical plane cutting *alpha Aquilæ*. (Azimuth of the star then, by calculation, 8° 22′ E.) The corona at these times not very definitely formed.

At 9h 5m, a bright mass of light noticed in the east, irregular, expanding, and stretching obliquely upwards and towards the south. At 9h 10m this was met by a similar irregular mass of light stretching around simultaneously from the west, forming an imperfect band or arch, with very little light below it, its lower edge at this time having an altitude of 27° on the meridian. At 9h 12m its altitude was 20° 30′, at 9h 23m, 16° 15′, and at 9h 31m, 16°, soon after which it faded. While this second curtain was shutting down in the south, it was noticed that the light in the north was rising gradually. At 9h 26m 30s, its lower edge passed Polaris, and three minutes later was at an altitude of 62°, leaving the sky below nearly free from auroral light. At the same time, the phenomena overhead began to be more active and brilliant, streamers and cloudy masses of light of various hues, chiefly crimson, forming and vanishing about the corona, attaining a maximum of splendor from 36 to 43 minutes after 9, and at 49m having become comparatively faint. This magnificent *umbrella-like* canopy, first formed by these tinted streamers and flashes about 9h 33m, and then extending not more than 30° or 40° from the corona, with an irregularly scallopped or fringed margin, rapidly expanded in all directions, being more brilliant towards the north, and there presenting the appearance of a descending curtain, or rather succession of curtains, until at 9h 38m, it had shut down to the horizon all round, except in the south. The magnificence of the display at this time was not surpassed by anything in the brilliant Auroras of 1837, as remembered by the writer. The curtains just mentioned had at one time something of the drapery-like appearance characterizing the Auroras seen by the French commission at Bossekop in 1838-9.

Although the position of the corona is known to coincide in general with the direction of the dipping needle, its altitude was several times noted with a view to ascertaining its fluctuations, if any. The coronal point, however, was seldom or never sufficiently definite to make the observations of much value for this purpose. In addition to the notes of the coronas before 9 o'clock given above, the following (see Table 1.3) were also made at the time.

Flashes and pulsations continued with varying brilliancy until after 11 o'clock, and according to the testimony of others, the display continued through the night, at times with much splendor.

The mean of the above altitudes of the corona is about 73° 20′. The dip at New Haven is about 73° 50′.

A similar display of rosy streamers and waving light, though less brilliant, was witnessed on the morning of Sept. 2, after midnight, as noticed in one of the morning papers. It was observed about daybreak by Prof. Forrest Shepherd, whose attention was particularly attracted by the rapid flashes and pulsations overhead, which seemed to him to indicate a very low elevation of the phenomena above the

Table 1.3
Observations made at Yale College, New Haven, Conn., USA on the evening of 28 August 1859

Time	Altitude	Observational remarks
9h 15m 30s		Altitude of C. 73°, very definite
9h 18m		Bright streak or cloud above C. (alt. 76°) lasted 1½ m
9h 22m	73°	Fine corona, long streamers
9h 24m 30s	68° 30′	Bright wisp near corona. C. not definite
9h 26m 30s	72° 15′	Good corona
9h 28m	73° 15′	Good corona
9h 30m 40s	73° 0′	Coronal cloud with rays from it
9h 33m	73° 40′	Definite, dark center of grand corona
9h 34m 30s	74° 30′	Very fine and definite
9h 36m 30s	75° 15′	C. not definite, colored streamers, splendid canopy
9h 38m	72° 45′	Tints brilliant
9h 40m	74° 0′	C. definite, bright red, whole display magnificent
9h 41m 30s	74° 0′	Splendid
9h 49m	73° 45′	Display much less brilliant
9h 52m to 58m,		Brilliant flashes and pulsations, chiefly towards corona
9h 53m 10s		A shooting star appeared about 15° above Polaris, moving rapidly towards the west over an arc of 15° or 20°
9h 58m		Auroral light diffused, faint-colored flashes
10h 0m		Very little except in north

The times are local time.

earth. The display was continued on the evening of the same day, being most brilliant between 9 and 10 o'clock when the whole northern heavens to the zenith, and often beyond, was filled with upward flashes and pulsations here and there, chiefly of whitish light, and with but few streamers.

On Sunday evening Sept. 4th, there were indications of a bright Aurora, though clouded sky prevented it from being particularly observed.

Auroral indications were also noticed on some other evenings of the preceding week.

Unfortunately no magnetic observations were made at New Haven.

The time piece used in noting the phenomena of the 28th was compared the same evening with the astronomical clock of the writer's observatory and found to be only 5 seconds fast of N.H. mean time[2].

4. *Observations of Prof.* ALEXANDER C. TWINING *on the Aurora of Aug.* 28*th,*1859, *made at West Point, New York.*

While the evening twilight was yet so strong as to make the phenomenon scarcely discernible, a rosy hue was seen spreading over a space reaching from the northeastern horizon to the north star and thence to my zenith, of uniform breadth throughout, and bounded south by a line through Alpha Lyrae, passing vertically down to the east. The time was 7h 25m by the watch – which however varied six minutes from true local time (too fast it is believed, making the local time 7h 19m). In about ten minutes the southern boundary moved to Alpha Aquilae, and the rosy light had extended itself visibly over to the west, and streamers were seen in the northeast. Very soon the northern sky became variegated nearly up to the zenith with advancing bands and flakes of yellowish and reddish cloud with streamers intermixed. At a quarter before eight o'clock, by estimation of the true local time, the streamers in the north were numerous; and by careful observation they were perceived universally to move towards the west.

At 8h 35m (by the watch) I looked again. A corona was then formed, and the auroral clouds and streamers were colored with tints of red and yellowish white. The most remarkable phenomenon was exhibited at the southern margin of the illumination. A yellowish cloud of extraordinary density and low altitude was seen advancing southward with an even and massive boundary which stretched entirely across the sky, in striking contrast with the clear blue beneath. It advanced beyond the bright star Antares, but soon receded and took a position which it retained ten or twelve minutes in a nearly level line exactly through that star, and a degree and a half, by estimation, below the star Epsilon Sagittarii. Its altitude therefore during that period – say from 8h 40m to 8h 50m (local time) – was about $11\frac{1}{4}^{\circ}$, at the first named star, and about $11\frac{3}{4}^{\circ}$ at the last: – at the meridian it was, probably, 12°. This southern line gave an opportunity for comparative observations in different latitudes, which, if improved, will determine the height of that auroral cloud with an unparalled certainty and accuracy. There was also during this period another phenomenon equally remarkable and, if extensively observed in widely different latitudes, equally valuable. Ten or fifteen minutes before nine o'clock a bright spot formed at or near the meridian, and three or four degrees below the above named level margin. It soon became a long and narrow cloud – say 8° long and $2\frac{1}{2}^{\circ}$ broad at the middle – but pointed at its eastern and western extremities. It moved to the west in the clear sky, and parallel to the cloudy margin above it. In its course it passed centrally over the pair of bright contiguous stars in the end of the Scorpion's tail, – showing an altitude, at the cloud's middle line, of 7°. In two minutes – as I estimated from subsequent, recollection – it moved about forty degrees. It then was hidden by the mountains in the vicinity. Soon after this disappearance it was observed that the entire expanse of cloud in the south from the zenith down was making a similar progress west, – at about the same rate, as nearly as could be estimated. At 8h 52m (local time) the original mass of vapor had moved nearly out of the southern field – leaving a far less dense and bright accumulation of cloudy strata over all that quarter.

At twenty minutes to a quarter before ten o'clock I observed again. The corona was then finely formed by streamers thickly and completely developed on every side. In about three minutes the display became suddenly very gorgeous, the red and white (yellowish-white) streamers and banks being very brilliant. So they continued for a quarter of an hour at least. In this period pulsations or auroral waves were seen propagating themselves rapidly upwards, and quite to the corona. That these did move upwards was determined by a close scrutiny. The *dome* was completed on every side. The southern streamers were particularly observed to originate beneath in a line or arch which I roughly, and without express verification, judged to be at about the altitude of the cloudy margin as observed at a little before nine o'clock. It may have been somewhat higher. At ten o'clock, or a little earlier, the phenomenon of the narrow cloud moving westward was strikingly repeated. The cloud however in this instance was longer and less definite in shape.

From ten o'clock to 12h 15m I did not observe. At this last mentioned time the auroral twilight shone brilliantly in the north, but my view in that quarter was obstructed.

I observed again from 2h 45m to 3h. The corona and dome were more regularly and completely formed than previously at ten o'clock, and more than I have seen them in either of the grand auroras of the last thirty years. The streamers were narrow, thick set, evenly distributed, and traceable to the corona. High in the north, observed against the constellation Cassiopeia, they moved across it from west to east, contrariwise to the motion in every

[2] N.H. represents New Haven mean time.

instance I have before observed in any aurora. Yet my morning observations on this particular (and nearly or quite universal and yet generally unnoticed) phenomenon of transverse motion have not been so numerous as at evening.[3] At the spot observed the motion was estimated as being fully 20° per minute. The ever varying wisps of cloud at the corona, and the southern streamers were also moving to the east. I left the display in full action without observing farther.

The repetition which took place Sept. 3d, although on a vastly diminished scale of grandeur, I observed about one hour, – say from 9h to 10h P.M. It was remarkable for the character of the auroral waves, which passed upward, illuminating successively different definite spaces in their path. The motion of these waves was far more moderate than I have ever before remarked. In this instance I could not estimate it to exceed forty-five degrees of arc in a second of time. The movement was everywhere distinctly upward; but the determination of arcual or angular motion in this phenomenon, is excessively difficult and inexact.

5. *Two letters from Prof. Daniel Kirkwood, Bloomington, Ind. [First letter.]*

Aug. 29th, 1859.

TO THE EDITORS, & c.

Gentlemen: – The most extraordinary display of the Aurora Borealis I have ever witnessed was seen from this place last night. It was observed immediately after the close of twilight, and, in the course of an hour, the whole northern horizon from east to west was illuminated. *The phenomenon continued from twilight to twilight*; the brilliancy being greater at 4 o'clock this morning than at any previous hour. It was the lightest moonless night our citizens have ever known. Tints of various colors were seen in different parts of the heavens; but what struck spectators generally with wonder was a thin, gauzy cloud of brilliant red, which appeared first in the east about 9 o'clock in the evening, and which seemed to move almost horizontally till it reached the northwest; at 9h 30m, lying precisely over the stars *Alioth*, *Mizar* and *Benetnash*, where it took the form of streamers converging towards a point somewhat south of the zenith. At the same time an arch of light appeared, having one extremity in the horizon beneath, or rather westward of, these red streamers, the other in the southeast; the zenith distance of its summit being about 40°, and its outer edge just reaching *Arcturus*.

Subsequently a splendid corona was formed, towards which the streamers moved in beautiful undulations. The most remarkable feature in the phenomenon, however, was its *extent*; not only the entire northern part of the visible hemisphere was illuminated, but the greater portion also of the southern.

I have just learn that during the night some lines of the magnetic telegraph were so much disturbed as to stop communication between different points.

[Second letter.]

Bloomington, Indiana, Sept. 9th, 1859.

TO THE EDITORS, & c.

Gentlemen: – Since the date of my hasty note of the 29th ult., we have had several more displays of the Aurora. Not having witnessed them myself, however, I have collected from others the following facts in regard to them: the first – a magnificent one – was seen by many of our citizens on the night of September 1st. It was noticed in the north about 11 o'clock, and gradually increased in brilliancy and extent until *the whole visible heavens were illuminated*; the light at times being such that ordinary print could be read without much difficulty. At 1 o'clock in the morning the portion of the heavens in which the light was most intense was almost exactly southeast, about midway between the zenith and horizon. The Stark County (Ill.) News thus describes the phenomenon:

"On yesterday morning, (Sept. 1st) between one and two o'clock, the whole heavens were aglow with deep red light, which presented every variety of beautiful aspect imaginable. When we first looked out, it looked as if two brilliant suns had just set, one in the east and one in the west, and the sky, at either point was painted in broad streams of crimson and gold. This lasted but a moment, then a deep glow overspread the whole sky, brighter at some points than others, but all red. The light was so strong at times, that we could see to read fine print with ease, and gave to buildings and other objects, a dim glow, like fire-light. An arc of some 20° was formed over the southern horizon, the inside of which presented a silvery appearance like the edge of a cloud brightened by the moon, and from this, broad streams of a lilac color would flash up toward the zenith and abruptly end."

The displays on the nights of the 1st and 2nd, are described by the Indianapolis Journal of the 3rd inst., as follows:

[3] My conjecture as to the occasion of this remarkable feature of auroral phenomena has heretofore been the following: – a streamer may be taken as the visible path of some portion of an electric current, normal, or nearly so, to the great thermal current of the earth. Such a normal current, in conformity with known laws, will experience a lateral movement under influence of the thermal current. It will also act upon the latter, – thus affecting magnetic intensity at the earth's surface, and, almost of necessity the declination and dip; which seem to be merely resultants of all the electro-dynamic actions upon the needle, subsisting at the time. Under the above hypothesis, therefore, every development of streamers must ordinarily concur with three other phenomena, viz., a lateral movement of the streamers, a change of the needle's direction, and a change of magnetic intensity. The hypothesis of a magnetic property in the auroral medium – whatever the latter be – seems wholly gratuitous. It is only requisite that the medium, or substance through or along which the current passes, shall be susceptible of illumination by such passage. Certain phenomena however indicate that the current transports the auroral vapor laterally with itself. The importance of this class of observations to questions relating to the cause of the aurora, as well as to the direction of currents, is obvious. (Footnote from original publication.)

"Another Aurora. – Yesterday morning (Sept. 1) from midnight till day another Aurora, more brilliant than the first, in this locality at least, was witnessed by those who had the good luck to be up at that time. At half past 11 o'clock it was quite brilliant, as a low arch of pure white light in the north, with but few radiations of colored light, and none that rose very high. It was very luminous, we could see as plainly as by moon light, when the moon is quarter full, though the light was a paler and more ghastly kind, more like faded daylight than moonlight. Later in the night it grew much brighter still, and extended over the whole visible heavens. A beautiful column of red rays rose in the northeast, and another rose in the northwest, and met in the zenith, and from this point of junction a flood of red light poured out over the sky running down to the horizon on all sides, south as well as north, and the whole earth colored under its beautiful but ghastly crimson. Many who saw it say it was far more brilliant than the one of Sunday night, and it certainly was much more luminous, though less marked by the darting rays and wonderful pulsations that made the first so splendid. It was seen at Cincinnati, and all over the Union, we suppose, as the first one was. Such frequency and splendor of Auroras at this season we never saw or heard of before.

"Still another. – Another very beautiful Aurora Borealis was seen last night (Sept. 2) about half past eight o'clock. At that time it was confined to the north entirely. The rays shot up in very distinct cones or peaks of light, and beautifully variegated in color.

On Monday the 5th, about 2 o'clock in the morning the phenomenon was witnessed for the fourth time within a week. Several beautiful streamers shot up from the northwest towards the zenith. The light, however, was of short duration.

It may be proper to remark that last evening, the 8th, about 9 o'clock, notwithstanding the bright moonlight, indications of the Aurora were again discoverable.

6. *On the Meteorological and Magnetic Phenomena accompanying the Aurora Borealis of Aug.* 28*th,* 1859, *as observed at Springhill (near Mobile), Alabama;* by Prof. A. CORNETTE, S.J.

I have thought that the meteoric conditions which preceded, accompanied and followed the Aurora Borealis of August 28th would be read with interest by all who witnessed that phenomenon on this memorable occasion. I copy from my daily journal without translating the French metrical numbers which I have for many years employed.[4]

I add some hourly observations upon the perturbations of the magnetic current after the phenomenon (see Tables 1.4 and 1.5), as well also as some observations on the subject at large.[5]

In order to a full understanding of these tables it would be requisite to know also the whole course, absolute and relative, of the various atmospheric phenomena. This would be too long an undertaking, although the means are at command. But from the observations of the four days mentioned, we are able to draw the following conclusions:[6]

1st. The density of the air shows an unusual course. The barometer daily rises, as we know, under the equator (and at Springhill), from four to nine o'clock in the morning, and from four until nine in the evening, and it falls regularly in the intermediate hours. During six years I have scarcely found a single exception to this law between the equator and Mexico, and the exceptions are very rare at Springhill. Such an exception happened on the night of the Aurora Borealis (Aug. 28) when the barometer remained stationary from three to nine, and rose after nine when it should have fallen.

2d. The temperature fell considerably but not until the next day (29th) under a northwest wind, which had not blown for a long time, and which is ordinarily cold.

3d. The tension of water vapor in the air was slightly modified. The mean degree of saturation on the 27th and 28th was 21°.35, tension 18.7mm; 29th and 30th was 22°.40, tension 19.9. The 28th at 9 in the evening during the phenomena 22°.26, tension 19.7; 28th at 10 in the evening after the phenomena 23°.47, tension 21.2mm.

4th. The absorption of water by the atmosphere either in an open vase, upon the belvidere of the college, in a room, or in the forest, was considerably more before than after the phenomena.

5th. On the 28th of August there were two diametrically opposite winds. The south, on the earth, and the north, in the upper regions, driving the cirrus clouds to the southward. The 29th the northwest wind prevailed, lowering the barometer.Without doubt this opposition of winds is due to some extraordinary phenomenon, by which the atmospheric equilibrium was destroyed. I have been able both here and under another sky, to recognize that there is some intimate

[4] In the original publication, a table of meteorological observations at Springhill, Alabama is given on page 399. This table has been omitted from this compilation. Of note is that there were nebulous clouds on the evening of 28 August and nebulous clouds to serene and slight stratus clouds during the night of 28 August. The morning of 29 August was cloudy.

[5] In conformity with our design to give at present only facts, we reserve Father Cornette's ingenious speculations to another occasion. (Footnote from original publication.)

[6] Apparently at that time there was a belief that the aurora was associated with meteorological phenomena. From the meteorological tables presented in the original article, Professor Cornette draws six conclusions related to the meteorological observations and one conclusion related to the magnetic variations. For completeness, and for historical reference, we have included the first six conclusions of Professor Cornette as well as the seventh conclusion which is pertinent to his discussion of the magnetic observations at Springhill, Alabama.

Table 1.4
Magnetic declination (relative diurnal) at Springhill, Alabama, USA from 27-30 August 1859

Date 1859	4h	6h	9h	12h	3h	6h	9h
Aug. 27	23′ 29.5″		34′ 56.5″		26′ 40.5″	23′ 29.5″	22′ 10.0″
Aug. 28	34′ 56.5″		47′ 59.0″		29′ 50.0″	41′ 59.0″	66′ 54.3″
Aug. 29	61′ 47.5″	47′ 6.0″	36′ 14.0″	40′ 0.5″	37′ 34.0″	30′ 50.0″	37′ 34.0″
Aug. 30	36′ 15.0″		28′ 7.0″		25′ 59.0″		31′ 7.0″

Table 1.5
Magnetic Declination (relative diurnal) at Springhill, Alabama, USA in the night of August 28, after the Aurora Borealis[a]

Hours	Declination
9h 10m	82′ 52.0″
9h 15m	76′ 29.0″
9h 20m	71′ 22.0″
9h 25m	58′ 39.5″
9h 29m	50′ 17.5″
9h 34m	55′ 25.0″
9h 37m	56′ 39.0″
9h 50m	64′ 21.0″
10h 0m	65′ 39.0″
10h 10m	61′ 47.5″
4 A.M.	61′ 47.5″
5 A.M.	32′ 24.0″

[a] Magnetic declination values extracted from the original table which also contained meteorological observations.

relation not only between the struggle of the winds and the course of the magnetic currents, but also (the discussion of which is out of place here) to reach an induction in explanation of earthquakes. That fearful phenomenon which I have felt and observed seventy-three times, has always occurred during a calm following a struggle of winds.

6th. Before the Aurora Borealis cirrus clouds (frequently caused by contrary winds) prevailed.

7th. The magnetic declination is the essential point which demands our attention: declination relative, hourly or daily. The normal daily course of the magnetic needle in the northern hemisphere is well known, viz., it moves to the east from four o'clock in the morning till near eleven, and from three till near ten in the evening, and returns to the west in the intermediate hours. In the southern hemisphere the course is opposite.

Near the equator the course is regular and the amplitude restricted. In high latitudes it is more disturbed and the amplitude larger. Three years observations in 4°, 14°, and 19° north latitude, leaving me no doubt upon the accuracy of these maxima and minima. In these latitudes this daily march was disturbed only during earthquakes and returned to its normal order after the quaking. In Springhill (where I have followed its daily course five times and even eight times a day according to my occupations, since June, 1858) it has had a regular course depending on the wind from the end of September (1858) until the 17th of August last. In short, from August and in September it has experienced great perturbations which I was tempted to attribute to the influence of the comet of last fall. But the Aurora of August has destroyed my conjectures and cast a new light upon this mystery. Since the 17th of last month (Aug.) the normal course of diurnal declination was scarcely recognizable and consequently I have followed it with the more interest. This disordered movement reached its maximum of observed perturbation at 9 o'clock 10 minutes in the evening of the 28th of August immediately after the auroral phenomena, and its course has since become as irregular as before. The perturbations were finished near 4 o'clock in the morning of the 29th, and last evening (September 1st) the declination had gradually diminished.

By the tables at the opening of this communication (i.e. Tables 1.4 and 1.5) we see that the easterly declination between 3 in the evening and 9h 10 in the night was 53′ 2.0″. This is the first occasion I have been able to seize upon so considerable an anomaly in so short time. The needle subsequently made two new oscillations up to 10 o'clock 10 min., when I retired.

This morning at 4 the needle had attained another considerable maximum. I ran to the window in time to see the conclusion of another Aurora Borealis. The Aurora of the evening lasted, I understand, until near 3 o'clock, and with a light as brilliant as that of the moon, but without luminous rays, neither was there much diffused purple light. The same cause had produced the same effect, since that moment, (which does not coincide exactly with its maximum) the declination has decreased gradually. The Aurora today descended quite to the horizon; it appeared as a little cloud at the northeast and was dissipated at 4 o'clock 30 minutes A.M.

The purple light extended from the north on the night of the 28th of August at an angle of 80°, accompanied by thin sheafs of white light which shot up for a moment from the magnetic pole to the height of Polaris (30° 41′).

If observers in different latitudes could have established the conclusion that the opposed aerial movement reigned simultaneously in the atmosphere and developed in the air electric tension, that a calm followed the struggle, and that the Aurora Borealis happened during a calm, they would have made a glorious conquest for science.

But these facts remain yet to be observed. No Aurora Borealis appeared to me in the equinoctial regions as far as lat. 20° from 1847 to 1857. The first which I saw at Troy, N. Y., July 25th, 1857 – took place after a rain storm and

above a low characteristic cloud during a calm which followed a contest between a south and southeast wind. It was less brilliant than that of August 28th.

The Aurora of August 28th, took place in a calm, after a struggle between two opposite winds, and that of today took place in the calm after a day in which the north wind prevailed in the morning and the south in the evening, but the clouds were immovable and induced the belief that the south wind was low, and that the north wind had ceased.

The Aurora Borealis of the 28th appears to authorize the inference that the light diverged from the magnetic pole, or that it was produced by a radiation of the polar magnetism from the terrestrial magnet. The most brilliant rays which escaped, emanated rapidly from a center below the horizon and that center was in the direction of the magnetic pole. A simple plumb line showed that the rays which reached Polaris were not perpendicular beneath that star but were inclined to the east some degrees.

Now the magnetic pole at Springhill is at 6° 28′ east, (mean from several observations). The other inclined rays might have served to determine the place of this center had time permitted my arranging an instrument for taking their sine.[7]

The low clouds frequently characteristic of the Aurora Borealis did not appear with those of last night. On the 28th there was an expanded and regular stratus in the horizon even to the height of about 8°, with heat lightning from time to time from the northwest.

7. *Observations at Jefferson Co., Miss.* (about lat. 31° 50′, lon. 91°), by an anonymous correspondent – published September 9th in the Port Gibson Reveille.

The Aurora Borealis of Sept. 1, 1859. – My attention was attracted at 11 o'clock last night, (Sept. 1st) to this rare but beautiful celestial phenomenon.

A belt of white light tinged with pink shot up from the northern horizon to the height of twenty or twenty-five degrees and extended east and west nearly the same elevation. Looking to those points I noticed the color deepening until about N.E. and N.W. it attained a bright deep scarlet red, like deeply tinged clouds of our dry-weather sunsets. It shot up in irregular columns arising in places almost to the zenith and spreading out fan shaped and paling as it rose. The white light was stationary except apparently sinking lower or rising higher. The colored portions evolved, rolled, curled, and changed place and color, like the vapors climbing a mountain side. There was a very light surface breeze from the N.N.E. but the tendency of the meteor was to S.S.E. At half-past twelve, it embraced almost the entire northern hemisphere west, and at the height of from 45 to 60 degrees, a broad scarlet belt pointing S.W. to N.E. appeared, 30 degrees long and half as wide, having a dozen bright bars running longitudinally from end to end. It presented every color of the rainbow except blue. At the same time a brownish red column shot up from the N.E. resembling the flame of a huge lamp or candle vibrating and flickering as though disturbed by wind. No sound was heard.

At 1 o'clock A.M., the white light under and to the left of the polar star was as bright as twilight half an hour before sunrise of a fair morning and extended almost to the zenith. I could see every object in the rooms – the hands of a clock and watch – out of doors the earth had a reddish glare, and everything was as visible as at half moon, but more distinct as no shadows were cast.

In the white portions the stars were dim but in the colored parts east, west, and overhead were very bright but reddish, like the planet Mars. *Aldebaran*, the *Pleiades*, *Orion* and the two dog stars rose during the time and were unusually brilliant. The southern hemisphere looked dark and gloomy from contrast, but was without a cloud. All around the northern horizon there was a thin narrow belt, barely reaching the tree tops of cirro-stratus clouds. The lights were evidently beyond these. I counted seven meteors shooting athwart the heavens, from S.W. to N.E. during the two and a half hours I was up, similar to those of the great meteoric shower of November 13th, 1833, and such as may be seen any fair night between the 10th of August and 1st of December.

We witnessed an Aurora the early part of October 1851, large and brilliant for this latitude, but in no ways comparable to the one of last night. The succeeding winter was long and unusually cold.

SENEX, SR.

Jefferson Co., Miss., Sept. 2d, 1859.

8. *Description of two magnificent Auroœ Boreales observed at Havana, Cuba.* (In a letter from M. ANDREAS POEY, Director of the Physio-Meteorological Observatory at Havana, Sept. 8th, to the Editors.)

The appearance of the Aurora Borealis in the twenty-third degree of north latitude is an event so rare that it naturally produces fear in the common mind, and arrests the attention of men of science. The records and traditions of Cuba show but few examples of the occurrence of this phenomenon. The *first* is said to have been seen on the 13th of November, 1784; the *second* upon the 14th of November, 1789; the *third* in 1833 (Nov.?); the *fourth* on the 17th of November, 1848; and finally the *fifth* and *sixth* now recorded.

First aurora on the night of Aug. 28th–29th, 1859. – The first appearance of a reddish gleam was seen at 5 minutes past 9 in the evening, which rapidly rose exactly in the north and extended over the space embraced between the N.E. and N.W., reaching the height of *Polaris* about 23°. Some persons, it is said, saw it as early as 8h 45m. Its color grew brighter until 9h 30m, but from this time it faded to its total disappearance at 10h. A slight luminous and whitish tint afterwards covered this part of the sky. But at 1

[7] It was equally impossible to prove that the rays change their direction at the same time that the magnetic needle changes its direction. (Footnote from original publication.)

o'clock it reappeared, reaching again to *Polaris*. It attained its maximum brilliancy at 4h to 4h 10m – its base being of a beautiful carmine red, from which rose divergent rays of a variable diameter, some fire-colored, others whitish, and rising to the zenith, the reddish tint covering a space of 180° from N.E. to N.W. At 4h 20m the aurora disappeared entirely.

Second Aurora on the night of the 1*st–*2*d of September*. – This second Aurora having been incomparably more brilliant, more extended, and more permanent than the first, it seems best to notice the details of its development with care, as points of comparison with observations in higher latitudes. This aurora was not visible before 12h 30m, and from that moment to 5h A.M. I followed all its changes. From 12h 30m to 12h 45m it spread towards the east, and afterwards towards the west, then turning yet more towards the east with white rays which grew pale at the extreme west. From 12h to 1h, after the white rays became extinct a portion of the east appeared of a beautiful fire-red. A part of the west became also more flaming, and the summit of the arch, poorly defined, attained the height of *Polaris*, with a movement of translation toward the east. At 1h a brightness streamed from the north moving towards the N.N.E., defining by its light the outlines of cumulus clouds, of the horizon, of the sea, and the entrance of the fort. As this brilliancy increased and rose above the horizon its tints passed into light blue, involving the red portion at the northeast, and presently it began to fade out. The upper red segment rose considerably above *Polaris*. The illumination faded towards the northwest and embraced the whole of the auroral base; afterwards it rose again to the height of 12°. White rays with red and blue were then seen towards the west, which dilated longitudinally, oscillated laterally, were extinguished and resumed their brilliancy again by turns. The intensity of the illumination increased towards the east, and the red segment towards the west became more brilliant and more extended, until at the E.N.E. it reached its maximum of brilliancy. At 1h 15m these rays were spread over the whole Aurora. The illumination attained to the E.N.E. in the space of three minutes, then it extended to the N.N.W. The east and still more the west then became very red. The illumination reappeared next at the east. The whole Aurora now became very red with rays to the north and west. This shade spread almost to the zenith. The fire-red of the west remained constant. The general depth of the Aurora faded while the whitish and reddish rays became more brilliant. But it was from 1h 30m to 3h 15m that the half hemisphere of the north from east to west was completely covered by a rich red tint, more orange than carmine, the gently arched summit of which passed the zenith towards the northeast, attaining the height of 100 degrees, accompanied with whitish rays and also with the red rays, more vivid then the general tones of the segment rising to the zenith, yet without passing it. At 2h the Aurora had attained its highest magnificence. The heavens then appeared stained with blood and in a state of complete conflagration. At a vast distance above the upper red segment appeared a second whitish segment which rose 23° above the horizon, while the upper red segment spread for 100° to the northeast and towards the constellation of Orion. The illumination whose different phases I have followed then constituted a white arch, the central and visible base of the Aurora above a bed of cumulus clouds which reached 8° above the horizon. At 2h 45m the two segments or arches of the Aurora declining toward the horizon, the lower white one first disappeared at 3h 15m A.M. From 3h 30m to 4h the general reddish tint disappeared and reappeared many times but remained more intense towards the northeast. From 4h to 5h it gradually declined as the dawn commenced. At last the Aurora disappeared at 5h A.M. in the prolongation of the magnetic meridian where it made its first appearance. From 1h the west was constantly more flame-colored than the east.

These two Auroras have manifested the following peculiarities worthy of remark.

1st. The reappearance on the third night.
2d. Their magnificence: in height considerably more than 100° in extent over 180°, their long continuance to day-dawn here under this latitude of 23°.
3d. The absence of an obscure lower segment although it might readily have been covered with the cumulous clouds which rose 8° above the horizon: above all, the expanse of the Aurora, a segment the extent of which has not been well established.
4th. The great height of 23° of the luminous segment or lower white arch visible only in the second Aurora.
5th. The rays or jets of light, some of which rose diverging from a point very far below the horizon, while others springing from the centre of the Aurora appeared to converge slightly toward the zenith. Again they vanished for an instant to reappear over other points, some having a brilliant red, others a dense white mass with a feeble lateral pulsation and an alternate elongation and shortening. Sometimes the base of the rays was most brilliant and most deeply red colored, soon again the deepest and most brilliant color was on the upper extremities.
6th. The reiterated movement of translation of the whole aurora from east to west, followed by retrocession in an opposite direction, movements noted as being very rarely observed.

Space does not allow me to notice the concomitant phenomena which were produced, which from their importance will be the object of the next communication which I shall have the honor to address the Academy. I enumerate the principal points observed.

1st. There was no noise in the aurora.
2d. The freely suspended needle of Marianini's Ré-Electrometer manifested not the slightest oscillation.

3d. The gold leaf electroscope of Bohnenberger gave no sign of atmospheric electricity. This neutrality of the magneto-electric force in the presence of so magnificent an Aurora Borealis is worthy of remark, for these two pieces of apparatus constructed by M. Ruhmkorff have great sensibility.
4th. There was no trace of polarization in the auroral light but very sensibly in its reflection upon the surface of the sea and upon the opposite clouds.
5th. It was perfectly calm.
6th. The temperature and barometric pressure were as usual.
7th. Two days after the Aurora the barometer rose from a half millimeter to one millimeter, following the height of the diurnal tide, and a northeast breeze set up.

9. Observation *at San Francisco, California;* by Dr. JOHN B. TRASK. (In a letter to the Editors, dated Sept. 1st, 1859).

On the night of the 28th of August, at the hour of 10 o'clock, and continuing from that hour until near daylight we had for the first time in ten years in California a fine display of the Aurora. The sky was illuminated from the northwest to the northeast, with a flood of crimson light extending to the zenith through which the whiter and yellow columns would start at varied intervals. It was a magnificent display and will compare favorably with the best varieties of your wintry months.

10. *Height of the base of the Auroral curtain, Aug.* 28.

The minimum altitude above the southern horizon of the lower margin of the meridional part of the auroral curtain, seen during the display of Aug. 28th, previous to 9 P.M., was determined independently by Prof. C. S. Lyman and by Mr. E.C. Herrick at New Haven, and by Prof. A. C. Twining at West Point, N. Y. These three determinations were made at about the same absolute time (about 8h 40m New Haven time) and range from 10° 40′ to 12°. Fortunately, a like observation was made at Philadelphia, Pa., (N lat. 39° 57′), by Mr. Chas. J. Allen, where and at Burlington, N.J. the display was observed by Mr. Allen and by Messrs. Benj. V. Marsh and Samuel J. Gummere. Mr. Allen found this minimum altitude at Philadelphia to be about $22\frac{1}{2}^{\circ}$. Assuming that the curtain was for a moderate distance parallel to the earth's surface, and that the observers saw the same curtain, it follows that the lower visible margin thereof was about forty miles above the earth. The probable error of this result seems to be quite small, yet it is highly desirable that the conclusion should be tested by observations taken at places between New Haven or West Point and Philadelphia and beyond, as far as Annapolis or Washington. The elevation of auroral belts observed in New England has been found to exceed one hundred miles, but the relation between auroral belts and streamers is little understood.

11. *Appeal to Observers.*

It is conceded that there is much connected with the auroral light which has not yet been fully explained, but it is unquestionably one of the most important of all meteorological phenomena, and its full explanation, would probably bring with it the explanation of a large number of other phenomena, such as the origin and laws of atmospheric electricity, as well as of terrestrial magnetism. It is then of the highest importance to science that we should ascertain what the aurora is. The Aurora of Aug. 28th and following days affords a peculiarly favorable opportunity for deciding this question, and it is therefore important that this Aurora be thoroughly investigated. A thorough investigation of a single Aurora promises to do more for the promotion of science than an imperfect investigation of an indefinite number. It has been decided therefore to make a strenuous effort to investigate the laws of this auroral exhibition. For this purpose we need a careful collection of all the observed facts; and it is earnestly requested that every person who made accurate observations of the Aurora of Aug. 28th would communicate them to us for publication. This appeal is addressed to men of science in every part of North America where an Aurora was seen on the night of Aug. 28th. It is also addressed to observers on the ocean, and indeed throughout every portion of the globe, with the sole exception of Europe; for we assume that the appearances in Europe will be fully reported through the European journals. It is not improbable that this auroral exhibition may have been witnessed throughout the principal part of the northern hemisphere; and it is of great importance to know how far it did extend.

In order to render the communications of observers more definite and precise, we will briefly indicate the kind of information we desire.

