ANNALS
OF
THE ASTRONOMICAL OBSERVATORY OF HARVARD COLLEGE.
VOL. XIX.—PART I.

METEOROLOGICAL OBSERVATIONS
Made during the Years 1840 to 1888 inclusive,

Under the direction of
WILLIAM CRANCH BOND, GEORGE PHILLIPS BOND, JOSEPH WINLOCK, AND EDWARD C. PICKERING,

Successive Directors of the Observatory.

Printed from the Stubbs Fund.

CAMBRIDGE:
JOHN WILSON AND SON,
University Press.
1889.
CHAPTER III.

OBSERVATIONS OF AURORA BOREALIS.

The original records of the following observations occur chiefly in the meteorological memoranda of the Observatory; but some of them have been found in the astronomical records. It is not known that any regular watch for auroras was kept before 1877. The auroras observed before that year are probably not such as happened to attract attention enough to secure a record, and it is likely that the amount of attention paid to auroral phenomena varied considerably at different periods. During the years 1877-1879, auroras were regularly looked for at 8th P.M., except during the months of June and July. In the years 1880-1888, it was regularly looked for at some time during every clear evening. To print the observations of the absence of aurora for the years following 1876 seems, therefore, to be superfluous; but such observations have been copied out for the previous years in the comparatively few cases in which they occur.

The names of the observers are not in all cases known. For the period 1840-1858, it is probable that most of the observations were made by Professor W. C. Bond; for the period 1860-1864, Professor G. P. Bond is most likely to have been the observer, in the absence of any indication to the contrary. During 1865, Professor T. H. Safford was in charge of the Observatory. For the period 1866-1868, the observations were made in part by Professor J. Winlock, and in part by Messrs. E. P. Austin, S. P. Langley, C. S. Peirce, and G. M. Saras. After 1888, the meteorological record was usually kept by Mr. Arthur H. Sears, but other observers have often made records of auroras. Mr. E. L. Trouvelot was connected with the Observatory during the years 1872-1874, and for this period his observations of auroras were very frequent. Many of his observations made at Medford (near Cambridge) in 1870 and 1874 are also compiled in the list below, but in all cases specially designated, to distinguish them from the Cambridge observations. The notes of different observers have frequently been used to form a description of a given aurora; but in such cases care has been taken not to combine two accounts of the same phenomenon.

When the observers are mentioned, it is frequently by their full names. The initials R. F. (for Richard F. Bond) occur in addition to those of the gentlemen already named.

OBSERVATIONS OF AURORA BOREALIS.

September 19. Aurora at 10th P.M.

September 21. Aurora.

September 22. Aurora.

September 23. Aurora at midnight.

September 24. Aurora at 12th P.M. bright and flashing at 12th P.M.

September 25. Aurora.

September 26. Aurora at 8th 30th P.M.

October 2. Aurora.

October 3. Aurora through clouds.

October 8. Aurora in northeast at 2th A.M.

October 24. Faint aurora all the evening.

November 29. Faint aurora on midwinter.

1868.

March 19. Aurora.

March 22. Aurora.

April 13. Aurora at 9th P.M.

April 18. Fine aurora; no vertical lines; at 12th P.M., vertical lines detached from the bright cloud.

April 28. Aurora, not very bright.

April 28. Aurora, faint.

July 10. Very bright and remarkable white aurora. At 10th 55th P.M., very rapid vibrations toward zenith at intervals of 1 second. Pretty faint at 11th 15th P.M.

HAD been visible since dark. One bright line observed with spectroscope at $5500 \pm (J. W.), 5600 \pm (C. S. F.).$

September 5. Brilliant aurora at 8th 30th P.M.

November 19. Aurora at 8th P.M., with steady streamers and upward waves of white light.

1869.

January 6. Brilliant aurora from 9th 30th to 9th 30th P.M.

January 7. Aurora about 10th P.M.

February 5. Fine aurora, with streamers, last midnight.

