SMITHSONIAN

CONTRIBUTIONS TO KNOWLEDGE.

VOL. XIII.

EVERY MAN IS A VALUABLE MEMBER OF SOCIETY, WHO, BY HIS OBSERVATIONS, RESEARCHES, AND EXPERIMENTS, PROCURES KNOWLEDGE FOR MEN.—SMITHSON.

CITY OF WASHINGTON:
PUBLISHED BY THE SMITHSONIAN INSTITUTION.
MDCCCLXIII.

ADVERTISEMENT.

THIS volume forms the thirteenth of a series, composed of original memoirs on different branches of knowledge, published at the expense, and under the direction, of the Smithsonian Institution. The publication of this series forms part of a general plan adopted for carrying into effect the benevolent intentions of JAMES SMITHSON, Esq., of England. This gentleman left his property in trust to the United States of America, to found, at Washington, an institution which should bear his own name, and have for its objects the "*increase* and *diffusion* of knowledge among men." This trust was accepted by the Government of the United States, and an Act of Congress was passed August 10, 1846, constituting the President and the other principal executive officers of the general government, the Chief Justice of the Supreme Court, the Mayor of Washington, and such other persons as they might elect honorary members, an establishment under the name of the "SMITHSONIAN INSTITUTION FOR THE INCREASE AND DIFFUSION OF KNOWLEDGE AMONG MEN." The members and honorary members of this establishment are to hold stated and special meetings for the supervision of the affairs of the Institution, and for the advice and instruction of a Board of Regents, to whom the financial and other affairs are intrusted.

The Board of Regents consists of three members *ex officio* of the establishment, namely, the Vice-President of the United States, the Chief Justice of the Supreme Court, and the Mayor of Washington, together with twelve other members, three of whom are appointed by the Senate from its own body, three by the House of Representatives from its members, and six persons appointed by a joint resolution of both houses. To this Board is given the power of electing a Secretary and other officers, for conducting the active operations of the Institution.

To carry into effect the purposes of the testator, the plan of organization should evidently embrace two objects: one, the increase of knowledge by the addition of new truths to the existing stock; the other, the diffusion of knowledge, thus increased, among men. No restriction is made in favor of any kind of knowledge; and, hence, each branch is entitled to, and should receive, a share of attention.

The Act of Congress, establishing the Institution, directs, as a part of the plan of organization, the formation of a Library, a Museum, and a Gallery of Art, together with provisions for physical research and popular lectures, while it leaves to the Regents the power of adopting such other parts of an organization as they may deem best suited to promote the objects of the bequest.

After much deliberation, the Regents resolved to divide the annual income into two equal parts—one part to be devoted to the increase and diffusion of knowledge by means of original research and publications—the other half of the income to be applied in accordance with the requirements of the Act of Congress, to the gradual formation of a Library, a Museum, and a Gallery of Art.

The following are the details of the parts of the general plan of organization provisionally adopted at the meeting of the Regents, Dec. 8, 1847.

DETAILS OF THE FIRST PART OF THE PLAN.

I. To INCREASE KNOWLEDGE.—*It is proposed to stimulate research, by offering rewards for original memoirs on all subjects of investigation.*

1. The memoirs thus obtained, to be published in a series of volumes, in a quarto form, and entitled "Smithsonian Contributions to Knowledge."

2. No memoir, on subjects of physical science, to be accepted for publication, which does not furnish a positive addition to human knowledge, resting on original research; and all unverified speculations to be rejected.

3. Each memoir presented to the Institution, to be submitted for examination to a commission of persons of reputation for learning in the branch to which the memoir pertains; and to be accepted for publication only in case the report of this commission is favorable.

4. The commission to be chosen by the officers of the Institution, and the name of the author, as far as practicable, concealed, unless a favorable decision be made.

5. The volumes of the memoirs to be exchanged for the Transactions of literary and scientific societies, and copies to be given to all the colleges, and principal libraries, in this country. One part of the remaining copies may be offered for sale; and the other carefully preserved, to form complete sets of the work, to supply the demand from new institutions.

6. An abstract, or popular account, of the contents of these memoirs to be given to the public, through the annual report of the Regents to Congress.

II. To increase Knowledge.—*It is also proposed to appropriate a portion of the income, annually, to special objects of research, under the direction of suitable persons.*

1. The objects, and the amount appropriated, to be recommended by counsellors of the Institution.

2. Appropriations in different years to different objects; so that, in course of time, each branch of knowledge may receive a share.

3. The results obtained from these appropriations to be published, with the memoirs before mentioned, in the volumes of the Smithsonian Contributions to Knowledge.

4. Examples of objects for which appropriations may be made:—

(1.) System of extended meteorological observations for solving the problem of American storms.

(2.) Explorations in descriptive natural history, and geological, mathematical, and topographical surveys, to collect material for the formation of a Physical Atlas of the United States.

(3.) Solution of experimental problems, such as a new determination of the weight of the earth, of the velocity of electricity, and of light; chemical analyses of soils and plants; collection and publication of articles of science, accumulated in the offices of Government.

(4.) Institution of statistical inquiries with reference to physical, moral, and political subjects.

(5.) Historical researches, and accurate surveys of places celebrated in American history.

(6.) Ethnological researches, particularly with reference to the different races of men in North America; also explorations, and accurate surveys, of the mounds and other remains of the ancient people of our country.

I. To diffuse Knowledge.—*It is proposed to publish a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge not strictly professional.*

1. Some of these reports may be published annually, others at longer intervals, as the income of the Institution or the changes in the branches of knowledge may indicate.

2. The reports are to be prepared by collaborators, eminent in the different branches of knowledge.

3. Each collaborator to be furnished with the journals and publications, domestic and foreign, necessary to the compilation of his report; to be paid a certain sum for his labors, and to be named on the title-page of the report.

4. The reports to be published in separate parts, so that persons interested in a particular branch, can procure the parts relating to it, without purchasing the whole.

5. These reports may be presented to Congress, for partial distribution, the remaining copies to be given to literary and scientific institutions, and sold to individuals for a moderate price.

The following are some of the subjects which may be embraced in the reports:—

I. PHYSICAL CLASS.

1. Physics, including astronomy, natural philosophy, chemistry, and meteorology.
2. Natural history, including botany, zoology, geology, &c.
3. Agriculture.
4. Application of science to arts.

II. MORAL AND POLITICAL CLASS.

5. Ethnology, including particular history, comparative philology, antiquities, &c.
6. Statistics and political economy.
7. Mental and moral philosophy.
8. A survey of the political events of the world; penal reform, &c.

III. LITERATURE AND THE FINE ARTS.

9. Modern literature.
10. The fine arts, and their application to the useful arts.
11. Bibliography.
12. Obituary notices of distinguished individuals.

II. To DIFFUSE KNOWLEDGE.—*It is proposed to publish occasionally separate treatises on subjects of general interest.*

1. These treatises may occasionally consist of valuable memoirs translated from foreign languages, or of articles prepared under the direction of the Institution, or procured by offering premiums for the best exposition of a given subject.

2. The treatises to be submitted to a commission of competent judges, previous to their publication.

DETAILS OF THE SECOND PART OF THE PLAN OF ORGANIZATION.

This part contemplates the formation of a Library, a Museum, and a Gallery of Art.

1. To carry out the plan before described, a library will be required, consisting, 1st, of a complete collection of the transactions and proceedings of all the learned societies in the world; 2d, of the more important current periodical publications, and other works necessary in preparing the periodical reports.

2. The Institution should make special collections, particularly of objects to verify its own publications. Also a collection of instruments of research in all branches of experimental science.

3. With reference to the collection of books, other than those mentioned above, catalogues of all the different libraries in the United States should be procured, in order that the valuable books first purchased may be such as are not to be found elsewhere in the United States.

4. Also catalogues of memoirs, and of books in foreign libraries, and other materials, should be collected, for rendering the Institution a centre of bibliographical knowledge, whence the student may be directed to any work which he may require.

5. It is believed that the collections in natural history will increase by donation, as rapidly as the income of the Institution can make provision for their reception; and, therefore, it will seldom be necessary to purchase any article of this kind.

6. Attempts should be made to procure for the gallery of art, casts of the most celebrated articles of ancient and modern sculpture.

7. The arts may be encouraged by providing a room, free of expense, for the exhibition of the objects of the Art-Union, and other similar societies.

8. A small appropriation should annually be made for models of antiquity, such as those of the remains of ancient temples, &c.

9. The Secretary and his assistants, during the session of Congress, will be required to illustrate new discoveries in science, and to exhibit new objects of art; distinguished individuals should also be invited to give lectures on subjects of general interest.

In accordance with the rules adopted in the programme of organization, each memoir in this volume has been favorably reported on by a Commission appointed for its examination. It is however impossible, in most cases, to verify the statements of an author; and, therefore, neither the Commission nor the Institution can be responsible for more than the general character of a memoir.

The following rules have been adopted for the distribution of the quarto volumes of the Smithsonian Contributions:—

1. They are to be presented to all learned societies which publish Transactions, and give copies of these, in exchange, to the Institution.

2. Also, to all foreign libraries of the first class, provided they give in exchange their catalogues or other publications, or an equivalent from their duplicate volumes.

3. To all the colleges in actual operation in this country, provided they furnish, in return, meteorological observations, catalogues of their libraries and of their students, and all other publications issued by them relative to their organization and history.

4. To all States and Territories, provided there be given, in return, copies of all documents published under their authority.

5. To all incorporated public libraries in this country, not included in any of the foregoing classes, now containing more than 10,000 volumes; and to smaller libraries, where a whole State or large district would be otherwise unsupplied.

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[1] Each memoir is separately paged and indexed.

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

TIDAL OBSERVATIONS

IN THE

ARCTIC SEAS.

BY

ELISHA KENT KANE, M.D., U.S.N.

MADE DURING THE SECOND GRINNELL EXPEDITION IN SEARCH OF SIR JOHN FRANKLIN, IN 1853, 1854, AND 1855, AT VAN RENSSELAER HARBOR.

REDUCED AND DISCUSSED,

BY

CHARLES A. SCHOTT,
ASSISTANT U. S. COAST SURVEY.

[ACCEPTED FOR PUBLICATION, JULY, 1860.]

COLLINS, PRINTER.
PHILADELPHIA.

CONTENTS.

INTRODUCTORY LETTER.

WASHINGTON, July 4th, 1860.

PROFESSOR JOSEPH HENRY, LL. D.,

Secretary of the Smithsonian Institution:

DEAR SIR: The records of the tidal observations made under the direction of Dr. Kane, in the second Grinnell Expedition to the Arctic Regions, were placed in my hands by his late lamented father, Judge Kane, in December, 1857.

Dr. Kane had selected Assistant Charles A. Schott, of the U. S. Coast Survey, for the reduction of a considerable portion of the observations made on that expedition; and I, therefore, placed them in Mr. Schott's possession for reduction, and recommend his paper for publication in the "Smithsonian Contributions to Knowledge." It is proper to state that the computations were at the expense of the Smithsonian Institution. This is the sixth and last paper of the series.

Very respectfully, yours,

A. D. BACHE,

Superintendent U. S. Coast Survey.

RECORD AND REDUCTION OF THE TIDES.

The observations and discussion of the tides at Van Rensselaer Harbor, the winter quarters of the Advance during 1853–54 and 1854–55, will form the last of the series of papers on the results of the expedition, prepared by me for publication.

Occasional tidal observations were made after passing Smith Straits, when, owing to the peculiar navigation through the narrow openings between the coast and the bay ice, the vessel was much exposed to the tidal action, frequently grounding at low water, and otherwise, by taking advantage of high tides, slowly advancing to her winter quarters.

The bay, near the head of which the Advance was laid up, and used as the winter quarters by Dr. Kane's party, is freely exposed to the north (true) and northwest; the indentation of the shore line is about five miles; some rocky islands are situated within the bay.

Shortly after the vessel entered the harbor a tide staff was arranged, and a series of tidal observations was commenced on September 11, 1853, and continued, with occasional interruptions (partly owing to defects in the pulley-gauge, afterwards rigged up, and partly owing to other unavoidable accidents) till the 24th of January, 1855, on which date the regular log book appears to have been discontinued.

The several series of observations during this period are of very unequal value, as will appear in the detailed examination and discussion of the results. The difficulties to be overcome in the attempt to secure a reliable set of observations were considerable, those of a physical nature being the greatest. The observations with the staff or sounding line are subject to irregularities from a slow movement of the vessel, which, though imbedded in ice during the greater part of the year, is yet not stationary; these observations may also be affected by the softness of the bottom; the observations by means of a pulley tide gauge may be defective, on account of a slow drift of the vessel and motion of the ice field, also in consequence of a lengthening or shortening of the rope, or it may be in consequence of slipping of the rope on the circumference of the wheel. The latter defect, or one similar in its nature, has been a source of much annoyance, requiring the application of corrections to the readings, in order to refer all observations to the same zero of the scale. There is another defect to which pulley-gauges are subject, namely, the gradual rise of the vessel, in consequence of the consumption of provisions and fuel. Notices of these defects will appear in the subsequent discussion.

The pulley-gauge is described by Dr. Kane, in volume I of the *Narrative*, p. 117, as follows: "Our tide register was on board the vessel, a simple pulley-gauge, arranged with a wheel and index, and dependent on her rise and fall for its rotation."[1]

In order to ascertain the nature of the tides, as well as the degree of accuracy of the different observations, the readings were roughly plotted for a first examination; the following series were found suitable for discussion:—

SERIES I. *From October 10th*, 1853, *to December 28th*, 1853.—This series, with the exception of three days, is complete; the observations in the latter part of December appear to be of less reliable character. The observations between September 11 and October 4, 1853, are too fragmentary to be used. The pulley-gauge observations between October 4 and October 9 seem to have been only experimental. The hourly readings are superseded by half-hourly readings on November 8, and continue half hourly, day and night, to the end of the series. After November 28, corrective soundings were taken at noon each day. In order to make use of these soundings, the mean depth of the water at the anchorage was deduced from them as follows:—

		Mean reading.	
December,	1853.	43.8 feet, from	31 soundings (at noon).
January,	1854.	44.9	21
February,	"	44.3	17
March,	"	43.3	19
April,	"	41.8	20
May,	"	43.5	9

The individual soundings will appear in the record following.

Mean depth of water at anchorage, in winter, 1853–54, 43.6 feet, as obtained from 117 soundings. The monthly mean values for the tidal level accord well, and show that no lateral change took place in the position of the brig (or else that the bottom was level). It will be seen that for Series I the reading 7.0 was adopted to express the mean level, the zero of the scale was, therefore, at an elevation of 36.6 feet from the bottom. The readings of the pulley guage are expressed in feet,[2] as I have been informed by Mr. Sonntag.

SERIES II. *From January 28th*, 1854, *to April 7th*, 1854.—The double half-hourly readings of the pulley-gauge are continued. The series is complete with the exception of ten days, which had to be omitted. The register broke January 22d; observations commenced January 24th, but were not sufficiently regular for use

[1] The following note is appended: One end of the cord represented a fixed point, by being anchored to the bottom; the free end, with an attached weight, rose and fell with the brig, and recorded its motion on the grooved circumference of a wheel. This method was liable to objections, but it was corrected by daily soundings. The movements of our vessel partook of those of the floe in which she was imbedded, and were unaccompanied by any lateral deviation.

[2] The following is an extract from Mr. Sonntag's letter to me, dated New York, March 23, 1860: "The circumference of the wheel (of the pulley-gauge) was divided into feet and tenths of a foot, and the records by the sounding line are also expressed in feet and decimals. The records of the wheel are very uncertain, as often the rope slid over the wheel without turning it, owing to the ice which surrounded the axis."

until January 28th. The corrective soundings at noon are continued, with occasional omissions, throughout this series. After April 7th there is a break in the observations, those between the 14th and 20th appear to be irregular.

SERIES III. *From April 20th*, 1854, *to August 3d*, 1854.—The double half-hourly readings of the pulley-gauge continue to May 5th, after which date single half-hourly readings are recorded. The corrective soundings cease on the 12th of May. Interruptions occur between May 4th and May 7th, also on July 8th, also between July 15th and 18th, and between July 20th and the 28th. On the 8th of August the brig was released from her ice cradle, and rose two and a half feet; occasional warpings of the brig after this date render the observations worthless. On the 23d of August the brig was in but seven feet of water, and grounded.

SERIES IV. *From September 7th*, 1854, *to October 22d*, 1854.—The hourly observations assume again a more regular appearance on the 7th of September; they were taken with the sounding line, and are expressed in fathoms and feet (as stated in a note, August 12th). The following note is of October 21st, 1854: "The tide register as yet not rigged, observations very faulty by sounding line." The irregularities increase after this date; on the 15th of November following, the tide register was arranged, and observations (hourly) commenced on the 17th; the slipping of the rope, however, was of so frequent occurrence and of so great an extent, that it was considered better to take no further notice of these observations; the record continues to January 24th, 1855, when the strength of the party no longer permitted due attention to the tidal phenomena.

It was apparent that before any closer insight into the nature of these tides could be obtained, they must first be reduced to the same zero or mean level of the sea. To effect this in a manner apparently best suiting the case, and otherwise unobjectionable, two curved lines were traced on the diagrams, the upper one enveloping the highest high water of each day, the other enveloping the lowest low water of each day; in tracing these lines some allowance was made, when necessary, for disturbing causes, so as to obtain tolerably smooth curves; cases of abrupt changes were, of course, treated accordingly. A line, equidistant from these curves, was assumed as representing the mean level, and when straightened out was adopted as axis of the mean level of the sea. The corrections to refer each observation to this adopted mean level; or, in other words, the corrections required to refer each observation to the same zero of the scale, so as to make them comparable with each other, were taken from the projection, and are given in the column headed "reduction," in the following record.

This method of treatment excludes necessarily in Series I, II, and III, any discussion of the variation in the mean level of the sea, the oscillations of which have been found small at other places. As an illustration of this, the tides at Singapore might be referred to; the Rev. W. Whewell (7th series of researches on the tides, *Phil. Trans. of the Roy. Soc.*, Part I, 1837), finds for these tides that, if a line is drawn representing the mean height (midway between high and low water each day) it is very nearly constant, though the successive low waters often differ by six feet (on account of the diurnal inequality), the mean level only oscillates through a few inches. It appears from Mr. Lloyd's paper (*Phil. Trans.* of 1831) that the mean level at Sheerness is higher in spring tides than in neap tides by seven inches nearly; also there seems to be no doubt (as shown by Mr. Whewell, *Phil. Trans.*, 1839 and 1840) that the mean level increases as the moon's declination increases, amounting to three inches at Plymouth, when the moon's declination is 25°; at Petropaulofsk and Novo-Arkhangelsk the mean level rises as the moon's declination increases.

The use of the soundings intended to furnish corrections to the readings of the pulley-gauge is in many cases a doubtful remedy, on account of the continued change in the zero of the wheel's index; in fact, it would have required numerous soundings at other hours than noon. As it is, a combination of the corrections by enveloping curves and soundings had to be adopted. Thus, for December 5th, soundings at noon 43.0 feet (see record further on), mean level 36.6, hence reading of scale at noon 6.4; reading of pulley-gauge at that hour 19.0, correction by curve —12.5, corrected reading 6.5, which agrees with the first number; this is, however, a very favorable case. For intermediate hours the correction as given by the curves serve as guides. The reduction to the same level affects the times generally very little.

The following table contains the soundings taken at noon between the interval of the first and second series, those taken during the series being given in the record.

SOUNDINGS AT NOON.

1853.	Fath.	Feet.	Inch.	Register.	1854.	Fath.	Feet.	Inch.	Register.
December, 29.	7	3	0		January 13.	7	3	6	
30.	8	0	0	18.1 (changed.)	14.	---	---	---	
31.	8	2	0		15.	8	1	0	
1854. Jan. 1.	8	1	6		16.	7	2	6	
2.	8	1	6		17.	---	---	---	
3.	7	5	6		18.	7	3	9	
4.	7	3	0	Changed to 16.0	19.	7	5	6	
5.	7	1	6		20.	6	3	0	
6.	6	4	6	Changed to 10.5	21.	6	4	0	Changed to 10
7.	6	3	0		22.	Tide register broken.			
8.	---	---	---		23.	"	"	"	
9.	6	4	2		24.	"	"	"	
10.	7	0	0		25.	---	---	---	
11.	---	---	---		26.	---	---	---	
12.	7	4	0		27.	7	1	9	

The following soundings were taken between the second and third series:—

1854.	Fath.	Feet.	Inches.	1854.	Fath.	Feet.	Inches.
April 8.	6	5	6	April 16.	7	5	6
9.	6	4	0	(Fall 15 feet 8 inches.)			
10.	7	0	6	(17.	6	5	0
11.	6	5	6	at 20 minutes to 5.)			
13.	7	4	0	(18.	6	0	0
14.[1]	7	5	6	at 8^h 15^m P. M.)			
15.	8	0	0	19.	6	2	0
(Low water to high water 14 ft. 8 inch.)							

[1] For the past ten days the tide register has not been reliable on account of the rope slipping.

The note of February 3d, 1854, is very instructive in regard to the effect of the tides on the ice floe, viz: "The enormous elevation of the land ice by the tides has raised a barrier of broken tables seventy-two feet wide and twenty feet high between the brig and islands. This action has caused a recession of the main floe; our vessel has changed her position twenty feet within the last two spring tides, and the hawser connected with Butler Island parted with the strain." The cutwater of the brig was then 280 feet from the margin of the ice. (Note of February 4th.)

The mean of all the soundings taken during the fourth series is very nearly fifteen feet, hence the constant index error, to refer the observations to the level previously adopted, is eight feet, which correction was applied, converting at the same time the record of fathoms into feet.

The following tidal record extends, therefore, over about nine and a half lunations between October 10, 1853, and October 22, 1854, during which interval the time and height of nearly five hundred high and as many low waters were secured.

Record of the Observations of the Tides at Van Rensselaer Harbor, North Greenland, in 1853, 1854, *and* 1855.

POSITION OF THE WINTER QUARTERS,

Latitude 78° 37′ north, and longitude 70° 53′, or $4^h\ 43^m.5$ west of Greenwich.[1]

The first column for each day is copied from the original log-book, the second column contains the reduction to the adopted zero of scale found graphically as explained, and the third column contains the observations referred to the same mean level.

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[1] See my discussion of the astronomical observations of the expedition in vol. XII of the Smithsonian Contributions to Knowledge, 1860.

SERIES I.—TIDAL OBSERVATIONS FROM OCTOBER 10, 1853, TO DECEMBER 28, 1853.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

October, 1853.

Mean solar hour.	10th.	Red. to level.	Ref. obs.	11th.	Red. to level.	Ref. obs.	12th.	Red. to level.	Ref. obs.	13th.	Red. to level.	Ref. obs.	14th.	Red. to level.	Ref. obs.	17th.	Red. to level.	Ref. obs.
1	---		---	5.4	—1.0	4.4	5.0	—1.0	4.0	7.5	—1.3	6.2	7.0	—1.5	5.5	---		---
2	6.6	—1.0	5.6	5.4	"	4.4	5.0	"	4.0	6.4	"	5.1	5.4	"	3.9	---		---
3	7.6	"	6.6	5.5	"	4.5	5.2	"	4.2	5.0	"	3.7	4.4	"	2.9	---		---
4	8.1	"	7.1	6.0	"	5.0	6.0	"	5.0	5.5	"	4.2	4.2	"	2.7	---		---
5	8.7	"	7.7	6.9	"	5.9	7.0	"	6.0	7.9	"	6.6	4.4	—1.6	2.8	---		---
6	8.7	"	7.7	7.3	"	6.3	8.5	"	7.5	8.3	"	7.0	5.5	"	3.9	---		---
7	8.7	"	7.7	7.7	"	6.7	8.9	"	7.9	8.7	—1.4	7.3	7.5	"	5.9	---		---
8	9.0	"	8.0	7.7	"	6.7	8.9	"	7.9	9.4	"	8.0	9.6	"	8.0	---		---
9	6.4	"	5.4	7.6	"	6.6	---		---	10.5	"	9.1	11.2	"	9.6	---		---
10	5.9	"	4.9	6.6	"	5.6	7.8	—1.1	6.7	10.5	"	9.1	11.4	"	9.8	---		---
11	5.7	"	4.7	6.1	"	5.1	6.7	"	5.6	10.3	"	8.9	11.3	"	9.7	---		---
Noon	5.8	"	4.8	5.8	"	4.8	5.6	"	4.5	9.9	"	8.5	11.0	—1.7	9.3	---		---
1	6.7	"	5.7	5.8	"	4.8	5.3	"	4.2	7.6	"	6.2	9.4	"	7.7	---		---
2	7.3	"	6.3	5.8	"	4.8	5.3	"	4.2	6.7	"	5.3	7.4	"	5.7	---		---
3	8.9	"	7.9	6.3	"	5.3	5.3	"	4.2	5.6	—1.5	4.1	6.6	"	4.9	---		---
4	9.3	"	8.3	7.7	"	6.7	5.3	"	4.2	4.6	"	3.1	4.4	"	2.7	---		---
5	10.2	"	9.2	9.0	"	8.0	6.4	—1.2	5.2	6.5	"	5.0	4.6	"	2.9	4.2	—2.7	1.5
6	10.2	"	9.2	10.1	"	9.1	7.8	"	6.6	9.0	"	7.5	5.9	"	4.2	4.5	"	1.8
7	10.2	"	9.2	10.5	"	9.5	9.9	"	8.7	10.5	"	9.0	9.2	"	7.5	---		---
8	9.9	"	8.9	10.5	"	9.5	11.0	"	9.8	11.6	"	10.1	12.0	—1.8	10.2	9.5	"	6.8
9	8.8	"	7.8	9.8	"	8.8	11.3	—1.3	10.0	12.4	"	10.9	12.4	"	10.6	12.6	"	9.9
10	7.5	"	6.5	9.0	"	8.0	11.3	"	10.0	12.4	"	10.9	13.1	"	11.3	13.0	"	10.3
11	6.3	"	5.3	7.2	"	6.2	9.7	"	8.4	12.4	"	10.9	13.1	"	11.3	13.4	"	10.7
Midn't	5.7	"	4.7	5.6	"	4.6	8.3	"	7.0	10.4	"	8.9	13.0	—1.9	11.1	13.4	"	10.7

October, 1853.

Mean solar hour.	18th.	Red. to level.	Ref. obs.	19th.	Red. to level.	Ref. obs.	20th.	Red. to level.	Ref. obs.	21st.	Red. to level.	Ref. obs.	22d.	Red. to level.	Ref. obs.	23d.	Red. to level.	Ref. obs.
1	11.5	—2.7	8.8	13.6	—2.2	11.4	13.8	—2.3	11.5	11.6	—1.7	9.9	10.7	—0.2	10.5	7.0	+0.8	7.8
2	8.9	"	6.2	12.0	"	9.8	12.6	"	10.3	---	"	---	10.2	"	10.0	8.0	"	8.8
3	6.8	"	4.1	8.9	"	6.7	10.5	"	8.2	10.8	—1.6	9.2	10.0	—0.1	9.9	9.5	"	10.3
4	5.5	"	2.8	6.6	"	4.4	8.0	"	5.7	9.6	—1.5	8.1	9.0	"	8.9	9.0	+0.9	9.9
5	4.4	—2.6	1.8	4.5	"	2.3	7.9	—2.2	5.7	6.7	—1.4	5.3	8.0	0.0	8.0	6.9	"	7.8
6	4.4	"	1.8	3.8	"	1.6	7.9	"	5.7	4.6	"	3.2	7.0	"	7.0	4.5	"	5.4
7	6.5	"	3.9	3.8	"	1.6	7.9	"	5.7	4.1	—1.3	2.8	5.0	"	5.0	3.4	"	4.3
8	8.7	"	6.1	4.7	"	2.5	8.9	"	6.7	4.1	—1.2	2.9	5.0	+0.1	5.1	3.0	"	3.9
9	11.8	—2.5	9.3	5.3	"	3.1	8.7	"	6.5	6.7	"	5.5	3.3	"	3.4	3.1	"	4.0
10	---		---	11.0	"	8.8	8.7	"	6.5	8.5	—1.1	7.4	4.5	+0.2	4.7	3.5	"	4.4
11	---		---	13.6	"	11.4	12.9	"	10.7	10.8	"	9.7	6.3	"	6.5	3.7	"	4.6
Noon	---		---	14.4	"	12.2	13.6	"	11.4	11.7	—1.0	10.7	7.2	"	7.4	4.5	"	5.4
1	---		---	14.6	"	12.4	14.0	—2.1	11.9	11.9	"	10.9	7.0	+0.3	7.3	6.5	"	7.4
2	14.8	"	12.3	12.6	"	10.4	14.0	"	11.9	11.9	—0.9	11.0	7.5	"	7.8	7.0	"	7.9
3	10.6	—2.4	8.2	10.4	"	8.2	---		---	11.9	—0.8	11.1	9.5	+0.4	9.9	8.5	"	9.4
4	8.6	"	6.2	9.6	—2.3	7.3	---		---	11.8	"	11.0	9.2	"	9.6	9.5	"	10.4
5	6.6	"	4.2	6.6	"	4.3	7.7	"	5.6	9.0	—0.7	8.3	9.2	"	9.6	8.0	+0.8	8.8
6	4.4	"	2.0	5.2	"	2.9	6.2	"	4.1	7.5	"	6.8	6.7	+0.5	7.2	7.4	"	8.2
7	4.4	—2.3	2.1	4.2	"	1.9	5.5	"	3.4	5.5	—0.6	4.9	5.2	"	5.7	7.0	"	7.8
8	5.5	"	3.2	4.8	"	2.5	5.2	—2.0	3.2	5.0	"	4.4	3.9	+0.6	4.5	6.1	"	6.9
9	8.3	"	6.0	6.8	"	4.5	4.7	"	2.7	5.0	—0.5	4.5	3.9	"	4.5	5.5	"	6.3
10	10.4	"	8.1	9.4	"	7.1	6.8	—1.9	4.9	5.0	"	4.5	4.0	"	4.6	4.5	+0.7	5.2
11	12.6	"	10.3	11.6	"	9.3	9.8	"	7.9	5.0	—0.4	4.6	6.3	+0.7	7.0	5.0	"	5.7
Midn't	13.7	—2.2	11.5	13.4	"	11.1	11.0	—1.8	9.2	5.0	—0.3	4.7	---		---	5.5	"	6.2

Regular observations commence October 10, 2 A. M.

Oct. 15. Tide rope found broken at 10 A. M., and the lead lost through the ice hole.

Oct. 17. Tides irregular, index changed 12 units; hence most of the observations on this day had to be omitted.

Oct. 20. The observation for 10 A. M. is incorrect, on account of obstruction by the ice.

Oct. 21. Flood [rise] commenced at 8 P. M.

Oct. 23. Slack water [stand] at 8 o'clock, flood commences.

SERIES I.—TIDAL OBSERVATIONS FROM OCTOBER 10, 1853, TO DECEMBER 28, 1853.
Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

October, 1853.

Mean solar hour.	24th.	Red. to level.	Ref. obs.	25th.	Red. to level.	Ref. obs.	26th.	Red. to level.	Ref. obs.	27th.	Red. to level.	Ref. obs.	28th.	Red. to level.	Ref. obs.	29th.	Red. to level.	Ref. obs.
1	6.5	+0.7	7.2	5.5	—0.1	5.4	5.0	+0.3	5.3	4.0	+0.8	4.8	4.5	+1.1	5.6	5.1	+0.9	6.0
2	7.0	"	7.7	5.8	"	5.7	5.5	"	5.8	4.0	"	4.8	3.5	"	4.6	4.4	"	5.3
3	8.0	"	8.7	6.5	—0.2	6.3	5.5	+0.4	5.9	4.5	"	5.3	3.4	"	4.5	2.8	"	3.7
4	8.0	+0.6	8.6	7.2	"	7.0	5.8	"	6.2	5.0	+0.9	5.9	4.3	"	5.4	2.5	"	3.4
5	7.3	"	7.9	7.3	"	7.1	5.8	"	6.2	6.0	"	6.9	5.3	"	6.4	3.0	"	3.9
6	6.5	"	7.1	7.0	—0.3	6.7	6.2	+0.5	6.7	6.8	"	7.7	5.6	"	6.7	5.5	"	6.4
7	5.4	"	6.0	6.4	"	6.1	6.5	"	7.0	7.1	+1.0	8.1	7.3	"	8.4	7.0	"	7.9
8	4.0	+0.5	4.5	5.6	"	5.3	6.5	"	7.0	7.1	"	8.1	8.2	"	9.3	7.8	"	8.7
9	5.0	"	5.5	5.6	—0.4	5.2	6.1	"	6.6	7.1	"	8.1	- - -		- - -	9.8	"	10.7
10	5.0	"	5.5	5.6	"	5.2	5.6	"	6.1	6.0	"	7.0	- - -		- - -	9.8	"	10.7
11	5.0	"	5.5	5.6	"	5.2	5.5	+0.6	6.1	5.6	"	6.6	- - -		- - -	9.6	"	10.5
Noon	5.0	+0.4	5.4	5.6	"	5.2	5.5	"	6.1	4.5	"	5.5	- - -		- - -	9.3	"	10.2
1	7.7	"	8.1	7.3	—0.3	7.0	5.5	"	6.1	4.5	"	5.5	4.8	"	5.9	6.8	"	7.7
2	- - -		- - -	6.3	"	6.0	5.5	"	6.1	5.0	"	6.0	4.3	"	5.4	4.8	"	5.7
3	- - -		- - -	6.8	—0.2	6.6	6.0	"	6.6	5.3	"	6.3	4.0	"	5.1	4.0	"	4.9
4	- - -		- - -	7.5	"	7.3	6.5	"	7.1	6.3	"	7.3	4.0	"	5.1	4.0	"	4.9
5	9.5	+0.2	9.7	7.3	—0.1	7.2	7.5	+0.7	8.2	7.7	"	8.7	6.0	"	7.1	4.0	"	4.9
6	9.5	"	9.7	7.6	"	7.5	8.0	"	8.7	7.3	+1.1	8.4	7.1	"	8.2	5.5	"	6.4
7	8.1	+0.1	8.2	8.3	"	8.2	8.2	"	8.9	8.6	"	9.7	8.0	+1.0	9.0	6.7	"	7.6
8	7.0	"	7.1	8.5	0.0	8.5	8.5	"	9.2	8.7	"	9.8	9.4	"	10.4	9.0	"	9.9
9	6.0	0.0	6.0	7.1	"	7.1	8.5	"	9.2	8.7	"	9.8	9.8	"	10.8	9.5	"	10.4
10	5.8	"	5.8	6.1	+0.1	6.2	7.1	"	7.8	7.1	+1.2	8.3	9.8	"	10.8	10.5	"	11.4
11	5.5	—0.1	5.4	5.4	"	5.5	6.1	+0.8	6.9	6.3	"	7.5	9.0	+0.9	9.9	10.5	"	11.4
Midn't	5.5	"	5.4	5.0	+0.2	5.2	4.8	"	5.6	5.9	"	7.1	7.3	"	8.2	8.5	"	9.4

	October, 1853.						November, 1853.											
Mean solar hour.	30th.	Red. to level.	Ref. obs.	31st.	Red. to level.	Ref. obs.	1st.	Red. to level.	Ref. obs.	2d.	Red. to level.	Ref. obs.	3d.	Red. to level.	Ref. obs.	4th.	Red. to level.	Ref. obs.
1	4.5	+0.9	5.4	5.4	+1.5	6.9	6.8	+1.7	8.5	9.1	+1.4	10.5	13.5	—1.7	11.8	13.0	—1.4	11.6
2	3.5	"	4.4	3.8	"	5.3	4.0	"	5.7	8.8	+1.3	10.1	12.0	"	10.3	12.5	"	11.1
3	2.0	"	2.9	3.0	+1.6	4.6	2.5	"	4.2	7.1	+1.2	8.3	9.0	"	7.3	11.2	"	9.8
4	2.0	"	2.9	0.0	"	1.6	1.0	"	2.7	4.7	+1.0	5.7	6.7	—1.6	5.1	9.8	"	8.4
5	3.2	"	4.1	1.0	"	2.6	1.0	"	2.7	1.5	+0.7	2.2	3.7	"	2.1	6.0	"	4.6
6	4.2	"	5.1	1.2	"	2.8	2.2	"	3.9	0.5	+0.5	1.0	1.8	"	0.2	4.4	"	3.0
7	6.2	+1.0	7.2	3.1	+1.7	4.8	3.2	"	4.9	0.7	+0.2	0.9	1.5	—1.5	0.0	2.0	"	0.6
8	8.5	"	9.5	6.5	"	8.2	7.0	"	8.7	3.0	0.0	3.0	2.4	"	0.9	1.7	"	0.3
9	10.1	+1.1	11.2	8.5	"	10.2	9.5	+1.6	11.1	7.2	—0.2	7.0	3.4	"	1.9	3.7	"	2.3
10	10.4	"	11.5	9.3	"	11.0	10.5	"	12.1	9.8	—0.5	9.3	4.2	"	2.7	7.3	"	5.9
11	10.4	"	11.5	10.3	"	12.0	10.7	"	12.3	10.9	—0.7	10.2	6.0	"	4.5	10.5	"	9.1
Noon	10.4	+1.2	11.6	10.0	"	11.7	10.7	"	12.3	15.3	—1.0	14.3	6.7	"	5.2	12.6	"	11.2
1	8.2	"	9.4	7.5	"	9.2	10.2	"	11.8	15.2	—1.2	14.0	15.7	"	14.2	- - -		- - -
2	5.5	"	6.7	5.2	"	6.9	9.2	"	10.8	13.6	—1.5	12.1	15.2	"	13.7	- - -		- - -
3	3.7	"	4.9	3.7	"	5.4	8.1	"	9.7	10.5	—1.6	8.9	12.5	"	11.0	- - -		- - -
																12.0	"	10.6
4	3.4	"	4.6	0.1	"	1.8	4.5	+1.5	6.0	6.8	—1.7	5.1	10.1	"	8.6	11.5	"	10.1
5	2.6	+1.3	3.9	0.2	"	1.9	3.0	"	4.5	3.8	"	2.1	6.5	"	5.0	9.0	"	7.6
6	3.4	"	4.7	1.2	"	2.9	2.3	"	3.8	2.0	"	0.3	4.5	"	3.0	5.5	"	4.1
7	5.1	"	6.4	3.0	"	4.7	2.1	"	3.6	1.8	"	0.1	3.5	"	2.0	3.2	"	1.8
																3.0	"	1.6
8	6.8	"	8.1	5.2	"	6.9	4.0	"	5.5	3.2	"	1.5	3.5	"	2.0	3.0	"	1.6
													3.0	"	1.5			
9	9.5	+1.4	10.9	8.1	"	9.8	9.0	"	10.5	3.3	"	1.6	4.5	"	3.0	3.1	"	1.7
10	10.3	"	11.7	9.5	"	11.2	10.1	"	11.6	3.3	"	1.6	7.3	"	5.8	5.0	"	3.6
11	10.3	"	11.7	9.5	"	11.2	10.1	"	11.6	3.3	"	1.6	9.3	"	7.8	7.5	"	6.1
Midn't	9.0	+1.5	10.5	10.5	"	12.2	10.1	"	11.6	3.3	"	1.6	12.0	"	10.5	9.8	"	8.4

Oct. 29. Slack water [stand] of ebb at $4^h\ 30^m$ A. M.
Oct. 31. Slack water [stand] of ebb at 5 A. M.
Nov. 2 to Nov. 6. Between these dates there are occasionally half-hourly readings, but unless they occur near high or low water they are omitted in the above.

SERIES I.—TIDAL OBSERVATIONS FROM OCTOBER 10, 1853, TO DECEMBER 28, 1853.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

November, 1853.

Mean solar hour.	5th.	Red. to level.	Ref. obs.	6th.	Red. to level.	Ref. obs.	7th.	Red. to level.	Ref. obs.	8th.	Red. to level.	Ref. obs.	9th.	Red. to level.	Ref. obs.	10th.	Red. to level.	Ref. obs.
										4.3		3.8	3.8	+0.2	4.0	4.5	—0.2	4.3
1	11.5	—1.4	10.1	9.0	—1.0	8.0	6.6	—0.6	6.0	5.3	—0.5	4.8	3.9	"	4.1	4.5	"	4.3
										5.6	"	5.1	4.2	"	4.4	4.3	"	4.1
2	11.0	"	9.6	9.8	"	8.8	7.9	"	7.3	6.2	"	5.7	4.0	"	4.2	4.0	"	3.8
				9.9	"	8.9	8.8	"	8.2				4.5	"	4.7	4.2	"	4.0
3	10.0	"	8.6	10.0	"	9.0	8.8	"	8.2	7.1	"	6.6	5.0	"	5.2	4.5	—0.3	4.2
				10.0	"	9.0	8.8	"	8.2							4.5	"	4.2
4	9.2	—1.3	7.9	10.0	—0.9	9.1	8.8	"	8·2	7.9	"	7.4	6.0	"	6.2	4.1	"	3.8
				8.1	"	7.2	8.8	"	8.2	7.9	—0.4	7.5				5.8	"	5.5
5	5.7	"	4.4	7.7	"	6.8	8.6	"	8.0	8.2	"	7.8	7.5	"	7.7	6.5	"	6.2
										8.0	"	7.6						
6	3.5	"	2.2	5.5	"	4.6	7.8	—0.5	7.3	7.8	"	7.4	7.9	"	8.1	8.5	"	8.2
													7.9	"	8.1	9.9	"	9.6
7	2.3	"	1.0	4.5	"	3.6	6.5	"	6.0	7.3	—0.3	7.0	8.0	+0.1	8.1	9.5	"	9.2
				4.0	"	3.1							8.0	"	8.1	10.0	"	9.7
8	2.0	"	0.7	3.6	—0.8	2.8	5.4	"	4.9	6.3	"	6.0	8.0	"	8.1	10.2	—0.4	9.8
	2.0	"	0.7	3.1	"	2.3							7.4	"	7.5	10.2	"	9.8
9	2.4	"	1.1	3.1	"	2.3	4.0	"	3.5	5.5	"	5.2	6.9	"	7.0	10.2	"	9.8
	2.6	"	1.3	3.2	"	2.4	4.0	"	3.5							10.1	"	9.7
10	2.7	—1.2	1.5	4.3	"	3.5	3.7	"	3.2	5.3	"	5.0	6.0	"	6.1	9.8	"	9.4
							3.9	"	3.4									
11	6.7	"	5.5	5.7	—0.7	5.0	4.4	"	3.9	5.5	"	5.2	4.8	"	4.9	9.0	"	8.6
							5.5	"	5.0	5.3	—0.2	5.1						
Noon	11.1	"	9.9	8.3	"	7.6	6.8	"	6.3	5.1	"	4.9	4.6	0.0	4.6	7.5	—0.5	7.0
										5.3	"	5.1						
1	13.1	"	11.9	---			8.1	"	7.6	5.6	"	5.4	4.4	"	4.4	6.5	"	6.0
	13.6	"	12.4										4.5	"	4.5	6.3	"	5.8
2	14.2	"	13.0	---			9.5	"	9.0	7.1	"	6.9	4.5	"	4.5	6.0	"	5.5
	14.2	"	13.0										5.1	"	5.1	6.0	"	5.5
3	14.1	—1.1	13.0	---			10.6	"	10.1	8.3	"	8.1	5.5	"	5.5	6.5	—0.6	5.9
	13.0	"	11.9				10.9	"	10.4									
4	12.3	"	11.2	---			11.2	"	10.7	9.5	"	9.3	7.1	"	7.1	7.0	"	6.4
				11.5	—0.6	10.9	11.2	"	10.7									
5	10.8	"	9.7	11.0	"	10.4	11.1	"	10.6	10.1	—0.1	10.0	9.2	—0.1	9.1	7.9	"	7.3
				10.7	"	10.1	10.2	"	9.7	10.5	"	10.4	9.6		9.5			
6	8.2	"	7.1	9.1	"	8.5	10.2	"	9.7	10.5	"	10.4	10.1	"	10.0	9.5	"	8.9
										10.5	"	10.4	9.5		9.4			
7	5.1	"	4.0	7.5	"	6.9	8.5	"	8.0	10.5	"	10.4	11.1	"	11.0	10.9	"	10.3
										10.5	"	10.4	11.1		11.0	11.4	"	10.8
8	3.3	"	2.2	5.4	"	4.8	7.5	"	7.0	10.0	0.0	10.0	11.0	"	10.9	11.0	"	10.4
	2.9	"	1.8										9.8		9.7	11.0	"	10.4
9	3.0	"	1.9	4 2	"	3.6	5.6	"	5.1	8.1	"	8.1	8.9	"	8.8	11.0	"	10.4
	3.5	"	2.4	4.0	"	3.4										11.3	"	10.7
10	4.1	—1.0	3.1	3.2	"	2.6	4.4	"	3.9	7.0	+0.1	7.1	7.0	"	6.9	11.3	—0.7	10.6
				3.2	"	2.6	4.3	"	3.8							10.9	"	10.2
11	6.0	"	5.0	4.0	"	3.4	4.1	"	3.6	4.9	"	5.0	4.7	—0.2	4.5	9.5	"	8.8
				4.5	"	3.9	4.1	"	3.6	4 2	"	4.3	4.7		4.5			
Midn't	7.3	"	6.3	4.9	"	4.3	4.0	"	3.5	4.0	+0.2	4.2	4.5	"	4.3	8.5	"	7.8

Nov. 8. From this date the observations are half-hourly: in the above record, however, only those half-hourly readings were inserted, which occur near a high or low water.

SERIES I.—TIDAL OBSERVATIONS FROM OCTOBER 10, 1853, TO DECEMBER 28, 1853.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

November, 1853.

Mean solar hour.	11th.	Red. to level.	Ref. obs.	12th.	Red. to level.	Ref. obs.	13th.	Red. to level.	Ref. obs.	14th.	Red. to level.	Ref. obs.	15th.	Red. to level.	Ref. obs.	16th.	Red. to level.	Ref. obs.
	6.1	—0.7	5.4													16.8	—5.5	11.3
1	4.6	“	3.9	6.0	—0.9	5.1	8.8	—1.6	7.2	11.5	—4.1	7.4	13.0	—5.2	7.8	15.1	“	9.6
	4.4	“	3.7															
2	3.6	—0.8	2.8	5.5	“	4.6	6.7	“	5.1	9.1	—4.2	4.9	10.0	“	4.8	14.7	—5.6	9.1
	3.1	“	2.3	4.5	“	3.6												
3	3.5	“	2.7	4.0	—1.0	3.0	4.9	—1.7	3.2	7.5	—4.3	3.2	8.0	“	2.8	13.0	“	7.4
	3.6	“	2.8	4.0	“	3.0	4.6	“	2.9	7.0	“	2.7						
4	4.1	“	3.3	3.8	“	2.8	4.4	—1.8	2.6	6.5	—4.4	2.1	6.6	“	1.4	10.5	“	4.9
				4.1	“	3.1	4.5	“	2.7	6.5	“	2.1	6.0	“	0.8	6.1	—5.7	0.4
5	5.0	“	4.2	4.6	“	3.6	4.5	—1.9	2.6	6.5	“	2.1	5.9	“	0.7	6.1	“	0.4
							5.0		3.1	6.5	“	2.1	5.9	“	0.7	6.3	—5.8	0.5
6	5.6	“	4.8	7.1	“	6.1	5.5	“	3.6	7.0	—4.5	2.5	6.2	“	1.0	6.3	“	0.5
7	8.0	“	7.2	8.6	“	7.6	7.5	—2.0	5.5	9.0	“	4.5	8.0	“	2.8	7.3	—5.9	1.4
	8.3	“	7.5															
8	9.5	“	8.7	10.5	“	9.5	10.2	—2.1	8.1	12.4	—4.6	7.8	10.5	“	5.3	10.0	—6.0	4.0
	10.3	“	9.5	11.5	“	10.5												
9	10.3	“	9.5	12.0	“	11.0	12.7	“	10.6	15.5	“	10.9	12.9	“	7.7	12.7	“	6.7
	10.0	“	9.2	12.2	“	11.2	13.0	—2.2	10.8									
10	10.0	“	9.2	12.2	“	11.2	13.7	“	11.5	17.0	—4.7	12.3	16.0	“	10.8	16.4	—6.1	10.3
				12.0	“	11.0	13.7	—2.3	11.4	17.5	—4.8	12.7	17.3	“	12.1			
11	9.5	“	8.7	11.7	—1.1	10.6	13.5	“	11.2	17.3	—4.9	12.4	18.5	“	13.3	17.9	“	11.8
							12.9	“	10.6	17.1	“	12.2	18.5	“	13.3	18.5	—6.2	12.3
Noon	7.5	“	6.7	9.0	“	7.9	12.1	—2.4	9.7	16.4	—5.0	11.4	18.3	—5.3	13.0	19.9	—6.3	13.6
													18.0	“	12.7	19.9	“	13.6
1	6.0	“	5.2	8.0	“	6.9	11.1	—2.5	8.6	14.1	“	9.1	17.6	“	12.3	18.7	—6.4	12.3
2	5.3	“	4.5	6.3	“	5.2	9.1	—2.6	6.5	12.0	“	7.0	15.5	“	10.2	17.9	“	11.5
	5.3	“	4.5	5.6	“	4.5												
3	5.0	“	4.2	4.9	“	3.8	7.8	—2.7	5.1	9.3	—5.1	4.2	12.0	“	6.7	15.0	“	8.6
	5.0	“	4.2	5.0	“	3.9												
4	5.5	“	4.7	5.0	“	3.9	6.3	—2.8	3.5	8.5	“	3.4	10.3	“	5.0	12.6	—6.5	6.1
				5.0	“	3.9				9.0	“	3.9	9.5	“	4.2			
5	6.6	“	5.8	5.5	—1.2	4.3	6.3	—2.9	3.4	8.0	“	2.9	8.9	“	3.6	10.6	“	4.1
							5.5	“	2.6	8.0	“	2.9	8.9	“	3.6	10.3	—6.7	3.6
6	8.0	“	7.2	6.4	“	5.2	5.5	—3.0	2.5	8.5	—5.2	3.3	8.9	—5.4	3.5	10.0	“	3.3
							6.8	—3.1	3.7				8.9	“	3.5	10.0	—6.8	3.2
7	10.0	“	9.2	7.7	“	6.5	8.7	—3.2	5.5	9.6	“	4.4	9.2	“	3.8	10.0	—6.9	3.1
																11.0	“	4.1
8	11.4	—0.9	10.5	10.4	—1.3	9.1	11.0	—3.3	7.7	11.4	“	6.2	10.7	“	5.3	11.5	—7.0	4.5
	11.8	“	10.9															
9	12.7	“	11.8	11.8	“	10.5	13.7	—3.4	10.3	13.1	“	7.9	13.7	“	8.3	14.0	“	7.0
	12.7	“	11.8	12.8	“	11.5												
10	12.1	“	11.2	12.7	—1.4	11.3	14.4	—3.6	10.8	14.7	“	9.5	16.6	“	11.2	16.0	“	9.0
				12.5	“	11.1	14.5	—3.7	10.8	15.0	“	9.8						
11	11.4	“	10.5	11.9	“	10.5	14.8	—3.8	11.0	14.6	“	9.4	17.8	“	12.4	17.5	—7.1	10.4
							14.4	—3.9	10.5	14.5	“	9.3	18.5	—5.5	13.0	18.0	“	10.9
Midn't	9.2	“	8.3	10.6	—1.5	9.1	13.6	—4.0	9.6	14.1	“	8.9	18.5	“	13.0	17.9	“	10.8

SERIES I.—TIDAL OBSERVATIONS FROM OCTOBER 10, 1853, TO DECEMBER 28, 1853.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

November, 1853.

Mean solar hour.	17th.	Red. to level.	Ref. obs.	18th.	Red. to level.	Ref. obs.	19th.	Red. to level.	Ref. obs.	20th.	Red. to level.	Ref. obs.	21st.	Red. to level.	Ref. obs.	22d.	Red. to level.	Ref. obs.
	17.8	—7.2	10.6	1.4	+12.3	13.7	16.5	—6.7	9.8	16 5	—8.2	8.3						
1	17.0	"	9.8	1.0	"	13.3	16.5	"	9.8	17.0	"	8.8	17.3	—9.6	7.7	3.5	+3.2	6.7
				20.3	—7.6	12.7	16.5	"	9.8	17.4	—8.3	9.1	17.5	"	7.9	3.9	"	7.1
2	16.0	—7.3	8.7	20.0	—7.5	12.5	16.0	"	9.3	16.8	"	8.5	17.6	"	8.0	4.3	+3.1	7.4
													17.6	"	8.0	4.4	+3.0	7.4
3	14.9	—7.4	7.5	18.0	"	10.5	15.1	—6.8	8.3	16 0	"	7.7	17.6	—9.7	7.9	4.5	+2.9	7.4
													17.0	"	7.3	4.5	"	7.4
4	12.0	—7.5	4.5	16.5	"	9.0	13.8	"	7.0	14.5	—8.4	6.1	16.5	"	6.8	4.0	+2.8	6.8
5	10.4	"	2.9	14.3	—7.4	6.9	11.4	—6.9	4.5	12.7	"	4.3	13.6	"	3.9	3.2	+2.6	5.8
6	9.8	—7.6	2.2	13.5	"	6.1	10.2	"	3.3	12.0	—8.5	3.5	13.4	—9.8	3.6	3.5	+2.5	6.0
	9.0	"	1.4	---	"		9.5	—7.0	2.5				13.2	"	3.4			
7	9.0	—7.7	1.3	7.2	—7.3	-0.1	9.0	—7.1	1.9	11.6	"	3.1	13.0	"	3.2	3.3	+2.4	5.7
	10.0	"	2.3	7.5	"	0.2	10.0	—7.2	2.8	11.2	"	2.7	13.0	"	3.2	3.0	"	5.4
8	11.0	"	3.3	7.8	"	0.5	10.2	—7.3	2.9	11.2	—8.6	2.6	13.0	"	3.2	3.0	+2.3	5.3
				9.6	"	2.3				11.5	"	2.9	13.0	"	3.2	2.8	"	5.1
9	13.5	"	5.8	11.9	—7.2	4.7	12.0	"	4.7	12.4	—8.7	3.7	13.1	"	3.3	2.9	"	5.2
																3.0	+2.2	5.2
10	16.1	—7.8	8.3	14.5	"	7.3	14.9	—7.4	7.5	14.5	—8.8	5.7	16.7	"	6.9	3.5	"	5.7
11	19.3	"	11.5	17.0	—7.1	9.9	17.3	"	9.9	17.5	—8.9	8.6	19.1	"	9.3	4.3	"	6.5
	20.0	"	12.2															
Noon	20.8	"	13.0	18.5	—7.0	11.5	19.2	—7.5	11.7	19.5	—9.0	10.5	19.5	—9.9	9.6	5.6	+2.1	7.7
	20.8	"	13.0	19.0	"	12.0	19.5	"	12.0	20.0	"	11.0						
1	20.6	"	12.8	19.0	—6.9	12.1	20.0	"	12.5	20.5	—9.1	11.4	20.0	"	10.1	7.2	+2.0	9.2
	20.5	"	12.7	18.9	"	12.0	20.5	"	13.0	20.5	"	11.4						
2	19.0	—7.9	11.1	18.5	—6.8	11.7	20.0	—7.6	12.4	20.6	"	11.5	1.0	+9.6	10.6	8.0	+1.8	9.8
							19.6	"	12.0	20.5	—9.2	11.3	3.5	+7.2	10.7			
3	17.0	"	9.1	16.3	"	9.5	19.0	"	11.4	20.2	"	11.0	5.2	+4.9	10.1	8.4	+1.6	10.0
													5.2	"	10.1	8.5	"	10.1
4	16.0	"	8.1	14.4	"	7.6	17.4	—7.7	9.7	18.9	—9.3	9.6	5.0	+4.8	9.8	8.5	+1.4	9.9
													4.3	"	9.1	8.5	"	9.9
5	12.0	"	4.1	11.0	"	4.2	15.4	"	7.7	17.0	"	7.7	3.9	+4.6	8.5	8.5	+1.3	9.8
	11.4	"	3.5													8.0	"	9.3
6	11.0	"	3.1	10.0	"	3.2	13.0	—7.8	5.2	15.2	—9.4	5.8	3.2	+4.4	7.6	4.8	+1.2	6.0
	11.0	"	3.1															
7	11.0	"	3.1	9.0	"	2.2	12.0	—7.9	4.1	13.5	"	4.1	1.6	+4.2	5.8	5.6	+1.1	6.7
	11.4	"	3.5	8.7	"	1.9	11.0	"	3.1				1.0	"				
8	12.0	"	4.1	8.0	"	1.2	10.3	—8.0	2.3	13.2	—9.5	3.7	0.3	+4.0	4.3	4.6	+1.0	5.6
				10.3	"	3.5	11.0	"	3.0	13.1	"	3.6	0.4	"	4.4			
9	14.5	"	6.6	11.1	—6.7	4.4	12.5	—8.1	4.4	13.1	"	3.6	0.6	+3.8	4.4	3.1	+0.9	4.0
										13.5	"	4.0	0.5	"	4.3	3.1	"	4.0
10	17.5	"	9.6	14.0	"	7.3	14.5	"	6.4	13.7	—9.6	4.1	0.8	+3.6	4.4	3.1	+0.8	3.9
													0.5	"	4.1	3.1	+0.7	3.8
11	19.7	—7.8	11.9	16.2	"	9.5	15.9	"	7.8	14.7	"	5.1	0.2	+3.4	3.6	3.1	+0.6	3.7
	20.3	"	12.5										1.2		4.6	3.5	+0.5	4.0
Midn't	1.4	+12.2	13.6	16.5	"	9.8	16.1	—8.2	7.9	16.2	"	6.6	1.7	+3.3	5.0	4.1	+0.4	4.5

Nov. 17. The scale reads up to 20, hence the reading 1.4 at midnight is equivalent to 21.4.
Nov. 21. At 1 P. M. the upper limit of the scale was reached, the index was changed afterwards.