We desire an accurate but concise description of all the phenomena with the *exact time* of their occurrence.

1. If a dark segment was seen resting either on the northern or southern horizon, or both of them, its altitude and position should be accurately stated.
2. If the streamers were seen to converge to a single point of the heavens, this point should be accurately located and the time of observation given.
3. If any single phenomenon (such as a detached luminous arch extending from the east to the west horizon) was so conspicuous as to be easily identified, it is important to have an accurate statement of its position and the altitude of its vertex, with the time of its formation and disappearance.
4. Was the Aurora seen in the southern half of the heavens, and how near the southern horizon did it extend?
5. Describe the color of the light, as well as its intensity.
6. If the Aurora exhibited any great variations of brilliancy it is important to know the times of least as well as the times of greatest brilliancy.

7. Did the Aurora exhibit any sudden flashes? Were there any pulsations like waves of light rushing up from the horizon?
8. If any observations were made showing the influence of the Aurora upon the magnetic needle, it is desirable that they should be communicated in detail.
9. The kind and degree of influence exerted upon telegraph wires.
10. Was any motion of translation observed in the Aurora, and if so, in what apparent direction and with what velocity?

It is proposed to publish in future numbers of this Journal, the most important part of whatever information may be obtained as the result of this appeal; and it is intended to present the facts in such a form that each one will have all the materials which are necessary to conduct the investigation for himself. After all the facts have been communicated it is proposed to present an analysis of the whole, with some speculations on the general subject of Auroras. Observers may forward their communications either to the "Editors of the Journal of Science, New Haven, Ct.," or to "Prof. Elias Loomis, New York City," who has consented to undertake the discussion of the phenomena.

Postscript. – An exact data, relating to the remarkable auroral arch of April 29,1859 – mentioned by Mr. Herrick on p. 154 of this volume, will *be very acceptable*.

Appendix B. ART. XII. - *The Great Auroral Exhibition of August* 28*th to September* 4*th*, 1859. – (2d ARTICLE)*

In our last Number we gave some observations of this grand auroral exhibition, from a number of stations widely distant from each other. We now put on record some facts observed respecting the influence of the Aurora upon the wires of the electric telegraph. We hope in our next Number to be able to communicate additional intelligence respecting this Aurora.

1. *Observations made at Boston, Mass., and its vicinity by* GEORGE B. PRESCOTT, *Telegraph Superintendent.*

My attention was first called to the possibility of the Aurora Borealis affecting the telegraph wires in 1847, while operating the Morse (electro-magnetic) telegraph at New Haven; but I was not fortunate enough to observe it until the winter of 1850. At this time I became connected with Bain's (electro-chemical) telegraph in this city, and observed some effects of the aurora; but, owing to the feeble displays, only to a limited extent.

In September, 1851, there was a remarkable display of the Aurora Borealis, which completely took possession of all the telegraph lines running out of the city, and effectually prevented any business being done over them during its continuance.

The following winter there was another remarkable display which occurred upon the 19th of February, 1852. I furnish from data recorded in my journal at that time the following particulars in regard to this phenomenon.

The system of telegraphing used upon the wires during the observations of February, 1852, was Bain's electro-chemical. The circuit was what is known as the open circuit, – that is, the key, which throws the current from the battery upon the line, was always open when a message was being received from a distant station, and the current passed through the chemically prepared paper to the earth without uniting with the home battery. Each station was furnished with its own battery, the negative pole of which was invariably connected with the earth, and the positive, by the depression of the key, with the line.

The line extended in a direction nearly northeast and southwest. The paper was prepared with a solution of cyanid of potassium, made after the following recipe. Six parts prussiate potassa dissolved in water; two parts nitric acid; two of ammonia. This solution will scarcely color the paper, while it will render it quite sensitive to the action of the electric current. The stylus was made of No. 30 iron wire. A battery of ten cups Grove, with the line well insulated, will decompose the salts, and uniting with the iron stylus, leave a bright blue mark upon the paper, at a distance of 230 miles.

The positive pole only produces a colored mark; the negative bleaches the paper.

When there is no electric current upon the wires, the pen leaves no impression upon the paper; but the slightest current will produce decomposition; and the color of the mark depends upon the strength of the current.

Free or common electricity produces no color upon the paper. It emits a bright spark in passing from the stylus to the moistened paper; produces a quick, sharp noise, like the snapping of a pistol and disappears. This effect is totally unlike that of the Aurora Borealis, as will be seen from the following.

Thursday, February 19, 1852. Towards evening a blue line appeared upon the paper, which gradually grew darker and larger, until a *flame of fire* followed the pen, and burned through a dozen thicknesses of the prepared paper. The paper was set on fire by the flame, and produced considerable smoke. The current then subsided as gradually as it came on, until it entirely disappeared, and was then succeeded by a negative current, which bleached instead of colored, the paper; this also gradually increased, until, as with the positive current, it burned the paper, and then subsided, to be followed by the positive current again. This state of things continued during the entire evening, and effectually prevented any business being done over the wires. The current came in waves of varying intensity – light at first, then stronger, until having attained to the volume and intensity of at least two hundred Grove cups, it subsided, and was followed by a current of the reverse polarity. This *invariably occurred*, and may be set down as an established fact, that the currents from the Aurora Borealis always change their polarity during every wave.

* Originally compiled by the Editors and published in the American Journal of Science, Second Series, Vol. 29, No. 85, pp. 92–97, 1860.

I have seen the auroral current produce magnetism, decompose chemicals, and produce heat and fire.

The effects of the magnetic storm of August 28th, 1859, were apparent upon the wires during a considerable portion of Saturday evening, and during the entire day, Sunday. At 6 P.M. the line to New Bedford (60 miles in length, running a little west of south) could be worked only at intervals, although, of course, no signs of the Aurora Borealis were visible to the eye at that hour. The same was true of the wires running east through the state of Maine as well as those running north to Montreal. The wire between Boston and Fall River had no battery connected with it on Sunday, and yet there was a current upon it during the entire day, which caused the keepers of the electro-magnets to open and close as the waves came on and receded.

Upon the lines which had batteries connected Sunday evening, it was observed that the poles changed during every wave of the aurora – each wave occupying from fifteen seconds to half a minute. When the poles of the Aurora were in unison with the poles of the battery upon the line, the effect was to increase the current; but when they were opposed, to neutralize it, I will give my proofs of this farther on. It is to be observed that the effects I have illustrated in relation to the Aurora of August 28th, 1859, were observed upon the Morse (electro-magnetic) system. The same were, however, observed upon the House and Hughes lines running out of the same office.

It is not true that there is any difference in the effect produced upon the wires by the Aurora Borealis, whether they run east and west, or north and south. Lines running to every point of the compass diverge from the office here and were equally affected. Even the short wire running from the office in State street to the observatory in Cambridge (five miles long) was sensibly affected.

In an article which I published in the Boston Journal, August 31st, I stated that the current from the Aurora Borealis could have been used for telegraphic purposes, but I did not imagine it would be so soon verified by the actual fact.

On Friday, September 2nd, 1859, upon commencing business at 8 o'clock A.M. it was found that all the wires running out of the office were so strongly affected by the auroral current as to prevent any business being done, except with great difficulty. At this juncture it was suggested that the batteries should be cut off, and the wires simply connected with the earth. The Boston operator accordingly asked the Portland operator to cut off his battery and try to work with the auroral current alone. The Portland operator replied, "I have done so. Will you do the same?" Boston operator answered, "I have cut my battery off and connected the line with the earth. We are working with the current from the Aurora Borealis alone. How do you receive my writing?" "Very well indeed," rejoined the Portland operator; "much better than with the batteries on. There is much less variation in the current, and the magnets work steadier. Suppose we continue to work, so until the Aurora subsides?" "Agreed," said the Boston operator. "Are you ready for business?" "Yes; go ahead," was the response. The Boston operator then commenced sending private dispatches, which he was able to do much better than when the batteries were on, and continued to use the wire in this manner for about two hours, when, the Aurora having subsided, the batteries were resumed. While this singular phenomenon was taking place upon the wires between Boston and Portland, the operator at South Braintree – Miss Sarah B. Allen – informed me that she was working the wire between that station and Fall River – a distance of about forty miles south – with the auroral current alone. Since then I have visited Fall River and have the statement verified by the intelligent operator upon the railroad line at the dépôt in that village.

The office at the dépôt is about half a mile from the regular office in the village. The battery is kept at the latter place, but the operator at the dépôt is provided with a button or switch, by which he can throw the battery off the line, and put the wire in connection with the ground at pleasure. The battery at the other terminus of the line is at Boston, but the operator at South Braintree is furnished with a similar switch, which enables her to dispense with its use at pleasure. There are no intermediate batteries; consequently if Fall River operator puts his wire to the earth, and the South Braintree operator puts her wire to the earth, the line is without battery, and of course, without an electrical current.

Such was the state of the line upon the 2nd of September last, when for nearly two hours, they held communication over the wire with the aid of the celestial batteries alone!

I have restricted myself in this article to facts observed by myself. I have stated nothing which I am not absolutely certain of, and which, if necessary, can be proved by a number of reliable witnesses.

2. *Observations made at White River Junction, Vt., communicated by* J. H. NORRIS, *Telegraph Superintendent.*

During the forenoon of Sept. 2d, an unusual current of varying intensity was present most of the time on the wires of the Vermont and Boston telegraph. The polarity of this current appeared to change frequently, sometimes being opposite to and nearly or quite neutralizing the battery current when an attempt was made to use the line; at other times much increasing the force of the battery current. The auroral current produced the same marks upon our chemical paper (we use the Bain or chemical system of telegraph) as those produced by the use of the battery. Signals and messages were transmitted between Boston and Manchester *by the sole use of the auroral current.*

3. *Observations made at Springfield, Mass., by* J.E. SELDEN.

On the evening of Aug. 28th, upon the Boston and New York circuit, at one moment there was a very heavy current on the wire, and the next none at all. On the Albany and Springfield circuit, a *flash* passed across from the break key of the telegraph apparatus to the iron frame, the flame of which was about half the size of an ordinary jet of gas. It was accompanied by a humming sound similar to a heavy current passing between two metal points almost in

contact. The heat was sufficient to cause the smell of scorched wood and paint to be perceptible.

[The observations at Springfield, as well as those at New York and Washington were communicated by Messrs. Lewis and Lovett of the New York telegraph office.]

4. *Observations made at New York by* J.C. CROSSON, *Telegraph operator*.

On the evening of Aug. 28th, at $7\frac{1}{2}$ o'clock, I experienced considerable difficulty in working, on account of the variation of current. I could work south by constantly altering the adjustment of my magnets, but the magnetism on the eastern circuit was so nearly destroyed that I could do nothing. About ten o'clock I could see nothing of the Aurora in the southern hemisphere, yet the same variations of current were manifest upon the line for an hour afterward. There was during this time a very strong turning current from the east, which resembled a reversed current so much that I disconnected my battery and put on a 'ground,' but I could not then get magnetism sufficient to work a simple armature. At 12h 30m the current from the east assumed a new feature, producing enough magnetism to work quite well, yet wavering and varying in intensity.

5. *Observations made at Philadelphia, communicated by* H. EMMONS THAYER, *Telegraph Superintendent*.

On the evening of Aug. 28th, about 8 o'clock, we lost current on all our four wires running from Philadelphia to New York, and we had strong circuit as if from a near ground connection; but there was no interruption on wires running south to Baltimore and Washington. At 9h 10m the wires were relieved to a great extent from the influence of the Aurora, giving us our usual working current.

On testing wires at 8 o'clock on the morning of Sept. 2d, I found two of our wires, those running *via* Camden and Amboy to New York, strongly under the influence of an Aurora. The effect was different from that of Aug. 28th. There was an intensity of current which *gave a severe shock* when testing, giving a reversed current, neutralizing our batteries, and destroying magnetism. On removing the batteries, we had a very strong circuit, giving powerful magnetism, but could not raise New York. On the line running from this city to Pittsburgh, the operator, Mr. Steacy, succeeded in transmitting a business message to Pittsburgh *wholly on the auroral current*. The current was changeable, suddenly disappearing and returning at intervals of from five to ten minutes. The signals were distinct and the conversation lasted four or five minutes, the operators exchanging remarks as to the singularity of the phenomenon. At 9 A.M. all the wires were relieved from the effects of the Aurora, and worked well as usual.

6. *Observations made at Washington, D.C., by* FREDERICK W. ROYCE, *Telegraph operator*.

On the evening of Aug. 28th I had great difficulty in working the line to Richmond, Va. It seemed as if there was a storm at Richmond. I therefore abandoned that wire, and tried to work the northern wire, but met with the same difficulty. For five or ten minutes I would have no trouble, then the current would change, and become so weak that it could hardly be felt. It would then gradually change to a 'ground' so strong that I could not lift the magnet. The Aurora disappeared at a little after 10 o'clock, after which we had no difficulty. During the auroral display, I was calling Richmond, and had one hand on the iron plate. Happening to lean towards the sounder, which is against the wall, my forehead grazed a ground wire. Immediately I received *a very severe electric shock*, which stunned me for an instant. An old man who was sitting facing me, and but a few feet distant, said that he saw *a spark of fire* jump from my forehead to the sounder.

7. *Observations made at Pittsburgh, Pa., communicated by* E.W. CULGAN, *Telegraph manager*.

During the Aurora of Aug. 28th the intensity of the current evolved from it varied very much, being at times no stronger than an ordinary battery, and then suddenly changing the poles of the magnets it would sweep through them, charging them to their utmost capacity, and compelling a cessation of work while it continued.

On the morning of Sept. 2d, at my request the Philadelphia operator detached his battery, mine being already off. We then worked with each other at intervals as long as the auroral current continued, which varied from thirty to ninety seconds. During these working intervals we exchanged messages with much satisfaction, and *we worked more steadily when the batteries were off than when they were attached.*

On the night of Aug. 28th the batteries were attached, and on breaking the circuit there were seen not only sparks (that do not appear in the normal condition of a working line) but at intervals regular *streams of fire*, which, had they been permitted to last more than an instant, would certainly have fused the platinum points of the key, and *the helices became so hot* that the hand could not be kept on them. These effects could not have been produced by the batteries.

Appendix C. ART. XXIV. – *The Great Auroral Exhibition of August* 28*th to September* 4*th,* 1859. – 3D ARTICLE.[*]

In the two preceding numbers of this Journal we have given observations of the Aurora of Aug. 28th to Sept. 4th, from numerous places in North America. We now continue our record of the phenomena, and intend in a subsequent number to present a summary of the observations made in other parts of the world. We are indebted to Mr. Benj. V. Marsh, of Philadelphia, for a considerable number of the following notices.

1. *Observations at Montreal* (lat. 45° 31′), *by* Dr. ARCHIBALD HALL.

August 28th about 8h 20m P.M. the sky was about seven tenths obscured by massive cumuli, when in the interval

[*] Originally compiled by the Editors and published in the American Journal of Science, Second Series, Vol. 29, No. 86, pp. 249–265, 1860.

between them I observed streamers of a ruddy tint passing from the south towards the zenith. The wind was N.N.W, and blowing rather stiffly. About 10 P.M. the streamers seemed to converge towards the zenith in all directions, and to possess a deep ruddy tint. There was a large cumulus cloud in the W.S.W. and from a clear space beneath it a streamer shot upwards and distinctly traversed the cloud, illuminating it vividly. The same phenomenon was witnessed by another observer at the other end of the city.

At 2h 10m A.M. Sept. 2d, a brilliant aurora was seen in the vacant space between masses of huge cumuli and lasted until 3h 30m A.M. The sky was at first of a bright coppery red tint and the light emitted so great that it was possible to read moderately large print by it. This space became interspersed with streamers of a rich roseate hue stretching to the zenith. The manifestation was chiefly observed in the W.S.W.

Sept. 2, at 9h 40m P.M. we had another auroral display. The streamers were mostly white, springing from three well-defined arches, stretching between the N.E. and N.W. They flickered magnificently about 10h 20m P.M. in the zenith, where they formed a huge corona having a tent-like appearance. These displays have been the finest seen here for many years, and it is to be regretted that on the two first occasions, clouds should so far have concealed them from our view.

2. *Observations at Montreal* (lat. 45° 31′), *by* Prof. CHARLES SMALLWOOD, LL.D.

Aug. 28th at 9 P.M. we had a splendid aurora extending over nearly the whole horizon with the exception of a small space in the south and S.W., varying in color from a pale yellow to deep orange and violet or crimson, and nearly as light as when the moon is at its full. The aurora was first noticed between 8h 30m and 9h P.M., and this appearance lasted, with modifications, till nearly sunrise.

On the following night, Aug. 29th, there was also a fine display, but not to be compared in brilliancy to that of the previous evening. The sky was on this occasion cloudless, and a few streamers were occasionally seen tinted with a pale violet color.

The most remarkable incident was the unusual amount of atmospheric electricity present. At 9 P.M., Aug. 28th, the electrometers indicated a maximum of 250 degrees in terms of Volta's electrometer No. 1, of a positive character (but almost constantly varying in intensity); an amount equalled only during the thunder storms of summer, and the heavy snow storms of winter. The amount during the following day and night indicated a maximum of ten degrees, which is however somewhat above the usual average.

The appearances would lead to the opinion that the clouds might have been the medium of conducting the atmospheric electricity to the earth, for the indications of the electrometers were such as are observed during the passage of clouds charged with electricity, and this phenomenon seems to have extended to the wires of the electro-magnetic telegraph.

The following day and night indicated a small increase on the usual amount of electricity, which may be owing to the continued presence of the aurora, or in some measure to the decrease in temperature.

Similar indications of the electrical state of the atmosphere during the aurora were never observed here, although its effect on the magnetic telegraph has been before witnessed.

3. *Observations at St. Paschal* (lat. 47° 40′ N., long. 67° 40′ W.), *communicated by* Prof. C. SMALLWOOD.

It was about 10 P.M. Aug. 28th, that the aurora was first noticed here. It was a magnificent display which threw out streamers from the zenith all around the horizon, and the light was nearly that of the day. I believe it was visible at Lake St. John on the Saguenay, lat. 48° 8′, long. 71° 9′.

4. *Observations at Halifax* (lat. 44° 39′), *by* Lieut. N. HOME, *of the Royal Engineers.*

Aug. 28th at 5 P.M., I remarked a long narrow belt of cloud from E. to W. having a peculiar orange-white appearance.

At 8 P.M. I observed this cloud (which in the interim appeared to be stationary) suddenly to become luminous, particularly at its eastern extremity. This cloud was about 10° wide, and appeared to extend from horizon to horizon; no other clouds were visible.

Soon after 8 P.M, two arcs of light N. and S. appeared, that to the south being the brightest. Under both these arcs the heavens were dark; but observers were uncertain as to whether the darkness was cloud or not. No stars were seen below the arcs, although quite visible above them.

At $9\frac{1}{4}$ P.M. the appearance was as if these two arcs were a small circle of the sphere, dipping to the south at an angle (measured by sextant) of 15° to the horizon, and 12° above it. The corona being formed at a point (by sextant) 10° south of zenith. There was only one band or arc of light, and that was continuous around the whole heavens. There were two remarkable patches, one due west, at an elevation of about 36°, having a red color; and the other east by north, at an elevation of 25°, having an orange color. These points were brightest during the whole display.

Two distinct sets of streamers appeared to be formed; one set from the arc of light, the other from the corona, which seemed to be constant or nearly so; as during the five hours I watched the aurora, there appeared to be always light in or near the zenith and always in the arc. The streamers were the variables and appeared to work from W. by N. to south. I think they worked along from E. to W., but another observer said from W. to E. To the south they were so vivid and rapid it was not easy to tell.

A volume of light, as if a quantity of burning spirit was poured over the heavens, appeared to stream across from north to south quite independent of the streamers. The corona sent down rays, but it seemed to be only half way; the streamers from the arc meeting them and toothing in, appearing to alternate short and long ones.

5. *Observations at Grafton, Canada West* (lat. 44° 3′ N., long. 78° 5′), *by* JAMES HUBBERT.

Aug. 28th at 8h 30m P.M. my attention was attracted by the peculiar appearance of the southwestern sky. Streamers and flashes of light of a pale yellow and red color were rising, sailing towards a point 8° south of the zenith, and meeting others, from the N.W. and north. By 8h 53m the whole northern and eastern sky was a blaze of lurid light, which seemed most dense in a band seven degrees wide, extending from N.W. to S.E along which there was a constant succession of streamers and nebulous patches, exhibiting every shade of white, yellow and red. Columns were now darting up from all parts of the horizon. The aurora hung along the south, in a line at a maximum height of 17°. This from 8h 50m to 9h was very perfect; while a similar arch but much less regular was formed in the north reaching to the east. The latter had an altitude of 27°, and like the other seemed to rest on a dark bank. The first corona that I observed was formed at 9h, at an altitude of 70°. It was imperfect and vanished almost instantly; but was soon replaced by another in nearly the same spot. This in turn gave place to another still more complete. From 9h 15m to 10h 15m the drapery was gorgeous in the highest degree. A diffused light made surrounding objects very distinct. Cocks crew, and the animal world seemed to think that day was dawning.

I noted constant changes which were little more than a repetition of the above till 3h in the morning. The corona was distinct from 12h 37m to lh 5m. The color was white, merging into every shade of yellow, crimson, scarlet, purple, and sometimes tinged with green. I listened with great earnestness, and once or twice thought I heard a rustling noise, but I think it must have been the wind. When the wind was hushed, as it was at intervals in the latter part of the night, not a sound could be heard. Just at 10h the aurora, after nearly disappearing, became intensely brilliant, equalling the light of the moon at the quarter. The aurora continued till daylight, when it gradually faded away.

The evening of Aug. 29th was clear; and at 8h 45m the aurora was again visible, but very much less extended and brilliant than on the preceding night. There were thin, misty clouds of a nebulous appearance, with occasional streamers of a pale white light, sometimes merging into red.

On the night of Aug. 30th I observed no unusual appearance.

Aug. 31st the sky was covered with a dense mass of clouds; but the existence of the aurora was evident from the clearness of the night. After midnight the clouds disappeared, and the display was magnificent. All the characteristics of the night of the 28th were repeated; but the arch was rather lower along the southern horizon. A fiery bank was formed in the south, from which rays were constantly darting upward, and the whole sky was a gorgeous canopy of crimson and gold. This was most vivid from 1h 15m to 1h 45m, but was continued till almost day light.

Sept. 1st was cloudy, and I saw no indications of the aurora.

Sept. 2d there were dense clouds, yet the aurora might be occasionally seen. It was confined to the N. and N.E., and was particularly bright from 9h 51m to 11h.

Sept. 3d was clear. At 8h 50m the aurora appeared in the N.N.E. and W. The light was yellow and white, with traces of crimson and green. At 10h an imperfect corona was formed, but almost instantly disappeared. Others followed, but none of them were complete.

Sept. 4. The same phenomena were observed, but much diminished in brilliancy.

Sept. 5. No trace of the aurora was visible.

6. *Observations at Rochester, N. Y.* (lat. 43° 8′), *by* Prof. C. DEWEY.

The aurora of Aug. 28th was exceedingly splendid both before and after midnight, with the corona a little south of the zenith; and exhibited many colors, with red or crimson predominant.

Sept. 1st. The aurora began late in the evening, and exhibited the usual appearances.

Sept. 2d at 1 A.M. it was cloudy, but very bright and red in the N.E.; the light increased rapidly and extended. At 2 A.M. there was a magnificent glow of red over the southeast, south and southwest; yellowish green, green and crimson, forming a gorgeous display quite down to the south horizon as seen from the housetops. A splendid corona was formed just south and east of the zenith, with splendid coruscations from towards the horizon up to the zenith. The streamers shot upward towards where the corona was formed, but none went to it.

Sept. 3d. The aurora was considerable at 9 P.M. and over the north, streamers were shooting upwards. At 10 P.M. there was a bright red space in the N.W. or W.N.W. with white and greenish-white bands on each side. The flashing of light, upwards soon began, and the streams or clouds of aurora were splendid. At $10\frac{1}{2}$ P.M. the corona began a little S.E. of the zenith, and was very splendid, towards which the streaming upwards was on all sides but less from the south. At 11 P.M. nearly disappeared. This aurora was equal to that of November 1837.

7. *Observations at Newburyport, Mass.* (lat. 42° 48′), *by* Dr. HENRY C. PERKINS.

The aurora of Aug. 28th was the most splendid ever witnessed at Newburyport by the present generation. About $7\frac{1}{2}$ P.M., the eastern sky seemed to outvie the western, but with reversed colors, the pink of the morning taking the place of the golden hues of the setting sun. In a few

moments these hues were repeated in the northeast and the west, and the yellowish-white luminous arch had passed the zenith and was fast covering the southern sky, and at $7\frac{3}{4}$ P.M. had enveloped Antares. At 7h 52m the star Tau Scorpii was at the southwestern edge of the luminous fringe. At 9 P.M. Lambda Scorpii marked its southern border. At $9\frac{3}{4}$ P.M. the northern border of a luminous arch passing from the east to the west, was marked by Nu in the right foot of the Swan, while the whole southern and southwestern heavens were glowing with streamers rushing to the pole of the Dipping-needle, the whole northern heavens being entirely destitute of the auroral light. At this juncture, in an instant as it were, the merry dancers sprang up from the northern heavens, and at 10 P.M. the whole celestial vault was glowing with streamers, crimson, yellow, and white, gathered into waving brilliant folds, a little to the south and east of the zenith, affording a canopy of the richest tints and most magnificent texture. The light was examined by the polariscope, and found not polarized. The stars were so lost amid the effulgence as to render it somewhat difficult to make out the constellations. Print might be read by the aid of a small lens, and the time ascertained from the watch by the simple light of the aurora.

During the evening of Sept. 1st the aurora was quite bright, and about a quarter to one (Sept. 2) it spread very rapidly, and soon enveloped the whole heavens. At about one the spectacle was magnificent, a perfect dome of alternate red and green streamers being formed, and the light being so great that ordinary print could be read as easily as in the day-time. It continued till morning.

8. *Observations at Lunenburg, Mass.* (lat. 42° 35′), *by* Prof. WILLIAM B. ROGERS.

The aurora of Aug. 28th has rarely been equalled in this latitude, and the meteor was repeated with more or less splendor for the eight following nights. The displays of Sept. 1st and 2d were scarcely inferior in beauty to that of the 28th, while that of Sept. 2d, in some of its features, was the most interesting of them all.

On the evening of Aug. 28th, throughout most of the northern half of the sky, the stars were dimmed by what seemed to be a luminous haze, which in some places quite eclipsed their light, and which itself glowed changefully with a golden and crimson coloring. In the earlier stage, the obscure space on the northern horizon had not assumed the usual arched form, and was sufficiently translucent to show a few flaky clouds, floating within its confines. At 8h 20m this dark space had become more opaque, and had moulded itself into a symmetrical arch, bounded by a broad luminous band.

At 9h 30m the display attained its highest magnificence. The dome of the heavens was hung around with white and golden and rose-tinted streamers converging from all quarters towards the magnetic pole. Over the glowing stripes of this marvellous pavilion there came broad flushes of the richest crimson light, until it suffused all the upper part of the sky, and the whole southern quarter except a narrow space next the horizon.

At l0h 30m nothing remained of this wonderful spectacle but a faint auroral arch low down in the north, accompanied by a few dim streamers.

The aurora recurred in great splendor between 1 and 2 A.M., Aug. 29th, when the crimson color was particularly remarkable. At 3h 30m A.M. there was a fine auroral arch in the north, with a long array of streamers rising from it.

Sept. 2d, a clear sunset was followed by a peculiar greenish and purplish light extending round the horizon, even beyond the north. Over the northeast quarter, the air to the height of 30° had a dark opacity, which had the effect of arresting the light coming from beyond.

At 7h 30m P.M. an irregular obscure space began to form along the northern horizon. At 7h 50m a faint arch of white light made its appearance, resting on the horizon a little north of the E. and W. points, and culminating some distance below the pole star. This continued to rise until 8 P.M. when its apex was within a few degrees of the pole.

At 9h 20m a low luminous segment showed itself on the horizon beneath the arch. The latter now resolved itself into an array of bright streamers, with equidistant shadowy spaces between them.

At 9h 30m the streamers had extended and grown brighter while the low luminous segment, diffusing itself upward, had merged into the outer arch, which now reached nearly to the pole star. At this moment the arch began to send off successive waves of light, rapidly following one another towards and beyond the zenith. In a few seconds this wave movement gave place to more rapid and seemingly broken pulsations, flitting upwards in close succession through the northern, eastern and western quarters of the sky, and visible, though less distinctly in the south. This wonderful appearance exhibited everywhere a convergency of the lines of motion towards a point considerably south of the zenith.

When these luminous phenomena were at their height, every spot to which the eye was directed, except the southern quarter near the horizon, was traversed by quickly successive flashs of white, greenish, and pale roseate light, all seemingly moving upwards.

At 10h 30m the pulsating movement again extended over all the northern and part of the southern half of the sky. Innumerable waves of white, yellowish and purplish light chased each other from every quarter towards the magnetic pole, while the crimson flush spread wider and higher from the west.

The various phases of this aurora recurred according to a somewhat uniform order of succession. First, the dark segment on the northern horizon took a regular arched form, and as it rose, became bounded above by a broad luminous curve, at the same time developing one or more bright concentric arches within. The streamers now shot forth from all parts of the luminous zone; and as these increased the upper arch faded away, as if it had expended itself in producing them. And now the lower arch took its place, to be obliterated in its turn by a like seeming process of exhaustion. At length, one of the grander effusions of

light coming on, the whole arch was broken up, and the dark segment below was reduced to a shapeless mass. Then there occurred a comparative pause in the phenomena, until the dark segment again took form, with its one or more luminous bands, and a like cycle of development was repeated.

9. *Observations at Steubenville, Ohio,* (lat. 40° 25′), *from the Steubenville Daily Journal*.

The magnificent auroral display of Aug. 28th was unusually interesting.

1st. It covered a much larger space of the heavens than any we ever saw before, at least since 1835.
2d. It lasted from dark until daylight, appearing with the first approach of darkness and only disappearing as daylight gradually overpowered it.
3d. Instead of an arch, shooting up rapid and various colored rays, its first appearance was that of a luminous mist, with barely perceptible rays along its southern border, and moving with the rolling motion of clouds, rather than the straight darting motion usually seen in auroras.
4th. It varied in intensity more than any we have ever seen before, twice fading nearly out, and remaining so for nearly half an hour or more, and then kindling up with greater brilliancy than before.

About $7\frac{1}{2}$ P.M. it was a barely perceptible light in the northeast. As the darkness deepened, this luminous spot grew brighter, and moved to the south, till a little before 8 P.M. when the light spreading from it met that coming from the west, and formed an arch about half way between the zenith and southern horizon, and there its advance ended, and it began instantly fading out. It retreated just as it had advanced, only more rapidly, and at 8h 10m there were left only the two centres in the northeast and northwest with a fitful gleam between them. During this retreat, portions of the luminous cloud broke off and floated for some minutes far away from the main body, surrounded by deep darkness, like islands. One of them, and the most beautiful, was a long bright bar in the south, which extended more than half way across the sky from west to east, with a wide sea of darkness between it and the parent cloud, which gradually melted away and disappeared to the westward.

At 9 P.M. the light advanced again, this time with a blood red tinge in the eastern and western portions, and passed clear to the south as before, but shooting up many and variously colored rays, sometimes from the east, sometimes from the west, sometimes from the north, and from all parts of an irregular luminous arch that bent over the northern horizon about twenty degrees above it. This display faded away in an hour, and at $10\frac{1}{2}$ P.M. there was no light that would attract attention, more than is frequently seen in the north.

About 3 A.M. it blazed up with redoubled brilliancy, shooting up white rays far above the zenith, and making the earth as light as a full moon behind a mist could have done. This time the rays seemed to dart up in broad masses, giving the sky the appearance of being covered with slabs of light, which were tinged with red in the zenith, and rested on a broken irregular arch in the north that in some places fell to the horizon, and in others rose in angular openings to thirty degrees above. During this last display, the pulsations of the aurora were beautifully marked, the rays shooting up in a sort of volley, many hundreds together; while broken and separate masses of luminous cloud were seen in various parts of the sky.

10. *Observations at Burlington, N. J.,* (lat. 40° 5′), *by* BENJAMIN V. MARSH.

Aug. 28th an arch of light rose in the north, passed the zenith and descended to within about 20° of the south horizon by 8h 30m P.M. Soon after this, the whole space overhead was occupied by a dense unbroken cloud of milky whiteness. There was however up to this time a considerable number of small black clouds moving southward, which soon afterward disappeared entirely. These clouds were very thin, and we were for a while in doubt whether they were not patches of clear sky; but by watching their effect upon the stars, we satisfied ourselves that they were clouds.

Still later, about 20° above the south horizon, there was a dense whitish arch a few degrees in width, its lower margin being regular and well-defined. About 30° or 35° above the north horizon was the top of another arch, wider than the first, but not so regular or well-defined. Between these two arches were numerous streams and fragments of white auroral cloud.

Between $9\frac{1}{2}$ and $9\frac{3}{4}$ P.M. there was a perfect corona; the streamers on the south side were short, and mostly white, and moved pretty rapidly westward. Their number at one time was probably five or six. At one time the central space was perfectly clear; but afterwards the streamers ran through it to its centre.

11. *Observations at Crawfordsville, Indiana,* (lat. 40° 3′), *by* Prof. JOHN L. CAMPBELL.

Aug. 28th, the aurora began about 7h 30m P.M. with an unusual white light in the form of an arch in the north. At 8h 45m P.M., the white light appeared in two brilliant spots about 60° on each side of the magnetic pole.

At 9 P.M. streamers of white, red and pink light in circular currents about the magnetic pole (variation 5° 45′ east) extending beyond the zenith.

At $9\frac{1}{4}$ P.M. the streamers were concentrated into brilliant ones passing nearly along the magnetic prime vertical.

At 10 P.M. streams of white light were formed in the east, and rapidly passed westward, a little south of the zenith. These streams or clouds were entirely separate from each other, and the more northern band, and possessed a real motion. The time occupied in passing was about one second. Not less than twenty flashes passed over. They were formed about 30° above the eastern horizon, and disappeared about 60° above the western. After 10 o'clock the white light in the north became more brilliant, and tinged with red, extended very far towards the south. We traced

the red tinge on the east to within 40° of the south point, and on the west to within 50° of the same. At 11 P.M. the aurora was still bright in the north.

Aug. 29th, 2 A.M. Very brilliant streams of white and red light filled the northern hemisphere. These streams were perpendicular to the horizon in the north, and were inclined at regular decreasing angles towards the east and west to about 70°. Brilliant flashes passed across the heavens, originating in the northeast, and passing in a southerly direction vanished in the southeast.

At 2h 45m A.M. Heavy bank of red light ten degrees north of east. Patches of white light in north with occasional streams.

At 3 A.M. the whole northern hemisphere was filled with streams of white light with the same inclination as at 2 A.M. At 3h 15m A.M. the auroral storm was at its height. Flashes of red and white light each instant flew across the northern hemisphere. At 3h 30m A.M., a bright band of white light covered the hemisphere except low down in the north; and the incessant flashes in the northeast and east still continued. Long streams of light flashed across the entire hemisphere. The lower part of the band passed through the heavens at an elevation of 40°. In the zenith was displayed a brilliant red bank. In the east red and white flashes were very brilliant – better defined but not so rapid in transition as at 3h 15m A.M.

At 3h 45m A.M. Magnificent corona in the zenith. Central portion spiral, red and white, changing instantly to a beautiful rose color, with spiral streams shooting forth into all parts of the heavens; the most brilliant streams flowing east and west. The heavens were completely covered with these streams of light.

At 4 A.M. the white light in the north was still very bright, but the dawn obscured the eastern bank.