March 9. Very brilliant aurora indeed. Spectrum of one remarkably bright line, $5700 \pm (J. W.), 5650 \pm (C. S. F.); this line as bright as the brightest in the spectrum of the nebula in Orione, and quite narrow when the slit is closed.
up J. W. also saw a very faint continuous spectrum crossed by dark bands or stripes more refrangible than the bright line; some continuous light far up in the violet; the continuous spectrum was not nearly as bright as that of the nebula in Ovina.  
April 5. Fine aurora. Single line in spectrum at λ 5660 A (C. S. P.); seen also by J. W.  
April 9. Fine aurora at 10 p.m., with strong vertical streamers and very dark sky under the arch. Some auroral light has appeared on several evenings lately.  
April 10. Aurora; not very fine; not perceptible in spectroscope at first. One line seen on a new trial; another very doubtful.  
April 15. Aurora covering larger part of the sky, first noticed about 7 p.m., by C. S. P. Part of it was then rose-colored, part of the usual yellowish-green. Rose-color disappeared before telescope could be turned on it. At 10h sidereal time [8h 25p.m.], streamers converging spirally from all quarters to a point near η Lepis; spiral from west to north, north to east, east to south, south to west; clouds partly cut off the view toward midnight.  
The spectrum was observed by C. S. P. with the large telescope. The rose color having then disappeared, no red line was seen in the spectrum. The places of seven lines were determined and reduced to the scale of Mr. Huggins. The results were printed in the "American Journal of Science," XCVIII, 404, and in Volume VIII. of these Annals, p. 50. Reducing the measurements to wave-lengths by means of the data given by Dr. Gibbs in the "American Journal of Science," XCVIII, 268, we shall have the following approximate values:

<table>
<thead>
<tr>
<th>No.</th>
<th>Ranges</th>
<th>( \lambda )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1560</td>
<td>5670</td>
</tr>
<tr>
<td>2</td>
<td>1600</td>
<td>5646</td>
</tr>
<tr>
<td>3</td>
<td>1650</td>
<td>5620</td>
</tr>
<tr>
<td>4</td>
<td>1700</td>
<td>5590</td>
</tr>
<tr>
<td>5</td>
<td>1750</td>
<td>5560</td>
</tr>
<tr>
<td>6</td>
<td>2400</td>
<td>5510</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

April 16. Moderate aurora about 8 p.m.  
May 7. Moderate aurora about 9 p.m.; one bright line seen with spectroscope.  
June 6. Aurora. Bright arch at 10 p.m., with little appearance of streamers at 10h 15m. At 11h 20m aurora much more brilliant, streamers extending to zenith. At 2h 20m A.M. (June 7) renewed activity of aurora, streamers extending to and beyond the zenith. At 3h 30m overcast to the south.  
The spectrum at about 10h 15m. (June 6) showed only the usual line in the green. At 11h 20m, this line was well seen in a direct-vision spectro-
One line very distinct, four other lines or bands seen by C. S. P., also two of them by J. W. and A. G. Clark, very faint but indubitable. Seen with chemical spectroscope without telescope.

September 3. Aurora arch at 22° [11° 9° p.m.], extending from eastern horizon to western between α Andromedae and γ Pegasus, over β Pegasus and β Cygni and so on to western horizon; drifted slowly to southward; had a continuous spectrum with some signs of the bright line. (E. P. A.)

This arch showed continuous spectrum with the auroral line faintly but decidedly. (C. S. P.)

September 5. Much auroral light in the early part of the evening. An uncommonly bright streamer appeared about 8° 45° p.m. It was high in the sky (Vega being about in its centre) and detached from the auroral arch; it was not straight, but of a sinuous form. Detached clouds of auroral light (like cirrus-stratus) also appeared, remaining stationary longer than common.

September 11. Aurora in the evening, lasting till after midnight.

September 12. Aurora in the evening, lasting till after midnight.

September 14. Aurora very visible at midnight, September 14-15; not bright.

September 15. Some faint auroral light in the evening.

September 27. Aurora through the evening; fine and very bright; extended to zenith; very brilliant white streamers about 9° p.m.

September 28. Aurora in the evening.

September 29. Some aurora in the evening.