SERIES I.—TIDAL OBSERVATIONS FROM OCTOBER 10, 1853, TO DECEMBER 28, 1853.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

November, 1853.

Mean solar hour.	23d.	Red. to level.	Ref. obs.	24th.	Red. to level.	Ref. obs.	25th.	Red. to level.	Ref. obs.	26th.	Red. to level.	Ref. obs	27th.	Red. to level.	Ref. obs.	28th.	Red. to level.	Ref. obs.
				6.7	—3.0	3.7	10.0	—6.3	3.7	14.8	—10.3	4.5						
1	4.7	+0.4	5.1	7.4	—3.2	4.2	10.2	"	3.9	14.5	—10.	4.2	14.7	—10.4	4.3	17.5	—12.0	5.5
				7.8	—3.3	4.5	10.4	—6.4	4.0	14.6	"	4.3						
2	5.6	+0.2	5.8	8.1	—3.4	4.7	10.7	—6.5	4.2	14.7	—10.4	4.3	13.7	"	3.3	15.3	—12.1	3.2
													13.3	"	2.9	14.9	"	2.8
3	6.2	0.0	6.2	9.1	—3.5	5.6	11.2	—6.6	4.6	15.2	—10.5	4.7	13.1	—10.3	2.8	14.7	—12.2	2.5
													13.0	"	2.7	14.5	"	2.3
4	7.0	—0.2	6.8	10.0	—3.6	6.4	12.5	—6.7	5.8	15.5	—10.6	4.9	13.2	—10.4	2.8	14.5	—12.3	2.2
																14.8	"	2.5
5	7.0	—0.3	6.7	10.5	—3.7	6.8	13.6	—6.9	6.7	16.5	"	5.9	16.0	"	5.6	15.6	—12.4	3.2
6	7.5	—0.5	7.0	11.1	—3.8	7.3	15.0	—7.0	8.0	18.0	—10.7	7.3	17.3	"	6.9	18.2	—12.5	5.7
	7.5	—0.6	6.9				15.6	"	8.6									
7	7.6	—0.7	6.9	11.6	—3.9	7.7	15.7	—7.1	8.6	19.4	"	8.7	19.8	—10.5	9.3	20.3	—12.6	7.7
	7.8	—0.8	7.0	11.9	"	8.0	16.0	—7.2	8.8									
8	7.9	—0.9	7.0	12.5	—4.0	8.5	15.6	—7.3	8.3	20.0	—10.8	9.2	20.9	—10.6	10.3	22.6	—12.7	9.9
	7.8	—0.9	6.9	11.6	—4.1	7.5				20.2	"	9.4	21.2	"	10.6	23.8	"	11.1
9	7.7	—1.0	6.7	11.0	—4.2	6.8	15.2	—7.4	7.8	20.0	"	9.2	21.5	—10.7	10.8	24.5	—12.8	11.7
	7.7	"	6.7							19.5	"	8.7	21.6	"	10.9	24.7	"	11.9
10	7.7	—1.1	6.6	9.5	—4.4	5.1	15.7	—7.6	8.1	19.0	—10.7	8.3	21.3	—10.8	10.5	24.8	"	12.0
	7.7	"	6.6										20.9	"	10.1	24.3	"	11.5
11	8 0	—1.2	6.8	9.0	—4.5	4.5	16.0	—7.8	8.2	17.8	"	7.1	20.9	—10.9	10.0	23.8	—12.9	10.9
				8.8	"	4.3												
Noon	8.6	—1.3	7.3	8.0	—4.6	3.4	15.5	—8.0	7.5	16.3	"	5.6	19.2	"	8.3	22.7	"	9.8
				8.9	"	4.3	15.5	—8.1	7.4									
1	9.6	—1.5	8.1	9.9	—4.7	5.2	15.4	—8.2	7.2	15.7	"	5.0	18.2	—11.0	7.2	21.4	—13.0	8.4
							15.2	—8.3	6.9	15.4		4.7						
2	10.4	—1.6	8.8	10.3	—4.8	5.5	15.8	—8.4	7.4	15.1	"	4.4	17.1	"	6.1	18.4	"	5.4
										15.0		4.3						
3	11.4	—1.8	9.6	11.4	—4.9	6.5	16.0	—8.6	7.4	15.1	"	4.4	15.2	—11.1	4.1	17.1	"	4.1
										15.4		4.7	14.9	"	3.8	15.8	"	2.8
4	11.8	—2.0	9.8	12.6	—5.0	7.6	16.4	—8.8	7.6	15.5	—10.6	4.9	14.6	—11.2	3.4	15.7	"	2.7
	12.0	—2.1	9.9										16.9	"	5.7	15.6	"	2.6
5	12.0	—2.2	9.8	13.5	—5.1	8.4	18.1	—9.0	9.1	17.0	"	6.4	17.5	—11.3	6.2	15.9	"	2.9
	12.0	—2.3	9.7	13.9	—5.2	8.7	19.1	—9.1	10.0							16.4	"	3.4
6	12.2	"	9.9	14.6	—5.3	9.3	19.6	—9.3	10.3	19.1	"	8.5	19.3	—11.4	7.9	17.7	"	4.7
	11.8	—2.4	9.4	14.9	—5.4	9.5	19.7	—9.4	10.3									
7	11.4	"	9.0	14.4	—5.5	8.9	19.8	—9.5	10.3	20.0	"	9.4	20.9	—11.5	9.4	20.0	"	7.0
				14.4	—5.6	8.8	20.0	—9.7	10.3	20.5		9.9	22.0	"	10.5			
8	10.0	—2.5	7.5	13.7	—5.7	8.0	19.4	—9.8	9.6	20.4	—10.5	9.9	22.1	—11.6	10.5	22.0	"	9.0
										20.4		9.9	22.8	"	11.2			
9	9.0	—2.6	6.4	12.8	—5.9	6.9	18.5	—9.9	8.6	20.4	"	9.9	22.9	—11.7	11.2	23.7	"	10.7
										20.1		9.6	22.9	"	11.2	23.9	"	10.9
10	8.2	—2.7	5.5	12.5	—6.0	6.5	18.0	—10.0	8.0	19.8	"	9.3	22.6	—11.8	10.8	23.9	"	10.9
													22.1	"	10.3	24.0	"	11.0
11	7.7	—2.8	4.9	11.5	—6.1	5.4	16.0	—10.1	5.9	17.7	"	7.2	21.6	—11.9	9.7	23.5	"	12.5
	7.4	—2.9	4.5													21.1	"	8.1
Midn't	7.2	—3.0	4.2	10.9	—6.2	4.7	15.0	—10.3	4.7	16.2	—10.4	5.8	19.7	—12.0	7.7	20.8	"	7.8

Nov. 26. From 11 A. M. of this day two readings are given for each half hour; the mean of the two observations has been inserted above. The two corresponding readings agree generally within a few tenths, the difference being due to the effect of the small waves.

Nov. 28. Orders were given to observe and record careful soundings by lead line at the tide hole every day at twelve o'clock.

SERIES I.—TIDAL OBSERVATIONS FROM OCTOBER 10, 1853, TO DECEMBER 28, 1853.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

	November, 1853.						**December, 1853.**											
Mean solar hour.	29th.	Red. to level.	Ref. obs.	30th.	Red. to level.	Ref. obs.	1st.	Red. to level.	Ref. obs.	2d.	Red. to level.	Ref. obs.	3d.	Red. to level.	Ref. obs.	4th.	Red. to level.	Ref. obs.
							---		---	18.0	—8.7	9.3	---		---	18.0	—10.8	7.2
1	18.7	—13.0	5.7	13.1	—5.8	7.3	15.0	—6.6	8.4	17.6	"	8.9	19.3	—9.9	9.4	18.6	"	7.8
													18.8	"	8.9	19.2	—10.9	8.3
2	15.8	—12.9	2.9	9.3	"	3.5	12.4	"	5.8	15.5	—8.8	6.7	17.8	"	7.9	19.2	"	8.3
																19.1	"	8.2
3	14.7	"	1.8	7.2	"	1.4	9.2	—6.7	2.5	12.1	—8.9	3.2	16.0	"	6.1	18.7	—11.0	7.7
	14.1	"	1.2	7.0	"	1.2												
4	13.8	—12.8	1.0	6.2	"	0.4	8.2	—6.8	1.4	10.1	—9.0	1.1	14.1	"	4.2	17.1	"	6.1
	13.5	"	0.7	5.9	"	0.1												
5	13.6	"	0.8	6.8	"	1.0	6.0	"	—0.8	8.0	—9.1	—1.1	11.6	"	1.7	14.0	—11.1	2.9
	14.2	—12 7	1.5	8.2	"	2.4	5.6	"	—1.2	7.3	"	—1.8				12.5	"	1.4
6	14.7	"	2.0	9.6	"	3.8	6.5	—6.9	—0.4	7.1	—9.2	—2.1	10.1	"	0.2	11.4	—11.2	0.2
							6.7	"	—0.2	9.0	—9.3	—0.3	9.7	"	—0.2	11.3	"	0.1
7	16.8	—12.6	4.2	11.7	"	5.9	7.5	—7.0	0.5	9.8	—9.4	0.4	9.5	"	—0.4	11.5	"	0.3
													10.0	"	0.1	12.0	—11.3	0.7
8	19.7	—12.5	7.2	13.8	"	8.0	11.0	"	4.0	10.5	—9.5	1.0	11.2	"	1.3	12.0	"	0.7
9	23.5	—12.4	11.1	17.7	"	11.9	13.8	—7.1	6.7	14.6	—9.6	5.0	14.2	"	4.3	13.8	"	2.5
10	25.2	—12.3	12.9	19.2	"	13.4	18.1	—7.2	10 9	17.8	—9.7	8.1	16.0	"	6.1	17.3	—11.4	5.9
	25.5	—12.2	13.3	19.5	"	13.7												
11	25.5	—12.1	13.4	19.5	"	13.7	19.3	—7.3	12.0	20.2	—9.8	10.4	18.3	"	8.4	19.8	"	8.4
	25.8	—12.0	13.8	19.2	"	13.4	19.8	"	12.5	22.4	—9.9	12.5						
Noon	18.2	—5.8	12.4	18.3	"	12.5	20.2	—7.4	12.8	22.9	—10.0	12.9	21.6	—9.8	11.8	21.7	—11.5	10.2
	17.1	"	11.3				20.0	"	12.6	23.3	"	13.3						
1	15.2	"	9.4	16.3	"	10.5	19.8	—7.5	12.3	23.6	"	13.6	22.5	"	12.7	23.8	"	12.3
										23.1	"	13.1	22.6	"	12.8	24.7	"	13.2
2	11.7	"	5.9	13.0	—5.9	7.1	16.9	—7.6	9.3	22.0	"	12.0	22.7	—9.9	12.8	25.2	"	13.7
													21.5	"	11.6	24.3	"	12 8
3	8.7	"	2.9	9.0	"	3.1	13.7	—7.7	6.0	19.8	"	9.8	20.5	10.0	10.5	23.9	"	12.4
	8.2	"	2.4															
4	7.0	—5.8	1.2	8.1	—6.0	2.1	10.1	—7.8	2.3	16.2	"	6.2	18.0	10.1	7.9	21.8	"	10.3
	7.2	"	1.4	8.0	"	2.0												
5	7.1	"	1.3	7.7	"	1.7	8.5	—7.9	0.6	12.9	"	2.9	15.7	"	5.6	19.8	"	8.3
	7.4	"	1.6	7.7	"	1.7	8.1	"	0.2									
6	7.8	"	2.0	8.0	—6.1	1.9	7.7	—8.0	—0.3	10.9	"	0.9	14.5	10.2	4.3	16.7	"	5.2
	9.2	"	3.4	9.2	"	3.1	7.7	"	—0.3	10.3	"	0.3						
7	10.0	"	4.2	10.2	"	4.1	8.2	—8.1	0.1	10.0	"	0.0	11.9	10.3	1.6	14.5	"	3.0
										10.6	"	0.6	11.2	"	0.9			
8	13.3	"	7.5	11.9	—6.2	5.7	11.1	—8.2	2.9	10.6	"	0.6	10.4	10.4	0.0	13.6	"	2.1
													10.3	"	—0.1	13.3	"	1.8
9	14.8	"	9.0	14.4	"	8.2	12.6	—8.3	4.3	12.0	"	2.0	11.3	10.5	0.8	13.1	"	1.6
																13.3	"	1.8
10	15.9	"	10.1	16.2	—6.3	9.9	15.3	—8.4	6.9	14.9	"	4.9	13.7	10.6	3.1	14.0	"	2.5
	16.5	"	10.7															
11	16.5	"	10.7	16.6	—6.4	10.2	17.3	—8.5	8.8	17.0	"	7.0	15.6	10.7	4.9	16.0	"	4.5
	16.3	"	10.5	17.0	"	10.6	17.9	"	9.4	18.2	"	8.2						
Midn't	16.1	"	10.3	17.3	—6.5	10.8	18.1	—8.6	9.5	18.9	"	8.9	18.2	10.8	7.4	17.8	—11.5	6.3

Nov. 29. Tide register corrected at noon. Sounding at noon 7 fath., 0 feet, 4 inches, register 18.2. It may be remarked that soundings are subject to uncertainty in case of any drift of the ice field in which the vessel was imbedded, and also in case the bottom be soft. Some allowance must be made for stretch of the line.

		Fath.	Feet.	Inch.	Reg.	
Nov. 30.	Sounding at noon	7	2	3	18.2	(This sounding was not used, apparently not reliable.)
Dec. 1.	" "	8	0	0	20.2	A mean correction was used for these days, as deduced from enveloping curves and the soundings.
" 2.	" "	7	5	6	22.7	
" 3.	" "	8	0	0	22.0	
" 4.	" "	7	4	0	22.0	

SERIES I.—TIDAL OBSERVATIONS FROM OCTOBER 10, 1853, TO DECEMBER 28, 1853.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

December, 1853.

Mean solar hour.	5th.	Red. to level.	Ref. obs.	6th.	Red. to level.	Ref. obs.	7th.	Red. to level.	Ref. obs.	8th.	Red. to level.	Ref. obs.	9th.	Red. to level.	Ref. obs.	10th.	Red. to level.	Ref. obs.
										2.3	+1.4	3.7	1.8	—0.1	1.7			
1	19.7	—11.6	8.1	20.1	—15.3	4.8	4.7	—2.7	2.0	2.5	+1.0	3.5	1.2	"	1.1	7.5	—1.8	5.7
	20.2	"	8.6							3.1	+0.8	3.9	1.4	—0.2	1.2	7.3	"	5.5
2	20.5	—11.7	8.8	21.6	—15.8	5.8	5.2	—3.1	2.1	3.7	+0.7	4.4	1.6	"	1.4	7.1	—1.9	5.2
	20.8	"	9.1	22.1	—16.1	6.0										7.2	"	5.3
3	20.4	—11.8	8.6	22.5	—16.4	6.1	7.9	—3.5	4.4	4.7	+0.5	5.2	2.7	—0.3	2.4	7.5	—2.0	5.5
	19.9	"	8.1	22.4	—16.6	5.8												
4	19.2	—11.9	7.3	22.5	—16.9	5.6	9.0	—3.9	5.1	5.6	—0.3	5.9	3.6	"	3.3	8.2	"	6.2
				22.5	—17.1	5.4												
5	17.9	—12.0	5.9	22.1	—17.3	4.8	10.0	—4.4	5.6	7.0	0.0	7.0	7.0	—0.4	6.6	9.5	—2.1	7.4
										8.0	—0.7	7.3						
6	17.1	—12.1	5.0	21.2	—17.6	3.6	11.0	—5.0	6.0	9.1	—1.5	7.6	9.1	"	8.7	11.2	—2.2	9.0
							12.1	—5.2	6.9	9.8	—2.2	7.6						
7	14.7	—12.2	2.5	21.3	—17.9	3.4	11.9	—5.4	6.5	9.9	—3.0	6.9	10.3	—0.5	9.8	12.3	"	10.1
	14.3	"	2.1	20.5	—18.1	2.4	12.5	—5.7	6.8									
8	13.6	—12.3	1.3	20.6	—18.3	2.3	12.4	—5.9	6.5	11.3	—4.5	6.8	11.3	"	10.8	13.0	—2.3	10.7
	13.6	"	1.3	20.7	—18.4	2.3	12.5	—6.1	6.4				11.8	—0.6	11.2	13.1	"	10.8
9	13.7	—12.4	1.3	21.1	—18.6	2.5	12.3	—6.3	6.0	11.4	—6.0	5.4	11.6	"	11.0	13.3	—2.4	10.9
	14.4	"	2.0				11.7	—6.5	5.2				11.2	—0.7	10.5	13.5	"	11.1
10	15.2	—12.5	2.7	21.6	—18.9	2.7	12.2	—6.8	5.4	12.4	—7.5	4.9	10.7	"	10.0	13.3	—2.5	10.8
11	17.8	—12.6	5.2	22.7	—19.3	3.4	11.2	—7.3	3.9	13.2	—9.0	4.2	9.7	—0.8	8.9	11.8	"	9.3
Noon	19.0	—12.7	6.3	24.7	—19.6	4.1	11.1	—7.7	3.4	13.6	—10.5	3.1	8.0	—0.9	7.1	9.8	—2.6	7.2
										14.1	—11.2	2.9						
1	20.9	—12.9	8.0	26.7	—19.9	6.8	17.1	—13.1	4.0	15.0	—12.0	3.0	4.5	"	3.6	9.2	—2.7	6.5
													4.7	—1.0	3.7	8.6	—2.8	5.8
2	23.5	—13.1	10.4	28.3	—20.3	8.0	19.7	—13.6	6.1	Readings omitted.	Corrections uncertain.	Rope slipping on the wheel.	4.7	"	3.7	8.2	—2.9	5.3
	23.4	—13.2	10.2	29.5	—20.4	9.1										8.3	"	5.4
3	24.1	—13.3	10.8	30.3	—20.6	9.7	21.3	—14.2	7.1				5.2	—1.1	4.1	8.7	—3.0	5.7
	24.3	—13.2	11.1	31.0	—20.8	10.2										9.2	—3.1	6.1
4	24.1	—13.5	10.6	31.3	—21.0	10.3	24.2	—14.7	9.5				7.2	—1.2	6.0	9.7	"	6.6
				31.5	—21.2	10.3												
5	23.2	—13.7	9.5	31.5	—21.3	10.2	4.9	+4.8	9.7				10.2	"	9.0	10.2	—3.2	7.0
				30.5	—21.5	9.0												
6	21.6	—13.9	7.7	28.5	—21.7	6.8	5.3	+4.4	9.7				11.2	—1.3	9.9	11.2	—3.3	7.9
							5.7	+4.2	9.9									
7	18.9	—14.1	4.8	27.5	—22.0	5.5	6.4	+4.0	10.4				12.8	"	11.5	11.9	—3.5	8.4
							6.8	+3.8	10.6				13.0	—1.4	11.6	12.2	"	8.7
8	17.2	—14.2	3.0	24.7	—22.4	2.3	7.0	+3.6	10.6				13.2	"	11.8	12.9	—3.6	9.3
				24.5	—22.5	2.0	6.7	+3.4	10.1				13.1	—1.5	11.6	12.7	—3.7	9.0
9	16.1	—14.4	1.7	24.7	—22.7	2.0	6.0	+3.2	9.2				12.4	"	10.9	13.0	—3.8	9.2
	15.5	—14.5	1.0	24.9	—22.9	2.0										13.0	—3.9	9.1
10	15.8	—14.6	1.2	25.0	—23.1	1.9	4.2	+2.7	6.9				11.1	—1.6	9.5	12.6	—4.0	8.6
	16.6	—14.7	1.9	24.7	—23.3	1.4												
11	17.1	—14.8	2.3	24.7	—23.5	1.2	2.9	+2.2	5.1				9.8	"	8.2	11.2	—4.1	7.1
				24.7	—23.7	1.0												
Midn't	18.9	—15.0	3.9	25.1	—23.9	1.2	2.0	+1.8	3.8				8.2	—1.7	6.5	9.5	—4.2	5.3

		Fath.	Feet.	Inch.	Reg.
Dec. 5.	Sounding at noon	7	1	0	20, changed to 19.
" 6.	" "	6	5	0	25
" 7.	" "	6	4	0	11.1, changed to 16.
" 8.	" "	6	3	7	13.6
" 9.	" "	6	4	0	7.6 (The mean of the two readings is 8.0.)
" 10.	" "	6	4	6	9.7 (" " " " " 9.8.)

On these days (Dec. 5, 6, 7) the corrections deduced by enveloping curves or soundings agree very well.

From the 9th to the 18th of December the corrections deduced from curves and soundings differ by a constant of nearly 4 feet. The differences are partly due to imperfect soundings, partly to sudden changes of the pulley-gauge (see readings between noon and 1 P. M. on the 9th). The heights given, as corrected by the soundings and curves, are, during this period, of little value, the times being less affected. The soundings were increased by 4 feet, equal to a reading of the mean level of 32.6.

Series I.—Tidal Observations from October 10, 1853, to December 28, 1853.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

December, 1853.

Mean solar hour.	11th.	Red. to level.	Ref. obs.	12th.	Red. to level.	Ref. obs.	13th.	Red. to level.	Ref. obs.	14th.	Red. to level.	Ref. obs.	15th.	Red. to level.	Ref. obs.	16th.	Red. to level.	Ref. obs.
							21.4	—14.0	7.4							23.0	—10.6	12.4
1	8.2	—4.3	3.9	12.2	—8.8	3.4	20.7	—14.1	6.6	13.9	—7.6	6.3	15.4	—8.5	6.9	22.7	—10.8	11.9
2	7.4	—4.4	3.0	11.1	—9.1	2.0	20.3	—14.3	6.0	12.9	"	5.3	13.7	"	5.2	20.4	—11.1	9.3
3	6.8	—4.5	2.3	10.2	—9.3	0.9	19.8	—14.5	5.3	11.2	—7.7	3.5	12.2	—8.6	3.6	18.5	—11.4	7.1
	6.3	—4.6	1.7	10.0	—9.5	0.5	18.9	—14.6	4.3	10.2	"	2.5						
4	6.5	—4.7	1.8	10.0	—9.7	0.3	18.2	—14.7	3.5	10.0	"	2.3	11.5	"	2.9	16.0	—11.7	4.3
	7.5	—4.8	2.7	10.2	—9.8	0.4	18.7	—14.8	3.9	10.0	"	2.3	11.3	"	2.7	15.3	—11.8	3.5
5	8.7	—4.9	3.8	10.4	—10.0	0.4	19.4	—14.9	4.5	10.0	"	2.3	11.1	—8.7	2.4	15.4	—12.0	3.4
										10.2	"	2.5	11.4	"	2.7	15.9	—12.2	3.7
6	11.8	—5.0	6.8	12.9	—10.2	2.7	29.8	—15.1	5.7	10.6	—7.8	2.8	11.7	"	3.0	16.1	—12.3	3.8
													12.2	—8.8	3.4			
7	12.4	—5.1	7.3	15.5	—10.4	5.1	22.5	—15.3	7.2	12.1	"	4.3	12.9	"	4.1	17.2	—12.6	4.6
8	13.7	—5.2	8.5	18.0	—10.7	7.3	24.7	—15.5	9.2	15.1	—7.9	7.2	15.2	"	6.4	19.1	—12.9	6.2
	14.2	—5.3	8.9															
9	14.7	—5.4	9.3	19.7	—10.9	8.8	25.7	—15.7	10.0	17.2	"	9.3	17.8	—8.9	8.9	21.2	—13.4	7.8
	15.0	—5.5	9.5															
10	15.0	"	9.5	20.4	—11.1	9.3	26.7	—15.9	10.8	19.4	—8.0	11.4	19.6	"	10.7	24.0	—13.7	10.3
	14.7	—5.6	9.1	20.8	—11.2	9.6	27.0	—16.0	11.0	20.2	"	12.2						
11	14.3	"	8.7	21.2	—11.3	9.9	27.0	—16.1	10.9	20.5	"	12.5	20.5	"	11.6	26.0	—14.1	11.9
				20.2	—11.4	8.8	27.1	—16.2	10.9	20.2	"	12.2						
Noon	13.4	—5.7	7.7	20.2	—11.5	8.7	26.8	—16.3	10.5	19.6	—8.1	11.5	21.0	—9.0	12.0	27.3	—14.5	12.8
							12.0	?	- - -				22.0	"	13.0	27.5	—14.7	12.8
1	11.2	—5.9	5.3	20.2	—11.7	8.5	11.9		- - -	18.2	"	10.1	22.3	—9.1	13.2	27.3	—14.8	12.5
													21.2	"	12.1	26.8	—15.0	11.8
2	9.4	—6.1	3.3	18.5	—11.9	6.6	10.9	?	- - -	16.2	"	8.1	20.1	—9.2	10.9	26.0	—15.1	10.9
	8.7	—6.2	2.5															
3	8.3	—6.4	1.9	16.8	—12.1	4.7	10.8	—7.1	3.7	13.8	—8.2	5.6	17.6	—9.3	8.3	23.1	—15.3	7.8
	8.3	—6.5	1.8															
4	8.7	—6.7	2.0	15.9	—12.3	3.6	10.2	—7.2	3.0	11.5	"	3.3	16.2	—9.4	6.8	21.0	—15.5	5.5
				15.2	—12.4	2.8	10.0	"	2.8	11.1	"	2.9						
5	9.7	—6.9	2.8	15.6	—12.5	3.1	10.3	"	3.1	10.8	"	2.6	15.6	—9.5	6.1	18.3	—15.6	2.7
							10.3	"	3.1	10.8	"	2.6	15.4	"	5.9			
6	11.2	—7.1	4.1	17.7	—12.7	5.0	10.7	—7.3	3.4	10.7	—8.3	2.4	15.1	—9.6	5.5	17.6	—15.8	1.8
										10.9	"	2.6	15.2		5.6	17.5	"	1.7
7	12.3	—7.3	5.0	19.7	—12.9	6.8	12.2	"	4.9	11.2	"	2.9	15.7	—9.7	6.0	17.5	—15.9	1.6
																17.5	"	1.6
8	13.7	—7.6	6.1	21.0	—13.1	7.9	13.0	"	5.7	13.7	"	5.4	16.8	—9.8	7.0	17.7	—16.0	1.7
9	15.2	—7.8	7.4	21.9	—13.3	8.6	15.1	—7.4	7.7	15.6	"	7.3	18.8	—9.9	8.9	19.7	—16.1	3.6
	15.7	—7.9	7.8				15.7	"	8.3									
10	15.8	—8.1	7.7	22.8	—13.5	9.3	16.0	"	8.6	16.9	—8.4	8.5	21.2	—10.1	11.1	21.5	—16.2	5.3
	15.8	—8.3	7.5	23.2	—13.6	9.6	16.0	"	8.6	17.2	"	8.8						
11	15.3	—8.4	6.9	23.3	—13.7	9.6	16.0	—7.5	8.5	17.3	"	8.9	22.4	—10.3	12.1	23.1	—16.3	5.8
				23.4	—13.8	9.6	15.7	"	8.2	17.2	"	8.8	22.9	—10.4	12.5			
Midn't	13.7	—8.6	5.1	23.4	—13.9	9.5	15.2	"	7.7	17.1	"	8.7	23.0	—10.5	12.5	23.8	—16.4	7.4

		Fath.	Feet.	Inch.	Reg.
Dec. 11.	Sounding at noon	6	2	9	13.3
" 12.	" "	6	4	0	19.9
" 13.	" "	7	1	3	13.3 (Changed from 26.8)
" 14.	" "	7	2	2	19.4
" 15.	" "	7	4	0	21.2
" 16.	" "	7	3	6	27.6

SERIES I.—TIDAL OBSERVATIONS FROM OCTOBER 10, 1853, TO DECEMBER 28, 1853.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the seale. Increasing numbers indicate rise of water.

December, 1853.

Mean solar hour.	17th. *	Red. to level.	Ref. obs.	18th. *	Red. to level.	Ref. obs.	19th. *	Red. to level.	Ref. obs.	20th.	Red. to level.	Ref. obs.	21st.	Red. to level.	Ref. obs.	22d.	Red. to level.	Ref. obs.
	24.0	—16.5	7.5	23.4	—17.6	5.8	4.1	+3.0	7.1									
1	23.7	—16.6	7.1	23.4	"	5.8	4.2	+2.9	7.1	14.5	—3.9	10.6	20.4	—10.7	9.7	20.6	—13.7	6.9
				23.4	"	5.8	5.0	+2.7	7.7									
2	23.8	—16.7	7.1	23.2	"	5.6	5.7	+2.5	8.2	15.1	—4.2	10.9	21.4	—11.0	10.4	21.6	"	7.9
				22.6	"	5.0	5.7	+2.3	8.0	15.3	—4.4	10.9	22.4	—11.1	11.3			
3	22.9	"	6.2	21.7	"	4.1	5.0	+2.2	7.2	15.2	—4.5	10.7	22.9	—11.3	11.6	22.2	"	8.5
										14.2	—4.7	9.5	22.3	—11.4	10.9	22.4	"	8.7
4	21:5	—16.8	4.7	20.2	"	2.6	3.7	+2.0	5.7	13.5	—4.8	8.7	21.3	—11.6	9.7	22.5	—13.8	8.7
																22.9	"	9.1
5	20.5	"	3.7	21.3	"	3.7	2.1	+1.8	3.9	12.2	—5.2	7.0	21.0	—11.9	9.1	22.3	"	8.5
	19.9	"	3.1															
6	19.6	—16.9	2.7	20.0	"	2.4	1.4	+1.6	3.0	10.5	—5.5	5.0	19.3	—12.2	7.1	21.7	"	7.9
	19.7		2.8	19.3	"	1.7	1.1	+1.4	2.5									
7	20.2	"	3.3	18.5	"	0.9	1.1	+1.3	2.4	10.1	—5.8	4.3	18.3	—12.4	6.9	20.9	"	7.1
				20.2	"	2.6	0.9	+1.1	2.0									
8	21.7	—17.0	4.7	20.4	—17.6	2.8	1.6	+1.0	2.6	9.6	—6.1	3.5	17.8	—12.6	5.2	19.3	—13.9	5.4
										7.7	—6.3	1.4	17.2	—12.7	4.5	19.4		5.5
9	25.0	"	8.0	4.3	?	- - -	2.9	+0.8	3.7	8.0	—6.4	1.6	17.4	—12.8	4.6	19.0	"	5.1
										8.7	—6.5	2.2	17.8	—12.9	4.9	19.0		5.1
10	27.7	—17.1	10.6	7.8	"	- - -	5.0	+0.6	5.6	9.5	—6.7	2.8	18.3	—13.0	5.3	19.3	"	5.4
11	28.8	"	11.7	8.3	"	- - -	7.1	+0.3	7.4	11.3	—7.1	4.2	19.5	—13.2	6.3	20.3	"	6.4
	29.7	—17.2	12.5															
Noon	23.0	?	- - -	10.9	"	- - -	8.2	0.0	8.2	13.1	—7.5	5.6	21.2	—13.4	7.8	21.7	—14.0	7.7
	22.6	"	- - -										27.8	?	- - -			
1	21.8	"	- - -	12.4	"	- - -	10.4	—0.2	10.2	16.9	—7.7	9.2	27.7	"	- - -	23.0	"	9.0
				12.5	"	- - -	10.7	—0.3	10.4									
2	20.0	"	- - -	12.5	"	- - -	10.7	—0.5	10.2	18.2	—7.9	10.3	24.4	—13.4	11.0	24.5	—14.1	10.4
							10.7	—0.6	10.1	18.4	—8.0	10.4						
3	18.6	"	- - -	- - -		- - -	10.6	—0.8	9.8	18.5	—8.1	10.4	24.7	—13.5	11.2	25.3	—14.2	11.1
										18.5	—8.2	10.3	25.0	"	11.5	25.0	"	10.8
4	18.5	—17.6	0.9	- - -		- - -	9.0	—1.0	8.0	17.9	—8.3	9.6	25.0	"	11.5	25.8	—14.3	11.5
	18.3	"	0.7										24.4	"	10.9	25.9	"	11.6
5	18.2	"	0.6	- - -		- - -	8.2	—1.2	7.0	17.0	—8.5	8.5	23.5	"	10.0	25.6	—14.4	11.2
	18.2	"	0.6							16.2	—8.6	7.6				25.1	"	10.7
6	18.3	"	0.7	- - -		- - -	8.5	—1.5	7.0	15.6	—8.7	6.9	22.1	"	8.6	24.3	—14.5	9.8
	18.4	"	0.8							16.0	—8.9	7.1						
7	18.3	?	- - -	15.2	?	- - -	7.7	—1.7	6.0	16.6	—9.1	7.5	20.2	"	6.7	22.5	—14.6	7.9
	18.3	"	- - -				7.6	—1.9	5.7									
8	18·3	"	- - -	15.4	"	- - -	7.6	—2.0	5.6	17.0	—9.4	7.6	19.3	—13.6	5.7	21.0	—14.7	6.3
	18.8	"	- - -				9.8	—2.2	7.6				18.3	"	4.7			
9	19.4	"	- - -	16.0	"	- - -	10.4	—2.4	8.0	17.0	—9.7	7.3	18.0	"	4.4	20.8	—14.8	6.0
													18.0	"	4.4			
10	20.8	"	- - -	17.6	"	- - -	11.6	—2.8	8.8	17.6	—10.0	7.6	18.0	"	4.4	19.8	—14.9	4.9
													18.3	"	4.7	19.4	"	4.5
11	21.9	"	- - -	20.2	"	- - -	13.6	—3.2	10.4	18.2	—10.2	8.0	19.2	"	5.6	19.2	—15.0	4.2
																19.4	"	4.4
Midn't	23.3	—17.6	5.7	23.2	—17.0	6.2	15.7?	—3.6	(12.1)	18.9	—10.4	8.5	19.5	—13.7	5.8	19.8	—15.1	4.7

		Fath.	Feet.	Inch.	Register.	
Dec. 17.	Sounding at noon	7	5	0	30.0 changed to 23.0.	* Results doubtful.
" 18.	" "	7	5	3	31.3 (=11.3).	Tide register broke down at 2½ P. M.; was repaired and observations commenced at 7 P. M.
" 19.	No sounding taken.					
" 20.	" "					
" 21.	Sounding at noon	7	3	6	21.5.	Correction at noon by soundings 12.3, by curves 14.5, mean adopted.
" 22.	" "	7	3	6	21.7.	Mean correction —14.0.

The heights on the 18th and 19th have been rejected.

SERIES I.—TIDAL OBSERVATIONS FROM OCTOBER 10, 1853, TO DECEMBER 28, 1853.

Hourly observations on the pulley-gauge: Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

December, 1853.

Mean solar hour.	23d.	Red. to level.	Ref. obs.	24th.	Red. to level.	Ref. obs.	25th.	Red. to level.	Ref. obs.	26th.	Red. to level.	Ref. obs.	27th.	Red. to level.	Ref. obs.	28th.	Red. to level.	Ref. obs.
							19.5	"	2.7									
1	20.0	—15.2	4.8	19.1	—16.0	3.1	19.3	—16.9	2.4	1.9	+1.4	3.3	3.1	—0.4	2.7	7.1	—2.0	5.1
							19.3	"	2.4	1.8	"	3.2	2.7	"	2.3			
2	21.1	—15.3	5.8	19.7	"	3.7	19.6	—17.0	2.6	1.8	"	3.2	2.3	—0.5	1.8	5.7	—2.1	3.6
										1.9		3.3	2.7	"	2.2			
3	22.0	—15.4	6.6	21.0	"	5.0	20.3	—17.1	3.2	2.1	+1.3	3.4	3.5	—0.6	2.9	4.4	"	2.3
																4.1	—2.2	1.9
4	22.7	—15.5	7.2	21.7	—15.9	5.8	21.8	—17.2	4.6	3.2	+1.2	4.4	?3.0	"	?2.4	4.2	"	2.0
																4.3	—2.3	2.0
5	23.0	—15.6	7.4	22.0	"	6.1	23.4	—17.3	6.1	5.6	"	6.8	4.7	—0.7	4.0	4.7	"	2.4
	23.1	"	7.5															
6	23.1	—15.7	7.4	23.4	"	7.5	24.9	—17.4	7.5	6.7	+1.0	7.7	6.6	"	5.9	6.9	—2.4	4.5
	22.7	"	7.0	23.6	"	7.7												
7	23.0	—15.8	7.2	23.6	—15.8	7.8	25.3	—17.5	7.8	8.2	+0.9	9.1	8.5	—0.8	7.7	9.2	"	6.8
				23.1	"	7.3	25.5		8.0	8.7	"	9.6						
8	22.4	—15.9	6.5	22.9	"	7.1	25.6	—17.6	8.0	9.2	+0.8	10.0	10.6	—0.9	9.7	11.1	—2.5	8.6
							25.6	"	8.0	10.7	"	11.5						
9	21.9	—16.0	5.9	22.3	"	6.5	25.1	"	7.5	9.8	+0.7	10.5	11.9	—1.0	10.9	13.3	"	10.8
													12.2	"	11.2	13.8	"	11.3
10	20.6	—16.1	4.5	21.2	"	5.4	23.6	—17.7	5.9	8.5	"	9.2	12.1	—1.1	11.0	14.2	—2.6	11.6
													11.6	"	10.5	14.2	"	11.6
11	19.4	—16.2	3.2	21.0	"	5.2	22.9	—17.8	5.1	6.7	+0.6	7.3	11.0	—1.2	9.8	13.7	"	11.1
	19.3	"	3.1	20.7	"	4.9	22.3	"	4.5									
Noon	20.4	—16.3	4.1	20.3	—15.7	4.6	22.0	—17.9	4.1	5.6	+0.6	6.2	9.2	—1.3	7.9	11.7	—2.7	9.0
				21.3		5.6	22.0	"	4.1									
1	21.4	"	5.1	21.7	"	6.0	22.2	—18.0	4.2	4.4	"	5.0	6.9	"	5.6	10.0	—2.9	7.1
										4.4	"	5.0						
2	22.5	"	6.2	22.5	—15.8	6.7	22.5	"	4.5	4.3	+0.5	4.8	5.2	—1.4	3.8	9.6	—3.3	6.3
										4.3	"	4.8						
3	23.6	—16.2	7.4	23.5	—15.9	7.6	23.2	—18.1	5.1	4.3	"	4.8	4.5	—1.5	3.0	9.5	—3.8	5.7
										4.3	"	4.8	4.4	"	2.9			
4	24.6	"	8.4	24.5	—16.0	8.5	23.6	—18.2	5.4	4.5	+0.4	4.9	4.4	"	2.9	9.5	—4.5	5.0
	25.0	"	8.8										4.4	"	2.9	9.6	—4.7	4.9
5	24.9	"	8.7	25.1	—16.1	9.0	24.6	"	6.4	5.2	+0.3	5.5	4.7	—1.6	3.1	9.8	—4.9	4.9
	24.7	"	8.5													10.0	—5.1	4.9
6	24.6	"	8.4	25.4	—16.2	9.2	25.3	—18.3	7.0	6.8	"	7.1	6.3	"	4.7	10.4	—5.3	5.1
				25.5	"	9.3												
7	23.7	—16.1	7.6	25.1	—16.3	8.8	25.3	"	7.0	8.1	+0.2	8.3	7.8	—1.7	6.1	12.6	—5.7	6.9
							25.6	"	7.3	8.5	"	8.7						
8	22.3	"	6.2	24.2	—16.4	7.8	25.4	—18.4	7.0	9.1	+0.1	9.2	9.3	"	7.6	14.2	—6.0	8.2
										9.1	"	9.2						
9	20.1	"	4.0	23.1	—16.5	6.6	25.0	"	6.6	9.1	0.0	9.1	10.0	—1.8	8.2	16.3	—6.3	10.0
													10.9	"	9.1			
10	19.4	"	3.3	22.6	—16.6	6.0	24.1	—18.5	5.6	8.1	—0.1	8.0	10.8	"	9.0	17.1	—6.9	10.2
													10.4	"	8.6	17.4	—7.0	10.4
11	19.1	"	3.0	22.1	—16.7	5.4	23.1	"	4.6	7.2	—0.2	7.0	10.2	—1.9	8.3	17.7	—7.1	10.6
	19.0		2.9													17.7	—7.2	10.5
Midn't	19.0	—16.0	3.0	21.4	—16.8	4.6	22.4	—18.6	3.8	5.2	—0.3	4.9	9.0	—2.0	7.0	17.7	—7.3	10.4

		Fath.	Feet.	Inch.	Correction.
Dec. 23.	Sounding at noon	6	3	8	—16.3 mean of sounding and curves.
" 24.	" "	6	4	8	—15.7 " " "
" 25.	" "	6	3	0	—17.9 " " "
" 26.	" "	7	1	0	+ 0.6 " " "
" 27.	" "	7	2	0	— 1.3 " " "
" 28.	" "	7	4	6	(Ebb tide at 2½ P. M.) Correction —2.7 mean of sounding and

curves; afternoon corrections from the curves. Between this date and the commencement of the second series the observations are too much affected by irregularities to be inserted.

Series II.—Tidal Observations from January 28 to April 7, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

	January, 1854.												February, 1854.					
Mean solar hour.	28th.	Red. to level.	Ref. obs.	29th.	Red. to level.	Ref. obs.	30th.	Red. to level.	Ref. obs.	31st.	Red. to level.	Ref. obs.	1st.	Red. to level.	Ref. obs.	2d.	Red. to level.	Ref. obs.
	13.2	—2.6	10.6	21.9	—10.0	11.9	16.5	—7.5	9.0	14.9	—5.8	9.1				13.2	—6.2	7.0
1	12.8	—2.8	10.0	21.5	—10.1	11.4	16.2	—7.4	8.8	15.5	"	9.7	16.2	—5.8	10.4	13.5	"	7.3
										15.2	"	9.4						
2	12.0	—3.3	8.7	19.6	—10.2	9.4	15.6	—7.3	8.3	14.7	"	8.9	16.8	—5.9	10.9	14.3	"	8.1
													17.0	"	11.1			
3	11.0	—3.8	7.2	17.7	—10.3	7.4	12.8	—7.2	5.6	14.3	—5.7	8.6	17.0	"	11.1	15.6	"	9.4
													17.0	"	11.1	16.0	"	9.8
4	8.8	—4.2	4.6	16.1	—10.4	5.7	10.5	—7.1	3.4	11.7	"	6.0	16.9	—6.0	10.9	16.2	"	10.0
																16.2	"	10.0
5	6.3	—4.7	1.6	15.0	—10.5	4.5	9.2	—7.0	2.2	9.2	"	3.5	12.6	"	6.6	15.7	"	9.5
	5.9	—4.9	1.0															
6	6.2	—5.1	1.1	12.2	—10.6	1.6	7.4	—6.9	0.5	6.9	"	1.2	10.6	—6.1	4.5	14.0	"	7.8
	6.7	—5.3	1.4	11.9	"	1.3	7.4	"	0.5	5.9	—5.6	0.3						
7	8.2	—5.4	2.8	12.1	—10.7	1.4	7.5	—6.8	0.7	5.3	"	—0.3	8.5	"	2.4	10.6	"	4.4
				13.4	"	2.7	7.8	"	1.0	5.3	"	—0.3	7.9	"	1.8			
8	11.0	—5.9	5.1	14.6	—10.8	3.8	8.2	—6.7	1.5	5.3	"	—0.3	7.7	"	1.6	8.9	"	2.7
										5.3	—5.5	—0.2	7.7	"	1.6	9.1	"	2.9
9	15.6	—6.4	9.2	18.6	—10.9	7.7	10.3	—6.6	3.7	6.9	"	1.4	7.5	—6.2	1.3	8.2	"	2.0
													8.3	"	2.1	8.2	"	2.0
10	17.7	—7.2	10.5	20.7	—11.0	9.7	12.2	—6.5	5.7	10.0	"	4.5	10.0	"	3.8	8.7	"	2.5
11	19.9	—8.0	11.9	23.4	—11.1	12.3	14.3	—6.4	7.9	13.0	—5.4	7.6	13.0	"	6.8	11.2	"	5.0
Noon	21.0	—8.8	12.2	24.5	—11.2	13.3	18.3	—6.3	12.0	16.2	—5.3	10.9	16.3	—6.3	10.0	13.0	—6.1	6.9
	21.2	"	12.4	20.7	—11.1	9.6				17.3	"	12.0						
1	20.4	—8.9	11.5	19.7	—11.0	8.7	20.1	"	13.8	18.3	"	13.0	17.7	"	11.4	14.6	"	8.5
				19.2	—10.9	8.3	20.2	"	13.9	19.0	"	13.7						
2	18.8	—9.0	9.8	18.7	—10.8	7.9	19.7	—6.2	13.5	18.2	—5.4	12.8	18.4	"	12.1	16.0	"	9.9
													19.0	"	12.7	16.2	"	10.1
3	17.1	—9.1	8.0	15.6	—10.6	5.0	17.7	—6.1	11.6	16.8	"	11.4	19.2	"	12.9	16.7	"	10.6
													18.9	"	12.6	16.0	"	9.9
4	15.6	—9.2	6.4	12.0	—10.4	1.6	14.6	"	8.5	15.7	—5.5	10.2	18.2	"	11.9	16.0	"	9.9
5	13.7	—9.3	4.4	10.8	—10.2	0.6	8.2	—6.0	2.2	13.0	"	7.5	15.8	"	9.5	14.9	—6.2	8.7
6	12.2	—9.4	2.8	10.0	—10.0	0.0	6.3	"	0.3	9.7	—5.6	4.1	12.4	"	6.1	13.9	"	7.7
	12.0	"	2.6	9.7	—9.9	—0.2	6.1	"	0.1									
7	12.2	—9.5	2.7	9.2	—9.8	—0.6	5.7	"	—0.3	7.3	"	1.7	10.0	"	3.7	10.8	"	4.6
				8.6	—9.7	—1.1	5.6	—5.9	—0.3	7.2	"	1.6						
8	14.2	—9.6	4.6	7.8	—9.6	—1.8	5.5	"	—0.4	7.2	"	1.6	8.7	"	2.4	8.1	"	1.9
				7.7	—9.5	—1.8	5.7	"	—0.2	7.2	—5.7	1.5	8.5	"	2.2			
9	17.1	—9.7	7.4	8.7	—9.4	—0.7	6.7	"	0.8	7.4	"	1.7	8.4	"	2.1	6.6	"	0.4
										8.0	"	2.3	8.4	"	2.1	6.6	"	0.4
10	19.9	—9.8	10.1	10.8	—9 2	0.6	9.3	"	3.4	9.0	"	3.3	8.6	"	2.3	6.6	—6.3	0.3
																6.6	"	0.3
11	21.1	—9.9	11.2	13.4	—9.0	4.4	12.1	"	6.2	12.0	"	6.3	10.0	"	3.7	7.2	"	0.9
Midn't	21.6	—10.0	11.6	14.8	—8.7	6.1	14.0	—5.8	8.2	14.6	—5.8	8.8	12.1	—6.2	5.9	9.3	"	3.0

Jan. 27. At 11 P. M., 13.7; at $11^h\ 30^m$, 13.8; at 28th, 0^h, 13.9, high water; corrected high water 11.3.

		Fath.	Feet.	Inch.	
Jan. 28.	Sounding at noon	8	0	0	Corrected reading by sounding 11.4, by curves 13.1, mean 12.2.
" 29.	" "	8	1	6	Index changed to 19.6. Corrected reading by sounding 12.9, by curves 13.7, mean 13.3.
" 30.	" "	8	0	6	Corrected reading by sounding 11.9, by curves 12.1, mean 12.0.
" 31.	" "	---	---	---	Corrected reading by curves 10.9.
Feb. 1.	" "	7	4	6	Ebb tide at 7½ A. M.
" 2.	" "	7	1	0	Ebb tide at 4 P. M. (probably means ebb commences). Index 13.0.

Note to Feb. 1 and 2. The correction is derived from the soundings and curves.

SERIES II.—TIDAL OBSERVATIONS FROM JANUARY 28 TO APRIL 7, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

February, 1854.

Mean solar hour.	3d.	Red. to level.	Ref. obs.	4th.	Red. to level.	Ref. obs.	5th.	Red. to level.	Ref. obs.	6th.	Red. to level.	Ref. obs.	7th.	Red. to level.	Ref. obs.	8th.	Red. to level.	Ref. obs.
							10.6	—6.8	3.8	11.7	—7.2	4.5	9.5	—5.2	4.3			
1	12.0	—6.4	5.6	11.2	—6.0	5.2	10.9	—7.0	3.9	11.7	—7.1	4.6	9.3	"	4.1	9.7	—4.4	5.3
										12.2	"	5.1				9.2	"	4.8
2	13.0	"	6.6	13.0	—5.9	7.1	11.7	—7.1	4.6	12.6	—7.0	5.6	9.5	—5.1	4.4	9.2	—4.5	4.7
																9.2	"	4.7
3	14.0	—6.5	7.5	14.3	"	8.4	12.9	—7.2	5.7	13.5	—6.9	6.6	10.2	—5.0	5.2	9.2	"	4.7
	14.4	"	7.9	14.7	—5.8	8.9										9.2	"	4.7
4	15.0	"	8.5	14.9	"	9.1	13.7	—7.3	6.4	15.9	"	9.0	11.1	—4.9	6.2	9.2	"	4.7
	15.0	"	8.5	14.9	"	9.1				15.8	—6.8	9.0				9.6	"	5.1
5	14.8	—6.6	8.2	14.9	—5.7	9.2	17.1	—7.4	9.7	16.1	"	9.3	12.0	"	7.1	10.0	"	5.5
				14.8	"	9.1				16.0	"	9.2						
6	13.9	"	7.3	14.2	—5.6	8.6	17.5	—7.5	10.0	16.0	—6.7	9.3	13.0	—4.8	8.2	11.5	"	7.0
							17.5	"	10.5	16.0	"	9.3						
7	12.1	"	5.5	12.8	"	7.2	17.7	—7.6	10.1	16.0	—6.6	9.4	13.7	—4.7	9.0	12.6	—4.6	8.0
							17.7	"	10.1	16.0	"	9.4	14.0	"	9.3			
8	11.1	"	4.5	11.7	—5.5	6.2	17.4	—7.7	9.7	16.0	—6.5	9.5	14.0	—4.6	9.4	13.4	"	8.8
	10.6	"	4.0	9.8	"	4.3				16.0	"	9.5	13.7	"	9.1			
9	10.1	—6.7	3.4	9.2	—5.4	3.8	16.3	—7.8	8.5	15.2	—6.4	8.8	13.3	—4.5	8.8	13.9	"	9.3
	10.2	"	3.5	9.2	"	3.8										14.0	"	9.4
10	10.8	"	4.1	9.8	—5.4	4.4	15.5	—8.0	7.5	14.4	—6.3	8.1	12.8	—4.4	8.4	14.1	"	9.5
																14.1	"	9.5
11	11.9	"	5.2	10.5	"	5.1	15.2	—8.1	7.1	13.6	"	7.3	12.2	—4.3	7.9	13.9	"	9.3
										13.0	"	6.7						
Noon	12.6	—6.8	5.8	10.7	—5.3	5.4	15.0	—8.2	6.8	10.0	—6.2	3.8	11.8	—4.2	7.6	11.6	—4.7	6.9
							13.2	"	5.0	10.1	"	3.9						
1	12.9	"	6.1	11.2	—5.4	5.8	13.7	—8.1	5.6	10.5	—6.1	4.4	11.0	"	6.8	10.2	"	5.5
							14.1	"	6.0				11.0	"	6.8			
2	14.1	—6.7	7.4	12.8	—5.5	7.3	14.4	—8.0	6.4	11.0	—6.0	5.0	10.0	"	5.8	9.1	"	4.4
													10.0	"	5.8	8.2	"	3.5
3	14.8	"	8.1	13.5	—5.6	7.9	15.5	—7.9	7.6	11.3	"	5.3	10.0	"	5.8	8.0	"	3.3
	15.1	—6.6	8.5										10.0	"	5.8	8.0	"	3.3
4	15.2	"	8.6	14.2	—5.7	8.5	17.7	—7.8	9.9	12.0	—5.9	6.1	10.0	"	5.8	8.0	"	3.3
	---	"	---										10.0	"	5.8	---		---
5	14.6	—6.5	8.1	14.6	—5.8	8.8	18.3	—7.7	10.5	12.5	—5.8	6.7	11.3	—4.3	7.0	8.1	"	3.4
				14.7	"	8.9	18.4	"	10.7									
6	12.9	"	6.4	14.6	—5.9	8.7	18.0	—7.6	10 4	12.6	—5.7	6.9	11.4	"	7.1	9.7	"	5.0
										12.6	"	6.9						
7	11.2	—6.4	4.8	14.2	—6.0	8.2	17.2	—7.5	9.7	12.7	—5.6	7.1	12.2	"	7.9	10.2	"	5.5
										12.7	"	7.1	12.5	"	8.2			
8	9.6	—6.3	3.3	13.5	—6.1	7.4	15.0	—7.4	7.6	12.7	—5.5	7.2	12.5	"	8.2	11.1	"	6.4
										12.7	"	7.2	12.2	"	7.9	11.2	"	6.5
9	8.7	"	2.4	12.2	—6.2	6.0	13.7	—7.4	6.3	12.5	—5.4	7.1	12.0	—4.4	7.6	11.4	"	6.7
	8.4	—6.2	2.2													11.4	"	6.7
10	8.4	"	2.2	11.0	—6.4	4.6	12.4	—7.3	5.1	11.3	"	5.9	11.8	"	7.4	11.4	"	6.7
	8.6	—6.1	2.5													11.3	"	6.6
11	8.8	"	2.7	10.6	—6.5	4.1	11.9	"	4.6	9.5	—5.3	4.2	11.2	"	6.8	11.1	"	6.4
				10.6	—6.6	4.0	11.8	"	4.5	9.0	"	3.7						
Midn't	9.7	—6.0	3.7	10.6	—6.7	3.9	11.7	—7.2	4.5	9.0	—5.2	3.8	10.7	—4.4	6.3	11.0	"	6.3

		Fath.	Feet.	Inch.	
Feb. 3.	Sounding at noon	6	5	6	Corrected reading by sounding 4.9, by curves 6.7, mean 5.8.
" 4.	" "	---	---	---	
" 5.	" "	---	---	---	
" 6.	" "	6	4	0	Corrected reading by sounding 3.4, by curves 4.3, mean 3.8.
" 7.	" "	---	---	---	
" 8.	" "	6	5	6	Corrected reading by sounding and curves 6.9.

SERIES II.—TIDAL OBSERVATIONS FROM JANUARY 28 TO APRIL 7, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

February, 1854.