12. *Observations at Philadelphia,* (lat. 39° 57′), *by* CHARLES J. ALLEN.

Soon after half past 8, Aug. 28th, the southern margin of the luminous auroral curtain was well defined, and its position between two fixed objects carefully noted. It was afterwards ascertained by actual measurement that this gave an elevation of about $22\frac{1}{2}$ degrees above the southern horizon.

13. *Observations at Sandy Spring, Md.,* (lat. 39° 9′), *by* Prof. BENJAMIN HALLOWELL.

The elevation of the southern margin of the luminous auroral curtain above the southern horizon, Aug. 28th, about 9 P.M., I thought, and mentioned to those with me, was about the meridian altitude of the equator say 51 degrees.

14. *Observations at Stockton, California,* (lat. 38° 10′), *from the San Joaquin Republican.*

The aurora of Aug. 28th first appeared about 9 P.M. when faint white light commenced about north and extended to about east by north. About $9\frac{1}{4}$ P.M. great streams of red and blue shot up all along the northeastern horizon, but they appeared to shoot highest about mid-way of the light. These streams would faint and brighten in such a wonderful manner, that we imagined some painter in the skies drew his great brush from the horizon up to 40 or 50 degrees, dipped with vermillion, then with sky blue, and then with white and flesh color.

15. *Observations at Sacramento, California,* (lat. 38° 34′), *by* THOMAS M. LOGAN, M.D.

I have observed the aurora only at five different times during a residence of nine years at Sacramento, viz., Dec. 16, 1857, Oct. 27, 1858, Aug. 28, 1859, Sept. 1, 1859, and Oct. 18, 1859. I know of but three other well authenticated instances of the phenomenon having been witnessed in California; one by Geo. H. Goddard at Sonora, Jan. 19th, 1852; and two by Henry Gibbons, M.D., at San Francisco, Jan. 19th, 1852, and Feb. 19th, 1852. This shows the infrequency of its appearance in this State.

The aurora of Aug. 28th, 1859, commenced at 9 P.M. and ended about 3 A.M. next morning. The appearances exhibited during this extended period were so various as to render it impossible to note the particular hours of the different changes. In its perpetual movements and fantastic changes were recognized all of the characteristic features that mark this phenomenon, from its close resemblance to the aspect of the sky before sunrise, to the formation of the luminous arc, darting forth palpitating rays towards the zenith, of white, pale red, and deep blood color. This last mentioned feature was seen in its greatest glory at about midnight; and lambent streamers about this time were noticed to shift gradually from west to east, and vice versa. The summit of the arc was not more than six or eight degrees above the horizon, and appeared to coincide with the magnetic meridian. The lower segment of the arc was not as obscure as in the other auroras observed by us. The most remarkable feature during the whole display, was the long continued gleaming of a dark rose or carmine illumination, particularly at the western extremity of the arc; this rosy light passing occasionally along the belt with a fluctuating movement towards the opposite end. The whole northern sky at one time seemed to be a cupola on fire, supported by columns of divers colors, relieved and intensified by dark shadows or rather streaks. The sky remained almost entirely clear the whole night. This aurora was observed in all parts of the State, and very generally throughout the whole north Pacific region.

The aurora of Sept. 1, 1859, was first observed about 10 P.M. There was seen first a warm glow in the northwest, and two white silvery clouds in the north. Soon the light extended in all directions, until the entire firmament was suffused with a ruddy light so bright at times that the hour could be distinguished on the dial of a watch. At midnight a splendid glowing corona was seen extending from the eastern to the western horizon, and the whole southern hemisphere appeared to be in one continuous blaze. These ever changing phenomena continued to manifest themselves until lost in the dawning day.

16. *Observations at St. Louis, Mo.* (lat. 38° 37′), *from a St. Louis Journal.*

On the night of Sept. 1st we had a most beautiful exhibition of the aurora. The view did not approach its highest grandeur until after 11 o'clock. At first there was a hazy appearance, embellished here and there by faint streaks and tremulous touches of light. Then the wavy pencillings grew stronger and broader, and the light spread until it had crept up to the zenith, when half of the world seemed enveloped in a sheet of mellow flame.

17. *Observations at Louisville, Ky.* (lat. 38° 3′), *from the Louisville Journal.*

One of the most magnificent auroras ever witnessed in this latitude was seen about 9 o'clock, Aug. 28th. The whole heavens, from the northern horizon to the zenith, were brilliantly illuminated with a rose colored light, and the flashes were very vivid. The northwestern sky was the portion most brilliantly illuminated, but in the northeast, the rosy flush was exquisitely beautiful.

18. *Observations at Charleston, S. C.* (lat. 32° 46′), *from the Charleston Mercury.*

Aug. 28. The northern heavens were brilliantly lighted until about 2 o'clock Monday morning, when the aurora faded entirely away. On the morning of Sept. 2d the auroral exhibition far surpassed any former instance observed in this city, for the general extent and diffusion of the lights.

19. *Observations at Bermuda* (lat. 32° 34′), *from the Bermuda Royal Gazette.*

The aurora of Aug. 28th appeared to ascend from a few degrees above the northern horizon a great distance upwards towards the zenith, assuming a variety of shades and beautiful colors; sometimes in tremulous sheets of pale yellow, changing gradually into a deep crimson, or shooting upwards in streams of light resembling those frequently observed from the setting sun. It covered at times the entire space between N.W. and N.E., leaving the sky from the horizon to its apparent base perfectly clear. Towards 10 o'clock its brilliancy gradually died away, but it continued more or less visible till the dawn of day.

Sept. 2d, between 2 and 3 A.M., the aurora displayed itself in greater splendor than it did on the 28th. Many persons were awakened from their slumbers by the intense light which entered their chambers.

20. *Observations at Savannah, Ga.* (lat. 32° 5′), *from the Savannah Republican.*

On the evening of Aug. 28th we had a brilliant display of the aurora borealis. The northern sky, for an extent of some forty-five degrees, was luminous with a mass of red light, from whence shot up towards the zenith the usual streaks, at times vivid and beautiful.

Sept. 2d, about 1 A.M. the aurora again appeared and was of a very intense and beautiful color, being a mixture of pink, gold and purple. After it had reached an elevation of about 45°, it seemed to dissolve in the centre, and spread out both east and west. About 2 o'clock it formed a complete arch overhead, from N.E. to S.W. About 3 A.M. it gathered in the zenith, and sent out bright fiery flashes in every direction. It was far more magnificent than the aurora of Aug. 28th.

21. *Observations at Mobile, Ala.* (lat. 30° 41′), *from the Mobile Daily Register.*

The aurora showed itself a little east of north about $7\frac{1}{4}$ P.M. Aug. 28th, and kept up the exhibition until about 9 P.M. when its paling light died out. It was of a reddish hue, inclining to yellow, and its flickering light assumed a kind of pyramidal form, shooting up into the heavens, nearly to the zenith. Then the centre seemed to grow dim, and a division took place, its right wing moving to the extreme north, where the left wing after a short time joined it.

Between 12 and 3 o'clock on the morning of Sept. 2d, the aurora was repeated upon a scale of beauty and grandeur never before witnessed in the south. A bright pink colored light shot up from the northern horizon, and darted off into beautiful rays, flickering and brightening until they reached the zenith, and soon encircled the hemisphere like a belt from east to west. After about three-quarters of an hour, during which time the aurora occasionally furnished light enough to read by, the bright and beautiful light suddenly clothed the entire firmament.

22. *Observations at New Orleans, La.* (lat. 29° 57′), *from the New Orleans Daily Delta.*

A grand auroral display appeared between 8 and 9 o'clock, Aug. 28th, in the northern horizon. A column of light first shot up into the sky, which soon spread up towards the zenith, and around the horizon, and made one of the most magnificent appearances that the sky has ever exhibited.

About 11 P.M., Sept. 1st, the aurora reappeared and continued until 3 or 4 o'clock in the morning. Nearly the whole visible northern hemisphere was covered with a fiery, blood-reddish, though transparent vapor. The deepest color was on the east and west, a space around the polar centre seeming to be the only non-illumined portion of the northern heavens. Over this crimson ground, spears and pencils of pale flickering light shot up at intervals from the horizon, converging at a point near the zenith. The whole sky along those lines was at once luminous and tremulous. In a moment vast segments of arches would rise, and then suddenly disappear.

23. *Observations at Galveston, Texas* (lat. 29° 17′), *by* Prof. C.G. FORSHEY.

Aug. 28th, as early as twilight closed, the northern sky was slightly lurid, and at times lighter than other portions of the heavens. At 7h 30m a few streamers showed themselves. Soon the whole sky, from Ursa Major to the zodiac in the east, was occupied by the streams or spiral columns that rose from the horizon. Spread over the same extent, was an exquisite roseate tint which faded and returned. Stately columns of light reaching up about 45° from the horizon, moved westward about one degree

for every ninety seconds of time. There were frequent flashes of lightning, apparently from distant clouds, along the whole extent of the aurora; but no clouds were visible, except a single streak near the horizon. At 9 P.M. the whole of the streaking had faded, leaving only a sort of twilight over the northern sky, and we ceased our observations.

At 3 A.M. Aug. 29th, I awoke and perceiving that it was very light outside, rose, and found the whole northern heavens again on fire. Such a display I have never seen equalled since the aurora of Sept. 1, 1839. The whole distance before-named was tinted with the roseate hue; darker, nearly crimsoned at the two flanks. In the centre, near the meridian, stood a stupendous pyramid of white light with its apex near the zenith. On either side at some twenty degrees, stood a pyramid of rosy light, each about sixty degrees in height and in exactly symmetrical positions. Scarcely had I sketched the outline of this noble spectacle when the columns drifted westward and faded.

Another fine display of the aurora commenced about $10\frac{1}{2}$ P.M. Sept. 1st, and lasted until near daylight the next morning. A dusky red, like the reflection of an immense conflagration, over-spread almost the entire heavens, beyond the zenith, far down towards the southern horizon.

24. *Observations at Sea* (lat. 28° 30′, long. 79° 30′), *Barque Pride of the Sea.*

Sept. 2d, at 12h 35m A.M. a bright spot or cloud appeared in the N.W. which shot up rays resembling the aurora, and in thirty or forty minutes formed an arch across the horizon from N.W. to N.E., which became lighter as it arose, and at 1h 15m A.M. it was light enough to read the smallest print without light. At the time the horizon was cloudy, but overhead was clear, the larger stars being just seen. At 2h 15m the arch passed over to the southward, when it became dark again.

25. *Observations at Key West* (lat. 24° 32′), *from a Journal*.

A brilliant exhibition of the aurora was witnessed at this place Aug. 28th, and a still more brilliant one on the morning of Sept. 2d. The whole northern half of the heavens was tinged with crimson, red as blood. Occasional flashes of blue and white light shot up towards the zenith and then slowly melted away.

26. *Observations at Havanna, Cuba* (lat. 23° 9′), *by* M. ANDREAS POEY.

In his former communication. (Am. Jour., vol. xxviii, p. 406) Mr. Poey stated that during the auroras of Aug. 28th and Sept. 1st he was unable to obtain any indications of atmospheric electricity. In a later communication he states that neither at the time of these auroras, nor on the preceding or following days, was there the smallest interruption or disturbance experienced on the electro-magnetic telegraph lines of Cuba.

27. *Observations at Inagua, Bahama Islands* (lat. 21° 18′), *from the New York Journal of Commerce*

The aurora of Aug. 28th was distinctly seen from this place, and was supposed to have been a large fire in the neighborhood. It was remarkably brilliant, but was not attended by that flashing appearance which is sometimes noticed in higher latitudes.

28. *Observations at Cohe, Cuba* (lat. 20°), *by* GEORGE F. ALLEN.

On the night of Sept. 1st a Spanish mechanic who worked for me called me out of bed to see the great light in the northern sky. He was much struck with it, and said the people in St. Jago de Cuba would think the end of the world was at hand. I found a display which would have been considered more than ordinary even in the latitude of New York. It resembled the auroral displays occasionally seen in New York when more than usually brilliant. The same rosy light, on a darker horizon, fading off into yellower and whiter as it spread upwards, variegated occasionally with white streamers. It extended horizontally, according to my rough estimate, about one-third or two-fifths of the horizon, and upwards about two-fifths of the arch of the visible heavens. It was a very brilliant display, and surprised me much by its brilliancy in that latitude.

29. *Observations at Kingston, Jamaica* (lat. 17° 58′), *from the New York Herald.*

An extraordinary light appeared in the north on the night of Sept. 1st and the morning of Sept. 2d. It appeared as if there was a colossal fire on earth which reflected its flames on the heavens. The whole island was illuminated. The light was seen at Montego Bay (lat. 18° 21′) at 10 P.M., but it was not observed at Kingston until 1 A.M. Sept. 2. It continued until 5 A.M., when it gradually disappeared. It looked as if Cuba was on fire, and many believe that a portion of this island had been destroyed by a conflagration. Other persons were of opinion that the light was that of an aurora, but the aurora has never before been seen in this latitude. A similar fire was observed on the north side of Jamaica Aug. 28th.

30. *Observations at Guadeloupe, West Indies* (lat. 16° 12′), *from L'Institut*

On the 2nd of September, from $1\frac{1}{2}$ h till daylight, an Aurora Borealis was seen at Guadeloupe to the great astonishment of the population. Its ruddy light was noticeable in the interior of the houses. At the centre of this vast conflagration were noticed two rays of whitish light which rose parallel to each other, passing a little to the left of the pole star. The aurora attained its maximum of brightness at 3 A.M.

31. *Observations at La Union, San Salvador* (lat. 13° 18′), *from the Gaceta del Estado.*

On the night of Sept. 2d, a most extraordinary phenomenon was witnessed. About 10 o'clock, a red light illuminated all the space from north to west, to an elevation of about 30° above the horizon. The light was equal to that of day-break,

but was not sufficient to eclipse the light of the stars. The sea reflected the color, and appeared as if of blood. This lasted until three in the morning, when a dense black cloud arose in the east, and commenced to spread over the colored portion of the heavens, presenting a most curious spectacle; for in the parts where the cloud was not dense enough, the red light shone through, and formed a thousand fantastic figures, as if painted with fire on a black ground.

In the city of Salvador (lat. 13° 44′) the same phenomenon was visible, occupying the same space in the heavens, and the red light was so vivid that the roofs of the houses and the leaves of the trees appeared as if covered with blood.

February, 1860.

Appendix D. ART. XXXV. – *The Great Auroral Exhibition of Aug. 28th* to Sept. 4*th,* 1859. – 4TH ARTICLE.*

In the three preceding numbers of this Journal we have given observations of the Aurora of Aug. 28th to Sept. 4th, from almost every part of North America between the parallels of 13° and 48° north latitude. We now present a summary of observations of the same aurora in Europe, with some reports from Asia, and accounts of a simultaneous auroral exhibition in the southern hemisphere.

1. *Observations at Christiania, Norway,* (lat. 59° 54′), *by* Prof. CHRISTOPH HANSTEEN

1859, Aug. 28th. At 10 P.M. only an indistinct coruscation behind the clouds in the north.

Aug. 29th, 12h 10m A.M. perfectly bright, almost as at full moon; the air dim with cirro-stratus, nevertheless the aurora shone through everywhere with strong radiating and flaming motion, very irregularly and unsteady. Corona was often formed; best formed at 12h 17.5m. Altitude 71° 37′ from south, azimuth 9° 57′ east. At 12h 18.5m a purple-colored beam shot in east to γ Andromedæ. At 12h 21.5m altitude of corona 72° 27′; azimuth 14° 55′ east. At no time were there regular bows. There was always a vacant space over the south horizon, but often of a suspicious character. It continued after 1 A.M. without essential variation in strength or character.

Aug. 29th, evening, rain – heavens covered.

Aug. 30th, evening, rain – heavens covered.

Aug. 31st, $11\frac{1}{2}$ P.M., lightning and thunder in southwest.

Sept. 1st, heavy rain – thunder.

Sept. 2d, radiating and strong flaming aurora, $12\frac{1}{2}$ h.

Sept. 3d, radiating aurora over the whole northern heavens to a little south of zenith; rather dimly. It continued to illuminate the heaven after it was almost covered. At $1\frac{3}{4}$ A.M. very clear behind the skies everywhere.

Sept. 4th, 10 P.M., radiating aurora in the north to 80° altitude. Later in the night, vehemently flaming with broad flames.

Sept. 5th, 10 P.M. elegant radiating aurora which dilated from the whole northern horizon to south of zenith, mostly behind a veil of cirro-stratus. At an altitude of 45° it was partly flaming. At 12h it had nearly ceased.

Sept. 6th, at 10 P.M. an arc from 6° to 8° broad, the lower edge of which had an altitude of 5°.

Table 4.1 shows the state of the Bifilar magnetometer between Aug. 28th and Sept. 6th.

The greatest difference observed during this period was 1195.91 parts of the scale. One division of the scale corresponds to 1/15070 of the horizontal intensity. Hence the variation of the horizontal intensity from Aug. 29 to Sept. 2 amounted to nearly 1/13 of its whole value.

The inclination of the magnetic needle is shown in Table 4.2. The mean inclination of the needle in 1859 was 71° 18′.[1]

The effect of this aurora upon the telegraph lines in Norway, was much greater than in France and Germany. The effect was noticed from the opening of the stations at 7 A.M. On the 29th communication was interrupted till 11 A.M. on almost all the lines; and likewise Sept. 2d, but with a long repetition after 2 P.M. Sept. 3d, only towards $8\frac{1}{2}$ A.M. During the remaining parts of those days, the perturbations were more or less uninterrupted, nevertheless communication could be maintained in some degree. Strong currents caused simultaneous attractions of all the armatures. The galvanometer showed strong deviation,

* Originally compiled by the Editors and published in the American Journal of Science, Second Series, Vol. 29, No. 87, pp. 386–397, 1860.

[1] This footnote has been provided by Larry Newitt of the National Research Council, Ottawa, Canada. Using the Bloxum-Jackson series of models to calculate the horizontal intensity in southern Norway in 1860, I obtain a value for H of approximately 15000 nT. (F was ~49000 nT. The model give $I = 72.0$, close to the observed value of 71.3). Perhaps it is no coincidence that 1 scale division is equal to $1/15070 \times H$; however, I do not know when the equivalent of the nT was first used. British units of force were still in use in the 1880s, but there certainly could have been more than one system in use in 1859. With a scale division of roughly 1 nT, the maximum perturbation is 1195 nT. In a unifilar magnetometer a magnetized needle is suspended by a single (torsionless) thread so that the needle is free to rotate and to align itself in the magnetic meridian. In a bifilar magnetometer, the needle is suspended by two threads so that its movement is constrained. Both instruments can be used for measuring (absolute) horizontal intensity. The bifilar can also be used to measure horizontal field variations. The unifilar can also be used to record absolute or relative declination.

Table 4.1
Bifilar magnetometer readings at Christiania, Norway between Aug. 28th and Sept. 6th, 1859

Date	Hour	Bifilar
1859	h m	
Aug. 28	9 23 A.M.	704.09
Aug. 28	2 10 P.M	764.98
Aug. 29	9 28 A.M.	243.0
Aug. 29	9 43 A.M.	349.3
Aug. 29	10 09 A.M.	638.78
Aug. 29	10 15 A.M.	531.81
Aug. 29	10 27 A.M	709.11
Aug. 29	10 30 A.M.	670.18
Aug. 29	10 33 A.M.	723.43
Aug. 29	1 55 P.M.	941.50
Aug. 29	5 35 P.M.	801.42
Aug. 30	9 15 A.M.	670.10
Aug. 30	1 55 P.M.	751.18
Aug. 30	5 30 P.M.	732.08
Aug. 31	9 16 A.M.	667.72
Aug. 31	1 55 P.M.	737.95
Sept. 1	9 21 A.M.	678.02
Sept. 1	2 05 P.M.	711.26
Sept. 2	9 21 A.M.	609.70
Sept. 2	9 49 A.M.	780.07
Sept. 2	11 29 A.M.	616.87
Sept. 2	2 25 P.M	1381.77
Sept. 2	4 27 P.M.	1438.91
Sept. 2	5 30 P.M.	1104.69
Sept. 2	6 30 P.M.	1020.41
Sept. 3	9 21 A.M.	650.12
Sept. 3	1 58 P.M.	926.13
Sept. 4	9 19 A.M.	670.05
Sept. 4	4 28 P.M.	1034.2
Sept. 4	4 45 P.M.	959
Sept. 5	9 14 A.M.	705.15
Sept. 5	9 15 P.M.	1060.49
Sept. 6	9 11 A.M.	641.85

Table 4.2
Inclination of the magnetic needle at Christiania, Norway, on Aug. 29th and Sept. 2d, 1859

Date	Time	Inclination
Aug. 29th,	10h 21m A.M.	71° 31.5′
	5h 23m P.M.	71° 19.8′
Sept. 2d,	10h 23m A.M.	71° 29.0′
	4h 16m P.M.	70° 26.9′
	6h 26m P.M.	71° 5.8′

sometimes with slow, sometimes with sudden movements, from one side to the opposite.

The intensity of the currents was greatest upon the longest lines going towards the north, on which sparks and uninterrupted discharges were from time to time observed. Pieces of paper were set on fire by the sparks of these discharges. In Bergen, where the line to Stavanger runs in a north and south direction, the current was at times so strong, especially Sept. 2d and 3d, that it was necessary to connect the line with the earth in order to save the apparatus from destruction. The phenomena appeared less strong in Christiansand, in the southern part of Norway, where the lines run east and west.

2. *Observations made in different parts of England; extracted from the London Times.*

A. Durham (lat. 54° 46′)

Sept. 1, aurora; Sept. 2, vivid white aurora; Sept 3, aurora. Sept. 4, faint aurora.

B. Preston (lat. 53° 45′) by R.C.

Sept. 2d, there was a brilliant auroral display, continuing from 11 to 12 o'clock, and a second appearance, though not so brilliant, at a little before 2 o'clock on the morning of Sept. 3d. During the first display, the whole of the northern hemisphere was as light as though the sun had set an hour before, and luminous waves rolled up in quick succession as far as the zenith, some of a brilliancy sufficient to cast a perceptible shadow on the ground. To the northwest there was a large patch of light of a deep crimson hue, while the waves of light were white, as also were the streamers which occasionally shot across the northern part of the sky. It was the most brilliant aurora that has been witnessed here for many years.

C. Nottingham (lat. 52° 57′), by E. J. Lowe

On the evening of Aug. 28th and morning of Aug. 29th there was an unusually brilliant auroral display. From 8h 40m P.M. until 9 P.M. Aug. 28th curtains of red light were visible near the zenith. By 11h 40m P.M. the glare of orange light in the north was powerful enough (even through much cloud) to make the hands of a watch visible. At 12h 25m A.M. the light was so strong that it gave the impression of daylight. At 12h 45m an opening in the clouds near the zenith disclosed the cupola which was situated exactly on Alpha Andromedæ. At 1h 15m A.M. magnificent rays of light met two degrees east of Alpha Andromedæ. At this time three-fourths of the sky was covered with aurora. At 2h 30m, there being more clear sky, a splendid mass of aurora was visible, forming an ever changing cupola close to Gamma Trianguli. All the coruscations moved slowly eastward. At 3h 15m the cupola was formed near Gamma Andromedæ.

Sept. 3, strong aurora near the horizon.

Sept. 4, aurora.

D. Grantham (lat. 52° 55′).

Aurora Aug. 28th, 29th, 30th, 31st, and Sept. 3d.

E. London (lat 51° 37′).

Aug. 28th, at 11h 30m P M., auroral light in the north. At 0h 15m A.M. Aug. 29th it assumed the form of a luminous arch, similar to daybreak, and in the southwest there was an intense glare of red covering a very large extent; at 0h 20m streamers; at 0h 25m the streamers rose to the zenith and were tinged with crimson at their summits; at 0h 45m frequent coruscations; at 1h 0m the arch which had partially faded was re-formed, the body of light being very strong, but not sufficient to enable one to read any but

very large print; at lh 30m light equally strong, but outline indistinct; at 2 A.M. much less light and very indistinct. Continued till 2h 30m A.M.

Sept. 3, aurora.

F. Clifton (lat. 51° 27′), by William C. Burder.

Aug. 28th, about 10h 45m P.M., commenced a brilliant auroral display. At first there were several fine streamers, some of them white, and some faint crimson, extending from near the horizon almost vertically to α and β Ursæ Majoris. From that time till midnight there were generally very beautiful streamers, but without lateral motion, most of them being not quite vertical, but inclining slightly towards the east at the top. There was also always a general light, extending at midnight from northeast to west, and sometimes bright enough to enable a person to read the time on the face of an ordinary watch.

The aurora was repeated Sept. 1st, Sept. 2d, and Sept. 3d.

G. Aldershot (lat. 51° 15′)

Magnificent display of aurora Aug. 28th, and till early morning Aug. 29.

H. Brighton (lat. 50° 50′).

Aug. 29th, about half past one o'clock, a fine aurora occupied more than one-half the sky. It had the appearance of an irregular hemisphere of white light fringed with a band of crimson from twenty to thirty degrees broad, stretching from southwest to northeast by east.

3. *Observations at St. Valery, France,* (lat. 50° 10′ N., long. 1° 37′ E.), *by* H. LARTIGUE, *from Comptes Rendus,* T. XLIX, p. 367.

Near St. Valery a white light of considerable intensity was noticed in the north at 11h 40m P.M. Aug. 28th. A red column, with sides nearly parallel, and 4° or 5° in breadth, rose from the N.N.W. nearly to the zenith, but disappeared after a few minutes. About 12h 10m the white light near the horizon had increased in intensity; a large part of the heavens was colored red, and the exhibition attained its greatest brilliancy at 12h 20m. Magnificent columns and brilliant rays, changing from red to green and white, rose to the zenith, sometimes passed beyond it, and occupied the entire space between Aquila and the meridian, and a few minutes later extended to the constellation Auriga. The light was bright enough to allow objects to be seen at a distance of one mile, as during a clear night with a full moon. The illumined portion of the sky increased till 12h 40m. After this time the brightness diminished near the meridian, but the east and west portions continued red. At 1h 15m the vertical columns again appeared very brilliant, and nearly as extensive as at 12h 40m, but they soon disappeared. The red light grew fainter, and disappeared entirely at 2h. The white light which marked the commencement of the phenomenon continued three-quarters of an hour longer.

4. *Observations at Paris, France,* (lat. 48° 50′), by M. COULVIER GRAVIER, *from Comptes Rendus,* T. XLIX, p. 338.

The aurora was first noticed at Paris at 2h on the morning of August 29th, and it soon rose to a great height above the horizon. About 2h 45m the vertex of the grand arch had reached the trapezium in Cetus, being 150° from the northern horizon, and it extended from Monoceros to 10° south of θ Aquilæ; having an amplitude of more than 200°. The vertex of the small arch rose to η Draconis, being a height of 26°; and it extended from Cerberus to Leo Minor, having an amplitude of more than 100°. The exhibition continued until the morning twilight. A motion of translation from W. SW. to E. SE. was suspected, but the motion was not very appreciable. When the aurora appeared in its greatest brilliancy, the substance which composed it appeared to be in a state of great agitation; and the rays exhibited a red color, sometimes like that of iron heated to redness and sometimes to a white heat. The space occupied by the small arch was, as usual, of a greenish color; the centre near the horizon being black, and the whole destitute of rays. The aurora exhibited the greatest brilliancy between the W. and N.E. points of the horizon. A few cirrus clouds were noticed during the exhibition; they were all black, without any reflection of the light of the aurora, proving that this light emanated from a region much above that of the clouds.

***Magnetic effects of the Aurora; from the Comptes Rendus,* T. XLIX, p. 473.**

On the 26th of August some anomalies were noticed in the motions of the magnetic instruments at the Observatory of Paris, the declination having changed 22′ between $9\frac{1}{2}$ A.M. and noon.

Aug. 28th at 5 P.M. the motion of all the magnetic instruments was very irregular. Between midnight and 1 A.M. of Aug. 29th the horizontal intensity varied 0.0074. At 9 A.M. of the 29th the horizontal intensity had diminished by 0.01, while the vertical component had increased 0.0013.

During the forenoon of the 29th the declinometer was very much disturbed, and at 11 A.M. it oscillated 41′ on each side of its mean position. Towards evening the disturbances disappeared; but a fresh disturbance commenced on the 1st of September, at 11h 30m A.M. About 4 P.M. Sept. 2d, there commenced a new magnetic storm, more violent than that of Aug. 29th. The magnets were carried beyond the range of their scales, showing a change of the horizontal intensity exceeding 0.014 but as the observations were only recorded photographically, the extreme range could not be determined.

***Effect on the Telegraph Wires, from the Comptes Rendus,* T. XLIX, p. 365.**

From the evening of Aug. 28th until the morning of the 29th the needles of the magnetic telegraph at Paris were almost constantly in motion, as if a permanent current was passing through the telegraph wires. Business was

therefore entirely interrupted, and could not be resumed until 11 A.M. Aug. 29th. The same effect was noticed on the telegraph lines from 4h to 8h on the morning of Sept. 2d, although no aurora was noticed on that day. Business was again interrupted, the needles were disturbed, and the bells were rung.

The galvanometers were violently deflected, sometimes to the right and sometimes to the left. The needles were turned from zero 10° or 20°, remained there stationary for a short time then suddenly moved to 30° or 50°, then returned and were defected in like manner on the other side of the zero point. The effect was more powerful and longer continued on the lines from Paris to Bordeaux, Marseilles and northward, than it was on the east and west lines. During the night of Aug. 29th some intelligible signals were received from Strasbourg.

During the day, Aug. 30th, the telegraph operators experienced frequent interruptions. On the afternoon of Sept. 1st some difficulty was experienced in telegraphing; but Sept. 2nd, at 4h 50m A.M. there was a general disturbance on all the lines first on those to Bordeaux, Toulouse, Marseilles, London and Brussels, and a few minutes later on those to Basle, Strasbourg, Havre and Brest. At 7 A.M. *bright sparks* were noticed on the conductors of the lines to Bordeaux and Toulouse. The line to Strasbourg was less affected than the others. About 3 P.M. telegraphic communication was resumed on all the lines; but during the evening and the next morning it frequently happened that the communication was difficult.

Observations of Ozone.

Regular observations are made at Versailles on the amount of ozone in the atmosphere. During the auroras of Aug. 29 and Sept. 2, the quantity of ozone was decidedly greater than usual. Table 4.3 shows the sums of ozone collected during each period of six days, from Aug. 4, to Sept. 8, 1859.

5. *Observations at Brussels,* (*lat.* 50° 51′), by M. QUETELET, from L'Institut of Feb. 1, 1860.

At 12h 35m A.M. Aug. 29th, the sky was overcast with a light and uniform veil, with the exception of the northern horizon, which presented a slight appearance of twilight. Soon there appeared in the N.W. a rosy light, which, in a few seconds, assumed enormous dimensions. It rose to an altitude of 60°, and illumined all that portion of the sky. The rosy light rapidly extended, and soon changed to purple, presenting the appearance of a vast conflagration. There was a constant oscillatory movement, and the light varied from a bright yellow to the deepest red. Near the horizon the sky presented a greyish and dirty appearance. There were faint traces of an obscure segment, whose centre was on the magnetic meridian. Bright rays of a yellowish white shot up from this part of the horizon, traversed the rosy light in the N.W., and terminated in a bundle at a distance of 90° from their origin.

About 12h 45m A.M., the twilight which illumined all the northern region became more intense; the general tint continued of a yellowish white, but on the eastern and western borders passed into a yellowish green. Then there appeared on the N.N.E. a second rosy light, but less decided than that of the N.W. This was also traversed by yellow rays; but the latter were much more brilliant and broader than those which traversed the light in the N.W. Those rays also terminated in a bundle at a distance of 43° from their origin.

Subsequently the aurora presented frequent alternations of brightness, but the general appearance continued the same until 2 o'clock, when observations were suspended.

At 9 A.M. Aug. 29th a disturbance of the magnetic instruments was noticed at the Observatory. Table 4.4 shows the extreme indications of the instruments for each hour, from 9 A.M. to 9 P.M. of Aug. 29th. Between 9h and 10h A.M. the fluctuations of the horizontal intensity were too great to be observed by the fixed telescope.

About midnight Aug. 28th–29th, the employés in the telegraph office at Brussels noticed signals from their bells, such as often occur during a storm. The employés in the offices at Mons, Antwerp, Gand and Ostend were also awakened by their bells, and enquired what was wanted. Communication with Paris, London, and Berlin were interrupted till 1h 30m. Paris and London inquired of our operators if they saw a light in the heavens. The effect ceased at 1h 30m on all the lines except the submarine line from Ostend to Dover, which was charged with electricity throughout the entire morning. It was not till 3h 30m,

Table 4.3
Atmospheric ozone measurements at Versailles from Aug. 4th to Sept. 8th, 1859

	Dates	Morning	Evening
From	Aug. 4 to Aug. 10	64.0	55.6
	Aug. 10 to Aug. 16	87.0	59.0
	Aug. 16 to Aug. 22	82.0	60.0
	Aug. 22 to Aug. 28	65.0	55.0
	Aug. 28 to Sept. 2	97.0	64.0
	Sept. 2 to Sept. 8	81.0	58.0

Table 4.4
Magnetic Extremes at Brussels on Aug. 29th, 1859

Hour		Declination		Horizontal intensity	
h.	h.	Max d.	Min d.	Max d.	Min d.
9 to 10		50.12	58.63		
10 to 11		49.33	53.60	1.07	−2.84
11 to 12		51.77	55.89	1.89	−0.85
12 to 1		51.68	53.58	6.50	2.53
1 to 2		52.68	53.32	6.47	5.00
2 to 3		53.13	53.85	6.04	5.40
3 to 4		53.54	57.55	9.63	4.93
4h 30m		57.96	57.55	8.83	4.60
4h 30m		57.02	57.55	5.54	
6h 30m		56.60	57.55	3.78	
8h		55.43	57.55	6.12	
9h		55.73	57.55	5.85	

Editors' note: The notation "d" probably indicates the number of divisions on the magnetometer.

and after nearly doubling the battery, that communication was re-established.

September 2, between 5h and 6h A.M., there was a second disturbance on all the telegraph lines, and communication between Brussels, Paris, and London was interrupted. Table 4.5 gives the observations made at the Observatory of Brussels.

6. *Effects of the Aurora upon the Telegraph Lines of Wurtemburg; from Poggendorff's Annalen,* Band 108, p. 506.

During the night of Aug. 28th, from 11h 15m P.M. to near noon of the 29th, there was remarked from time to time on all the telegraph lines proceeding from Stuttgard, an extraordinary attraction of the armatures, which continued from 20 to 40 minutes, and generally appeared first on the line to Heilbronn, after about 5 minutes on the Ulm line, next on the line to Carlsruhe, and last on the Tubingen line. This attraction was repeated every 5 or 10 minutes, and, towards morning, every 2 or 3 minutes. After 5 o'clock only bell signals could be obtained from the local stations, as the armatures were held fast. During this period the deflections of the galvanometers were very remarkable. In a single minute the needles changed their position 5 or 6 times even to 40° west. While on the Ulm line the deviation was easterly, on the Bruchsal line the deviation was westerly.