October 1. Some aurora behind clouds.

October 2. Some aurora behind clouds.

October 6. Pretty bright aurora this evening; arch distinct; not much appearance of streamers.

October 25. Aurora arch formed early in the evening. At 8° p.m. light unusually green, with some appearance of streamers. At 11° p.m. faint, a little yellow; a few streamers.

October 27. Some aurora all the evening.

October 31. Aurora; double and sometimes triple arch. Some appearance of streamers at 9° p.m. Later, the streamers extended at times nearly to the zenith and showed rose-color.

November 8. Aurora behind clouds during evening.

November 9. Aurora; streamers and arch.

November 11. Appearance of some aurora behind clouds in the evening.

November 25. Aurora at 7° 20° p.m.; pretty bright.

Observations of Aurora Borealis.

Red light, reaching beyond the zenith; it soon faded again. C. S. Peirce noticed a bright arch at 9° p.m.; very bright about 9° 15° p.m. He thought the red light which appeared about 10° 30° p.m. much redder than that of any previous aurora. It appeared to A. Storm not redder, perhaps even paler than that of the aurora of October 14, 1870. With the spectroscope C. S. Peirce found no trace of light less refrangible than the usual green line; but there were lines more refrangible, which, with the continuous light between them, looked red in color. The red and green were mingled in the sky in irregular bundles. A. Storm at Medford saw red light at 6° p.m., particularly toward west, where it formed a pyramid with its base almost on the horizon. There was also a bright green streamer about a half hour higher than elsewhere. The red light was a little redder than the green, and only a pale light remained after a dark segment in the north. Toward 11° p.m. there were bright streamers. Between midnight and 1° a.m. (November 10) there were still streamers, but pale and colorless, colors not having appeared since 9° [in marked contrast to the observations at Cambridge]. No undulatory or pulsating movement was noticed, nor even any such lateral movement of streamers from east to west as is often seen.

November 10. Auroras by nightfall seen by E. L. Trouvelot at Medford.

November 12. Faint aurora most of the night seen by E. L. Trouvelot at Medford.

November 14. Some auroral light from 2° 30° to 6° a.m. seen over bank of clouds; no distinct arch or streamers.

November 17. Clear night; no light seen by E. L. Trouvelot at Medford.

November 19. Faint aurora, without streamers, seen by E. L. Trouvelot at Medford; suspected at Cambridge.

November 23. Faint aurora, with dark segment, but no streamers, between 6° and 9° p.m.; observation by E. L. Trouvelot at Medford.

December 8. Rather fine aurora seen by E. L. Trouvelot at Medford, with long dark segment and fine light above; all not over 45° altitude; no streamers; auroral arch observed at Cambridge at times from 7° p.m. to midnight; few streamers; arch quiet, narrow at first, afterward rather wide.

December 9. Low auroral arch at 7° 50° p.m. At 6° p.m. another below the first, on the horizon; aurora seen by E. L. Trouvelot at Medford; began at 6° 30° p.m.; streamers ten minutes later of an unusual kind, being short and not anywhere higher than 30° or 30°; no trace of aurora left at 10° p.m.; the streamers began to appear in the northeast.
red light, reaching beyond the zenith; it soon faded again. C. S. Peirce noticed a bright arch at 9h p.m.; very bright about 9h 15m p.m. He thought the red light which appeared about 10h 30m p.m. much redder than that of any previous aurora. It appeared to A. Searle not redder, perhaps even paler than that of the aurora of October 14, 1870. With the spectroscope C. S. Peirce found no trace of light less refrangible than the usual green line; but there were lines more refrangible, which, with the continuous light between them, looked red in the spectroscope. The red and green were mingled in the sky in irregular blotches. E. L. Trouvelot at Medford saw red light at 6h p.m., particularly, as usual, in the northwest, where it formed a pyramid with its base almost on the horizon and reaching much higher than elsewhere. There was a similar pyramid in the northeast, smaller and fainter. At 6h [? perhaps 9h] p.m. the red light was mostly gone, and only a pale light remained over a dark segment in the north. Toward 11h p.m. there were bright streamers. Between midnight and 1h A.M. (November 10) there were still streamers, but pale and colorless, colors not having appeared since 6h [in marked contrast to the observations at Cambridge]. No undulatory or pulsating movement was noticed, nor even any such lateral movement of streamers from east to west as is often seen.