Mean solar hour.	9th.	Red. to level.	Ref. obs.	10th.	Red. to level.	Ref. obs.	11th.	Red. to level.	Ref. obs.	12th.	Red. to level.	Ref. obs.	13th.	Red. to level.	Ref. obs.	14th.	Red. to level.	Ref. obs.
													14.7	—6.7	8.0			
1	9.9	—4.6	5.3	11.4	—5.6	5.8	10.7	—6.3	4.4	11.1	—6.2	4.9	14.2	"	7.5	19.5	—9.4	10.1
2	8.8	"	4.2	11.0	—5.7	5.3	10.1	"	3.8	11.1	"	4.9	13.6	"	6.9	18.5	—9.6	8.9
	8.4	"	3.8															
3	8.4	"	3.8	10.4	—5.8	4.6	8.8	"	2.5	10.2	"	4.0	12.7	—6.8	5.9	16.0	—9.8	6.2
	8.4	"	3.8															
4	8.4	"	3.8	10.0	—5.9	4.1	8.2	"	1.9	9.0	"	2.8	9.7	"	2.9	14.0	—10.0	4.0
	8.4	"	3.8				7.9	"	1.6	9.5	"	3.3						
5	8.8	"	4.2	10.0	—6.0	4.0	7.5	—6.2	1.3	9.2	"	3.0	8.2	"	1.4	13.7	—10.1	3.6
							7.5	"	1.3	9.0	"	2.8	8.0		1.2			
6	10.0	"	5.4	10.0	—6.1	3.9	7.8	"	1.6	9.0	"	2.8	7.6	—6.9	0.7	13.3	—10.3	3.0
				9.8	"	3.7				9.0	"	2 8	8.5	"	1.6	12.9	—10.4	2.5
7	11.6	"	7.0	11.0	—6.2	4.8	9.1	"	2.9	9.7	"	3.5	8.9	"	2.0	12.9	—10.5	2.4
																13.7	—10.6	3.1
8	12.8	"	8.2	12.8	—6.3	6.5	10.3	—6.1	4.2	11.2	"	5.0	10.9	"	4.0	14.7	—10.7	4.0
9	13.5	"	8.9	15.0	—6.4	8.6	12.6	"	6.5	13.2	"	7.0	13.0	—7.0	6.0	16.2	—10.8	5.4
				15.2	"	8.8												
10	14.1	"	9.5	15.7	—6.5	9.2	15.5	"	9.4	15.3	"	9.1	16.0	"	9.0	18.7	—10.9	7.8
	14.3	"	9.7	15.7	"	9.2				16.6	"	10.4	16.9	"	9.9			
11	14.2	"	9.6	15.7	"	9.2	16.1	"	10.0	17.7	"	11.5	19.1	"	12.1	20.8	—11.1	9.7
	13.8	"	9.2	15.0	"	8.5	16.4	"	10.3	17.4	"	11.2	19.6	"	12.6			
Noon	13.6	—4.5	9.1	14.0	—6.6	7.4	16.5	—6.0	10 5	17.1	—6.3	10.8	19.5	—7.1	12.4	21.7	—11.2	10.5
							16.1	"	10.1				19.5	—7.2	12.3	- - -		- - -
1	13.5	"	9.0	13.9	"	7.3	15.7	"	9.7	16.0	"	9.7	19.5	—7.3	12.2	24.8	"	13.6
																24.3	"	13.1
2	12.7	"	8.2	13.4	"	6.8	13.6	"	7.6	14.7	"	8.4	17.9	—7.5	10.4	23.2	—11.3	11.9
3	11.2	—4.6	6.6	10.7	"	4.1	11.4	"	5.4	12.3	—6.4	5.9	16.7	—7.7	9.0	21.5	—11.4	10.1
4	9.0	—4.7	4.3	8.7	—6.5	2.2	9.5	"	3.5	10.0	"	3.6	16.3	—7.9	8.4	19.5	"	8.1
	8.3	"	3.6	8.0		1.5	8.0	"	2.0				14.5	—8.0	6.5			
5	8.0	"	3.3	8.0	"	1.5	7.8	"	1.8	9.7	"	3.3	12.9	—8.1	4.8	16.7	—11.5	5.2
	8.7	—4.8	3.9	8.0	"	1.5	8.0	"	2.0				12.3	—8.2	4.1			
6	9.3	"	4.5	8.0	"	1.5	8.0	"	2.0	8.9	—6.5	2.4	13.1	—8.3	4.8	14.7	"	3.2
				8.0	"	1.5				8.8	"	2.3				14.3	"	2.8
7	9.7	—4.9	4.8	8.5	"	2.0	9.6	"	3.6	8.8	"	2.3	15.2	—8.4	6.8	14.2	—11.6	2.6
										8.9	"	2.4				14.2	"	2.6
8	11.0	—5.0	6.0	9.8	—6.4	3.4	10.3	—6.1	4.2	9.7	"	3.2	16.3	—8.5	7.8	14.6	"	3.0
9	11.7	—5.1	6.6	11.2	"	4.8	11.4	"	5.3	9.9	—6.6	3.3	16.3	—8.7	7.6	15.1	"	3.5
10	12.4	—5.2	7.2	12.3	"	5.9	12.1	"	6.0	12.6	"	6.0	18.7	—8.8	9.9	15.8	—11.7	4.1
										14.3	"	7.7	19.1	—8.9	10.2			
11	12.3	—5.3	7.0	12.7	"	6.3	12.9	"	6.8	15.0	"	8.4	19.6	—9.0	10.6	16.6		4.9
	12.6	—5.4	7.2	12.7	"	6.3	13.3	"	7.2	15.0		8.4	19.5	—9.1	10.4			
Midn't	12.4	—5.5	6.9	12.9	—6.3	6.6	13.8	"	7.7	15.1	—6.7	8.4	19.5	—9.2	10.3	17.4	—11.8	5.6

		Fath.	Feet.	Inch.	
Feb. 9.	No sounding.				
" 10.	Sounding at noon	7	2	0	Corrected by sounding —6.6, by curves —6.6.
" 11.	" "	- - -	- - -	- - -	
" 12.	" "	7	4	6	Ebb tide at 6 P. M. Corrected by sounding —6.6, by curves —6.0, mean —6.3.
" 13.	" "	8	1	6	Corrected by sounding —6.6, by curves —7.6, mean —7.1.
" 14.	No sounding.				

Series II.—Tidal Observations from January 28 to April 7, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.9, expressed in units of the scale. Increasing numbers indicate rise of water.

February, 1854.

Mean solar hour.	15th.	Red. to level.	Ref. obs.	16th.	Red. to level.	Ref. obs.	17th.	Red. to level.	Ref. obs.	18th.	Red. to level.	Ref. obs.	19th.	Red. to level.	Ref. obs.	20th.	Red. to level.	Ref. obs.
	23.6	—11.8	11.8	22.2	—9.1	13.1	20.7	—9.7	11.0									
1	23.6	"	11.8	22.2	—9.2	13.0	21.2	—9.6	11.6	16.5	—8.0	8.5	17.8	—8.2	9.6	11.3	—5.4	5.9
	23.5	"	11.7	22.1	—9.3	12.8	21.6	"	12.0									
2	23.5	—11.9	11.6	22.1	—9.4	12.7	21.8	—9.5	12.3	18.0	"	10.0	18.6	"	10.4	13.7	"	8.3
							21.8	"	12.3	18.4	—7.9	10.5						
3	23.5	"	11.6	20.9	—9.6	11.3	21.9	—9.4	12.5	18.5	"	10.6	19.4	—8.3	11.1	15.5	"	10.1
							21.9	"	12.5	18.5	"	10.6	19.6	"	11.3	15.9	"	10.5
4	19.7	"	7.8	19.0	—9.8	9.2	21.9	—9.3	12.6	18.2	—7.8	10.4	19.6	—8.4	11.2	16.2	"	10.8
													19.6	"	11.2	14.9	"	9.5
5	17.7	—12.0	5.7	16.3	—9.9	6.4	19.0	—9.2	9.8	16.3	"	8.5	19.3	"	10.9	14.0	—5.5	8.5
6	16.1	—12.1	4.0	14.7	—10.1	4.6	16.4	—9.1	7.3	15.0	—7.6	7.4	17.7	—8.5	9.2	12.7	"	7.2
7	15.3	"	3.2	13.2	—10.3	2.9	14.3	—9.0	5.3	11.8	"	4.2	15.8	"	7.3	11.4	"	5.9
				12.9	—10.4	2.5	12.9	"	3.9									
8	15.5	—12.2	3.3	12.7	—10.5	2.2	12.9	—8.9	4.0	10.6	"	3.0	14.2	—8.6	5.6	11.0	"	5.5
				13.7	—10.6	3.1	13.0	"	4.1	10.4	"	2.8				11.0	"	5.5
9	17.6	—12.3	4.8	14.8	—10.7	4.1	13.5	—8.8	4.7	10.2	—7.5	2.7	13.5	"	4.9	11.0	"	5.5
										10.2	"	2.7				11.4	"	5.9
10	19.7	—12.4	7.3	16.0	—10.9	5.1	15.4	—8.7	6.7	10.3	"	2.8	13.3	—8.7	4.6	11.0	"	5.5
													13.3	"	4.6	11.0	"	5.5
11	22.3	"	9.9	17.5	—11.0	6.5	18.0	"	9.3	13.5	"	6.0	13.2	"	4.5	11.0	"	5.5
							20.1	—8.6	11.5				13.3	"	4.6	11.3	"	5.8
Noon	24.6	—12.5	12.1	21.2	—11.1	10.1	14.6	?	---	14.5	—7.4	7.1	13.6	—8.8	4.8	11.7	—5.6	6.1
	25.2	"	12.7	22.1	"	11.0								---				
1	19.5	—6.8	12.7	24.0	—11.0	13.0	17.0	?	---	15.3	"	7.9	14.3	—5.5	8.8	12.2	"	6.6
	19.8	—6.9	12.9	23.9	"	12.9												
2	19.8	—7.0	12.8	24.0	—10.9	13.1	18.3	—6.6	11.7	17.2	—7.5	9.7	15.6	"	10.1	15.5	"	9.9
				24.0	"	13.1				17.7	"	10.2	15.9	"	10.4			
3	18.3	—7.2	11.1	22.5	—10.8	11.7	18.2	—6.7	11.5	17.7	—7.6	10.1	16.2	"	10.7	15.5	"	9.9
										17.6	"	10.0	16.2	"	10.7	16.0		10.4
4	18.4	—7.4	11.0	21.9	—10.7	11.2	17.2	—6.9	10.3	17.5	"	9.9	15.7	"	10.2	16.3	"	10.7
																15.7	"	10.1
5	17.2	—7.6	9.6	18.8	—10.6	8.2	15.4	—7.1	8.3	15.9	—7.7	8.2	15.4	—5.5	9.9	15.8	"	10.2
6	14.7	—7.8	6.9	16.0	—10.5	5.5	12.9	—7.2	5.7	14.4	"	6.7	14.3	"	8.8	15.5	"	9.9
7	12.7	—8.0	4.7	15.6	—10.4	5.2	11.2	—7.3	3.9	12.8	—7.8	5.0	12.0	"	6.5	15.5	?	---
	12.4	—8.1	4.3															
8	12.3	—8.2	4.1	12.9	—10.3	2.6	8.8	—7.5	1.3	11.6	"	3.8	10.3	"	4.8	15.5	"	---
	13.7	—8.3	5.4	12.5	—10.2	2.3	8.0	—7.6	0.4	11.1	—7.9	3.2						
9	15.6	—8.4	7.2	12.8	—10.1	2.7	8.0	—7.7	0.3	10.9	"	3.0	8.9	—5.4	3.5	14.1	"	---
							8.0	"	0.3	10.9	"	3.0						
10	18.1	—8.6	9.5	14.3	—10.0	4.3	8.7	—7.8	0.9	11.0	—8.0	3.0	8.4	"	3.0	13.7	"	---
													8.4	"	3.0	13.6		---
11	19.3	—8.8	10.5	17.1	—9.9	7.2	11.0	—7.9	3.1	12.3	"	4.3	8.4	"	3.0	13.5	"	---
													8.5	"	3.1	13.5	"	---
Midn't	20.4	—9.0	11.4	19.7	—9.8	9.9	13.8	—8.0	5.8	14.3	—8.1	6.2	9.4	—5.3	4.1	13.5	"	---

		Fath.	Feet.	Inch.	
Feb. 15.	Sounding at noon	8	1	0	Correction by sounding —12.2, by curves —12.8, mean —12.5.
" 16.	" "	---	---	---	
" 17.	" "	7	2	6	
" 18.	" "	7	1	6	Corrected reading by sounding 6.9, by curves 7.3, mean 7.1.
" 19.	" "	7	0	0	Corrected reading by sounding 5.4, by curves 4.2, mean 4.8.
" 20.	No sounding.				

Series II.—Tidal Observations from January 28 to April 7, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

February, 1854.

Mean solar hour.	21st.	Red. to level.	Ref. obs.	22d.	Red. to level.	Ref. obs.	23d.	Red. to level.	Ref. obs.	24th.	Red. to level.	Ref. obs	25th.	Red. to level.	Ref. obs.	26th.	Red. to level.	Ref. obs.
				10.5	—6.0	4.5												
1	- - -		- - -	10.7	"	4.7	12.4	—7.2	5.2	14.4	—10.9	3.5	9.8	—2.1	7.7	10.6	—2.2	8.4
							11.8	—7.3	4.5	14.2	"	3.3						
2	- - -		- - -	11.5	"	5.5	11.8	—7.4	4.4	14.5	—11.0	3.5	7.8	"	5.7	8.8	—2.4	6.4
							11.8	—7.5	4.3									
3	- - -		- - -	12.9	"	6.9	11.8	—7.7	4.1	14.9	—11.1	3.8	5.8	—2.2	3.6	6.4	—2.7	3.7
							12.1	—7.8	4.3				5.3	"	3.1			
4	- - .		- - -	14.2	"	8.2	13.0	—8.0	5.0	16.1	—11.2	4.9	5.1	—2.3	2.8	5.2	—3.0	2.2
													15.4	"	3.1	4.1	—3.1	1.0
5	- - -		- - -	14.1	?	- - -	14.3	—8.2	6.1	17.2	—11.3	5.9	5.6	"	3.3	4.2	—3.2	1.0
																4.3	—3.3	1.0
6	- - -		- - -	13.6	"	- - -	15.8	—8.3	7.5	18.3	—11.5	6.8	7.6	—2.4	5.2	4.7	—3.5	1.2
7	- - -		- - -	13.2	"	- - -	16.8	—8.5	8.3	19.4	—11.6	7.8	9.7	"	7.3	6.6	—3.7	2.9
8	- - -		- - -	12.7	"	- - -	18.1	—8.6	9.5	21.7	—11.8	9.9	11.0	—2.5	8.5	9.0	—4.0	5.0
				15.0	—6.2	8.8												
9	- - -		- - -	15.5	"	9.3	18.4	—8.7	9.7	22.2	—11.9	10.3	12.7	"	10.2	11.0	—4.3	6.7
				15.6	"	9.4				22.2	"	10.3						
10	- - -		- - -	14.9	"	8.7	19.1	—8.8	10.3	22.3	—12.0	10.3	13.8	—2.6	11.2	13.0	—4.6	8.4
							19.5	"	10.7				13.8	"	11.2			
11	- - -		- - -	14.2	"	8.0	19.3	—8.9	10.4	22.2	—12.1	10.1	13.8	"	11.2	14.6	—4.9	9.7
Noon	- - -		- - -	12.8	—6.2	6.6	18.7	—9.0	9.7	20.7	—12.3	8.4	13.7	—2.7	11.0	15.4	—5.4	10.0
											- - -					17.0	—5.5	11.5
1	- - -		- - -	12.2	"	6.0	17.9	—9.3	8.6	10.0	—1.7	8.3	11.4	—1.9	9.5	17.5	—5.6	11.9
																15.7	—5.7	10.0
2	- - -		- - -	12.2	"	6.0	16.7	—9.6	7.1	7.6	"	5.9	9.0	—1.0	8.0	15.0	—5.8	9.2
3	- - -		- - -	12.2	—6.3	5.9	16.1	—9.9	6.2	6.6	—1.8	4.8	6.0	—1.1	4.9	13.1	—6.0	7.1
							16.0	—10.0	6.0	5.0		3.2						
4	- - -		- - -	12.5	"	6.2	16.0	—10.2	5.8	4.6	"	2.8	4.7	—1.3	3.4	10.2	—6.1	4.1
				11.0	"	4.7	16.0	"	5.8	5.3	"	3.5	3.3	"	2.0			
5	- - -		- - -	11.7	—6.4	5.3	16.2		5.7	5.6	"	3.8	3.7	—1.4	2.3	9.5	—6.2	3.3
				12.9	"	6.5	16.6	"	6.4							9.4	—6.3	3.1
6	- - -		- - -	14.2	"	7.8	17.0	—10.3	6.7	6.4	"	4.6	4.1	—1.5	2.6	9.4	—6.4	3.0
																9.5	—6.5	3.0
7	- - -		- - -	15.1	—6.5	8.6	18.0	"	7.7	7.7	"	5.9	5.4	—1.6	3.8	9.8	—6.6	3.2
				15.2	"	8.7												
8	13.5	—5.8	7.7	15.7	—6.6	9.1	18.9	—10.4	8.5	9.6	—1.9	7.7	8.0	—1.7	6.3	11.5	—6.7	4.8
				15.6	"	9.0	19.3	"	8.9									
9	12.5	"	6.7	15.3	—6.7	8.6	19.3	—10.5	8.8	10.8	"	8.9	10.2	—1.8	8.4	15.0	—6.8	8.2
				15.1		7.4	19.3	"	8.8	11.3		9.4						
10	11.2	—5.9	5.3	15.0	—6.8	8.2	19.0	—10.6	8.4	11.6	"	9.7	11.9	—1.9	10.0	16.3	—6.9	9.4
										11.6		9.7	12.3	"	10.4			
11	10.4	"	4.5	14.6	—6.9	7.7	18.5	—10.7	7.8	11.6	"	9.7	12.4	—2.0	10.4	17.8	—7.0	10.8
	10.5	"	4.6							11.6		9.7	12.4	"	10.4			
Midn't	10.2	"	4.3	13.8	—7.0	6.8	16.4	—10.8	5.6	10.6	—2.0	8.6	12.3	—2.0	10.3	18.4	—7.1	11.3

Feb. 21. Readings irregular, tide-gauge out of order at 8 A. M., repaired at noon. Sounding 7 fath., 1 ft., 0 in.

Feb. 22 and 23. No sounding.

	Fath.	Feet.	Inch.	
Feb. 24. Sounding at noon	6	5	0	Corrections derived from curves.
" 25. " "	7	0	6	Ebb tide at 11 A. M. Corrections derived from curves.
" 26. " "	7	5	6	Correction derived from the means by sounding and curves.

Series II.—Tidal Observations from January 28 to April 7, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

	February, 1854.						March, 1854.											
Mean solar hour.	27th.	Red. to level.	Ref. obs.	28th.	Red. to level.	Ref. obs.	1st.	Red. to level.	Ref. obs.	2d.	Red. to level.	Ref. obs.	3d.	Red. to level.	Ref. obs.	4th.	Red. to level.	Ref. obs.
				15.0	—4.9	10.1	15.5	—5.0	10.5	16.2	—5.0	11.2	14.5	—5.4	9.1			
1	18.3	—7.3	11.0	14.8	"	9.9	16.3	"	11.3	17.0	"	12.0	15.5	"	10.1	13.1	—5.1	8.0
										17.0	"	12.0	16.0		10.6			
2	17.5	—7.4	10.1	12.8	"	7.9	16.3	"	11.3	17.0	"	12.0	16.0	"	10.6	15.4	—5.0	10.4
										16.5	"	11.5	16.0		10.6	15.9	"	10.9
3	17.8	—7.5	10.3	11.0	"	6.1	13.9	"	8.9	16.0	"	11.0	16.0	"	10.6	16.0	—4.9	11.1
													15.7		10.3	16.0	"	11.1
4	19.3	?	- - -	7.8	"	2.9	12.0	"	7.0	15.1	"	10.1	14.8	—5.5	9.3	15.8	"	10.9
	5.3	—4.8	0.5															
5	4.4	"	—0.4	5.5	"	0.6	10.5	"	5.5	12.8	"	7.8	13.6	"	8.1	14.2	—4.8	9.4
	4.4	"	—0.4	5.5	"	0.6												
6	5.0	"	0.2	5.0	"	0.1	7.2	"	2.2	11.1	"	6.1	12.4	"	6.9	12.1	"	7.3
				5.0	"	0.1	5.5	"	0.5									
7	5.8	"	1.0	5.0	"	0.1	5.5	"	0.5	9.0	"	4.0	11.1	—5.6	5.5	9.7	—4.7	5.0
				6.2	"	1.3	5.5		0.5	8.8	"	3.8				9.1	"	4.4
8	8.3	"	3.5	7.0	"	2.1	5.5	"	0.5	7.5	"	2.5	9.4	"	3.8	8.6	"	3.9
					"		5.7	"	0.7		"		8.1		2.5	8.7	"	4.0
9	11.1	"	6.3	10.0	"	5.1	7.0	"	2.0	8.2	"	3.2	9.0	"	3.4	9.0	"	4.3
10	14.4	"	9.6	12.9	"	8.0	9.5	"	4.5	10.0	"	5.0	9.7	—5.7	4.0	8.4	"	3.7
																8.7	"	4.0
11	16.3	"	11.5	16.0	"	11.1	13.5	"	8.5	12.8	"	7.8	11.2	"	5.5	9.7	"	5.0
	16.9		12.1															
Noon	17.6	—4.9	12.7	17.7	—4.9	12.8	16.1	—5.0	11.1	15.6	—5.0	10.6	13.3	—5.8	7.5	12.1	—4.6	7.5
	16.0	"	11.1	17.9	"	13.0												
1	15.3	"	10.4	17.9	"	13.0	17.6	"	12.6	17.9	"	12.9	15.7	"	9.9	13.5	"	8.9
				17.2	"	12.3	17.9	"	12.9	18.0	"	13.0						
2	14.1	"	9.2	15.9	"	11.0	17.9	"	12.9	18.0	"	13.0	16.0	—5.7	10.3	15.3	"	10.7
							17.2	"	12.2				16.6	"	10.9	15.5	"	10.9
3	12.8	"	7.9	13.4	"	8.5	16.7	"	11.7	17.2	—5.1	12.1	16.3	"	10.6	15.6	—4.5	11.1
													16.3	"	10.6	15.2	"	10.7
4	8.7	"	3.8	9.7	"	4.8	13.9	"	8.9	15.8	"	10.7	15.3	"	9.6	15.0	"	10.5
5	4.7	"	—0.2	7.8	"	2.9	12.4	"	7.4	14.4	—5.2	9.2	14.9	—5.6	9.3	12.9	—4.4	8.5
	4.5	"	—0.4															
6	4.0	"	—0.9	6.2	"	1.3	11.7	"	6.7	13.4	"	8.2	14.2	"	8.6	11.2	"	6.8
	4.0	"	—0.9	6.0	"	1.1												
7	4.7	"	—0.2	6.0	"	1.1	11.1	"	6.1	12.0	"	6.8	13.5	—5.5	8.0	9.9	"	5.5
				6.0	"	1.1				11.3	"	6.1						
8	6.5	"	1.6	6.0	"	1.1	9.4	"	4.4	10.0	—5.3	4.7	12.1	"	6.6	8.2	—4.3	3.9
				6.4	"	1.5	8.5	"	3.5	7.7	"	2.4	8.6	"	3.1	6.4	"	2.1
9	8.9	"	4.0	8.0	"	3.1	6.3	"	1.3	7.5	"	2.2	6.9	—5.4	1.5	5.2	—4.2	1.0
							7.2	"	2.2	7.2	"	1.9	6.9	"	1.5	5.3	"	1.1
10	11.6	"	6.7	10.4	"	5.5	8.9	"	3.9	8.5	"	3.2	7.2	"	1.8	5.3	"	1.1
																6.0	—4.1	1.9
11	13.8	"	8.9	15.8	"	10.9	11.8	"	6.8	11.2	"	5.9	9.2	—5.3	3.9	6.4	"	2.3
	14.7	"	9.8	17.0	"	12.1												
Midn't	15.2	"	10.3	17.3	"	12.4	14.6	"	9.6	13.9	—5.4	8.5	11.4	—5.2	6.2	8.6	—4.0	4.6

	Fath.	Feet.	Inch.	
Feb. 27. Sounding at noon	7	5	6	Mean correction by sounding and curves adopted, the latter [showing weight 2.
" 28. No sounding.				
March 1. No sounding.				
" 2. Sounding at noon	7	5	6	Corrected reading by sounding 11.0, by curves 10.2, mean 10.6.
" 3. " "	7	1	6	Corrected reading by sounding 7.0, by curves 8.0, mean 7.5.
" 4. No sounding.				

Series II.—Tidal Observations from January 28 to April 7, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

March, 1854.

Mean solar hour.	5th.	Red. to level.	Ref. obs.	6th.	Red. to level.	Ref. obs.	7th.	Red. to level.	Ref. obs.	10th.	Red. to level.	Ref. obs.	11th.	Red. to level.	Ref. obs.	15th.	Red. to level.	Ref. obs.
													15.1	—6.9	8.2	17.6	—6.4	11.2
1	10.5	—3.8	6.7	10.7	—3.5	7.2	9.7	—4.1	5.6	9.6	—4.7	4.9	14.3	"	7.4	17.5	—6.5	11.0
										9.1	"	4.4						
2	11.8	"	8.0	12.1	"	8.6	11.0	"	6.9	8.9	—4.8	4.1	13.2	—7.0	6.2	15.7	—6.7	9.0
										8.9	"	4.1						
3	12.7	—3.7	9.0	13.2	—3.6	9.6	12.1	"	8.0	8.9	—4.9	4.0	12.5	"	5.5	15.2	—6.9	8.3
	12.8	"	9.1							9.0	"	4.1	12.4	"	5.4			
4	12.8	—3.6	9.2	14.0	"	10.4	12.8	"	8.7	9.0	—5.0	4.0	12.4	"	5.4	14.0	—7.1	6.9
	11.9	"	8.3	14.1	"	10.5	12.9		8.8	9.0	"	4.0	12.4	"	5.4			
5	11.7	—3.5	8.2	14.1	—3.7	10.4	12.9	"	8.8	9.0	—5.1	3.9	12.4	"	5.4	11.5	—7.3	4.2
	11.2	"	7.7	14.0	"	10.3	12.9		8.8	9.6	—5.2	4.4	12.4	"	5.4			
6	10.9	—3.4	7.5	13.9	"	10.2	12.9	—4.2	8.7	10.0	—5.3	4.7	12.4	"	5.4	10.2	—7.5	2.7
							12.9		8.7				12.5	"	5.5	10.0	—7.7	2.3
7	9.7	"	6.3	12.9	—3.8	9.1	12.9	"	8.7	11.3	—5.4	5.9	12.8	"	5.8	10.7	—7.9	2.8
							12.9		8.7									
8	8.7	—3.3	5.4	12.2	"	8.4	12.9	"	8.7	13.1	—5.5	7.6	14.2	"	7.2	12.4	—8.1	4.3
	7.4	"	4.1				12.7		8.5									
9	6.3	—3.2	3.1	10.1	—3.9	6.2	12.1	"	7.9	15.2	—5.6	9.6	16.0	"	9.0	17.0	—8.3	8.7
	6.6	"	3.4	10.0	"	6.1				15.5	—5.6	9.9						
10	6.6	—3.1	3.5	10.0	"	6.1	10.5	"	6.3	15.5	—5.7	9.8	17.2	"	10.2	19.2	—8.5	10.7
	6.7	"	3.6	10.0	"	6.1	10.5		6.3	15.5	"	9.8	17.5	"	10.5			
11	7.3	"	4.2	10.0	"	6.1	10.0	"	5.8	15.3	—5.8	9.5	17.6	"	10.6	20.7	—8.7	12.0
				10.4		6.5	10.2		6.0							21.5	—8.8	12.7
Noon	9.5	—3.0	6.5	10.4	—4.0	6.4	10.2	—4.3	5.9	15.0	—5.9	9.1	- - -			18.0	—8.9	9.1
1	10.5	"	7.5	11.3	"	7.3	10.5	"	6.2	14.0	—6.0	8.0				18.3	—9.0	9.3
2	11.8	—3.1	8.7	12.0	"	8.0				11.9	—6.1	5.8				17.3	—9.1	8.2
	12.3	"	9.2															
3	13.2	"	10.1	12.6	"	8.6				11.5	—6.2	5.3				16.0	—9.2	6.8
	13.2	"	10.1							11.4	"	5.2						
4	13.2	—3.2	10.0	12.9	"	8.9	Observations become irregular.			11.3	"	5.1	Observations become irregular.			13.7	"	4.5
	12.7	"	9.5							11.3	—6.3	5.0						
5	11.9	"	8.7	13.3	"	9.3				11.3	"	5.0				12.9	—9.3	3.6
				13.6	"	9.6				11.6	"	5.3						
6	10.4	—3.3	7.1	13.3	"	9.3				11.8	—6.4	5.4				12.6	—9.4	3.2
																12.4	"	3.0
7	9.8	"	6.5	12.7	"	8.7				12.3	—6.5	5.8				12.3	—9.5	2.8
																12.3	"	2.8
8	8.8	"	5.5	12.2	"	8.2				12.9	"	6.4				12.3	—9.6	2.7
																12.3	"	2.7
9	7.7	—3.4	4.3	9.5	"	5.5				13.5	—6.6	6.9				14.0	—9.7	4.3
	7.4	"	4.0															
10	7.3	"	3.9	8.2	"	4.2				15.0	—6.7	8.3				16.5	—9.8	6.7
	7.5	"	4.1	8.1	"	4.1				15.5	"	8.8						
11	7.8	"	4.4	8.1	"	4.1				15.5	"	8.8				19.1	—9.9	9.2
				8.4	"	4.4				15.5	"	8.8						
Midn't	9.2	—3.5	5.7	8.6	—4.1	4.5				15.5	—6.8	8.7				20.5	—10.0	10.5

March 5. Soundings at noon 6 fath., 3 feet, 6 inches. Correction from curves.

" 7. Tide register broke at 9 A. M., was repaired immediately. No sounding.

March 6. No sounding.

March 8. No sounding.

	Fath.	Feet.	Inch.
" 9. Sounding at noon	6	4	0
" 10. " "	7	0	0
" 11. " "	7	—	—
" 14. " "	7	5	6
" 15. " "	8	—	—

March 12. No sounding and but a few observations taken.

" 13. But few observations taken.

The corrections after March 7 are derived from curves.

SERIES II.—TIDAL OBSERVATIONS FROM JANUARY 28 TO APRIL 7, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

March, 1854.

Mean solar hour.	16th.	Red. to level.	Ref. obs.	17th.	Red. to level.	Ref. obs.	18th.	Red. to level.	Ref. obs.	19th.	Red. to level.	Ref. obs.	20th.	Red. to level.	Ref. obs.	23d.	Red. to level.	Ref. obs.
	20.5	—10.0	10.5										19.8	—11.0	8.8			
1	20.5	"	10.5	21.4	—9.6	11.8	19.5	—8.8	10.7	21.4	—10.3	11.1	20.9	"	9.9	Irregular.		
	20.5	"	10.5	21.6	"	12.0	20.3	"	11.5									
2	20.0	"	10.0	21.6	"	12.0	20.9	"	12.1	22.2	—10.4	11.8	21.3	"	10.3			
				21.0	"	11.4	20.8	"	12.0	22.7	"	12.3	21.5	"	10.5			
3	17.5	"	7.5	19.8	—9.5	10.3	19.5	"	10.7	22.7	—10.5	12.2	21.7	"	10.7			
										22.7	"	12.2	22.4	"	11.4			
4	15.4	"	5.4	17.5	"	8.0	17.7	—8.7	9.0	22.2	—10.6	11.6	22.4	"	11.4	10.4	—4.0	6.4
													22.4	"	12.4			
5	15.1	—10.1	5.0	16.7	—9.4	7.3	15.9	"	7.2	19.2	"	8.6	22.2	"	11.2	10.5	—4.1	6.4
6	14.8	"	4.7	14.8	"	5.4	12.4	"	3.7	17.0	—10.7	6.3	19.3	"	8.3	11.5	—4.2	7.3
																12.3	"	8.1
7	14.3	"	4.2	12.7	"	3.3	11.2	"	2.5	15.0	"	4.3	19.0	"	8.0	13.2	"	9.0
										14.1	"	3.4				13.7	"	9.5
8	13.9	"	3.8	10.3	"	0.9	10.7	"	2.0	13.4	"	2.7				13.2	—4.3	8.9
	13.3	"	3.2	10.0	—9.3	0.7	10.5	"	1.8	14.1	"	3.4						
9	15.6	"	5.5	11.2	"	1.9	10.3	"	1.6	14.7	—10.8	3.9				12.6	—4.4	8.2
							10.3	"	1.6									
10	16.5	"	6.4	16.0	"	6.7	10.3	"	1.6	16.2	"	5.4				12.0	—4.5	7.5
11	18.3	"	8.2	19.6	—9.2	10.4	13.3	"	4.6	17.2	"	6.4				11.0	—4.7	6.3
Noon	18.3	—10.2	8.1	17.0	?	---	14.6	—8.6	6.0	19.3	"	8.5				11.2	—4.8	6.4
	18.4	"	8.2															
1	18.6	"	8.4	19.6	—9.2	10.4	16.9	"	8.3	20.3	"	9.5	Observations irregular.			11.1	—5.0	6.1
	18.5	"	8.3													11.1	"	6.1
2	18.5	—10.1	8.4	19.5	"	10.3	18.2	—8.7	9.5	21.5	"	10.7				10.4	—5.1	5.3
							18.1		9.4	21.6	—10.9	10.7				10.5	"	5.4
3	15.0	"	4.9	18.6	—9.1	9.5	18.1	"	9.4	21.6	"	10.7				11.1	—5.2	5.9
										21.6	"	10.7						
4	13.5	—10.0	3.5	17.2	"	8.1	16.0	—8.8	7.2	21.4	"	10.5				11.8	—5.4	6.4
	13.2	"	3.2															
5	13.0	"	3.0	16.8	"	7.7	14.6	—8.9	5.7	20.2	"	9.3				12.2	—5.5	6.7
	13.0	"	3.0															
6	13.0	—9.9	3.1	15.7	—9.0	6.7	14.1	—9.0	5.1	17.2	"	6.3				13.4	—5.6	7.8
	13.0	"	3.1															
7	13.0	"	3.1	14.3	"	5.3	13.1	—9.1	4.0	13.9	"	3.0				13.9	—5.7	8.2
	13.0	"	3.1				12.6	—9.2	3.4	13.7	"	2.8						
8	13.0	"	3.1	12.1	"	3.1	12.4	—9.3	3.1	13.5	"	2.6				14.2	—5.8	8.4
	13.3	"	3.4	10.2	"	1.2	12.5	—9.4	3.1	13.5	"	2.6				14.3	"	8.5
9	14.8	—9.8	5.0	10.4	"	1.4	13.0	—9.6	3.4	13.5	"	2.6				14.0	"	8.2
				11.3	"	2.3				13.5	"	2.6						
10	15.8	"	6.0	13.2	—8.9	4.3	14.2	—9.8	4.4	14.0	"	3.1				13.8	—5.9	7.9
11	18.3	"	8.5	13.6	"	4.7	17.2	—10.0	7.2	18.4	"	7.5				12.2	"	6.3
Midn't	20.0	—9.7	10.3	13.9	"	5.0	19.2	—10.2	9.0	20.9	—11.0	9.9				12.0	—6.0	6.0

	Fath.	Feet.	Inch.	
March 16. Sounding at noon	8	—	—	
" 17. " "	7	5	6	
" 18. " "	7	3	0	
" 19. No sounding.				
" 20. " "				Corrections from curves.
" 21. Sounding at noon	6	1	0	
" 22. " "	6	0	0	
" 23. No sounding.				

SERIES II.—TIDAL OBSERVATIONS FROM JANUARY 28 TO APRIL 7, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

March, 1854.

Mean solar hour.	24th.	Red. to level.	Ref. obs.	25th.	Red. to level.	Ref. obs.	26th.	Red. to level.	Ref. obs.	27th.	Red. to level.	Ref. obs.	28th.	Red. to level.	Ref. obs.	29th.	Red. to level.	Ref. obs.
																15.5	—3.5	12.0
1	11.3	—6.0	5.3	8.5	—0.1	8.4	9.9	—2.9	7.0	10.2	—1.1	9.1	15.0	—4.7	10.3	15.3	—3.3	12.0
	10.9	"	4.9													14.0	"	10.7
2	10.9	—6.1	4.8	6.5	—0.2	6.3	8.3	—3.0	5.3	8.2	—1.3	6.9	12.4	—4.9	7.5	13.3	—3.2	10.1
	10.9	"	4.8	5.5	"	5.3												
3	11.2	—6.2	5.0	5.5	—0.3	5.2	7.5	—3.2	4.3	6.0	—1.4	4.6	9.7	—5.1	4.6	11.3	—3.1	8.2
				5.5	"	5.2	7.3	—3.3	4.0									
4	12.1	"	5.9	5.5	—0.4	5.1	7.3	—3.4	3.9	4.1	—1.5	2.6	9.0	—5.2	3.8	9.0	—3.0	6.0
				5.6	"	5.2	7.3	—3.5	3.8	3.9	—1.6	2.3						
5	12.9	—6.3	6.6	5.7	—0.5	5.2	7.6	—3.6	4.0	3.9	—1.7	2.2	8.0	—5.3	2.7	7.5	"	4.5
										4.2	—1.8	2.4	7.7	—5.4	2.3	7.1		4.1
6	13.8	"	7.5	8.2	—0.7	7.5	9.2	—3.8	5.4	4.5	—1.9	2.6	7.5	—5.5	2.0	6.5	"	3.5
													8.2	—5.6	2.6	6.5	"	3.5
7	15.0	—6.4	8.6	9.2	—0.8	8.4	11.8	—4.0	7.8	5.3	—2.0	3.3	8.7	—5.7	3.0	6.5	"	3.5
	16.0	"	9.6													7.2	"	4.2
8	16.7	—6.5	10.2	9.9	—1.0	8.9	13.5	—4.2	9.3	8.0	—2.1	5.9	11.2	—5.8	5.4	8.6	"	5.6
	16.4	"	9.9															
9	16.0	—6.6	9.4	11.2	—1.1	10.1	16.0	—4.4	11.6	12.1	—2.2	9.9	16.4	"	10.6	12.8	"	9.8
				11.5	—1.2	10.3	16.2	—4.5	11.7									
10	15.5	—6.7	8.8	11.5	—1.3	10.2	16.2	—4.7	11.5	13.7	—2.4	11.3	16.9	"	11.1	14.9	"	11.9
				11.5	"	10.2	15.5	—4.9	10.6	14.0	—2.5	11.5	17.2	"	11.4			
11	15.0	—6.8	8.2	11.5	—1.4	10.1	14.0	—5.2	8.8	14.0	—2.1	11.9	17.7	"	11.9	16.5	"	13.5
	---			10.5	"	9.1				14.0	—2.7	11.3	17.8	"	12.0			
Noon	8.7	—0.7	8.0	9.5	—1.5	8.0	12.0	—5.5	6.5	13.9	—2.8	11.1	16.0	—5.9	10.1	17.2	—3.0	14.2
							---									17.5	"	14.5
1	7.7	—0.5	7.2	8.7	—1.6	7.1	10.3	?	---	12.6	—2.9	9.7	16.3	"	10.4	17.5	"	14.5
																17.4		14.4
2	5.8	—0.3	5.5	7.7	—1.7	6.0	8.7	"	---	9.4	—3.1	6.3	16.3	—5.8	10.5	16.9	"	13.9
	5.6		5.3															
3	5.6	—0.1	5.5	6.6	—1.9	4.7	6.2	"	---	6.6	—3.2	3.4	16.6	—5.6	11.0	11.0	"	8.0
	5.6	"	5.5															
4	5.6	0.0	5.6	6.3	—2.0	4.3	3.7	0.0	3.7	6.5	—3.4	3.1	12.8	—5.3	7.5	7.7	"	4.7
							3.4	"	3.4	4.9	"	1.5						
5	6.0	"	6.0	6.6	—2.1	4.5	3.5	—0.1	3.4	5.1	—3.5	1.6	11.5	—5.1	6.4	5.0	"	2.0
				7.3	"	5.2				4.9	—3.6	1.3						
6	6.8	"	6.8	7.8	—2.2	5.6	3.9	—0.3	3.6	5.2	—3.7	1.5	10.2	—4.9	5.3	2.9	"	—0.1
													3.5	—4.8	—1.3	2.8	"	—0.2
7	7.6	"	7.6	9.3	—2.3	7.0	4.6	—0.4	4.2	6.9	—3.9	3.0	3.8	—4.7	—0.9	3.2	"	0.2
													5.2	"	0.5			
8	7.7	"	7.7	10.9	—2.4	8.5	6.9	—0.5	6.4	8.6	—4.1	4.5	6.2	—4.6	1.6	5.2	"	2.2
9	8.3	"	8.3	11.4	—2.5	8.9	9.9	—0.6	9.3	12.3	—4.2	8.1	11.6	—4.4	7.2	7.2	"	4.2
				12.0	"	9.5												
10	9.1	"	9.1	12.2	—2.6	9.6	11.2	—0.8	10.4	13.9	—4.3	9.6	12.6	—4.2	8.4	10.5	"	7.5
	9.2	"	9.2	12.0	"	9.4				14.4	"	10.1						
11	9.2	"	9.2	12.0	—2.7	9.3	11.9	—0.9	11.0	14.8	—4.4	10.4	14.6	—4.0	10.6	13.7	"	10.7
	8.7	"	8.7				12.3	"	11.4	15.3	"	10.9						
Midn't	8.4	"	8.4	11.5	—2.8	8.7	11.4	—1.0	10.4	15.2	—4.5	10.7	15.5	—3.7	11.8	15.2	"	12.2

	Fath.	Feet.	Inch.	
March 24. Sounding at noon	6	2	6	
" 25. " "	6	3	6	
" 26. " "	7	0	0	
" 27. No sounding.				
" 28. Sounding at noon	7	4	0	Correction by sounding —6.6, by curve —5.2, mean —5.9
" 29. " "	7	5	6	

SERIES II.—TIDAL OBSERVATIONS FROM JANUARY 28 TO APRIL 7, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

	March, 1854.						April, 1854.											
Mean solar hour.	30th.	Red. to level.	Ref. obs.	31st.	Red. to level.	Ref. obs.	4th.	Red. to level.	Ref. obs.	5th.	Red. to level.	Ref. obs.	6th.	Red. to level.	Ref. obs.	7th.	Red. to level.	Ref. obs.
	15.3	—3.0	12.3							8.3	—3.0	5.3	7.5	—1.7	5.8	7.0	—1.5	5.5
1	15.3	"	12.3	13.8	—3.0	10.8	---			9.6	"	6.6	7.8	"	6.1	7.5	"	6.0
	15.4	"	12.4	14.5	"	11.5												
2	15.5	"	12.5	14.5	"	11.5	---			10.5	—2.9	7.6	8.4	—1.6	6.8	7.5	"	6.0
	15.3	"	12.3	13.2	"	10.2												
3	14.6	"	11.6	12.0	"	9.0	---			11.2	—2.8	8.4	9.6	"	8.0	7.5	"	6.0
4	13.6	"	10.6	9.7	"	6.7	---			11.8	"	9.0	10.0	"	8.4	8.0	"	6.5
5	11.8	"	8.8	7.0	"	4.0	---			12.2	—2.7	9.5	10.4	"	8.8	8.6	"	7.1
										12.4	"	9.7	10.4	"	8.8			
6	9.4	"	6.4	5.6	"	2.6	---			12.4	"	9.7	10.4	"	8.8	9.8	"	8.3
																9.9	"	8.4
7	6.9	"	3.9	5.0	"	2.0	---			11.2	—2.6	8.6	10.4	"	8.8	10.0	"	8.5
				4.7	"	1.7							10.4	"	8.8	10.0	"	8.5
8	6.3	"	3.3	4.5	"	1.5	---			9.2	—2.5	6.7	10.4	"	8.8	10.0	"	8.5
				5.0	"	2.0							10.2	"	8.6	10.0	"	8.5
9	7.2	"	4.2	6.0	"	3.0	---			8.1	"	5.6	10.0	"	8.4	10.0	"	8.5
																10.0	"	8.5
10	10.1	"	7.1	8.0	"	5.0	---			7.4	—2.4	5.0	9.1	"	7.5	9.5	"	8.0
										7.4	"	5.0						
11	12.9	"	9.9	10.1	"	7.1	---			7.4	"	5.0	8.5	"	6.9	8.8	"	7.3
	15.2	"	12.2							7.4	"	5.0						
Noon	16.5	"	13.5	11.9	"	8.9	9.0	—4.0	5.0	8.0	—2.3	5.7	8.0	—1.5	6.5	8.5	—1.5	7.0
	16.1	"	13.1															
1	15.3	"	12.3	14.7	"	11.7	9.7	"	5.7	8.6	"	6.3	7.5	"	6.0	7.0	"	5.5
				16.0	"	13.0										7.0	"	5.5
2	13.3	"	10.3	15.8	"	12.8	11.0	—3.9	7.1	8.9	—2.2	6.7	7.5	"	6.0	7.0	"	5.5
				16.0	"	13.0							7.5	"	6.0	7.0	"	5.5
3	12.3	"	9.3	15.2	"	12.2	11.3	"	7.4	8.9	—2.1	6.8	7.5	"	6.0	7.0	"	5.5
							12.3	—3.8	8.5							7.0	"	5.5
4	8.1	"	5.1	14.7	"	11.7	13.1	"	9.3	8.9	"	6.8	7.5	"	6.0	7.0	"	5.5
							12.9	—3.7	9.2									
5	7.0	"	4.0	12.9	"	9.9	11.7	"	8.0	8.6	—2.0	6.6	7.9	"	6.4	7.5	"	6.0
										8.9	"	6.9						
6	5.5	"	2.5	10.8	"	7.8	9.9	—3.6	6.3	8.9	"	6.9	8.0	"	6.5	8.1	"	6.6
										8.7	—1.9	6.8						
7	4.4	"	1.4	11.5	"	8.5	9.0	"	5.4	8.7	"	6.8	8.0	"	6.5	8.7	"	7.2
	4.3	"	1.3															
8	4.3	"	1.3	8.4	—2.9	5.5	8.0	—3.5	4.5	8.1	"	6.2	8.0	"	6.5	9.0	"	7.5
	4.4	"	1.4	7.0	"	4.1												
9	6.8	"	3.8	6.1	—2.8	3.3	8.2	—3.4	4.8	8.0	—1.8	6.2	8.2	"	6.7	9.0	"	7.5
				7.6	"	4.8	7.8	"	4.4							9.0	"	7.5
10	10.3	"	7.3	8.8	—2.7	6.1	7.5	—3.3	4.2	7.5	"	5.7	7.8	"	6.3	9.0	"	7.5
							7.5	"	4.2	7.5	"	5.7				9.0	"	7.5
11	12.2	"	9.2	11.4	—2.6	8.8	7.5	—3.2	4.3	7.5	"	5.7	7.3	"	5.8	9.0	"	7.5
				12.2	"	9.6	7.7	"	4.5	7.5	"	5.7	7.0	"	5.5			
Midn't	13.1	"	10.1	13.0	—2.5	10.5	8.3	—3.1	5.2	7.5	—1.7	5.8	7.0	"	5.5	9.0	"	7.5
				12.4	"	9.9												

		Fath.	Feet.	Inch.	
March 30.	Sounding at noon	7	4	6	Correction by curves preferred.
" 31.	No sounding,				
April 1–3.	" "				
" 4.	Sounding at noon	6	3	0	Corrections derived from curves, readings (heights) not reliable, see preceding note of April 14.
" 5.	" "	6	2	0	
" 6.	" "	6	2	6	
" 7.	" "	6	2	6	

SERIES III.—TIDAL OBSERVATIONS FROM APRIL 20 TO AUGUST 3, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

April, 1854.

Mean solar hour.	20th.	Red. to level.	Ref. obs.	21st.	Red. to level.	Ref. obs.	22d.	Red. to level.	Ref. obs.	23d.	Red. to level.	Ref. obs.	24th.	Red. to level.	Ref. obs.	25th.	Red. to level.	Ref. obs.
				6.7	—2.2	4.5	7.8	—3.5	4.3									
1				7.3	“	5.1	7.5	“	4.0	10.0	—4.2	5.8	9.4	—4.0	5.4	11.1	—3.5	7.6
							7.5	“	4.0									
2				7.9	—2.3	5.6	7.7	—3.6	4.1	9.9	“	5.7	7.5	“	3.5	8.8	“	5.3
										8.5	“	4.3						
3				9.0	—2.4	6.6	7.9	“	4.3	8.3	“	4.1	6.7	“	2.7	7.5	“	4.0
										8.5	“	4.3	6.5	“	2.5			
4	Irregular.			10.2	“	7.8	8.9	—3.7	5.2	8.7	“	4.5	6.5	—3.9	2.6	6.4	—3.4	3.0
													6.7	“	2.8	5.8	“	2.4
5				11.4	—2.5	8.9	9.7	“	6.0	10.2	“	6.0	7.1	“	3.2	5.0	“	1.6
																6.0	“	2.6
6				12.1	“	9.6	12.2	—3.8	8.4	11.8	“	7.6	8.8	“	4.9	7.0	“	3.6
7				12.5	—2.6	9.9	13.3	“	9.5	13.2	“	9.0	10.5	“	6.6	8.5	“	5.1
				12.6	“	10.0	13.7	“	9.9	14.0	“	9.8						
8				12.5	—2.7	9.8	14.3	—3.9	10.4	14.9	“	10.7	12.9	“	9.0	10.9	—3.3	7.6
							14.0	“	10.1	14.9	“	10.7	15.0	“	11.1			
9	11.3	—1.0	10.3	11.0	—2.8	8.2	13.7	“	9.8	13.0	“	8.8	15.0	“	11.1	13.4	“	10.1
																14.5	“	11.2
10	8.3	—1.1	7.2	9.9	“	7.1	12.3	“	8.4	?8.1	?	- - -	14.9	“	11.0	15.5	“	12.2
																15.3	“	12.0
11	6.7	—1.2	5.5	8.5	—2.9	5.6	11.3	“	7.4	10.7	“	- - -	14.6	“	10.7	14.1	“	10.8
	6.4	“	5.2															
Noon	6.4	—1.3	5.1	7.9	—3.0	4.9	10.7	—4.0	6.7	11.5	—4.3	7.2	12.9	—3.8	9.1	12.5	—3.2	9.3
	6.4	“	5.1	7.4	“	4.4												
1	6.7	“	5.4	7.0	“	4.0	8.7	“	4.7	9.5	“	5.2	10.6	“	6.8	10.3	“	7.1
				7.0	“	4.0												
2	7.1	—1.4	5.7	7.0	—3.1	3.9	8.3	“	4.3	8.3	“	4.0	9.0	“	5.2	8.3	“	5.1
				7.4	“	4.3	8.0	“	4.0									
3	7.9	“	6.5	8.0	“	4.9	8.0	“	4.0	7.2	—4.2	3.0	7.4	“	3.6	6.9	“	3.7
							8.0	“	4.0	6.6	“	2.4						
4	9.0	—1.5	7.5	8.8	—3.2	5.6	8.0	“	4.0	6.1	“	1.9	6.1	—3.7	2.4	5.2	“	2.0
							8.3	“	4.3	6.0	“	1.8	5.4	“	1.7	5.0	“	1.8
5	9.5	“	8.0	8.5	“	5.3	9.0	—4.1	4.9	6.5	—4.1	2.4	5.7	“	2.0	5.0	“	1.8
	9.7	“	8.2													5.0	“	1.8
6	9.7	—1.6	8.1	9.2	—3.3	5.9	10.8	“	6.7	7.5	“	3.4	8.1	“	4.4	5.2	“	2.0
	9.7	“	8.1	10.1	“	6.8												
7	9.5	“	7.9	10.5	“	7.2	11.5	“	7.4	9.3	“	5.2	9.0	“	5.3	7.5	“	4.3
				10.5	“	7.2												
8	8.8	—1.7	7.1	10.5	“	7.2	12.5	“	8.4	10.8	“	6.7	10.4	—3.6	6.8	9.7	—3.1	6.6
				10.5	“	7.2												
9	7.9	—1.8	6.1	10.5	—3.4	7.1	13.0	“	8.9	12.0	“	7.9	13.5	“	9.9	- - -		- - -
				10.0	“	6.6	13.9	“	9.8	12.8	“	8.7	13.5	“	9.9			
10	7.0	—1.9	5.1	9.1	“	5.7	13.9	“	9.8	13.6	—4.0	9.6	13.5	“	9.9	- - -		- - -
							13.0	—4.2	8.8	13.6	“	9.6	12.5	“	8.9			
11	6.9	—2.0	4.9	8.4	“	5.0	12.0	“	7.8	13.0	“	9.0	12.0	“	8.4	- - -		- - -
Midn't	6.9	—2.1	4.8	7.9	—3.5	4.4	11.3	“	7.1	9.0	“	5.0	11.5	—3.5	8.0	- - -		- - -

April 20. No sounding.

		Fath.	Feet.	Inch.	
“ 21.	Sounding at noon	6	1	0	The corrections were deduced from the curves.
“ 22.	“ “	6	3	0	
“ 23.	“ “	6	3	6	
“ 24.	“ “	6	4	5	
“ 25.	“ “	7	0	6	

SERIES III.—TIDAL OBSERVATIONS FROM APRIL 20 TO AUGUST 3, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

	April, 1854.															May, 1854.		
Mean solar hour.	26th.	Red. to level.	Ref. obs.	27th.	Red. to level.	Ref. obs.	28th.	Red. to level.	Ref. obs.	29th.	Red. to level.	Ref. obs.	30th.	Red. to level.	Ref. obs.	1st.	Red. to level.	Ref. obs.
				14.4	"	11.4				16.4	—3.4	13.0	16.4	—3.6	12.8	16.2	"	12.3
1	10.1	—3.0	7.1	14.5	—3.0	11.5	9.2	—3.0	6.2	16.0	"	12.6	15.3	"	11.7	16.5	"	12.6
				14.1	"	11.1										16.5	"	12.6
2	9.1	"	6.1	12.8	"	9.8	7.8	"	4.8	14.9	"	11.5	12.8	"	9.2	15.9	—4.0	11.9
3	7.1	"	4.1	10.5	"	7.5	7.0	"	4.0	13.1	"	9.7	10.3	"	6.7	14.7	"	10.7
	6.3	"	3.3															
4	5.6	"	2.6	8.3	"	5.3	6.0	"	3.0	11.7	"	8.3	7.6	"	4.0	13.4	"	9.4
	5.8	"	2.8				5.3	"	2.3									
5	6.3	"	3.3	6.8	"	3.8	5.0	"	2.0	9.8	"	6.4	6.2	"	2.6	12.2	"	8.2
							5.1	"	2.1				5.5	"	1.9			
6	7.3	"	4.3	4.7	"	1.7	5.7	"	2.7	8.0	"	4.6	6.2	"	2.6	10.0	"	6.0
				4.0	"	1.0												
7	8.5	"	5.5	4.0	"	1.0	6.6	—3.1	3.5	5.9	"	2.5	7.7	"	4.1	8.9	"	4.9
				5.9	"	2.9				5.5	"	2.1						
8	9.4	"	6.4	8.7	"	5.7	7.5	"	4.4	6.2	"	2.8	9.1	"	5.5	8.2	"	4.2
																8.0	"	4.0
9	10.6	"	7.6	10.9	"	7.9	8.8	"	5.7	8.3	"	4.9	10.1	"	6.5	7.9	"	3.9
																8.4	"	4.4
10	11.4	"	8.4	12.7	"	9.7	10.3	"	7.2	10.9	"	7.5	11.2	"	7.6	9.7	"	5.7
11	13.9	"	10.9	14.4	"	11.4	11.7	"	8.6	13.5	"	10.1	13.0	"	9.4	11.9	"	7.9
	14.4	"	11.4	14.5	"	11.5				14.6	"	11.2						
Noon	15.0	"	12.0	15.1	"	12.1	13.7	—3.2	10.5	15.5	—3.5	12.0	14.7	—3.7	11.0	13.1	—4.1	9.0
	14.0	"	11.0	15.2	"	12.2	14.5	"	11.3	14.5	"	11.0	15.0	"	11.3	13.5	"	9.4
1	13.1	"	10.1	15.0	"	12.0	14.8	"	11.6	13.2	"	9.7	14.4	"	10.7	13.0	"	8.9
							14.4	"	11.2									
2	10.7	"	7.7	12.4	"	9.4	14.3	"	11.1	10.9	"	7.4	12.6	"	8.9	11.3	"	7.2
3	8.7	"	5.7	10.3	"	7.3	12.4	"	9.2	9.6	"	6.1	10.2	"	6.5	10.2	—4.2	6.0
4	6.1	"	3.1	7.3	"	4.3	9.2	"	6.0	7.1	"	3.6	8.0	"	4.3	9.8	"	5.6
				6.2	"	3.2							6.3	"	2.6			
5	4.1	"	1.1	5.2	"	2.2	6.0	"	2.8	5.3	—3.5	1.8	5.5	—3.8	1.7	9.1	"	4.9
				5.9	"	2.9				5.0	"	1.5	5.5	"	1.7	8.6	"	4.4
6	3.2	"	0.2	7.7	"	4.7	5.5	"	2.3	5.1	"	1.6	6.2	"	2.4	8.0	"	3.8
	3.1	"	0.1				5.3	"	2.1							8.0	"	3.8
7	4.6	"	1.6	9.6	"	6.6	5.3	—3.3	2.0	7.1	"	3.6	7.6	"	3.8	8.0	—4.3	3.7
							6.1	"	2.8							8.4	"	4.1
8	7.2	"	4.2	10.8	"	7.8	7.8	"	4.5	8.6	"	5.1	8.5	"	4.7	8.8	"	4.5
9	10.7	"	7.7	12.3	"	9.3	10.2	"	6.9	10.4	"	6.9	9.5	"	5.7	10.2	"	5.9
10	12.3	"	9.3	14.0	"	11.0	12.8	"	9.5	13.4	"	9.9	11.3	"	7.5	11.3	"	7.0
11	14.2	"	11.2	15.7	?	---	14.8	"	11.5	15.3	"	11.8	13.9	—3.9	10.0	12.7	"	8.4
										16.2	"	12.7						
Midn't	14.3	"	11.3	16.7	"	---	15.5	—3.3	12.2	16.4	"	12.9	15.4	"	11.5	14.1	—4.4	9.7

		Fath.	Feet.	Inch.	
April 26.	Sounding at noon	7	3	0	Corrections deduced from the curves.
" 27.	" "	7	3	2	" " " "
" 28–30.	No sounding.				
May 1.	Sounding at noon	7	4	0	

SERIES III.—TIDAL OBSERVATIONS FROM APRIL 20 TO AUGUST 3, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

May, 1854.