Table 4.5
Magnetic observations at the Observatory of Brussels, Sept. 2d and Sept. 3d, 1859

Date	Time	Declination		Horizontal intensity	
		Max d.	Min d.	Max d.	Min d.
Sept. 2	9 to 10 A.M.	54.75	57.65	10.43	6.25
	10 to 11 A.M.	53.62	59.40	9.82	3.36
	11 to 12 A.M.	53.72	58.15	0.30	4.64
	12 to 1 P.M.	52.06	66.24	8.05	7.36
	1 to 2 P.M.	49.34	62.81	?	?
	2 to 3 P.M.	43.40	57.87	17.79	0.00
	3 to 4 P.M.	48.32	58.40	15.53	10.12
	4 to 5 P.M.	51.15	55.00	14.01	10.48
	5h 0m P.M.	54.75		10.24	
	6h 0m P.M.	54.44		8.87	
	7h 5m P.M.	56.67		7.80	
	8h 24m P.M.	56.59		7.21	
	9h 0m P.M.	60.62		5.64	
	10h 0m P.M.	53.47		8.04	
Sept. 3	9 to 10 A.M.	57.17	58.23	4.89	4.09
	10 to 11 A.M.	54.56	56.53	5.21	4.46
	11 to 12 A.M.	53.73	54.96	7.08	5.55
	12 to 1 P.M.	50.59	53.63	10.64	7.40
	1 to 2 P.M.	51.03	53.15	11.28	8.88
	2 to 3 P.M.	51.63	51.90	10.42	8.75
	3 to 4 P.M.	48.37	51.52	13.75	8.36
	4h 30m P.M.	51.52		12.50	
	5h 0m P.M.	53.50		14.83	
	9h 0m P.M.	57.58		7.31	

Editors' note: The notation "d" probably indicates the number of divisions on the magnetometer.

The cause of this phenomenon is found in a brilliant aurora which was everywhere, observed from 9 P.M. Aug. 28th till towards morning of the 29th.

7. *Effects of the Aurora upon the Telegraph Lines of Prussia; from Poggendorff's Annalen, Band* 108, p. 504.

The electrical currents on the conducting wires exhibited themselves in violent deflections of the galvanometers. The needles swung violently from 30° to 70° to one side, returned slowly to zero, and then moved slowly to the other side. On the line proceeding from Berlin westward, the disturbance commenced between 1 and 2 o'clock on the morning of Aug. 29th, when all connection with the stations ceased. Notice had previously been received of disturbance at the easterly stations, Konigsberg, Kowno, Riga and Petersburg. During the day of the 29th, on the western lines, communication was uninterrupted, while on the eastern lines it was occasionally suspended.

On the 2nd of September, when at 7 A.M. almost all the lines were in use, the disturbance occurred on all the lines, and interrupted communication from 5 to 40 minutes. The interruption was first experienced at Konigsberg 5 A.M.; at Stettin 5h 55m; Coblentz and Cologne 6h 45m; Berlin 6h 50m; Kowno and Riga at 7 A.M. About 9 A.M. the disturbance was greatest, and it declined till 9h 45m, when communication was resumed with most of the stations. At Stettin communication on all the lines was resumed at 9h 24m, and at Cologne at 10h. At Konigsberg the disturbance still continued, and at Berlin it increased to 1 o'clock, so that all communication was suspended with the west. In the course of the day, news was received of disturbance at Hamburg, Breslau, Brussels, Paris, and Amsterdam. From the latter station came the intelligence that the submarine line to England was also interrupted by the aurora.

8. *Auroral Observations in Austria; communicated by* Prof. W. HAIDINGER, Vienna, to Prof. SILLIMAN.

The Aurora of Aug. 28th to Sept. 4th, was seen at the following places in the Austrian empire as detailed in Table 4.6.

9. *Effects of the Aurora on the Telegraph Lines of Switzerland; from the Comptes Rendus,* T. XLIX, p. 662.

The intensity and direction of the currents excited in the telegraph wires during the aurora of September 2nd, were determined by M. Hipp, at Berne, by the deviation of a magnetic needle, surrounded by a wire, making thirty coils. The regular current employed in telegraphing should have been a sufficient force to deflect this needle 30°. M. Hipp found that the short lines gave no indication of a current, while the most marked effects were indicated by the longest lines, and especially by those which were directed from north to south, as the line from Zurich to Berne, Fribourg and Lausanne. The current on this line, directed from Zurich to Lausanne, would increase gradually, until the needle was deflected 42°. It would then slowly decline, and at the end of two or three minutes become zero. It would then

Table 4.6
Aurora observations in the Austrian empire from Aug. 28th to Sept. 4th, 1859

Location	Latitude	Longitude	Comments
Bodenbach, Bohemia	50° 47′	14° 10′	Aug. 29th, from 2 to 3 A.M.
Schossl, Bohemia	50° 27′	13° 30′	From $11\frac{3}{4}$ Aug. 28th to $2\frac{1}{2}$ A.M. Aug. 29th
Prague, Bohemia	50° 5′	14° 25′	Aug. 29th, morning. Also faint in the night from Sept. 1st to 2nd
Rzeszow, Galicia	50° 3′	22° 4′	Sept. 2nd and 3rd, evening
Biala, Galicia	49° 50′	19° 5′	Sept. 3, 8 o'clock
Iristen, Austria			Aug. 28, from midnight onwards
Lintz, Austria	48° 17′	14° 15′	September 3, 8 P.M.
Vienna, Austria	48° 13′	16° 23′	Great magnetic disturbances were noticed from noon Aug. 28th to the evening of Aug. 29th. Also from Sept. 2 early in the morning to Sept. 3, morning; and from Sept. 4, morning, to Sept. 5th in the evening
Kremsmûnster, Austria	48° 3′	14° 7′	Aurora, Sept. 3rd, from $8\frac{1}{4}$ to $8\frac{1}{2}$ P.M.
Schemnitz, Hungary	48° 27′	18° 50′	From Aug. 28th, 10 P.M. to Aug. 29th, 3 A.M. Also Sept. 3rd, 9 P.M.
Neutra, Hungary	48° 17′	18° 50′	Sept. 3, 9 P.M.
Mitterdorf, Styria			Sept. 2, evening
Laibach, Carniola	46° 3′	14° 30′	Sept. 3, after 8 P.M.

change its direction, returning from Lausanne to Zurich, and attain a maximum of 30 degrees. The latter current, after continuing 60 or 90 seconds, became zero, and again changed its direction.

It appears from these observations that two currents succeeded each other on the telegraph wires, having a general direction from north to south, the one proceeding from north to south having a double intensity and a double duration, the other proceeding from south to north having a less intensity and a less duration.

M. Hipp obtained deviations of 58 degrees between Zurich and Berne, and of 64 degrees between Berne and Basle, indicating currents at least threefold the ordinary current employed in telegraphing.

10. *Effects of the Aurora of Aug.* 28*th and* 29*th upon the Telegraph Lines of Tuscany, by* M. CH. MATTEUCCI; *from the Annales de Chimie et de Phys.,* Tom. LVII, p. 419.

About 6 A.M., Aug. 29th, the disturbance became sensible on the telegraph lines. About 10 A.M. a current, which marked 25 degrees on the galvanometer, and equal to about 30 feeble elements of Daniell, traversed the upper wire of our telegraph lines, in the direction from Pisa to Florence. The current slowly increased, attained its maximum in about five minutes, and then rapidly declined. These periods were renewed a great number of times, and, during the intervals, telegraphic communication was held in the usual manner. About 3 P.M. the auroral effect upon our telegraph lines had ceased.

During the disturbance, on all the lines where there are several wires stretched one above the other in the same vertical plane, the strongest current was uniformly observed in the upper wire, while in the wire nearest the earth, the current was either feeble or inappreciable. This extraordinary current was the most intense on the longest wires.

11. *Observations at Rome, Italy,* (*lat.* 41° 54′), *by* M. SECCHI; *from the Comptes Rendus,* T. XLIX, p. 347 and 458.

On the 29th of August we had a superb aurora. The sky at Rome was covered with a red veil, and was crossed by the most brilliant rays, in the form of luminous columns. The magnetic instruments were very much disturbed. The declinometer deviated 34′ from its normal position, and the inclination varied 42′. The instruments for measuring the horizontal and vertical force both passed beyond the range of their scales, showing that the variation of the horizontal force must have been at least 0.0135, and of the vertical force at least 0.0075. The disturbance continued for a long time during the forenoon, and the vertical magnet, which before noon, was beyond the scale, in consequence of the elevation of its north pole, at one o'clock passed beyond the scale on the opposite side, from a depression of its north pole.

A still more remarkable disturbance of the magnetic instruments occurred on the 1st and 2nd of September. At 4 P.M. Sept. 1st, the vertical magnetometer passed beyond its scale, showing a diminution of vertical force.

Sept. 2, at 7 A.M., the magnets were very much disturbed. At 7h 10m the declinometer pointed 2° 50′ to the west of its ordinary position. After this the needle returned rapidly to the east, and at 7h 30m pointed 1° 23′ east of its mean position, thus describing an arc of 4° 13′ in less than half an hour. This disturbance is the more remarkable, as the greatest range heretofore observed at Rome was only 45′ or 50′.

The bifilar indicated a diminution of the horizontal component, amounting to 0.129, or about *one-eighth* of its mean value.

These disturbances continued with variable intensity all day. At 4h 15m P.M. the vertical magnet again passed beyond the range of its scale. At 9 P.M. the magnet was more tranquil, and at midnight they had all returned nearly to their normal condition.

The variations of the declinometer, the bifilar and the vertical magnetometer were not simultaneous, but their maxima occurred at different times. The great vibrations were cotemporaneous with the currents observe on the telegraph lines. The clouds observed in the heavens had the exact appearance of those of the aurora borealis when it occurs by day, and such as were noticed at Rome Aug. 29th.

Similar observations were made at Leghorn, where at 6h 30m A.M. Sept. 2nd the declination was 15° 10′, while at

6h 30m P.M. it was only 14° 18′. The inclination of the magnetic needle was also very much increased during the day.

12. *Observations from Western Asia*

A. Yozgat (lat. 39° 45′), by FAYETTE JEWETT, M.D., American Missionary.

The auroral phenomena referred to in your circular were not observed at Yozgat. On the 28th of August, and for several days before and after that date, I was in Arabkir, a town nearly 300 miles almost east of Yozgat. The aurora was not noticed there. While I was at Arabkir, owing in part to the mildness of the temperature, and also to the peculiar clearness of the atmosphere, my attention was almost every evening directed to the study of the constellations. The natives, too, at that season, slept upon the roofs of their houses.

B. Kharpoot, (lat. 38° 40′), by Rev. C. H. WHEELER, American Missionary

Aug. 28th and the following nights, nothing unusual was seen here by me or by others of whom I have made inquiries. It is also a fact, so far as I know, that the usual displays of the aurora are less brilliant here than in New England.

C. Mosul, (lat. 36° 22′), by H. B. HASKELL, M.D. Missionary Physician.

No unusual appearance was observed Aug. 28th, 1859, either here, at Mardin, or Diarbekir. During the residence of American missionaries in Mosul (ten years) no auroral phenomena have been noticed.

13. *Observations in the Southern Hemisphere*

Ship Southern Cross, (near lat. 50° S., long. 80 W.), from the Alta California.

On the night of Sept. 2d, during a tremendous gale, the rare spectacle of an aurora australis was witnessed. It commenced about half past one o'clock in the morning, and increased in splendor until towards daylight, when it gradually faded before the light of day. The whole heavens were of a deep red, which color was reflected from the ocean. During the night a tremendous squall with hail burst upon the ship. Through the whole of this the flames assumed the same roseate hue; and when a spray flew over the ship, it fell to the leeward in ruddy showers. Between the squalls, in the clear places in the sky, the mysterious lights were seen shooting up in spiral streaks nearly to the zenith now flashing out with meteoric brilliancy; and now looming up against the horizon, as with the blaze of some terrible conflagration. During the gale, several times at night, brilliant balls of fire appeared flickering at the mast-heads, yard-arms, and other salient points. The captain and his officers say that they have never witnessed anything equaling this display for magnificence.

14. *Observations at Concepcion, Chili,* (*lat.* 36° 46′), *from the Mercurio of Valparaiso*

An aurora was visible here on the nights of Sept. 1st and 2nd. It appeared at midnight in the south part of the horizon, and was visible until two o'clock in the morning. It had a movement of translation from east to west. In appearance it resembled a cloud of fire, or a large ignis fatuus, which threw out some flame or vapor, and spread a light like that of the moon. For more than an hour the city was brilliantly illuminated by this heavenly light.

15. *Observations at Santiago de Chili,* (*lat.* 33° 28′), *from the Mercurio of Valparaiso*

On the morning of Sept. 2nd, about two o'clock, the sky to the south of Santiago was brilliantly illuminated by a light, composed of blue, red, and yellow colors, which remained visible for about three hours. This phenomenon is very rare in Chili. The aurora was also seen in Valparaiso (lat. 33° 6′).

16. *Observations at Kapunda, South Australia,* (*lat. about* 35°), *by* J. B. AUSTIN; *from the London Times of Nov.* 14, 1859.

On Monday evening, Aug. 29th, just after dark, the aurora appeared like a large and brilliant pink cloud extending about 25° or 30° above the horizon, and 60° or 70° in length. It continued visible for about twenty minutes, during the last five of which, splendid streamers of pink and white light were shooting vertically through it. It was seen almost throughout these colonies at the same time, and on four nights in the same week; but I saw it only twice, once Aug. 29th, and again on Friday, Sept. 2nd, when the most gorgeously brilliant display took place. It commenced immediately after sunset, and increased in splendor during the evening. For several hours, little was to be seen but a deep rich pink light over the southern part of the sky; but by degrees it extended, and, about nine o'clock, a huge pillar of fire appeared in the west, where it remained until midnight. After the moon went down, the brilliancy of the aurora increased, and from about half past eleven till past twelve, a beautiful pale, soft, greenish-blue light, like the dawn of morning, extended itself above the southern horizon for about 100° or 110°, and about 18° or 20° in height. From this, streamers of radii of red, white and blue light shot upward to beyond the zenith, fully half the sky being covered with this splendid illumination, the light from which equalled that of the full moon in England. These radii converged towards a point about 15° north of the zenith, but did not themselves extend more than half that distance beyond the zenith. This was its last appearance, and a splendid finale it was. The powerful electric excitement in the atmosphere had an extraordinary effect on the telegraph wires, agitating the instruments violently in some places, and quite interfering with the transmission of messages.

Appendix E. ART. XI. - *The Great Auroral Exhibition of Aug. 28th to Sept. 4th*, 1859; *and the Geographical Distribution of Auroras and Thunderstorms.* – 5TH ARTICLE. By Prof. ELIAS LOOMIS.[*]

Since the publication of our former articles on the great aurora of Aug. 28th to Sept. 4th, we have received some additional observations which we here subjoin.

[*] Originally published in American Journal of Science, Second Series, Vol. 30, No. 88, pp. 79–94, 1860.

1. *Extract from a Journal of the weather in Swedish Bothnia,* (lat. 67° N., long. 22° E.), *by* ROBERT RAWLINSON, *copied from the London Times of Oct. 5.*

Aug. 27–28. Morning gloomy; clouds gray and electric looking; a sort of dense ''Noah's Ark'' sky.
Aug. 28. Night, heavy rain.
Aug. 29. Night bright and clear, but bitterly cold; ice a quarter of an inch thick round tent.
Aug. 30. Day fine; sun very hot. No observation at night.
Aug. 31. Day fine, clear and calm. No observation at night.
Sept. 1. Morning, heavy clouds showing for wet.
Sept. 2. Heavy thunder storm at night, vivid lightning and deluges of rain.
Sept. 3. Morning cloudy; thick mist over forest.
Sept. 4. Morning cloudy; heavy dew in night, thick fog.
Sept. 5. Cloudy, but fine.

2. *Observations at St. Petersburg, Russia,* (lat. 59° 56′), *communicated by* Prof. A. T. KUPFFER, *Director of the Central Physical Observatory.*

From Aug. 28th to Sept. 4th, 1859, the disturbances of the magnetic instruments at St. Petersburg were very remarkable not only for their extent but for their long continuance. The magnetic observations are ordinarily made every hour, but on the preceding days, observations were made every five minutes. We have not room to publish these observations entire, but Table 5.1 exhibits the most remarkable deflections of the magnetometers.

The north pole of the unifilar magnetometer moves towards the east, when the numbers of the scale increase. The value of one division of the scale is 26.3″.

When the numbers on the scale of the bifilar magnetometer increase, the magnetic intensity increases. The value of one division of the scale is 0.0001 of the total intensity.[1]

In these observations the day is supposed to begin at noon.

From the data in Table 5.1 we can determine the range of the magnetometers for each day; these values are shown

[1] This footnote has been provided by Larry Newitt of the National Research Council, Ottawa, Canada. In a unifilar magnetometer a magnetized needle is suspended by a single (torsionless) thread so that the needle is free to rotate and to align itself in the magnetic meridian. In a bifilar magnetometer, the needle is suspended by two threads so that its movement is constrained. Both instruments can be used for measuring (absolute) horizontal intensity. The bifilar can also be used to measure horizontal field variations. The unifilar can also be used to record absolute or relative declination. For values given in terms of divisions, I calculate the following. At St Petersburg F was 49300 so 1 division is roughly 5 nT. In Table 5.2, therefore, the maximum excursion in H, (571.5 divisions) would equate to approximately 2850 nT. At Catherineburg, F was ~52800. At Barnaul, F was ~ 56100. At Nertchinsk, F was ~57000.

Table 5.1
Magnetometer measurements, Aug. 28th–Sept. 4th, 1859, from St. Petersburg, Russia

Hour	Min	Unifilar	Bifilar
August 28, 1859			
0	0	132.5	185.4
3	0	105.8	193.7
9	0	143.0	207.0
13	0	108.0	186.0
16	0	169.3	420.0
19	0	122.0	420.0
22	0	192.0	420.0
23	5	105.0	106.7
23	20	165.0	230.2
23	40	102.0	127.5
August 29, 1859			
0	0	135.5	209.0
0	45	103.0	168.0
0	55	194.0	321.2
1	5	111.0	66.5
2	40	143.0	222.8
4	0	132.3	187.0
5	5	220.5	257.5
5	30	140.0	195.0
6	10	185.0	190.0
7	20	100.0	98.0
7	35	90.0	100.0
8	0	150.0	138.0
8	45	129.0	133.3
19	0	153.0	124.0
23	0	137.4	125.0
September 1, 1859			
0	0	101.2	136.5
2	0	75.5	183.0
9	0	150.8	167.9
12	0	120.0	159.0
20	0	151.5	419.0
20	30	410.5	419.0
21	0	530.0	419.0
21	10	601.5	419.0
21	30	302.0	216.0
21	40	9.0	12.0
21	45	Off scale	7.8
21	55	94.0	0.0
22	5	Off scale	119.0
22	15	320.0	177.0
22	30	85.0	0.0
22	50	123.7	98.5
23	15	10.0	150.0
23	30	128.0	100.0
23	45	59.5	86.0
September 2, 1859			
0	5	135.0	205.3
0	35	67.0	150.0
0	45	134.5	65.0
1	55	81.0	178.0
2	20	186.0	393.0
2	25	82.0	555.0
2	40	Off scale	304.5
3	20	134.0	306.0
3	40	13.5	519.2
4	0	147.0	292.5
4	45	85.0	420.5
5	0	122.4	571.5
5	10	41.0	501.0

(*continued on next page*)

Table 5.1 (*continued*)

Hour	Min	Unifilar	Bifilar
5	50	104.5	277.5
6	45	100.0	172.2
8	0	234.5	420.0
8	5	242.0	303.4
8	25	115.0	166.0
10	35	95.3	90.3
12	0	70.1	50.2
12	15	63.0	10.2
12	25	47.3	Off scale
12	50	160.9	70.6
13	35	156.0	Off scale
14	45	116.2	78.0
15	15	122.4	44.6
16	20	113.0	108.0
17	5	98.0	104.2
18	35	160.0	109.5
20	20	147.0	129.0
20	55	127.0	123.0
21	45	150.3	115.2
22	5	136.0	106.3
23	55	120.0	136.0
September 3, 1859			
0	15	126.0	143.0
0	50	111.9	127.5
1	55	85.0	247.0
2	55	75.5	210.0
4	15	50.0	237.0
4	55	45.0	229.0
6	45	110.0	275.0
8	0	144.0	142.0
8	40	44.0	55.0
9	0	101.0	52.5
10	0	158.0	154.0
13	40	72.0	Off scale
14	20	65.0	35.5
16	20	157.0	135.2
18	15	150.0	140.0
20	55	127.0	84.0
21	20	84.2	109.0
21	45	131.0	109.0
23	55	110.7	140.4
September 4, 1859			
0	40	104.0	122.0
1	15	98.0	135.6
2	35	113.8	134.0
3	20	79.0	233.0
4	0	101.5	257.0
5	10	142.5	158.0
5	40	180.0	247.0
7	20	124.5	127.0
9	35	113.5	150.0
16	0	140.2	134.2
20	0	126.3	159.0
23	0	115.0	136.0

in Table 5.2. It should be remarked that in Table 5.2, a value of 0 indicates that the magnets passed beyond the range of their scales; so that we can only conclude that on Sept. 1st and 2nd the range of the magnets certainly *exceeded* the values here given.

3. *Observations at Catherinenburg, Russia* (lat. 56° 50′, long. 60° 34′ E.), *communicated by* Prof. A. T. KUPFFER.

The observations from Catherinenburg, Russia listed in Table 5.3 are arranged in the same manner as those from St. Petersburg. The value of one division of the unifilar scale is 33.4″. The value of one division of the bifilar scale is 0.0001 of the total intensity.

4. *Observations at Barnaul, Russia* (lat. 53° 20′, long. 83° 27′ E.), *communicated by* Prof. A. T. KUPFFER.

The observations from Barnaul, Russia, are given in Table 5.4. The value of one division of the unifilar scale is 32.8″. One division of the bifilar scale = 0.0001 of the total intensity.

5. *Observations at Nertchinsk, Russia,* (lat. 51° 18′, long. 119° 20′E.), *communicated by* Prof. A. T. KUPFFER.

Table 5.5 lists the observations from Nertchinsk, Russia. The value of one division of the unifilar scale is 33.8″. One division of the bifilar scale = 0.0001 of the total intensity.

6. *Observations at Athens, Greece* (lat. 37° 58′), *by* J. F. L. SCHMIDT, *Director of the Observatory*. (Communicated through Rev. Mr. King, Am. Missionary at Athens.)

The aurora was not seen at Athens Aug. 28th and 29th. Both evenings were very clear and still, especially Aug. 28th. Aug. 29th from 7h to 8h P.M. some clouds were seen in the west over the Morea. Aug. 30–31 was likewise clear, with a very few small clouds. Aug. 31st, in the evening, lightning in the N.W. Sept. 1st, evening, partly clear, partly cloudy, with lightning in the west.

Sept. 2d, 7h 15m A.M., beginning of a storm from the west, rain and thunder; at 8h 30m A.M., rain, hail and lightning. From noon to 12h 40m P.M., violent shower from the west. Then became clear with sunshine. The evening was clear, and in the north there appeared a dark bank of ordinary cloud (not the dark segment of the aurora), above which, from 7h 30m P.M. to 8 P.M., was seen a fine aurora of a carmine red color. The cloud bank which extended 60° in azimuth, was elevated somewhat above the horizon, so that stars were seen beneath it. The centre of the auroral light was not in the north, but N.N.W. On the west it was bounded by Cor Caroli, and on the east by α Persei. No streamers or fluctuations of light were observed. By 10 P.M. the cloud bank had disappeared, the auroral light having disappeared previously.

Sept. 3d. The entire day was clear; and at 4 P.M. I went on board a steamer for Syra. From $7\frac{1}{2}$ to 8 P.M. near the island Egina I saw in the north and northwest the carmine red light of an aurora. From $9\frac{1}{2}$ to $10\frac{1}{2}$ P.M., near Cape Sunium, a faint trace of the aurora was still seen; but no dark segment, streamers or fluctuations of light.

7. Observations at Camp Simeahmoo, Washington Territory, (lat. 49°, long. 122° 30′ W.), *by* ARCHIBALD CAMPBELL, *Commissioner of N.W. Boundary Survey*.

At 8 P.M. Aug. 28, 1859, a diffused light, without definite form, was observed a little east of north, covering about one-fourth of the heavens, which gradually increased to

Table 5.2
Range of magnetometer measurements, Aug. 28 to Sept. 4, 1859, from St. Petersburg, Russia

Date	Unifilar magnetometer			Bifilar magnetometer		
	d	d	d	d	d	d
Aug. 28	From 102 to 192	= 90	= 39′ 27″	From 106.7 to 420	= 313.3	= .031
Aug. 29	From 90 to 220.5	= 130.5	= 57′ 12″	From 66.5 to 321.2	= 254.7	= .025
Sept. 1	From 0 to 601.5	= 601.5	= 263′ 39″	From 0 to 419.0	= 419.0	= .042
Sept. 2	From 0 to 242	= 242	= 107′ 44″	From 0 to 571.5	= 571.5	= .057
Sept. 3	From 44 to 158	= 114	= 49′ 58″	From 0 to 275	= 275	= .027
Sept. 4	From 79 to 180	=101	= 44′ 16″	From 122 to 257	= 135	= .013

Editors' note: The notation "d" probably indicates the number of divisions on the magnetometer.

Table 5.3
Magnetometer measurements, Sept. 1–2, 1859, from Catherinenburg, Russia

Hour	Unifilar	Bifilar
September 1, 1859		
0	496.0	308.5
2	490.0	311.6
6	507.5	319.0
12	510.3	321.0
18	525.0	320.2
21	580.0	201.0
22	Off scale	Off scale
23	Off scale	180.0
September 2, 1859		
0	434.0	238.0
3	519.0	281.2
6	427.0	396.0
7	520.0	412.0
8	536.5	300.5
10	481.0	295.7
11	519.0	297.0
14	512.0	238.0
20	539.0	285.4
23	528.0	291.8

Table 5.4
Magnetometer measurements, Aug. 28–29, 1859 and Sept. 1–2, 1859, from Barnaul, Russia

Hour	Unifilar	Bifilar
August 28, 1859		
0	391.5	171.6
1	383.6	175.4
4	392.6	185.0
10	402.3	171.4
14	408.0	161.5
18	423.4	69.0
20	431.8	7.2
23	412.5	Off scale
August 29, 1859		
0	416.5	Off scale
2	402.5	20.0
3	382.0	121.0
5	420.0	48.0
6	437.0	94.0
9	404.0	116.0
10	422.0	106.5
18	417.5	125.0
23	408.5	107.5
September 1, 1859		
22	413.2	152.5
23	519.3	Off scale
September 2, 1859		
0	Off scale	466.5
2	358.5	32.3
6	385.0	262.0
8	350.6	156.5
9	440.5	77.4
19	397.0	166.6
23	404.0	107.5

the west, sending across from east to west an arch of a whitish color, the arch itself being much brighter than the circumjacent light. This arch remained visible until 2 A.M. At 9h 25m P.M. strongly marked rays became visible, which rising from the horizon converged to a point on the arch a little south of the zenith, and in this position remained visible about one hour. The rays in the northwest were of a pink color, those in the southeast were purple, alternately brightening and fading to a whitish color. At midnight, all disappeared except the arch, and at intervals undulating flashes of light appeared, not visible longer than three seconds. Occasionally streamers shot up from the horizon, the lower part disappearing before the upper part had reached the zenith. Sometimes these streamers were broad at the horizon, and came to a point near the zenith, and sometimes the reverse. The arch before mentioned was easily identified, and was still visible at 2h A.M., and probably remained so until daylight, which at that season, in this latitude, occurs not long after that time. This arch was situated very little, if any, to the southward of the zenith, and was the limit of all light in that direction. The light was sufficiently intense, between 11 and 12 o'clock, to enable a person to read the ordinary print of a newspaper. After the aurora was fully formed, it remained stationary, and did not move either to the west or east. At midnight, the barometer stood at 30.13; external thermometer 64° F.

August 29th a faint diffused light was seen in the north at 9 P.M., and was still visible at midnight.

August 30th a similar light was first seen at $8\frac{1}{2}$ P.M. and was still visible at midnight. No observations were made after midnight. There was no exhibition of the auroral light at this place from Aug. 31st to Sept. 4th.

Table 5.5
Magnetometer measurements, Sept. 2, 1859, from Nertchinsk, Russia

Hour	Unifilar	Bifilar
September 2, 1859		
0	347.0	285.1
1	383.0	235.4
2	635.4	370.1
3	355.5	321.5
4	214.0	181.0
5	294.8	205.6
6	327.1	224.1
7	339.5	256.5
8	335.0	250.4
9	312.2	288.5
10	311.9	243.5
11	450.0	260.0
12	333.0	246.0
13	345.4	243.0
17	327.0	269.0
19	352.0	279.0
23	343.5	243.0

The view of the northern horizon at this place is cut off by a dense forest of firs, and the sight of the heavens in that direction is some 5 or 6 degrees above the horizon.

8. *Observations at Hamilton, C.W.* (lat. 43° 16′ N.), *by* Dr. J. HURLBURT.

Answers to the questions in our first article, vol. xxviii, p. 408.

1. On the 28th of August the sky was overcast by a dark sombre cloud-like substance, but which was not cloud as the stars could be seen through it. There was no dark segment resting on the northern horizon, but one was seen at the south between 8 and 9 P.M. rising 8° or 10° in the centre. Sept. 1st between 8 and 9 P.M. this dark segment was well defined at the north, with an altitude of about 10°, and skirted the horizon fully 120°. At 1 A.M. Sept. 2d, an unusually large segment was distinctly defined at the south, where it rose fully 15° in the centre, and stretched over 130° of the horizon.
2. At 8 P.M. Aug. 28th, and from 1 to 3 A.M. Sept. 2d, the streamers of the aurora converged to a point a little east of the meridian, and 15° or 20° south of the zenith, forming a brilliant corona.
3. Aug. 28th, both in the southwest and southeast there was a dark red spot about 14° in breadth, and extending from altitude 35° to alt. 55°. Both spots presented the same appearance, and hung in corresponding parts of the heavens east and west.
4. At 1 A.M. Sept. 2d, the whole of the southern half of the sky was lighted up, resembling the sky at late dawn.
5. On the night of Aug. 28th, the most frequent and conspicuous color was red and its different shades. The aurora of Sept. 1st was scarcely at all marked with any of these colors. The light was chiefly white, resembling the dawn just before sunrise.
6. The aurora of Aug. 28th was most brilliant at 8 P.M. It was also very brilliant at 1 and 3 A.M. Aug. 29th. The aurora of Sept. 2d was most brilliant at 1 A.M.

9. *Observations at Rome, N. Y.* (lat. 43° 13′), *by* Mr. EDWARD HUNTINGTON.

During the auroral display on the evening of Sept. 2d, there was a very rapid and incessant flashing of white light, like waves running up to the corona, the light being intermitted for some seconds after the passage of each wave, and the next wave pursuing the same course, and following certain curvatures which remained constant for a considerable time, perhaps half an hour. There was a succession of waves flashing up from a point in the northwest, where the effect was as if a luminous fluid were in its course passing through a narrow strait, from which it issued, expanding like water violently forced through a narrow passage out upon a broad level area, and being at the same time somewhat deflected from its former course. Fig. 5.1 is designed to convey some idea of this appearance.

From another point nearly in the east, there was a succession of waves of light, directed to a point north of the corona, but turning suddenly into it nearly at a right angle with their former course, the light disappearing after the passage of each wave, and being renewed after a short interval in precisely the same form. Fig. 5.2 is designed to give some idea of this appearance.

10. Observations at Cleveland, Ohio (lat. 41° 31′), by Capt. B. A. STANARD

Aug. 28th, at 8h 30m P.M., the aurora began to show itself, lighting up the northern sky, rising towards the zenith, in a broad belt of luminous haze of about 40° in width, the southern edge starting a little to the westward of the star Arcturus, and running through the head of Hercules, a little south of Altair in Aquila, through the head and neck of Pegasus. The eastern end was bright enough to light up the edges of the detached masses of cumuli that were driving over from the north. In the zenith and the western end it was of moderate brightness.

At 9 P.M. another belt began to rise up in the north, and as the convex edge attained a height of about 40° it began to shoot out long, attenuated, bright rays, close together,

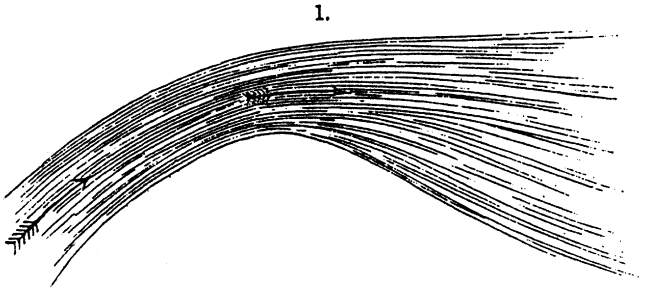

Fig. 5.1. Drawing of auroral observations in Rome, NY. See text for description.

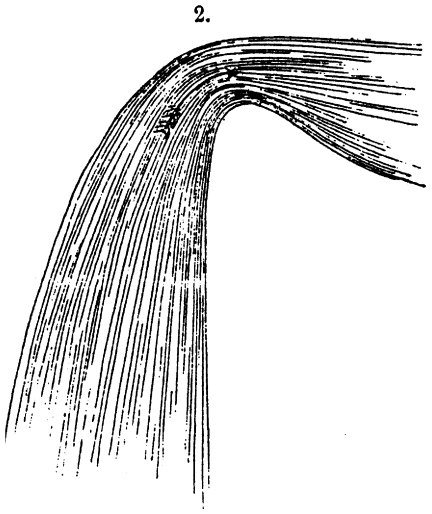

Fig. 5.2. Drawing of auroral observations in Rome, NY. See text for description.

moving slowly to the westward, and reaching to the zenith. Near the convex edge they were of a bright yellow, changing as they shot up to orange, and near the zenith to a bright red, the middle and lower ends remaining yellow and orange. As the fiery points of the rays shot into the broad belt overhead, which had still remained, like a belt of luminous haze or fog, the whole thing was changed in an instant into a bright red color, deepening as it nearer the eastern horizon, to a bright crimson, and at the western end near the star Arcturus, into a bright scarlet, gradually growing fainter in the zenith, and increasing in brightness nearer the horizon.

At 9h 15m P.M. it resolved itself into converging rays. The zenith at that time was covered by a massive cloud, covering the point where the rays would meet, which must have been near the star β Cygni.

At 9h 30m P.M. the whole had disappeared, except a steady white light in the north, very bright, forming a curve from the western edge of Böotes, through Cepheus and Perseus. The northern horizon was too clouded the whole time to see anything near it.

Sept. 2nd, at 7h 45m P.M. the northern lights began to show, forming a low narrow arch extending from the N.W. to N.E. the lower edge about 10° in height, well defined, of moderate brightness, and remaining without perceptible change until 8h 45m P.M., when bright vertical rays shot up simultaneously the whole length of the arch, of an exceedingly bright white color, with no perceptible motion E. and W. Shooting slowly up towards the zenith, at an altitude of about 45°, they began to change color rapidly, varying from white, yellow, orange and at the upper ends red; diffusing a soft pink color over the northern sky at an altitude of about 45°. At 9 P.M. they gradually disappeared, the arch was broken up, leaving some irregular white blotches in the north, which faded away and disappeared altogether. Then commenced a series of quick, sudden flashes of undefined light; here and there in the north, scimitars bearing a strong resemblance to heat lightning, sometimes in undefined rays, and sometimes in undefined shimmering light.

This continued until 9h 40m P.M. when a double arch was formed of two narrow belts of light about 15° in height, running from Canes Venatici to the southern edge of Perseus, the bright star Capella shining through the narrow black space between the two arches.

At 9h 55m P.M. bright rays suddenly shot up in quick successive flashes from the lower through the upper arch, reaching nearly to the zenith, and moving slowly to west until they reached the constellation Corona Borealis, lighting up the north western sky with yellow, orange and red. After the last rays from the east had passed the Pole, there commenced a sudden flashing of horizontal wavy bands from the upper arch towards the zenith.

At 10h 10m P.M. the rays and arches disappeared and the northern sky seemed to be covered with a steady white light, with horizontal wavy bands of dark haze rolling up in quick succession, and vanishing as they attained an altitude of about 60°, continuing until 10h 30m P.M. and gradually fading away.