November 10. Aurora by nightfall seen by E. L. Trouvelot at Medford.
November 12. Faint aurora most of the night seen by E. L. Trouvelot at Medford.
November 14. Some auroral light from 2h 30m to 5h A.M. seen over bank of clouds; no distinct arch or streamers.
November 17. Clear night; no light seen by E. L. Trouvelot at Medford.
November 19. Faint aurora, without streamers, seen by E. L. Trouvelot at Medford; suspected at Cambridge.
November 23. Faint aurora, with dark segment, but no streamers, between 6h and 9h p.m.; observation by E. L. Trouvelot at Medford.

December 8. Rather fine aurora seen by E. L. Trouvelot at Medford, with long dark segment and fine light above; all not over 45° altitude; no streamers; auroral arch observed at Cambridge at times from 7h p.m. to midnight; few streamers; arch quiet, narrow at first, afterward rather wide.
December 9. Low auroral arch at 7h 30m p.m. At 9h p.m. another below the first, on the horizon; aurora seen by E. L. Trouvelot at Medford; began at 8h 30m p.m.; streamers ten minutes later of an unusual kind, being short and not anywhere higher than 25° or 30°; no traces of aurora left at 10h p.m.; the streamers began to appear in the northeast.
OBSERVATIONS OF AURORA BOREALIS.

the pale tint peculiar to periods of aurora showed itself; then mists slowly gathered in the north horizon, and at the end of half an hour formed a very high and not well-defined segment. At 8h 40m. two short streamers issued from the red light in the south-southeast; toward 9h 50m. two or three undefined streamers appeared above the northeastern mists. At 10h 30m. rather fine streamers issued from the segment, but not well-defined nor rising above 60° to 70°. At 10h 50m. the reddish light in the south exactly resembled in form and position the whitish light in the north, and seemed like a copy of it; was it the northern auroral light reflected over to the southern mists? At 11h 10m. the aurora was much diminished; the red tint was nearly gone, and so was the whitish light in the north.

The bright red light in the south was observed with the spectroscope by J. W. and C. S. P.; no line seen in red, though five other lines were seen in fainter aurora (green) at north.

February 5. Faint aurora in the north at 9h 40m. P.M., without streamers; sky below remarkably dark; aurora seen also at 10h 20m. P.M.

February 7. Aurora at 7h 45m. P.M.; some pale auroral light behind a dark segment only a few degrees in altitude; not conspicuous, but clearly recognized. At 8h 45m. no trace of it could be seen; none seen at 9h 30m. P.M.

February 10. A faint aurora seen toward midnight by J. W.

February 11. Auroral light toward 10h P.M.; faint, with a dark segment.

February 10. Aurora at 9h 50m. without streamers; it was a light above a dark segment well seen in spite of moonlight.

February 21. Aurora toward 10h P.M.; faint; undefined light in the north.

February 27. Aurora visible at 7h 50m. P.M.; only a rather strong light; no streamers; a little auroral light low in the north from 8h 30m. to 9h 1m. P.M.; no traces to be seen of it at 9h 45m. P.M., the moon then rising.

March 1. A pretty bright aurora at 9h 45m. P.M., without streamers, and with a low and very dark segment. At 9h 25m. aurora more extensive and brighter; segment higher; wind not at nightfall, pretty strong upon the appearance of the aurora; the arched appearance peculiar to this aurora was soon lost and a greenish mist rose near the upper limit of the light, forming an immense segment bordered by a pale and much diffused light. At 10h 45m. P.M. arch and some streamers, both undefined.

March 5. Aurora at 9h 45m.; no streamers, but pretty bright light over dark segment.

March 6. Aurora at 10h 30m.; faint; no streamers; with dark segment; calm; at 10h 30m. still visible.