Mean solar hour.	2d.	Red. to level.	Ref. obs.	3d.	Red. to level.	Ref. obs.	4th.	Red. to level.	Ref. obs.	7th.	Red. to level.	Ref. obs.	8th.	Red. to level.	Ref. obs.	9th.	Red. to level.	Ref. obs.
										10.2	—4.2	6.0	10.5	—4.8	5.7			
1	15.1	—4.4	10.7	13.2	“	8.5	13.6	—5.2	8.4	10.2	“	6.0	10.0	“	5.2	10.7	—5.5	5.2
										10.5	“	6.3	11.5	“	6.7	10.0	“	4.5
2	16.7	“	12.3	14.0	“	9.3	14.0	—5.3	8.7	10.8	“	6.6	11.5	—4.9	6.6	10.0	—5.6	4.4
	16.8	“	12.4													10.5	“	4.9
3	16.5	“	12.1	14.2	“	9.5	14.8	—5.4	9.4	11.3	“	7.1	11.8	“	6.9	11.3	“	5.7
				14.3	“	9.6												
4	14.2	—4.5	9.7	14.3	“	9.6	16.1	—5.6	10.5	11.8	“	7.6	12.4	“	7.5	12.6	—5.7	6.9
				14.2	“	9.5												
5	12.5	“	8.0	14.1	“	9.4	16.2	—5.8	10.4	12.4	“	8.2	13.0	“	8.1	14.3	“	8.6
6	11.0	“	6.5	13.1	“	8.4	16.2	—6.0	10.2	13.2	—4.3	8.9	14.1	—5.0	9.1	15.6	“	9.9
							15.7	—6.1	9.6									
7	8.4	“	3.9	12.0	“	7.3	15.3	—6.3	9.0	13.2	“	8.9	16.2	“	11.2	16.4	—5.8	10.6
																16.9	“	11.1
8	6.7	“	2.2	10.9	“	6.2				13.0	“	8.7	16.0	“	11.0	17.2	—5.9	11.3
	6.4	“	1.9	10.2	“	5.5							16.5	“	11.5	17.2	“	11.3
9	6.4	—4.6	1.8	10.0	“	5.3				12.2	“	7.9	16.5	—5.1	11.4	17.2	—6.0	11.2
				10.3	“	5.6							16.3	“	11.2	16.6	“	10.6
10	7.4	“	2.8	10.5	“	5.8				11.0	“	6.7	16.0	“	10.9	16.0	—6.1	9.9
				10.8	“	6.1												
11	9.5	“	4.9	11.0	“	6.3				10.2	“	5.9	15.1	“	10.0	14.9	—6.2	8.7
Noon	11.3	—4.7	6.6	11.4	4.7	6.7				9.0	—4.4	4.6	14.1	—5.2	8.9	13.8	—6.3	7.5
1	13.1	“	8.4	12.8	“	8.1				8.1	“	3.7	13.0	“	7.8	?	“	---
				13.4	“	8.7				8.0	“	3.6						
2	14.9	“	10.2	13.8	“	9.1	Readings irregular.			8.0	“	3.6	10.6	“	5.7	11.2	“	4.9
	15.0	“	10.3	13.8	“	9.1				8.0	“	3.6						
3	14.5	“	9.8	13.8	“	9.1				8.4	“	4.0	9.0	—5.3	3.7	10.0	—6.2	3.8
				13.8	“	9.1							8.4	“	3.1	9.3	“	3.1
4	13.6	“	8.9	13.8	“	9.1				9.0	—4.5	4.5	8.0	“	2.7	8.0	“	1.8
				13.1	“	8.4							8.7	“	3.4	8.0	“	1.8
5	12.6	“	7.9	12.7	“	8.0				9.8	“	5.3	9.0	—5.4	3.6	8.9	“	2.7
6	10.1	“	5.4	12.1	—4.8	7.3				10.3	“	5.8	10.2	“	4.8	11.2	—6.1	5.1
7	9.5	“	4.8	11.8	“	7.0				11.0	—4.6	6.4	11.6	“	6.2	13.0	“	6.9
8	9.0	“	4.3	11.6	—4.9	6.7				11.3	“	6.7	12.3	“	6.9	14.2	“	8.1
	9.0	“	4.3	11.6	“	6.7												
9	9.0	“	4.3	11.4	“	6.5				12.0	“	7.4	12.9	“	7.5	15.5	“	9.4
	9.1	“	4.4	11.6	“	6.7				12.5	“	7.9	13.3	“	7.9			
10	9.5	“	4.8	12.0	—5.0	7.0				12.5	—4.7	7.8	13.5	“	8.1	14.6	“	8.5
										12.5	“	7.8	13.5	“	8.1			
11	10.1	“	5.4	12.7	“	7.7				12.0	“	7.3	13.3	“	7.9	14.0	“	7.9
Midn't	11.1	“	6.4	13.3	—5.1	8.2				10.5	—4.8	5.7	12.7	—5.5	7.2	13.5	—6.0	7.5

		Fath.	Feet.	Inch.	
May 2.	Sounding at noon	7	1	0	Correction derived from sounding and curves.
“ 3.	“ “	7	2	0	“ “ “ “ “
“ 4.	“ “	7	1	0	
“ 5.	“ “	6	5	0	From this day there is but one reading at each half hour.
“ 6.	No sounding.				
“ 7.	Sounding at noon	6	3	0	
“ 8.	“ “	7	2	0	
“ 9.	“ “	7	1	6	Correction from sounding and curves.

SERIES III.—TIDAL OBSERVATIONS FROM APRIL 20 TO AUGUST 3, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

May, 1854.

Mean solar hour.	10th.	Red. to level.	Ref. obs.	11th.	Red. to level.	Ref. obs.	12th.	Red. to level.	Ref. obs.	13th.	Red. to level.	Ref. obs.	14th.	Red. to level.	Ref. obs.	15th.	Red. to level.	Ref. obs.
				17.0	“	10.8										20.6	—6.7	13 9
1	12.5	—6.0	6.5	16.5	—6.3	10.2	17.4	—6.3	11.1	17.3	—6.5	10.8	18.3	—6.7	11.6	20.6	“	13.9
																19.7	“	13.0
2	9.8	“	3.8	13.7	“	7.4	16.0	“	9.7	16.1	“	9.6	16.2	“	9.5	18.8	“	12.1
3	9.5	“	3.5	11.5	“	5.2	13.7	“	7.4	15.3	“	8.8	12.3	“	5.6	17.6	“	10.9
4	8.3	“	2.3	9.6	“	3.3	10.8	“	4.5	14.0	“	7.5	9.9	“	3.2	16.5	“	9.8
	8.2	“	2.2	8.2	“	1.9												
5	8.0	“	2.0	8.3	“	2.0	8.4	“	2.1	---		---	---		---	15.4	“	8.7
	8.0	“	2.0				7.3	“	1.0									
6	8.0	“	2.0	9.5	“	3.2	7.3	“	1.0	---		---	---		---	10.4	“	3.7
	8.5	—6.1	2.4				9.2	“	2.9									
7	9.2	“	3.1	11.8	“	5.5	10.4	“	4.1	---		---	---		---	9.0	“	2.3
																8.4	“	1.7
8	11.7	“	5.6	15.4	“	9.1	12.3	“	6.0	---		---	---		---	9.0	“	2.3
9	12.5	“	6.4	15.0	“	8.7	14.2	“	7.9	16.5	—6.6	9.9	12.3	“	5.6	10.4	“	3.7
10	14.4	“	8.3	16.0	“	9.7	15.4	“	9.1	18.4	“	11.8	13.5	“	6.8	12.6	“	5.9
	15.0	“	8.9	16.8	“	10.5				19.0	“	12.4						
11	15.0	“	8.9	16.8	“	10.5	16.0	“	9.7	19.0	“	12.4	15.2	“	8.5	14.5	“	7.8
	14.2	“	8.1	16.8	“	10.5	16.5	“	10.2	18.4	“	11.8	17.8	“	11.1			
Noon	13.4	—6.2	7.2	16.0	—6.3	9.7	17.2	—6.2	11.0	18.0	—6.7	11.3	18.0	“	11.3	16.6	“	9.9
							16.9	“	10.7				17.4	“	10.7			
1	12.3	“	6.1	14.6	“	8.3	16.4	“	10.0	16.4	“	9.7	16.6	“	9.9	18.9	“	12.2
																19.0	“	12.3
2	10.3	“	4.1	13.0	“	6.7	13.4	“	7.2	14.4	“	7.7	14.7	“	8.0	19.0	“	12.3
	9.7	“	3.5													18.1	“	11.4
3	8.4	“	2.2	12.1	“	5.8	9.0	“	2.8	12.0	“	5.3	12.5	“	5.8	17.3	“	10.6
	8.4	“	2.2				8.3	“	2.1									
4	8.4	“	2.2	9.7	“	3.4	7.2	—6.3	0.9	9.8	“	3.1	10.6	“	3.9	15.5	“	8.8
	9.2	“	3.0	8.6	“	2.3				8.9	“	2.2						
5	10.3	“	4.1	7.6	“	1.3	7.2	“	0.9	8.0	“	1.3	9.0	“	2.3	12 3	“	5.6
				9.2	“	2.9	8.1		1.8	8.0	“	1.3	8.2	“	1.5			
6	11.0	“	4.8	10.3	“	4.0	9.5	“	3.2	9.3	“	2.6	7.5	“	0.8	10.3	“	3.6
													7.5	“	0.8			
7	12.7	“	6.5	12.4	“	6.1	10.7	“	4.4	11.1	“	4.4	8.0	“	1.3	7.9	“	1.2
																7.5	“	0.8
8	14.5	“	8.3	15.0	“	8.7	13.7	—6.4	7.3	12.9	“	6.2	10.2	“	3.5	7.2	“	0.5
																7.2	“	0.5
9	15.4	“	9.2	17.4	“	11.1	15.5	“	8.1	14.5	“	7.8	11.8	“	5.1	9.3	“	2.6
10	16.2	“	10.0	19.5	“	13.2	18.2	“	11.8	17.4	“	10.7	14.7	“	8.0	12.1	—6.8	5.3
				20.0	“	13.7												
11	17.1	“	10.9	20.0	“	13.7	19.5	“	13.1	20.3	“	13.6	18.2	“	11.5	16.5	—6.9	9.6
	17.8	“	11.6	19.6	“	13.3				20.1	“	13.4						
Midn't	18.0	“	11.8	18.8	“	12.5	19.5	“	13.1	20.1	“	13.4	20.2	“	13.5	19.0	—7.0	12.0

May 10 and 11. No sounding.
“ 12. Sounding at noon 8 fathoms (last sounding recorded). Correction by sounding and curves.

Series III.—Tidal Observations from April 20 to August 3, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

May, 1854.

Mean solar hour.	16th.	Ref. obs.	17th.	Ref. obs.	18th.	Ref. obs.	19th.	Ref. obs.	20th.	Ref. obs.	21st.	Ref. obs.	22d.	Ref. obs.	23d.	Ref. obs.	24th.	Ref. obs.
	19.6	12.4							12.0	5.2			10.3	3.4				
1	19.6	12.4	18.0	10.8	17.6	10.4	14.0	6.9	12.3	5.5	12.0	5.2	10.3	3.4	13.0	5.6	16.2	7.5
	19.0	11.8									11.6	4.8	10.3	3.4				
2	18.5	11.3	19.4	11.2	19.0	11.8	15.0	7.9	13.2	6.4	11.2	4.4	10.3	3.4	12.2	4.8	15.1	6.3
			20.0	12.8	19.7	12.5					11.2	4.4	10.3	3.4	11.3	3.8		
3	17.0	9.8	20.0	12.8	19.7	12.5	16.4	9.3	14.1	7.3	12.5	5.7	10.8	3.9	11.0	3.5	14.2	5.4
			18.9	11.7	19.7	12.5									11.5	4.0	13.8	4.9
4	16.0	8.8	18.0	10.8	19.7	12.5	17.7	10.6	15.2	8.5	14.2	7.4	11.5	4.6	12.0	4.4	13.0	4.1
					19.7	12.5	18.8	11.7									13.0	4.0
5	14.4	7.2	16.2	9.0	19.7	12.5	18.8	11.7	15.5	8.8	15.6	8.8	13.8	5.9	13.7	6.1	13.0	4.0
					18.6	11.4	18.8	11.7									13.5	4.5
6	12.5	5.3	14.3	7.1	17.8	10.6	18.8	11.7	15.5	8.8	16.8	10.0	15.2	8.2	15.2	7.5	14.2	5.1
							18.0	11.0	16.5	9.8	17.4	10.6	16.5	9.5				
7	10.0	2.8	12.6	5.4	15.8	8.6	17.4	10.4	16.5	9.8	17.9	11.1	17.6	10.6	17.2	9.5	16.6	7.5
	9.5	2.3							16.5	9.8	17.9	11.1	17.6	10.6	18.2	10.4	17.8	8.6
8	9.0	1.8	11.3	4.1	14.3	7.1	16.0	9.0	16.5	9.8	17.9	11.1	17.6	10.6	19.1	11.3	18.6	9.4
	9.7	2.5	10.2	3.0					15.8	9.1	17.6	10.8	17.6	10.6	19.1	11.2	18.1	9.9
9	10.0	2.8	9.0	1.8	13.0	5.8	14.4	7.4	14.9	8.2	17.0	10.2	17.0	10.6	18.7	10.8	17.8	8.5
			10.2	3.0														
10	10.9	3.7	11.1	3.9	10.0	2.8	12.4	5.4	13.6	6.9	15.7	8.9	16.5	9.5	17.5	9.5	16.7	7.4
					9.0	1.8												
11	12.4	5.2	13.4	6.2	9.0	1.8	11.7	4.7	12.8	6.1	14.6	7.8	15.1	8.1	16.0	8.0	15.1	5.8
					10.3	3.1	10.6	3.6										
Noon	14.3	7.1	14.6	7.4	11.6	4.4	10.0	3.0	12.1	5.4	12.8	6.0	13.7	6.7	15.3	7.3	14.5	5.2
							10.5	3.5										
1	16.2	9.0	15.9	8.7	14.0	6.8	10.8	3.8	11.5	4.8	11.2	4.4	12.0	5.0	14.2	6.2	13.8	4.5
	17.0	9.8									10.8	4.0						
2	17.6	10.4	17.6	10.4	15.2	8.0	11.8	4.8	11.0	4.3	10.5	3.7	11.0	4.0	13.0	5.0	13.1	3.8
	17.6	10.4	17.8	10.6					10.5	3.8	10.5	3.7	10.4	3.4				
3	17.6	10.4	17.8	10.6	16.3	9.1	12.8	5.8	10.5	3.8	10.5	3.7	9.5	2.5	12.0	3.9	12.1	2.8
			16.7	9.5	16.8	9.6			10.5	3.8	11.0	4.2	9.5	2.5	11.5	3.4	12.1	2.8
4	16.3	9.1	16.0	8.8	16.8	9.6	14.2	7.2	10.8	4.1	11.7	4.9	11.0	4.0	11.5	3.3	11.3	2.0
					15.8	8.6									11.5	3.3	11.3	2.0
5	14.4	7.2	14.0	6.8	15.6	8.4	15.7	8.7	12.7	6.0	12.6	5.8	11.7	4.7	12.4	4.0	12.5	3.2
							16.5	9.5										
6	12.0	4.8	12.8	5.6	14.0	6.8	17.2	10.2	14.3	7.6	13.7	6.9	13.1	6.1	14.0	5.6	14.2	4.9
	10.8	3.6					17.2	10.2										
7	9.5	2.3	10.6	3.4	13.3	6.1	16.5	9.5	14.9	8.2	14.5	7.7	14.1	7.0	15.5	7.0	16.5	7.3
	9.5	2.3	10.0	2.8					15.2	8.5	15.0	8.2						
8	9.8	2.6	9.2	2.0	12.4	5.2	15.7	8.7	15.4	8.7	15.4	8.6	16.4	9.3	16.6	8.1	18.4	9.2
			9.2	2.0	12.0	4.9			15.4	8.7	15.4	8.6	16.5	9.3				
9	11.7	4.5	10.4	3.2	11.3	4.2	15.0	8.1	15.4	8.7	15.4	8.6	16.5	9.3	18.3	9.7	19.4	10.2
					11.3	4.2			14.6	7.9	15.2	8.4	16.5	9.3	19.4	10.8		
10	13.5	6.3	12.0	4.8	11.5	4.4	14.0	7.1	14.2	7.4	14.7	7.9	16.5	9.3	20.0	11.4	20.1	10.9
					11.8	4.7							16.5	9.2	20.0	11.4		
11	15.3	8.1	13.6	6.4	12.4	5.3	13.0	6.1	13.3	6.5	14.0	7.2	16.3	9.0	19.2	10.6	21.4	12.2
																	22.1	12.9
Midn't	16.7	9.5	14.8	7.6	12.8	5.7	12.5	5.7	12.4	5.6	12.6	5.8	15.0	7.7	18.0	9.3	22.1	12.9

From about the middle of May to the end of the series the corrections change very little from day to day, and are given below:—

May 16.	Correction	—7.2
" 17.	"	—7.2
" 18.	"	—7.2
" 19.	"	—7.0
" 20.	"	—6.7
May 21.	Correction	—6.8
" 22.	"	—7.0
" 23.	"	—8.0
" 24.	"	—9.3

SERIES III.—TIDAL OBSERVATIONS FROM APRIL 20 TO AUGUST 3, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

Mean solar hour.	May, 1854. 25th.	Ref. obs.	26th.	Ref. obs.	27th.	Ref. obs.	28th.	Ref. obs.	29th.	Ref. obs.	30th.	Ref. obs.	31st.	Ref. obs.	June, 1854. 1st.	Ref. obs.	2d.	Ref. obs.
	19.8	10.6	17.4	8.5	21.2	12.5	19.0	10.7			19.0	11.5						
1	19.0	9.8	16.6	7.7	21.2	12.5	19.0	10.7	18.4	10.8	19.5	12.0	16.4	8.9	18.2	10.7	15.4	8.0
					19.6	10.9	18.6	10.4			18.6	11.1			18.4	10.9		
2	17.0	7.9	14.3	5.4	18.7	10.1	17.3	9.1	16.4	8.8	18.1	10.6	17.9	10.4	18.5	11.0	16.1	8.7
													18.5	11.0	18.5	11.0		
3	14.5	5.4	12.4	3.6	16.0	7.4	15.5	7.4	14.3	6.7	17.2	9.5	19.0	11.5	18.2	10.7	17.0	9.6
			11.8	3.0									19.0	11.5			17.2	9.8
4	12.0	2.9	11.5	2.7	14.7	6.1	12.4	4.3	12.1	4.5	16.1	8.6	18.2	10.7	17.8	10.3	17.2	9.8
	11.0	2.0	11.5	2.7													17.2	9.8
5	11.0	2.0	11.5	2.7	12.5	3.9	10.8	2.8	10.0	2.5	14.3	6.8	17.2	9.7	16.2	8.7	17.0	9.7
	11.0	2.0	11.5	2.7	11.2	2.6	10.0	2.0	9.0	1.5								
6	11.5	2.5	11.5	2.7	11.0	2.4	9.5	1.6	9.0	1.5	12.4	4.9	14.9	7.4	14.3	6.8	15.6	8.3
			11.8	3.0	11.0	2.4	9.5	1.6	9.0	1.5								
7	13.5	4.5	12.5	3.7	12.4	3.8	9.5	1.6	9.0	1.5	10.2	2.7	12.9	5.4	13.4	5.9	14.2	6.9
							9.5	1.6	9.0	1.5	10.0	2.5						
8	15.1	6.1	14.3	5.5	14.1	5.5	10.1	2.3	9.0	1.5	10.0	2.5	12.0	4.5	12.6	5.1	12.8	5.5
									9.0	1.5	10.0	2.5	11.2	3.7	12.0	4.5		
9	17.4	8.4	15.2	6.4	15.2	6.7	11.7	3.9	10.2	2.7	10.0	2.5	10.0	2.5	11.5	4.0	12.0	4.7
	18.2	9.2									11.3	3.8	10.0	2.5	11.5	4.0	11.3	4.0
10	19.0	10.0	16.3	7.5	17.3	8.8	13.0	5.2	12.4	4.9	12.4	4.9	10.5	3.0	11.5	4.0	11.0	3.7
	19.0	10.0			18.2	9.7									11.5	4.0	11.0	3.7
11	18.4	9.4	17.2	8.4	18.2	9.7	14.7	6.9	14.4	6.9	13.8	6.3	12.6	5.1	12.0	4.5	11.0	3.7
					18.0	9.5	15.4	7.6									11.5	4.2
Noon	16.0	7.0	18.4	9.6	17.5	9.0	16.5	8.7	15.5	8.0	14.9	7.4	13.7	6.2	13.0	5.5	11.8	4.5
			18.5	9.7			15.7	7.9	16.0	8.5								
1	15.0	6.0	18.5	9.7	16.6	8.1	15.1.	7.3	16.0	8.5	15.3	7.8	14.8	7.3	14.5	7.0	12.4	5.1
			17.7	8.9					15.6	8.1	16.0	8.5	15.4	7.9				
2	14.0	5.0	17.1	8.3	14.2	5.7	13.5	5.7	15.1	7.6	16.0	8.5	16.0	8.5	14.6	7.1	12.8	5.5
											16.0	8.5	16.0	8.5				
3	13.2	4.2	16.0	7.2	12.3	3.8	11.7	3.9	14.2	6.7	16.0	8.5	16.0	8.5	15.0	7.5	13.5	6.2
					9.6	1.1	10.8	3.1			15.2	7.7	15.4	7.9	15.5	8.0		
4	12.0	3.0	14.8	6.0	9.0	0.5	10.0	2.3	12.3	4.8	14.2	6.7	15.0	7.5	15.5	8.0	14.4	7.2
	11.4	2.4			9.0	0.5	10.0	2.3							15.5	8.0	15.0	7.8
5	11.0	2.0	13.6	4.8	9.5	1.0	10.0	2.3	11.6	4.1	12.8	5.3	13.5	6.0	15.5	8.0	15.0	7.8
	11.0	2.0	13.0	4.2			10.0	2.3			11.2	3.7			15.2	7.7	14.3	7.1
6	11.0	2.0	12.2	3.4	10.0	1.5	11.3	3.6	10.2	2.7	10.0	2.5	12.7	5.2	15.0	7.6	14.0	6.8
	12.1	3.1	12.2	3.4					9.5	2.0	10.0	2.5						
7	13.3	4.3	12.2	3.4	10.4	1.9	12.3	4.6	9.1	1.6	10.0	2.5	11.7	4.2	14.2	6.8	13.4	6.2
			12.6	3.9					9.1	1.6	10.0	2.5	11.5	4.0				
8	15.7	6.8	13.2	4.5	12.0	3.6	14.2	6.5	9.1	1.6	11.0	3.5	11.0	3.5	13.0	5.6	12.8	5.6
									10.2	2.7			11.0	3.5				
9	17.4	8.5	15.3	6.6	14.2	5.8	15.0	7.3	11.3	3.8	13.0	5.5	11.0	3.5	12.0	4.6	12.4	5.2
													11.5	4.0	11.4	4.0	12.0	4.8
10	19.5	10.6	17.6	8.9	16.4	8.0	16.1	8.4	13.7	6.2	14.4	6.9	12.0	4.5	11.0	3.6	12.0	4.8
	19.7	10.8													11.5	4.1	12.0	4.8
11	19.7	10.8	19.4	10.7	18.1	9.8	17.4	9.7	16.2	8.7	15.1	7.6	14.2	6.7	12.2	4.8	12.0	4.8
			20.1	11.4	18.7	10.4	18.0	10.3									12.3	5.1
Midn't	19.7	10.8	20.1	11.4	19.0	10.7	18.6	10.9	17.4	9.9	16.2	8.7	15.8	8.3	14.3	6.9	12.7	5.5,

May 25. Correction —9.0
" 26. " —8.8
" 27. " —8.5
" 28. " —7.8
" 29. " —7.5

May 30. Correction —7.5
" 31. " —7.5
June 1. " —7.5
" 2. " —7.3

SERIES III.—TIDAL OBSERVATIONS FROM APRIL 20 TO AUGUST 3, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

June, 1854.

Mean solar hour.	3d.	Ref. obs.	4th.	Ref. obs.	5th.	Ref. obs.	6th.	Ref. obs.	7th.	Ref. obs.	8th.	Ref. obs.	9th.	Ref. obs.	10th.	Ref. obs.	11th.	Ref. obs.
																	18.0	9.5
1	14.2	7.1	13.0	6.3	12.4	6.0	12.5	6.1	12.3	5.6	12.8	5.5	---	---	16.4	8.2	19.0	10.5
							12.5	6.1									19.9	11.4
2	15.8	8.7	14.0	7.4	12.8	6.4	12.5	6.1	12.5	5.8	11.8	4.4	---	---	14.9	6.7	18.0	9.5
							12.9	6.5			11.4	4.0	---	---				
3	16.4	9.3	15.2	8.6	13.8	7.4	13.6	7.2	12.0	5.3	11.4	4.0	---	---	12.1	3.9	15.2	6.7
4	16.6	9.6	16.0	9.4	15.2	8.8	14.2	7.8	11.0	4.3	14.5	7.0	---	---	12.0	3.7	13.2	4.6
5	---	---	---	---	15.4	9.0	14.8	8.4	15.6	8.8	14.7	7.4	---	---	10.4	2.1	10.4	1.8
6	---	---	---	---	15.8	9.4	15.0	8.6	16.0	9.2	15.0	7.7	---	---	10.9	2.6	10.4	1.8
7	---	---	---	---	16.0	9.6	15.6	9.2	17.0	?	15.6	8.2	---	---	11.5	3.2	10.4	1.8
8	---	---	---	---	16.1	9.7	16.0	9.6	15.5	8.7	16.8	9.3	---	---	11.1	?	13.2	4.6
9	11.5	4.5	---	---	14.1	7.7	16.5	10.1	17.1	10.2	16.6	9.1	---	---	---	---	16.0	7.4
							15.5	9.1	16.8	9.9								
10	12.0	5.0	---	---	12.2	5.8	14.8	8.4	15.5	8.5	16.2	8.6	16.0	8.0	20.0	11.7	18.0	9.4
															19.2	10.9		
11	12.5	5.5	---	---	11.5	5.1	14.5	8.1	14.5	7.5	13.4	5.8	13.9	5.9	18.0	9.7	18.0	9.4
					11.3	4.9												
Noon	13.0	6.0	---	---	11.1	4.7	13.3	6.9	12.9	5.9	12.5	4.9	12.6	4.6	17.6	9.3	17.2	8.6
					11.1	4.7												
1	13.5	6.5	---	---	11.1	4.7	11.6	5.2	11.9	4.9	11.8	4.2	12.0	4.0	16.4	8.1	16.8	8.2
					11.2	4.8	10.8	4.4			10.4	2.7	10.3	2.3				
2	14.0	7.0	11.4	5.0	11.2	4.8	10.5	4.0	11.4	4.4	9.5	1.8	11.0	3.0	14.7	6.4	16.0	7.4
							10.5	4.0	10.5	3.5								
3	14.5	7.6	12.4	6.0	11.4	5.0	10.5	4.0	10.5	3.4	9.5	1.8	9.4	1.4	13.2	4.9	15.0	6.4
	15.0	8.1					10.9	4.4	11.5	4.4	9.8	2.1						
4	15.0	8.1	13.6	7.2	12.4	6.0	11.4	4.9	12.6	5.5	10.5	2.8	10.3	2.3	11.7	3.3	14.2	5.6
	15.0	8.1																
5	14.8	8.0	14.4	8.0	13.6	7.2	13.2	6.6	14.0	6.9	11.9	4.1	11.4	3.4	10.2	1.8	12.9	4.3
															9.6	1.2		
6	14.6	7.8	14.4	8.0	14.8	8.4	14.8	8.2	14.7	7.5	13.1	5.3	12.6	4.5	9.0	0.6	12.0	3.4
																	10.6	2.0
7	14.0	7.2	15.0	8.6	14.4	8.0	16.2	9.6	17.0	9.8	14.0	6.2	16.4	8.3	12.0	3.6	11.5	2.8
8	13.4	6.6	15.0	8.6	15.2	8.8	17.0	10.4	18.0	10.8	16.2	8.4	19.5	11.4	15.4	7.0	13.6	4.9
9	13.0	6.2	14.0	7.6	15.6	9.2	16.6	10.0	18.4	11.1	18.6	10.8	21.0	12.9	---	---	16.2	7.5
	12.0	5.2																
10	12.0	5.2	13.0	6.6	14.6	8.2	16.2	9.6	18.0	10.7	19.4	11.6	20.6	12.5	---	---	19.2	10.5
	12.0	5.2																
11	12.3	5.6	12.5	6.1	13.2	6.8	16.2	9.6	17.2	9.9	19.0	11.2	20.0	11.9	---	---	20.2	11.5
Midn't	13.0	6.3	12.0	5.6	12.6	6.2	15.2	8.6	14.0	6.7	18.0	10.2	---	---	---	---	21.4	12.6

June 3. Correction —7.0
" 6. " —6.4
" 9. " —8.0
" 10. " —8.3
" 11. " —8.6

June 4. Correction —6.4
" 7. " —7.0

June 5. Correction —6.4
" 8. " —7.6

The record on this day is defective.

Readings between the full hours are less frequent than before, and are generally [given only near high or low water.

SERIES III.—TIDAL OBSERVATIONS FROM APRIL 20 TO AUGUST 3, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

June, 1854.

Mean solar hour.	12th.	Ref. obs.	13th.	Ref. obs.	14th.	Ref. obs.	15th.	Ref. obs.	16th.	Ref. obs.	17th.	Ref. obs.	18th.	Ref. obs.	19th.	Ref. obs.	20th.	Ref. obs.
			21.0	12.1			19.2	10.4										
1	22.0	13.2	21.0	12.1	21.0	12.1	20.1	11.3	16.0	7.3	17.3	8.6	14.4	6.1	14.0	6.2	13.5	5.8
	21.5	12.7			21.0	12.1											13.0	5.3
2	19.8	11.0	19.9	11.0	21.0	12.1	21.1	12.3	17.2	8.5	18.6	9.9	15.6	7.3	15.1	7.4	12.9	5.2
							21.1	12.3			19.2	10.5					12.9	5.2
3	18.5	9.7	18.2	9.3	20.2	11.3	21.1	12.3	19.0	10.3	20.0	11.4	17.0	8.7	15.9	8.2	14.0	5.3
							20.9	12.1	20.0	11.3								
4	15.2	6.4	18.0	9.1	19.6	10.7	20.2	11.5	20.4	11.7	19.9	11.3	18.2	9.9	16.2	8.6	14.0	6.2
5	12.5	3.7	13.2	4.3	15.3	6.4	16.3	7.6	19.0	10.3	17.6	9.0	18.4	10.2	18.0	10.4	15.6	7.8
6	10.4	1.6	11.6	2.7	12.2	3.3	14.4	5.7	16.8	8.1	16.4	7.8	18.0	9.8	18.1	10.5	16.4	8.6
7	10.4	1.6	10.0	1.1	10.5	1.6	11.5	2.8	14.3	5.6	14.2	5.6	17.5	9.3	18.0	10.4	17.6	9.8
8	13.2	4.4	10.0	1.1	10.5	1.6	10.8	2.1	12.8	4.1	12.4	3.8	17.0	8.8	17.8	10.2	17.7	9.9
			9.1	0.2			10.4	1.7			11.6	3.0						
9	15.5	6.7	10.0	1.1	12.6	3.7	10.0	1.3	11.4	2.7	11.4	2.8	13.4	5.3	15.6	8.0	17.6	9.8
							11.0	2.3	11.2	2.5								
10	16.6	7.8	12.2	3.3	14.0	5.1	12.0	3.3	11.4	2.5	12.2	3.6	12.5	4.4	15.0	7.4	16.5	8.7
11	18.6	9.8	16.4	7.5	16.0	7.1	14.5	5.8	13.0	4.3	12.6	4.0	11.6	3.6	14.0	6.4	14.8	7.0
	19.2	10.4											11.2	3.2				
Noon	17.6	8.8	18.4	9.5	17.6	8.7	16.2	7.5	14.6	5.9	14.5	5.9	11.4	3.4	13.0	5.4	14.5	6.7
			19.2	10.3	19.2	10.3	16.5	7.8										
1	15.8	7.0	19.2	10.3	19.1	10.2	17.2	8.5	15.9	7.2	15.9	7.3	12.0	4.0	12.0	4.4	14.0	6.2
			19.2	10.3			17.2	8.5	16.8	8.1					11.6	4.0		
2	13.8	5.0	18.9	10.0	19.1	10.2	17.2	8.5	17.6	8.9	17.3	8.7	13.3	5.3	12.0	4.4	13.6	5.8
							16.2	7.5	16.9	8.2	17.9	9.3						
3	13.0	4.2	17.6	8.7	17.4	8.5	15.5	6.8	16.2	7.5	17.5	8.9	16.6	8.6	13.0	5.4	13.0	5.2
																	12.2	4.4
4	11.6	2.8	16.2	7.3	16.0	7.1	15.0	6.3	15.5	6.8	17.0	8.4	16.3	8.3	14.0	6.4	12.4	4.6
													16.0	8.0				
5	10.3	1.5	14.8	5.9	14.2	5.3	13.4	4.7	14.8	6.1	16.6	8.0	18.5	10.5	15.0	7.4	14.0	6.1
	9.6	0.8											15.0	7.0				
6	9.2	0.4	14.2	5.3	13.0	4.1	12.6	3.9	14.6	5.9	16.1	7.5	14.3	6.3	16.5	8.9	15.0	7.1
	9.6	0.8			10.4	1.5												
7	10.2	1.4	14.0	5.1	10.4	1.5	11.6	3.9	14.2	5.5	15.8	7.2	13.2	5.2	17.4	9.8	16.7	8.8
					10.4	1.5	11.2	2.5							17.6	10.0		
8	12.4	3.6	10.0	1.1	10.2	1.3	11.0	2.3	12.8	4.1	15.2	6.7	13.6	5.6	17.4	9.8	17.8	9.9
			11.0	2.1	10.6	1.7	11.2	2.5										
9	15.0	6.2	12.0	3.1	11.0	2.1	11.4	2.7	12.4	3.7	14.2	5.7	14.3	6.3	16.8	9.1	18.4	10.5
10	18.5	9.7	15.0	6.1	12.4	3.6	13.6	4.9	13.0	4.3	13.4	4.9	15.0	?	15.5	7.8	18.5	10.5
11	21.0	12.2	18.0	9.1	15.0	6.2	15.0	6.3	14.0	5.3	13.0	4.6	14.0	6.2	14.5	6.8	16.9	8.9
Midn't	---	---	20.4	11.5	18.0	9.2	---	---	15.2	6.5	13.0	4.6	13.4	5.6	14.3	6.6	15.6	7.6

June 12. Correction —8.8 The record on this day is defective, the times being uncertain.

" 13. " —8.9

" 15. " —8.7

" 17. " —8.6

" 19. " —7.6

June 14. Correction —8.9

" 16. " —8.7

" 18. " —8.0

" 20. " —7.8

SERIES III.—TIDAL OBSERVATIONS FROM APRIL 20 TO AUGUST 3, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

June, 1854.

Mean solar hour.	21st.	Ref. obs.	22d.	Ref. obs.	23d.	Ref. obs.	24th.	Ref. obs.	25th.	Ref. obs.	26th.	Ref. obs.	27th.	Ref. obs.	28th.	Ref. obs.	29th.	Ref. obs.
							21.0	10.6									21.4	11.4
1	14.5	6.5	15.2	6.6	16.5	7.0	20.5	10.1	19.0	8.3	22.4	12.1	20.2	10.1	21.4	11.4	21.4	11.4
	14.2	6.2									22.4	12.1					21.4	11.4
2	13.8	5.8	13.9	5.3	14.7	5.2	18.0	7.6	17.0	6.3	20.0	9.7	20.2	10.1	21.4	11.4	21.4	11.4
	13.8	5.8																
3	13.8	5.8	11.5	2.9	13.8	4.3	15.8	5.3	16.0	5.3	17.6	7.3	18.5	8.4	19.1	9.1	20.0	10.0
	13.8	5.8	13.3	4.7	13.4	3.8	15.0	4.5										
4	14.9	5.9	---	---	13.2	3.6	14.2	3.6	14.1	3.5	15.0	4.8	17.0	6.9	16.3	6.3	18.0	8.0
5	14.4	6.3	---	---	14.0	4.3	14.2	3.6	13.0	2.4	12.2	2.0	12.0	1.9	15.3	5.3	16.6	6.6
6	15.7	7.6	---	---	14.6	4.9	15.1	4.4	13.4	2.8	13.4	3.2	12.2	2.1	14.4	4.4	15.5	5.5
7	16.3	8.2	---	---	15.0	5.2	15.3	4.6	14.0	3.4	13.8	3.7	12.8	2.7	13.8	3.8	13.9	3.9
8	17.2	9.1	16.7	7.6	15.6	5.8	15.5	4.7	14.5	3.9	14.4	4.3	13.4	3.3	13.2	3.2	13.6	3.6
	17.2	9.0													13.5	3.5	13.9	3.9
9	17.6	9.4	17.6	8.5	18.4	8.5	16.4	5.6	16.2	5.6	16.0	5.9	14.6	4.5	14.0	4.0	14.4	4.4
	17.2	9.0	19.0	9.9														
10	16.2	8.0	18.5	9.4	18.4	8.5	17.5	6.7	17.0	6.4	17.2	7.1	16.4	6.3	15.5	5.5	16.2	6.2
11	15.8	7.6	17.5	8.4	18.1	8.1	18.3	7.5	18.1	7.5	18.8	8.7	18.0	7.9	17.8	7.8	18.0	8.0
							18.5	7.7	18.8	8.2								
Noon	14.6	6.4	16.5	7.4	17.8	7.8	18.9	8.1	18.9	8.3	19.8	9.7	19.4	9.3	19.1	9.1	18.4	8.4
							18.9	8.1					19.9	9.8	19.2	9.2		
1	14.0	5.8	16.0	6.9	16.0	6.0	18.5	7.7	18.2	7.6	20.0	9.9	19.0	8.9	19.2	9.2	19.0	9.0
											19.0	8.9			19.2	9.2	19.1	9.1
2	13.0	4.8	15.4	6.3	15.5	5.5	15.9	5.1	16.5	5.9	18.2	8.1	17.6	7.5	18.6	8.6	19.1	9.1
	12.4	4.2															18.8	8.8
3	11.2	3.0	14.4	5.3	14.0	3.9	14.7	3.9	15.7	5.1	16.4	6.3	16.8	6.7	17.5	7.5	17.5	7.5
	11.9	3.7																
4	13.9	5.6	13.2	4.1	13.6	3.5	13.9	3.1	---	---	15.0	4.9	16.0	5.9	17.2	7.2	16.4	6.4
			12.8	3.7	13.5	3.3												
5	14.6	6.3	12.5	3.3	13.2	3.0	13.2	2.4	---	---	14.0	3.9	14.8	4.7	16.8	6.8	13.4	3.4
			13.0	3.8	13.2	2.9	12.8	2.0										
6	16.5	8.2	14.6	5.4	13.2	2.9	13.5	2.7	13.7	3.2	13.3	3.2	13.8	3.8	15.1	5.1	12.1	2.1
					14.2	3.9					12.5	2.4					12.0	2.0
7	18.4	10.0	17.2	7.9	15.0	4.7	15.0	4.2	13.6	3.1	13.0	2.9	13.8	3.8	12.8	2.8	12.6	2.6
													13.0	3.0	12.5	2.5		
8	19.5	11.1	18.0	8.7	16.0	5.7	17.0	6.2	15.0	4.5	15.0	4.9	13.2	3.2	13.1	3.1	13.5	3.6
9	20.0	11.6	19.0	9.6	19.0	8.7	19.0	8.2	18.0	7.5	19.4	9.3	15.0	5.0	15.1	5.1	15.2	5.3
	21.5	13.0	19.5	10.1														
10	20.5	12.0	20.0	10.6	21.0	10.6	21.0	10.2	20.2	9.8	22.2	12.1	17.5	7.5	17.2	7.2	16.7	6.8
			20.0	10.6			21.5	10.8										
11	18.5	10.0	19.8	10.3	21.4	11.0	22.0	11.3	21.5	11.1	22.4	12.3	20.0	10.0	19.2	9.2	17.8	8.0
					21.4	11.0	21.8	11.1										
Midn't	14.1	5.6	19.4	9.9	21.4	11.0	20.6	9.9	22.0	11.6	---	---	21.4	11.4	21.3	11.3	19.5	9.7

June 21. Correction — 8.2
" 23. " —10.0
" 25. " —10.6
" 27. " —10.1
" 28. " —10.0
" 29. " —10.0

June 22. Correction — 9.1
" 24. " —10.8
" 26. " —10.1

Some doubt about the time record in the afternoon.

SERIES III.—TIDAL OBSERVATIONS FROM APRIL 20 TO AUGUST 3, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

	June, 1854.		July, 1854.															
Mean solar hour.	30th.	Ref. obs.	1st.	Ref. obs.	2d.	Ref. obs.	3d.	Ref. obs.	4th.	Ref. obs.	5th.	Ref. obs.	6th.	Ref. obs.	7th.	Ref. obs.	9th.	Ref. obs.
													15.7	6.7				
1	19.0	9.2	18.5	9.0	20.6	11.0	14.5	5.9	16.3	7.6	15.2	6.5	15.0	6.0	17.0	7.8	15.5	8.3
													15.0	6.0	17.0	6.8		
2	20.8	11.0	19.8	10.3	21.0	11.3	16.3	7.7	16.9	8.2	15.6	6.9	15.0	6.0	15.8	5.6	13.0	5.8
													15.0	6.0	15.8	5.6		
3	21.0	11.2	20.7	11.2	21.4	11.7	17.3	8.7	17.4	8.7	16.8	8.1	15.0	6.0	15.8	5.6	11.0	3.9
	22.0	12.3	20.9	11.4			17.6	8.9					15.6	6.6	15.8	5.6		
4	20.4	10.7	21.0	11.5	21.4	11.7	17.8	9.1	18.6	9.9	17.3	8.6	15.6	6.6	15.8	5.6	9.8	2.7
			21.0	11.6			17.8	9.1							16.0	5.8	9.5	2.4
5	19.8	10.1	21.0	11.6	17.6	7.8	17.5	8.8	18.6	10.0	18.4	9.7	17.0	8.0	16.4	6.2	9.5	2.4
			20.7	11.3													9.5	2.5
6	18.0	8.4	19.5	10.1	15.7	5.9	17.0	8.2	18.6	10.0	18.6	9.9	17.6	8.5	17.2	7.0	9.8	2.8
									18.8	10.2	18.8	10.0						
7	17.0	7.4	17.1	7.7	14.4	4.6	16.3	7.5	18.8	10.2	18.9	10.1	18.2	9.1	18.8	8.6	10.5	3.5
									18.4	9.8	18.4	9.6	18.5	9.4	19.0	8.8		
8	15.0	5.4	15.7	6.3	12.7	4.5	15.7	6.9	17.6	9.0	18.4	9.6	18.5	9.4	19.4	9.2	12.4	5.4
	14.0	4.4											17.8	8.7	19.1	8.9		
9	13.5	3.9	13.5	4.1	12.0	3.8	14.0	5.2	15.0	6.4	18.2	9.4	17.0	7.8	18.5	8.3	13.8	6.8
	14.8	5.2	12.2	2.8	11.7	3.5	14.0	5.2										
10	16.1	6.5	12.0	2.6	11.4	2.2	13.6	4.8	14.0	5.4	17.0	8.2	16.2	7.0	16.8	6.6	15.4	8.4
			12.5	3.1	11.4	2.2	13.6	4.8	13.6	5.0							15.5	8.5
11	18.7	9.1	13.0	3.6	11.4	2.2	13.6	4.8	13.0	4.4	15.0	6.2	15.9	6.7	15.5	5.3	15.5	8.5
	18.9	9.3			11.4	2.2	15.0	6.2	13.0	4.4							14 9	7.9
Noon	19.0	9.4	15.4	6.0	11.9	3.7	16.5	7.7	13.1	4.5	14.0	5.2	14.0	4.8	15.5	5.3	14.3	7.3
	19.0	9.4									13.3	4.5	13.1	3.9				
1	18.8	9.2	17.2	7.8	12.2	3.9	18.3	?	13.2	4.6	13.1	4.3	13.1	3.9	14.4	4.2	13.2	6.2
											13.1	4.3	13.1	3.9				
2	17.0	7.4	18.1	8.7	13.4	5.1	16.2	7.4	14.0	5.4	13.1	4.3	13.1	3.9	13.3	3.1	11.2	4.3
											13.2	4.4	13.1	3.9	13.2	3.0		
3	15.8	6.2	18.3	8.9	14.4	6.1	17.2	8.4	15.3	6.7	13.4	4.6	13.4	4.2	13.2	3.0	9.1	2.2
															13.2	3.0	8.3	1.5
4	15.0	5.4	18.3	8.9	15.2	6.8	18.2	9.4	17.2	8.6	16.1	7.3	14.3	5.1	13.2	3.0	8.0	1.2
							18.4	9.6							13.7	3.5	8.0	1.3
5	14.0	4.4	18.7	9.3	15.6	7.2	18.6	9.8	17.4	8.7	17.5	8.7	17.3	8.1	14.2	4.0	8.0	1.3
			17.8	8.4	15.7	7.3	18.6	9.8							15.3		8.6	2.0
6	13.5	3.9	17.3	7.8	15.3	6.9	18.6	9.8	18.0	9.3	18.0	9.2	18.3	9.1		5.1	9.0	2.4
							18.3	9.5	18.5	9.8	18.7	9.9			16.6			
7	13.4	3.8	16.2	6.7	14.6	6.2	18.0	9.2	18.5	9.8	19.4	10.6	19.5	10.3		6.4	11.0	4.5
									18.5	9.8	19.4	10.5	19.9	10.7	17.4			
8	13.4	3.8	14.7	5.2	14.0	5.5	17.5	8.7	18.0	9.3	19.4	10.5	20.4	11.2		7.2	13.4	6.9
											19.4	10.5	20.4	11.2	18.0			
9	14.1	4.5	14.5	5.0	14.0	5.5	16.7	7.9	17.4	8.7	19.4	10.5	20.4	11.2		7.8	15.9	9.5
											19.2	10.3	20.4	11.2				
10	15.4	5.8	17.5	8.0	12.8	4.3	15.8	7.0	16.2	7.5	18.7	9.8	20.4	11.2	Readings irregular.		18.2	11.9
					12.4	3.9	15.6	6.9					20.1	10.9				
11	16.0	6.4	18.9	9.3	12.3	3.8	15.6	6.9	15.8	7.1	17.2	8.3	19.7	10.5			18.6	12.3
					12.3	3.8	15.6	6.9									18.7	12.5
Midn't	16.7	7.1	19.7	10.1	12.3	3.8	15.7	7.0	15.2	6.5	16.0	7.1	17.1	7.9			18.7	12.5

June 30. Correction —9.6

July 1. Correction —9.4

July 2. " —9.8 before 8 A. M., and —8.2 after 8 A. M.

" 3. " —8.8

" 4. " —8.6

" 5. " —8.8

" 6. " —9.2

" 7. " —9.2 Tide register out of order at 2 o'clock, changed index 1 foot; correction after 2 A. M. 10.2.

" 8. The readings appear irregular. Correction at noon —7.0, at midnight —6.2.

Series III.—Tidal Observations from April 20 to August 3, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

July, 1854.

Mean solar hour.	10th.	Ref. obs.	11th.	Ref. obs.	12th.	Ref. obs.	13th.	Ref. obs.	14th.	Ref. obs.	15th.	Ref. obs.	18th.	Ref. obs.	19th.	Ref. obs.	20th.	Ref. obs.
	18.4	12.3	19.3	13.4	19.3	13.3	19.5	13.5										
1	16.8	10.7	19.0	13.1	19.3	13.3	19.6	13.6	17.0	11.0	18.1	?	---	---	---	---	20.8	6.1
					19.3	13.3	19.6	13.6	18.0	12.0	16.1	"						
2	14.1	8.1	17.0	11.0	19.0	13.0	19.0	13.0	18.6	12.6	13.2	"	---	---	---	---	20.5	5.8
																	20.4	5.6
3	12.5	6.5	14.0	8.0	16.5	10.5	17.8	11.8	18.4	12.4			---	---	---	---	20.4	5.6
																	20.5	5.7
4	10.0	4.0	12.1	6.1	12.0	6.0	16.3	10.3	17.3	11.3			---	---	---	---	20.8	5.9
	9.0	3.0																
5	8.2	2.2	9.1	3.1	10.1	4.1	14.0	8.0	15.0	9.0				?	19.1	4.6	20.4	5.5
	8.2	2.2													19.2	4.7		
6	8.2	2.2	8.0	2.0	7.8	1.8	10.2	4.2	---	---				"	19.4	4.8	21.2	6.3
	8.5	2.5	7.5	1.5	7.1	1.1												
7	9.0	3.0	7.8	1.8	7.0	1.0	7.5	1.5	---	---			Readings irregular.	"	20.3	5.7	22.1	7.2
	9.4	?	8.5	2.5	7.3	1.3	7.0	1.0										
8	6.6	---	9.0	3.0	8.2	2.2	7.0	1.0	---	---				"	21.2	6.6	22.2	7.3
							7.1	1.1										
9	7.2	---	11.5	6.5	10.5	4.5	8.0	2.0	7.8	1.8				"	22.2	7.6	23.0	8.1
									7.8	1.8					21.7	7.1	23.3	8.4
10	10.3	4.5	14.0	8.0	13.0	7.0	10.2	4.2	7.9	1.9				"	21.2	6.6	23.6	8.7
																	23.5	8.6
11	12.1	6.3	15.6	9.6	15.4	9.4	12.6	6.6	9.3	3.3				"	21.8	7.2	23.5	8.6
					16.1	10.1												
Noon	13.5	7.7	16.0	10.0	16.1	10.1	14.9	8.9	12.3	6.3			21.3	7.0	20.0	5.4	22.2	7.3
	14.0	8.2	16.1	10.1	16.0	10.0	15.9	9.9					20.2	5.9				
1	14.2	8.4	16.0	10.0	16.0	10.0	16.0	10.0	14.1	8.1			19.1	4.8	19.6	5.0	20.1	5.2
	13.1	7.3					16.0	10.0	14.4	8.4			19.1	4.8	19.0	4.4		
2	12.1	6.3	15.2	9.2	15.3	9.3	16.0	10.0	15.2	9.2	Readings become very irregular.		19.1	4.8	19.3	4.7	19.4	4.5
							15.1	9.1	15.2	9.2			19.3	5.0			19.7	4.8
3	10.2	4.4	13.2	7.2	13.2	7.2	14.2	8.2	15.2	9.2			20.2	5.9	19.3	4.7	20.4	5.5
									14.4	8.4								
4	8.0	2.2	10.0	4.0	11.0	5.0	13.3	7.3	14.3	8.3			21.3	7.0	20.0	5.4	21.2	6.3
	7.8	2.0																
5	7.0	1.2	8.7	2.7	10.0	4.0	---	---	13.0	7.0			22.1	7.7	21.1	6.5		
	7.0	1.2	7.8	1.8														
6	7.6	1.7	7.2	1.2	8.7	2.7	---	---	12.8	6.8			23.2	8.8	22.4	7.8		
			7.2	1.2	8.0	2.0							23.4	9.0				
7	10.1	4.2	7.5	1.5	7.2	1.2	9.0	3.0	---	---			23.6	9.2	23.6	9.0		
					7.2	1.2	8.7	2.7					23.6	9.2				
8	13.1	7.2	9.0	3.0	7.6	1.6	8.4	2.4	---	---			23.6	9.2	23.9	9.2	Readings irregular.	
													23.3	8.9	24.0	9.3		
9	15.0	9.1	10.5	4.5	9.2	3.2	---	---	8.5	2.5			22.9	8.5	24.0	9.3		
									8.9	2.9					23.4	8.7		
10	17.0	11.1	13.9	7.9	12.2	6.2	---	---	9.0	3.0			22.1	7.7	23.4	8.7		
11	18.6	12.7	16.8	10.8	16.8	10.8	---	---	11.5	5.5			21.4	7.0	23.4	8.7		
	19.0	13.1																
Midn't	19.5	13.6	19.0	13.0	18.2	12.2	---	---	13.2	7.2			20.3	5.9	21.3	6.6		

July 10. Correction — 5.8
" 12. " — 6.0
" 14. " — 6.0
" 18. " —14.3
" 20. " —14.9

July 11. Correction — 6.0
" 13. " — 6.0
" 15. " ?
" 19. " —14.6

SERIES III.—TIDAL OBSERVATIONS FROM APRIL 20 TO AUGUST 3, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

	July, 1854.								August, 1854.					
Mean solar hour.	28th.	Ref. obs.	29th.	Ref. obs.	30th.	Ref. obs.	31st.	Ref. obs.	1st.	Ref. obs.	2d.	Ref. obs.	3d.	Ref. obs.
1	Correction to readings not sufficiently known.		10.6	10.1	10.6	10.5	8.3	8.3	8.0	8.0	6.8	7.0	5.3	5.7
					11.2	11.1							5.5	5.9
2			11.3	10.8	11.2	11.1	8.6	8.6	8.4	8.4	8.0	8.2	6.0	6.4
			12.3	11.8	11.2	11.1			9.1	9.1				
3			12.5	12.0	11.2	11.1	9.3	9.3	9.3	9.3	8.7	8.9	6.5	6.9
			11.3	10.8	11.0	11.0								
4			10.2	9.7	10.8	10.8	10.6	10.6	9.3	9.3	9.0	9.3	7.3	7.7
									9.2	9.2			8.2	8.6
5			8.4	8.0	10.2	10.2	---	---	9.0	9.0	10.2	10.5	8.4	8.8
									9.0	9.0			8.4	8.8
6			6.1	5.7	8.5	8.5	---	---	9.0	9.0	9.1	9.4	8.4	8.8
													8.4	8.8
7			3.0	2.6	6.4	6.4	---	---	7.5	7.5	7.4	7.8	8.4	8.8
			2.3	1.9	5.1	5.1								
8			2.0	1.7	3.2	3.2	---	---	5.5	5.5	6.4	6.8	7.7	8.1
			2.0	1.7	3.2	3.2								
9			2.2	1.9	3.2	3.2	4.0	4.0	4.6	4.6	5.0	5.4	6.0	6.4
					3.3	3.3			4.4	4.4				
10			3.5	3.2	3.4	3.4	5.2	5.2	4.4	4.4	4.2	4.6	4.4	4.8
									4.4	4.4	4.1	4.5		
11			4.8	4.5	4.2	4.2	5.5	5.5	4.4	4.4	4.1	4.5	3.4	3.8
									4.4	4.4	4.1	4.5	3.4	3.8
Noon	8.3	7.6	7.2	6.9	6.1	6.1	6.2	6.2	4.4	4.4	4.1	4.5	3.4	3.8
	9.1	8.4							5.0	5.0	4.3	4.7	3.2	3.6
1	9.2	8.5	9.2	8.9	7.0	7.0	7.5	7.5	5.7	5.7	4.8	5.2	3.2	3.6
	9.3	8.6					8.0	8.0					3.2	3.6
2	9.3	8.6	10.2	9.9	8.3	8.3	9.0	9.0	7.0	7.0	5.9	6.3	3.2	3.6
	9.3	8.6			8.5	8.5	9.0	9.0					4.0	4.4
3	9.2	8.5	11.3	10.0	9.2	9.2	9.0	9.0	8.7	8.7	6.4	6.8	4.5	4.9
			11.4	11.2	9.0	9.0	9.0	9.0	9.5	9.5				
4	7.4	6.8	11.5	11.3	8.3	8.3	9.0	9.0	10.4	10.5	6.8	7.2	6.2	6.6
			11.0	10.8					10.4	10.5				
5	5.5	4.9	10.0	9.8	7.2	7.2	9.1	9.1	10.4	10.5	7.0	7.4	7.4	7.8
									10.4	10.5	8.2	8.6		
6	3.7	3.1	7.8	7.6	6.0	6.0	8.0	8.0	10.2	10.3	9.1	9.5	8.2	8.6
											9.0	9.4		
7	2.9	2.3	4.2	4.1	5.1	5.1	6.6	6.6	9.0	9.1	9.0	9.4	8.8	9.2
	2.7	2.1			4.3	4.3							9.0	9.4
8	2.6	2.0	3.4	3.3	4.1	4.1	5.4	5.4	7.4	7.5	9.0	9.4	9.0	9.4
	3.0	2.4			4.1	4.1	4.8	4.8					9.0	9.4
9	3.2	2.7	3.3	3.2	4.1	4.1	4.8	4.8	6.2	6.3	7.4	7.8	9.0	9.4
			4.0	3.9	5.0	5.0	4.8	4.8	6.0	6.1			9.0	9.4
10	5.4	4.9	4.0	3.9	5.2	5.2	4.8	4.8	6.0	6.1	6.2	6.6	8.2	8.6
							4.8	4.8	6.0	6.1				
11	6.4	5.9	6.0	5.9	6.4	6.4	4.8	4.8	6.2	6.4	5.8	6.2	7.3	7.7
							5.1	5.1						
Midn't	9.0	8.5	8.0	7.9	---	---	5.6	5.6	6.5	6.7	5.6	6.0	6.0	6.4

Between the 20th and 27th of July the observations do not appear sufficiently regular to promise any reliable results.