11. *Observations at Fort Bridger, Utah Ter.* (lat. 41° 14′, long. 110° 33′), *by* KIRTLEY RYLAND, *Assist. Surgeon U.S. Army.*

Sept. 1st, 1859, a brilliant aurora was seen at this place. It was first observed about 11 P.M. and attained its greatest brilliancy before midnight. It extended from the northeastern horizon to the southern horizon, and was in fact a Borealo-Austral Aurora. Generally the light assumed the form of spikes and bars, but high above the horizon in the northeastern sky was a large blotch or spot, whose diameter was perhaps three times that of the constellation Orion. This blotch was of a deep crimson color, and remained for a considerable time unchanged in form, color or intensity, and faded gradually away. In the other portions of the aurora the light appeared to spout from the horizon, in the shapes already named, frequently reaching the zenith, and was of great brilliancy. It appeared to flow gradually from N.N.E. to the southern sky.

12. *Observations made at Cantonment Burgwin, New Mexico* (lat. 36° 21′, long. 105° 42′), *by* W.W. ANDERSON, *Assist. Surgeon U.S. Army.*

A member of the guard mounted Sept. 1st observed a light reflected from the clouds on that night about 10 P.M. as he was walking post, the clouds having probably just then thinned out or broken away a little. No other member of the guards from Aug. 28th to Sept. 5th saw anything unusual during the intervening nights. By reference to the Meteorological Register I find that the weather was cloudy during the whole time that the aurora was visible elsewhere. There was rain on the last four days of August, and also on the 1st, 2nd and 4th of September.

The exhibition was witnessed at Taos, about ten miles north of us, by persons residing there, but was not observed with sufficient attention to enable them to answer

any of your questions with accuracy. A physician, Dr. Ferris, who arrived at Taos from Pike's Peak during the fall, states that he was in the South Park at the time, and thinks that it was on the night of the 28th of August that the Aurora was observed by him. He saw it but one night. Streamers were seen to converge to the zenith about 10 P.M., but the aurora was not seen in the southern half of the heavens. The light was like a large fire in the distance, so that at first it was thought to be an extensive fire on the mountains. The aurora exhibited sudden flashes, and there were pulsations like waves of light rushing up from the horizon. I have been told that Capt. John G. Walker, of the Rifle Regiment, wrote a description of the aurora as it appeared at Fort Defiance (lat. 35° 44′), where it is said to have been very brilliant.

13. *Observations at the Sandwich Islands* (lat. 20° N., long. 157° W.), *from the Pacific Commercial Advertiser*.

The Advertiser of Sept. 8th, 1859, states: "There was quite a display of the Aurora a few nights since, visible at Honolulu. Broad fiery streaks shot up into and played among the heavens, almost as beautifully as those which are sometimes seen in more northern climes."

The Advertiser of Sept. 17th contains the following letter from S. E. Bishop, dated Lahaina, Sept. 9th. "Your statement that the Aurora was seen in Honolulu enabled me to account for the phenomenon I observed here a few nights since. At 10 P.M. I noticed a bright, unsteady crimson glow upon the sky, extending from N.E. to N., and about 35° of altitude. It resembled the reflection of a great conflagration at twenty or thirty miles distance, and I attributed it to heavy fires on the other side of the mountain. I was puzzled however by the fact that the clouds which rested on the mountain did not give the slightest reflection of the supposed fire. Moreover the light was far too pure and rich a crimson to have been caused by a fire.

14. *Observations at Porto Rico, West Indies* (lat. 18° N.), *by* M. du COLOMBIER, *from L'Institut of Feb.* 1*st*, 1860.

Having awakened at 2h 30m A.M. Sept. 2nd, I was greatly astonished to see my windows, which looked towards the north, brightly illumined by a brilliant purple light. Rising, immediately, I perceived that this light proceeded from a magnificent aurora, which, according to the testimony of the guard, commenced at 2 A.M. and was observed till 4h A.M. The luminous rays, red, purple and violet, extended even to the zenith. The oldest inhabitants of the place declared that they had never before seen a phenomenon of this kind.

15. *Observations at Santiago de Chili* (lat. 33° 26′ S.), *by* C. MOESTA, *Director of the Observatory*.

The aurora you allude to did occur at this and several other places in the south of Chili, during the night between Sept. 1st and Sept. 2nd, 1859. I did not witness the phenomenon myself, but it appears that the aurora was visible from about half past 1 until 4 A.M., showing a motion to the west. The watchmen were much alarmed at the colored light with which the southern part of the sky was covered, which gave rise to the belief that a small village about three leagues south of Santiago was on fire. This seems to be the first time that a polar light has been seen at Santiago. No notice has reached me as to its appearance north of this place.

16. *Observations near Cape Horn* (lat. 57° S., long. 66° W.), *by* RICHARD SCHUMACHER, *communicated by C. Moesta*.

Mr. Richard Schumacher, assistant to the Chili Observatory, was at the time on board a ship near Cape Horn. Being informed Aug. 29th that an aurora had been seen during the preceding night, he begged the mate of the vessel would let him know if there should be another. Accordingly he was awakened during the night from Sept. 1st to 2nd, between 2 and 4 A.M., when the aurora was already in its splendor. In a southerly direction there appeared a bright yellowish light forming an ellipse, whose diameters were as two to one, the centre of the ellipse being elevated about 15° above the horizon. The part of the horizon below this light seemed to be a cloudy mass of a dirty reddish color. From this ellipse, emanated a red light, apparently all over the heavens up to the zenith, and thence onwards to the north. Mr. S. did not distinguish any beams or columns of light, though the sky seemed illuminated all round nearly uniformly, except that the light of the ellipse was much brighter than the surrounding parts. There were also some light transparent clouds discernible near the zenith. The light was so brilliant that he could easily read the title page of the Nautical Almanac, and distinguish the seconds hand of a box chronometer.

The vessel was at noon, Sept. 1st, in lat. 57° 8′S., long. 66° 38′W and at noon on Sept. 2nd, in lat. 57° 36′S., long. 66° 47′W.

ON THE GEOGRAPHICAL DISTRIBUTION OF AURORAS IN THE NORTHERN HEMISPHERE.[2]

Auroras are very unequally distributed over the earth's surface. They occur most frequently in the higher latitudes, and are almost unknown within the tropics. At Havana (lat. 23° 9′) but six auroras have been recorded within a hundred years; and south of Havana, auroras are still more unfrequent. As we travel northward from Cuba, auroras increase in frequency and brilliancy; they rise higher in the heavens, and oftener attain the zenith. Table 5.6 furnishes the most precise data I have been able to collect for constructing an aurora chart of the northern hemisphere. Column first gives the name of the station of observation; columns second and third its latitude and longitude; column fourth the average number of auroras observed per year; column fifth, the greatest number of auroras recorded in a single month; column sixth shows

[2] While Tables 5.6–5.10 are not relevant to the Carrington event, they have been included for completeness of this compilation and to indicate the extensive research that Professor Loomis had undertaken.

Table 5.6
Average annual number of Auroras in North America and its vicinity, from longitude 30° to 170° west from Greenwich

Place	Latitude		Longitude		No. per year	Richest month	Years embraced	Authority
	Deg	Min	Deg	Min				
Havana	23	9	82	22	0.0625	1	100	Am. Jour., [2], xxvii, 403
San Francisco	37	47	122	26	0.5	1	4	Smithsonian Report, 1854, p. 258
Sacramento, Cal.,	38	34	121	27	0.5	1	9	Am. Jour., [2], xxix, 260
Washington, D.C.	38	53	77	0	9	3	4	Gilliss's Met. Observations
Wilmington, Del.,	39	44	75	32	8	4	7	Am. Jour., xxxiii, 299
Philadelphia	39	58	75	10	6	3	4	Bache's Met. Observations
New York	40	42	74	0	14	5	1	N.Y. Regents Rep., 1850, 255
New Haven	41	18	72	55	26	12	16	E.C. Herrick's observations
North Salem, N.Y.	41	26	73	38	8	2	10	N.Y. Regents Rep., 1850, 258
Deerfield, Mass.	42	33	72	35	4	2	1	Am. Jour., iv, 337
Fayetteville, Vt.	42	58	72	40	21	8	11	Am. Jour., vols. xii to xxiv
London, C.W.	42	58	81	25	27	7	4	Regents Rep., 1850, 290–293; Am. Jour., [2], xiv, 156
Toronto, C.W.	43	39	79	23	39	9	12	Regents Rep., 1850, 290–293; Am. Jour., [2], xiv, 156
Kingston, C.W.	44	8	76	40	36	11	4	Am. Jour., [2], xiv, 156
Somerville, N.Y.	44	26	75	20	70	14	2	Am. Jour., [2], xiv, 156
Halifax, N.S.	44	39	63	36	55	13	2	Am. Jour., [2], xiv, 156
Montreal, C.E.	45	31	73	32	34	10	2	Regents Rep., 1850, 290–291
Quebec, C.E.	46	49	71	12	42	12	4	Regents Rep., 1850, 290–291
St. John's, N. Foundland	47	33	52	38	52	10	3	Regents Rep., 1850, 290–291
Michipicoton	47	56	85	2	43	9	2	Am. Jour., [2], xiv, 156
Matawagomingen					26	7	1	Am. Jour., [2], xiv, 156
Moose Factory	51	10	81	0	141	19	1	Am. Jour., [2], xiv, 156
Martin's Falls	51	52	86	45	79	14	1	Am. Jour., [2], xiv, 156
Cumberland House	53	56	102	16	104	25	2	Gehler's Wörterbuch, vii, 144
Athabasca Lake	58	43	111	18	91	21	2	Athabasca Obs., p. 145; Am. Jour., [2], xiv, 156
Frances Lake	61	30	129	0	33		2	Lake Athabasca, p. 148
Lewis and Pelly	61	30	130	0	36	12	1	Am. Jour., [2], xiv, 156
Fort Simpson	61	51	121	32	50	24	1.5	Athabasca Obs. and Am. Jour., [2], xiv, 156
Great Slave Lake	62	46	109	1	105	28	2	Capt. Rack, 1833-1835
Godthaab	64	10	51	53	72	15	6	Observat. Meteorolog., 166-228
Fort Enterprise	64	28	113	6	142	28	1	Force, pp. 24–35
Fort Norman	64	40	124	45	32	15	0.5	Force, p. 54
Fort Franklin	65	12	123	12	43	17	0.5	Force, pp. 60–64
Youcon	66	0	147	0	24	7	0.5	Am. Jour., [2], xiv, 156
Winter Island	66	11	83	10	25	8	1	Force, pp. 66–72
Fort Hope	66	32	86	56	39	13	1	Force, pp. 75–77
Fort Confidence	66	54	118	49	100	30	2	Athabasca Obs., 324-350; Am. Jour., [2], xiv, 156
Peel's River	67	27	134	30	65	16	1	Am. Jour., [2], xiv, 156
Jakobshaven	69	12	51	0	18	5	8	Observat. Meteorolog., pp. 82–164
Felix Harbor	69	59	92	1	23	10	1	Force, pp. 84–87
Point Barrow	71	21	156	15	131	26	1	Phil. Trans., 1857, p. 497
Port Bowen	73	14	88	55	47	15	1	Force, p. 91
Melville Island	74	47	110	49	26	8	1	Force, pp. 97–103
Smith Sound	78	37	70	40	10	5	2	Dr. Kane's Obs.

the number of years embraced in the comparison; and column seventh shows the authority for the statement.

The numbers for several of the stations are derived from an article contained in vol. viii of the Smithsonian Contributions, entitled, Record of auroral phenomena observed in the higher northern latitudes, compiled by Peter Force. Such observations are indicated by the word "Force" in the last column of Table 5.6.

The auroral observations in Table 5.7 are generally confined to brief periods of time, and have therefore less importance than the ones in Table 5.6. They are nevertheless of some value in deciding in what part of the world auroras are most frequent and brilliant. These notices are all taken from Force's article in the Smithsonian Contributions, vol. viii.

Table 5.8 exhibits the average annual number of auroras in Europe. The table is arranged in the same manner as Table 5.6.

The observations in Table 5.9 are less definite than the ones in Table 5.8 and are therefore given in a separate table.

Table 5.10 presents the most definite observations I have been able to collect from the Asiatic continent.

If we project all the preceding observations upon a chart, we shall discover considerable uniformity in the distribution of auroras over the earth's surface. If we travel

Table 5.7
Notices of Auroras in North America and its vicinity, from longitude 30° to 170° west from Greenwich

Place	Latitude		Longitude		Auroras
	Deg	Min	Deg	Min	
Cedar Lake	53	13	100	10	Extremely brilliant and covered the whole sky
Off Cape Farewell	56	17	42	51	Frequently most brilliant
At sea	57		49		Occurred almost every night
York Fort	57	2	93		Very few winter nights without the aurora. One may read distinctly by it
At sea	57	30	45		Whole southern hemisphere illumined. Gave nearly as much light as the full moon
At sea	58	12	49	15	Radii shot from the southward
At sea	58	30	44	30	Far surpassed anything of the kind observed at Port Bowen
At sea	59		50		Seen in every part of the heavens
At sea	59	58	59	53	Brilliant coruscations
Hoarak	59	59	44	36	Four luminous arches
At sea	60		56		Whole sky illuminated
Kikkertak	60	4	43	2	Unusually brilliant coruscations
Nennortalik, Greenland	60	8	45	16	Of every day occurrence. Brighter than the full moon
Davis Straits	60	10	49	40	Yellow and reddish coruscations, extending near the zenith
At sea	61	4	49	50	Illumined the whole southern sky
Davis Straits	61	37	52		The whole sky was one living fire of aurora
Davis Straits	61	58	54	40	Most brilliant aurora danced to the zenith
At sea	62	30	63		Aurora seen in the south
Rankin's Inlet	62	35	93		Aurora very bright, spreading all over the sky
Hudson Strait	62	45	72	24	Aurora unusually splendid
Good Hope	64	10	51	42	Auroras always spring up in the E. or S.E.
Cape Lavenorn	64	30	39	30	Auroras unfrequent
At sea	65		63		Very brilliant, spread all over the heavens
Southampton Island	65	28	84	40	Visible during the whole of the night
At sea	65	50	61		Very brilliant, shooting rays to the zenith
Hudson's Bay	66	11	82	53	Very brilliant
Chamisso Island	66	13	161	47	Very brilliant
At sea	66	30	59		Seen in the south
Kozebue's Sound	66	30	163		Aurora always seen to the northward
Fort Macpherson	67		135		Six auroras seen in fifteen days
Cape Krusenstern	67	8	163	46	Shot up to the zenith; pink, purple, and green rays
Fort Good Hope	67	28	130	54	Spread all over the sky
Behring's Sea	68	30	167		Unusually brilliant display
Hearne's Sea	68	48	115	31	Most superb display
Igloolik	69	15	81	45	2 auroras in Nov.; 1 in Dec. 1822. Generally faint
Baffin's Bay	70	43	63	44	Faint aurora to southward
Baffin's Bay	71	20	62	28	Brilliant aurora
Baffin's Bay	72	10	68	36	Eleven auroras seen in Feb. 1851
Somerset House	72	48	95	41	Seldom seen in 1833
Baffin's Bay	72	49	70	59	Nine auroras seen in Jan. 1851
Batty Bay	73	17	91		Great luminous rays issued from the zenith
Austin's winter quarters	74	10	94	16	11 auroras in Jan. 1851; 12 in Feb. 1851; and 4 in March 1851
Lancaster Sound	74	18	82	10	Eleven auroras in Dec. 1850
Griffith Island	74	30	95	20	Vastly inferior to those seen in more southern latitudes
At sea	74	31	111	38	Aurora faint
Off Beechy Island	74	40	92		Ten auroras seen in Nov. 1850
Assistance Harbor	74	40	94	16	Much less vivid than in more southern latitudes
Barrow Strait	74	45	94		Two auroras in Sept. 1850
Wellington Channel	74	54	93		Seven auroras seen in Oct. 1850
Northumberland Sound	76	52	97		Five auroras seen in Dec. 1852

from the equator northward along the meridian of Washington, we find on an average near the parallel of 40°, only ten auroras annually. Near the parallel of 42°, the average number is 20 annually; near 45°, the number is 40; and near the parallel of 50° it amounts to 80 annually. Between this point and the parallel of 62°, auroras are seen almost every night. They appear high in the heavens, and as often to the south as the north. Further north they are seldom seen except in the south, and from this point they diminish in frequency and brilliancy as we advance towards the pole. Beyond lat. 62° the average number of auroras is reduced to 40 annually. Beyond lat. 67° it is further reduced to 20, and near lat. 78° to 10 annually. If we make a like comparison for the meridian of St. Petersburg, we shall find a similar result, except that the auroral region is situated further northward than it is in America; the region of 80

Table 5.8
Average annual number of Auroras in Europe

Place	Latitude		Longitude		No. per year	Richest month	Years embraced	Authority
	Deg	Min	Deg	Min				
Bologna	44	32	11	23 E	4	6	24	Mairan Aurore Boreale, p. 505
Paris	48	50	2	20 E	19		64	Gehler Wört., vii, 1, 135
Montmorency	49	0	2	19 E	5	4	27	Cotte Meteorologie, 355
Carlsruhe	49	1	8	25 E	8	5	11	Gehler Wört., vii, 1, 146
Plymouth	50	22	4	9 W	6	5	21	Am. Journal, xxxiii, 298
Leyden	52	9	4	29 E	26		29	Cotte Meteorologie, 355
Berlin	52	30	13	23 E	4	5	28	Mairan Aurore Boreale, p. 500
Franecker	53	12	5	32 E	25	8	7	Cotte Meteorologie, 355
Kendal	54	19	2	45 W	31	10	7	Dalton's Met. Essays, 54-58
Makerstoun	55	35	2	31 W	31		6	Am. Jour., [2], xi, 139
Dunse	55	47	2	20 W	24	11	10	Phil. Trans. Abstracts, vi, 291
Upsala	59	52	17	38 E	37	14	21	De la Rive Elec., iii, 301
Christiana	59	54	10	43 E	33	13	16	De la Rive Elec., iii, 300
St. Petersburgh	59	56	30	18 E	21	8	11	Mairan Aurore Boreale, p. 510
Bossekop	69	58	23	34 E	143		1	Pouillet Physique, ii, 663

Table 5.9
Notices of Auroras in Europe and its vicinity from longitude 60° East to 30° west from Greenwich

Place	Latitude		Longitude		Auroras	Authority
	Deg	Min	Deg	Min		
Teneriffe	28	16	16	39 W	Aurora seen Nov. 1837 for the first time in the memory of man	Alfred Diston
Shetland Islands	60	20	1	9 W	Constant attendant of clear evenings	Rees' Cyc., v. iii
At sea	60	30	25	W	A bright arch with coruscations	Force, p. 13
At sea	61		25	W	Passed through the zenith and eclipsed the moon in splendor	Force, p. 14
Iceland	64		22	W	Seen almost every clear night	Henderson, p. 148
Torneo	65	52	24	13 E	Frequently occupy the whole sky. Commonly seen in the north	Maupertuis, ii, 155

Table 5.10
Auroras in Asia and its vicinity from longitude 60° East to 170° west from Greenwich

Place	Latitude		Longitude		Auroras	Authority
	Deg	Min	Deg	Min		
Irkutsk	52	20	103	50 E	Two auroras seen in December 1735	Gmelin, p. 434
Tomsk	56	35	86	30 E	Only one aurora per month in 1741	Gmelin, p. 477
Catherinenberg	56	50	63	35 E	Four auroras seen in 1854	Kupffer Obs.
Turinsk	57	45	63	45 E	Three auroras seen in March 1742	Gmelin, p. 326
Kirenskoi Ostrog	58	0	108	E	Five auroras seen in March 1739	Gmelin, p. 458
Tobolsk	58	12	68	18 E	Not much more frequent than under the same latitude in Europe	Erman, i, 394
Jeniseisk	58	30	92	E	Three auroras seen in Feb. 1738	Gmelin, p. 453
Beresov	63	56	65	4 E	Sometimes seen for months together throughout the night	Erman, i, 470
Virchni Koorina	66		152	E	Constant and very brilliant	Billings, p. 57
Koliutchin Island	67	26	175	35 W	More frequent and brilliant than at Nijnei Kolymsk	Von Wrangell, 506
Nijnei Kolymsk	68	32	160	56 E	Seen almost every evening	Von Wrangell, 83
On the ice	69	58	168	41 E	An aurora of extraordinary beauty	Von Wrangell, 103
On the ice	70	20	174	13 E	Beautiful aurora all night	Von Wrangell, 318

auroras annually being found between the parallels of 66° and 75°.

Upon the accompanying chart[3] the deep red color indicates the region where the average number of auroras annually amounts to at least 80; and the pale red color indicates the region where the average number of auroras annually amounts to at least 40. We thus see that the region of greatest auroral action is a zone of an oval form surrounding the north pole, and whose central line crosses the meridian of Washington in lat. 56°, and the meridian of St. Petersburg in lat. 71°. Accordingly auroras are more frequent in the United States than they are in the same latitudes of

[3] The chart is not included in this compilation.

Table 5.11
Latitude distribution of annual number of thunderstorms

Latitude range	Average number of thunderstorms annually
0–30°	51.6
30–50°	19.9
50–60°	14.9
60–70°	4.0
>70°	0.0

Europe. On the parallel of 45°, we find in North America an average of 40 auroras annually; but in Europe less than ten.

GEOGRAPHICAL DISTRIBUTION OF THUNDER STORMS[4]

The geographical distribution of auroras is believed to be intimately related to the geographical distribution of thunder storms. I have therefore made a considerable collection of facts showing the average annual number of days of lightning at different points of the earth's surface.

It is obvious from an examination of the table[5] that thunderstorms prevail most frequently in the equatorial regions and diminish as we proceed towards the poles. It is also evident that the frequency of thundershowers depends upon other circumstances than simply latitude; but without stopping to enquire what these circumstances are, we will take the average of the observations included between different parallels of latitude. Our results are shown in Table 5.11.

Appendix F. ART. XXXI. – *The Great Auroral Exhibition of Aug.* 28th to *Sept.* 4th, 1859. – 6TH ARTICLE; by Prof. ELIAS LOOMIS.[*]

Since our last Auroral article was prepared for the press, the following letter has been received from the Secretary of the Smithsonian Institution.

Washington, June 6th, 1860.

Dear Sir: – Some time since, you wrote us in regard to the aurora of September, 1869, and I now write to inform you that we have a very large collection of materials in regard to this interesting meteor which in justice to the writers ought to be published. It is, however, a pity that the data for scientific deductions in regard to this interesting phenomenon should be scattered, and we will therefore present the whole to Silliman's Journal, provided the Editors will publish it. Will you take charge of it, and prepare it for the press?

JOSEPH HENRY, *Secretary S. I.*

The editors of this Journal have accepted the liberal proposition of Prof. Henry, so far as to publish whatever might be supposed to be of importance in an investigation of the theory of the Aurora. A considerable portion of the materials collected by the Smithsonian Institution have already appeared in former numbers of this Journal, and many of the reports are from neighboring stations where the Auroral appearances are almost identically the same. From the entire mass of materials we have aimed to select those Reports only which were the most complete and elaborate, and which were so distributed in geographical position as to afford a correct idea of the appearances throughout the entire area of the United States.

OBSERVATIONS OF THE AURORA OF AUGUST 28TH, 1859.

Selected from the Smithsonian Papers.

1. *Observations at Burlington, Minnesota,* (lat. 47° 1′, long. 92° 30′), *by* A. A. HIBBARD.

The aurora of Aug. 28th, commenced at 8 P.M., and increased very rapidly until $8\frac{1}{2}$ P.M., when it came to a centre directly over our heads. It went about three-fourths the circumference of the horizon at the base, and completely round at the top, and down about one-third on the south side. Stars very bright and light enough to read very fine print. At 9 P.M. it had nearly disappeared over head; and but few beams to be seen in any part of the horizon, although new beams were forming in the north. At $9\frac{1}{2}$ P.M., the beams were very light, and somewhat scattered. At 10 P.M. it had entirely disappeared.

2. *Observations at Marquette, Michigan,* (lat. 46° 32′, long. 87° 41′), *by* Dr. G. H. BLAKER.

Aug. 28th, at 8 P.M., a bright crown overhead, with beams or streamers extending to every point of the compass, but soon lost in a white haze. In the course of an hour these streamers extended to the horizon in every direction, with bright streams of white light shooting up towards the crown, all of which became perfectly red, or of a bright crimson color over head. This continued to increase in brightness until after midnight, with floods of white light at the horizon, all passing into crimson fleecy vapor in the zenith.

3. *Observations at Winona, Minnesota,* (lat. 44° 3′, long. 91° 36′), *by* T. F. THICKSTUN.

Aug. 28th, an auroral bank and a few pencilled streamers had formed at $9\frac{1}{2}$ P.M. At midnight the streamers and

[4] The final seven pages of the original article consider statistics related to the geographical distribution of thunderstorms and incidence of lightning. Dr. Loomis also includes a discussion on incidence of lightning and a table giving the days of lightning in the Atlantic Ocean. We have omitted the extensive thunderstorm and lightning tables and the remaining details of the thunderstorm and lightning discussion. The final sentence of this article reads as follows: "The bearing of the preceding facts upon the theory of auroras will be considered hereafter".

[5] Dr. Loomis presents a table containing extensive thunderstorm data with references from 131 locations world wide, from which the results shown in Table 5.11 were derived and included in his article. Since the auroral frequency in the polar regions had been shown to be less than in the sub-auroral regions and since the frequency of thunderstorms followed a similar pattern in the polar regions, there was apparently a belief at that time that the two phenomena were somehow related.

[*] Originally published in American Journal of Science, Second Series, Vol. 30, No. 90, 339–361, 1860.

corona filled the whole heavens except the N.E. portion. During the whole night the light was equal to that of a half moon.

4. *Observations at Green Bay, Wisconsin,* (lat. 44° 30′, long. 87° 56′), *by* D. UNDERWOOD.

Aug. 28th, about $7\frac{1}{2}$ P.M., the aurora was visible in the northern part of the heavens, but did not attract particular notice until about 9 P.M. Soon after eight the sky began to redden, and became nearly of a blood-red color. Soon the streaks were observed shooting upward from all points of the horizon, and concentrating in a large luminous mass in mid-heavens. The greatest intensity of color was at the zenith. Rays were constantly shooting up from all points of the horizon and the colors constantly changing. The rays emitted an intense red light for about half an hour, when they began slowly to fade away in the north and south, but in the east and west they continued to glow until 10 P.M., when they began to fade away. Flashes of white light appeared among them, commencing from the horizon and moving upwards, following each other in rapid succession like the waves of an immense sea of light. They grew brighter as the red color disappeared, and when this was wholly gone they also gradually faded away.

5. *Observations at Milwaukee, Wisconsin,* (lat. 43° 3′, long. 87° 57′), *by* Prof. E. P. LARKIN.

Aug. 28th, at 8 P.M. an aurora commenced. About $8\frac{1}{2}$ P.M. an arch formed from S.W. by the north to the S.E., with dark broken clouds below. The streamers now commenced, principally in the N.W. and N.E., and were surprisingly beautiful, of crimson, purple, peach and orange; the crimson predominating. At 8h 45m a perfect corona formed a few degrees south of the zenith.

At 9 P.M. the aurora began to fade, and at ten had nearly disappeared. At $10\frac{1}{2}$ P.M. the north gave indications of another aurora which occurred about 12 o'clock, nearly equal in splendor to the first, and still another occurred about 3 A.M. There were also auroras late in the night of the 30th and also of the 31st.

6. *Observations at Burlington, Wisconsin;* (lat. 42° 39′, long. 87° 44′), *by* D. MATHEWS.

Aug. 28th, at 8 P.M. the appearance was that of a large luminous ring surrounding the zenith; but this form was very transient, the light becoming concentrated in the west. Between 8 and 9 P.M. there were two arches formed in the north, the first almost 30° in altitude, and the second about 40°. From the outer edge of the larger arch darted a succession of streamers or rays of light. At 8h 15m a perfect flood of light came up in the east, not in streams, but like the dawn of day, just before sunrise. This appearance lasted about half an hour. At 9 P.M. streams of light radiated in every direction from a point about ten degrees south of the zenith, covering the whole heavens except a space in the south. One broad belt of red light extended from near the zenith to the horizon at a point a little north of west.

7. *Observations at Dubuque, Iowa,* (lat. 42° 30′, long. 90° 52′), *by* ASA HORR, M.D.

Aug. 28th, the aurora began with floating irregular masses of auroral clouds in the north, which soon spread over the sky, terminating in a broad zone of light spanning the heavens from E. to W. and reaching to 20° south of the zenith. At 8 P.M. many of the luminous clouds became distinctly crimson, with the deepest hue near the horizon. At 8h 15m, a distinct arch formed in the north crowned with tall flickering white streamers. The crimson clouds now dissolved into paler streamers; at 8h 35m the streamers subsided; and at 8h 40m the red clouds near the horizon and the diffuse light in the north appeared again. From this time till 9 P.M. a crimson shade was spread over the whole of the broad belt, with varying hue and brightness. The arch in the north formed again with whitish streamers which remained moderately bright until 11 P.M.

8. *Observations at Waltham, Massachusetts,* (lat. 42° 24′, long. 71° 14′), *by* Rev. THOMAS HILL.

Aug. 28th, at $7\frac{1}{2}$ P.M. there were visible some splendid masses of rose-colored light in the east and west near the horizon; that in the west being nearly obscured by twilight. At 7h 45m a well defined arch passed south of the zenith, and all the sky north of it was filled with light, radiating toward the pole of the dipping needle. I watched the aurora from 9 to $10\frac{1}{2}$ P.M., and at 3 A.M. got up again to look. It was then very brilliant and rosy all along the southern horizon.

9. *Observations at Monroe, Michigan,* (lat. 41° 50′, long. 83° 22′) *by* Miss HELEN J. WHELPLEY.

Aug. 28th, about $8\frac{1}{2}$ P.M. there was a broad line of intensely yellow light extending from east to west. In a few moments the whole sky to within 20° of the south, seemed to be permeated with a clear whitish light; yellowish rays constantly shooting up from the east, north and west horizon to the zenith. At the same time appeared a bright rose colored mass in the east, which gradually enlarged until it covered nearly three-fourths of the heavens, and about 9 P.M. the rays met and formed a perfect corona a little south of the zenith.

10. *Observations at Willow Creek, Illinois,* (lat. 41° 45′, long. 88° 56′), *by* E. E. BACON.

Aug. 28th – aurora first seen at 8 P.M., corona and beams at 8h 40m, arch 8h, 45m. Beams of red very brilliant in the east and west, and at the corona from 8h 35m to 8h 55m. At 9h the beams and corona had disappeared, and a broad red belt extended across the heavens, passing over to the south. Two distinct arches were formed in the north. At 9h 15m bright beams in the southeast, the red belt disappearing in the east. At 9h 25m redness nearly gone. At 9h 28m arches broken. At 9h 35m brilliant spot in N.E. At 9h 40m arch reformed, but not so brilliant.

At 12h 30m beams with far greater grandeur than at 8h 40m. Beams streamed from all round the horizon to the zenith. In the southern half of the sky, the beams flashed

like the blaze of a great fire. At 12h 45m a bright belt from E. to W., in the south, with a dark belt something like a cloud under it. At 1h 12m bright belt in the south gone. Aurora lasted till daylight.

11. *Observations at Sandwich, Illinois,* (lat. 41° 31′, long. 88° 30′), *by* Dr. N. E. BALLOU.

Aug. 28th, at $7\frac{1}{2}$ P.M. there was a bright luminous band, a degree in width, spanning the heavens. Soon it became tortuous; and in the zenith it pointed southward half way to the horizon. At 8 P.M. red gleams shot up in the N.W. directly to the zenith. At $8\frac{1}{2}$ P.M. the same appearance sprung up in the N.E. At 9 P.M. the entire northern half of the sky was brilliantly red, with gleams which soon culminated in a corona. At $9\frac{1}{2}$ P.M. the whole was tinged with red, alternating with beams of light. At 10 P.M. the red tinge floated away to the south. At midnight it presented much the same appearance as before.

12. *Observations at Sag Harbor, New York,* (lat., 41° 0′, long. 72° 20′), *from the Sag Harbor Express*

Aug. 28th – between 8 and 9 o'clock rays of clear, white light arose from every part of the horizon, and soon met in a common focus at a point about 15° S.E. of the zenith, amid the four stars forming the trapezium of the Dolphin. At 10 P.M. a more dense light appeared at two points on the horizon a little north of east and west. These were at first of a bright yellow light; but at $10\frac{1}{2}$ P.M. that in the east assumed a dark crimson hue, and the light in the west was tinged with a paler red. At this time began the waves of undulating light, their motions being upward and across the radial columns in a direction from east to west.

At midnight the brightness of the columns increased, the undulations increased, especially in the south, and their motions became exceedingly rapid. The usual dark bank now appeared upon the horizon in the south, well defined, but occasionally broken by minor columns of light. The whole heavens continued thus glowing, until the aurora was eclipsed by the light of day.

13. *Observations at Kanosha, Nebraska,* (lat. 40° 51′, long. 95° 44′), *by* BELA WHITE

There was a very brilliant light of a pink color from about 1 A.M. Aug. 29th until daylight in the northern half of the hemisphere, shooting upwards to the zenith, and passing off to the south. It was so light as to enable a person to read coarse print.

14. *Observations at Great Salt Lake City, Utah,* (lat. 40° 45′, long. 111° 26′), *by* W.W. PHELPS

Aug. 28th between 9 and 10 P.M. a palish light wavered up about 30° towards the zenith; thence it spread east and west with increasing grandeur, till about 11 P.M. when the perpendicular streams beautified a large portion of the northern hemisphere. The light about 20° above the horizon, decreased upward and downward, so that at nearly midway to the zenith, the light changed into a fine yellow green, which was joined by a rich livery of crimson spanning the whole heavens from east to west, as a belt several degrees wide. This magnificent phenomenon continued in varying hues, until about 1 A.M.

15. *Observations at New York City,* (lat. 40° 43′, long. 74° 5′), *by* Prof. O.W. MORRIS.

Aug. 28, 8 P.M. there was a bright band above the horizon, which spread upwards with rays. At 9h 10m, the light spread over the heavens, occupying the zenith and either side with white, and interspersed with pink colored portions. At 9h 20m it formed an arch in the south with a dark segment below, while the northern portion of the sky was perfectly clear. At 9h 25m the beams shot up from all sides to the zenith, forming a beautiful corona which lasted 5 or 8 minutes, sometimes putting on the appearance of conflicting waves. Nearly the whole sky was of a pink, and some portions of a dark red color. It faded gradually away, first disappearing in the south, and at 10 P.M. only a bright band across the northern portion without a dark segment. About l0h 30m occasional rays shot up to the zenith. At 11h it was very light, so that objects could be seen at a distance. The aurora continued with varied colors and brightness until the dawn of the 29th.

16. *Observations at Pekin, Illinois,* (lat. 40° 36′, long. 89° 45′), *by* J.H. RIBLET.

Aug. 28, 8h 20m P.M. a white band running from N.W. to E. with two columns shooting up, one by the north star the other through Ursa Major. 8h 30m it is passing westward and a high column is passing about 5° East of the north star, and about 10° above it. At 8h 40m two columns passing nearly to zenith on the east side of north star. At 8h 46m the column by the north star increased in width; the top bent over forming a semi-circle to west. Color white in the north, changing to a rose at its upper edge, and a red in the east. At 8h 55m arches forming; the lowest about 10° above the horizon, and of a pale color. The second about 30° above the horizon, and of a pale orange color. Streamers running from the lower arch through it and about 30° above it. The color was most intense in the east. At 8h 57m both arches better defined. The streamers passing from the lower through the upper to a point about 10° west of the zenith. At 9 P.M. less brilliant and ceased observing.

17. *Observations at Urbana, Ohio,* (lat. 40° 6′, long. 83° 43′), *by* Prof. M. G. WILLIAMS.

Aug. 28th, at 9 P.M. columns of white and yellowish light shot from all points of the arch which extended from N. 80° E. to N. 75° W. Many of the coruscations passed beyond the zenith; in the east the light was pink and deep crimson forming a mass about 30° broad and 60° high reaching down to the horizon. The color was sometimes almost blood red. At 9h 10m a similar mass formed in the N.W. At 9h 15m a remarkably beautiful column shot up at N. 50° W. having a breadth of 10° and reaching to the zenith. The colors were white, yellowish, pink and crimson. About 9h 20m an arch was formed in the south, having an altitude of 40° at the centre. A few minutes later, the

crimson light extended down from the zenith, quite to this arch, so that most of the sky was covered with colored light. At 9h 50m, a beam 2° broad, shot up from S. 80° W, passing 20° or 30° beyond the zenith. In a few minutes the beam seemed to be broken up into fragments of 5° or 6° in length, and presently vanished. At 10 P.M. the brightness was much diminished; at 10h 15m revived; the northern arch very brilliant and slightly tinged with crimson. At 10h 30m the arch extended from E. to N. 85° W. At midnight the exhibition was still fine. From $2\frac{1}{2}$ to 3 A.M. coruscations of white light shot up all along the horizon from E. to S. 15° W. The aurora continued to decline, till the dawn of day.

18. *Observations at Henry Co., Indiana,* (lat. 40°, long. 85° 15′), *by* WILLIAM DAWSON.

Aug. 28th, about 9 P.M. a red cloud covered a large portion of the eastern sky with a similar one in the N.W. and several large luminous beams extended from the north point to the zenith. Soon the red disappeared, and the bright streaks grew much shorter, leaving a bright cloud brilliantly fringed with white, near the northern horizon. After some minutes, several small bodies, like long white clouds, started from about 25° S.E. of the zenith, and moved slowly towards the west, disappearing about the same distance nearly S.W. of the zenith. About midnight, a dark cloud decked with immense streamers of white, glaring light, rested on the northern horizon, when suddenly it burst forth into streaming coruscations of red, purple and white lights, shooting to a point 15° or 20° south of the zenith, where these flashing lights presented the appearance of a cloud, tinted with vermillion and purple. At $12\frac{1}{2}$ A.M. fully two-thirds of the heavens were wrapt in flashing torrents of streamers directed towards this point. This tremulous illumination lasted about an hour, when it partly vanished; but soon the sky was again covered with darting streamers nearly as before, and the light seemed more vivid than at $12\frac{1}{2}$ A.M. At 2 A.M. the light had in a great measure passed away.

19. *Observations at Gettysburg, Pennsylvania,* (lat. 39° 49′, long. 77° 15′), *by* Rev. M. JACOBS.

Aug. 28th, the aurora was visible in the evening twilight especially to N. and N.E. At 9 P.M. the whole sky as far south as within 30° of the southern horizon was covered with alternate bands of luminous matter like cirrus cloud. At 9h 25m the luminous band within about 20° of the northern horizon began to shoot up streamers, and soon became a mass of streamers which filled the whole northern sky, darting up to a point about 2° East of Aquila, where they crossed, some radiating thence southward. The streams were visibly wafted round on the east and west, to the S.E., S.W. and even south. The streamers were mostly of orange, white below and crimson red above. At 10 P.M. the sky was mostly clear; the bank of vapor, dark below but luminous above, with a few streamers occupied the northern horizon, rising to the height of 20° or 25°. The light was equal to that of the moon at quadrature.

20. *Observations at College Hill, Ohio,* (lat. 39° 19′, long. 84° 26′), *by* Prof. J. H. WILSON.

Aug. 28th, the aurora commenced at 8 P.M. and continued with increased splendor till 1 A.M. The corona formed about 10 P.M. with arch and beams. At 1 A.M. the coruscations darted from the horizon upward to the zenith and about 20° beyond. The light was equal to the clearest full moon.

21. *Observations at Wyandott City, Kansas,* (lat 39° 7′, long. 94° 44′), *by* JOHN H. MILLAR.

Aug. 28th, at $11\frac{1}{2}$ P.M. a diffused light was observed in the N.N.E. gradually increasing until at 1 A.M. the whole northern sky from N.W. by W. to S.E. by E. was covered with rays and streamers of moderate brightness, shooting up to within 30° of the zenith, and changing rapidly, from a uniform white to a tinge of purple. The aurora passed off about $1\frac{1}{2}$ A.M.

22. *Observations at St. Louis, Missouri,* (lat. 38° 37′, long. 90° 15′), *by* A. FENDLER.

Aug. 28th, at 8h 30m P.M. I observed in the northern part of the sky some large patches of a deep red color, and the horizon towards the north was filled with a white light. The white as well as the red light rose gradually up to 45°. At 8h 35m the upper part of the light to the right was of an unusually deep red, while that to the left was greenish white. The aurora increased in splendor till 8h 50m, rising to the zenith, with red streamers running nearly N. and S. The aurora now declined in the north, but spread its red color to about 10° south of the zenith. By 9 P.M. the red color was gone, only a faint white light remaining near the northern horizon, which continued till 9h 20m when it became obscured by clouds.

Aug. 29th at 1 A.M. I awoke and found the aurora more brilliant than last evening. It reached 45° south of the zenith, and had a corona 15° or 20° south of the zenith, of a deep fiery red, sending rays in all directions from this point towards the horizon. Towards the north the light was white, and close to the northern horizon the sky was blue. By 1h 20m the aurora had retired to within 80° above the northern horizon.

23. *Observations at Fredericksburq, Virginia,* (lat. 38° 30′ long. 77° 30′), *by* CHARLES H. ROBEY.

Aug. 28th, a most brilliant light appeared 8 P.M. and disappeared about 4h 15m A.M. It was generally diffused over the face of the heavens with a brightness exceeding that of the full moon, the brightest part being N.E. and N.W. About N.E. it was of a red color.

24. *Observations at the eastern base of the Sierra Abajo, Utah,* (lat. 38°, long. 110°), *by* Dr. JOHN S. NEWBERRY.

Aug. 28th – being at an elevation of about 7,000 feet above the sea, from 11 to 12 o'clock the aurora appeared remarkably brilliant, the entire northern heavens being covered with a diffused red flush, with flashes of deeper red and white light. The auroral flush was noticeable in

the north before 10 o'clock, but was not conspicuous before 11.

25. *Observations at Santa Clara, California,* (lat. 37° 18′, long. 122° 0′), *by* OLIVER S. FRAMBES.

Aug. 28th, at 9 P.M., about 10° E. of north the sky seemed tinged with red light. In half an hour several columns of mellow light were formed which rose to a height of 40°, and the colors became very bright. The light gradually moved to the east, and after two hours or more gradually faded away.

26. *Observations at Paducah, Kentucky,* (lat. 37° 5′, long. 87° 21′), *by* A. MATTISON.

Aug. 28th, at midnight, the clouds cleared off and showed the most beautiful aurora I ever saw in this latitude. Sometimes it was red, and sometimes it sent up streamers overhead. Aug. 29th, 1 A.M., aurora very bright, but the sky became overcast. The light continued till near day break.

27. *Observations at Monterey, California,* (lat. 36° 36′, long. 122° 54′), *by* Dr. C. A. CANFIELD.

Aug. 28th – a very brilliant aurora from $9\frac{1}{2}$ P.M. to 11 or 12 P.M.

28. *Observations at Raleigh, North Carolina,* (lat. 35° 40′, long. 78° 52′) *by* WILLIAM H. HAMILTON.

Aurora appeared at 9 P.M. and lasted till 11 P.M. As light as if the moon was shining.

29. *Observations at Dallas, Texas,* (lat. 32° 45′, long. 96° 46′), *by* JOHN M. CROCKETT.

Aug. 28th, at dark the northern sky had the appearance of bright twilight. It continued to brighten until it extended from N. to N.E., and assumed a red tinge, with columns perpendicular to the horizon, and extending more than half way up the heavens. About the time of the greatest illumination, a round body in the N. E., about 15° in diameter, became of a beautiful bright scarlet, which in 20 or 30 minutes moved slowly towards the north, displacing the columns as it went. The whole scene occupied about one and a half hours and was constantly changing. The aurora continued with diminished brightness till near daylight.

30. *Observations at Selma, Alabama,* (lat. 32° 25′, long. 86° 51′), by S.K. JENNINGS, M.D.

Aug. 28th, about 8 P.M., there was a very well defined arch of red fleecy looking clouds extending up about 20°, that was beautifully brilliant for half an hour. From $8\frac{1}{2}$ till after 10 P.M. there were incessant flashes that might have been taken for diffuse lightning.

31. *Observations at Cahawba, Alabama,* (lat. 32° 19′, long. 87° 16′), *by* MATTHEW TROY, M.D.

Aug. 28th, from 8 to 9 P.M. a bright light was visible a little east of north. It was brightest near the horizon, and extended to a height of about 30°, gradually fading at its upper border.

32. *Observations at Jacksonville, Florida,* (lat. 30° 15′, long. 82° 0′), *by* Dr. A.J. BALDWIN.

Aug. 28th, about 8 P.M. was seen a remarkable aurora which continued until 2 A.M. Aug. 29th. At times it was of a vivid red, with streamers radiating towards the zenith. The brightest were from N.W. to N.E. The color would almost fade out at times, and then lighten up the heavens again with a brilliancy which was majestic. About 9 o'clock there was a dark cloud in the north extending from N.W. to N.E.; and the auroral display was beautiful along the fringe of this cloud.

33. *Observations at Micanopy, Florida,* (lat. 29° 35′, long. 82° 18′), *by* JAMES B. BEAN.

Aug. 28, just after dark I noticed a luminous appearance in the north, which at times disappeared and then reappeared with increased brightness, till 9 o'clock, when it exhibited streamers shooting up toward the zenith, and sometimes a deep red glare of rosy light toward the N.E. At 10 P.M. the streamers were quite distinct, presenting beams of gray and purple light. It disappeared about 11 P.M. but reappeared with more beauty between $1\frac{1}{2}$ and 2 A.M. The streamers were very distinct, exhibiting various colors, and shooting at times within 10° or 15° of the zenith. The luminous haze in the N.W. continued till it was obscured by day-light.

34. *Observations at Cedar Keys, Florida,* (lat. 29° 7′, long. 83° 2′), *by* Judge AUG. STEELE.

Aug. 28th, occurred an aurora, brightening up the northern horizon with most beautiful coruscations. It extended from N. to N.E. and upward to about 30° above the horizon, and exhibited frequent streaks of reddish yellow, shooting upward in pointed forms of the most dazzling brightness. It ceased about $9\frac{1}{2}$ P.M. but reappeared the next morning in still greater brilliancy and continued until overpowered by the light of day.

35. *Observations at Corpus Christi, Texas,* (lat. 27° 45′, long. 97° 30′), *by* A.M. LEA.

Aug. 28th, 9 P.M. an aurora reddened the sky in the north, through about 90° of the horizon, and rising about 40° above it, with columns of light stretching from the horizon towards the zenith.

36. *Observations at Key West, Florida,* (lat. 24° 33′, long. 81° 48′), *by* WILLIAM C. DENNIS.

Aug. 28th the aurora was faintly visible soon after sun-down and did not increase materially in brightness till $8\frac{1}{2}$ P.M. At 9 P.M. the color was of the most fiery red. The direction of the middle point of the aurora was N. 10° E. and both horizontally and vertically it subtended an angle of about 30°. There was a narrow line of immovable clouds along the northern horizon in the direction of the aurora. At 9 P.M. the aurora commenced fading rapidly, and had disappeared at $9\frac{1}{4}$ P.M.

OBSERVATIONS OF THE AURORA OF SEPT. 1ST AND SEPT. 2ND, 1859.

Selected from the Smithsonian Papers.

1. *Observations at St. Johns, Newfoundland,* (lat. 47° 35′, long. 52° 38′) *by* E.M.J. DELANEY.

Sept. 1st, an Aurora of various colors appeared in the west, moved towards the zenith and disappeared.

Sept. 2d at 8 P.M. an Aurora of various colors appeared in the north, south and west, moved towards the zenith and disappeared.

2. *Observations at Burlington, Minnesota,* (lat. 47° 1′, long. 92° 30′), *by* A. H. HIBBARD.

Sept. 2d, Aurora commenced at 8 P.M. in the north, and N.E.; increased very fast until $8\frac{1}{2}$ P.M. when it formed a perfect arch from N.E. to S.W. and ran about one-third of the way down from the zenith on the south side. The east and west parts were very red; the east part flashy like lightning. At 9 P.M. nearly disappeared. At $9\frac{1}{4}$ P.M. commenced in the north with very bright and flashy light; then very bright streamers ran up instantly almost to the zenith. At $9\frac{1}{2}$ nearly disappeared; only bright flashy spots E. and N.W.

Sept. 3d, Aurora commenced about $8\frac{1}{2}$ P.M.; beams ran up very rapid but very dim; formed perfect at about $9\frac{1}{2}$ P.M.

3. *Observations at Princeton, Minnesota,* (lat. 45° 50′, long. 93° 45′), *by* O.E. GARRISON.

Sept. 2d, a bright aurora extending from the N.W. to the E. and culminating in the zenith. It was a bright display of streamers in bands varying from a bright white to a red flame color; the portion on the eastern extremity was flashing rather than streaked; that on the west was of a reddish flame color. The bands were about two degrees wide reaching from the horizon to the zenith. The central portion of each band being brightest, diminishing to a slight light on the edges. The first appearance was at dark, and it was still bright at 10 P.M.

Sept. 3d, the Aurora was repeated, but much less brilliant and only about 45° elevation with a dark arch beneath about 20° above the horizon. Disappeared before 9 P.M.

4. *Observations at Gardiner, Maine,* (lat. 44° 11′, long. 69° 46′), *by* R.H. GARDINER.

Sept. 1st., brilliant aurora over dark arch.

Sept. 2d, very remarkable aurora. Colored streamers with constant, and very brilliant flashes of light at north and east, and reaching south of zenith. At $9\frac{1}{2}$ P.M. two very bright arches at the north, one about 12° the other about 25° above the horizon, the upper one being extremely bright; the sky between them and below the lowest, being of a dark purple.

Sept. 3d, very brilliant aurora with colored streamers in all parts of the sky.

5. *Observations at Ogdensburg, New York,* (lat. 44° 43′, long. 75° 26′), *by* W.E. GUEST.

Sept. 2d, at 1 A.M. a splendid aurora. The light continued for nearly two hours.

Sept. 2d, $9\frac{1}{2}$ P.M. A few faint streamers shot up in the east and at the same time there was a faint rose colored light in the west, when all at once there commenced on every side a display of waves of auroral light. It was an undulating motion commencing near the horizon, and waving up gradually toward the zenith. In ten or fifteen minutes it had reached the zenith, and a corona was formed, its rays of different lengths pointing downward. It disappeared almost as rapidly as it came on, and a faint light was spread on all sides. A few minutes before ten a large arch was formed, one extremity resting in the east, and the other in the N.W. Its base was dark, yet the stars were glittering through its whole length. The arch was somewhat irregular in form in the N.W. It rose gradually until a faint double arch was formed. The streamers were quite stationary, without any motion from right to left. In less than an hour it had lost its form, and the light was diffused throughout the glittering dome. There was some light continued through the night.

6. *Observations at Salem, Oregon,* (lat. 44° 58′, long. 123° 4′), *from the Statesman.*

Sept. 1st, about 8 P.M. a faint radiance was observed shooting up from the northern horizon, and gradually the whole heavens from north to south were covered with a delicate rosy tint, bright and glowing in the zenith, and decreasing in brilliancy near the horizon. It was most brilliant about 11 P.M. at which time it yielded sufficient light to read common print quite easily. It continued to shine with gradually decreasing splendor, and finally yielded as morning approached.

7. *Observations at Fort Umpqua, Oregon,* (lat. 43° 48′, long 124° 6′), *by* HENRY OATLEY, U.S. Army.

An aurora was observed on the night of Sept. 1st. The light was most intense about midnight, and was sufficient to enable one easily to read print.

8. *Observations at Rochester, New York,* (lat. 43° 8′, long. 77° 51′), *by* M.M. MATHEWS.

Sept. 2d, 1h 45m A.M. the southern sky was one entire sheet of red light, extending from near the zenith, quite down to the horizon, and reaching laterally from S.E. to N.W. At 2 A.M. the redness gathered intensity, and divided off into two nearly equal portions, one occupying the S.E. and the other the N.W. section of the sky, and for half an hour assuming a deep cherry red hue, with an occasional streamer of white light ascending nearly or quite to the zenith.

At 3 A.M. the whole sky from N.W. around to the S.E. became one entire blaze of deep red, and began sending off from all portions of its lower margin, the most brilliant streamers of white light which waved and flickered in front of the dark red back ground. They converged to a point

just south of the zenith. This corona was most distinct at 3h 15m A.M. when it presented the appearance of an immense fan resting on the horizon. At the north lay a heavy bank of cloud rising about 2° above the horizon, and during the most brilliant display at the south, the upper edge of these clouds was tinged with a most beautiful orange color. At 3h 30m A.M. the redness had become comparatively faint, and the streamers had entirely disappeared.

Sept. 3d, about 8 P.M. was another auroral display confined mostly to the northern sky, and consisting principally of white streamers that were constantly flickering and dancing. At 9 P.M. they reached a point south of the zenith, and were attended by flashes of extreme brightness. At 11 P.M. the light had become quite faint, and the streamers had disappeared.

9. *Observations at Ostego, Michigan,* (lat. 42° 28′, long. 85° 42′), *by* MATTHEW COFFIN.

Sept. 2d, aurora brightest about 2 A.M. when there was a beautiful corona a little S.W. of zenith, and rapidly shooting rays from N.W. and N.E. meeting at that point.

10. *Observations at Riley, Illinois,* (lat. 42° 11′, long. 88° 33′), *by* E. BABCOCK.

Sept. 1st, 11 P.M. aurora displaying beautiful red and white streamers covering all the northern half of the heavens. At midnight the whole north was covered with beautiful streamers of varied colors. At 12h 15m A.M., streamers shot up from the north; the whole moved south and rested about 20° above the southern horizon, at which time a dark belt appeared under the white. Immediately streamers shot up from all around the horizon centering near the zenith. The deep red prevailed at S.E. and N.W. In less than two minutes, the whole became a broken mass, and the streamers disappeared. The dark belt still rested upon the southern horizon, and the light continued all over the heavens.

11. *Observations at Davenport, Iowa,* (lat. 41° 30′, long. 90° 38′), *by* H.J. FINLEY.

Sept. 2d, 8 P.M. aurora in brilliant reddish parallel rays running east and west about 45° above the northern horizon. Corona pale and but few rays.

12. *Observations at Camp, No. 33, Nebraska,* (lat. 42°, long. 109° 50′) *by* Capt. J.H. SIMPSON.

Sept. 1st, at 11 P.M. about two-thirds of the whole southern heavens appeared one sheet of beautiful roseate light. For a while, the light continued in a state of repose; the most concentrated portion forming a limiting belt on its northern side, and extending from a point on the horizon about 10° north of east, across the heavens to a point on the horizon about due west. From this belt, the light with its roseate hue was diffused southwardly all over the heavens down to the arc of a circle whose plane was inclined to the horizon about 10°. At length the light assumed a more intense form and shot up in whitish coruscations to the apex of the illuminated portion which was about 20° south of the zenith. My assistant observed this aurora at 10 P.M., and as it disappeared about midnight it must have lasted about two hours.

13. *Observations at Great Salt Lake City, Utah,* (lat. 40° 45′, long. 111° 26′), *by* W.W. PHELPS.

An aurora was seen here on the evening of Sept. 1st and morning of the 2d. A little after midnight, it spread from north to south, from east to west; and by its light I could tell the time on my watch. There was a beautiful center equally rayed near the zenith. At times the southern hemisphere began with pale red at the zenith, and faded down to a dark orange horizon, while the northern hemisphere glowed with yellow and green. I continued my observations till past 2 A.M.

Sept. 3d, about 8 P.M. a faint light sprung up in the east, and rose about 45° high. At 9h 15m it glowed beautifully. After 10 P.M. it grew fainter, and disappeared a little after midnight.

14. *Observations at New York City,* (lat. 40° 43′, long. 74° 5′), *by* Prof. O.W. MORRIS.

Aurora from 10h 20m P.M. Sept. 1st, till dawn of the 2d. There was a dark band, at the south of 10° or 15°, then a white one and streamers of a variety of colors, mostly red, shot up in the S.E. and yellow in the S.W. interspersed with white beams. The corona was after 1 A.M. a little S.E. of the zenith.

Sept. 2d aurora from 10 P.M. to 11h 15m P.M. At first a faint light, then a dark segment above it on the northern horizon of about 15° in breadth; above it a band of about 8°; then another dark band, surmounted by a white one from which beams of bright light shot up along the upper edge. About 10h, 15m waves of white light shot up nearly to the zenith. It faded away gradually after 11 P.M. retaining only a steady light on the horizon.

15. *Observations at Carlisle, Pennsylvania,* (lat. 40° 12′, long. 77° 11′), *by* Prof. C.W. WILSON.

Very brilliant aurora lasting from midnight to 3 A.M. Sept. 2d. Also Sept. 2d, 9 P.M. It first appeared as a luminous arch extending from N.W. to N.E. and 10° or 20° high. From this the light shot up in streamers first white, then turning bright red about half way to the zenith. The arch finally disappeared and, the whole then presented the appearance of a mass of light clouds, with rapid flashes behind them. The whole lasted about half an hour.

16. *Observations at Urbana, Ohio,* (lat. 40° 6′, long. 83° 11′), *by* Prof. M.G. WILLIAMS.

Sept. 2d, my first observation was at lh 30m A.M. when the entire northern heavens were covered with a uniform yellowish light. There was also a large mass of crimson light in the S.W. At 2 A.M. the whole south was covered with pink and crimson light, soon after a distinct and beautiful corona was formed a few degrees south of the zenith, and continued about 15 minutes. At 2h 40m A.M. a beautiful column of light 12° in breadth white, yellowish, pink and crimson rose from the west at an angle of 70° with the southern horizon. At 3 A.M. the aurora was

considerably diminished in intensity, but continued with variations till dawn of day.

Sept. 2d, at 8h 45m P.M. the light was distinct and uniform along the northern horizon. At 9h 15m there were fine coruscations increasing in brilliancy till 10h. At 9h 30m the coruscations had for their base a well defined arch extending from N. 80° E. to N. 85° W., and its altitude at its center was 12°. Many of them reached the zenith but no corona was formed. The coruscations were mostly white.

Sept. 3d. The evening was cloudy, but the aurora was sufficiently strong to illuminate the clouds.

17. *Observations at Newark, Ohio,* (lat. 40° 4′, long. 82° 23′) *by* DAVID WYRICK.

Sept. 1st, about midnight the entire heavens except near the southern horizon were illuminated by a pale yellow light. In about ten minutes masses of red light appeared in the E. and W; and as they faded away others appeared in the N. and S. Subsequently there was a beautiful emanation of red rays from a circular center near the zenith. The whole phenomenon lasted about two and a half hours. In the S. and S.W. lay a dark cloud rising about five degrees above the horizon.

18. *Observations at Baltimore, Maryland,* (lat. 39° 18′, long. 76° 37′), *by* C. WESTBROOK, *Telegraph Superintendent.*

On the morning of Sept. 2d, I found the telegraph wires charged to an extent far beyond the strength of our ordinary batteries. Upon disconnecting the batteries I got clear and distinct writing from Cumberland, distant 179 miles. When the current was at its maximum strength, the manipulations of the operator at Cumberland worked the armature of the relay magnet here with a force nearly equal to that which would be produced by a Grove battery of 50 cups on a short circuit. The intensity of the spark at the instant of breaking the circuit, was such as to set on fire the wood work of the switch board. The current however was variable, and at times no sensible effect could be observed.

19. *Observations at Aurora, Indiana,* (lat. 39° 4′, long. 84° 54′), *by* GEORGE SUTTON, M.D.

Sept. 1st, about 10 P.M. a faint aurora was seen in the north; and about midnight the aurora extended over the whole heavens. In the north the light was of a pale color resembling the break of day, and a few faint streamers could be seen. About 1 A.M. the whole southern heavens presented a deep red appearance. At 1h 30m streamers were more frequently seen in the north, and occasionally a ray would appear in the S.E and S.W. Between 2 and 3 A.M. streamers arose in all directions, but much paler in the north than in the south. The streamers converged to a point presenting the appearance of a vast and gorgeous tent. From 1 A.M. until the break of day, the most brilliant display was in the south.

Sept. 2d, about $8\frac{1}{2}$ P.M. the aurora appeared again in the north. There were occasional flashes of light resembling distant lightning. It disappeared in a few hours.

20. *Observations at Auburn, California,* (lat. 38° 53′, long. 121° 2′), *by* ROBERT GORDON.

Sept. 1st, from $9\frac{1}{2}$ P.M. until daylight we had a most magnificent display of aurora, in which the whole sky north, south, east and west was almost all the night glowing with ruddy light. The northern point near the horizon where the aurora commenced continued rather dark.

21. *Observations at St. Louis, Missouri,* (lat. 38° 37′, long. 90° 15′), *by* A. FENDLER.

Sept. 2d, at 8h 20m P.M. aurora exhibited a white hazy light 15° above the northern horizon. Soon long white streaks appeared alternately on the right and left to 45° above the horizon, and a light red tint was sometimes visible. At 8h 30m the aurora disappeared. At 9h 20m P.M. it again threw out several white streaks to about 60° above the northern horizon. Presently it changed to a few fiery red spots. At 9h 27m a few short streaks shot up a little to the east of north. At 9h 32m the aurora became brilliant. At 9h 34m red with no streaks. Soon after nothing remained but white diffused light.

22. *Observations at Moneka, Kansas,* (lat. 38° 30′, long. 98°), *by* L. CELESTIA WATTLES.

Sept. 2d, an aurora appeared from 1 to 3 A.M. On the same night about 10 P.M. a light appeared in the S.E. like the rising of the moon. It grew redder and more brilliant as it extended up the sky until it reached the zenith. It now shot out to the westward, streaming continually across the sky to the horizon. It did not wholly disappear until the morning dawn.

23. *Observations at New Albany, Indiana,* (lat. 38° 17′, long. 85° 45′), *by* ALEXANDER MARVIN.

Sept. 2d, at 1h 30m A.M. a broad beam of crimson light extended up from the eastern horizon and met another from the west considerably south of the zenith. Beautiful streamers shot up all around the north to the point of meeting of the beams, south of the zenith. In the north a dark cloud extended from E. to W. in the form of a flat arch. Above it was an ever changing display of white and deep crimson streamers. A similar arch of cloud was visible in the south but not quite so flat, and above it, streamers concentrated in the point above mentioned. The greatest observed brilliancy was from 1h 50m to 2h 30m A.M.

Sept. 3d, 8h 45m P.M. streamers of white and pale red light shot from the horizon half way to the zenith. At 9 P.M. only a grey light in the north.

24. *Observations at Louisville, Kentucky,* (lat. 38° 3′, long. 85° 30′), *from the Louisville Journal.*

On the morning of Sept. 2d for some three hours commencing about midnight, the whole heavens were lighted up in the most brilliant manner. The light was generally diffused over the whole sky, but was reddest in a southwest direction. Towards the north it was whiter with occasional streaks of green and deep crimson darting up towards the zenith.

25. *Observations at the base of the Sierra Abajo, Utah,* (lat. 37° long. 110°), *by* Dr. JOHN S. NEWBERRY

Sept. 1st, no aurora was observed at 9 P.M. the heavens being partially obscured by broken clouds. At 1 A.M. I waked and was startled by the red light that penetrated the tent and tinged the landscape, which was illuminated as strongly as by the full moon shining through thin clouds. On going out I found the whole heavens of a bright crimson with streaks of white and yellow converging toward the zenith, where they formed a beautiful corona. These rays reached down within 20° of the southern horizon. The aurora continued almost without abatement till day-light.

26. *Observations at Bentonville, Arkansas,* (lat 36° 22′, long 94° 16′), *by* PAUL GRAHAM.

Sept. 1st, at 11 P.M. there was a bright sheet of light embracing the eastern and northeastern part of the horizon, from thence extending upwards 60°. It became so light that objects were clearly seen at a considerable distance. At the same time, the clouds in the S.W. were tinged with red. It continued very bright until 3 A.M. at which time it disappeared.

27. *Observations at Asheville, N. Carolina,* (lat. 35° 37′, long. 82° 29′), *by* H. H. STRAWBRIDGE.

Sept. 2d, at 12h 30m A.M. my attention was attracted to a singular fiery light in the N.E. at an elevation of about 45°. Some 3° or 4° to the east of north also appeared a space of whitish light. Both lights increased, the spots of faint reddish light extending quite to the zenith. At 12h 50m the lights diffused themselves over the sky, and from about N.E. to S.W. a complete belt of roseate light extended from horizon to horizon across the zenith. It was at first about 6° or 8° in breadth, its edges very ill-defined; but it gradually widened and changed its line of direction until it became a zone of rosy light from 25° to 40° in breadth, reaching from the west to a little north of east. From 1h 5m to 1h 25m A.M. I was able to read with perfect ease the smallest type in a newspaper. At lh 30m the light slightly decreased. At 2 A.M. a large space in the belt about E.S.E. and 50° above the horizon became more intense. From 2h 30m the clouds so thickened as to prevent observations, although the red zone was still clearly traceable.

28. *Observations at Memphis, Tennessee,* (lat. 35° 8′, long. 90° 0′), *by* R.W. MITCHELL, M.D.

Sept. 1st, at midnight a splendid aurora flamed up suddenly in the north. Its breadth was about 30°, extending 15° on each side of the meridian and its altitude was about 40°. At first its color was nearly blood red, and motionless; but about 12h 30m A.M. streamers began to appear though with little or no change of color. In less than an hour the deep red began to fade, and it continued thus until 4 A.M. when it vanished.

29. *Observations at Selma, Alabama,* (lat. 32° 25′, long. 86° 51′), *by* S.K. JENNINGS, M.D.

Sept. 2d, about $12\frac{1}{2}$ A.M. a strip of red cloud nearly transparent and 9° or 12° wide commenced in the east, and soon extended across to the west, forming a magnificent arch. It was striped with the various hues of red from light to brightest scarlet, with a tinge of straw color, and from the centre of the arch diverging rays looking to the south and reaching nearly to the horizon. The rays colored like the arch were soon scattered, but the main arch did not entirely disappear until $4\frac{3}{4}$ A.M.

30. *Observations at Paulding, Mississippi,* (lat. 32° 20′, long. 89° 20′), *by* Rev. E.S. ROBINSON.

Sept. 2d, at 2h 10m A.M. nearly the whole visible heavens were overspread with a gauze-like lurid tint which continued till 3h 30m A.M. It was most brilliant in the N.E. and N.W. and at 2h 30m extended thirty degrees south of the zenith.

31. *Observations at Cahawba, Alabama,* (lat. 32° 19′, long. 87° 16′), *by* Dr. MATTHEW TROY.

Sept. 2d, the aurora was first observed about 1 A.M. An arch spanned the heavens from E. to W. a few degrees south of the zenith. To the north the sky had a distinct greenish tinge. The most magnificent displays of colored light were nearly over head. The light was so great that fine newspaper print could be read by it; and it continued with varying brilliancy till obscured by daylight.

32. *Observations at Natchez, Mississippi,* (lat. 31° 34′, long. 91° 25′), *by* J.J. SCOTT.

Sept. 1st, the aurora commenced at 10 P.M. I began to observe it at 12h 15m A.M., Sept. 2d. A glowing arch of the deepest crimson and 8° or 10° in breadth, extending from the N.E. to the N.W. points of the horizon, rising to the height of about 40°, while a fainter arch appeared below it. At 12h 30m rays emanated in all directions except south of a great circle passing through a point situated in the wing of Pegasus. From this point issued a broad flare of light which waved like a pennant. Every where in the northern sky, patches of light would appear, glow for a time and gradually disappear. These appearances continued throughout the night, growing fainter as the dawn approached.

33. *Observations at Wheelock, Texas,* (lat. 30° 55′, long. 87° 29′), *by* F. KELLOGG.

At 10 P.M. Sept. 1st, I first observed a zone of crimson light 30° in breadth, reaching from 10° above the horizon due east, vertically overhead, and terminating 10° above the horizon due west. From the zenith to the eastern extremity of the zone the light was mild, the color increasing in intensity until within 15° of the horizon where it gradually faded. At 11h 20m a beam of whitish light passed due north through the zenith. At 11h 30m another beam diverged from the former to the west, making an angle with it of 40°. These two beams, if continued, would unite about 25° south of the zenith. At midnight the entire space between these beams was filled up with similar but shorter beams of light, converging toward each other. Soon these central rays began to shoot bright scintillating rays of white light from their northern and western ends which travelled

with great velocity. The eastern boundary of the zone became gradually paler until 12h 30m A.M. Sept. 2d, when the color in that direction entirely disappeared, and the brightest light was then in the west and northwest. At 1 A.M. the crimson color had entirely disappeared, and nothing remained but the fan-like appearance of the numerous divergent beams of white light. The two rays first formed never changed their form or position until they disappeared about 2 A.M.

34. *Observations at Thomasville, Georgia,* (lat. 30° 50′, long. 84° 0′), *by* W. BLAVETT.

Sept. 2d, about 2 A.M. the whole northern half of the heavens was beautifully illuminated. The daily track which the sun now describes formed the southern boundary of the illuminated portion of the heavens. Upon this southern boundary was a border of deep blood red light, of 2° or 3° in breadth, extending from the eastern to the western horizon. Streams of pale light diverged from the point where this band cut the meridian. These pale streamers, at one moment, were numerous, and the next moment scarce a trace of them could be seen. The great red belt sometimes changed to a beautiful orange color.

35. *Observations at Mobile, Alabama,* (lat. 30° 41′, 88° 1′), *from the Daily Mercury*.

Sept. 2d, the aurora appeared at midnight and soon after 1 A.M. the eastern sky seemed bathed in a flame of lurid light, while a yet deeper flame streaked with silvery beams the N.W. These two pillars were united in the zenith, by a broad belt of dimmer fire. The pyramidal foci of red light were situated, one in the east, the other in the N.W. A little later the red field in the N.W. extended southerly so that one half the western sky from the horizon to the zenith seemed a blaze of fire. Meantime brilliant streamers continued to shoot from the N.E. and N.W. towards the zenith, sometimes extending over 50° or 60° of the heavens. These streamers converged towards a point on the meridian about 15° south of the zenith, and from this point shot forth smaller pencils of silvery showers. At 3h 30m the play of the streamers had ceased, while the flash of fiery red had spread over the whole north. The red flush in the northern quarter of the heavens, continued to glow until obscured by the solar dawn.

36. *Observations at Washington, Texas,* (lat. 30° 26′, long. 96° 15′), *by* Maj. B.F. RUCKER.

Sept. 1st, at 10h 30m P.M. I observed a bright light in the north and N.E. At 11h 30m the light had become much stronger and a good deal more extended in the base; and some beautiful rays shot far up on the sky in the north. At midnight the base of fiery looking vapor extended from N.E. to N.W. The rays of fiery colored light rose from every direction like an inverted fan and converged towards a point several degrees south of the zenith. Some of these rays appeared like immense columns; others only as a thin streak; some were pale, others fiery. At 1 A.M. the light continued undiminished, although the darting rays were not so numerous. The aurora continued until obscured by the light of the sun.

37. *Observations at Jacksonville, Florida,* (lat. 30° 15′, long. 82°), *by* Dr. A.J. BALDWIN.