July 28. Correction —0.7 July 29. Correction —0.3 July 30. Correction 0.0
" 31. " 0.0 Aug. 1. " —0.0 Aug. 2. " +0.4
Aug. 3. " +0.4 After this date the observations are irregular.

On the 5th the rope slipped off the wheel.

Aug. 8. The brig was released from the ice cradle at 10 A. M., rising suddenly 2½ feet. She resumed this position upon very slight disturbance of the external ice, and is now on an even keel for the first time in eleven months. The brig was frozen in and fast since the 9th of September, 1853.

Aug. 10. The high-water mark was cut on the island by Mr. McGary.

Aug. 11. The warping of the ships was commenced. Tidal observations were resumed on the 12th. The register is kept in fathoms and feet.

SERIES IV.—TIDAL OBSERVATIONS FROM SEPTEMBER 7 TO OCTOBER 22, 1854.

Hourly observations on the pulley-gauge. Adopted reading of mean level 7.0, expressed in units of the scale. Increasing numbers indicate rise of water.

September, 1854.

Mean solar hour.	7th.	8th.	9th.	10th.	11th.	12th.	13th.	14th.	16th.	17th.	18th.	19th.	20th.	21st.	22d.	23d.	24th.	25th.	26th.	27th.
1	---	10.0	13.5	13.0	10.0	10.0	8.0	6.0	---	5.0	7.0	9.0	9.0	10.0	11.2	12.0	11.0	13.0	13.0	10.0
2	---	5.0	13.5	11.0	11.0	14.0	9.0	7.0	---	5.0	6.0	8.0	7.5	8.0	9.0	10.0	10.0	14.0	11.0	12.0
3	---	2.0	11.0	7.0	11.0	11.0	10.0	4.0	---	6.0	6.0	7.0	5.0	6.0	4.0	7.0	8.0	10.0	10.0	10.0
4	---	—1.0	7.0	4.7	9.0	9.0	9.0	3.0	---	7.0	5.0	5.0	3.0	5.0	3.0	3.0	6.0	7.0	8.0	8.0
5	---	—1.7	5.0	3.0	7.0	6.0	6.0	4.0	---	8.0	6.0	5.0	2.0	4.0	2.0	0.0	3.5	4.0	6.0	4.0
6	---	—1.7	3.0	1.0	5.0	4.0	4.0	5.0	---	9.0	7.0	7.0	4.0	5.0	3.0	—0.7	2.0	3.0	3.0	2.0
7	---	—1.0	2.2	—1.0	3.0	2.0	0.0	6.0	---	9.0	9.0	8.0	6.0	6.0	5.0	2.0	2.0	2.0	0.0	0.0
8	---	0.0	1.0	—1.0	0.0	0.0	1.0	8.0	---	9.0	8.5	10.0	7.0	7.0	6.0	4.0	2.0	0.0	1.0	—1.0
9	---	2.0	4.0	0.0	0.0	1.0	2.0	9.0	---	8.0	7.5	10.0	8.0	8.5	8.0	7.0	5.0	1.0	3.0	1.0
10	---	9.0	5.0	4.0	2.0	3.0	3.0	10.0	---	6.0	9.0	9.5	9.0	10.0	10.0	10.0	10.0	3.0	4.0	3.0
11	---	14.0	6.5	---	4.0	4.0	5.0	4.0	4.0	5.0	7.0	8.5	9.5	11.5	12.5	11.0	12.0	6.0	7.0	6.0
Noon	---	12.0	11.0	---	7.0	7.0	6.0		4.0	5.0	6.5	8.0	---	10.0	13.0	13.0	13.0	12.5	10.0	9.0
1	---	11.0	13.0 14.0	9.0	9.0	3.0	8.0		5.0	5.0	6.0	7.5	---	9.0	10.0	11.0	12.0	13.0	12.0	10.0
2	---	10.0	10.0	11.0	10.0	4.0	9.0	Observations irregular.	7.0	6.0	5.5	7.0	---	6.0	8.0	10.0	10.0	12.0	13.0	12.0
3	---	8.0	7.0	9.0	8.0	9.0	9.0		8.0	7.0	5.0	6.7	4.0	0.0	6.0	7.0	9.0	11.0	11.0	13.0
4	---	6.0	4.0	6.0	9.0	10.0	9.0		9.0	8.0	7.0	6.5	2.0	1.0	3.0	5.0	6.0	7.0	9.0	10.0
5	---	4.0	2.0	---	10.0	8.0	9.0		8.0	9.0	8.0	6.0	3.0	1.5	1.0	1.0	3.0	6.0	6.0	9.0
6	---	2.0	0.0	---	10.5	4.0	6.0		7.0	10.0	9.0	5.0	4.0	3.0	2.0	0.0	2.0	4.0	4.0	7.0
7	---	1.0	—0.5	---	9.0	1.0	4.0		8.0	10.0	10.0	8.0	6.0	4.0	3.0	0.0	1.0	2.0	3.0	3.0
8	---	0.0	—0.5	---	5.0	0.0	3.0		9.0	10.4	10.5	11.0	8.0	7.0	5.0	4.0	2.0	0.0	0.0	0.0
9	11.0	5.0	4.9	2.0	1.5	1.5	4.0		10.0	10.0	10.5	11.5	10.0	9.5	7.5	---	5.0	5.0	1.0	1.0
10	13.0	8.0	6.0	1.0	3.0	3.0	5.0		9.0	10.0	12.0	12.0	12.0	12.0	11.5	---	8.0	8.0	4.0	4.0
11	14.5	11.0	10.0	7.0	7.0	5.6	5 4		8.0	10.4	11.0	12.6	13.0	14.0	10.0	---	9.0	11.0	7.0	6.0
Midn't	14.2	13.0	12.0	10.0	8.6	7.0	7.0		6.6	9.0	10.0	11.6	11.0	13.0	9.0	---	10.0	12.0	9.5	8.0

	Sept. 1854.			October, 1854.																
Mean solar hour.	28th.	29th.	30th.	1st.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.	12th.	15th.	17th.	18th.	19th.	20th.	21st.	22d.
1	9.0	8.0	---	9.0	---	6.0	10.0	12.0	14.0	8.0	13.0	10.0	8.5	6.0	---	5.0	---	6.0	5.0	---
2	12.0	10.0	---	8.0	---	4.0	7.0	10.0	12.2	7.0	12.0	---	14.5	7.0	---	4.0	---	4.0	4.0	---
3	13.0	9.0	8.0	6.0	---	0.0	5.0	7.0	7.0	4.0	10.0	9.0	10.0	8.0	3.0	3.0	1.0	3.0	0.5	1.0
4	10.0	8.0	9.0	Soundings irregular.	---	—1.2	3.0	4.0	5.0	2.0	7.0	8.0	7.0	10.0	4.0	4.0	0.0	2.0	0.0	0.0
5	9.0	8.0	8.0		---	—1.0	—1.0	2.0	2.0	1.0	4.0	4.0	5.0	9.0	5.0	6.0	2.0	1.0	1.0	0.5
6	5.5	7.0	7.0		---	0.0	0.4	1.0	1.0	0.0	0.0	2.0	4.0	8.0	6.0	6.4	3.0	3.0	2.0	1.5
7	3.0	6.0	6.0		4.0	4.0	4.0	1.0	0.0	0.0	1.0	1.0	3.0	7.0	7.0	7.0	6.0	5.0	3.0	1.0
8	1.0	4.0	5.0		5.0	7.0	7.0	5.0	—1.0	0.5	1.5	0.0	2.0	6.0	8.0	8.0	9.0	7.0	6.0	3.0
9	2.0	3.0	5.0		10.0	10.0	10.0	8.5	7.0	7.0	2.5	2.0	3.5	5.0	9.0	11.0	12.0	10.0	8.0	7.0
10	3.0	2.0	4.0		10.0	11.0	11.5	11.5	9.0	10.0	5.0	5.5	5.0	4.0	10.0	10.0	11.5	11.0	11.0	10.0
11	7.0	4.0	3.0		9.0	12.0	12.0	13.0	11.2	10.0	7.0	11.0	6.0	3.0	8.0	8.0	10.0	12.0	12.0	13.0
Noon	9.0	6.0	4.0		8.0	13.0	12.0	14.0	13.0	12.0	10.0	13.0	8.0	4.0	6.0	7.0	8.0	10.0	12.0	13.0
1	12.0	7.0	6.0		6.0	7.0	12.0	13.0	13.0	13.0	13.0	14.0	10.0	5.2	5.0	6.0	7.5	8.0	10.0	12.0
2	10.0	9.0	7.0		4.0	4.0	8.5	9.0	12.0	14.0	14.0	13.0	13.0	5.0	4.0	5.0	4.0	3.0	7.0	9.0
3	11.0	10.0	8.0		2.0	2.0	7.0	5.0	8.0	9.0	12.5	12.0	14.0	6.0	3.0	2.0	1.0	0.5	4.0	4.0
4	12.0	11.5	9.0		0.0	0.0	3.0	3.0	3.0	7.0	9.0	10.0	14.0	7.0	4.0	2.0	1.0	0.0	2.0	1.5
5	10.0	11.0	16.0		0.0	—2.0	1.0	0.0	2.0	5.0	8.0	7.0	11.0	8.0	5.0	3.0	2.0	1.0	0.0	0.0
6	8.0	11.0	10.0		5.0	3.0	0 0	0.0	1.0	3.0	4.0	4.0	9.0	9.0	7.0	4.0	6.0	3.0	1.0	1.0
7	6.0	9.0	9.0		9.0	7.0	—0.5	2.0	0.0	1.0	2.0	3.0	7.4	9.0	7.0	7.0	7.0	4.0	1.0	3.0
8	4.0	6.0	8.0		10.0	9.0	0.0	5.0	1.0	0.0	0.5	2.0	6.0	10.0	7.0	9.5	8.0	7.0	3.0	7.0
9	2.0	3.0	7.0		12.0	13.0	9.0	7.0	4.0	3.0	3.0	3.0	4.0	8.0	8.0	12.0	9.0	8.0	7.0	10.0
10	3.0	4.0	5.5		13.0	13.2	12.0	10.0	6.0	5.5	4.0	4.0	6.0	6.0	11.0	10.0	10.0	9.0	10.0	12.0
11	5.0	5.5	5.0		14.0	14.0	14.0	13.6	9.0	8.0	7.0	7.0	8.0	5.0	8.0	7.0	10.0	9.0	12.0	13.0
Midn't	6.0	5.5	4.5		13.0	14.0	13.6	14.0	10.0	11.0	10.0	10.0	10.0	7.0	7.0	6.0	11.0	11.0	11.0	11.0

NOTE.—The above numbers were taken from the record, converting the fathoms into feet and deducting 8, in order to reduce the mean level of 15 feet to the adopted level of comparison of 7 feet. The observations are taken with the sounding line; bottom weedy.

Sept. 8. Some doubt about the time between 1 and 5 P. M.

After October 22 the soundings are too irregular, and later observations with the pulley-gauge too much affected by changes of the index.

This last series is considerably inferior in accuracy to the three preceding series.

Reduction of Tides, Van Rensselaer Harbor, 1853–'54.

Having given the tidal record in a form ready for use, the observations next require to be properly tabulated for the purpose of deducing empirically their laws, and for comparison with theory. In the United States Coast Survey two blank forms are in use for this tabulation; they have in their essential part been adopted as suitable for the Van Rensselaer Harbor tides, and were used with permission of the Superintendent of the Survey. They are strictly applicable only for such cases where the diurnal inequality is comparatively small, or is at least not approximating to the production of single day tides. In order to show, at a glance, the general character of the tides under discussion, they were plotted a second time, and are given in Plates I, II, and III; the observations having previously been referred to the same mean level. From these diagrams it appears that the diurnal inequality is not of so great an effect as to render the use of the ordinary method of reduction unavailable; on the other hand, it is sufficiently large to require a special discussion for time and height. The extension of the series of observations over a whole year must be considered as a fortunate circumstance, since the results thereby gain considerably in accuracy over others deduced only from a few disconnected lunations.

The tidal record would not be complete without the observations for direction and force of the wind, and for atmospheric pressure; the reader will find these records in my discussion of the meteorological material of the expedition, in Vol. XI, Smithsonian Contributions to Knowledge, 1859.

The following pages contain the first tabulation of the preceding record, viz: column 1 contains the date, civil reckoning, adopted for convenience sake. Column 2 gives the apparent time (civil reckoning) of the moon's superior and inferior transit over the Van Rensselaer meridian, obtained by adding nine minutes to the time of transit at Greenwich, allowing for a difference of longitude of $4^h\ 43\frac{1}{2}^m$ W. The mean time was converted into apparent time by applying the equation of time. The time for the lower transit was obtained by taking the mean of the time of the preceding and following upper transit. Columns 3 and 4 contain the apparent time of high and low water, taken from the record; in some cases a graphical method was resorted to, to obtain the instant of these phases with greater precision. The equation of time has been applied to the mean time in which the observations are expressed. Columns 5 and 6 contain the lunitidal interval between the time of high water and low water, and the time of the transit of the moon immediately preceding, though in some cases, owing to the half-monthly inequality, it may be the second preceding, the establishment being about $11\frac{3}{4}$ hours. This transit of comparison has been called transit F by Mr. Lubbock.[1] The next columns, 7 and 8, give the height of high and low water, extracted from the preceding abstract. The remaining columns contain the moon's parallax and declination at noon.

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[1] See an Elementary Treatise on the Tides, by J. W. Lubbock, Esq., London, 1839.

Table for the Reduction of Tides.—No. 1.

Showing the times of High and Low Water, and the Heights of High and Low Tides; together with the time of the Moon's passing the Meridian of the place, and the Lunitidal Intervals, at Van Rensselaer Harbor during the months of October 10, 1853, to October 22, 1855.

Series I.—From October 10 to December 28, 1853.

Date. 1853.	Moon passes the meridian. Appar. time. H.	M.	Apparent time of H. water. H.	M.	Apparent time of L. water. H.	M.	Lunitidal interval. H. water. H.	M.	Lunitidal interval. L. water. H.	M.	Height of H. water. Ft.	Dec.	Height of L. water. Ft.	Dec.	Moon's parallax at noon. Min.	Dec.	Moon's declination at noon. Degree.	Dec.
Oct. 9	6	28	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" 10	6	57	8	13	11	13	13	45	16	45	8	0	4	7	58	4	—23	8
	7	26	6	13	...	...	11	16	...	...	9	2	...	...				
" 11	7	54	7	58	1	43	12	32	18	46	6	7	4	4	57	8	—20	9
	8	22	7	43	1	13	11	49	17	47	9	5	4	8				
" 12	8	47	8	13	1	43	11	51	17	49	7	9	4	0	57	3	—17	0
	9	12	9	29	2	43	12	42	18	21	10	0	4	2				
" 13	9	37	9	59	3	14	12	47	18	27	9	1	3	7	56	7	—12	3
	10	02	10	14	3	59	12	37	18	47	10	9	3	1				
" 14	10	24	10	14	4	14	12	12	18	37	9	8	2	7	56	3	— 7	1
	10	47	10	44	3	59	12	20	17	57	11	3	2	7				
" 17	0	13	...	...	...	...	...	...	...	...	...	...	...	...	54	9	+ 8	9
	0	35	11	45	5	15	11	10	17	02	10	7	1	5				
" 18	0	57	...	...	6	00	...	...	17	25	...	...	1	8	54	5	+13	7
	1	18	...	...	6	30	...	...	17	33	12	3	2	0				
" 19	1	40	0	30	6	45	11	12	17	27	11	5	1	6	54	3	+17	9
	2	02	1	15	7	15	11	35	17	35	12	4	1	9				
" 20	2	25	1	15	5	45	11	13	15	43	11	5	5	7	54	2	+21	3
	2	48	1	45	9	00	11	20	18	35	11	9	2	7				
" 21	3	12	1	30	7	45	10	42	16	57	9	9	2	8	54	1	+23	8
	3	36	3	15	8	30	12	03	17	18	11	1	4	4				
" 22	4	00	1	15	9	16	9	39	17	40	10	5	3	4	54	2	+25	2
	4	25	3	16	8	46	11	16	16	46	9	9	4	5				
" 23	4	51	3	16	8	31	10	51	16	06	10	3	3	9	54	4	+25	5
	5	16	4	16	10	16	11	25	17	25	10	4	5	2				
" 24	5	42	3	31	8	31	10	15	15	15	8	7	4	5	54	8	+24	7
	6	07	5	46	...	...	12	04	...	...	9	7	...	...				
" 25	6	32	5	01	0	16	10	54	18	34	7	1	5	4	55	4	+22	6
	6	57	8	16	10	46	13	44	16	39	8	5	5	2				
" 26	7	22	7	46	0	31	12	49	17	59	7	0	5	2	56	1	+19	5
	7	46	8	46	0	46	13	24	17	49	9	2	6	1				
" 27	8	11	8	16	1	46	12	30	18	24	8	1	4	8	57	0	+15	3
	8	35	8	46	0	46	12	35	17	00	9	8	5	5				
" 28	8	59	...	...	3	01	...	...	18	50	9	3	4	5	57	9	+10	3
	9	23	9	46	3	46	12	47	19	11	10	8	5	1				
" 29	9	47	9	46	4	01	12	23	19	02	10	7	3	4	58	8	+ 4	6
	10	11	10	46	4	16	12	59	18	53	11	4	4	9				
" 30	10	36	12	01	3	46	13	50	17	59	11	6	2	9	59	7	— 1	5
	11	01	10	46	5	16	12	10	19	05	11	7	3	9				
" 31	11	26	11	31	4	16	12	30	17	40	12	0	1	6	60	4	— 7	7
	11	52	12	16	5	01	12	50	18	00	12	2	1	9				
Nov. 1	...	...	11	46	4	46	11	54	17	20	12	3	2	7	60	8	—13	6
	0	19	11	16	7	01	10	57	19	09	11	6	3	6				
" 2	0	48	...	...	7	01	...	...	18	42	...	...	0	9	61	0	—18	7
	1	16	0	16	7	16	11	28	18	28	14	3	0	1				
" 3	1	46	1	16	7	16	12	00	18	00	11	8	0	0	60	9	—22	7
	2	16	1	31	8	46	11	45	19	00	14	2	1	5				
" 4	2	47	1	16	8	01	11	00	17	45	11	6	0	3	60	5	—25	0
	3	19	...	...	8	01	...	...	17	14	...	...	1	6				
" 5	3	50	1	16	8	31	9	57	17	12	10	1	0	7	59	9	—25	6
	4	22	2	46	8	46	10	56	16	56	13	0	1	8				
" 6	4	52	4	01	9	01	11	39	16	39	9	1	2	3	59	1	—24	5
	5	23	4	46	10	31	11	54	17	39	10	9	2	6				
" 7	5	52	3	46	10	16	10	23	16	53	8	2	3	2	58	4	—21	9
	6	21	4	31	...	...	10	39	...	...	10	7	...	...				

Series I.—From October 10 to December 28, 1853.

Date 1853.	Moon passes the meridian.		Apparent time of				Lunitidal interval.				Height of				Moon's parallax at noon.		Moon's declination at noon.	
	Appar. time.		H. water.		L. water.		H. water.		L. water.		L. water.		H. water.					
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	Ft.	Dec.	Ft.	Dec.	Min.	Dec.	Degree.	Dec.
Nov. 8	6	48	5	16	0	16	10	55	18	24	7	8	3	5	57	6	—18	1
	7	14	6	46	0	16	11	58	17	55	10	4	4	9				
" 9	7	38	7	16	0	46	12	02	17	58	8	1	4	0	56	9	—13	5
	8	02	7	31	1	16	11	53	18	02	11	0	4	4				
" 10	8	25	8	46	0	46	12	44	17	08	9	8	4	3	56	3	— 8	4
	8	48	9	46	2	31	13	21	18	29	10	7	5	5				
" 11	9	09	10	01	2	46	13	13	18	21	9	5	2	3	55	7	— 3	1
	9	31	9	31	3	31	12	22	18	43	11	8	4	2				
" 12	9	52	10	01	4	16	12	30	19	07	11	2	2	8	55	2	+ 2	3
	10	13	9	46	3	31	11	54	18	00	11	5	3	8				
" 13	10	34	10	16	4	46	12	03	18	54	11	5	2	6	54	8	+ 7	5
	10	54	11	15	6	15	12	41	20	02	11	0	2	5				
" 14	11	15	10	45	5	0	11	51	18	26	12	7	2	1	54	5	+12	4
	11	37	10	45	5	30	11	30	18	36	9	8	2	9				
" 15	11	59	11	30	5	30	11	53	18	15	13	3	0	7	54	2	+16	8
	...	...	12	00	6	30	12	01	18	53	13	0	3	5				
" 16	0	21	12	30	5	0	12	09	17	01	13	6	0	4	54	1	+20	5
	0	44	11	45	7	15	11	01	18	54	10	9	3	1				
" 17	1	07	...	...	7	0	...	...	18	16	...	...	1	3	54	0	+23	2
	1	31	0	30	6	45	11	23	17	38	13	0	3	1				
" 18	1	55	0	45	7	15	11	14	17	44	13	7	—0	1	54	0	+25	0
	2	20	1	15	8	15	11	20	18	20	12	1	1	2				
" 19	2	44	1	14	7	14	10	54	16	54	9	8	1	9	54	1	+25	7
	3	09	1	44	8	14	11	00	17	30	13	0	2	3				
" 20	3	34	1	44	8	14	10	35	17	05	9	1	2	6	54	4	+25	2
	3	59	2	14	8	59	10	40	17	25	11	5	3	6				
" 21	4	24	2	29	7	59	10	30	16	00	8	0	3	2	54	7	+23	5
	4	49	2	44	11	14	10	20	18	50	10	7	3	6				
" 22	5	14	2	49	8	44	10	00	15	55	7	4	5	1	55	3	+20	7
	5	37	3	43	11	13	10	29	17	59	10	1	3	7				
" 23	6	01	6	13	10	28	12	36	16	51	7	1	6	6	55	9	+16	9
	6	25	4	43	...	...	10	42	...	...	9	9	...	...				
" 24	6	48	8	13	0	43	13	48	18	32	8	5	3	7	56	8	+12	3
	7	11	6	43	0	13	11	55	17	48	9	5	3	4				
" 25	7	34	7	48	0	43	12	37	17	55	8	8	3	7	57	7	+ 7	0
	7	56	6	57	1	42	11	23	18	31	10	3	6	9				
" 26	8	20	8	42	1	12	12	46	17	38	9	4	4	2	58	6	+ 1	2
	8	44	8	27	2	42	12	07	18	46	9	9	4	3				
" 27	9	08	9	42	3	42	12	58	19	22	10	9	2	7	59	6	— 4	9
	9	33	9	12	4	12	12	04	19	28	11	2	3	4				
" 28	9	58	10	12	4	12	12	39	19	04	12	0	2	2	60	5	—10	9
	10	24	11	11	4	41	13	13	19	08	12	5	2	6				
" 29	10	51	11	41	4	41	13	17	18	43	13	8	0	7	61	0	—16	5
	11	20	10	56	4	11	12	05	17	47	10	7	1	2				
" 30	11	50	10	56	4	41	11	36	17	50	13	7	0	1	61	4	—21	1
	...	...	...	...	5	26	...	...	18	06	...	...	1	7				
Dec. 1	0	21	0	11	5	41	12	21	17	51	10	8	—1	2	61	4	—24	3
	0	53	0	11	6	26	11	50	18	05	12	8	—0	3				
" 2	1	25	0	10	6	10	11	17	17	17	9	5	—2	1	61	0	—25	7
	1	58	1	10	7	10	11	45	17	45	13	6	0	0				
" 3	2	30	1	10	7	10	11	12	17	12	9	4	—0	4	60	4	—25	2
	3	03	1	55	8	40	11	25	18	10	12	8	—0	1				
" 4	3	32	1	54	6	39	10	51	15	36	8	3	0	1	59	6	—22	9
	4	03	2	09	9	09	10	37	17	37	13	7	1	6				
" 5	4	31	2	39	8	54	10	36	16	51	9	1	1	3	58	7	—19	4
	5	00	3	39	9	39	11	08	17	08	11	1	1	0				
" 6	5	26	3	09	8	24	10	09	15	24	6	1	2	3	57	7	—14	9
	5	52	4	24	11	39	10	58	18	13	10	3	1	0				
" 7	6	14	6	38	...	...	12	46	...	...	6	8	...	...	56	9	— 9	8
	6	38	7	53	0	08	13	39	18	16	10	6	3	4				
" 8	7	00	6	23	1	08	11	45	18	54	7	6	3	5	56	1	— 4	4
	7	22	...	...	0	38	...	...	18	00	...	...	2	9				
" 9	7	42	8	37	1	07	13	15	18	07	11	2	3	6	55	4	+ 1	0
	8	04	8	07	2	07	12	25	18	45	11	8	5	2				
" 10	8	25	9	37	2	07	13	33	18	25	11	1	5	3	54	9	+ 6	3
	8	46	9	07	2	07	12	42	18	03	9	2	5	3				

SERIES I.—FROM OCTOBER 10 TO DECEMBER 28, 1853.

DATE. 1853.	Moon passes the meridian. Appar. time.		Apparent time of H. water.		Apparent time of L. water.		Lunitidal interval. H. water.		Lunitidal interval. L. water.		Height of H. water.		Height of L. water.		Moon's parallax at noon.		Moon's declination at noon.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	Ft.	Dec.	Ft.	Dec.	Min.	Dec.	Degree.	Dec.
Dec. 11	9	06	9	51	3	36	13	05	19	11	9	5	1	7	54	5	+11	2
	9	27	9	36	3	36	12	30	18	50	7	8	1	8				
" 12	9	49	11	06	4	06	13	39	19	00	9	9	0	3	54	2	+15	7
	10	10	11	06	4	36	13	17	19	09	9	6	2	8				
" 13	10	31	10	35	4	05	12	35	18	16	11	0	3	5	54	0	+19	6
	10	54	10	20	4	35	11	49	18	25	8	6	2	8				
" 14	11	17	11	05	4	35	12	11	18	04	12	5	2	3	53	9	+22	6
	11	41	11	05	6	05	11	48	19	11	8	9	2	4				
" 15	...	...	...	...	5	05	...	...	17	48	...	...	2	4	53	9	+24	7
	0	06	1	04	6	04	13	23	18	23	13	2	5	5				
" 16	0	30	0	04	5	04	11	58	16	58	12	5	3	4	54	0	+25	6
	0	55	0	19	7	19	11	49	18	49	12	8	1	6				
" 17	1	20	0	34	6	03	11	39	17	08	7	5	2	7	54	2	+25	4
	1	44	...	...	5	18	...	...	15	58	...	...	0	6				
" 18	2	09	1	03	7	03	11	19	17	19	...	...	...	...	54	5	+24	0
	2	34	...	...	...	...	...	...	...	...	...	...	...	...				
" 19	2	58	2	03	7	32	11	29	17	58	...	...	...	...	54	8	+21	5
	3	22	1	32	8	02	10	34	17	04	...	...	...	...				
" 20	3	46	2	17	8	32	10	55	17	10	10	9	1	4	55	3	+18	0
	4	09	2	47	6	02	11	01	14	16	10	4	...	...				
" 21	4	32	3	02	8	31	10	53	16	22	11	6	4	5	55	9	+13	7
	4	54	3	46	9	31	11	14	16	59	11	5	4	4				
" 22	5	17	4	31	9	16	11	37	16	22	9	1	5	1	56	5	+ 8	7
	5	39	4	31	11	01	11	14	17	44	11	6	4	2				
" 23	6	01	5	31	11	30	11	52	17	51	7	5	3	1	57	4	+ 3	2
	6	24	4	30	11	30	10	29	17	29	8	8	2	9				
" 24	6	47	7	00	...	...	12	36	...	...	7	8	...	...	58	3	— 2	6
	7	10	6	30	0	00	11	43	17	36	9	3	4	6				
" 25	7	34	8	00	1	15	12	50	18	28	8	0	2	4	59	2	— 8	5
	7	59	7	30	0	15	11	56	17	05	7	3	4	1				
" 26	8	23	8	29	1	44	12	30	18	10	11	5	3	2	60	0	—14	1
	8	50	8	14	2	44	11	51	18	45	9	2	4	8				
" 27	9	18	9	28	1	59	12	38	17	36	11	2	1	8	60	7	—19	1
	9	46	9	28	3	58	12	10	19	08	9	1	2	9				
" 28	10	16	10	13	3	28	12	27	18	10	11	6	1	9	61	2	—22	9
	10	48	10	58	4	58	12	42	19	12	10	6	4	9				

SERIES II.—FROM JANUARY 28 TO APRIL 7, 1854.

DATE.	Moon passes the meridian. Appar. time.		Apparent time of H. water.		Apparent time of L. water.		Lunitidal interval. H. water.		Lunitidal interval. L. water.		Height of H. water.		Height of L. water.		Moon's parallax at noon.		Moon's declination at noon.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	Ft.	Dec.	Ft.	Dec.	Min.	Dec.	Degree.	Dec.
Jan. 27	10	58	...	...	...	...	...	...	...	...	...	...	...	...	60	7	—25	0
	11	30	...	...	...	...	...	...	...	...	...	...	...	...				
" 28	...	...	0	17	5	17	13	19	18	19	10	6	1	0	60	4	—22	5
	0	01	0	17	6	17	12	47	18	47	12	4	2	6				
" 29	0	31	0	17	6	17	12	16	18	16	11	9	1	3	59	9	—18	6
	1	01	0	2	8	02	11	31	19	31	13	3	—1	8				
" 30	1	27	0	16	6	01	11	15	17	00	9	0	0	5	59	1	—13	7
	1	55	1	16	7	46	11	49	18	19	13	9	—0	4				
" 31	2	20	0	46	7	16	10	51	17	21	9	7	—0	3	58	2	— 8	1
	2	45	1	16	8	16	10	56	17	56	13	7	1	5				
Feb. 1	3	08	2	46	8	46	12	01	18	01	11	1	1	3	57	3	— 2	4
	3	32	2	46	9	01	11	38	17	53	12	9	2	1				
" 2	3	54	4	01	9	01	12	29	17	29	10	0	2	0	56	4	+ 3	3
	4	16	2	46	10	01	10	52	18	07	10	6	0	3				
" 3	4	38	4	01	8	46	11	45	16	30	8	5	3	4	55	6	+ 8	7
	5	00	3	46	9	31	11	08	16	53	8	6	2	2				
" 4	5	21	4	46	9	01	11	46	16	01	9	2	3	8	55	0	+13	6
	5	43	5	16	12	16	11	55	18	55	8	9	3	8				
" 5	6	06	6	16	12	16	12	33	18	33	10	5	5	0	54	5	+17	8
	6	28	5	16	11	46	11	10	17	40	10	7	4	5				
" 6	6	51	8	16	11	46	13	48	17	18	9	5	3	8	54	3	+21	3
	7	14	8	01	11	16	13	10	16	25	7	2	3	7				
" 7	7	38	7	46	...	...	12	32	...	...	9	4	...	...	54	1	+23	9
	8	02	7	31	3	01	11	53	19	47	8	2	5	8				

SERIES II.—FROM JANUARY 28 TO APRIL 7, 1854.

DATE. 1854.	Moon passes the meridian.		Apparent time of				Lunitidal interval.				Height of				Moon's parallax at noon.		Moon's declination at noon.	
	Appar. time.		H. water.		L. water.		H. water.		L. water.		H. water.		L. water.					
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	Ft.	Dec.	Ft.	Dec.	Min.	Dec.	Degree.	Dec.
Feb. 8	8	26	10	01	2	46	13	59	19	08	9	5	4	7	54	1	+25	4
	8	50	9	15	3	15	12	49	19	13	6	7	3	3				
" 9	9	15	10	15	3	15	13	25	18	49	9	7	3	8	54	3	+25	7
	9	41	9	45	4	45	12	30	19	55	7	2	3	3				
" 10	10	06	10	15	6	15	12	34	21	00	9	2	3	7	54	6	+24	9
	10	32	11	45	5	15	13	39	19	31	6	6	1	5				
" 11	10	57	11	45	5	00	13	13	18	54	10	5	1	3	54	9	+22	8
	11	22	11	45	4	45	12	48	18	13	7	7	1	8				
" 12	11	46	10	45	5	00	11	23	18	03	11	5	2	8	55	4	+19	8
	...	...	11	15	6	30	11	29	19	08	8	4	2	3				
" 13	0	10	11	15	5	45	11	05	17	59	12	6	0	7	55	8	+15	6
	0	33	10	45	5	15	10	12	17	05	10	6	4	1				
" 14	0	58	...	...	6	46	...	...	18	13	...	...	2	4	56	3	+10	7
	1	21	0	46	7	16	11	48	18	18	13	6	2	6				
" 15	1	44	0	31	6	46	11	10	17	25	11	8	3	2	56	8	+ 5	3
	2	06	1	16	7	46	11	32	18	02	12	9	4	1				
" 16	2	29	0	16	7	46	10	10	17	40	13	1	2	2	57	3	— 0	3
	2	51	2	01	8	16	11	32	17	47	13	1	2	3				
" 17	3	14	3	16	7	16	12	25	16	25	12	6	3	9	57	7	— 6	0
	3	37	...	...	9	16	...	...	18	02	11	7	0	3				
" 18	4	00	3	01	9	01	11	24	17	24	10	6	2	7	58	2	—11	7
	4	24	2	16	9	16	10	16	17	16	10	2	3	0				
" 19	4	49	3	16	10	46	10	52	18	22	11	3	4	5	58	7	—16	8
	5	16	3	16	10	16	10	27	17	27	10	7	3	0				
" 20	5	42	3	46	9	16	10	30	16	00	10	8	5	5	59	1	—20	9
	6	10	3	46	...	...	10	04	...	...	10	7	...	...				
" 21	6	39	...	...	...	...	...	...	...	...	...	...	...	...	59	5	—24	1
	7	09	...	...	11	46	...	...	17	36	...	...	4	3				
" 22	7	40	...	...	...	...	...	...	...	...	...	...	...	...	59	8	—25	7
	8	10	7	46	4	16	12	06	21	07	9	1	4	7				
" 23	8	41	10	16	2	46	14	06	19	06	10	7	4	1	59	9	—25	6
	9	12	8	41	4	46	12	05	20	36	8	9	5	7				
" 24	9	45	9	17	1	17	12	05	16	36	10	3	3	3	59	9	—23	7
	10	15	10	17	3	47	12	32	18	35	9	7	2	8				
" 25	10	45	10	17	3	47	12	02	17	52	11	2	2	8	59	6	—20	3
	11	13	10	47	4	17	12	02	18	02	10	4	2	0				
" 26	11	41	12	47	4	47	13	34	18	02	11	9	1	0	59	2	—15	7
	...	...	11	47	6	02	12	06	18	49	11	3	3	0				
" 27	0	07	11	47	5	02	11	40	17	21	12	7	—0	4	58	6	—10	3
	0	33	11	47	6	02	11	14	17	55	10	3	—0	9				
" 28	0	57	12	32	6	17	11	35	17	44	13	0	0	1	57	9	— 4	5
	1	22	11	47	7	02	10	25	18	05	12	4	1	1				
March 1	1	45	...	...	7	02	...	...	17	40	...	...	0	5	57	1	+ 1	4
	2	09	1	32	8	47	11	47	19	02	12	9	1	3				
" 2	2	31	1	18	7	48	11	09	17	39	12	0	2	5	56	4	+ 7	0
	2	53	1	33	9	18	11	02	18	47	13	0	1	9				
" 3	3	15	2	03	8	18	11	10	17	25	10	6	2	5	55	7	+12	2
	3	38	2	18	9	03	11	03	17	48	10	9	1	5				
" 4	4	00	3	03	7	48	11	25	16	10	11	1	3	9	55	0	+16	7
	4	23	2	48	8	48	10	48	16	48	11	1	1	0				
" 5	4	46	3	48	8	48	11	25	16	25	9	2	3	1	54	6	+20	5
	5	09	3	03	9	48	10	17	17	02	10	1	3	9				
" 6	5	32	4	18	10	03	11	09	16	54	10	5	6	1	54	3	+23	4
	5	56	5	19	10	34	11	47	17	02	9	6	4	1				
" 7	6	22	4	49	10	49	10	53	16	53	8	8	5	8	54	2	+25	3
	6	47	...	...	...	...	...	...	...	...	...	...	...	...				
" 9	8	03	...	...	...	...	...	...	...	...	...	...	...	...			+25	5
	8	28	...	...	...	...	...	...	...	...	...	...	...	...				
" 10	8	53	9	49	4	21	13	21	20	18	9	9	3	9	54	9	+23	8
	9	18	10	50	4	35	13	57	20	07	8	8	5	0				
" 11	9	42	10	50	4	35	13	32	19	42	10	6	5	4	55	4	+21	0
	10	08	...	...	...	...	...	...	...	...	...	...	...	...				
" 14	11	43	...	...	...	...	...	...	...	...	...	...	...	...			+ 7	1
	0	06	12	21	...	...	12	15	...	...	11	2	...	...				

Date. 1854.	Moon passes the meridian. Appar. time.		Apparent time of H. water.		Apparent time of L. water.		Lunitidal interval. H. water.		Lunitidal interval. L. water.		Height of H. water.		Height of L. water.		Moon's parallax at noon.		Moon's declination at noon.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	Ft.	Dec.	Ft.	Dec.	Min.	Dec.	Degree.	Dec.
Series II.—From January 28 to April 7, 1854.																		
Mar. 15	0	29	11	21	6	21	10	52	18	15	12	7	2	3	57	6	+ 1	2
	0	52	...	...	8	06	...	...	19	37	...	...	2	7				
" 16	1	15	0	36	8	21	11	44	19	29	10	5	3	2	58	1	— 4	6
	1	38	1	21	6	36	12	06	17	21	8	4	3	0				
" 17	2	02	1	36	8	21	11	58	18	43	12	0	0	7	58	5	—10	5
	2	26	...	...	8	21	...	...	18	19	10	4	1	2				
" 18	2	52	1	52	9	22	11	26	18	56	12	1	1	6	58	8	—15	8
	3	18	1	52	8	07	11	00	17	15	9	5	3	1				
" 19	3	44	2	22	7	52	11	04	16	34	12	3	2	7	59	0	—20	4
	4	12	2	37	8	37	10	53	16	53	10	7	2	6				
" 20	4	40	4	22	...	...	12	10	...	...	12	4	...	...	59	2	—23	8
" 22	7	11	...	...	...	...	...	...	...	...	...	...	...	...			—26	0
" 23	7	42	7	23	...	...	12	12	...	...	9	5	...	...	59	2	—24	6
	8	12	8	23	1	53	12	41	18	42	8	5	5	3				
" 24	8	42	7	54	2	09	11	42	18	27	10	2	4	8	59	0	—21	6
	9	11	10	39	2	24	13	57	18	12	9	2	5	3				
" 25	9	39	9	54	3	54	12	43	19	12	10	3	5	1	58	7	—17	5
	10	05	9	54	3	54	12	15	18	43	9	6	4	3				
" 26	10	31	9	24	4	24	11	19	18	45	11	7	3	8	58	3	—12	4
	10	55	11	24	4	39	12	53	18	34	11	4	3	4				
" 27	11	19	10	54	4	54	11	59	18	23	11	9	2	2	57	8	— 6	7
	11	43	11	25	5	25	12	06	18	30	10	9	1	3				
" 28	...	...	11	25	5	55	11	42	18	36	12	0	2	0	57	3	— 0	8
	0	07	...	...	6	25	...	...	18	42	...	...	—1	3				
" 29	0	29	0	40	6	25	12	33	18	18	12	0	3	5	56	7	+ 4	9
	0	52	0	40	6	25	12	11	17	56	14	5	—0	2				
" 30	1	14	1	55	7	55	13	03	19	03	12	5	3	3	56	1	+10	4
	1	36	0	0	7	41	10	46	18	27	13	5	1	3				
" 31	1	59	1	41	7	56	12	05	18	20	11	5	1	5	55	5	+15	3
	2	22	1	56	8	56	11	57	18	57	13	0	3	3				
April 4	5	11	...	...	...	...	...	...	...	...	...	...	...	...	54	3	+26	1
	5	36	3	57	10	12	10	46	17	01	9	3	4	2				
" 5	6	01	5	42	10	42	12	06	17	06	9	7	5	0	54	3	+26	1
	6	27	5	42	10	42	11	41	16	41	6	9	5	7				
" 6	6	52	6	28	...	...	12	01	...	...	8	8	...	...	54	6	+24	8
	7	17	8	58	2	28	14	06	20	01	6	7	6	0				
" 7	7	41	8	13	0	0	12	56	17	08	8	5	5	5	55	0	+22	3
	8	07	9	58	2	28	14	17	19	11	7	5	5	5				
Series III.—From April 20 to August 3, 1854.																		
April 19	6	17	...	...	...	...	...	...	...	...	...	...	...	...				
" 20	6	45	...	...	...	...	...	...	...	...	...	...	...	...	58	8	—22	6
	7	13	6	01	0	16	11	16	17	59	8	1	5	1				
" 21	7	41	7	31	0	31	12	18	17	46	10	0	4	5	58	4	—18	7
	8	07	7	46	1	31	12	05	18	18	7	2	4	0				
" 22	8	35	8	02	1	17	11	55	17	36	10	4	4	0	57	9	—13	8
	8	59	9	47	3	17	13	12	19	10	9	8	4	0				
" 23	9	24	8	17	3	02	11	18	18	27	10	7	4	1	57	4	— 8	5
	9	47	19	17	4	32	12	53	19	33	9	6	1	8				
" 24	10	10	9	02	3	32	11	15	18	08	11	1	2	5	57	0	— 2	6
	10	32	9	32	4	32	11	22	18	45	9	9	1	7				
" 25	10	54	...	02	5	32	11	30	19	22	12	2	1	6	56	4	+ 3	1
	11	16	...	...	5	04	...	...	18	32	...	...	1	8				
" 26	11	38	...	...	4	02	...	...	17	08	...	...	2	6	56	0	+ 8	7
	12	00	0	02	6	32	12	46	19	16	12	0	0	1				
" 27	...	...	1	02	6	47	13	24	19	09	11	5	1	0	55	5	+13	8
	0	22	0	32	5	02	12	32	17	02	12	2	2	2				
" 28	0	45	...	...	5	03	...	...	16	41	...	...	2	0	55	0	+18	3
	1	09	1	03	7	03	12	18	18	18	11	6	2	0				
" 29	1	33	0	33	7	33	11	24	18	24	13	0	2	1	54	7	+21	9
	1	56	0	03	5	33	10	30	16	00	12	0	1	5				

Series III.—From April 20 to August 3, 1854.

Date. 1854.	Moon passes the meridian. Appar. time.		Apparent time of				Lunitidal interval.				Height of				Moon's parallax at noon.		Moon's declination at noon.	
			H. water.		L. water.		H. water.		L. water.		H. water.		L. water.					
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	Ft.	Dec.	Ft.	Dec.	Min.	Dec.	Degree.	Dec.
April 30	2	20	0	03	5	33	10	07	15	37	12	9	1	9	54	4	+24	5
	2	45	0	33	5	17	10	13	14	57	11	3	1	7				
May 1	3	09	1	18	9	03	10	33	18	18	12	6	3	9	54	2	+26	0
	3	34	0	33	7	03	9	24	15	54	9	4	3	7				
" 2	3	59	2	33	9	03	10	59	17	29	12	4	1	8	54	2	+26	3
	4	25	2	33	8	33	10	34	16	34	10	3	4	3				
" 3	4	50	3	48	9	03	11	23	16	38	9	6	5	3	54	3	+25	4
	5	15	3	03	9	03	10	13	16	13	9	1	6	5				
" 4	5	39	4	33	...	...	11	18	...	...	10	5	...	...	54	6	+23	4
	6	04	...	...	...	...	...	...	...	...	...	...	...	...				
" 6	7	14	...	...	...	...	...	...	...	...	...	...	...	...	55	6	+16	3
	7	38	...	...	...	...	...	...	...	...	...	...	...	...				
" 7	8	02	6	34	0	49	10	56	17	35	8	9	6	0	56	4	+11	4
	8	25	9	34	2	04	13	32	18	26	7	9	3	6				
" 8	8	48	8	34	1	04	12	09	17	02	11	5	5	2	57	3	+ 6	0
	9	10	10	19	4	04	13	31	19	39	8	1	2	7				
" 9	9	33	8	34	2	04	11	24	17	16	11	3	4	4	58	1	0	0
	9	56	9	04	3	19	11	31	18	09	9	4	1	8				
" 10	10	19	10	49	5	34	12	53	20	01	8	9	2	0	58	5	— 6	0
	10	43	12	04	3	34	13	45	17	38	11	8	2	2				
" 11	11	09	11	04	4	34	12	21	18	15	10	5	1	9	59	7	—12	0
	11	35	10	49	5	04	11	40	18	21	13	7	1	3				
" 12	12	02	12	04	5	49	12	29	18	40	11	0	1	0	60	2	—17	4
	...	...	11	34	4	34	11	32	16	59	13	1	0	9				
" 13	0	30	10	49	...	...	10	19	...	...	12	4	...	...	60	5	—22	0
	1	00	11	04	5	19	10	04	16	49	13	6	1	3				
" 14	1	30	...	...	...	...	...	...	...	...	...	...	...	...	60	6	—25	0
	2	01	0	4	6	19	10	34	16	49	11	3	0	8				
" 15	2	33	0	49	7	34	10	48	17	33	13	9	1	7	60	4	—26	3
	3	05	1	49	8	19	11	16	17	46	12	3	0	5				
" 16	3	38	0	49	8	04	9	44	16	59	12	4	1	8	60	0	—25	8
	4	09	2	34	7	19	10	56	15	41	10	4	2	3				
" 17	4	41	2	49	9	04	10	40	16	55	12	8	1	8	59	4	—23	5
	5	10	2	49	8	19	10	08	15	38	10	6	2	0				
" 18	5	40	3	49	10	49	10	39	17	39	12	5	1	8	58	8	—19	8
	6	07	3	49	9	19	10	09	15	39	9	6	4	2				
" 19	6	34	5	19	...	...	11	12	...	...	11	7	...	...	58	1	—15	0
	6	59	6	19	0	04	11	45	17	57	10	2	3	0				
" 20	7	24	7	19	0	34	12	20	18	00	9	8	5	2	57	5	— 9	7
	7	47	8	34	3	04	13	10	20	05	8	7	3	8				
" 21	8	10	7	34	2	19	11	47	18	55	11	1	4	4	56	9	— 4	0
	8	32	8	34	2	34	12	24	18	47	8	6	3	7				
" 22	8	55	8	04	1	34	11	32	17	24	10	6	3	4	56	3	+ 1	6
	9	16	9	04	3	19	12	09	18	47	9	3	2	5				
" 23	9	38	8	04	3	04	10	48	18	09	11	3	3	5	55	8	+ 7	3
	9	59	10	19	4	19	12	41	19	03	11	4	3	3				
" 24	10	21	8	48	4	48	10	49	19	10	9	9	4	0	55	3	+12	4
	10	43	11	48	4	18	13	27	18	19	12	9	2	0				
" 25	11	05	10	18	5	03	11	35	18	42	10	0	2	0	54	9	+17	1
	11	28	11	03	5	33	11	58	18	50	10	8	2	0				
" 26	11	51	12	45	5	03	13	17	17	58	9	7	2	7	54	6	+20	9
	...	...	12	45	6	33	12	54	19	05	12	5	3	4				
" 27	0	15	10	48	6	18	10	33	18	27	9	7	2	4	54	3	+23	9
	0	39	...	...	4	18	...	...	16	03	...	...	0	5				
" 28	1	04	0	33	6	48	11	54	18	09	10	7	1	6	54	1	+25	7
	1	29	0	03	4	48	10	59	15	44	8	7	2	3				
" 29	1	54	0	03	7	03	10	34	17	34	10	9	1	5	54	0	+26	3
	2	19	0	48	7	18	10	54	17	24	8	5	1	6				
" 30	2	44	1	03	8	18	10	44	17	59	12	0	2	5	54	0	+25	8
	3	09	2	18	6	48	11	34	16	04	8	5	2	5				
" 31	3	34	3	18	9	18	12	09	18	09	11	5	2	5	54	2	+24	1
	3	59	2	33	8	33	10	59	16	59	8	5	3	5				
June 1	4	22	2	18	9	47	10	19	17	48	11	0	4	0	54	5	+21	4
	4	47	4	17	10	02	11	55	17	40	8	0	3	6				

Series III.—From April 20 to August 3, 1854.

Date. 1854.	Moon passes the meridian.		Apparent time of				Lunitidal interval.				Height of				Moon's parallax at noon.		Moon's declination at noon.	
	Appar. time.		H. water.		L. water.		H. water.		L. water.		H. water.		L. water.					
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	Ft.	Dec.	Ft.	Dec.	Min.	Dec.	Degree.	Dec.
June 2	5	09	4	02	10	32	11	15	17	45	9	8	3	7	54	9	+17	6
	5	32	4	47	10	17	11	38	17	08	7	8	4	8				
" 3	5	54	...	...	...	...	...	...	...	...	9	6	4	5	55	5	+13	1
	6	16	4	02	10	02	10	08	16	08	8	1	5	2				
" 4	6	38	...	...	...	...	...	...	...	...	9	4	...	...	56	3	+ 8	0
	7	00	7	32	12	02	12	54	17	24	8	6	5	6				
" 5	7	22	8	02	...	...	13	02	...	...	9	7	...	...	57	2	+ 2	3
	7	44	9	02	0	32	13	40	17	32	9	2	4	7				
" 6	8	07	9	02	1	32	13	18	18	10	10	1	6	1	58	2	— 3	6
	8	30	8	02	2	32	11	55	18	48	10	4	4	0				
" 7	8	54	9	02	4	02	12	32	19	55	10	2	4	3	59	0	— 9	5
	9	18	9	02	3	02	12	08	18	32	11	1	3	4				
" 8	9	44	8	01	2	47	10	43	17	53	9	3	4	0	59	9	—15	2
	10	10	10	01	2	31	12	17	17	13	11	6	1	8				
" 9	10	38	...	...	...	...	...	...	...	...	...	...	...	...	60	6	—20	1
	11	07	9	01	3	01	10	23	16	51	12	9	1	4				
" 10	11	38	10	01	5	01	10	54	18	23	11	7	2	1	61	1	—23	9
	...	...	13	31	6	01	13	53	18	54	11	4	0	6				
" 11	0	10	10	31	6	01	10	21	18	23	9	4	1	8	61	2	—26	0
	0	43	13	01	6	31	12	18	18	21	13	2	2	0				
" 12	1	16	11	31	6	31	10	15	17	48	10	4	1	6	61	1	—26	2
	1	49	...	...	6	31	...	...	17	15	12	2	0	4				
" 13	2	21	...	...	8	30	...	...	18	41	...	...	0	2	60	6	—24	5
	2	52	1	00	8	00	10	39	17	39	10	3	1	1				
" 14	3	24	1	30	7	30	10	38	16	38	12	1	1	6	60	0	—21	0
	3	53	0	30	8	00	9	06	16	36	10	3	1	3				
" 15	4	23	2	30	9	00	10	37	17	07	12	3	1	3	59	2	—16	5
	4	49	1	30	8	00	9	07	15	37	8	5	2	3				
" 16	5	16	4	0	9	45	11	11	16	56	11	7	2	5	58	3	—11	2
	5	40	2	0	9	00	8	44	15	44	8	9	3	7				
" 17	6	04	3	0	9	00	9	20	15	20	11	4	2	8	57	4	— 5	4
	6	27	2	30	11	29	8	26	17	25	9	3	4	6				
" 18	6	49	4	59	11	29	10	32	17	02	10	2	3	2	56	7	+ 0	4
	7	11	4	59	11	59	10	10	17	10	10	5	5	6				
" 19	7	33	5	59	...	...	10	48	...	...	10	5	...	...	56	0	+ 6	0
	7	54	7	29	1	29	11	56	18	18	10	0	4	0				
" 20	8	16	7	59	2	14	12	05	18	41	9	9	5	2	55	4	+11	3
	8	37	9	29	3	29	13	13	19	35	10	5	4	4				
" 21	8	59	8	59	2	44	13	22	18	28	9	4	5	8	54	9	+16	0
	9	22	9	29	2	59	12	30	18	22	13	0	3	0				
" 22	9	44	9	28	2	58	12	06	17	59	9	9	2	9	54	5	+20	1
	10	07	10	13	4	58	12	29	19	36	10	6	3	3				
" 23	10	31	9	28	3	58	11	21	18	14	8	5	3	6	54	3	+23	2
	10	55	11	28	5	43	12	57	19	36	11	0	2	9				
" 24	11	19	12	13	4	28	13	18	17	57	8	1	3	6	54	1	+25	4
	11	44	10	58	5	28	11	39	18	33	11	3	2	0				
" 25	...	...	11	58	4	58	12	14	17	39	8	3	2	4	54	0	+26	3
	0	10	...	...	6	58	...	...	19	14	...	...	3	1				
" 26	0	35	1	13	4	58	13	03	16	48	12	1	2	0	53	9	+26	0
	0	59	0	57	6	27	12	22	17	52	9	9	2	4				
" 27	1	24	...	...	4	57	...	...	15	58	12	3	1	9	54	0	+24	6
	1	49	0	27	7	27	11	03	18	03	9	8	3	0				
" 28	2	13	0	57	7	57	11	08	18	08	11	4	3	2	54	2	+22	1
	2	37	0	57	7	27	10	44	17	14	9	2	2	5				
" 29	3	00	1	12	7	57	10	35	17	20	11	4	3	6	54	5	+18	6
	3	24	1	42	6	27	10	42	15	27	9	1	2	0				
" 30	3	46	3	27	8	57	12	03	17	33	12	3	3	9	54	9	+14	3
	4	08	0	12	7	27	8	26	15	41	9	4	3	8				
July 1	4	30	4	42	9	57	12	34	17	49	11	6	2	6	55	5	+ 9	4
	4	52	4	57	8	57	12	27	16	27	9	3	5	0				
" 2	5	12	3	26	10	41	10	34	17	49	11	7	2	2	56	2	+ 4	0
	5	33	5	26	11	26	12	14	18	14	7	3	3	8				
" 3	5	55	4	11	10	26	10	38	16	53	9	1	4	8	57	0	— 1	7
	6	17	5	26	10	56	11	21	17	01	9	8	6	9				
" 4	6	39	6	41	11	11	12	24	16	54	10	2	4	4	57	9	— 7	5
	7	02	6	56	...	...	12	17	...	...	9	8	...	...				