Sept. 2d, the aurora was witnessed from midnight till daylight. At 3 A.M. the entire heavens, even at the extreme south were in a red glow. Streamers ran up from a point in the N.W. and from the S.E. and tortuous waves, swelled up from the bottom of these streamers and illuminated the whole heavens. At times these looked like lambent flames, flickering like a blaze of fire.

38. *Observations at Union Hill, Texas,* (lat. 30° 11′, long. 96° 31′), *by* Dr. WM. H. GANTT.

Sept. 1st, at 11 P.M. a faint glimmering light was visible in the N.E., which gradually grew brighter and extended over a larger space. At midnight it reached from the north 35° eastward, and mounted nearly to the zenith, and soon began to be seen west of north. At 1 A.M. it extended from west to east, and beyond the zenith. Towards the north, extending east and west about 20°, and rising about 10° above the horizon was a dark looking cloud. Above this, the light was of a whitish color, and from it sprang streamers of pink merging into crimson. The grandest display was from 1 A.M. to 1h 35m. It now began to fade, and at 3h 30m was nearly gone. A few flashes of it, however, remained until daylight.

39. *Observations at Micanopy, Florida,* (lat. 29° 30′, long. 82° 18′), *by* JAMES B. BEAN.

Sept. 2d, at 12h 30m A.M. I first saw a luminous haze in the north, and at 12h 35m streamers shot up in the north. A few minutes before 1 o'clock a luminous arch appeared, but not well defined. At 1 A.M. it included 160° of the horizon; at 1h 10m there were many distinct streamers; at 1h 15m beautiful quivering streamers, while patches of white light appeared in different parts of the northern hemisphere. At 1h 25m the corona was very bright; at 1h 35m corona very distinct, of vivid white clouds of light. At 1h 40m very brilliant red beams in the west; at 1h 50m the arch extended from E. to W. passing through Aries and Pegasus; at 2h a faint corona; at 2h 11m distinct beams near the zenith and on each side E. and W.; at 2h 25m arch brighter red with red patches of light and distinct streamers reaching beyond the zenith; at 2h 35m arch fading, at 2h 40m red light in N.W. but streamers not so distinct; at 2h 50m beautiful beams in N.E.; at 3h arch disappearing, beams indistinct; at 3h 10m red haze and no beams; at 3h 30m very faint red haze, and faint white light near the horizon.

40. *Observations at Corpus Christi, Texas,* (lat. 27° 45′, long. 97° 30′), *by* A.M. LEA.

Sept. 1st, the aurora began about $11\frac{1}{2}$ P.M. and continued until daylight. Two-thirds of the whole visible heavens were lighted up with a rich red glow, whilst the tremulous columns of variegated light swept over the heavens, from the northern horizon through the zenith to a line within 40° of the horizon on the south. Its greatest intensity was about $1\frac{1}{2}$ A.M. Sept. 2d.

41. *Observations at Fort Jefferson, Florida,* (lat. 24° 37′, long. 82° 52′), *by* Capt. D.P. WOODBURY.

Sept. 2d, at 12h 45m A.M. a continuous arch of red color extended from N. 50° E. to N. 50° W. having an altitude of about 15°, and the thickness of the arch throughout was about 25°. The shade of red was deepest along the central part of the arch, gradually diminishing above and below. Soon rays began to appear in faint white lines; they grew brighter, and extended above and sometimes a little below the arch. Soon the rays became numerous, traversing the red arch in right lines, and converging to a point in the magnetic meridian somewhat south of the zenith. They sometimes extended as high as the zenith, and even beyond. The aurora continued, gradually fading, till day light.

42. *Observations at Key West, Florida,* (lat. 24° 33′, long. 81° 48′), *by* WILLIAM C. DENNIS.

Sept. 2d, at $2\frac{1}{2}$ A.M. there were two patches of brilliant ruddy lights one in the N.E. and the other in the N.W. From the North extending 15° toward the E. there were rays of light shooting toward the zenith, the longest reaching full 60°. At 2h 50m the patch of light in the N.E. broke up into most brilliant rays extending toward the zenith. At 3 A.M. the patch of light in the N.W. also broke up into rays of light in a similar manner. At 3h 15m the rays gradually disappeared, but there still remained brilliant ruddy lights in the N.E. and N.W. At $3\frac{1}{2}$ A.M. the aurora was decidedly fainter, and at 4 A.M. nothing but a faint glow remained. This glow did not entirely disappear until overcome by the light of day.

43. *Observations at Sea,* (lat. 12° 23′ N., long. 88° 28′ W.), *by* Commander W.D. PORTER, U.S. Navy.

Sept. 1st, about $11\frac{1}{2}$ P.M. the sky had a lurid appearance in the north, and there were occasional flashes of lightning. The rest of the sky was clear, bright and beautifully blue. The red appearance was very much like the aurora of high latitudes, and now and then it had a wavy appearance. About 1 A.M. a body of heavy clouds passed over with rain.

Appendix G. ART. XII – *The Great Auroral Exhibition of Aug. 28th* to Sept. 4*th* 1859. – 7TH ARTICLE; by ELIAS LOOMIS, Professor of Natural Philosophy and Astronomy in Yale College.*

Since the publication of my last auroral article I have obtained some additional information, chiefly collected during a recent visit to Europe.

1. *Observations at Highland, Illinois,* (lat. 38° 43′, long. 89° 48′ W), *by* A.F. BANDELIER, Jr.

At 9 P.M. Aug. 28, 1859, I was struck by the appearance of a broad purple ray extending lengthwise across the seven stars of Ursa Major to 80° of height. This ray remained for about half an hour, rapidly changing. Then appeared three rays in the east inclining to the south, which ascended from a bright yellow circle resting upon a segment of a brown misty appearance. Both arch and segment were gradually rising, the former illuminated as by the faint lightning of a distant tempest. The segment greatly agitated near its upper border, tossing and rolling its cloudy particles over each other in heavy undulations. No more rays appeared, but the yellow arch and the segment rose slowly. Through the latter I saw plainly α Aurigae rise without much diminution of brightness.

At 1 o'clock a quantity of rays shot, upwards from the lucid arch, purple at the base and middle, brilliant yellow at the top. A little S.E. from the zenith they united, forming a small semicircle of the most dazzling beauty, from which rays now shot downward. The corona lasted only a few minutes, then broke up and vanished. Some rays continued after it, but the great movement of the arch and segment ceased gradually.

At 4 A.M. both still stood on the northern horizon. The greatest height of the arch during the whole apparition was 60°, that of the segment was 20° to 25°.

Sept. 2nd at 9 P.M. I observed a dark segment in the north looking very much like a fog, of an irregular circular form, the upper borders broken up, and 5° or 6° above the horizon at its greatest elevation. Behind it a faint light broke out, not unlike a distant prairie fire. The whole ranged from 10° west to 40° east. At 9h 20m four rays darted out directly north. They were of a pale milky color. They seemed to descend into the segment below, and then suddenly prolonged themselves into the true ray or flame. The same lightning-like illumination of the arch was visible as in the aurora of Aug. 28th.

At 9h 30m a strong ray appeared N. 20° E.
At 9h 35m light diminishing east.
At 9h 45m strong decrease. Segment almost without motion; its borders were now completely regular; continued to decrease and fall below the horizon.
At 10h 30m only feebly visible.
At 11h 2m segment only a small stripe of 2° in breadth, a faint lighted border.
At 3h 30m A.M. all had entirely vanished. Clouds were gathering from the south.

2. *Observations at Greenwich, England,* (lat. 51° 28′), *communicated by* Prof. G.B. AIRY, Astronomer Royal of Great Britain.

Table 7.1 lists the observations at Greenwich, England from August 28th through September 4th.

3. *Deflections of the needles of the Vertical Galvanometers of Cooke and Wheatstone's Telegraph instruments, observed at Ramsgate Station in the County of Kent, England, upon three distinct lines of telegraph: namely, Ashford and Margate, distant in a direct line* $27\frac{1}{2}$ *miles; Ashford and*

* Originally published in American Journal of Science, Second Series, Vol. 32, No. 94, pp. 71–84, 1861.

Table 7.1
Magnetic Observations at Greenwich, England

Greenwich mean time		Western declination			Greenwich mean time		Horizontal force	Greenwich mean time		Vertical force
h	m	Deg	Min	Sec	h	m		h	m	
August 28th.					August 28th			August 28th		
00	00	21	31	30	00	00	.0897	00	00	.02143
05	23	21	12	30	02	15	.0953	03	15	.02170
08	15	21	17	15	03	30	.0890	06	40	.01969
11	15	21	52	10	05	00	.0926	09	04	.01880
11	20	20	57	30	05	25	.0935	10	39	.02019
11	38	21	52	10	07	45	.0904	11	46	.01510
12	46	20	47	10	08	19	.0897	12	37	.00260
14	04	21	53	05	09	15	.0916	13	02	.01561
14	45	21	16	50	09	51	.0929	13	21	.00263
16	05	22	01	50	21	00	.0832	14	09	.01836
17	11	21	03	00				14	27	.01340
18	09	21	23	30				16	49	.02263
18	55	21	05	30				18	10	.00840
19	06	21	55	40				22	06	.02251
21	15	21	04	10				22	43	.02120
August 29th					August 29th			August 29th		
00	00	21	34	10	00	00	.0845	00	00	.02143
02	39	21	27	10	03	13	.0933	02	30	.01989
05	28	21	07	10	03	50	.0958	05	10	.01556
05	50	21	24	20	04	09	.0809	05	26	.01580
07	20	21	16	30	05	30	.0895	07	22	.01352
14	26	21	28	00	18	27	.0865	12	28	.01464
19	46	21	12	00	19	39	.0832	14	58	.01654
23	45	21	29	30	21	56	.0844	19	20	.02229
August 30th					August 30th			August 30th		
00	00	21	28	20	00	00	.0861	00	00	.01852
05	20	21	20	25	02	39	.0886	09	01	.01349
12	52	21	27	50	07	45	.0880	18	47	.01963
19	03	21	15	00	14	11	.0893	23	15	.01730
21	37	21	20	30	21	45	.0854	23	59	.01481
August 31st					August 31st			August 31st		
00	00	21	46	10	00	00	.0867	00	00	.01481
07	06	21	18	40	07	18	.0900	05	15	.00950
09	22	21	09	30	09	20	.0909	16	40	.01568
14	10	21	23	40	12	45	.0883	17	30	.00301
16	17	22	05	20	15	53	.0930	17	45	.04158
19	45	20	57	45	18	47	.0839	17	56	.02297
20	12	20	31	10	19	30	.1027	18	20	.04261
20	14	21	07	10	20	10	.0763	18	30	.02722
20	16	20	55	10	20	15	.0940	18	41	.04139
20	18	21	22	20	20	41	.0841	19	06	.02228
20	24	20	56	25	20	50	.0938	19	15	.02817
20	27	21	24	10	21	19	.0787	20	15	.02031
21	40	21	01	30	21	44	.0947	20	33	.02166
22	10	21	26	10	22	15	.0777	21	37	.02097
22	42	21	10	00	23	10	.0888	23	20	.01730
September 1st					September 1st			September 1st		
00	00	21	33	35	00	00	.0885	00	00	.01719
01	56	21	42	35	01	57	.0906	08	33	.01051
08	20	21	15	00	04	28	.0885	21	00	.01658
14	10	21	25	35	09	21	.0900	23	30	.01563
20	00	21	12	30	13	00	.0905	23	43	.01438
23	42	21	35	40	20	55	.0873	23	56	.02043
23	54	21	08	45	22	40	.0869			
September 2nd					September 2nd			September 2nd		
00	00	21	18	00	00	00	.0940	00	00	.01978
00	16	21	04	10	01	33	.0169	01	22	.02556

(*continued on next page*)

Table 7.1 (*continued*)

Greenwich mean time		Western declination			Greenwich mean time		Horizontal force	Greenwich mean time		Vertical force
h	m	Deg	Min	Sec	h	m		h	m	
01	04	21	53	10	01	39	.0817	01	36	.01963
01	13	21	11	05	01	59	.1065	01	53	.02437
01	18	21	52	15	02	27	.0778	02	17	.02197
01	40	21	21	10	02	52	.1120	02	48	.02769
01	54	21	58	50	03	23	.1003	03	13	.02203
02	13	21	11	15	03	37	.1178	03	30	.02400
02	30	21	51	40	05	43	.0930	05	47	.01988
02	43	21	13	10	06	30	.0964	06	03	.02142
03	40	21	51	25	08	40	.0850	08	37	.01602
03	57	21	23	10	09	25	.0937	09	05	.01670
05	50	21	40	00	11	29	.0802	10	47	.01200
06	15	21	00	30	12	43	.0945	11	17	.01329
07	00	21	24	10	12	54	.0816	11	32	.01063
08	51	20	53	00	14	48	.0884	12	37	.01293
09	40	21	32	00	16	13	.0816	12	56	.01142
11	04	21	06	25	18	25	.0848	14	40	.01290
11	43	21	42	20	21	35	.0812	14	57	.01221
14	15	21	05	30	23	12	.0833	15	50	.01320
15	52	21	27	20				16	06	.01281
20	15	21	15	30				18	48	.01556
September 3rd					September 3rd			September 3rd		
00	12	21	27	20	00	00	.0889	00	00	.01739
03	03	21	58	45	00	31	.0940	03	30	.01620
05	53	21	21	10	03	15	.0837	04	40	.01946
06	12	20	50	05	05	09	.1075	05	32	.01683
06	53	21	28	15	06	27	.0887	06	04	.01936
07	30	21	00	30	06	31	.0930	06	58	.01300
07	58	21	28	30	08	05	.0835	07	26	.01405
08	15	21	11	30	10	44	.0891	08	04	.01347
11	50	21	36	00	12	39	.0811	08	15	.01425
13	08	21	15	10	13	45	.0850	12	36	.00900
16	07	21	25	00	15	15	.0822	15	07	.01510
21	06	21	13	00	19	12	.0861	19	38	.01923
September 4th					September 4th			September 4th		
00	00	21	33	00	00	00	.0830	00	00	.01809
01	20	21	41	46	02	16	.0936	02	04	.01763
02	37	21	22	30	03	22	.0845	02	36	.01846
03	30	21	30	20	03	52	.0912	03	31	.01682
10	54	21	12	10	05	19	.0837	03	56	.01701
12	04	21	30	30	12	55	.0871	14	04	.01102
19	23	21	03	30	13	54	.0827	21	53	.01732
23	15	21	37	10	19	32	.0883	23	59	.01739
					23	12	.0790			

Ramsgate, distant $27\frac{1}{2}$ ***miles; Ramsgate and Margate,*** **8** ***miles; furnished by*** **Mr. CHARLES V. WALKER.**

Table 7.2 indicates the deflections of the needles of the vertical galvanometers of Cooke and Wheatstone's telegraph instruments upon three telegraph lines in England. Note. – The direction in which the current moves is indicated by the letters N and S; N means that the current is from the more northerly to the more southerly station of the two; S means the reverse. The direction of Ashford from Ramsgate is S. 60° W., and that of Margate from Ramsgate N. 22° W.

In the "value column," "strong" means 30° or 40°; "hard over," 45°; horizontal from 70° to 80°. Ordinary strong telegraph signals produce about 60°.

4. ***Auroral observations made at Sea; furnished by*** **Rear-Admiral ROBERT FITZ ROY, of the British Navy.**

A. Lat. 50° 47′ N., long. 10° 12′ W.

Aug 28th. About 11h 30m P.M. the sky being cloudy, it brightened up like daybreak, remained so for twenty minutes, then turned a dark red, and soon after darkened in again as before.

B. Lat. 29° 48′ N., long. 45° 20′ W.

Aug. 28th. The aurora seen from 9 P.M. till 4 A.M. the next morning, of a rose color. Streamers about 30° high.

Table 7.2
Deflections of the needles of the vertical galvanometers of Cooke and Wheatstone's telegraph instruments along three telegraphs lines in England

Date 1859	Time		Telegraph line	Direction	Value
Aug. 29th	07 10 A.M.	07 25 A.M.	Ashford and Margate	S	Strong
Aug. 29th	07 36 A.M.	07 45 A.M.	Ashford and Margate	S	Hard over
Aug. 29th	07 46 A.M.	07 49 A.M.	Ashford and Ramsgate	N	Strong
Aug. 29th	07 50 A.M.	08 00 A.M.	Ashford and Ramsgate	S	Hard over
Aug. 29th	09 45 A.M.	10 00 A.M.	Ashford and Ramsgate	N	Hard over
Aug. 29th	10 20 A.M.	10 27 A.M.	Ashford and Ramsgate	N	Strong
Aug. 29th	10 27 A.M.	10 28 A.M.	Ashford and Ramsgate	S	Hard over
Aug. 29th	10 28 A.M.	10 36 A.M.	Ashford and Ramsgate	N	Strong
Aug. 29th	10 37 A.M.	10 40 A.M.	Ashford and Ramsgate	S	Hard over
Aug. 29th	10 40 A.M.	10 45 A.M.	Ashford and Margate	N	Hard over
Aug. 29th	10 45 A.M.	10 49 A.M.	Margate and Ashford	S	Hard over
Aug. 29th	10 50 A.M.	10 53 A.M.	Margate and Ashford	N	Hard over
Aug. 29th	10 53 A.M.	11 00 A.M.	Margate and Ashford	S	Horizontal
Aug. 29th	11 02 A.M.	11 25 A.M.	Margate and Ashford	N	Horizontal
Aug. 29th	11 25 A.M.	11 40 A.M.	Margate and Ashford	N	Hard over
Aug. 29th	11 45 A.M.	12 20 P.M.	Margate and Ashford	N	Hard over
Aug. 29th	12 30 P.M.	12 45 P.M.	Margate and Ashford	N	Strong
Aug. 29th	12 48 P.M.	01 03 P.M.	Margate and Ashford	N	Strong
Aug. 29th	01 05 P.M.	01 40 P.M.	Margate and Ashford	S	Strong
Aug. 29th	02 40 P.M.	02 58 P.M.	Margate and Ashford	N	Very Strong
Aug. 29th	03 40 P.M.	03 50 P.M.	Margate and Ashford	N	Very Strong
Aug. 29th	03 52 P.M.	04 05 P.M.	Margate and Ashford	S	Horizontal
Aug. 29th	03 52 P.M.	04 05 P.M.	Ashford and Ramsgate	S	Very strong
Aug. 29th	04 15 P.M.	04 50 P.M.	Ashford and Margate	N	Very strong
Aug. 29th	05 00 P.M.	05 20 P.M.	Ashford and Margate	N	Very strong
Aug. 29th	05 00 P.M.	05 20 P.M.	Ashford and Ramsgate	N	Very strong
Aug. 29th	05 25 P.M.	05 48 P.M.	Ashford and Margate	N	Very strong
Aug. 29th	06 10 P.M.	06 23 P.M.	Ashford and Margate	S	Very strong
Aug. 29th	06 50 P.M.	07 20 P.M.	Ashford and Margate	S	Very strong
Aug. 29th	07 53 P.M.	08 10 P.M.	Ashford and Margate	S	Slight
Sept. 1st	11 20 A.M.	11 26 A.M.	Ashford and Margate	S	Strong
Sept. 1st	11 28 A.M.	11 35 A.M.	Ashford and Margate	N	Slight
Sept. 2d	07 10 A.M.	07 42 A.M.	Ashford and Margate	N	Horizontal
Sept. 2d	07 10 A.M.	07 50 A.M.	Ramsgate and Margate	N	Horizontal
Sept. 2d	07 10 A.M.	07 42 A.M.	Ashford and Ramsgate	N	Horizontal
Sept. 2d	07 43 A.M.	07 48 A.M.	Ashford and Margate	S	Strong
Sept. 2d	07 43 A.M.	07 48 A.M.	Ashford and Ramsgate	S	Strong
Sept. 2d	07 49 A.M.	07 51 A.M.	Ashford and Margate	N	Hard over
Sept. 2d	07 49 A.M.	07 51 A.M.	Ashford and Ramsgate	N	Hard over
Sept. 2d	07 51 A.M.	07 56 A.M.	Ashford and Margate	S	Hard over
Sept. 2d	07 51 A.M.	07 56 A.M.	Ashford and Ramsgate	S	Hard over
Sept. 2d	07 56 A.M.	08 00 A.M.	Ashford and Margate	N	Hard over
Sept. 2d	07 56 A.M.	08 00 A.M.	Ashford and Ramsgate	N	Hard over
Sept. 2d	07 56 A.M.	08 00 A.M.	Ramsgate and Margate	N	Hard over
Sept. 2d	08 00 A.M.	08 07 A.M.	Ashford and Margate	S	Strong
Sept. 2d	08 00 A.M.	08 07 A.M.	Ashford and Ramsgate	S	Strong
Sept. 2d	08 00 A.M.	08 07 A.M.	Ramsgate and Margate	S	Strong
Sept. 2d	08 08 A.M.	08 12 A.M.	Ashford and Margate	S	Strong
Sept. 2d	08 08 A.M.	08 12 A.M.	Ashford and Ramsgate	S	Strong
Sept. 2d	08 08 A.M.	08 17 A.M.	Ramsgate and Margate	S	Strong
Sept. 2d	08 08 A.M.	08 17 A.M.	Ramsgate and Margate	S	Strong
Sept. 2d	08 12 A.M.	08 17 A.M.	Ashford and Ramsgate	S	Hard over
Sept. 2d	08 12 A.M.	08 17 A.M.	Ashford and Margate	S	Hard over
Sept. 2d	08 20 A.M.	08 30 A.M.	Ashford and Ramsgate	N	Hard over
Sept. 2d	08 20 A.M.	08 30 A.M.	Ashford and Margate	N	Hard over
Sept. 2d	08 31 A.M.	08 46 A.M.	Ashford and Margate	S	Hard over
Sept. 2d	08 31 A.M.	08 40 A.M.	Ashford and Ramsgate	S	Hard over
Sept. 2d	08 41 A.M.	08 46 A.M.	Ashford and Ramsgate	N	Hard over
Sept. 2d	08 41 A.M.	08 46 A.M.	Ashford and Margate	N	Hard over
Sept. 2d	08 47 A.M.	08 54 A.M.	Ashford and Margate	S	Hard over
Sept. 2d	08 47 A.M.	08 54 A.M.	Ashford and Ramsgate	S	Hard over
Sept. 2d	08 54 A.M.	09 00 A.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	08 54 A.M.	09 00 A.M.	Ashford and Margate	N	Strong

(*continued on next page*)

Table 7.2 (*continued*)

Date 1859	Time		Telegraph line	Direction	Value
Sept. 2d	09 22 A.M.	09 25 A.M.	Ashford and Margate	N	Strong
Sept. 2d	09 26 A.M.	09 28 A.M.	Ashford and Margate	S	Strong
Sept. 2d	09 29 A.M.	09 40 A.M.	Ashford and Margate	N	Strong
Sept. 2d	09 40 A.M.	09 52 A.M.	Ashford and Margate	S	Strong
Sept. 2d	09 55 A.M.	10 32 A.M.	Ashford and Margate	N	Strong
Sept. 2d	09 55 A.M.	10 32 A.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	10 35 A.M.	10 38 A.M.	Ashford and Margate	S	Strong
Sept. 2d	10 38 A.M.	10 40 A.M.	Ashford and Margate	N	Strong
Sept. 2d	10 41 A.M.	10 46 A.M.	Ashford and Margate	S	Strong
Sept. 2d	10 55 A.M.	11 00 A.M.	Ashford and Margate	S	Strong
Sept. 2d	11 02 A.M.	11 15 A.M.	Ashford and Margate	N	Strong
Sept. 2d	11 02 A.M.	11 15 A.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	11 16 A.M.	11 27 A.M.	Ashford and Margate	S	Strong
Sept. 2d	11 20 A.M.	11 32 A.M.	Ashford and Ramsgate	S	Strong
Sept. 2d	11 38 A.M.	11 40 A.M.	Ashford and Margate	N	Strong
Sept. 2d	11 40 A.M.	11 45 A.M.	Ashford and Margate	S	Strong
Sept. 2d	11 45 A.M.	11 49 A.M.	Ashford and Margate	N	Strong
Sept. 2d	11 45 A.M.	11 49 A.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	11 45 A.M.	11 50 A.M.	Ramsgate and Margate	N	Strong
Sept. 2d	11 50 A.M.	11 51 A.M.	Ashford and Ramsgate	S	Strong
Sept. 2d	11 50 A.M.	11 51 A.M.	Ramsgate and Margate	S	Strong
Sept. 2d	11 50 A.M.	11 51 A.M.	Ramsgate and Margate	S	Strong
Sept. 2d	11 52 A.M.	11 54 A.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	11 52 A.M.	11 54 A.M.	Ramsgate and Margate	N	Strong
Sept. 2d	11 52 A.M.	11 54 A.M.	Ashford and Margate	N	Strong
Sept. 2d	11 59 A.M.	12 03 P.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	11 59 A.M.	12 03 P.M.	Ashford and Margate	N	Strong
Sept. 2d	11 59 A.M.	12 03 P.M.	Ramsgate and Margate	N	Strong
Sept. 2d	12 04 P.M.	12 14 P.M.	Ashford and Ramsgate	S	Horizontal
Sept. 2d	12 04 P.M.	12 14 P.M.	Ashford and Margate	S	Strong
Sept. 2d	12 15 P.M.	12 30 P.M.	Ashford and Margate	N	Horizontal
Sept. 2d	12 15 P.M.	12 30 P.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	12 30 P.M.	12 35 P.M.	Ashford and Margate	N	Strong
Sept. 2d	12 30 P.M.	12 35 P.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	12 30 P.M.	12 35 P.M.	Ramsgate and Margate	N	Strong
Sept. 2d	12 36 P.M.	12 57 P.M.	Ashford and Margate	N	Strong
Sept. 2d	12 36 P.M.	12 57 P.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	12 57 P.M.	01 18 P.M.	Ashford and Margate	S	Strong
Sept. 2d	12 57 P.M.	01 18 P.M.	Ashford and Ramsgate	S	Strong
Sept. 2d	12 57 P.M.	01 18 P.M.	Ramsgate and Margate	S	Strong
Sept. 2d	01 20 P.M.	01 44 P.M.	Ashford and Margate	N	Strong
Sept. 2d	01 20 P.M.	01 44 P.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	01 20 P.M.	01 44 P.M.	Ramsgate and Margate	N	Strong
Sept. 2d	01 44 P.M.	01 47 P.M.	Ashford and Ramsgate	S	Strong
Sept. 2d	01 44 P.M.	01 47 P.M.	Ashford and Margate	S	Strong
Sept. 2d	01 47 P.M.	01 54 P.M.	Ashford and Margate	N	Strong
Sept. 2d	01 47 P.M.	01 54 P.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	02 00 P.M.	02 15 P.M.	Ashford and Margate	N	Strong
Sept. 2d	02 00 P.M.	02 15 P.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	02 15 P.M.	02 18 P.M.	Ashford and Margate	S	Strong
Sept. 2d	02 15 P.M.	02 18 P.M.	Ashford and Ramsgate	S	Strong
Sept. 2d	02 21 P.M.	02 31 P.M.	Ashford and Margate	S	Horizontal
Sept. 2d	02 21 P.M.	02 37 P.M.	Ashford and Ramsgate	S	Horizontal
Sept. 2d	02 38 P.M.	02 52 P.M.	Ramsgate and Margate	N	Strong
Sept. 2d	02 38 P.M.	02 52 P.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	02 38 P.M.	02 52 P.M.	Ashford and Margate	N	Strong
Sept. 2d	02 52 P.M.	02 55 P.M.	Ramsgate and Margate	S	Strong
Sept. 2d	02 52 P.M.	02 55 P.M.	Ashford and Ramsgate	S	Strong
Sept. 2d	02 52 P.M.	02 55 P.M.	Ashford and Margate	S	Strong
Sept. 2d	02 55 P.M.	03 02 P.M.	Ramsgate and Margate	N	Strong
Sept. 2d	02 55 P.M.	03 02 P.M.	Ashford and Ramsgate	N	Strong
Sept. 2d	02 55 P.M.	03 02 P.M.	Ashford and Margate	N	Strong

C. Lat. 26° 48′ N., long. 45° 40′ W.

Aug. 28th. Sky in the S.S.E. of a lurid fiery color; a vivid bright streak from the middle.

D. Lat. 25° 45′ N., long. 27° 4′ W.

Aug. 28th. From 11h 15m P.M. till midnight the N.W. portion of the sky of a deep red color, resembling an angry sunrise.

E. Lat. 33° 55′ N., long. 44° 13′W.

Sept. 2d. The aurora faintly visible in the north about 4 A.M.

F. Lat. 33° 33′ N., long. 33° 2′ W.

Sept. 2d. At 3 A.M. a low bank of straw colored aurora on the northern horizon; it became a beautiful rose color, covering about four tenths of the sky and gradually disappeared as the day broke.

G. Lat. 24° 10′ N., long. 35° 50′ W.

Sept. 2d. Aurora seen in the morning from N.W. to E.N.E. of a bright red color, interspersed with streaks of white, converging to a center nearly over the ship.

5. *State of the weather at the Russian magnetic observatories, during the Auroral display of Aug.* 28*th to Sept.* 2*d*, 1859; *furnished by* A. T. KUPFFER, Director of the Central Physical Observatory.

Table 7.3 presents the weather conditions at the Russian magnetic observatories during the auroral displays of Aug. 28th and Sept. 2d.

In vol. xxx pp. 80–82, of this Journal, observations are published showing an unusual disturbance of the magnetic instruments throughout the whole of the Russian empire, but no mention is made of any aurora. The preceding observations show that during this period the sky was generally overcast at each of the Russian stations.

6. *Observations of the Aurora of Aug.* 28*th and* 29*th*, 1859, *made in Australia; furnished by* Mr. JAMES GLAISHER, of the Greenwich Observatory.

A. Observations at Hobarton, lat. 42° 52′ S., long. 147° 27′ E.

Aug. 29th, from 6h 55m to 7h 25m P.M. there appeared a most brilliant aurora extending from W. by N. to the eastern part of the horizon in one continuous arc of about 190°, and shooting up to the zenith. The eastern and western extremities of the conoid were of a pale ruby and deep red color, intermixed through the whole vault with bands of pale yellow and shades of dark and light green, and with here and there a small dark cloud jutting in; elsewhere the circumpolar stars glittered like diamonds set in an emerald and ruby ground. The phenomenon had for 30 minutes a most magnificent appearance, the bands being in complete repose, forming a truncated cone of glory, the apex of which, if projected, would have terminated in the zenith. This brilliant storm appeared again about 9h 30m P.M., flickering in brisk coruscations of most beautiful color from the horizon to the zenith.

A second display of the aurora appeared on the night of Sept. 2d, equally brilliant and extensive and less transitory. From midnight to 1 A.M. the aurora broke out into flickering streamers and coruscations, forming in the zenith a well defined corona, which shortly after became diffused and then dispersed.

B. Observations at Cape Otway, lat. 30° 51′ S., long 143° 50′ E.

Aug. 29th. Aurora most magnificent at 6h 30m P.M. and continued visible until after 2 A.M., displaying itself in the form of a rainbow, the arc extending to about 60° or 70°. First color above the horizon a light blue with a tint of green, blending into second, a very light yellow, again blending into third, a deep red.

C. Observations at Portland, lat. 38° 20′ S., long. 141° 55′ E.

Aug. 29th. Aurora visible at 6h 40m, P.M. At 7 P.M. a bright band partly tinged with blue and pink, extending E. and W., pink rays converging to a centre on the band a little to the W. of the Milky Way. Gradually faded, and all disappeared by 8 P.M.

D. Observations at Melbourne Observatory, lat. 37° 49′ S., long 145° 9′ E., by GEORGE NEUMEYER.

On the evening of Aug. 28th great disturbances made themselves manifest in all the three magnetic elements, which became less violent during the early part of the morning of the 29th. At 4 A.M. Aug. 29th, the horizontal intensity was 0.0020 below the mean for the previous ten days, and then increased until 8h 50m A.M. when the disturbances assumed so violent a character that the intensity at times, and the inclination very frequently, could not be registered, the scales being out of the field of the telescope. At 8h 57m A.M. the horizontal intensity was 0.0284 below the mean above referred to, showing a decrease of 0.0264 in the space of one hour. The variation of the needle underwent similar changes, decreasing rapidly until 9h 35m, when it was 36 minutes below the mean for the ten days mentioned above. After 8 A.M. the magnetic instruments were registered every minute. Table 7.4 contains the means for declination and horizontal intensity.

The values in Table 7.4 do not give the greatest range; that for declination being 1° 8.8′; and for intensity 0.03197 of the absolute unit.

At 6h l0m P.M. the first traces of an aurora were observed towards S.E. by S. The luminous appearance increased rapidly, spreading towards S.W.

6h 40m P.M. A rosy color appearing on the clouds in S.E. and S.W. by W.

Table 7.3
Weather observations at the Russian magnetic observatories during the Auroral display of Aug. 28th to Sept. 2d, 1859

Hour	St. Petersburg	Catherinburg	Barnaoul	Nertchinsk
August 28th, 1859				
0	Overcast	Cloudy	Scat. clouds	Overcast
1	Overcast	Overcast	Scat. clouds	Overcast
2	Cloudy	Overcast	Scat. clouds	Overcast
3	Cloudy	Overcast	Scat. clouds	Overcast
4	Cloudy	Cloudy	Scat. clouds	Overcast
5	Cloudy	Cloudy	Clouds in hor'n	Overcast
6	Cloudy	Cloudy	Clouds in hor'n	Overcast
7	Cloudy	Cloudy	Clouds in hor'n	Clouds in hor'n
8	Cloudy	Cloudy	Clear	Clouds in hor'n
9	Cloudy	Cloudy	Clear	Cloudy
10	Light clouds	Cloudy	Clear	Cloudy
11	Light clouds	Clouds in hor'n	Clear	Cloudy
12	Light clouds	Clear	Clear	Cloudy
13	Cloudy	Clear	Clear	Overcast
14	Cloudy	Clear	Clear	Overcast
15	Cloudy	Clear	Clear	Overcast
16	Cloudy	Clear	Clouds in hor'n	Overcast
17	Cloudy	Clouds in hor'n	Clouds in hor'n	Overcast
18	Cloudy	Clouds in hor'n	Clouds in hor'n	Overcast
19	Cloudy	Clouds in hor'n	Clouds in hor'n	Overcast
20	Cloudy	Clouds in hor'n	Clouds in hor'n	Clouds in hor'n
21	Cloudy	Cloudy	Scat. clouds	Clouds in hor'n
22	Cloudy	Cloudy	Scat. clouds	Cloudy
23	Cloudy	Cloudy	Scat. clouds	Cloudy
September 2nd, 1859				
0	Scat. clouds	Cloudy	Cloudy	Cloudy
1	Scat. clouds	Cloudy	Scat. clouds	Cloudy
2	Scat. clouds	Cloudy	Cloudy	Cloudy
3	Light clouds	Cloudy	Cloudy	Overcast
4	Light clouds	Cloudy	Cloudy	Cloudy
5	Light clouds	Cloudy	Cloudy	Overcast
6	Light clouds	Cloudy	Cloudy	Overcast
7	Light clouds	Clouds in hor'n	Cloudy	Cloudy
8	Scat. clouds	Clouds in hor'n	Cloudy	Clouds in hor'n
9	Scat. clouds	Clouds in hor'n	Cloudy	Clear
10	Light clouds	Cloudy	Cloudy	Clear
11	Scat. clouds	Cloudy	Cloudy	Clouds in hor'n
12	Scat. clouds	Clouds in hor'n	Scat. clouds	Clouds in hor'n
13	Scat. clouds	Clouds in hor'n	Scat. clouds	Clouds in hor'n
14	Scat. clouds	Clouds in hor'n	Clouds in hor'n	Clouds in hor'n
15	Scat. clouds	Clouds in hor'n	Clouds in hor'n	Clouds in hor'n
16	Scat. clouds	Clouds in hor'n	Clouds in hor'n	Clouds in hor'n
17	Light clouds	Clouds in hor'n	Clouds in hor'n	Cloudy
18	Light clouds	Clouds in hor'n	Scat. clouds	Cloudy
19	Light clouds	Clouds in hor'n	Scat. clouds	Cloudy
20	Light clouds	Clouds in hor'n	Scat. clouds	Overcast
21	Light clouds	Scat. clouds	Scat. clouds	Overcast
22	Light clouds	Cloudy	Scat. clouds	Cloudy
23	Light clouds	Cloudy	Scat. clouds	Overcast

Note: clouds in hor'n indicates clouds in the horizon.