Series III.—From April 20 to August 3, 1854.

Date. 1854.	Moon passes the meridian. Appar. time.		Apparent time of H. water.		Apparent time of L. water.		Lunitidal interval. H. water.		Lunitidal interval. L. water.		Height of H. water.		Height of L. water.		Moon's parallax at noon.		Moon's declination at noon.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	Ft.	Dec.	Ft.	Dec.	Min.	Dec.	Degree.	Dec.
July 5	7	26	6	56	0	26	11	54	17	47	10	1	6	5	58	8	—13	1
	7	51	7	56	1	26	12	30	18	24	10	6	4	3				
" 6	8	18	7	41	1	56	11	50	18	30	9	4	6	0	59	7	—18	3
	8	45	8	56	1	26	12	38	17	35	11	2	3	9				
" 7	9	14	7	55	2	55	11	10	18	37	9	2	5	6	60	5	—22	5
	9	43	...	...	3	10	...	...	18	25	...	...	3	0				
" 8	10	15	...	...	...	...	...	...	...	...	...	...	...	...	61	1	—25	3
	10	47	...	...	...	...	...	...	...	...	...	...	...	...				
" 9	11	20	10	40	4	40	11	53	18	25	8	5	2	4	61	4	—26	3
	11	54	11	40	4	25	12	20	17	38	12	5	1	2				
" 10	...	...	12	55	5	25	12	51	18	05	8	4	2	2	61	4	—25	4
	0	27	11	55	5	10	11	28	17	26	13	6	1	2				
" 11	1	00	12	25	6	25	11	25	17	58	10	1	1	5	61	0	—22	5
	1	31	12	55	6	10	11	24	17	10	13	3	1	2				
" 12	2	02	11	40	6	55	9	38	17	24	10	1	1	0	60	3	—18	3
	2	31	...	...	7	10	...	...	17	08	...	...	1	2				
" 13	3	00	1	10	7	40	10	39	17	09	13	6	1	0	59	5	—12	9
	3	26	1	25	7	55	10	25	16	55	10	0	2	4				
" 14	3	52	1	55	9	10	10	29	17	44	12	6	1	8	58	5	— 7	2
	4	15	2	24	8	54	10	32	17	02	9	2	2	5				
" 15	4	39	...	...	...	...	...	...	...	...	...	...	...	...	57	6	— 1	2
" 17	6	31	...	...	...	...	...	...	...	...	...	...	...	...			+10	2
" 18	6	53	...	...	...	...	...	...	...	...	...	...	...	...	55	3	+15	1
	7	16	7	24	1	24	12	31	18	53	9	2	4	8				
" 19	7	38	8	54	...	...	13	38	...	...	7	6	4	6	54	7	+19	3
	8	01	8	39	1	24	13	01	18	08	9	3	4	4				
" 20	8	24	9	54	2	39	13	53	19	01	8	7	5	6	54	4	+22	6
	...	...	...	...	1	54	...	...	17	53	...	...	4	5				
" 27	2	04	...	...	...	...	...	...	...	...	...	...	...	...			+15	3
" 28	2	26	...	...	...	...	...	...	...	...	...	...	...	...	55	2	+10	4
	2	48	1	54	7	54	11	28	17	28	8	6	2	0				
" 29	3	09	2	54	8	09	12	06	17	21	12	0	1	7	55	7	+ 5	2
	3	30	3	54	8	54	12	45	17	45	11	3	3	2				
" 30	3	51	2	09	8	24	10	39	16	54	11	1	3	2	56	3	— 0	4
	4	13	2	54	8	24	11	03	16	33	9	2	4	1				
" 31	4	34	...	...	...	...	...	...	...	...	10	6	4	0	56	9	— 6	1
	4	56	2	39	9	39	10	05	17	05	9	0	4	8				
Aug. 1	5	19	3	24	10	39	10	28	17	43	9	3	4	4	57	7	—11	6
	5	43	4	39	9	54	11	20	16	35	10	5	6	1				
" 2	6	07	4	54	11	09	11	11	17	26	10	5	4	5	58	5	—16	8
	6	32	5	54	...	...	11	47	...	...	9	5	...	...				
" 3	6	59	5	54	0	54	11	22	18	47	8	8	5	7	59	3	—21	3
	7	27	8	24	1	09	13	25	18	37	9	4	3	6				

Series IV.—From September 7 to October 22, 1854.

Date. 1854.	Moon passes the meridian. Appar. time.		Apparent time of H. water.		Apparent time of L. water.		Lunitidal interval. H. water.		Lunitidal interval. L. water.		Height of H. water.		Height of L. water.		Moon's parallax at noon.		Moon's declination at noon.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	Ft.	Dec.	Ft.	Dec.	Min.	Dec.	Degree.	Dec.
Sept. 7	0	23	...	...	...	...	...	...	...	...	...	...	...	...	59	3	— 5	7
	0	47	11	2	...	...	10	15	...	...	14	5	...	...				
" 8	1	12	11	2	5	32	9	50	16	45	14	0	—1	7	58	5	+ 0	5
	1	36	...	...	8	02	...	...	18	50	...	...	0	0				
" 9	2	01	1	32	8	02	11	56	18	26	13	5	1	0	57	7	+ 6	6
	2	24	1	32	7	32	11	31	17	31	14	0	—0	5				
" 10	2	47	1	03	7	33	10	39	17	09	13	0	—1	0	56	9	+12	3
	3	10	2	03	10	03	11	16	19	16	11	0	1	0				
" 11	3	33	2	33	8	33	11	23	17	23	11	0	0	0	56	1	+17	2
	3	57	...	...	9	03	...	...	17	30	10	5	1	5				
" 12	4	22	2	04	8	03	10	07	16	06	14	0	0	0	55	4	+21	2
	4	46	4	03	8	03	11	41	15	41	10	0	0	0				
" 13	5	11	3	04	7	04	10	18	14	18	10	0	0	0	54	8	+24	2
	5	35	3	34	8	04	10	23	14	53	9	0	3	0				
" 14	6	00	2	04	...	...	8	29	...	...	7	0	...	...	54	5	+26	1
	6	25	...	...	...	...	...	...	...	...	...	...	...	...				
" 15	6	52	...	...	...	...	...	...	...	...	...	...	...	...			+26	7
	7	17	...	...	...	...	...	...	...	...	...	...	...	...				

SERIES IV.—FROM SEPTEMBER 7 TO OCTOBER 22, 1854.

DATE. 1854.	Moon passes the meridian. Appar. time.		Apparent time of H. water.		Apparent time of L. water.		Lunitidal interval. H. water.		Lunitidal interval. L. water.		Height of H. water.		Height of L. water.		Moon's parallax at noon.		Moon's declination at noon.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	Ft.	Dec.	Ft.	Dec.	Min.	Dec.	Degree.	Dec.
Sept. 16	7	43	...	...	11	35	...	...	16	18	...	...	5	0	54	2	+26	1
	8	08	...	...	...	...	...	...	...	...	10	0	...	...				
" 17	8	34	7	06	1	36	11	58	17	53	9	0	5	0	54	3	+24	4
	8	58	8	06	0	06	11	32	15	58	10	4	5	0				
" 18	9	22	...	...	4	06	...	...	19	32	9	0	5	0	54	5	+21	5
	9	47	10	06	3	06	12	44	18	08	12	0	5	0				
" 19	10	09	8	36	4	36	10	49	19	14	10	0	5	0	54	9	+17	7
	10	33	11	06	6	06	12	57	20	19	12	6	5	0				
" 20	10	55	...	...	5	07	...	...	18	58	...	...	2	0	55	3	+13	1
	11	17	11	07	4	07	12	12	17	34	13	0	2	0				
" 21	11	39	11	07	5	07	11	50	18	12	11	5	4	0	55	8	+ 7	8
	...	...	11	07	3	07	11	28	15	50	14	0	0	0				
" 22	12	00	...	...	5	07	...	...	17	28	...	...	2	0	56	4	+ 2	2
	0	22	0	07	5	07	12	07	17	07	13	0	1	0				
" 23	0	45	1	08	6	08	12	46	17	46	12	0	—0	7	56	9	— 3	6
	1	07	0	08	6	38	11	23	17	53	13	0	0	0				
" 24	1	29	1	08	7	08	12	01	18	01	11	0	2	0	57	4	— 9	5
	1	52	0	08	7	08	10	39	17	39	13	0	1	0				
" 25	2	15	2	08	8	08	12	16	18	16	14	0	0	0	57	9	—14	9
	2	39	1	08	8	08	10	53	17	53	13	0	0	0				
" 26	3	06	1	09	7	09	10	30	16	30	13	0	0	0	58	3	—19	7
	3	32	2	09	8	09	11	03	17	03	13	0	0	0				
" 27	3	59	2	09	8	09	10	37	16	37	12	0	—1	0	58	6	—23	5
	4	27	3	09	8	09	11	10	16	10	13	0	0	0				
" 28	4	56	3	09	8	09	10	42	15	42	13	0	1	0	58	9	—26	0
	5	25	4	09	9	09	11	13	16	13	12	0	2	0				
" 29	5	57	2	10	10	10	8	45	16	45	10	0	2	0	59	2	—26	8
	6	28	4	10	9	10	10	13	15	13	11	5	3	0				
" 30	6	59	4	10	11	10	9	42	16	42	9	0	3	0	59	4	—25	8
	7	30	5	40	12	10	10	41	17	11	10	0	4	5				
Oct. 1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	59	5	—23	3
" 3	10	20	...	...	...	...	...	...	...	...	...	...	...	...			—14	2
" 4	10	45	9	41	...	...	11	21	...	...	10	0	...	...	59	0	— 8	3
	11	10	11	11	4	41	12	26	18	21	14	0	0	0				
" 5	11	36	12	12	4	11	13	02	17	26	13	0	—1	2	58	6	— 2	0
	11	59	11	42	5	12	12	06	18	02	14	0	—2	0				
" 6	0	22	12	12	5	12	12	13	17	36	12	0	—1	0	57	9	+ 4	3
	...	...	11	12	7	12	10	50	19	13	14	0	—0	5				
" 7	0	46	...	...	6	42	...	...	18	20	...	...	1	0	57	3	+10	2
	1	09	0	12	5	42	11	26	16	56	14	0	0	0				
" 8	1	33	0	12	8	12	11	03	19	03	14	0	—1	0	56	6	+15	5
	1	57	0	43	7	13	11	10	17	40	13	0	0	0				
" 9	2	21	0	13	6	43	10	16	16	46	10	0	0	0	55	9	+20	0
	2	45	2	13	8	13	11	52	17	52	14	0	0	0				
" 10	3	10	1	13	6	13	10	28	15	28	13	0	0	0	55	3	+23	4
	3	35	2	13	8	13	11	03	17	03	14	0	0	5				
" 11	4	00	1	13	8	13	9	38	16	38	10	0	0	0	54	8	+25	7
	4	25	1	13	8	13	9	13	16	13	14	0	2	0				
" 12	4	51	2	13	8	13	10	48	15	48	14	5	2	0	54	5	+26	8
	5	17	3	44	9	14	10	53	16	23	14	0	4	0				
" 14	6	58	...	...	...	...	...	...	...	...	...	...	...	...	54	3	+25	3
" 15	7	23	...	...	11	14	...	...	16	16	10	0	3	0	54	4	+22	7
	7	47	8	14	11	14	12	51	15	51	10	0	5	0				
" 16	8	01	...	...	...	...	...	...	...	...	...	...	...	...	54	8	+19	2
	8	34	...	...	...	...	...	...	...	...	...	...	...	...				
" 17	8	57	10	15	3	15	13	41	19	14	10	0	3	0	55	2	+14	8
	9	19	10	15	3	15	13	18	18	41	11	0	3	0				
" 18	9	41	9	15	3	15	11	56	18	18	11	0	3	0	55	7	+ 9	7
	10	02	9	15	3	45	11	34	18	26	12	0	2	0				
" 19	10	24	9	15	4	15	11	13	18	34	12	0	0	0	56	4	+ 4	2
	10	46	...	...	3	45	...	...	17	43	11	0	1	0				
" 20	11	08	11	15	5	15	12	29	18	51	12	0	1	0	57	0	— 1	6
	11	30	12	15	4	15	13	07	17	29	11	0	0	0				
" 21	11	53	11	45	4	15	12	15	17	07	12	0	0	0	57	7	— 7	6
	...	...	11	15	5	15	11	22	17	45	12	0	0	0				
" 22	0	17	11	45	4	15	11	28	16	22	13	0	0	0	58	3	—13	4
	0	41	11	45	5	15	11	04	16	58	13	0	0	0				

The second form, or Table No. 2, for reduction of tides, is specially arranged to obtain the establishment and the half-monthly inequality in time and height. The first part is arranged in reference to the observed high waters; the second part, in reference to the low waters. That the inequality in time and height should also be made out from the low water, is specially important for stations where either the observations are of short extent, or else where difficulties tend to render the observations less accurate. The discussion of the low waters could not be omitted in our case. The headings to the columns of Table No. 2, explain the arrangement sufficiently. The results from the upper and lower transit of the moon are kept separate. (It need hardly be remarked that, in certain months, the sun's or moon's lower transit can be observed at Van Rensselaer Harbor.)

TABLE FOR THE REDUCTION OF TIDES.—No. 2.

Showing the Interval between the App. Time of the Moon's Superior Transit and the Time of High Water, and also the Heights of High Water, at Van Rensselaer Harbor, from Four Series of Observations made between October 10, 1853, and October 22, 1854.

0^h to 1^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
0	57	...	...	12	3	
0	19	10	57	11	6	
0	21	12	09	13	6	I.
0	53	11	17	9	5	
0	30	11	49	12	8	
0	01	12	16	11	9	
0	10	11	05	12	6	
0	58	11	48	13	6	
0	33	11	14	10	3	II.
0	29	10	52	12	7	
0	07	12	33	12	0	
0	52	13	03	12	5	
0	30	10	19	12	4	
0	39	11	54	10	7	
0	10	10	21	9	4	III.
0	10	13	03	12	1	
0	59	...	...	12	3	
0	22	12	46	12	0	
0	46	11	26	14	0	IV.
0	41	11	04	13	0	

1^h to 2^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
1	40	11	35	12	4	
1	16	12	00	11	8	
1	07	11	23	13	0	I.
1	55	11	20	12	1	
1	58	11	12	9	4	
1	01	11	15	9	0	
1	55	10	51	9	7	
1	44	11	32	12	9	
1	22	10	25	12	4	II.
1	15	12	06	8	4	
1	36	12	05	11	5	
1	09	11	24	13	0	
1	56	10	07	12	9	
1	30	10	34	11	3	
1	29	10	34	10	9	III.
1	16	10	15	10	4	
1	49	11	08	11	4	
1	00	11	25	10	1	
1	12	9	50	14	0	
1	07	12	01	11	0	IV.
1	52	12	16	14	0	
1	33	11	10	13	0	

2^h to 3^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
2	25	11	20	11	9	
2	16	11	00	11	6	I.
2	44	11	00	13	0	
2	58	10	34	...	...	
2	45	12	01	11	1	
2	29	11	32	13	1	
2	09	11	09	12	0	II.
2	53	11	10	10	6	
2	02	...	...	10	4	
2	52	11	00	9	5	
2	45	10	33	12	6	
2	33	11	16	12	3	
2	19	10	44	12	0	
2	21	10	39	10	3	III.
2	37	10	35	11	4	
2	02	9	38	10	1	
2	48	12	06	12	0	
2	01	11	31	14	0	
2	47	11	16	11	0	IV.
2	39	10	30	13	0	
2	21	11	52	14	0	

MEANS.

0^h–1^h H.	M.	H.	M.	Ft.	Dec.	No.	1^h–2^h H.	M.	H.	M.	Ft.	Dec.	No.	2^h–3^h H.	M.	H.	M.	Ft.	Dec.	No.
0	29	11	40	...	...	18	1	29	11	12	...	...	22	2	32	11	04	...	...	20
0	31	...	...	12	1	20	1	29	...	...	11	6	22	2	29	...	...	11	8	20

TABLE FOR THE REDUCTION OF TIDES.—No. 2.

Showing the Interval between the App. Time of the Moon's Superior Transit and the Time of High Water, and also the Heights of High Water, at Van Rensselaer Harbor, from Four Series of Observations made between October 10, 1853, and October 22, 1854.

3^h to 4^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
3	12	12	03	11	1	I.
3	19	9	57	10	1	
3	34	10	40	11	5	
3	03	10	51	8	3	
3	46	11	01	10	4	
3	32	12	29	10	0	II.
3	14	...	...	11	7	
3	38	11	25	11	1	
3	44	10	53	10	7	
3	34	10	59	12	4	III.
3	38	10	56	10	4	
3	09	12	09	11	5	
3	59	10	19	11	0	
3	24	9	06	10	3	
3	24	12	03	12	3	
3	00	10	25	10	0	
3	52	10	32	9	2	
3	30	10	39	11	1	
3	33	...	...	10	5	IV.
3	32	10	37	12	0	
3	10	11	03	14	0	
MEANS.						
3	30	10	57	...	...	19
3	29	...	...	10	9	21

The highest and lowest value of the interval balance nearly.

4^h to 5^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
4	00	11	16	9	9	I.
4	51	11	25	10	4	
4	22	11	39	9	1	
4	24	10	20	10	7	
4	03	10	36	9	1	
4	32	11	14	11	5	
4	16	11	45	8	5	II.
4	00	10	16	10	2	
4	49	10	27	10	7	
4	23	11	25	9	2	
4	25	11	23	9	6	III.
4	41	10	08	10	6	
4	47	11	15	9	8	
4	23	9	07	8	5	
4	08	12	34	11	6	
4	52	10	34	11	7	
4	13	...	...	10	6	
4	56	10	28	9	3	
4	22	11	41	10	0	IV.
4	27	10	42	13	0	
4	00	9	13	14	0	
4	51	10	53	14	0	
MEANS.						
4	27	10	52	...	...	21
4	27	...	...	10	5	22

5^h to 6^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
5	42	12	04	9	7	I.
5	23	10	23	8	2	
5	14	10	29	10	1	
5	00	10	09	6	1	
5	52	12	46	6	8	
5	17	11	14	11	6	
5	00	11	46	9	2	II.
5	43	12	33	10	5	
5	42	10	04	10	7	
5	09	11	09	10	5	
5	56	10	53	8	8	
5	36	12	06	9	7	
5	15	11	18	10	5	III.
5	40	10	09	9	6	
5	32	...	...	9	6	
5	16	8	44	8	9	
5	33	10	38	9	1	
5	43	11	11	10	5	
5	11	10	23	9	0	IV.
5	25	8	45	10	0	
MEANS.						
5	27	10	53	...	...	19
5	27	...	...	9	5	20

The criterion rejects no value of the interval, the two high and two low values balance nearly.

TABLE FOR THE REDUCTION OF TIDES.—No. 2.

Showing the Interval between the App. Time of the Moon's Superior Transit and the Time of High Water, and also the Heights of High Water, at Van Rensselaer Harbor, from Four Series of Observations made between October 10, 1853, and October 22, 1854.

6^h to 7^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
6	28	13	45	8	0	I.
6	32	13	44	8	5	
6	21	10	55	7	8	
6	01	10	42	9	9	
6	48	11	55	9	5	
6	38	11	45	7	6	
6	01	10	29	8	8	
6	47	11	43	9	3	
6	28	13	48	9	5	II.
6	27	12	01	8	8	
6	45	11	16	8	1	III.
6	34	11	45	10	2	
6	16	...	...	9	4	
6	04	8	26	9	3	
6	49	10	10	10	5	
6	17	12	24	10	2	
6	53	12	31	9	2	
6	32	11	22	8	8	
6	28	9	42	9	0	IV.
MEANS.						
6	30	11	35	...	...	18
6	29	...	...	9	1	19

Peirce's criterion rejects the value 8^h 26^m, new mean—

6	31	11	45	...	...	17

7^h to 8^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
7	26	12	32	6	7	I.
7	22	13	24	9	2	
7	14	12	02	8	1	
7	34	11	23	10	3	
7	22	13	15	11	2	
7	34	11	56	7	3	
7	14	12	32	9	4	II.
7	40	12	06	9	1	
7	42	12	41	8	5	
7	17	12	56	8	5	
7	41	12	05	7	2	III.
7	38	10	56	8	9	
7	24	13	10	8	7	
7	00	13	02	9	7	
7	44	13	18	10	1	
7	33	11	56	10	0	
7	02	11	54	10	1	
7	51	11	50	9	4	
7	38	13	01	9	3	
7	43	...	...	10	0	IV.
7	23	12	51	10	0	
MEANS.						
7	28	12	26	...	...	20
7	29	...	...	9	1	21

8^h to 9^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
8	22	11	51	7	9	I.
8	11	12	35	9	8	
8	59	12	47	10	8	
8	02	12	44	9	8	
8	48	13	13	9	5	
8	20	12	07	9	9	
8	04	13	33	11	1	
8	46	13	05	9	5	
8	23	11	51	9	2	
8	02	13	59	9	5	II.
8	50	13	25	9	7	
8	41	12	05	8	9	
8	28	13	21	9	9	
8	42	13	57	9	2	
8	35	13	12	9	8	III.
8	25	12	09	11	5	
8	10	12	24	8	6	
8	55	12	09	9	3	
8	30	12	32	10	2	
8	16	13	13	10	5	
8	59	12	30	13	0	
8	45	11	10	9	2	
8	34	11	32	10	4	IV.
8	57	13	18	11	0	
MEANS.						
8	32	12	42	...	...	24
8	32	...	...	9	9	24

Table for the Reduction of Tides.—No. 2.

Showing the Interval between the App. Time of the Moon's Superior Transit and the Time of High Water, and also the Heights of High Water, at Van Rensselaer Harbor, from Four Series of Observations made between October 10, 1853, and October 22, 1854.

9h to 10h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
9	12	12	47	9	1	I.
9	47	12	59	11	4	
9	31	12	30	11	2	
9	08	12	04	11	2	
9	58	13	13	12	5	
9	27	13	39	9	9	
9	18	12	10	9	1	
9	41	12	34	9	2	II.
9	45	12	32	9	7	
9	18	13	32	10	6	
9	39	12	15	9	6	
9	24	12	53	9	6	III.
9	10	11	24	11	3	
9	56	12	53	8	9	
9	38	12	41	11	4	
9	18	10	43	9	3	
9	44	12	29	10	6	
9	22	12	44	12	0	IV.
9	41	11	34	12	0	

10h to 11h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
10	02	12	12	9	8	I.
10	36	12	10	11	7	
10	13	12	03	11	5	
10	54	11	51	12	7	
10	51	12	05	10	7	
10	10	12	25	11	0	
10	.54	12	11	12	5	
10	16	12	42	10	6	
10	58	13	19	10	6	II.
10	32	13	13	10	5	
10	45	12	02	10	4	
10	31	12	53	11	4	
10	10	11	22	9	9	III.
10	43	12	21	10	5	
10	21	13	27	12	9	
10	31	12	57	11	0	
10	47	11	53	8	5	
10	09	12	57	12	6	IV.
10	55	12	12	13	0	
10	20	11	21	10	0	
10	24	...	...	11	0	

11h to 12h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
11	26	12	50	12	2	I.
11	37	11	53	13	3	
11	50	12	21	10	8	
11	41	13	23	13	2	
11	32	11	23	11	5	II.
11	41	12	06	11	3	
11	19	12	06	10	9	
11	38	13	24	11	5	III.
11	35	12	29	11	0	
11	05	11	58	10	8	
11	51	12	54	12	5	
11	07	10	54	11	7	
11	19	11	39	11	3	
11	54	12	51	8	4	
11	39	11	28	14	0	IV.
11	10	13	02	13	0	
11	59	12	13	12	0	
11	08	13	07	11	0	
11	53	11	22	12	0	

MEANS.

	H.	M.	H.	M.	Ft.	Dec.	No.
9h to 10h	9	31	12	30	...	...	19
	9	31	...	...	10	4	19
10h to 11h	10	32	12	23	...	...	20
	10	31	...	...	11	1	21
11h to 12h	11	32	12	17	...	...	19
	11	32	...	...	11	7	19

The value 10h 43m is rejected by Peirce's criterion, and there is no corresponding high value to balance it; the new mean becomes—

9	32	12	36	...	...	18

Table for the Reduction of Tides.—No. 2.

Showing the Interval between the App. Time of the Moon's Inferior Transit and the Time of High Water, and also the Heights of High Water, at Van Rensselaer Harbor, from Four Series of Observations made between October 10, 1853, and October 22, 1854.

0^h to 1^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
0	35	11	10	10	7	I.
0	48	11	28	14	3	
0	44	11	01	10	9	
0	21	11	50	12	8	
0	06	11	58	12	5	
0	55	11	39	7	5	
0	31	11	31	13	3	II.
0	33	10	12	10	6	
0	07	11	40	12	7	
0	57	11	35	13	0	
0	06	12	15	11	2	
0	52	11	44	10	5	
0	29	12	11	14	5	
0	00	12	32	12	2	III.
0	45	12	18	11	6	
0	02	11	32	13	1	
0	15	10	33	9	7	
0	43	12	18	13	2	
0	35	12	22	9	9	
0	27	11	28	13	6	
0	47	10	15	14	5	IV.
0	00	12	07	13	0	
0	45	11	23	13	0	
0	22	10	50	14	0	
0	17	11	28	13	0	
MEANS.						
0	29	11	34	...	...	25
0	29	...	...	12	2	25

1^h to 2^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
1	18	11	12	11	5	I.
1	46	11	45	14	2	
1	31	11	14	13	7	
1	25	11	45	13	6	
1	44	11	19	...	...	
1	27	11	49	13	9	II.
1	21	11	10	11	8	
1	45	11	47	12	9	
1	38	11	58	12	0	
1	14	10	46	13	5	
1	59	11	57	13	0	
1	33	10	30	12	0	III.
1	00	10	04	13	6	
1	04	10	59	8	7	
1	54	10	54	8	5	
1	49	...	...	12	2	
1	24	11	03	9	8	
1	31	11	24	13	3	
1	36	11	56	13	5	IV.
1	29	10	39	13	0	
1	09	11	03	14	0	
1	57	10	16	10	0	
MEANS.						
1	31	11	13	...	...	21
1	31	...	...	12	3	21

2^h to 3^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
2	02	11	13	11	5	I.
2	48	10	42	9	9	
2	20	10	54	9	8	
2	30	11	25	12	8	
2	34	11	29	...	...	
2	20	10	56	13	7	II.
2	06	10	10	13	1	
2	51	12	25	12	6	
2	31	11	02	13	0	
2	26	11	26	12	1	
2	20	10	13	11	3	III.
2	01	10	48	13	9	
2	44	11	34	8	5	
2	52	10	38	12	1	
2	13	10	44	9	2	
2	31	10	39	13	6	
2	26	11	28	8	6	
2	24	10	39	13	0	IV.
2	15	10	53	13	0	
2	45	10	28	13	0	
MEANS.						
2	27	10	59	...	...	20
2	27	...	...	11	8	19

TABLE FOR THE REDUCTION OF TIDES.—No. 2.

Showing the Interval between the App. Time of the Moon's Inferior Transit and the Time of High Water, and also the Heights of High Water, at Van Rensselaer Harbor, from Four Series of Observations made between October 10, 1853, and October 22, 1854.

3ʰ to 4ʰ.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
3	36	9	39	10	5	I.
3	50	10	56	13	0	
3	09	10	35	9	1	
3	59	10	30	8	0	
3	32	10	37	13	7	
3	22	10	55	10	9	
3	08	11	38	12	9	II.
3	54	10	52	10	6	
3	37	11	24	10	6	
3	15	11	03	10	9	
3	18	11	04	12	3	
3	09	9	24	9	4	III.
3	59	10	34	10	3	
3	05	9	44	12	4	
3	34	10	59	8	5	
3	53	10	37	12	3	
3	00	10	42	9	1	
3	46	8	26	9	4	
3	26	10	29	12	6	
3	09	12	45	11	3	
3	51	11	03	9	2	
3	10	11	23	11	0	IV.
3	57	10	07	14	0	
3	06	11	03	13	0	
3	59	11	10	13	0	
3	35	9	38	10	0	
MEANS.						
3	31	10	40	...	...	26
3	31	...	...	11	1	26

The two greatest deviations from the mean, viz., 8ʰ 26ᵐ and 12ʰ 45ᵐ, nearly balance in the mean, hence no value was rejected.

4ʰ to 5ʰ.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft	Dec.	No. of observations and series.
4	25	10	51	10	3	I.
4	52	11	54	10	9	
4	49	10	00	7	4	
4	31	11	08	11	1	
4	09	10	53	11	6	
4	54	11	37	9	1	
4	38	11	08	8	6	II.
4	24	10	52	11	3	
4	00	10	48	11	1	
4	46	16	17	10	1	
4	12	12	10	12	4	
4	50	10	13	09	1	III.
4	09	10	40	12	8	
4	22	11	55	8	0	
4	49	11	11	11	7	
4	30	12	27	9	3	
4	34	10	05	9	0	
4	46	10	18	10	0	IV.
4	56	11	13	12	0	
4	25	10	48	14	5	
MEANS.						
4	33	11	01	...	...	20
4	33	...	...	10	5	20

5ʰ to 6ʰ.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
5	16	10	15	8	7	I.
5	52	10	39	10	7	
5	37	12	36	7	1	
5	26	10	58	10	3	
5	39	11	52	7	5	
5	21	11	55	8	9	II.
5	16	10	30	10	8	
5	32	11	47	9	6	
5	11	10	46	9	3	
5	10	10	39	12	5	III.
5	09	11	38	7	8	
5	54	10	08	8	1	
5	40	9	20	11	4	
5	12	12	14	7	3	
5	55	11	21	9	8	
5	19	11	20	10	5	
5	35	8	29	7	0	IV.
5	57	10	13	11	5	
MEANS.						
5	30	10	56	...	...	18
5	30	...	...	9	4	18

The criterion rejects no value of the interval; the low value 8ʰ 29ᵐ is so near the limit of rejection and not balanced in the mean that I prefer to reject it.

5	30	11	04	...	...	17

Table for the Reduction of Tides.—No. 2.

Showing the Interval between the App. Time of the Moon's Inferior Transit and the Time of High Water, and also the Heights of High Water, at Van Rensselaer Harbor, from Four Series of Observations made between October 10, 1853, and October 22, 1854.

6h to 7h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
6	57	11	16	9	2	I.
6	07	10	54	7	1	
6	57	12	49	7	0	
6	48	11	58	10	4	
6	25	13	48	8	5	
6	14	13	39	10	6	
6	24	12	36	7	8	
6	06	11	10	10	7	II.
6	51	13	10	7	2	
6	01	11	41	6	9	
6	52	14	06	6	7	
6	07	11	12	11	7	III.
6	59	12	20	9	8	
6	38	12	54	8	6	
6	27	10	32	10	2	
6	39	12	17	9	8	
6	07	11	47	9	5	
6	59	13	25	9	4	
6	59	10	41	10	0	IV.
6	58	...	...	10	0	
Means.						
6	33	12	13	...	...	19
6	34	...	...	9	1	20

There are two high and two low values, viz., 14h 06m, 13h 48m, and 10h 32m, 10h 41m, nearly balancing each other; there was, therefore, no rejection required.

7h to 8h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
7	54	11	49	9	5	I.
7	46	12	30	8	1	
7	38	11	53	11	0	
7	11	12	37	8	8	
7	56	12	46	9	4	
7	42	12	25	11	8	
7	10	12	50	8	0	
7	59	12	30	11	5	
7	38	11	53	8	2	II.
7	11	12	12	9	5	
7	41	14	17	7	5	
7	13	12	18	10	0	III.
7	47	11	47	11	1	
7	22	13	40	9	2	
7	11	10	48	10	5	
7	54	12	05	9	9	
7	26	12	30	10	6	
7	16	13	38	7	6	
...	...	...	...	...	...	IV.
Means.						
7	33	12	28	...	...	18
7	33	...	...	9	6	18

The high and low values in the interval balance.

8h to 9h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
8	47	12	42	10	0	I.
8	35	...	...	9	3	
8	25	13	21	10	7	
8	44	12	58	10	9	
8	25	12	42	9	2	
8	50	12	38	11	2	
8	26	12	49	6	7	II.
8	10	14	06	10	7	
8	53	13	57	8	8	
8	12	11	42	10	2	
8	07	11	55	10	4	III.
8	59	11	18	10	7	
8	02	13	32	7	9	
8	48	13	31	8	1	
8	32	11	32	10	6	
8	07	11	55	10	4	
8	54	12	08	11	1	
8	37	12	22	9	4	
8	18	12	38	11	2	
8	01	13	53	8	7	
8	08	11	58	9	0	IV.
8	58	...	...	9	0	
8	34	13	41	10	0	
Means.						
8	29	12	44	...	...	21
8	30	...	...	9	7	23

TABLE FOR THE REDUCTION OF TIDES.—No. 2.

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9^h to 10^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
9	37	12	37	10	9	I.
9	23	12	23	10	7	
9	09	12	22	11	8	
9	52	11	54	11	5	
9	33	12	39	12	0	
9	06	12	30	7	8	
9	49	13	17	9	6	
9	46	12	27	11	6	
9	15	12	30	7	2	II.
9	12	12	05	10	3	
9	11	12	43	10	3	
9	47	11	15	11	1	III.
9	33	11	31	9	4	
9	16	10	48	11	3	
9	59	10	49	9	9	
9	44	12	17	11	6	
9	22	12	06	9	9	
9	47	10	49	10	0	IV.
9	19	11	56	11	0	

10^h to 11^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
10	24	12	20	11	3	I.
10	11	13	50	11	6	
10	34	12	41	11	0	
10	24	13	17	13	8	
10	31	11	49	8	6	
10	06	13	39	6	6	II.
10	57	12	48	7	7	
10	15	12	02	11	2	
10	05	11	19	11	7	
10	55	11	59	11	9	
10	32	11	30	12	2	III.
10	19	13	45	11	8	
10	43	11	35	10	0	
10	38	10	23	12	9	
10	07	11	21	8	5	
10	55	13	18	8	1	
10	45	12	26	14	0	IV.
10	02	11	13	12	0	
10	46	12	29	12	0	

11^h to 12^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. H. water. H.	M.	Height of H. water. Ft.	Dec.	No. of observations and series.
11	01	12	30	12	0	I.
11	52	11	54	12	3	
11	15	11	30	9	8	
11	59	12	01	13	0	
11	20	11	36	13	7	
11	17	11	48	8	9	
11	30	12	47	12	4	II.
11	46	11	29	8	4	
11	13	13	34	11	9	
11	43	11	42	12	0	
11	16	12	46	12	0	III.
11	09	11	40	13	7	
11	28	13	17	9	7	
11	38	13	53	11	4	
11	44	12	14	8	3	
11	20	12	20	12	5	
11	17	11	50	11	5	IV.
11	36	12	06	14	0	
11	30	12	15	12	0	

MEANS.

Interval	H.	M.	H.	M.	Ft.	Dec.	No.
9^h to 10^h	9	30	12	03	...	...	19
	9	30	...	...	10	4	19
10^h to 11^h	10	29	12	18	...	...	19
	10	29	...	...	10	9	19
11^h to 12^h	11	28	12	16	...	...	19
	11	28	...	...	11	5	19

There being three low and but one high value in the interval, it seemed preferable to adopt a mean resulting after the rejection of 10^h 48^m, viz:—

H.	M.	H.	M.	Ft.	Dec.	No.
9	30	12	07	...	...	18

Table for the Reduction of Tides.—No. 2.

Showing the Interval between the App. Time of the Moon's Superior Transit and the Time of Low Water, and also the Heights of Low Water, at Van Rensselaer Harbor, from Four Series of Observations made between October 10, 1853, and October 22, 1854.

0h to 1h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
0	13	17	02	1	5	I.
0	57	17	33	2	0	
0	19	18	42	0	9	
0	21	18	54	3	1	
0	53	17	17	—2	1	
0	30	18	49	1	6	
0	01	18	16	1	3	II.
0	10	17	05	4	1	
0	58	18	18	2	6	
0	33	17	44	0	1	
0	29	19	37	2	7	
0	07	18	18	3	5	
0	52	19	03	3	3	
0	22	16	41	2	0	III.
0	30	16	49	1	3	
0	39	18	09	1	6	
0	10	18	21	2	0	
0	10	16	48	2	0	
0	59	15	58	1	9	
0	22	17	46	—0	7	IV.
0	46	16	56	0	0	

1h to 2h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
1	40	17	35	1	9	I.
1	16	18	00	0	0	
1	07	17	38	3	1	
1	55	18	20	1	2	
1	58	17	12	—0	4	
1	20	15	58	0	6	
1	01	17	00	0	5	II.
1	55	17	21	—0	3	
1	44	18	02	4	1	
1	22	17	40	0	5	
1	15	17	21	3	0	
1	36	18	20	1	5	
1	09	18	24	2	1	III.
1	56	15	37	1	9	
1	30	16	49	0	8	
1	29	17	34	1	5	
1	16	17	15	0	4	
1	49	18	08	3	2	
1	00	17	10	1	2	
1	12	18	50	0	0	IV.
1	07	18	01	2	0	
1	52	18	16	0	0	
1	33	17	40	0	0	

2h to 3h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
2	25	18	35	2	7	I.
2	16	17	45	0	3	
2	44	17	30	2	3	
2	58	17	04	...	...	
2	45	18	01	1	3	II.
2	29	17	47	2	3	
2	09	17	39	2	5	
2	53	17	25	2	5	
2	02	18	19	1	2	
2	52	17	15	3	1	
2	45	18	18	3	9	III.
2	33	17	46	0	5	
2	19	17	59	2	5	
2	21	17	39	1	1	
2	37	17	20	3	6	
2	02	17	08	1	2	
2	48	17	21	1	7	
2	01	17	31	—0	5	IV.
2	47	19	16	1	0	
2	39	16	30	0	0	
2	21	17	52	0	0	

MEANS.

Range	H.	M.	H.	M.	Ft.	Dec.	No.
0h to 1h	0	30	17	49	...	...	21
	0	30	...	...	1	7	21
1h to 2h	1	29	17	34	...	...	23
	1	29	...	...	1	3	23
2h to 3h	2	31	17	43	...	...	21
	2	30	...	...	1	7	20

0h to 1h: The highest and lowest value of the intervals balance in the mean, hence no value is rejected.

1h to 2h: The low value 15h 37m is rejected, hence new mean—

H.	M.	H.	M.	Ft.	Dec.	No.
1	28	17	39	...	...	22

TABLE FOR THE REDUCTION OF TIDES.—No. 2.

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3^h to 4^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
3	12	17	18	4	4	I.
3	19	17	12	0	7	
3	34	17	25	3	6	
3	03	15	36	0	1	
3	46	14	16	...	...	
3	32	17	29	2	0	II.
3	14	18	02	0	3	
3	38	16	10	3	9	
3	44	16	53	2	6	
3	34	17	29	1	8	III.
3	38	15	41	2	3	
3	09	18	09	2	5	
3	59	17	48	4	0	
3	24	16	36	1	3	
3	24	17	33	3	9	
3	00	16	55	2	4	
3	52	17	02	2	5	
3	30	16	54	3	2	
3	33	17	30	1	5	IV.
3	32	16	37	—1	0	
3	10	17	03	0	5	
MEANS.						
3	28	16	56	...	...	21
3	27	...	...	2	1	20

The low values 14^h 16^m is rejected, hence new mean—

3	28	17	04	...	...	20

4^h to 5^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
4	00	16	46	4	5	I.
4	51	17	25	5	2	
4	22	16	39	2	3	
4	24	18	50	3	6	
4	03	16	51	1	3	
4	32	16	59	4	4	
4	16	16	30	3	4	II.
4	00	17	16	3	0	
4	49	17	27	3	0	
4	23	16	25	3	1	
4	25	16	38	5	3	III.
4	41	15	38	2	0	
4	47	17	45	3	7	
4	23	15	37	2	3	
4	08	17	49	2	6	
4	52	17	49	2	2	
4	13	...	...	4	0	
4	56	17	43	4	4	
4	22	15	41	0	0	IV.
4	27	15	42	1	0	
4	00	16	13	2	0	
4	51	16	23	4	0	
MEANS.						
4	27	16	52	...	...	21
4	27	...	...	3	1	22

The high value 18^h 50^m is in a measure balanced by two low values, 15^h 37^m and 15^h 37^m.

5^h to 6^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
5	42	18	34	5	4	I.
5	23	16	53	3	2	
5	14	17	59	3	7	
5	00	15	24	2	3	
5	52	18	16	3	4	
5	17	17	44	4	2	
5	00	16	01	3	8	II.
5	43	18	33	5	0	
5	09	16	54	6	1	
5	56	16	53	5	8	
5	36	17	06	5	0	
5	40	15	39	4	2	III.
5	32	...	...	4	5	
5	16	15	44	3	7	
5	33	16	53	4	8	
5	43	17	26	4	5	
5	11	14	53	3	0	IV.
5	25	16	45	2	0	
MEANS.						
5	27	16	55	...	...	17
5	27	...	...	4	1	18

The low value 14^h 53^m is rejected, hence new mean—

5	27	17	02	...	...	16

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6^h to 7^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
6	28	16	45	4	7	I.
6	32	17	59	5	2	
6	21	17	55	4	9	
6	01	18	32	3	7	
6	48	17	55	3	7	
6	38	18	00	2	9	
6	01	17	29	2	9	
6	47	18	28	2	4	
6	28	17	18	3	8	II.
6	27	20	01	6	0	
6	45	17	46	4	5	III.
6	34	18	00	5	2	
6	04	17	25	4	6	
6	49	17	10	5	6	
6	17	16	54	4	4	
6	53	...	...	4	6	
6	32	18	37	3	6	
6	28	16	42	3	0	IV.

7^h to 8^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
7	26	17	47	4	8	I.
7	22	18	24	4	8	
7	14	18	02	4	4	
7	34	17	38	4	2	
7	22	18	45	5	2	
7	34	18	10	3	2	
7	14	19	47	5	8	II.
7	40	19	06	4	1	
7	42	18	27	4	8	
7	17	19	11	5	5	
7	41	17	36	4	0	III.
7	38	18	26	3	6	
7	24	18	55	4	4	
7	00	17	32	4	7	
7	44	18	48	4	0	
7	33	18	41	5	2	
7	02	18	24	4	3	
7	51	17	35	3	9	
7	38	19	01	5	6	
7	43	17	53	5	0	IV.
7	23	15	51	5	0	

8^h to 9^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
8	22	18	21	4	2	I.
8	11	18	50	4	5	
8	59	19	02	3	4	
8	02	18	29	5	5	
8	48	18	43	4	2	
8	20	19	22	2	7	
8	04	18	03	5	3	
8	46	18	50	1	8	
8	23	17	36	1	8	
8	02	19	13	3	3	II.
8	50	19	55	3	3	
8	41	16	36	3	3	
8	28	20	07	5	0	
8	42	19	12	5	1	
8	35	18	27	4	1	III.
8	25	19	39	2	7	
8	10	17	24	3	4	
8	55	18	09	3	5	
8	30	18	32	3	4	
8	16	18	28	5	8	
8	59	17	59	2	9	
8	45	18	25	3	0	
8	34	19	32	5	0	IV.
8	01	19	14	3	0	
8	57	18	18	3	0	

MEANS.

H.	M.	H.	M.	Ft.	Dec.	No.	H.	M.	H.	M.	Ft.	Dec.	No.	H.	M.	H.	M.	Ft.	Dec.	No.
6	28	17	49	...	...	17	7	29	18	17	...	...	21	8	30	18	15	...	...	25
6	29	...	...	4	2	18	7	29	...	...	4	6	21	8	30	...	...	3	7	25

The high value $20^h\ 01^m$ is rejected, hence new mean—

H.	M.	H.	M.	Ft.	Dec.	No.
6	28	17	42	...	...	16

The low value $15^h\ 51^m$ is rejected, hence new mean—

H.	M.	H.	M.	Ft.	Dec.	No.
7	29	18	24	...	...	20

TABLE FOR THE REDUCTION OF TIDES.—No. 2.

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9^h to 10^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
9	12	18	47	3	1	I.
9	47	17	59	2	9	
9	31	18	00	3	8	
9	08	19	04	2	2	
9	58	18	43	0	7	
9	27	19	09	2	8	
9	18	18	10	1	9	
9	41	19	34	1	5	II.
9	45	17	52	2	8	
9	39	18	45	3	8	
9	24	18	08	2	5	III.
9	10	18	09	1	8	
9	56	17	38	2	2	
9	38	19	10	4	0	
9	18	17	13	1	8	
9	44	18	14	3	6	
9	22	19	14	5	0	IV.
9	41	18	34	0	0	
MEANS.						
9	32	18	28	...	...	18
9	32	...	...	2	6	18

10^h to 11^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
10	02	17	57	2	7	I.
10	36	17	40	1	6	
10	13	20	02	2	5	
10	54	18	36	2	9	
10	51	17	50	0	1	
10	10	18	25	2	8	
10	54	19	11	2	4	
10	58	18	19	1	0	II.
10	32	18	13	1	8	
10	45	18	02	1	0	
10	31	18	23	2	2	
10	10	19	22	1	6	III.
10	54	17	08	2	6	
10	43	18	21	1	3	
10	21	18	42	2	0	
10	10	16	51	1	4	
10	31	17	57	3	6	
10	47	17	38	1	2	
10	09	18	58	2	0	IV.
10	55	18	12	4	0	
10	20	18	21	0	0	
10	24	18	51	1	0	
MEANS.						
10	32	18	19	...	...	22
10	32	...	...	1	9	22

11^h to 12^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
11	26	17	20	2	7	I.
11	37	18	53	3	5	
11	50	17	51	—1	2	
11	41	18	23	5	5	
11	22	19	08	2	3	II.
11	41	17	21	—0	4	
11	19	18	36	2	0	
11	38	19	09	1	0	III.
11	35	16	59	0	9	
11	05	17	58	2	7	
11	51	18	27	2	4	
11	07	18	54	0	6	
11	19	17	39	2	4	
11	54	17	26	1	2	
11	39	17	28	2	0	IV.
11	10	18	02	—2	0	
11	59	19	13	—0	5	
11	08	17	07	0	0	
11	53	16	22	0	0	
MEANS.						
11	32	18	01	...	...	19
11	32	...	...	1	3	19

Table for the Reduction of Tides.—No. 2.

Showing the Interval between the App. Time of the Moon's Inferior Transit and the Time of Low Water, and also the Heights of Low Water, at Van Rensselaer Harbor, from Four Series of Observations made between October 10, 1853, and October 22, 1854.

0^h to 1^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
0	35	17	25	1	8	I.
0	48	18	28	0	1	
0	44	18	16	1	3	
0	21	18	05	—0	3	
0	06	16	58	3	4	
0	55	17	08	2	7	
0	31	19	31	—1	8	II.
0	33	18	13	2	4	
0	07	17	55	—0	9	
0	57	18	05	1	1	
0	06	18	15	2	3	
0	52	19	29	3	2	
0	29	17	56	—0	2	
0	00	17	02	2	2	III.
0	45	18	18	2	0	
0	15	16	03	0	5	
0	43	17	48	1	6	
0	35	17	52	2	4	
0	27	17	58	1	5	
0	47	16	45	—1	7	IV.
0	00	17	07	1	0	
0	45	17	53	0	0	
0	22	18	20	1	0	
0	17	16	58	0	0	

1^h to 2^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
1	18	17	27	1	6	I.
1	46	19	00	1	5	
1	31	17	44	—0	1	
1	25	17	45	0	0	
1	44	17	19	...	...	
1	27	18	19	—0	4	II.
1	21	17	25	3	2	
1	45	19	02	1	3	
1	38	18	43	0	7	
1	14	18	27	1	3	
1	59	18	57	3	3	
1	33	16	00	1	5	III.
1	04	15	44	2	3	
1	54	17	24	1	6	
1	49	18	41	0	2	
1	24	18	03	3	0	
1	31	17	24	1	0	
1	36	18	26	1	0	IV.
1	29	17	39	1	0	
1	09	19	03	—1	0	
1	57	16	46	0	0	

2^h to 3^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
2	02	15	43	5	7	I.
2	48	16	57	2	8	
2	47	17	14	1	6	
2	20	16	54	1	9	
2	30	18	10	—0	1	
2	34	17	58	...	...	
2	20	17	56	1	5	II.
2	06	17	40	2	2	
2	51	16	25	3	9	
2	31	18	47	1	9	
2	26	18	56	1	6	
2	20	14	57	1	7	III.
2	01	17	33	1	7	
2	44	16	04	2	5	
2	52	16	38	1	6	
2	13	17	14	2	5	
2	31	17	09	1	0	
2	26	17	28	2	0	
2	24	17	09	—1	0	IV.
2	15	17	53	0	0	
2	45	15	28	0	0	

MEANS.

	H.	M.	H.	M.	Ft.	Dec.	No.
0^h to 1^h	0	30	17	50	...	...	24
	0	30	...	...	1	1	24
1^h to 2^h	1	33	17	52	...	...	21
	1	33	...	...	1	1	20
2^h to 3^h	2	28	17	09	...	...	21
	2	28	...	...	1	7	20

0^h to 1^h: The two high and two low values of the intervals nearly balance in the mean.

1^h to 2^h: The value 15^h 44^m is rejected, hence new mean—

H.	M.	H.	M.	Ft.	Dec.	No.
1	34	17	58	...	...	20

2^h to 3^h: The lowest value 14^h 33^m is rejected, hence—

H.	M.	H.	M.	Ft.	Dec.	No.
2	28	17	15	...	...	20

TABLE FOR THE REDUCTION OF TIDES.—No. 2.

Showing the Interval between the App. Time of the Moon's Inferior Transit and the Time of Low Water, and also the Heights of Low Water, at Van Rensselaer Harbor, from Four Series of Observations made between October 10, 1853, and October 22, 1854.

3^h to 4^h.

Moon's transit. App time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
3	36	17	40	3	4	I.
3	50	16	56	1	8	
3	09	17	05	2	6	
3	59	16	00	3	2	
3	32	17	37	1	6	
3	22	17	10	1	4	
3	08	17	53	2	1	II.
3	54	18	07	0	3	
3	37	17	24	2	7	
3	15	17	48	1	5	
3	18	16	34	2	7	
3	09	15	54	3	7	III.
3	59	16	34	4	3	
3	05	16	59	1	8	
3	34	16	59	3	5	
3	53	17	07	1	3	
3	00	15	27	2	0	
3	46	15	41	3	8	
3	26	17	44	1	8	
3	09	17	45	3	2	
3	51	16	33	4	1	
3	10	17	23	0	0	IV.
3	57	16	06	0	0	
3	06	17	03	0	0	
3	59	16	10	0	0	
3	35	16	38	0	0	
MEANS.						
3	31	16	56	...	...	26
3	31	...	...	2	0	26

4^h to 5^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
4	25	16	06	3	9	I.
4	52	17	39	2	6	
4	49	15	55	5	1	
4	31	17	08	1	0	
4	09	16	22	4	5	
4	54	16	22	5	1	
4	38	16	53	2	2	II.
4	24	18	22	4	5	
4	00	16	48	1	0	
4	46	17	02	3	9	
4	50	16	13	6	5	III.
4	09	16	55	1	8	
4	22	17	40	3	6	
4	49	16	56	2	5	
4	30	16	27	5	0	
4	34	17	05	4	8	
4	46	14	18	0	0	IV.
4	56	16	13	2	0	
4	25	15	48	2	0	
MEANS.						
4	34	16	38	...	...	19
4	34	...	...	3	3	19

The value 14^h 18^m is rejected, hence new mean—

H.	M.	H.	M.	Ft.	Dec.	No.
4	34	16	45	...	...	18

5^h to 6^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
5	16	15	15	4	5	I.
5	52	18	24	3	5	
5	37	16	51	6	6	
5	26	18	13	1	0	
5	39	17	51	3	1	
5	21	18	55	3	8	II.
5	16	16	00	5	5	
5	32	17	02	4	1	
5	11	17	01	4	2	
5	10	17	39	1	8	III.
5	09	17	08	4	8	
5	54	16	08	5	2	
5	40	15	20	2	8	
5	12	18	14	3	8	
5	55	17	01	6	9	
5	19	16	35	6	1	
5	57	15	13	3	0	IV.
MEANS.						
5	30	16	59	...	...	17
5	30	...	...	4	2	17

The three highest and three lowest values of the intervals balance in the mean.

TABLE FOR THE REDUCTION OF TIDES.—No. 2.

Showing the Interval between the App. Time of the Moon's Inferior Transit and the Time of Low Water, and also the Heights of Low Water, at Van Rensselaer Harbor, from Four Series of Observations made between October 10, 1853, and October 22, 1854.

6^h to 7^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
6	57	18	46	4	4	I.
6	07	16	39	5	2	
6	57	17	49	6	1	
6	48	17	58	4	0	
6	25	17	48	3	4	
6	14	18	54	3	5	
6	24	17	36	4	6	
6	06	17	40	4	5	II.
6	51	16	25	3	7	
6	10	17	36	4	3	
6	01	16	41	5	7	
6	52	17	08	5	5	
6	17	17	59	5	1	III.
6	07	17	57	3	0	
6	59	20	05	3	8	
6	38	17	24	5	6	
6	27	17	02	3	2	
6	39	17	47	6	5	
6	31	18	53	4	8	
6	07	18	47	5	7	
6	59	17	11	4	5	IV.
6	58	16	16	3	0	
MEANS.						
6	31	17	45	...	...	22
6	31	...	...	4	6	22
The high value 20^h 05^m is rejected, hence new mean—						
6	30	17	39	...	...	21

7^h to 8^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
7	54	17	49	4	0	I.
7	46	17	00	5	5	
7	38	17	08	4	3	
7	11	18	31	6	9	
7	56	18	46	4	3	
7	00	18	07	3	6	
7	42	18	25	5	3	
7	10	17	05	4	1	
7	59	18	45	4	8	
7	38	19	08	4	7	II.
7	09	21	07	4	7	
7	11	18	42	5	3	
7	13	18	18	4	0	III.
7	14	17	35	6	0	
7	47	18	47	3	7	
7	22	18	10	6	1	
7	11	18	18	4	0	
7	54	19	35	4	4	
7	26	18	30	6	0	
7	16	18	08	4	4	
7	17	16	18	5	0	IV.
MEANS.						
7	28	18	18	...	...	21
7	28	...	...	4	8	21
The high value 21^h 07^m is rejected, hence new mean—						
7	29	18	10	...	...	20

8^h to 9^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
8	47	18	27	3	7	I.
8	35	19	11	5	1	
8	25	18	21	2	3	
8	44	19	28	3	4	
8	25	19	11	1	7	
8	50	19	08	2	9	
8	26	18	49	3	8	II.
8	10	20	36	5	7	
8	03	20	18	3	9	
8	53	19	42	5	4	
8	12	18	12	5	3	
8	07	19	10	4	0	III.
8	59	19	33	1	8	
8	02	17	02	5	2	
8	48	17	16	4	4	
8	32	18	47	2	5	
8	07	19	55	4	3	
8	54	17	53	4	0	
8	37	18	22	3	0	
8	18	18	37	5	6	
8	01	17	53	4	5	
8	08	15	58	5	0	IV.
8	58	18	08	5	0	
8	34	18	41	3	0	
MEANS.						
8	29	18	41	...	...	24
8	29	...	...	4	0	24
The low value 15^h 58^m is rejected, hence new mean—						
8	30	18	48	...	...	23

TABLE FOR THE REDUCTION OF TIDES.—No. 2.

Showing the Interval between the App. Time of the Moon's Inferior Transit and the Time of Low Water, and also the Heights of Low Water, at Van Rensselaer Harbor, from Four Series of Observations made between October 10, 1853, to October 22, 1855.

9^h to 10^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
9	37	18	37	2	7	I.
9	23	18	53	4	9	
9	09	19	07	2	8	
9	52	18	54	2	6	
9	33	19	08	2	6	
9	06	19	00	0	3	
9	49	18	16	3	5	
9	46	19	12	4	9	
9	15	21	00	3	7	II.
9	12	18	35	2	8	
9	11	18	43	4	3	
9	47	18	45	1	7	III.
9	33	20	01	2	0	
9	16	19	03	3	3	
9	59	18	19	2	0	
9	22	19	36	3	3	
9	47	20	19	5	0	IV.
9	19	18	26	2	0	
MEANS.						
9	30	19	06	...	...	18
9	30	...	...	3	0	18

The highest value $21^h\ 00^m$ is rejected, hence new mean—

9	30	19	00	...	...	17

10^h to 11^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
10	11	19	05	3	9	I.
10	34	18	26	2	1	
10	24	17	47	1	2	
10	31	18	04	2	3	
10	06	18	54	1	3	II.
10	57	18	03	2	8	
10	15	18	02	2	0	
10	05	18	34	3	4	
10	55	18	30	1	3	
10	32	18	32	1	8	III.
10	19	18	15	1	9	
10	43	18	50	2	0	
10	38	18	23	2	1	
10	07	19	36	2	9	
10	55	18	33	2	0	
10	15	18	25	2	4	
10	33	17	34	2	0	IV.
10	45	17	26	—1	2	
10	02	17	43	1	0	
10	46	17	29	0	0	
MEANS.						
10	29	18	19	...	...	20
10	29	...	...	1	9	20

11^h to 12^h.

Moon's transit. App. time. H.	M.	Lunitidal interval. L. water. H.	M.	Height of L. water. Ft.	Dec.	No. of observations and series.
11	01	18	00	1	9	I.
11	52	19	09	3	6	
11	15	18	15	0	7	
11	59	17	01	0	4	
11	20	18	06	1	7	
11	17	17	48	2	4	
11	30	18	47	2	6	II.
11	46	17	59	0	7	
11	13	18	49	3	0	
11	43	18	42	—1	3	
11	16	19	16	0	1	III.
11	09	18	40	1	0	
11	28	19	05	3	4	
11	38	18	23	1	8	
11	44	19	14	3	1	
11	20	18	05	2	2	
11	17	15	50	0	0	IV.
11	36	17	36	—1	0	
11	30	17	45	0	0	
MEANS.						
11	28	18	14	...	...	19
11	28	...	...	1	4	19

The low value $15^h\ 50^m$ is rejected, hence new mean—

11	28	18	21	...	...	18

The preceding tables (No. 2) contain the individual and mean values for interval and height, for high and low water, and the moon's upper and lower transit. The mean, in some cases, was improved by the application of Peirce's criterion for the rejection of doubtful observations; a few other rejections were made, as stated, in order to obtain a well-balanced mean; of 982 observations of the interval, but 17 were thus rejected.

Half-monthly Inequality.—For the comparison of the observed with the theoretical values, it is customary to use the forms of the equilibrium theory or of the wave theory,[1] certain modifications being necessary to produce an agreement between these theories with observation. According to the equilibrium theory the formula for the position of the pole of the tidal spheroid is:

$$tan.\ 2\,\theta' = -\frac{h\ sin.\ 2\,\phi}{h' + h\ cos.\ 2\,\phi},$$

where h and h' are the elevations of the spheroid due to the sun and moon respectively, ϕ the angular distance of the moon from the sun and θ' the angular distance of the pole of the spheroid (or of high water) from the moon's place. In reality, however, the pole of this spheroid follows the moon at a certain distance, the mean value λ' of which is known as the "mean establishment" (also fundamental hour, corrected establishment), and which corresponds to a distance of the sun and moon of $\phi - \alpha$ instead of ϕ. This retroposition of the theoretical tide has been called the age of the tide. For the comparison of the observed and computed values for the half-monthly inequality *in time*, we have the formula:[2]

$$tan.\ 2\,(\theta' - \lambda') = -\frac{h\ sin.\ 2\,(\phi - \alpha)}{h' + h\ cos.\ 2\,(\phi - \alpha)}.$$

This inequality goes through its period twice in each month. Proper values have to be found for the ratio $\frac{h}{h'}$ and the angle α.

The observations of 480 *high waters* furnish us with the following values, derived from the preceding tabulation on form No. 2:—

[1] An account of the Equilibrium, Laplace's and the Wave Theories, will be found in the Encyclopædia of Astronomy, forming a portion of the Encyclopædia Metropolitana, London, 1848; article "On Tides and Waves," by G. B. Airy, Esq., Astronomer Royal.

[2] Phil. Trans. Royal Society, 1834, Part I. On the Empirical Laws of the Tides in the Port of London, with some Reflections on the Theory; by the Rev. W. Whewell.

See also Phil. Trans. Royal Society, 1836, Part I. Researches on the Tides, fourth series: On the Empirical Laws of the Tides in the Port of Liverpool. By the Rev. W. Whewell.

From ☾'s upper transit.			From ☾'s lower transit.			From ☾'s upper and lower transit.		
Apparent solar time of moon's transit.	Lunitidal interval.	No. of observations.	Apparent solar time of moon's transit.	Lunitidal interval.	No. of observations.	Apparent solar time of moon's transit.	Lunitidal interval.	No. of observations.
0^h 29^m	11^h 40^m	18	0^h 29^m	11^h 34^m	25	0^h 29^m	11^h 37^m	43
1 29	11 12	22	1 31	11 13	21	1 30	11 12	43
2 32	11 04	20	2 27	10 59	20	2 30	11 01	40
3 30	10 57	19	3 31	10 40	26	3 30	10 47	45
4 27	10 52	21	4 33	11 01	20	4 30	10 56	41
5 27	10 53	19	5 30	11 04	17	5 29	10 58	36
6 31	11 45	17	6 33	12 13	19	6 32	11 59	36
7 28	12 26	20	7 33	12 28	18	7 30	12 27	38
8 32	12 42	24	8 29	12 44	21	8 30	12 43	45
9 32	12 36	18	9 30	12 07	18	9 31	12 22	36
10 32	12 23	20	10 29	12 18	19	10 30	12 21	39
11 32	12 17	19	11 28	12 16	19	11 30	12 16	38
Mean and sum	11 44	237	Mean and sum	11 43	243	Mean and sum	11 43.3	480

The mean establishment resulting from the observed times of 480 high waters at Van Rensselaer Harbor is therefore 11^h 43.3^m, referred to the moon's transit immediately preceding and corresponding to a mean horizontal parallax of the moon and sun, and to the moon's and sun's declination of 16° nearly. The mean interval corresponds to the moon's transit of 0^h 21^m nearly, indicating that the epoch would have come out 0^h 0^m if transit E (see An Elementary Treatise on the Tides, by J. W. Lubback, Esq., London, 1839) or that immediately preceding transit F had been used.

In like manner we obtain the following table from the observed times of 485 *low waters* at Van Rensselaer Harbor:—

From ☾'s upper transit.			From ☾'s lower transit.			From ☾'s upper and lower transit.		
Apparent solar time of moon's transit.	Lunitidal interval.	No. of observations.	Apparent solar time of moon's transit.	Lunitidal interval.	No. of observations.	Apparent solar time of moon's transit.	Lunitidal interval.	No. of observations.
0^h 30^m	17^h 49^m	21	0^h 30^m	17^h 50^m	24	0^h 30^m	17^h 50^m	45
1 28	17 39	22	1 34	17 58	20	1 31	17 48	42
2 31	17 43	21	2 28	17 15	20	2 30	17 29	41
3 28	17 04	20	3 31	16 56	26	3 30	16 59	46
4 27	16 52	21	4 34	16 45	18	4 30	16 49	39
5 27	17 02	16	5 30	16 59	17	5 29	17 00	33
6 28	17 42	16	6 30	17 39	21	6 30	17 40	37
7 29	18 24	20	7 29	18 10	20	7 29	18 17	40
8 30	18 15	25	8 29	18 48	23	8 30	18 31	48
9 32	18 28	18	9 30	19 00	17	9 31	18 43	35
10 32	18 19	22	10 29	18 19	20	10 30	18 19	42
11 32	18 01	19	11 28	18 21	18	11 30	18 11	37
Mean and sum	17 46	241	Mean and sum	17 50	244	Mean and sum	17 48.0	485

The mean establishment resulting from the observed times of 485 low waters is 17^h 48.0^m, referred to the moon's transit immediately preceding low water, and the same to which the preceding high water has been referred; the difference between the two mean intervals is 6^h 04.7^m.

To obtain a numerical expression for the half-monthly inequality in time, the value for α should be determined so as to furnish, in particular, good results for

$5^h\ 30^m$, $6^h\ 30^m$, $7^h\ 30^m$, where the curve is steepest; the value $\frac{h}{h'}$ is obtained from the greatest range of the inequality determined, for a first approximation, by a graphical process. I find from the observed high waters $\alpha = 0^h\ 21^m$ or $5°\ 15'$, and from the low waters $\alpha = 0^h\ 50^m$ or $12°\ 30'$. Range of inequality, from the high waters, $1^h\ 51^m$ or $27°\ 48'$, the *sin.* of which is 0.4649, and for the low waters, range $1^h\ 54^m$ or $28°\ 30'$, the *sin.* of which is 0.4771; hence the expression for the half-monthly inequality *in time* becomes

From the observed high waters $tan.\ 2(\theta' - 175°\ 49'.5) = -\frac{0.4649\ sin.\ 2(\phi - 5°\ 15')}{1 + 0.4649\ cos.\ 2(\phi - 5°\ 15')}$

" " " low waters $tan.\ 2(\theta' - 267°\ 00') = -\frac{0.4771\ sin.\ 2(\phi - 12°\ 30')}{1 + 0.4771\ cos.\ 2(\phi - 12°\ 30')}$

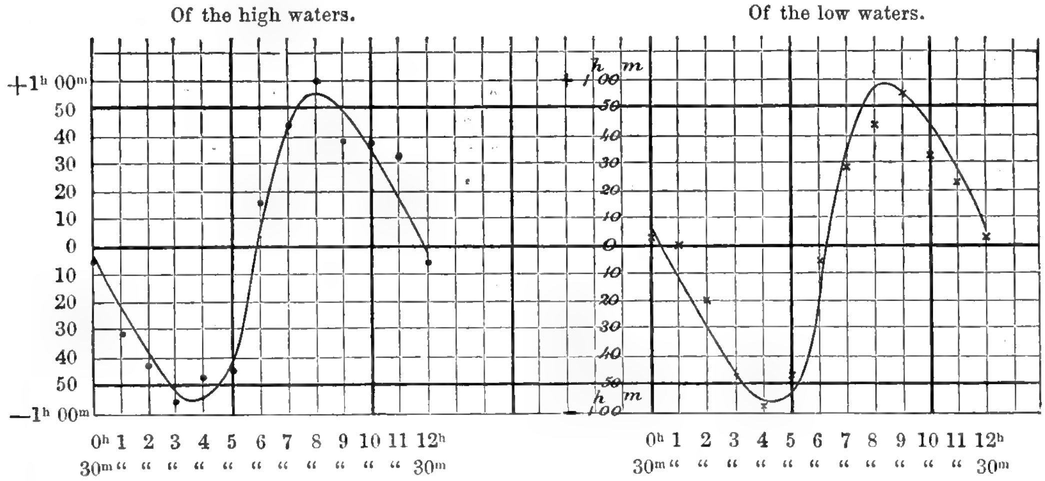
These expressions furnish us with the following comparison:—

HALF-MONTHLY INEQUALITY IN TIME.

From high waters.				From low waters.			
Apparent solar time of moon's transit.	Observed.	Computed.	Difference.	Apparent solar time of moon's transit.	Observed.	Computed.	Difference.
$0^h\ 29^m$	-6^m	-3^m	-3^m	$0^h\ 30^m$	$+2^m$	$+6^m$	-4^m
1 30	−31	−22	−9	1 31	0	−13	+13
2 30	−42	−39	−3	2 30	−19	−31	+12
3 30	−56	−52	−4	3 30	−49	−47	−2
4 30	−47	−55	+8	4 30	−59	−56	−3
5 29	−45	−38	−7	5 29	−48	−52	+4
6 32	+16	+8	+8	6 30	−8	−18	+10
7 30	+44	+46	−2	7 29	+29	+33	−4
8 30	+60	+56	+4	8 30	+43	+56	−13
9 31	+39	+48	−9	9 31	+55	+54	+1
10 30	+38	+34	+4	10 30	+31	+42	−11
11 30	+33	+16	+17	11 30	+23	+25	−2

Considering that the times of high and low water are only observed to the nearest half hour and for some time to the nearest hour, the agreement as shown above and by the diagrams, seems to be satisfactory.

Observed and computed half-monthly inequality in time for observations.
Of the high waters. Of the low waters.



In the above diagram, the observed values are indicated by dots; the computed values are represented by curves. From the times we have seen the mean value $\frac{h}{h'}$ $\left(\text{or } \frac{S''}{M''}\right.$ of the wave theory and (A) of Lubbock's) = 0.471, and $\alpha = 0^h\ 36^m$; hence, the age of the tide, or the time requisite for the moon to increase its right ascension by that amount, becomes $\frac{36}{48}$ days, or 18 hours.

Half-monthly Inequality in Height.—The theoretical expression for the half monthly inequality in height of high water is:

$$\eta = \sqrt{\ } \{h'^2 + h^2 + 2\ h'h\ cos.\ 2\ \phi\}$$ [1]

where η expresses the height of the pole of the equilibrium spheroid above the mean level of the surface; for its application, and according to the wave theory, it must be changed to:

$$\eta = \sqrt{\ } \{h'^2 + h^2 + 2h'h\ cos.\ 2\ (\phi - \alpha)\}$$ [2]

The following table contains the results of the observations from the high and low waters, and the moon's superior and inferior transit:

From superior transits.			From inferior transits.			Means.	
Moon's transit.	Height of high water.	Number.	Moon's transit.	Height of high water.	Number.	Height of high water.	Number.
	Feet.			Feet.		Feet.	
$0^h\ 31^m$	12.1	20	$0^h\ 29^m$	12.2	25	12.1	45
1 29	11.6	22	1 31	12.3	21	11.9	43
2 29	11.8	20	2 27	11.8	19	11.8	39
3 29	10.9	21	3 31	11.1	26	11.0	47
4 27	10.5	22	4 33	10.5	20	10.5	42
5 27	9.5	20	5 30	9.4	18	9.5	38
6 29	9.1	19	6 34	9.1	20	9.1	39
7 29	9.1	21	7 33	9.6	18	9.3	39
8 32	9.9	24	8 30	9.7	23	9.8	47
9 31	10.4	19	9 30	10.4	19	10.4	38
10 31	11.1	21	10 29	10.9	19	11.0	40
11 32	11.7	19	11 28	11.5	19	11.6	38
		248			247	10.67	495

From superior transits.			From inferior transits.			Means.	
Moon's transit.	Height of low water.	Number.	Moon's transit.	Height of low water.	Number.	Height of low water.	Number.
	Feet.			Feet.		Feet.	
$0^h\ 30^m$	1.7	21	$0^h\ 30^m$	1.1	24	1.4	45
1 29	1.3	23	1 33	1.1	20	1.2	43
2 30	1.7	20	2 28	1.7	20	1.7	40
3 27	2.1	20	3 31	2.0	26	2.0	46
4 27	3.1	22	4 34	3.3	19	3.2	41
5 27	4.1	18	5 30	4.2	17	4.1	35
6 29	4.2	18	6 31	4.6	22	4.4	40
7 29	4.6	21	7 28	4.8	21	4.7	42
8 30	3.7	25	8 29	4.0	24	3.8	49
9 32	2.6	18	9 30	3.0	18	2.8	36
10 32	1.9	22	10 29	1.9	20	1.9	42
11 32	1.3	19	11 28	1.4	19	1.4	38
		247			250	2.72	497

[1] See Phil. Trans. Royal Soc., 1834 and 1836.

[2] Encyclopædia Metropolitana, Tides and Waves, Art. (535). The expression given by Mr. Lubbock is:

$$h = D + (E) \left\{ (1 + \frac{q}{c})(A)\ cos.\ (2\psi - 2\phi) + (1 + \frac{q'}{c}) cos.\ 2\psi \right\};$$

for which see his treatise.

The values for h', h and α were found from the maxima and minima values of the inequality, viz., for the high water:

$$y = \sqrt{\{10.6^2 + 1.5^2 + 31.8 \cos. 2 (\phi - 15°)\}};$$

for the low waters:

$$y' = \sqrt{\{2.95^2 + 1.75^2 - 5.16 \cos. 2 (\phi - 15)\}};$$

These expressions may be changed to

$$y = 10.6 + 1.5 \cos. 2 (\phi - 15°), \text{ and } y' = 2.7 - 1.7 \cos. 2 (\phi - 15°);$$

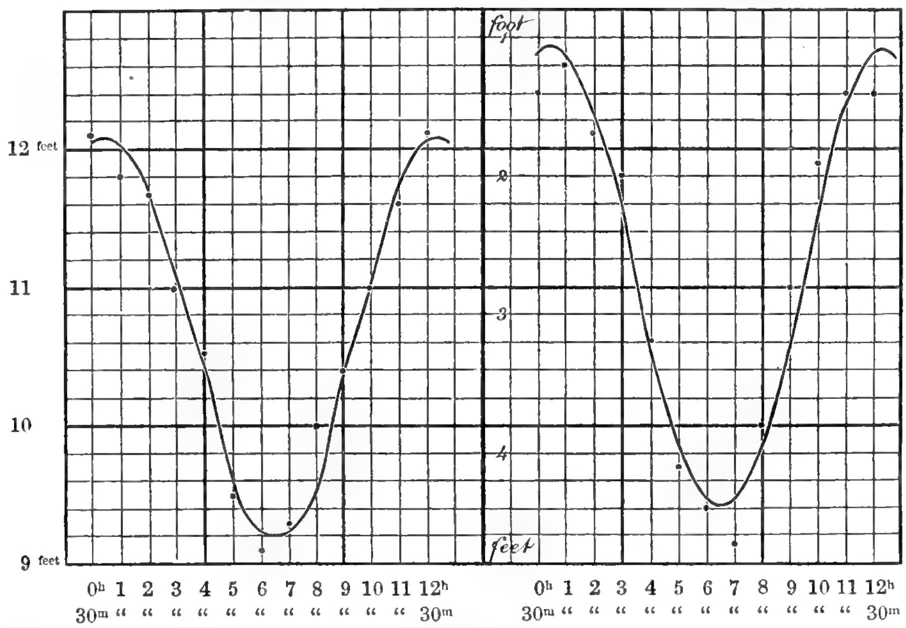
they leave the following differences between the computed and observed values:—

Moon's transit.	Height of high water.			Height of low water.		
	Computed.	Observed.	Difference.	Computed.	Observed.	Difference.
0h 30m	12.1	12.1	0.0	1.1	1.4	+0.3
1 30	12.0	11.9	—0.1	1.1	1.2	+0.1
2 30	11.7	11.8	+0.1	1.5	1.7	+0.2
3 30	11.0	11.0	0.0	2.3	2.0	—0.3
4 30	10.2	10.5	+0.3	3.1	3.2	+0.1
5 30	9.5	9.5	0.0	3.9	4.1	+0.2
6 30	9.1	9.1	0.0	4.3	4.4	+0.1
7 30	9.2	9.3	+0.1	4.3	4.7	+0.4
8 30	9.5	9.8	+0.3	3.9	3.8	—0.1
9 30	10.2	10.4	+0.2	3.1	2.8	—0.3
10 30	11.0	11.0	0.0	2.3	1.9	—0.4
11 30	11.7	11.6	—0.1	1.5	1.4	—0.1

The differences may be considered within the uncertainty of the observations. The annexed diagram shows the comparison given above:—

Observed and computed half-monthly inequality in height from observations.

Of the high waters. Of the low waters.



From the inequality in height $\frac{h}{h'}$ or $\frac{S'''}{M'''}$ (notation of the wave theory) $= 0.367$

whereas from the inequality in times $\frac{h}{h'}$ or $\frac{S''}{M''}$ . . . . . $= 0.471$

The ratio[1] of the solar to the lunar tide is deduced with more exactness from the inequality in times, and the above value is certainly greater than the average value deduced at more southern stations. One of the reasons why this ratio is not constant, and which probably applies here, is given in (538, β) (Tides and Waves), viz.: If tides are communicated by different channels to the same port, the proportion of the solar and lunar waves will depend on the length of those channels. This explanation would require a polar tide to enter through Kennedy Channel, to combine with the principal tide which passes up Baffin's Bay, and enters by Smith's Straits. According to the equilibrium theory, there should be no tide at the pole, and but a small tide in latitude 78½°; but it is the tide wave propagated from the Atlantic, which is felt in this part of the polar regions. With regard to α, its value as found by the heights is more accurate than that found by the times; the latter gave $\alpha = 9°$, the former 15° (the same from high and low waters). Adopting 15°, the retard or age of the tide becomes 1¼ day, by which interval the spring and neap tides follow the syzygies and quadratures, respectively. The time-value of α is here smaller than the height-value, which is more in accordance with theory than the opposite, as observed at a number of places on the coast of England (543 and 546, Tides and Waves). Compared with other values of α, the Van Rensselaer value appears somewhat smaller than an average at more southern stations.

We have further, mean rise and fall of tides at Van Rensselaer Bay 7.9 feet, range of spring tides 11.1 feet, and range of neap tides 4.7 feet. These numbers are averages from the discussions of 9½ lunations, and obtain without regard to the diurnal inequality, which will be investigated further on.

Effect of the Changes in the Moon's Declination and Parallax on the half-monthly Inequality, in Time.—In reference to the investigation of the half-monthly inequality, it is comparatively of little consequence which transit of the moon is taken for comparison; it is otherwise in the investigation of the effect of a change in the moon's declination and parallax, as well as for a similar effect due to the sun, which latter, however, cannot become a subject of investigation for the tidal series in hand, on account of its short extent; for the same reason, the variation in the inequality, in height, will have to be passed over. To ascertain the effect due to the moon's declination and parallax, an anterior value, corresponding to a certain age of the tide, is to be taken in the comparison; the preceding investigation gave for the retard 1¼ day, each lunitidal interval, minus its corresponding mean value for the respective hour of the moon's transit, was therefore tabulated in respect to the moon's declination and parallax (separately for each), corresponding to one day anterior to the time of high or low water, thus referring the results to transit E. The present investigation can only furnish an approximation to the true results; the

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[1] For comparison of different values for this ratio, the following have been selected: $\frac{S''}{M''}$ for London, 0.379; for Plymouth, 0.407; from the discussions of the Superintendent of the U. S. Coast Survey, for Key West, 0.325; San Diego, 0.39; and San Francisco, 0.342. (*Annual Reports* of 1853 and '54.) $\frac{S'''}{M'''}$ for Dundee, 0.277; for Brest, 0.346; for Plymouth, 0.294.

observations, while they give reliable value for the half-monthly inequality, cannot be expected to give more than an approximation to its variations. For any one station, and any one inequality or correction to it, special examinations require to be made to ascertain that transit of the moon, best suited for the purpose; this has hardly been done for any standard station, and it suffices to state here that, by referring to an anterior transit, the whole half-monthly inequality is moved backward through nearly twenty-four minutes for every transit preceding. Upon the inequality itself, the effect is but of a differential character. Thus to refer our table to transit *E*, deduct 24^m from each value.

To concentrate as many values as possible to a mean, the changes of declination and parallax were grouped for three values. The separate parcels for declination are for declination 0 to 13°, 13° to 21°, and 21° to 27°.5, irrespective of sign. The parallax groups are: 54′ to 56′, 56′ to 58′, and 58′ to 61′.4.

The differences of interval for the high and low waters were made out separately, and, in general, agreed tolerably well. I obtained the following results:—

TABLE SHOWING THE CORRECTION (IN MINUTES) TO THE MEAN HOURLY INTERVAL, FOR A CHANGE IN THE MOON'S DECLINATION AND PARALLAX.

Moon's transit.	Correction to interval for moon's declination.			Correction to interval for moon's parallax.		
	0° to 13°.	13° to 21°.	21° to 27°.5.	54′ to 56′.	56′ to 58′.	58′ to 61′.4.
0^h 30^m	-2^m	-7^m	$+5^m$	-12^m	$+14^m$	-7^m
1 30	+15	−5	−18	−17	+17	+5
2 30	+21	−7	−12	−11	+12	−2
3 30	+23	−11	−9	−1	+20	−10
4 30	+9	0	−13	−1	+1	−3
5 30	+14	+4	−15	+16	+19	−36
6 30	−9	+18	−3	+7	−3	−2
7 30	+1	−13	+9	+5	−3	−6
8 30	−2	+9	+15	+26	−10	+8
9 30	−6	+1	+22	+9	−11	−5
10 30	+1	−6	+10	+10	−9	−7
11 30	−3	−2	+3	−4	+4	+4
Mean	$+5^m$	-1^m	-1^m	$+2^m$	$+4^m$	-5^m
No. of observ.	373	262	348	387	244	333

Mean declination 16°.0. Mean parallax 57′.0.

The above table of declination corrections exhibits systematic values for the periodical part of the lunar effect, or for the term D *sin.* $2\ (\phi-\gamma)$. Between 0° and 13° of declination, the correction is positive for transits between 1^h and 7^h, for other hours negative; for declinations between 13° and 21° it is positive, between the hours of 4 and 10; for remaining hours it is negative, and for declinations 21° to 27°.5, the correction is positive, for hours 7 to 1, and negative for remaining hours of transit. The quantity D is accordingly about 14 minutes, and γ equals 15°, 60°, and 105° respectively.

The variation in the inequality due to the changes of the moon's declination appears large when compared with its value at other places, but is in conformity with the large value of the half-monthly inequality itself.

The periodical part of the parallax correction is of the same form as given above.

The empirical values for the groups of small and middle values of parallax appear systematic; the values in the last column for large parallax are less regular. The maximum correction on the average is somewhat greater than one-fourth of an hour.

The corrections to the mean establishment for changes of the sun's declination and parallax may be taken as one-third of the corresponding lunar values, and in the present case will probably not exceed five minutes of time.

The means of each column, containing the non-periodical part, are small, and appear rather irregular; they are variable with the transit or the moon's age adopted in the discussion.[1]

Diurnal Inequality.—We now proceed to the examination of a prominent feature in the Rensselaer Harbor tides, namely, the diurnal inequality. This inequality is well marked in the diagrams, Plates I, II, and III. Although the existence of this inequality, in height and times, has long been known to practical men, it was not until about twenty-five years ago that its laws were understood and reduced to computation by Mr. Whewell.[2] The subject has since been taken up by the present superintendent of the U. S. Coast Survey, Prof. Bache;[3] his researches commenced about nine years ago, and resulted in a further extension of the method of discussion as well as in the recognition of the geographical limits of the phenomena on our own coast; further, the discussion of single day tides, produced by this inequality in extreme cases, and here complicated by an extremely small rise and fall of the tides, was now successfully accomplished. According to the equilibrium theory, the diurnal tide ought to be very small in latitude 79°; but viewing the Rensselaer Harbor tide as a wave, produced principally in the Atlantic, and propagated through Davis's and Smith's Straits, the existence of the diurnal inequality in so high a northern latitude cannot surprise us. The following notes were extracted from Captain McClintock's narrative of the voyage of the "Fox,"

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[1] On this point the reader may consult Whewell's 9th series of tidal researches: "Laws of the Tides from a Short Series of Observations," Phil. Trans. 1838; also Airy, "Tides and Waves," articles 552 and following.

[2] Researches on the Tides, sixth series. On the Results of an Extensive System of Tide Observations made on the Coasts of Europe and America in June, 1835. By the Rev. W. Whewell. Phil. Trans. Roy. Soc. 1836.

Researches on the Tides, seventh series. On the Diurnal Inequality of the Height of the Tide, especially at Plymouth and Singapore. By the same author. Phil. Trans. 1837.

Researches on the Tides, eighth series. On the Progress of the Diurnal Inequality Wave along the Coasts of Europe. By the same author. Phil. Trans. Roy. Soc. 1837.

[3] Note on a Discussion of Tidal Observations at Cat Island in the Gulf of Mexico, by Prof. A. D. Bache. Coast Survey Report for 1851, App. No. 7; Additional Notes thereto, Coast Survey Report for 1852, App. No. 22.

On the Tides at Key West and of the Western Coast of the United States. Coast Survey Report for 1853, App. Nos. 27 and 28. By Prof. A. D. Bache.

Comparison of the Diurnal Inequality of the Tides at San Diego, San Francisco, and Astoria, on the Pacific Coast of the United States. Coast Survey Report for 1854, App. No. 26. By Prof. A. D. Bache.

Approximate Co-Tidal Lines of Diurnal and Semi-Diurnal Tides of the Coast of the United States on the Gulf of Mexico. Coast Survey Report for 1856, App. No. 35. By Prof. A. D. Bache.

For the theoretical investigation of the diurnal tide, see also Airy's Tides and Waves, articles 46 and following; and articles 562 and following.

in 1857, '58, '59. Referring to Bellot Strait: "As in Greenland, the night tides are much higher than the day tides." Speaking of the ice motion, and remarking that the tides are the chief cause of it, he says: "Now we know that the night tides in Greenland greatly exceed the day tides." Also, when near Buchan Island, north of Upernavik, and in the vicinity of Cape Shackleton: "We had grounded during the day tide, and were floated off by the night tide, which on this coast occasions a much greater rise and fall." By the labors of Dr. Kane we now know that the diurnal inequality extends as high up as 79° of latitude on the northwestern coast of Upper Greenland. In a report of Mr. Sonntag's to Dr. Kane, dated Godhavn, Sept. 12, 1855, he says: The mean height of spring tides is 12.8 feet, and at the time of new and full moon high water is at $12^h\ 0^m$; the highest spring tide is three days after full moon, and the night tide is at this time fully three feet higher than the day tide. At Northumberland Island, Sept. 10, 1854, at (after) the time of full moon high water was at 11^h P. M., and the night tide rose three feet more than the day tide. These statements, crude as they necessarily are, show that the attention of the party was fully directed to the phenomenon.

A cursory examination of the Plates (I, II, and III) shows that the diurnal inequality extends without exception over the whole series of observation, that it is well marked in the difference of the height of high water, but very little or irregularly in the height of low water; that sometimes the day tide, at other times the night tide is the higher of the two occurring in a lunar day; further, that it vanishes a day or two after the moon's crossing the equator, and that it amounts in maximo to about three feet some time after the moon attains her greatest declination. There is but one instance where the inequality approximates to the production of a single day tide. See curve for Nov. 23, 1853.

We may now enter somewhat more fully into the discussion of this inequality, which is produced by the interference of two independent waves, the diurnal and the semi-diurnal, the former depending for its size chiefly on the moon's declination. For a complete study of these compound waves, they require to be examined in their separate parts, and it would therefore be our first object to effect their separation into the diurnal and the semi-diurnal; a process which, when graphically performed, is neither too laborious nor lacking in accuracy; it is nevertheless a process of some nicety, and requires observations of standard excellence. Upon trial, I found the less rigorous method employed by Mr. Whewell in his discussion of the Plymouth and Singapore tides, was better suited to the general mass of the observations at Van Rensselaer, and that the above described process of separation had better be reserved to that portion of our observations which are apparently of the best character.

The observed heights of high and low water were laid down graphically, and a line was drawn by the eye, cutting off the zigzags of the successive high waters, leaving equal portions above and below the intermediate curve. These differences from the mean height were then set off from another axis, and those belonging to the high water next following the moon's superior transit were marked by a curve of dashes; those following the moon's inferior transit were marked by a curve of dots. These curves, without exception, were found to have alternately, as the moon has north or south declination, positive and negative ordinates, in perfect accordance with the equilibrium theory, according to which the tide (high water) which belongs to a south transit of the moon should be the greater of the two of the same day, the moon's declination being north, or should be the smaller of the two, the moon having south declination; when the moon crosses the equator (or, according to experience, some time after it), the inequality vanishes; the time by which the full effect is produced is, as in other cases of the application of this theory, later than theoretically indicated. On Plate III are given specimens of the diurnal inequality curve, constructed as explained above and on the same scale as the other diagrams on these plates. By means of the diagrams, the epoch when the inequality vanishes has been made out as follows:—

TABLE SHOWING THE OBSERVED TIMES WHEN THE DIURNAL INEQUALITY VANISHES, TOGETHER WITH THE TIME WHEN THE MOON CROSSES THE EQUATOR, AND THE DIFFERENCE OF THESE TIMES, OR THE NUMBER OF DAYS BY WHICH THE CAUSE PRECEDES THE EFFECT. THIS DIFFERENCE IS ALSO CALLED THE EPOCH.

Year.	Inequality disappears.	Moon's declination equal 0.	Difference, or epoch.	Year.	Inequality disappears.	Moon's declination equal 0.	Difference, or epoch.
1853	Oct. not observed	15d 7h	- - -	1854	April 28d 8h	24d 11h	3d 21h
"	Oct. 30d 21h	29 18	1d 3h	"	May 9 24	9 0	1 0
"	Nov. 12 10 / 13 6	11 13	1 7	"	" 23 14	21 17	1 21
"	" 27 22	26 4	1 18	"	June 7 9	5 10	1 23
"	Dec. 9 9	8 19	0 14	"	" 19 9	17 22	1 11
"	" 25 12	23 13	1 23	"	July 5 4	2 17	2 11
1854	Jan. not observed.	5 2	- - -	"	" 31 22	29 22	2 0
"	" " "	19 18	- - -	"	Sept. 9 3	7 22	1 5
"	Feb. 3 4	1 10	1 18		Remaining observations of Series IV not sufficiently reliable.	22 9	- - -
"	" 16 18	15 23	0 19			Mean.	1d 15h
"	Mar. 3 12 / 1 12	28 19	1 17				
"	" 16 0	15 5	0 19				
"	Mar. obs'n incompl.	28 4	- - -				

The results for the epoch are very regular, and with the exception of part of the last series, which is of inferior accuracy, no observation has been omitted. The inequality vanishes at the distance of 1.62 days' motion of the moon from her nodes.

The magnitude of the diurnal inequality, and its variation depending on twice the moon's declination, was made out by dividing the inequality curves in six parts between the times of disappearance, and by tabulating the ordinates as well as the corresponding declination of the moon, the following results were obtained from 12 complete cycles, omitting no value, viz:—

AMOUNT OF DIURNAL INEQUALITY IN THE HEIGHT OF HIGH WATER.

Ordinate.	(In feet.)												Mean dh.	Mean declination.
0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0°
1	1.1	2.1	0.8	2.7	1.0	0.3	0.2	1.4	2.7	1.5	1.5	1.0	1.4	12
2	0.5	2.9	2.3	4.0	4.2	2.5	1.0	1.5	2.2	2.0	2.1	3.0	2.3	21
3	1.5	2.2	3.0	4.6	4.0	2.8	1.1	1.6	2.2	3.1	2.0	2.0	2.5	25
4	1.6	2.3	3.0	4.6	0.2	3.6	1.5	1.4	1.8	1.9	3.3	2.7	2.3	22
5	0.8	1.1	1 1	3.0	2.4	1.2	0.7	3.5	2.2	1.0	2.0	2.0	1.7	13
6	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0

The mean declination corresponds to an epoch 1.6 days anterior, which remark applies also to the formula $dh = C \sin. 2 \delta'$, representing the diurnal inequality dh in two successive high or low waters, δ' being the moon's declination. For the value of C we obtain 3.3, which gives us the following comparison:—

DIURNAL INEQUALITY IN HEIGHT.

(Epoch 1.6 days.)

Moon's declination.	Observed *dh*.	Computed *dh*.	Difference.
	Feet.	Feet.	Feet.
0°	0.0	0.0	0.0
12	1.4	1.4	0.0
21	2.3	2.2	0.1
25	2.5	2.5	0.0
22	2.3	2.3	0.0
13	1.7	1.5	0.2
0	0.0	0.0	0.0

The diurnal inequality in time I have tried to exhibit by numbers as well as by diagrams; it seems, however, that the incidental irregularities in the observations themselves, coupled with the fact that the observations generally were only made half-hourly and at other times hourly—so far exceed in magnitude the inequality itself as to make the effect of the changes of the moon's declination exceedingly obscure. The lunitidal intervals (for high and low water) between Oct. 17 and Dec. 28, 1853, between Jan. 28 and March 7, 1854, and between June 1 and July 7, 1854, were tabulated in vertical columns; the means of the alternate values were tabulated in the 2d column, and placed in the horizontal line opposite the intermediate value of column one. The numbers in the first column were next subtracted from the corresponding numbers in the second column, if the interval belonged to the inferior transit; if belonging to the superior, the values in the second column were subtracted from those in the first. The moon's declination, for noon each day, was also set down. The 276 values for diurnal inequality in time, thus obtained, were plotted. After attempting to deduce an epoch and arranging the values for different assumptions for epoch, no satisfactory result could be obtained in any way according with the expression

$$d\psi = \frac{g \tan. \delta'}{1 + A \cos.^2 \phi} \text{ (see Lubbock, Phil. Trans. 1837),}$$

and the results of the investigation must be confined to the following general remark. The diurnal inequality in time is in maxima probably not exceeding two hours; it seems to be less in amount for the times of high water than for the times of low water, a result the reverse of that belonging to the inequality in height. A similar conclusion was arrived at in the discussion of the tides at San Francisco, Cal. (Prof. A. D. Bache in Coast Survey Report for 1853, p. *81), when the *smaller* inequality in height of high water (when compared with that for low water) corresponded to the *greater* inequality in time of high water (when compared with the inequality for low water). Whether the inequality of the height for high or low water is the greater or smaller depends only on the epoch of the diurnal wave compared with the epoch of the semi-diurnal wave. There is no regular increase of the inequality corresponding to an increasing (irrespective of sign) declination of the moon, but the curve appears double-crested about the time of maximum declination, there being a sudden diminution in the inequality, preceded and followed by high values; about the time of the moon's crossing the equator the inequality is very irregular.

On Plate IV, the actual separation of the semi-diurnal and the diurnal wave has been effected graphically, for which purpose a part of the best observations was selected; these observations extend over the period from Oct. 30 to Nov. 22, 1853. The process of decomposition in use in the U. S. Coast Survey was at first an analytical one, by computing sine curves; since 1855, however, a graphical process, equivalent thereto, was substituted; this latter method, as introduced by assistant L. F. Pourtales, may be briefly explained as follows: After the observations are plotted and a tracing is taken, the traced curves are shifted in epoch 12 (lunar) hours forward, when a mean curve is pricked off between the observed and traced curves; this process is repeated after the tracing paper has been shifted 12 hours backward; the average or mean pricked curve thus obtained represents the semi-diurnal wave. On an axis parallel with that on which the time is counted, the differences between the originally observed and the constructed semi-diurnal wave were laid off; this constitutes the diurnal curve. In the case in hand I have simplified the process of separation by blackening the under surface of the tracing paper with a lead pencil, and running in with a free hand; the intermediate curves by the pressure of a style, an average of the two traces thus left on the lower paper, gave the semi-diurnal wave in quite an expeditious manner. On the diagram, the diurnal curve with its epoch of high water nearly coinciding with that of the semi-diurnal wave, appears plainly with its variation in size depending on the moon's declination.

Investigation of the Form of the Tide Wave.—The shape of the tide wave has been ascertained in the manner described in art. (479) Tides and Waves, and depends on the hourly observations of 60 tides, 30 during spring tides and an equal number during neap tides, that is, the observed heights on the day of the syzygies and quadratures and on the first and second day after, were tabulated, forming ten groups of three columns each, from low water to low water. The columns of an equal number of hours (they vary from 16 hours to 11 hours) were united in a mean. In order to combine these it was assumed that the interval from the observed low water to the next following low water corresponds to 360° of phase, and the time of every intermediate observation was converted into phase by that proportion. In order to render the observed heights comparable, the range from high to low water in every half tide (the reading of low water for phase 0 generally not being identical with the reading of the succeeding low water or phase 360°) was supposed to correspond to 2.00, and the elevation above the low water was converted into number by that proportion, thus furnishing a series of ordinates for equidistant abscissæ. The means of all the phases and corresponding converted depressions within every 30th degree of phase were then taken with proper regard to the weights, depending on the number of columns, of equal hours, united at the commencement of the reduction. By observation of the progress of the numbers, it was easy to alter the latter so as to make them exactly correspond to the phases 30°, 60°, 90°, 120°, etc. In this manner the following numbers have been obtained:—

FOR THE SPRING-TIDE WAVE OCCURRING ONE AND A QUARTER DAY AFTER FULL AND NEW MOON.

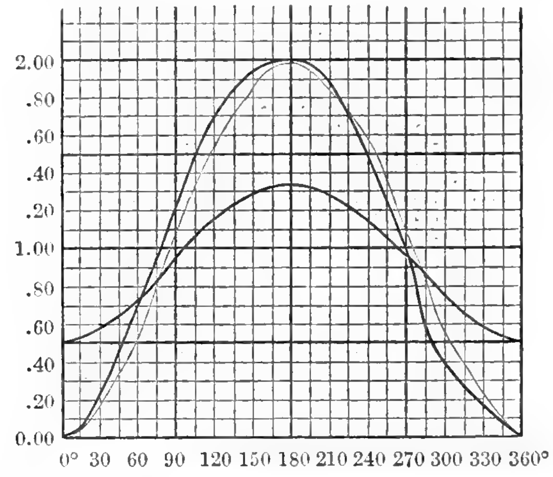
	Phase of groups.							Proportional height above low water.					
						Mean.							Mean.
	0°	0°	0°	0°	0°	0°		0.00	0.00	0.00	0.00	0.00	0.00
	26	28	30	33	36	30		0.06	0.23	0.24	0.27	0.10	0.21
	51	55	60	65	72	59		0.32	0.68	0.90	0.70	0.46	0.71
	77	83	90	98	108	89		0.91	1.13	1.36	1.32	1.17	1.24
	103	111	120	131	144	120		1.39	1.68	1.73	1.76	1.52	1.70
	129	138	150	164	180	156		1.84	2.04	1.98	1.93	2.00	1.95
	154	166	180	196	216	180		1.94	1.98	2.00	2.00	1.88	2.00
	180	194	210	229	252	208		2.00	2.00	1.84	1.56	1.23	1.88
	206	222	240	262	288	237		1.84	1.84	1.45	1.15	0.70	1.46
	231	249	270	294	324	270		1.58	1.23	1.00	0.65	0.41	0.97
	257	277	300	327	360	300		1.14	0.79	0.27	0.25	0.00	0.37
	283	305	330	360		330		0.60	0.40	0.17	0.00		0.17
	309	332	360			360		0.15	0.16	0.00			0.00
	334	360						0.02	0.00				
	360							0.00					
Weight	5	4	13	7	1		Weight	5	4	13	7	1	

The columns headed "mean" show the ordinates of the waves for (nearly) equidistant intervals of time.

The following table contains the corresponding numbers for the neap tide wave occurring 1¼ day after the first and last quarter, and as derived from 30 tides observed hourly from low to low water:—

	Phase of groups.								Proportional height above low water.						
							Mean.								Mean.
	0°								0.00						
	24	0°							0.07	0.00					
	48	26	0°						0.26	0.17	0.00				
	72	51	28	0°			0°		0.49	0.55	0.24	0.00			0.00
	96	77	55	30	0°		29		0.89	1.11	0.59	0.20	0.00		0.20
	120	103	83	60	33	0°	58		1.19	1.53	0.93	0.50	0.60	0.00	0.52
	144	129	111	90	65	36	89		1.55	1.83	1.35	1.05	1.02	0.00	1.08
	168	154	138	120	98	72	119		0.82	2.00	1.73	1.60	1.44	0.35	1.51
	192	180	166	150	131	108	147		2.00	1.95	2.00	1.85	1.81	1.06	1.82
	216	206	194	180	164	144	180		1.92	1.62	1.96	2.00	2.00	1.88	1.97
	240	231	222	210	196	180	213		1.64	1.43	1.72	2.00	1.72	2.00	1.84
	264	257	249	240	229	216	241		1.25	1.09	1.32	1.84	1.43	1.63	1.58
	288	283	277	270	262	252	271		0.94	0.67	0.80	1.37	0.79	0.99	1.08
	312	309	305	300	294	288	301		0.51	0.24	0.32	0.79	0.15	0.10	0.56
	336	334	332	330	327	324	331		0.23	0.05	0.04	0.42	0.00	0.00	0.22
	260	360	360	360	360	360	360		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weight	3	4	8	13	1	1		Weight	3	4	8	13	1	1	

The results are represented in the annexed diagram. The result for the neap tide curve has also been multiplied by $\frac{4.7}{11.1}$, the ratio of neap and spring tide range as found on a preceding page, and was increased by 0.5 to refer it to the same level.



The full curves in the diagram show the form of the spring and neap tide wave (the scales being arbitrary), to which has been added for convenient comparison the dotted curve representing the neap tide wave on the same relative scale as the spring tide wave. It is apparent that the spring tide wave is slightly steeper between low and high water than between high and low water, and that the neap tide wave is very nearly symmetrical in respect to rise and fall.

We have seen that the duration of rise is $6^h\ 04^m.7$, hence the duration of fall will be $6^h\ 19.^m7$; or in making ebb the time is 15 minutes greater than in making flood, a circumstance in conformity with the shape of the curves of rise and fall. This holds good for an average tide; according to art. (510) Tides and Waves, if the place of observation is not far from the sea, or, as in our case, in a bay, the water will occupy a shorter time to rise than to fall, and the inequality will be greater at spring tides than at neap tides; this is fully illustrated in the preceding diagram, the spring tide wave being the steeper of the two.

The form of the tide waves will be found closely represented by the following expressions:—

For the spring tide wave—

$$5.83 + 5.58\,sin.\,(\theta + 278°) + 0.20\,sin.\,(2\,\theta + 281°);$$

For the neap tide wave—

$$2.42 + 2.25\,sin.\,(\theta + 269°) + 0.09\,sin.\,(2\,\theta + 290°);$$

in which expressions the angle θ counts from low water to low water, from 0 to 360°, and the height of the wave is expressed in feet.

The relative numbers, given above, as the ordinates, have been changed in the proportion of 2 to 11.1 for the higher and of 2 to 4.7 for the lower wave. The following table shows the agreement between observation and the numerical expressions, in which the 3d and higher terms are zero:—

FORM OF THE TIDE WAVE AT VAN RENSSELAER HARBOR.

Phase.	Height of Spring tide, in feet.		Height of neap tide, in feet.	
	Observed.	Computed.	Observed.	Computed.
0	0.0	0.1	0.0	0.1
30	1.2	1.4	0.5	0.4
60	3.9	3.9	1.3	1.3
90	6.9	6.8	2.5	2.5
120	9.4	9.3	3.5	3.5
150	10.7	10.9	4.3	4.3
180	11.1	11.1	4.6	4.6
210	10.4	10.2	4.3	4.4
240	7.9	8.0	3.7	3.7
270	5.4	5.3	2.5	2.5
300	2.1	2.4	1.3	1.3
330	0.9	0.5	0.5	0.4
360	0.0	0.1	0.0	0.1

Respecting the effect of the wind and ice on the tides, it may be remarked that the former can only be slight, since the sea is protected from the direct action of the wind by its icy cover for the greater part of the year. When the sea is partially open, the effect becomes sensible, as may be seen by the following note extracted from the log-book:—

"August 17, 1853. The above records show a heavy gale from the southward gradually hauling to the eastward; the effect of this gale on the tides was very marked; our flood rose two feet above any previous register, overflowing the ground ice, and our last ebb or outgoing tide was hardly perceptible." The ice crust cannot sensibly affect (by friction on its lower surface) the progress of the tide wave, and will certainly not sensibly interfere (by friction on the ice foot and breakage of the ice fields) with the rise and fall of the tide.

Progress of the Tide Wave.—The tide at Van Rensselaer Harbor may be taken as a derived tide, and transmitted to it from the Atlantic Ocean, and in part modified by the small tide originating in the waters of Baffin's Bay; which latter tide, however, must necessarily be small, particularly on account of the general direction of the bay, which is very unfavorable for the production of a tide wave. That the tide wave is travelling up along the western coast of Greenland, or, in other words, reaches Van Rensselaer Harbor from the southward, may be seen from the following observed establishments:—

Holsteinborg Harbor, latitude 66° 56′, longitude 53° 42′. High water at F. & C. 6^h 30^m. Spring tides rise 10 feet.—Capt. Inglefield, 1853.

Whalefish Islands (near Disco), latitude 68° 59′, longitude 53° 13′. Time of high water F. & C. 8^h 15^m. Highest tide 7½ feet.—Parry's 3d Voyage of Discovery.

Godhavn (Disco), latitude 69° 12′, longitude 53° 28′. Tidal hour 9^h. Rise and fall 7½ feet.—See Map in Narrative of Kane's First Voyage.

Upernavik, latitude 72° 47′, longitude 56° 03′. High water at F. & C. 11^h. Rise 8 feet.—Capt. Inglefield, 1854.

Wolstenholm Sound, latitude 76° 33′, longitude 68° 56.′ High water at F. & C. 11^h 8^m. Rise, both at spring and neaps, 7 to 7½ feet.—(See Admiralty Chart of Baffin's Bay, sheet 1, 1853, corrected to 1859.) The observations themselves, taken by Captain Saunders of H. M. S. North Star, in 1849 and 1850, were kindly furnished to Prof. Bache by the Hydrographer to the Admiralty, Captain J. Washington, R. N., and are given in the appendix to this paper. And finally,

Van Rensselaer Harbor, latitude 78° 37′, longitude 70° 53′. High water at F. & C. $11^h\ 50^m$, as derived from the preceding analytical expression. Rise and fall at spring tide 11.1 feet, at neap tide 4.7 feet, average range 7.9 feet.

By means of the difference in the establishments of Holsteinborg and Van Rensselaer, we can obtain an approximation to the depth of Baffin's Bay and Smith's Straits, viz:—

	Tidal hour.	Longitude.	Sum.	Difference.	
Holsteinborg	$6^h\ 30^m$	$3^h\ 35^m$	$10^h\ 05^m$	$6^h\ 28^m$	Difference corrected for the moon's motion $6^h\ 26^m$.
Van Rensselaer	11 50	4 43	16 33		

Assuming the distance along the channel to be 770 nautical miles, we have a velocity of the tide wave of about 202 feet in a second, which, according to Airy's table (174), Tides and Waves, would correspond to a depth of nearly 1300 feet, or about 220 fathoms—a result probably smaller than the true value, since the other observations indicate a greater depth, it may be taken as an inferior limit; in the same manner we find from the co tidal hours of Upernavik and Van Rensselaer a depth of near 800 fathoms, and a similar result from the Wolstenholm observations; this last result may perhaps be taken as an upper limit.

Soundings.—The following soundings have been copied from the log-book:—

June 19, 1853. Lat. 51° 12′, long. 52° 8′ (government sounding twine and 32-pound shot).

Chronometer time.	Mark.
$8^h\ 47^m\ 0^s$	Red, started.
49 10	White.
52 10	Bottom, with 178 fathoms; shot brought up with gray mud and fine sand. The line was afterwards measured.

June 26, 1853. Lat. 59° 48′, long. 50° 3′ (government sounding twine and 32-pound shot).

Chronometer time.	Mark.	Chronometer time.	Mark.
$3^h\ 56^m\ 35^s$	Started 75 fathoms from the next mark.	$4^h\ 21^m\ 25^s$	White.
57 25	Red.	25 10	Red.
58 50	White	29 15	White.
4 00 37	Red.	33 25	Red.
2 48	Black.	37 30	Black.
5 16	White.	42 0	White.
8 0	Red.	46 30	Red.
11 0	White.	51 15	White.
14 5	Red.	56 0	Red.
- - - - -	Missed the mark.	58 0	Bottom with 1817 fathoms, line cut.

August 1, 1838. Melville Bay, lat. 75° 40′, long. 62° 12′ (government sounding twine and 32-pound shot).

Chronometer time.	Mark.
$5^h\ 47^m\ 6^s$	Started.
48 8	Red.
49 40	White.
51 40	Red.
54 0	Black.
54 45	Bottom with 429 fathoms; shot brought up with dark green sand (specimen preserved).

APPENDIX.

TIDAL OBSERVATIONS MADE ON BOARD H. M. S. NORTH STAR, COMMANDER SAUNDERS, AT THE WINTER QUARTERS IN WOLSTENHOLM SOUND. (FROM THE SHIP'S LOG.)

DATE.	High water.		Low water.	
1849.	Time.	Height.	Time.	Height.
		Ft. In.		Ft. In.
Nov. 16, A. M.	$12^h\ 0^m$	78 0	$4^h\ 0^m$	69 4
" 17, A. M.			5 30	70 11
" 17, P. M.	0 30	78 6		
" 29, A. M.	11 0	76 5	5 0	71 4
" 30, A. M.	10 0	79 1	4 30	70 0
Dec. 14, P. M.	11 0	69 6	6 0	65 2
" 22, P. M.	4 0	70 9	10 30	65 4
" 29, A. M.	11 0	73 10	3 30	64 0
1850.				
Jan. 13, A. M.	12 0	71 6	5 30	64 2
" 21, P. M.	4 0	70 4	10 30	65 1
" 27, A. M.	11 0	72 4	5 30	64 2
Feb. 3, P. M.	3 30	70 0	9 0	63 10
" 19, P. M.	4 0	70 3	9 30	66 8
March 5, P. M.	4 30	70 0	10 0	66 10
" 13, A. M.	11 30	76 0		

DATE.	High water.		Low water.	
1850.	Time.	Height.	Time.	Height.
		Ft. In.		Ft. In.
Mar. 13, P. M.			$6^h\ 0^m$	69 0
" 19, A. M.	$3^h\ 0^m$	75 6		
" 19, P. M.			11 0	70 10
" 27, P. M.	11 0	76 2	5 30	67 9
April 4, A. M.			12 0	69 9
" 4, P. M.	4 0	72 2		
" 12, A. M.	11 30	70 1	5 0	69 2
" 26, A. M.	11 0	70 3	5 0	69 2
May 4, P. M.	5 0	75 0		
" 19, A. M.	5 30	77 2		
" 19, P. M.			11 30	72 6
" 26, A. M.	1 0	75 10	6 0	69 0
June 2, P. M.	1 0	68 11		
" 23, P. M.	11 0	74 4		
July 9, P. M.	11 0	74 10	3 0	66 1

From the rough manner with which the above observations appear to have been made, an approximate establishment and rise of tide only can be deduced from them.

H. W. F. and C. appears to take place between $XI^h\ 0^m$ and $XI^h\ 15^m$, say $XI^h\ 8^m$, and the rise both at springs and neaps from 7 to 7½ feet.

(Signed) JNO. BURWOOD, MASTER R. N.,
(*Tide Computer*).

ADMIRALTY, 3*d July*, 1860.

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WASHINGTON CITY,
OCTOBER, 1860.