6h 50m. Splendid aurora. Red streamers very bright, S.E., S.W., and W. by S. visible to an altitude of 50° or 90°. One very bright whitish streamer in S.W. by S. looking as if there were a thin red curtain before a beautiful white luminous curtain. Lower edge about 12° above the horizon. Well defined in S. by W. and S.S.W.; upper portion scarce visible at 45°. The folds of the luminous curtain and the red streamers, if produced, would probably meet one another about 10° S. of the zenith.

7h 15m P.M. Aurora fading away. Red patch in S.

7h 20m P.M. Red color disappearing from S. to S.W. giving place to white; at the same time the white in S.S.E. becoming reddish.

Table 7.4
Magnetic Observations at the Melbourne, Australia observatory on Aug. 28th, 1859

Time	Declination	Horizontal intensity
Between 07 h and 08 h A.M.	8° 24.20′	2.36264
Between 08 h and 09 h A.M.	8° 22.23′	2.33677
Between 09 h and 10 h A.M.	8° 08.52′	2.35072
Between 10 h and 11 h A.M.	8° 13.00′	2.34711
Between 11 h and 12 h A.M.	8° 22.86′	2.34983
Between 12 h and 01 h P.M.	8° 34.33′	2.35160
Between 01 h and 02 h P.M.	8° 37.54′	2.35539
Between 02 h and 03 h P.M.	8° 37.40′	2.35755
Between 03 h and 04 h P.M.	8° 38.46′	2.34353
Between 04 h and 05 h P.M.	8° 35.83′	2.35479
Between 05 h and 06 h P.M.	8° 34.21′	2.35412

7h 21m P.M. Sky in south becoming very bright and white. Low bank of well defined cumulostratus 5° to 6° above the horizon.

7h 23m P.M. A well defined arch of white light 10° to 12° high above the bank of cloud before mentioned, extending from S.S.E. to W.S.W. being brightest in W.S.W.

7h 30m P.M. Very faintly red in S.E. Two pink streamers. Two whitish streamers, one in the zodiac, and the other through the cross.

7h 34m P.M. Faint rosy light in E.S.E. nearly as high as the zenith.

7h 43m P.M. White streamers in S.W. by W.

7h 49m P.M. A large patch of very bright light in S.E., white below, reddish above.

7h 50m P.M. A white luminous cloud appearing in S.W. About 30° high, below the southern cross, a rosy streamer in S.E. by E. very faint.

7h 55m P.M. The white and red light in S.E. increasing in brightness, yellowish white below, and red above. Top 40° high.

8h 3m P.M. Luminosity in S.E. almost gone, especially the red.

8h 20m P.M. Rosy arc from E.S E. to W. by N., passing nearly through the zenith.

9h 50m P.M. Three red streamers in S.E. very bright, and several white ones in S.W.

12h 15m A.M. Bright broad streamers S.S.W. to S.W. partly covered with clouds.

12h 40m A.M. Luminosity in S. and S.W. 25° high.

2h 15m A.M. Luminosity from S.S.E. to W., brightest in S.S.W.

The magnetic disturbances continued with more or less intensity until 4 A.M. Aug 30th.

During the whole of the 29th the instruments of the electric telegraph were disturbed to such a degree as to interfere with the working of the lines extending over New South Wales, Adelaide and Victoria. This effect was similar to that produced by atmospheric electricity.

E. Observations at Ballaarat; lat 37° 36′ S., long. 143° 51′ E.

Aurora visible Aug. 29th at 6h 45m P.M. It gradually spread to the east and formed a magnificent arch, the colors of which were red, green and violet. The rays of light were distinct and beautiful. The southern portion of the sky was illuminated until 7h 30m sufficiently to cast a shadow.

F. Observations at Longwood, lat. 36° 54′ S., long. 145° 41′ E.

At 6h 10m P.M. Aug. 29th, an aurora appeared from a dusky line in the S.W. part of the horizon, which gradually ascended with a tremulous motion towards the zenith, assuming all shapes and varieties of color, from a pale red or yellow, to a deep vermillion, and extending to the N.E., serving to illuminate the earth, until its disappearance at 7h 15m P.M.

G. Observations at Sandhurst, lat. 36° 48′ S., long. 144° 24′ E.

Aurora very brilliant from 7 P.M., Aug. 29th, until a little after midnight.

H. Observations at Beechworth, lat. 36° 22′ S., long. 146° 52′ E.

Aug. 29th. Aurora visible for nearly an hour and a half, commencing about 5h 45m P.M., gradually increasing in beauty and brilliancy of tint until shortly before 7h, when the rays became gradually indistinct, disappearing at about 7h 15m P.M. During the whole day the telegraph wires were strongly affected.

I. Observations at Sydney Observatory, lat. 33° 52′ S., long. 151° 12′ E., made by W. SCOTT.

The aurora was first noticed, Aug. 29th, at 7h 20m P.M. and continued visible for about half an hour, when it gradually faded away, and the sky became rapidly covered with clouds. I was in the act of observing a transit of the Pole star, when I was struck with the redness of the southern sky. On looking out I was surprised to find a considerable

portion of the southern sky in a glow of red light, similar to that which sometimes precedes the rising of the sun. This red light formed a tolerably regular arch from E.S.E. to W.S.W., extending in depth from the south pole to within a few degrees of the horizon. There was a partial break to the S.S.W., and in some places there were radiating streams of light brighter and of a lighter red than the rest.

At about 10 A.M., Aug. 29th, the wires of the electric telegraph were seized with an unaccountable fit of restiveness. They did not altogether refuse to work, but acted irregularly, the adjustment of the instrument altering so frequently that it was almost impossible to get any continuous message through. This state lasted until the evening, when the wires began to work better.

Summary by Professor Elias Loomis.

From the preceding observations, and from those which have been heretofore published in this Journal, it appears that the remarkable auroral display which prevailed throughout a large portion of the northern hemisphere from Aug. 28th to Sept. 4th, 1859, was accompanied by a display about equally remarkable in the southern hemisphere; and the periods of greatest brilliancy were nearly cotemporaneous in both hemispheres. In order to determine whether such a coincidence is a common occurrence I have sought for some long and continuous record of the aurora in the southern hemisphere. The most complete record of this kind which I have found is that made at the British magnetic observatory at Hobarton, on Van Dieman's Island during the years 1841–48. These observations have been published by the British Government, and Table 7.5 contains all the instances of auroral exhibitions which I have been able to find in these volumes.

Table 7.6 contains the corresponding observations made at New Haven by Mr. E.C. Herrick, who kept a careful

Table 7.5
Observations of the Aurora at Hobarton, Van Dieman's Island (lat. 42° 52′ S.; long. 147° 27′ E., Magnetic Dip in 1845 = 70° 35.6′)

Hobarton mean time, Astronomical reckoning			Notices of Auroras
Year	Day	Hour	
1841	March 16	17	Slight appearance of Aurora
1841	March 22	15	Faint appearance of Aurora
1841	May 17	13	Slight appearance of Aurora
1841	July 20	9	Aurora very brilliant in S.E.
1841	Dec. 17	11	Slight Aurora in south
1842	Jan. 1	11	Appearance of Aurora to the south
1842	Feb. 2	9	Slight appearance of Aurora in S.W.
1842	Feb. 18	9	Appearance of Aurora in the south
1842	April 11	9	Slight appearance of Aurora in the south
1842	April 13	13–15	Aurora in the south
1842	April 14	9	Aurora in the south
1842	April 15	9	Aurora in the south
1842	May 16	9–15	Aurora from S.E. to S.
1842	June 13	11	Faint Aurora in the south
1842	July 2	7–11	Slight Aurora in the south
1842	Sept. 2	13	Steady bright light in the south
1842	Dec. 31	9	Slight Aurora in the south
1844	April 16		Aurora in the evening and night
1844	April 25	9	Faint appearance of the Aurora
1846	Sept. 22		Aurora very brilliant throughout the night
1847	April 20		Aurora very distinct during the night
1847	April 21		Aurora visible
1847	Sept. 24		Aurora very bright
1847	Sept. 25		Aurora visible
1847	Sept. 26		Aurora visible
1847	Oct. 22		Aurora visible and very brilliant
1847	Oct. 23		Aurora visible
1847	Oct. 24		Aurora still visible
1847	Dec. 20		Aurora visible
1848	March 24		Aurora very distinct at night
1848	April 6		Aurora very distinct at night
1848	Oct. 18		Aurora visible
1848	Nov. 19		Aurora visible
1848	Dec. 21	10	Slight signs of Aurora to the south

Table 7.6
Observations of the Aurora at New Haven (lat. 41° 18′ N.; long. 72° 55′ W., Magnetic Dip in 1844 = 73° 21′)

Date			Notices
Year	Day	Hour	
1841	March 16		Snowing
1841	March 21	10 45 P.M.	Faint Aurora
1841	March 22		Cloudy
1841	March 23	10 P.M.	Aurora with streamers
1841	May 17		Clear. No Aurora seen up to 10h 15m
1841	July 19	10 P.M.	Aurora with streamers
1841	July 20		Clear. No Aurora at 10h 15m
1841	July 21	10 P.M.	Aurora
1841	Dec. 17		Overcast
1842	Jan. 1		Clear. No Aurora up to 10h
1842	Feb. 2		Somewhat hazy. No Aurora up to 10h 30m
1842	Feb. 18		Overcast
1842	April 11		Aurora with streamers
1842	April 13		Raining
1842	April 14	10 P.M.	Aurora reaching 20° altitude
1842	April 15	3 A.M.	Aurora reaching 45° altitude
1842	May 16		Hazy; moonshine; no Aurora up to 10h
1842	June 13		Raining
1842	July 2		Overcast
1842	Sept. 2	8 30 P.M.	Aurora with streamers
1842	Dec. 31		Clear. No Aurora up to 11h
1844	April 16		Overcast
1844	April 25		Overcast
1846	Sept. 21		Aurora
1846	Sept 22	8 P.M.	Aurora
1847	April 20		Overcast
1847	April 21		Overcast
1847	Sept. 24		Raining
1847	Sept. 25		Raining
1847	Sept. 26		Raining
1847	Oct. 22		Overcast
1847	Oct. 23		Overcast
1847	Oct. 24		Raining
1847	Dec. 20	5 A.M.	grand Auroral display
1848	March 24	8 P.M.	Aurora with streamers
1848	April 6	9 30 P.M.	Aurora with streamers
1848	Oct. 18		Raining
1848	Nov. 19	8 P.M.	Aurora
1848	Dec. 21		Snowing

Table 7.7
Observations of the Aurora at the Academies in the State of New York. (Magnetic Dip from 73° to 75°)

Date			Notices of Auroras
Year	Day	Hour	
1841	March 16		Aurora seen at Fredonia
1841	March 22		Aurora at Newberry, Vt.
1841	July 20		Aurora seen at St. Lawrence
1842	Feb. 1		Aurora seen at Courtland
1842	April 11		Aurora at Albany, Rochester, and many other places
1842	April 12		Aurora at Malone
1842	April 14		Aurora at Albany and many other places
1842	April 15		Aurora at Rochester and many other places
1842	June 13		Aurora at Ellisburgh
1842	July 2	10 P.M.	Bright Aurora at several places
1842	Sept. 2		Aurora at North Salem
1844	April 17		Aurora at Onondaga
1846	Sept. 21		Aurora at North Salem and several other places
1846	Sept. 22		Aurora at Onondaga
1847	Oct. 23		Aurora at Rochester and Casenovia
1847	Oct. 24	3 A.M.	Brilliant Aurora at Rochester
1847	Dec. 20		Aurora at Hamilton and Mexico
1848	March 24		Aurora at New York, Fredonia, and many other places
1848	April 6		Brilliant Aurora at Albany, Rochester, and many other places
1848	Nov. 18		Morning. Splendid Aurora at New York

Table 7.8
Observations of the Aurora at Toronto (lat. 43° 40′N.; long. 79° 23′ W., Magnetic Dip in 1845 = 75° 15′)

Date			Notices
Year	Day	Hour	
1841	July 19		Aurora from 9h to 13h
1841	Dec. 17	14h	Faint auroral light in north
1842	Feb. 18		Rain and snow
1842	April 10	14h	Bright bank of auroral light in N.
1842	April 14	14h	Brilliant aurora
1842	April 15	8h	Aurora visible from 8h to 14h
1842	July 3	14h	Brilliant aurora
1842	Sept. 2	9h	Faint auroral light at 9h and 10h
1842	Dec. 31		Snow
1844	April 16		Auroral light
1844	April 25		Rain
1846	Sept. 21		From 9h to 17h brilliant Aurora
1847	April 19		From 13h to 16h Auroral light in N.
1847	April 21		Rain
1847	Sept. 24		Rain
1847	Sept. 25		Rain
1847	Sept. 26		Rain
1847	Oct. 22	16h	Remarkable appearance of Aurora
1847	Dec. 19	17h	Aurora. Great magnetic disturbance
1848	March 24		From 9h to 12h Aurora
1848	April 5		From 10h to 15h Aurora
1848	Oct. 18		Auroral light through the clouds
1848	Nov. 19		Slight auroral light
1848	Dec. 21		Snow

Editors' Note: The times given appear to be Toronto Astronomical Time. Thus 8h would be 8 P.M. of the date shown; 14h would be 2 A.M. of the following calendar date.

Table 7.9
Dates of aurora (1841–1848) seen in Hobarton but not observed in New Haven, Toronto or reported by the Academies in the State of New York

Year	Date	Comments
1841	May 17	Unusual magnetic disturbance at Greenwich, England
1842	Jan. 1	Unusual magnetic disturbance at Greenwich
1842	Feb. 18	Unusual magnetic disturbance at Greenwich; Aurora at Christiana, Norway
1842	May 16	Unusual magnetic disturbance at Toronto and Greenwich
1842	Dec. 31	Magnetic disturbance at Greenwich
1844	April 25	Unusual magnetic disturbance at Philadelphia and Toronto
1847	April 21	Unusual magnetic disturbance at Greenwich
1847	Sept. 24	Aurora 9h to 10h at Greenwich
1847	Sept. 25	Unusual magnetic disturbance at Greenwich
1847	Sept. 26	Unusual magnetic disturbance at Greenwich Aurora at Carlisle, England
1848	Dec. 21	Aurora in Newfoundland

record (negative as well as positive,) of all auroral phenomena from 1837 to 1853, except from Mch. to Sept. 1851.

Table 7.7 contains auroral notices from the State of New York, as published in the annual Regents' Reports; and Table 7.8 contains auroral notices from the Toronto meteorological observations.

Table 7.5 contains a list of 34 auroras observed at Hobarton. Table 7.6 shows that in 11 of these cases an aurora was seen on the same day at New Haven. These observations were not strictly cotemporaneous, for Hobarton and New Haven being in nearly opposite longitudes, when an aurora was seen at Hobarton it could not be seen at New Haven on account of the presence of the sun. Moreover, the New Haven observations were chiefly made in the early part of the night; but in 11 cases an aurora was seen within about 12 hours of its appearance at Hobarton. In several cases when an aurora was seen at Hobarton it was cloudy at New Haven, and there were eight other corresponding cases in which an aurora was seen at some one of the Academies in New York, although not noticed at New Haven. In four additional cases an aurora was seen at Toronto when none was recorded at New Haven or in the State of New York.

There remain then only 11 cases of auroras at Hobarton for which we do not find corresponding observations from one of these three sources in the northern hemisphere, and in eight of these cases the sky was overcast from New Haven to Toronto. Table 7.9 show the dates of these auroras, and opposite to the dates I have placed notices of auroral or magnetic phenomena from some station in the northern hemisphere.

It thus appears that in every instance when an aurora was observed at Hobarton, an aurora was seen on the same day in the northern hemisphere; or there were observed unusual disturbances of the magnetic instruments, indicating the existence of an aurora at no very remote station. So far then as a conclusion is authorized from so small a

Table 8.1
Observations of the Aurora at Christiania, Norway, lat. 59° 54′, long. 10° 43′ E. Magnetic dip in 1859, 71° 18′

Year	Date	Hour[a]	Notices of Aurora
1841	March 15	10	Aurora
1841	March 22		Rain
1841	May 17		Rain
1841	July 20		No aurora visible
1842	Feb. 18	11–14	Aurora faint
1842	April 11	9–15	Slight aurora. Faint arch at 15h
1842	April 12	9–14	Rays and flames extending to the zenith
1842	April 13	9–13	Rays and flames
1842	April 15	11–15	Flaming aurora
1842	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
1847	Sept. 24	7–10	Corona formed. Rays of a dark red color
1847	Sept. 26	10	Magnificent arc, radiating
1847	Oct. 22	10	Rain
1847	Oct. 23	6	High aurora. Radiating behind clouds
1847	Oct. 24	$5\frac{1}{2}$–12	One of the most brilliant auroras we have observed. Corona formed Vivid colors, red and yellow
1847	Dec. 19	10	Strong aurora, yellow rays, red masses without motion
1848	March 24		Rain
1848	April 5	10	Faint aurora
1848	April 7	10	Arc radiating
1848	Oct. 18	$7\frac{3}{4}$–10	Vigorous radiation over the whole vault. Red color, very intense
1848	Nov. 19	10	Aurora
1848	Dec. 22	10	Faint aurora

[a] Editors' note: The original Loomis paper does not indicate the time system used in this table. The times are probably Göttingen Astronomical Times in keeping with the convention used at that time. The reader is refereed to the original documents published in Belgium for additional information.

number of observations, we should infer that whenever an aurora is seen at Hobarton, where the magnetic dip is −70° an aurora occurs at some place in the northern hemisphere as far south as where the magnetic dip does not much exceed 75°; in other words, an unusual auroral display in the southern hemisphere is always accompanied by an unusual display in the northern hemisphere. As any cause which affects the intensity of the magnetism at one pole of the magnet, usually affects the other pole, so an exhibition of auroral light about one magnetic pole of the earth, is uniformly attended by a simultaneous exhibition of auroral light about the opposite magnetic pole.

New Haven, May, 1861.

Appendix H. ART. XXXVI. – *On the great Auroral Exhibition of Aug.* 28*th to Sept* 4*th* 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, listed in Table 8.1, 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.

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 was 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

* Originally published in American Journal of Science, Second Series, Vol. 32, No. 96, 318–335, 1861.

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 West Asia in lat. 40°.

In North America, the aurora of Sept. 2d appeared in the zenith at places as far south as lat. $22\frac{1}{2}^{\circ}$, 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 the 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. Table 8.2 presents a summary of a few of the most definite observations on the aurora of Aug. 28th, 1859, at about 8h 42m P.M. New Haven time.

Table 8.3 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.

If we combine the preceding observations in Tables 8.2 and 8.3, we shall find that the lower limit of the auroral light was elevated forth-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 in Fig. 8.1, making an angle of 71° 20′ with the curve line AB which represents a portion of the earth's surface, we may

Table 8.2
Auroral observations on Aug. 28th, 1859, at about 8h 42m P.M., New Haven time

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

[a] The letters A.J. represent the American Journal of Science.

Table 8.3
Auroral observations on Aug. 28th, 1859, at about 8h P.M., New Haven time, for locations where the auroral light covered the entire northern heavens as well as a portion of the southern

Locality	Latitude	Extent of auroral display	Authority[a]
Sandy Spring, Md.	39° 9′	Extended to 51° from south horizon	A.J., v. 29, p. 259
Gettysburgh, Pa.	39° 49′	Extended to 30° from south horizon	A.J., v. 30, p. 345
Philadelphia, Pa.	39° 57′	Extended to $22\frac{1}{2}^{\circ}$ from south horizon	A.J., v. 29, p. 259
Burlington, N.J.	40° 5′	Extended to 20° from south horizon	A.J., v. 29, p. 258
New Haven, Conn.	41° 18′	Extended to $10\frac{1}{2}^{\circ}$ from south horizon	A.J., v. 28, p. 391
West Point, N.Y.	41° 23′	Extended to 12° from south horizon	A.J., v. 28, p. 394
Newburyport, Mass.	42° 48′	Extended to 6° from south horizon	A.J., v. 29, p. 254
Lewiston, Maine	44° 5′	Extended to 5° from south horizon	A.J., v. 28, p. 386

[a] The letters A.J. represent the American Journal of Science.

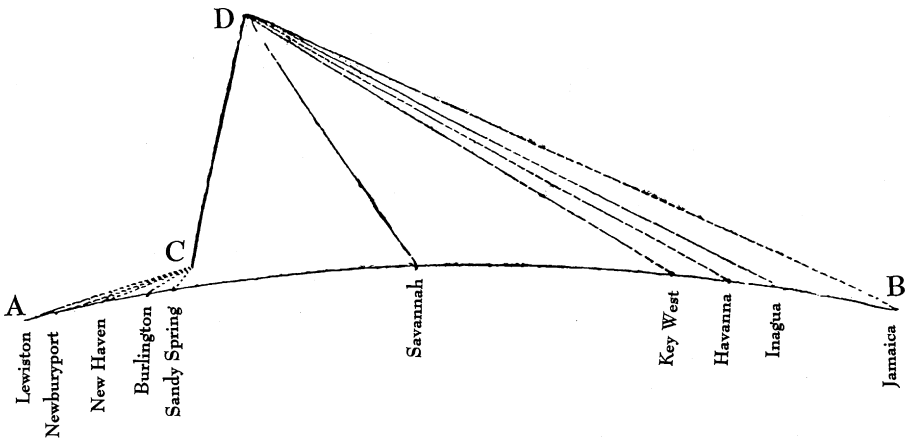

Fig. 8.1. Graphical representation of the upper limit of the auroral light above the earth's surface at approximately 8h 42m P.M. New Haven time on 28 August 1859.

Table 8.4
Auroral observations on Sept. 2, 1859, at about 2 A.M. Havanna time

Locality	Latitude	Longitude	Hour	Extent of auroral display	Authority[a]
At Sea	12° 23′	88° 28′	Midnight	Sky lurid – wavy appearance	A.J., v. 30, p. 361
La Union, San Salvador	13° 18′	87° 45′	10 P.M.–3 A.M.	About 30° above the North horizon.	A.J., v. 29, p. 265
Salvador	13° 44′	88° 55′		Same as at La Union	A.J., v. 29, p. 265
Kingston, Jamaica	17° 58′	76° 50′	01–05 A.M.	Appeared like a colossal fire	A.J., v. 29, p. 265
Cohe, Cuba	20° 0′	76° 10′		Extended upwards about 72°	A.J., v. 29, p. 265
Havanna, Cuba	23° 9′	82° 22′	02 A.M.	More than 100° in height	A.J., v. 28, p. 405
Fort Jefferson, Fla.	24° 37′	82° 52′	02 A.M.	Extended beyond the zenith	A.J., v. 30, p. 360
Micanopy, Fla.	29° 30′	82° 18′	0230 A.M.	Corona very distinct	A.J., v. 30, p. 360
Jacksonville, Fla.	30° 15′	82° 0′	03 A.M.	Extreme south in a red glow	A.J., v. 30, p. 359
Thomasville, Ga.	30° 50′	84° 0′	02 A.M.	Corona formed	A.J., v. 30, p. 358
Paulding, Miss.	32° 20′	89° 20′	0210 A.M.	Whole visible heavens overspread	A.J., v. 30, p. 357
Indianapolis, Ind.	39° 55′	86° 5′		Down to south horizon	A.J., v. 28, p. 398
Rochester, N.Y.	43° 8′	77° 51′	02 A.M.	Down to south horizon	A.J., v. 29, p. 253

[a] The letters A.J. represent the American Journal of Science.

assume that the line CD represents the southern boundary of the auroral illumination. If then we assume that the observations of Table 8.2 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.

Table 8.4 presents a summary of the most definite observations of the aurora of Sept. 2, 1859, made generally about 2 A.M. Havanna time.

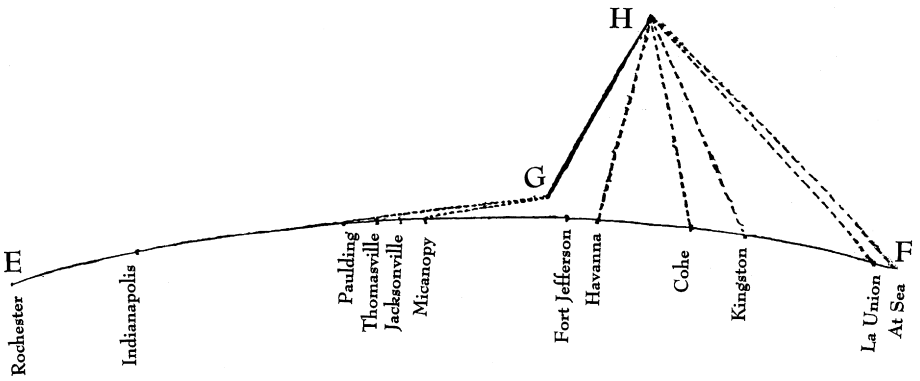

Fig. 8.2. Graphical representation of the upper limit of the auroral light above the earth's surface at approximately 2 A.M. Havanna time on 2 September 1859.

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 8.4 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 as shown in Fig. 8.2.

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. $22\frac{1}{2}^{\circ}$, 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 threefold the ordinary current employed in telegraphing. (Ib., xxix, 396.)
5. A current of electricity defects 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 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 in Table 8.5 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.

Table 8.5
Effect of a current assumed to move from N. 45° E. to S. 45° W.

Telegraph lines	Direction	Inclination of current	Efficient current
Boston to Cambridge	West	45°	0.71
Philadelphia to Pittsburgh	N. 82° W.	53°	0.60
Springfield to Albany	N. 58° W.	77°	0.22
Boston to Manchester	N. 25° W.	70°	0.34
New Bedford to Boston	N. 7° W.	52°	0.62
Fall River to Braintree	N. 12° E.	33°	0.84
Richmond to Washington	N. 15° E.	30°	0.87
Boston to Portland	N. 24° E.	21°	0.93
Philadelphia to New York	N. 49° E.	4°	0.99
Springfield to Boston	N. 79° E.	34°	0.83

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

Table 8.6
"Observed deflections" of the horizontal magnetic needle

No.	Year	Date	h	m	Observation
1	1836	Aug. 17	07	50	Maximum at Upsala, Berlin, Göttingen, Leipsic and Munich
			07	55	Maximum at Hague
2	1836	Aug. 17	09	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	08	55	Max. at Upsala, Berlin, Hague, Göttingen, Breslau, Leipsic, Marburg, Munich and Milan
6	1836	Sep. 24	11	00	Min. at Hague
			11	05	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	00	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	08	55	Max. at Upsala, Altona, Berlin, Göttingen, Breslau, Freiberg, Augsburg, Munich and Milan
12	1837	Jan. 28	09	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	09	45	Max. at Copenhagen
			09	50	Max. at Upsala, Berlin, Breda, Göttingen, Breslau and Marburg
			09	55	Max. at Munich and Milan
			10	00	Max. at Leipsic
16	1837	July 29	06	20	Max. at Petersburgh
			06	35	Max. at Upsala and Copenhagen
			06	40	Max. at Berlin, Breda, Göttingen, Breslau, Leipsic, Freiberg, Marburg, Munich and Milan
17	1837	July 29	07	00	Min. at Petersburgh
			07	15	Min. at Upsala, Copenhagen and Breslau
			07	20	Min. at Berlin, Breda, Göttingen, Freiberg, Leipsic, Marburg and Munich
18	1837	July 29	08	55	Max. at Petersburgh
			09	00	Max. at Upsala, Copenhagen, Berlin and Breslau
			09	05	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	06	35	Max. at Upsala, Berlin, Göttingen, Breslau, Leipsic, Marburg, Munich and Milan
			06	45	Max. at Dublin
23	1837	Aug. 31	08	55	Min. at Upsala
			09	00	Min. at Berlin. Göttingen, Breslau, Leipsic, Marburg, Munich and Milan
			09	05	Min. at Dublin
24	1837	Aug. 31	09	20	Max. at Upsala
			09	25	Max. at Berlin, Göttingen, Breslau, Leipsic, Marburg, Munich and Milan
			09	30	Max. at Dublin
25	1837	Aug. 31	09	50	Min. at Upsala, Berlin, Göttingen, Breslau, Leipsic, Marburg and Munich
			09	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	05	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	03	50	Max. at Upsala, Copenhagen, Berlin, Göttingen, Breslau, Leipsic, Marburg and Milan
30	1837	Sep. 30	07	30	Max. at Upsala, Copenhagen, Berlin, Göttingen, Breslau, Leipsic, Marburg and Milan
			07	35	Max. at Breda
31	1837	Sep. 30	10	45	Min. at Upsala, Copenhagen, Berlin, Breda, Göttingen, Breslau, Marburg and Milan

(*continued on next page*)

Table 8.6 (*continued*)

No.	Year	Date	h	m	Observation
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	06	25	Max. at Petersburgh, Upsala, Stockholm, Copenhagen, Berlin, Göttingen, Breslau, Leipsic, Freiberg and Marburg
			06	35	Max. at Munich
			06	40	Max. at Dublin
35	1837	Nov. 18	08	50	Min. at Petersburgh, Upsala and Stockholm
			09	05	Min. at Copenhagen, Berlin, Breda, Göttingen, Breslau, Freiberg, Leipsic and Marburg
			09	10	Min. at Milan
			09	15	Min. at Dublin and Munich
36	1837	Nov. 13	09	20	Max. at Petersburgh, Upsala and Stockholm
			09	25	Max. at Copenhagen, Berlin, Breda, Göttingen, Breslau, Freiberg, Leipsic and Marburg
			09	30	Max. at Dublin
			09	35	Max. at Munich
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 Petersburg
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	07	35	Max. at Upsala, Copenhagen, Berlin, Breda, Göttingen, Breslau, Leipsic and Milan
			07	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	07	35	Min. at Upsala, Berlin, Göttingen, Breslau, Leipsic and Milan
			07	40	Min. at Breda and Munich
42	1838	Nov. 24	08	05	Max. at Upsala and Breslau
			08	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	00	Min. at Breslau, Leipsic and Heidelberg
			14	05	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	00	Min. at Copenhagen, Berlin, Breda and Breslau
			11	05	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	05 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	00	Max. at Breda
			20	05	Max. at Munich
			20	10	Max. at Upsala, Copenhagen, Berlin, Göttingen, Leipsic, Breslau, Marburg, Prague, Kremsmunster and Milan
52	1839	Aug. 31	08	20	Max. at Breda
			08	25	Max. at Upsala
			08	30	Max. at Copenhagen, Berlin, Göttingen, Leipsic, Breslau, Marburg, Kremsmunster, Munich and Milan
53	1839	Nov. 30	06	25	Min. at Upsala

Table 8.6 (*continued*)

No.	Year	Date	h	m	Observation
			06	30	Min. at Copenhagen, Seeburg, Berlin, Göttingen, Breslau, Leipsic, Marburg, Prague, Kremsmunster and Milan
			06	35	Min. at Dublin
			06	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 Petersburg
			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	00	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 Upsa1a
63	1840	Aug. 28	18	55	Min. at Petersburg, Upsala, Berlin, Göttingen, Breslau, Cracow, Marburg and Kremsmunster
			19	00	Min. at Dublin, Greenwich, Copenhagen, Breda, Leipsic, Brussels, Prague and Milan
64	1840	Nov. 28	00	50	Min. at Upsala, Stockholm, Copenhagen, Dublin, Greenwich, Berlin, Breda, Brussels, Göttingen, Leipsic, Breslau, Prague, Marburg, Cracow and Milan
			00	55	Min. at Petersburgh
65	1840	Nov. 28	02	55	Min. at Petersburgh
			03	10	Min. at Upsala, Stockholm, Copenhagen and Breslau
			03	15	Min. at Dublin, Greenwich, Berlin, Breda, Brussels, Göttingen, Leipsic, Marburg, Kremsmunster and Milan
66	1840	Nov. 28	06	40	Max. at Petersburgh, Stockholm and Copenhagen
			06	45	Max. at Berlin, Breda, Göttingen, Leipsic, Breslau, Prague, Cracow, Kremsmunster and Milan
			06	50	Max. at Dublin, Greenwich and Marburg
67	1840	Nov. 28	09	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	Min. at Göttingen
			13	00	Min. at Breda, Leipsic, Berlin, Marburg, Prague, Kremsmunster and Milan
			13	05	Min. at Breslau, Brussels and Geneva
69	1841	Feb. 26	13	25	Max. at Upsala and Stockholm
			13	30	Max. at Copenhagen

(*continued on next page*)

Table 8.6 (*continued*)

No.	Year	Date	h	m	Observation
			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	05	15	Max. at Petersburgh
			05	25	Max. at Upsala
			05	30	Max. at Copenhagen, Ber1in, Göttingen, Leipsic, Breslau and Prague
			05	35	Max. at Breda, Brussels, Geneva and Milan
72	1841	May 28	14	05 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	00	Max. at Upsala and Christiania
			11	05	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	08	40	Max. at Petersburgh and Stockholm
			08	45	Max. at Upsala, Christiania, Berlin, Breda, Göttingen, Leipsic, Breslau, Prague and Cracow
			08	50	Max. at Makerstoun and Brussels

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. Table 8.6 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

Table 8.7
Geographic coordinates of the locations mentioned in Table 8.6

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

Table 8.8
Number of cases of maximum deviation of the magnetic needle with respect to Göttingen measurements

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

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.

Table 8.7 shows the latitude and longitude of the places mentioned in the catalogue (Table 8.6).

Table 8.8 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.

From Table 8.8 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.

Table 8.9 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

Table 8.9
Number of cases of minimum deviation of the magnetic needle with respect to Göttingen measurements

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

Table 8.10
Number of cases of extreme deviation of the magnetic needle with respect to Göttingen measurements

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

Table 8.11
Auroras corresponding to the dates in Table 8.6

Year	Date	Hour[a]	Location	Observations
1837	Aug. 31	10 h	Christiania	Slight aurora
1837	Nov. 12	$6\frac{1}{2}$ h	England	Bright aurora with streamers reaching to the zenith
1837	Nov. 12-13		France	Brilliant aurora of a reddish color seen throughout France
1837	Nov. 13		England	Rain
1837	Nov. 14		England	Broad patches and streamers of a fiery red color
1837	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	$6\frac{1}{2}$ 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

[a] Editors' note: The hours are mostly likely Göttingen Astronomical Times.

same instant as at Göttingen; and in how many cases it occurred later than at Göttingen.

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 drawer 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 results shown in Table 8.10.

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 Table 8.6, 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. Table 8.11 is the list of auroras corresponding to dates in the catalogue (Table 8.6).

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. 2, at 7h 20m A.M. Göttingen time[1]. At Petersburgh it took place at 7h 48m 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.

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[1] The original printed text of this sentence in the Loomis paper gives a date of 1 Sept. This is most likely a misprint inasmuch as the major geomagnetic disturbance was associated with a sudden commencement at 0450 A.M. (Greenwich mean time) on 2 Sept. (Bartels, J., Solar eruptions and their ionospheric effects – a classical observation and its new interpretation, Terr. Mag. Atmos. Elect., 42, 235-239, 1937). The editors have changed the date from 1 Sept. to 2 Sept. in the above text.