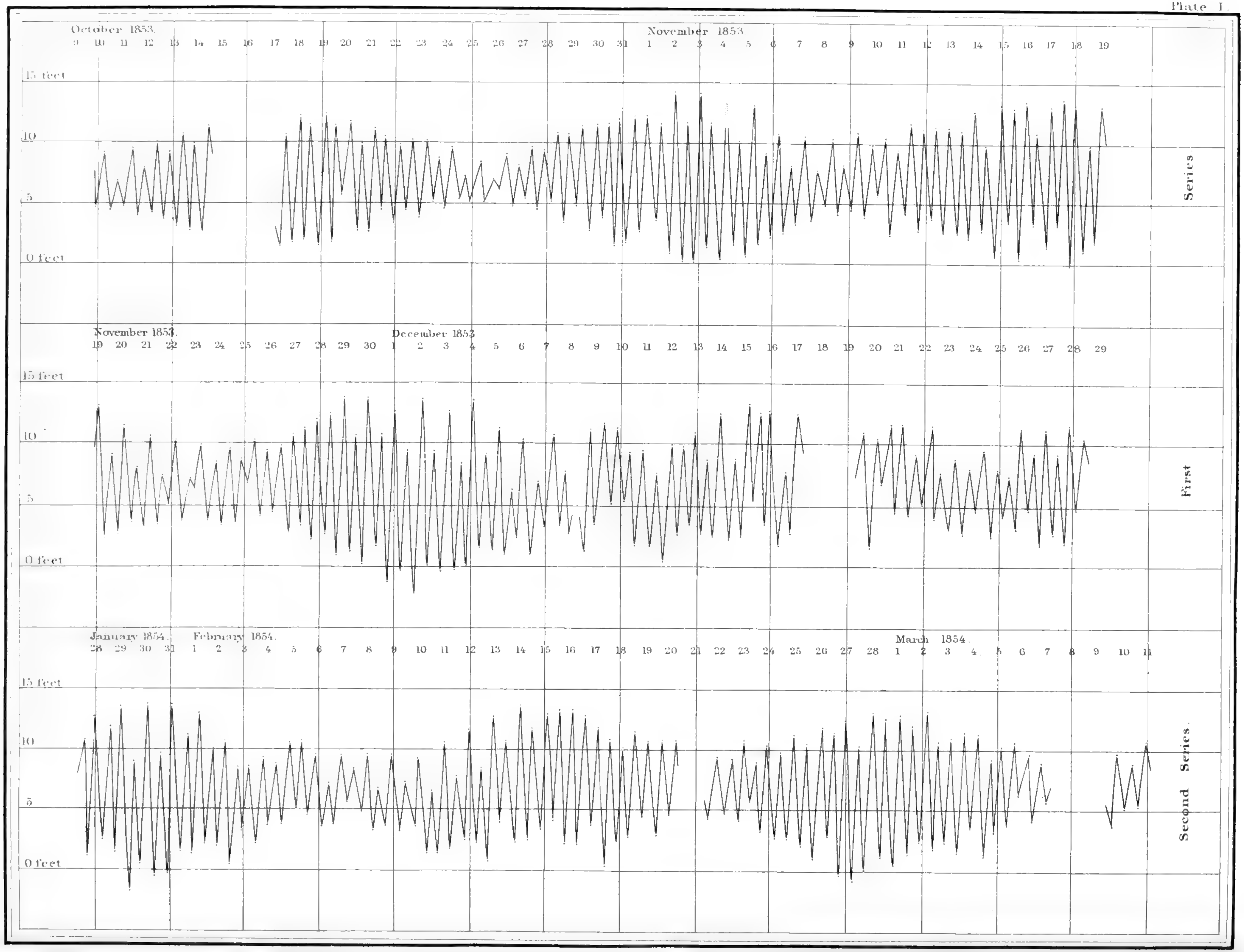
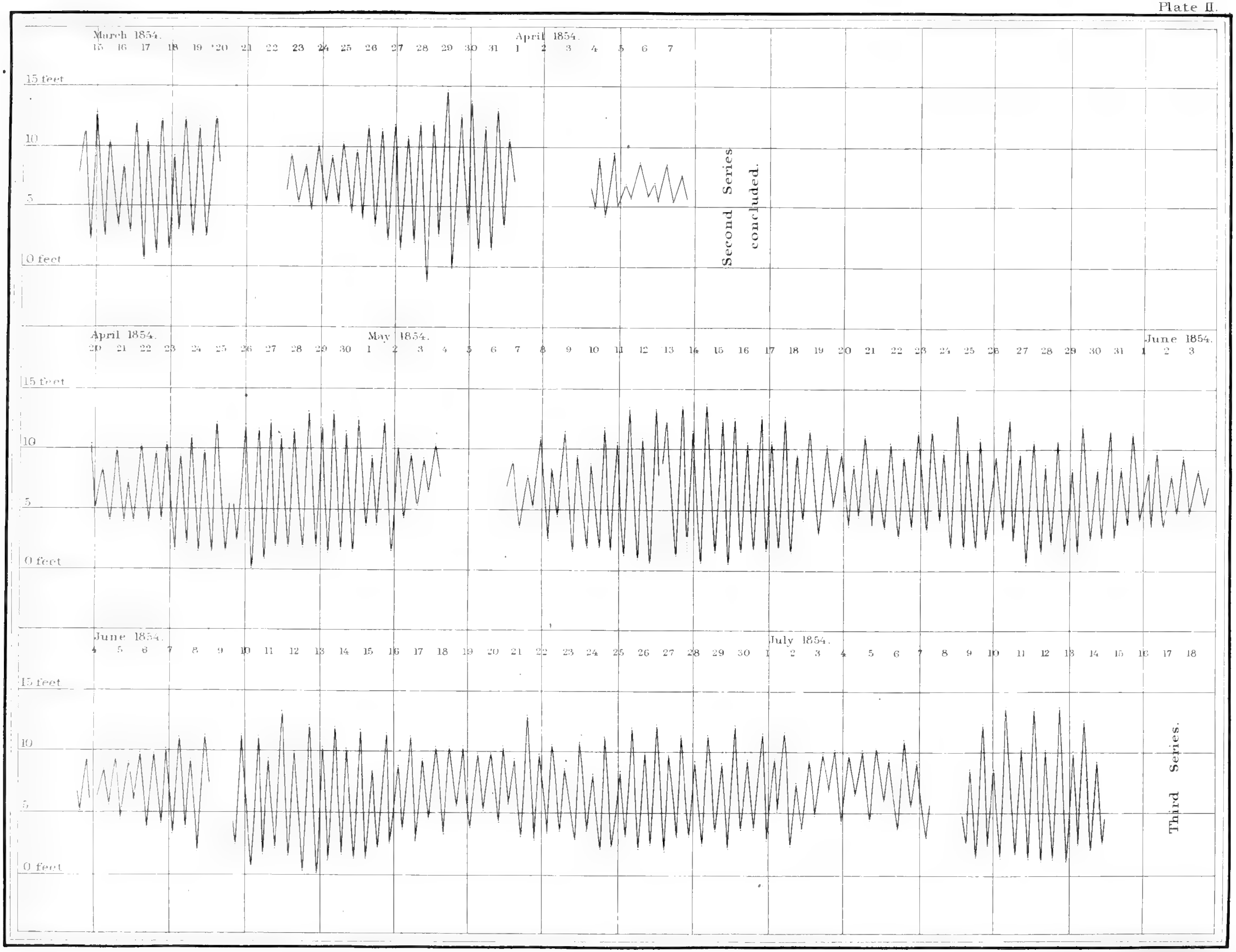

October 1853.
November 1853.
December 1853.
January 1854.
February 1854.
March 1854.
15 feet
10
5
0 feet
First Series.
Second Series.

Plate II.



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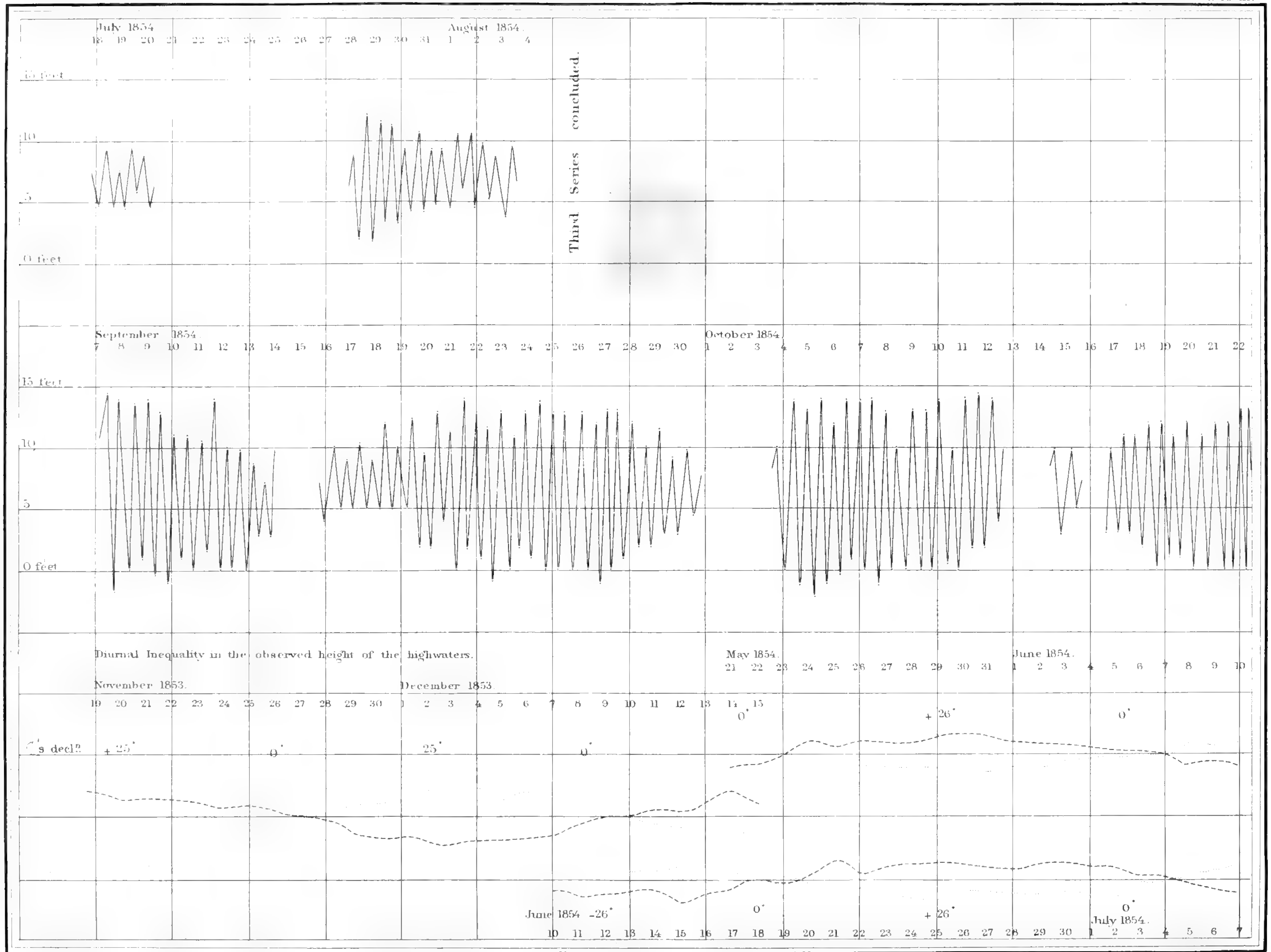

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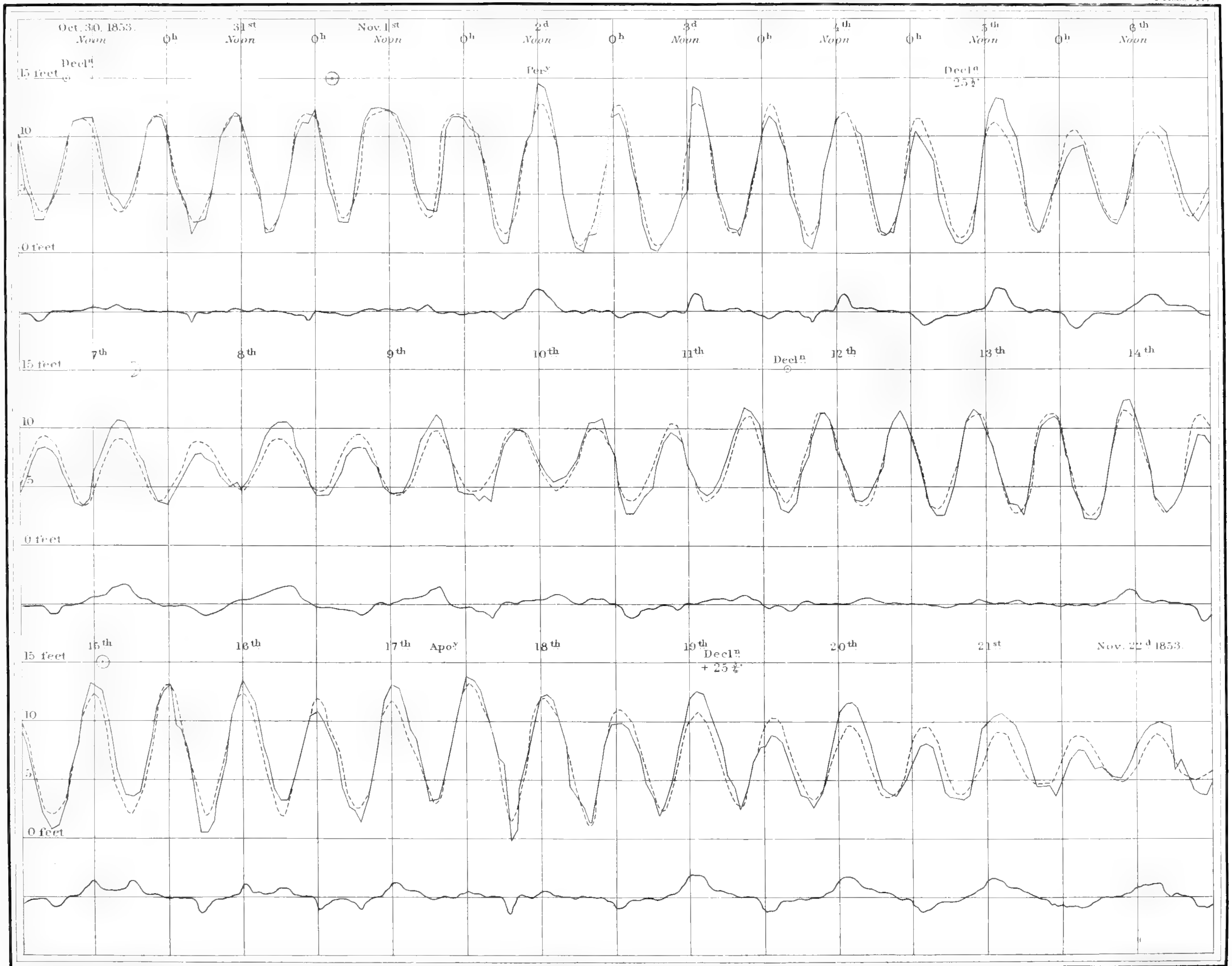
Plate IV.



D. McClelland sc.

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.
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METEOROLOGICAL OBSERVATIONS

IN THE

ARCTIC SEAS.

BY

SIR FRANCIS LEOPOLD M'CLINTOCK, R.N.

MADE ON BOARD THE ARCTIC SEARCHING YACHT "FOX," IN BAFFIN BAY AND PRINCE REGENT'S INLET, IN 1857, 1858, AND 1859.

REDUCED AND DISCUSSED,

AT THE EXPENSE OF THE SMITHSONIAN INSTITUTION.

BY

CHARLES A. SCHOTT,
ASSISTANT U. S. COAST SURVEY.

[ACCEPTED FOR PUBLICATION, APRIL, 1861.]

COLLINS, PRINTER.
PHILADELPHIA.

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APPENDIX.

ILLUSTRATIONS.

PLATES.

WOODCUTS.

PREFACE.

The following series of reduced meteorological observations have been prepared from the records kept on board the yacht "Fox," in 1857, '58, '59, during the expedition in search of Sir John Franklin, under the command of Captain M'Clintock,[1] R. N.

The records of these observations were presented by the commander of the expedition to the Institution, to be used in such manner as might be deemed best suited to advance the science of meteorology. They were accordingly placed in the hands of Mr. Charles A. Schott, of the U. S. Coast Survey, to be discussed in accordance with the plan proposed by Sir John Herschel in his work on meteorology, and which was adopted in regard to the records made during the voyage of Dr. Kane in the Arctic regions. These reductions form a part of a series of articles on the climatology of the Arctic portions of the North American continent, which are in the course of preparation and publication by the Smithsonian Institution. Of these the investigations relative to the winds of the Northern Hemisphere, by Prof. Coffin, the observations by Dr. Kane, and those by Dr. Hayes, form portions. It is to be hoped that an opportunity will be afforded for a thorough discussion of all the observations which have been made by the different Arctic explorers on a similar plan, since such a work would not only throw much light on the climatology of the continent of North America, but also on the meteorology of the globe.

The following brief account of the expedition of "the Fox," compiled from the narrative of the commander, and other sources, will perhaps be of service in rendering the observations more easily understood, as well as of interest to those who may not have ready access to the works from which the compilation has been made:—

Sir John Franklin was appointed in 1845 to the command of an expedition consisting of two ships, the *Erebus* and *Terror*, fitted out for a further attempt to discover a northwest passage. The expedition sailed from England on the 26th of May, 1845, and was last seen by a whaler in Baffin's Bay on the 26th of July following. In the autumn of 1847 public anxiety began to be manifest for the safety of the explorers, from whom nothing more had been heard, and several expeditions were sent from 1848 to 1854 in search of them. In these active exertions

---

[1] Now Sir Francis Leopold McClintock.

Lady Franklin took the lead, and by her unwearied labors and sacrifices aroused the sympathy of the whole civilized world. Aid was offered by France and even by Tasmania. Citizens of the United States replied to her call by equipping two expeditions, the expense of which was principally borne by Mr. Henry Grinnell, of New York.

In August, 1850, traces of the missing explorers were discovered, where they had spent their first winter, but no further tidings were obtained until the spring of 1854, when Dr. Răe, of the Hudson's Bay Company, ascertained that they had been seen by the Esquimaux on the west coast of King William's Island, in the spring of 1850, and it was thought that they had all died on an estuary of the great Fish River. The attempt, in 1855, of the Hudson's Bay Company to explore this river resulted in obtaining but little additional information, and a few relics from the Esquimaux.

It was at this time that Lady Franklin, who had previously sent out three expeditions at her own expense, again earnestly urged the renewal of the search, that the fate of her husband and his companions might not be left in uncertainty, and in the spring of 1857 commenced the preparations for another expedition as a final effort to trace "the footsteps of these gallant men in their last journey upon earth," and, if possible, to rescue from entire loss some of the scientific results for which they had sacrificed their lives.

The small steamer Fox, of 177 tons burthen, was purchased for the service, and Lady Franklin was highly gratified in obtaining the willing service of Captain M'Clintock as commander of the expedition. This officer had signally distinguished himself in the voyages of Sir James Ross and Admiral Austin, and especially in his extensive journeys on the ice when associated with Captain Kellett.

The voyagers sailed from Aberdeen, July 1st, 1857, and after a favorable run across the Atlantic, passed Cape Farewell, the southern point of Greenland, on the 13th, and arrived at Fredericshaab on the 19th of the same month. After stopping to take in coal at Waigat, they reached Upernavik, the most northerly of the Danish stations in Greenland, and then bore away, on the 6th of August, directly westward for the purpose of crossing Baffin's Bay; but, on the evening of the 8th, their progress in that direction was stopped by impenetrable ice in Latitude 72° 40′ and Longitude 59° 50′ west. They then steered northward with the hope of finding a passage westward in a higher latitude, but in this they were disappointed, and, on the 19th of August, became entangled in the ice, and thus remained two hundred and forty-two days, until April, 1858. During this period, the "Fox" drifted from Latitude 75° north and Longitude 62° west, eleven hundred and ninety-four geographical miles in a southerly direction, almost to the lower extremity of Greenland. (See the accompanying map.)

On the 26th of April, the ice suddenly and almost entirely disappeared; the ship was again headed northward for another attempt, and arrived on the 19th of June in Melville Bay. They then again steered westward across Baffin's Bay, and, finally, entered Lancaster Sound in the beginning of August. They next sailed westerly and southerly until they reached the Longitude of 96° west, and about Latitude 73° north. From this point, they returned eastward through Barrow's

Straits, which they found clear of ice, and went southerly down Prince Regent's Inlet to the mouth of Bellot Straits, where they arrived on the 20th of August, and near which they were destined to remain for more than a year.

Bellot Strait, which is near Latitude 72° north, is the water communication between Prince Rupert's Inlet and that part of the western sea now known as Franklin Channel. It separates the extreme northern part of the continent of North America, or Boothia Felix, from North Somerset. The shores of this strait are faced in many places with lofty granite cliffs, and some of the adjacent hills rise to fifteen or sixteen hundred feet above the level of the sea. Through this channel the tide runs at the rate of six or seven knots an hour, and also frequent stormy winds blow from the west which probably affect the local meteorology of the country immediately around the eastern entrance.

At the time of the arrival of the expedition, this strait was choked up with masses of ice, but as the season advanced these obstacles so far gave way that the voyagers were enabled to work the ship through to the western outlet. But beyond this point they were unable to advance further in the same direction, and on account of the exposed position they were obliged to return and seek for safer winter quarters. These they found near the eastern entrance of the strait in a commodious harbor named Port Kennedy. At this place they remained frozen up from the 27th of September, 1858, until the 9th of August, 1859.

Early in the spring, three exploring parties set out from Port Kennedy in different directions, severally under the command of Captain M'Clintock, Captain Young, and Lieutenant Hobson. The routes traversed by these parties included the southern portion of the coast of Prince of Wales Island—the western coast of Boothia Felix, and the entire circumference of King William's Land. These explorations furnished important additions to the map of the Arctic regions as well as definite information relative to the fate of Sir John Franklin and his devoted companions. On the western coast of King William's Island, several relics of the lost mariners were found, and among the number a tin-case containing a record of the unfortunate explorers.

From this record, the following facts were obtained, namely, the Franklin Expedition spent the first winter after leaving England at Beechy Island near the southwestern point of North Devon (see map). From this place it passed down Franklin Channel to within fifteen miles of the northwest coast of King William's Island (see the spot indicated on the map), where the ships were frozen in the ice, and finally abandoned on the 22d of April, 1848. Sir John Franklin died on the 11th of June, 1847, and several other deaths had occurred. The survivors, one hundred and five in number, under the command of Captain Crozier, landed on King William's Island, where all knowledge of their subsequent journeying ceases; they probably, however, all perished in their endeavor to reach a less inhospitable region.

Although the whole shore of King William's Island was three times patiently examined by Captain M'Clintock and Lieutenant Hobson, no vestige of the wrecks was seen, and it was doubted whether any portion of them remained above water.

After making the explorations above mentioned, the object of the expedition having been measurably attained, the explorers in the Fox waited for the advance of the season to be released from the ice, but though the summer at Port Kennedy was a warm one, they were not able to move before the 9th of August. At this time they commenced their homeward voyage and arrived at Portsmouth on the 23d of September following.

During the whole time of the exploration of "the Fox," a regular series of observations was made upon the temperature, the pressure and movements of the atmosphere, as well as upon the variations of the elements of terrestrial magnetism, the tides, &c.

The meteorological observations were under the care of Dr. David Walker, of Belfast, and were made at equal intervals of time during day and night. In winter they were generally taken at intervals of two hours; and in summer of four hours. Occasionally, there are found some irregularities in the time of observation, and omissions noted in the records, but these are of rare occurrence, and are corrected approximately in the reductions.

The reductions have been made at the expense of the Smithsonian Institution, by Mr. Schott, whose previous labors in the reduction of the observations of Dr. Kane have met with general approval.

The series of observations is divided into three parts, relating to the following subjects, namely:—

1. The temperature.
2. The direction and force of the winds.
3. The pressure of the atmosphere.

To these are added, in an appendix, miscellaneous phenomena, such as the face of the sky, appearance of plants and animals, auroras, &c.

The following remarks relative to the observations are from communications addressed by Captain M'Clintock to the Secretary of the Smithsonian Institution:—

"I have much pleasure in transmitting to you the meteorological records of my whole voyage in the Fox. I have had my two-hourly observations for the temperature and pressure of the air reduced according to the method adopted in Kane's observations, but they have not been published in any book, nor do I think they will be, the time required and the expense being an objection. Admiral Fitzroy has published in the fourth number of the Meteorological Papers of the Board of Trade a part of my observations [the temperature for noon, the face of the sky, and the specific gravity of sea water, &c., without reduction], which I fear will not be sufficient for your purpose. You are at full liberty to make any use you may think fit of the observations, and should you deem them worthy of publication, it would afford me much pleasure."

"I think it better to send the whole record than to make extracts which would increase the chance of error and perhaps not be sufficient after all. You will thus be able to trace my drift down Baffin's Bay and Davis' Straits and to compare it with De Haven's drift.

"My magnetical observations are in the hands of General Sabine. In the appendix of the second edition of my narrative, now published, you will see an article on the Tides, as also one upon the Geology, by Professor Haughton. Observations upon Halos, &c., with the Polariscope, have been sent to Professor Stokes; a series of earth temperatures, to Dr. Jos. Hooker, of Kew Botanic Gardens, as also the specimens of dried and living plants. Natural history specimens have also been made over to scientific friends of the Expedition, my sole object being, to render our labors subservient to scientific ends, and with the least possible delay."

"I quite agree with Kane's remarks as to the increase of cold during full moon. The fact was noticed as far back as 1829–30, by Sir John Ross, in the Victory.

"I also agree with you in opinion that the apparent quantity of ozone depends upon the velocity of the air which has free access to the box containing the prepared paper."

"I likewise think that when you have fully examined my data now in your possession you will in a great measure subscribe to my opinion as to the ice-movement [as connected with the wind]. I referred in my letter only to the winter movements of the ice when there is no discharge of water whatever from the land, and when the precipitation in the northern regions is reduced to its minimum. The Barrow Strait stream is almost lost in the vast expanse of Baffin's Bay, but its line is tolerably well indicated by De Haven's drift. The entire current which brings such quantities of ice round Cape Farewell, and up to about 65° N., appears to be deflected off shore to the westward by banks which lie in about the latitude of 67°. It sweeps very swiftly past Cape Walsingham, curves southward, and having united with Barrow Strait current continues its course downward along the Labrador coast; so that the Labrador current is not due, in my opinion, so much to water flowing from the upper part of Baffin's Bay as to the Arctic current which sets around Cape Farewell from the East."

"The long drift of the Terror through Hudson's Straits in 1836–37 appears to me to be another instance of the effect of wind upon the ice, as in this case it does not seem possible that any considerable current could always, that is to say all winter, set out of Hudson's Bay. But it is my anxious endeavor to bring to light facts instead of advancing hypotheses, and I do know from repeated observations in the Fox, in 1837, and in H. M. S. Bulldog during the past summer, that the Arctic currents [from around Cape Farewell] flow northward along the coast of Greenland—off Frederickshaab, for instance, at from eighteen to twenty-four miles daily, and that West India seeds have been borne by it as far north as Egedesminde, which is in about 68° of north latitude. Our observations, therefore, upon the volume of water setting out of Baffin's Bay [on the west side] should not be extended south of this point without making considerable allowance for the current which flows around Cape Farewell, and northward up the coast."

In one of his communications, Captain M'Clintock states that the beams of the aurora were most frequently seen in the direction of open water, or else in that of places where vapor was rising. In some cases, patches of light could be plainly seen a few feet above a small mass of vapor over an opening in the ice. This observation is in accordance with a deduction from an examination of a large number of notices of the aurora in the voyages of Arctic explorations by Peter Force, Esq., of Washington; published in Vol. VIII. of Smithsonian Contributions (in 1856), namely, "that on the Atlantic Ocean, and other open water, the aurora is most frequent and most brilliant." These facts would appear to favor the hypothesis that auroral displays are due to electrical discharges between the air and the earth, since such discharges would, at least in part, be interrupted by a stratum of non-conducting ice.

The accompanying map, to illustrate the voyage of the Fox, is drawn by Mr. Schott on the plan of the projection known as the polyconic, which is a development of the earth's surface on cones tangent to each parallel of latitude; the radius being the distance between the arc of the parallel and the earth's axis.

Points of intersection of the parallels and the meridians are, according to Mr. Schott, readily computed by substitution in the following formulæ, in which x and y are the co-ordinates for any difference of longitude, n, on any parallel of latitude, L, and N the normal ending at the polar axis.

$$x = N \cos L \left(n - \frac{n^3}{6} \sin^2 L + \ldots\right)$$

$$y = N \cos L \left(\frac{n^2}{2} \sin L - \frac{n^4}{24} \sin^3 L + \ldots\right)$$

This projection is used in the United States Coast Survey, and is described in the Report of the Superintendent, Dr. Bache, for 1859, Appendix, 33.

JOSEPH HENRY,
Secretary S. I.

SMITHSONIAN INSTITUTION,
WASHINGTON, December, 1862.

PART I.

TEMPERATURES.

RECORD AND DISCUSSION OF TEMPERATURES.

The registers herewith presented include observations extending over twenty-seven months, and amount to a total number of upwards of seven thousand. The time is given in civil reckoning, and the latitude and longitude refer to noon each day (unless otherwise stated). All necessary explanations are contained in the notes accompanying the tables in which the observations are given.

The following statement is made in the preface to the Record: The registering thermometers were frequently compared with the standard thermometers supplied from Kew Observatory, and may be considered as free from sensible error. The corrections were deduced from the following table, furnished by Captain McClintock:—

"A Table showing the Comparisons of Six Thermometers, made at Different Temperatures, on board the Yacht Fox.

The Kew Standards were most beautiful instruments, too valuable to leave exposed. Newman's, being filled with colored spirit, were more easily read off during winter. No. 16 having been used in 1850–51, enables us to compare the temperatures of that winter with those of the Fox.

Thermometers compared.	10th March, 1858.	3d March, 1858.	19th Feb. 1858.	13th Feb. 1858.	22d Feb. 1858.	27th Feb. 1858.	13th Feb. 1858.	6th Feb. 1858.	3d Feb. 1858.	9th Feb. 1858.	7th Feb. 1858.	16th Jan. 1859.	28th Jan. 1858.	8th Feb. 1858.	Same day.	Same day.	29th Jan. 1858.	30th Jan. 1858.
		+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kew Standard (mercury), No. 19	21.7	2.4	0.4	10.4	12.7	13.0	14.1	15.2	24.0	29.2	33.8	36.3	37.3	39.7	. .	. .	. .	34.7
Kew Standard (white sp'it), No. 8	21.3	2.2	0.4	10.8	12.9	13.4	14.2	16.0	24.9	30.0	34.8	37.0	38.5	40.8	41.0	41.3	48.5	36.3
Kew Standard (white sp'it), No. 6	21.1	2.2	0.3	10.5	12.7	13.1	14.0	15.5	24.7	30.0	34.5	37.3	38.4	40.7	40.9	41.2	48.0	35.8
Newman (colored spirit), No. 11[1]	21.3	3.0	1.1	10.7	12.7	12.8	14.0	15.2	24.0	29.2	34.1	. .	37.7	39.1	39.3	40.1	46.0	35.7
Newman (colored spirit), No. 7[2]	21.8	3.7	. .	. .	. .	11.9	. .	15.2	24.2	. .	. .	36.3	37.5	38.8	38.9	39.5	. .	36.3
Newman (colored spirit), No. 16[3]	20.8	3.0	1.4	11.8	13.5	13.4	15.2	16.5	25.5	30.6	. .	. .	39.6	40.4	40.7	41.3	47.8	37.9

[1] This thermometer was used throughout the winter of 1857–58 as the "registering thermometer"—subsequently broken.

[2] This thermometer was used from September, 1858, to August, 1859. It has been brought home.

[3] This thermometer was used on board H. M. S. Assistance, at Griffith's Island, during the winter of 1850–51; has been brought home.

"On February 8th, 1858, the mercurial standard No. 19 fell steadily to —40°.2; then the mercury appeared to freeze, and descended into the bulb. Had the stem been graduated down to the neck of the bulb, it would then have indicated —70°. A globule of mercury corked up in a small test-tube remained fluid. Two other mercurial thermometers (good instruments) were exposed; one fell to —42°, the other to —40°.5. This was a very fair set of observations; the thermometers were taken to a distance from the ship, and freely suspended at five feet above the snow."

Taking the mean of the three Kew standards, Nos. 19, 8, and 6, and comparing the same with the readings of Newman, Nos. 11 and 7, we obtain the following corrections to each of the registering thermometers:—

	10th March, 1858.	3d March, 1858.	19th Feb. 1858.	13th Feb. 1858.	22d Feb. 1858.	27th Feb. 1858.	13th Feb. 1858.	6th Feb. 1858.	3d Feb. 1858.	9th Feb. 1858.	7th Feb. 1858.	16th Jan. 1859.	28th Jan. 1858.	8th Feb. 1858.	Same day.	Same day.	29th Jan. 1858.	30th Jan. 1858.
		+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mean of Nos. 19, 8, and 6	21.4	2.3	0.4	10.6	12.8	13.2	14.1	15.6	24.5	29.7	34.4	36 9	38.1	40.4	41.0	41.2	48.2	35.6
Corr'n to Newman, No. 11	+0.1	—0.7	+0.7	+0.1	—0.1	—0.4	—0.1	—0.4	—0.5	—0.5	—0.3	. .	—0.4	—1.3	—1.7	—1.1	—2.2	+0.1
Corr'n to Newman, No. 7	—0.4	—1 4	. .	. .	. .	—1.3	. .	—0.4	—0.3	. .	. .	—0.6	—0.6	—1.6	—2.1	—1.7	. .	+0.7

From the above, it appears that the following small corrections may properly be applied, viz:—

For thermometer, Newman No. 11, used in winter 1857-58—

Between	0° and —39°,		—0°.2
"	—39	" —48,	—1.6

For thermometer, Newman No. 7, used from Sept. 1858 to Aug. 1859—

Between	0° and —39°,		—0°.5
"	—39	" —48,	—1.8

As remarked above, no correction is applied to the record, and to the results only when *specially* stated.

There were a number of other thermometers on board; but, since the numbers of these instruments are not given in connection with the observations, it suffices to show that their corrections are small. The following table is copied from p. 3 of the Meteorological Register in the fourth number of the papers published by authority of the Board of Trade:—

SPIRIT THERMOMETERS.

	Corrections at 32°	52°	72°	
Newman, No. 16,	+0.5	+0.7	+0.4	Compared at Kew, Nov. 1859.
Pastorelli, No. 19,	+1.9	+1.2	+0.1	
" No 23,	+0.7	+0.3	—0.2	

MERCURIAL THERMOMETERS.

	Corrections at 42°	62°	82°		
Negretti, A 499,	—0.1	—0.1	—0.2	At departure.	Compared at Kew, Feb. 1857.
" 500,	0.0	—0.2	—0.3		
" 501,	—0.1	—0.2	—0.3		
" 502,	—0.1	—0.2	+0.1		
" 503,	—0.1	—0.3	—0.3		
" 504,	0.0	—0.2	—0.3		
Negretti, A 500,	—0.3	—0.3	—0.4	At return.	Compared at Kew Observatory.
" 501,	—0.1	—0.4	—0.4		
" 502,	—0.4	—0.4	—0.1		
" 503,	—0.4	—0.5	—0.4		
" 504,	—0.2	—0.3	—0.4		

The corrections in regard to the barometer are explained in the third part of the series, on page 79.

Temperature of the Air in Shade observed on board the Yacht Fox.

(Expressed in degrees of Fahrenheit's scale.)

July, 1857.

Day of the month.	Latitude north.	Longitude west of Greenwich.	4h	8h	Noon.	4h	8h	Midn't.	Mean.	Deduced mean.
1	Aberdeen		..	..	..	..	..	..	..	--
2	58° 19′	2° 35′	..	..	..	..	57°	..	..	57.2°
3	58 56	4 13	..	57°	..	..	57.5	..	..	57.7
4	59 45	7 16	..	54	..	..	49	..	..	52.0
5	60 18	13 49	..	49.5	..	..	53	..	..	51.7
6	60 1	15 1	..	53.5	56°	60°	56.5	55°	..	56.1
7	60 6	15 42	54°	58	61	61	57	57	58.0°	..
8	60 38	19 20	59	59	59	59.5	56	55	57.9	..
9	61 17	25 40	55	55	57	57	55	51	55.0	..
10	61 16	28 56	52	53	55	54	54	54	53.7	..
11	61 3	32 49	53	54	56	53	52	51	53.2	..
12	59 37	38 44	50	50	50.5	50	48	47	49.3	..
13	59 19	41 38	46	48	48	46	44	46	46.3	..
14	59 24	44 48	44	40	44	47.5	44	44	43.9	..
15	60 6	48 19	44	43	41.5	43	41.5	41	42.3	..
16	60 24	49 40	43	41	43	44	39	41	41.8	..
17	61 22	50 36	35	36	37	36	33	33	35.0	..
18	61 57	50 11	32	32	34	35.5	37	36	34.4	..
19	Frederickshaab		40	..	..	..	..	..	..	40.5
20	"		44	40	41	40	41	36	40.3	..
21	- - -	- - -	36	41	43	43	..	31	..	38.8
22	62 26	51 5	34	35	36	36	37	37	35.8	..
23	Fiskernaes		38	41	42	54	49	45	44.8	..
24	63 30	52 10	43	40	41	41	41	39	40.8	..
25	Off Goodhaab		38	38	40	41	41	38	39.3	..
26	64 7	53 15	39	41	41	41	40	39	40.2	..
27	64 34	55 0	40	38	40	39	36	38	38.5	..
28	65 1	55 20	36	37	39	39.5	40	39	38.4	..
29	67 23	55 30	38	39	38	42	39	39	39.2	..
30	68 29	55 12	38	42	42	41.5	40	41	40.8	..
31	Lievely		44	45	45	45	43	42	44.0	..
Mean	62.0	39.1	+44.78	+45.24	+46.46	+47.24	+45.36	+44.26	+45.56	

Correction to refer to mean from 24 observations in a day = —0°.03.

August, 1857.

Day of the month.	Latitude north.	Longitude west of Greenwich.	4h	8h	Noon.	4h	8h	Midn't.	Mean.
1	In Disco Fiord		42°	45°	44°	44°	44°	43°	+43.7
2	69° 7′	52° 58′	45	44	45	46	45	45	45.0
3	Off Issung Point		43	44	45	46	48	51	46.2
4	At Rittenbenk		51	50	51	47	40	39	46.3
5	71 7	55 25	38	39	41	43	40	40	40.2
6	Off Upernavik		41	..	..	44	40	37	41.2
7	72 42	58 1	34	33	33	34	34	31	33.2
8	72 34	59 47	29	30	34	35	37.5	40	34.2
9	73 19	58 43	38	33.5	35	34	34	34	34.7
10	74 29	58 38	36	35	35	33.5	33	32	34.1
11	74 45	59 26	32	33	36	36	34	32	33.8
12	75 6	59 20	28	30	34	36	36	33	32.8
13	75 11	59 4	32.5	35	46	37	37	32	36.6
14	75 9	59 11	34	34	36.5	37	38	33	35.4
15	75 9	59 11	33	35	39	36	34	32	34.8
16	75 7	59 29	31	34	36	36.5	32	31	33.4
17	75 10	61 18	31	31	31	33.5	32	31	31.6
18	75 17	62 8	29	30	33	35	32	29	31.3
19	75 16	62 16	29.5	30	34	31.5	27	27	29.8
20	75 17	- - -	27.5	29	30	31	29	28	29.1
21	75 17	62 16	28	29	32	35	33	31	31.3
22	75 22	62 41	30	31.5	35	35.5	32	29	32.2
23	75 22	62 41	30	31	33.5	33	33	27	31.2
24	75 20	63 9	25	27	30	31	27	26	27.7
25	- - -	- - -	23	28	34	35	34	34	31.3
26	75 23	63 12	32	32	31.5	32.5	31.5	33.5	32.2
27	75 26	63 15	34	35	37	35	35	34	35.0
28	- - -	- - -	34.5	35	34	35	34	33	34.2
29	75 26	63 55	31	29	33	33	28	26	30.0
30	- - -	- - -	24	27	32.5	33	34	34	30.7
31	75 30	64 4	32	32.5	34	32	29	25	30.8
Mean	74.0	59.8	+33.16	+33.99	+36.39	+36.32	+34.74	+33.31	+34.65

Correction to refer mean of 6 observations to mean of 24 observations, 0°.00.

Temperature of the Air in Shade observed on board the Yacht Fox.

(Expressed in degrees of Fahrenheit's scale.)

September, 1857.

Day of the month.	Lat. north.	Long. west of Green.	2h	4h	6h	8h	10h	Noon.	2h	4h	6h	8h	10h	Midn't.	Mean of 6 obs'ns.	Mean of 12 obs'ns.
1	75°28′	- - -	..	22°	..	23°	..	29°.5	..	32°	..	30°	..	29	+27°.6	+27°.5
2	- - -	- - -	..	31	..	34	..	35	..	36	..	32.5	..	28	32.7	32.5
3	- - -	- - -	..	28	..	25.5	..	30	..	32	..	30.5	..	29	29.2	29.1
4	- - -	- - -	..	27.5	..	28	..	29.5	..	26	..	26	..	25	27.0	26.8
5	75 27	64°21′	..	28	..	29	..	31	..	31	..	31	..	30	30.0	29.9
6	75 26	64 31	..	29	..	30	..	32	..	27.5	..	26	..	18	27.1	26.9
7	75 24	64 31	..	20	..	24.5	..	28.5	..	28	..	27.5	..	33	26.9	26.8
8	- - -	- - -	..	27	..	26.5	..	30	..	32	..	29	..	28	28.8	28.6
9	- - -	- - -	..	28.5	..	32	..	33	..	33	..	33	..	33	32.1	32.0
10	- - -	- - -	..	32	..	34	..	33.5	..	35	..	31.5	..	30	32.7	32.5
11	- - -	- - -	..	30	..	30.5	..	33	..	34	..	34	..	31	32.1	32.0
12	75 31	- - -	..	23	..	23	..	22	..	21	..	16	..	16.5	20.2	20.0
13	75 32	65 32	..	17	..	7	..	17	..	15	..	18	..	18	15.3	15.2
14	- - -	- - -	..	20	..	24	..	31	..	28	..	19	..	6	21.3	21.1
15	75 33	64 52	..	5	..	10.5	..	10.5	..	19	..	13	..	6	10.7	10.6
16	- - -	- - -	..	9	..	16.5	..	22	..	22.5	..	17.5	..	11	16.4	16.2
17	75 32	66 1	..	3.5	..	3	..	10	..	16	..	12	..	—2	7.1	7.0
18	75 30	65 39	..	4	..	8	..	7	..	14	..	13.5	..	11.5	9.7	9.5
19	75 23	65 32	..	10.5	..	9.5	..	15.5	..	17	..	9	..	7	11.4	11.3
20	75 21	65 24	..	5	..	6	..	13	..	16	..	10.5	..	10.5	10.2	10.0
21	75 17	65 21	..	13.5	..	17	..	25.5	27°	26.5	23°	21	21°	21	20.7	20.3
22	75 12	65 12	23°.5	23	23°	21.5	17°	17	17	16.5	15	16	17.5	18	18.7	18.8
23	75 10	65 5	17	17	13	19	15.5	17	18	17	8	5.5	6	5	13.4	13.2
24	75 8	65 20	6	6	5	9.5	10.5	10	12	13	8	6	3	4	8.1	7.8
25	75 5	65 20	5	5	6	9	12	14.5	16	16	10.5	8	8	6	9.8	9.6
26	75 4	65 23	3	5	6	7.5	11.5	12	13	14	11	8.5	9	9	9.3	9.1
27	75 1	- - -	8	7	8.5	12	14	14	15.5	20	20.5	21	19	18	15.3	14.8
28	- - -	- - -	13	10.5	10.5	10.5	15	19.5	21.5	19.5	15	15.5	18	19	15.7	15.6
29	75 1	- - -	19	18	17	18	19	20	20.5	19	14.5	12	11	11	16.3	16.6
30	- - -	- - -	12	12	11	15	18	19.5	18.5	16	16	16	15	12	15.1	15.1
Mean	75.3	65.5	+17.15	+17.23	+16.75	+18.78	+20.42	+22.07	+23.16	+23.10	+20.16	+19.63	+18.63	+17.38	..	+19.54

Correction to refer to mean of 24 observations = —0°.04.

October, 1857.

Day of the month.	Lat. north.	Long. west of Green.	2h	4h	6h	8h	10h	Noon.	2h	4h	6h	8h	10h	Midn't.	Mean.
1	- - -	- - -	+6°	+5°	+2°	+3°.5	+ 6°	+13°	+18°	+18°	+18°.5	+20°	+20°.5	+21°	+12°.6
2	- - -	- - -	19	17.5	17.5	20	22	22	19	11.5	8	12	7	9	+15.4
3	74° 58′	65° 52′	6	8	10	9	9	9.5	10	10	5	3	2	4	+ 7.1
4	74 56	- - -	5.5	8	8	11	15.5	17	19.5	16	16	12	12	6.5	+12.2
5	74 54	- - -	8.5	7.5	7	11	14	12	12	9	3	1	1	2	+ 7.3
6	74 52	65 45	—2	—1	10	14	16	17	13.5	14.5	13	3.5	1	—3	+ 8.0
7	74 52	65 42	—5	—6	—6	—3.5	—3.5	0	3	4	1	3	1	1.5	— 0.9
8	- - -	- - -	2	2	2	1	4	4	3.5	4.5	4	3.5	3	—3	+ 2.5
9	- - -	- - -	—3.5	—3	8	12	13	14	14	12.5	10	10.5	8	—3	+ 7.7
10	- - -	- - -	—3	—3	—3	2	0	0	—1.5	—1.5	—3.5	—7	—4	1	— 2.0
11	- - -	- - -	—1	—1	—2	—3	—5.5	0	—2	—1	—1	—2	0	5	— 1.1
12	74 52	- - -	6	9	9	9	14	15.5	15.5	15.5	15.5	13	2	5	+10.8
13	- - -	- - -	8	7	9	9	8.5	8.5	10	10.5	18.5	23	26.5	28	+13.9
14	- - -	- - -	29	29	28.5	30	32	32	29	26	21	23	24	26	+27.4
15	- - -	- - -	27	28	29.5	30	30.5	31	30	27	25	25	24	24	+27.6
16	- - -	- - -	27	28	28	28.5	29	28	27	26.5	26	25	27	21.5	+26.8
17	75 18	69 30	12	8	7	11	13	11	19	18.5	19	19	19	20	+14.7
18	- - -	- - -	21	21.5	19	17	14	13	12	12	12	11	11	11	+14.5
19	75 18	69 30	12	11	9	7.5	6.5	7	7	5.5	6	6.5	6	6	+ 7.5
20	- - -	- - -	6	7	9	9	10.5	10.5	11	10.5	10	11	10.5	11	+ 9.7
21	75 30	69 34	10	10	12	11.5	11	8	9	9	11.5	15	16	13	+11.3
22	- - -	- - -	12	11	9	6.5	2	1.5	4.5	4	4	4	2	1	+ 5.1
23	75 33	- - -	—2	—3	—4	—4	—8	—8	—9.5	—11	—11	—11	—11	—8	— 7.5
24	- - -	- - -	—3	—6	—5	—3	—3	—4	—6	—7.5	—9.5	—9.5	—10	—11.5	— 6.5
25	75 27	68 41	—12	—13	—9	—5	—5	—2.5	—3.5	—4	—8	—10	—10	—8	— 7.5
26	75 27	68 50	—7	—8	—5.5	—7.5	—7	—7	—8	—4	—3	—4	—4	—6	— 6.0
27	- - -	- - -	—7	—7	—5	—4.5	—3.5	—3	—3	—3	—3	—1	0	—1	— 3.4
28	75 22	- - -	—1	—1	—1	—1	—0.5	0	—4	—6	—8	—10	—11	—11	— 4.5
29	75 21	- - -	—13.5	—12	—12	—10	—10	—9	—10	—11	—8	—7	—7	—10	—10.0
30	75 13	68 40	—10	—11	—10	—8	—6.5	—8	—8	—9	—10	—12	—12.5	—12.5	— 9.8
31	- - -	- - -	—11.5	—9	—7	—6	—5.5	—4	—4	—4	—6	—6.5	—5	—6	— 6.2
Mean	7.52	67.9	+4.37	+4.31	+5.29	+6.29	+6.86	+7.39	+7.32	+6.55	+5.68	+5.29	+4.81	+4.31	+5.71

Correction to refer mean of 12 to mean of 24 observations in a day = +0°.02.

TEMPERATURE OF THE AIR IN SHADE OBSERVED ON BOARD THE YACHT FOX.
(Expressed in degrees of Fahrenheit's scale.)

November, 1857.

Day of the month.	Lat. north.	Long. west of Green.	2h	4h	6h	8h	10h	Noon.	2h	4h	6h	8h	10h	Midn't.	Mean.
1	75° 13′	68° 50′	— 4°	— 7°	—10°	—10°	— 8°	— 4°	— 1°	+ 2°	— 3°	— 3°	— 5°	— 5°.5	—4°.9
2	- - -	- - -	— 4.5	— 3	— 4	— 7.5	— 7	— 7	— 5	— 3	— 4	+ 2	+ 3	— 5	— 3.8
3	75 10	69 30	— 7.5	— 8	— 8	—11	—11.5	— 7.5	—10.5	— 8	— 4	— 3.5	+ 1	+ 1.5	— 6.4
4	- - -	- - -	+ 2	+ 3	+ 4	+ 3	+ 4	+ 5	+ 4.5	+ 3	+ 3	+ 3	+ 2	+ 1	+ 3.1
5	- - -	- - -	— 1	— 4	— 7	— 6	— 5	— 3	— 5.5	— 7	— 7	— 8.5	— 8	— 6	— 5.7
6	- - -	- - -	— 6	— 5	— 2	— 1.5	+ 1.5	— 4	— 1	— 1	— 2	— 4.5	— 6	— 8	— 3.5
7	74 57	69 20	— 7	— 8	— 8	— 8	— 7	— 7	— 8	— 7	— 3	— 4	— 3	— 2.5	— 6.0
8	- - -	- - -	— 3	— 4	— 4	— 4	— 4	— 5	— 4	— 5	— 3	— 1	— 1	— 1	— 3.3
9	- - -	- - -	— 2	— 2	— 4.5	— 5	— 5	— 5	— 5	— 4	— 5	— 8	— 7	— 7	— 5.0
10	74 42	68 6	— 8	— 8.5	— 6	— 6	— 9	—11	—11.5	—13	—16.5	—15.5	—15	—14	—11.2
11	- - -	- - -	—12	— 9	— 8	— 7	— 4	— 7	— 8	— 8	— 7	— 8	— 7	— 6	— 7.6
12	74 34	- - -	— 7	— 7	— 8	— 8.5	— 9	— 8	— 9	— 9	—10	—10	—11	— 9	— 8.8
13	74 34	- - -	— 6.5	— 6	— 7	— 6	— 7	— 9.5	— 7	— 8	—10	—12	—10	—11.5	— 8.4
14	- - -	- - -	—10	— 6.5	— 5	— 3	— 1	— 1	0	— 1	+ 1	— 1	— 1	— 1	— 2.4
15	- - -	- - -	— 1	— 1	+ 1.5	+ 3.5	+ 7	+ 7.5	+ 6	+ 6	+ 5	+ 6.5	+ 8	+ 7	+ 4.6
16	- - -	- - -	+11	+16	+13	+15	+16	+16	+16	+14.5	+12	+11	0	— 2	+11.5
17	- - -	- - -	— 5	— 3	— 4	— 3	— 2	— 3	— 4	— 5	— 6	— 5	— 6	— 8	— 4.5
18	- - -	- - -	—10	—10.5	—11	—12	—12	— 5	— 5.5	— 5	— 7	— 8	— 8	— 9	— 8.6
19	74 47	- - -	— 9	— 8	— 9.5	—10	—10	—11	—12	—11	— 9.5	— 8	— 8	— 8	— 9.5
20	- - -	- - -	— 8	— 9	—10	—11	—11	—11.5	—13	—11	—10.5	—10	— 7	— 5	— 9.8
21	74 47	68 54	— 5	— 3	— 2	— 2	— 2.5	0	— 2	+ 2	+ 5	+ 9	+19	+15	+ 2.8
22	- - -	- - -	+18	+20	+22	+25	+30	+31	+30.5	+30.5	+28.5	+25	+21	+19	+25.0
23	- - -	- - -	+16	+13	+11	+10	+ 8	+ 7	+ 4	0	— 4	— 5	— 7	— 8	+ 3.8
24	75 2	70 22	— 5	— 4	— 6	— 9	— 6	— 3	— 1	+ 2	0	— 1	— 1	— 3	— 3.1
25	75 2	70 22	+ 3	+ 6	+ 8	+ 9	+ 6	+ 6	+ 6	+ 8	+ 5	+ 3	— 1	— 4	+ 4.6
26	- - -	- - -	— 7	— 7	— 8	—10	—10	— 9	—10	— 8	— 4.5	— 4.5	— 5	— 6	— 7.4
27	- - -	- - -	— 7.5	— 8	—10	—10	—11	—12	—12	—12.5	—15	—16	—16	—15	—12.1
28	74 48	69 36	—16	—17	—18	—18.5	—19	—20	—20	—21	—22	—22	—23	—23	—20.0
29	- - -	- - -	—20	—21	—22	—20	—20.5	—21	—20	—21	—21	—22	—23	—26	—21.5
30	- - -	- - -	—26	—26	—27	—26	—30	—30.5	—30.5	—31	—30	—29	—30	—32	—29.0
Mean	74.8	69.1	—4.93	—4.58	—4.98	—4.98	—4.63	—4.42	—4.62	—4.38	—4.82	—5.00	—5.17	—6.07	—4.88

Correction to refer the mean of 12 to the mean of 24 readings = +0°.12.

December, 1857.

Day of the month.	Lat. north.	Long. west of Green.	2h	4h	6h	8h	10h	Noon.	2h	4h	6h	8h	10h	Midn't.	Mean.
1	74° 41′	69° 10′	—32°	—31°.5	—33°	—31°	—31°	—31°	—30°	—31°	—31°	—30°.5	—32°	—33°	—31°.4
2	- - -	- - -	32	32	33	33	33	33	35	33.5	33	33	33	33	—33.0
3	- - -	- - -	35	35	34	33	30	23	21	21	21	20.5	22	29	—27.0
4	- - -	- - -	27	28	29	26	26	29	28	27	27	28	31	32	—28.2
5	- - -	- - -	31	30.5	29	29	28	25	23	21	21	19	15	16	—24.0
6	- - -	- - -	17	17	14	14	17	17	20	21	22	22	23	23	—19.0
7	74 30	68 43	23	29	28	28	28	30	27	27	27	26	26.5	27	—27.2
8	- - -	- - -	26	23	21	19	19	22	22	22	21	20	18	21	—21.3
9	- - -	- - -	25	26	27	27	26	26	24	26	28.5	29	26.5	29	—26.7
10	74 31	68 21	27	28	28	28	27.5	27	28	29	29	28.5	28	29	—28.1
11	- - -	- - -	29	29	26	18	14	16.5	20.5	20	21	20	20	19	—21.1
12	- - -	- - -	17.5	26	15	15	17	14	14	12	12	10	12	12	—14.7
13	- - -	- - -	12	12.5	12	14	13	12	14	15	16	17	18	18	—14.5
14	74 12	67 10	20	21	21	21.5	21.5	22	22	23	22	25	24	24.5	—22.2
15	74 7	67 7	28	25	26	26	26	26	27	27	28	27	28.5	28.5	—26.9
16	- - -	- - -	27	27	27	27	27	25	25	18.5	14	13	14	12	—21.4
17	- - -	- - -	9	11.5	14	15.5	16	18	19	20	19.5	18	20	21	—16.8
18	- - -	- - -	20	21	22	22	22.5	22.5	21	21	22	24	24	23.5	—22.1
19	- - -	- - -	23	18	15.5	16	14	17.5	20	23	25	24	26.5	20	—20.2
20	74 5	66 27	17	16	14	13	11	10.5	11	12.5	9	8	8	7	—11.4
21	- - -	- - -	8	10.5	14	18	23	25.5	27.5	29	30.5	31	32	33	—23.5
22	- - -	- - -	28	26	24	22.5	22	23	23	22	20	17	16	16	—21.6
23	- - -	- - -	16	16	12	11	11.5	9.5	7.5	7.5	10	12	14	18	—12.1
24	- - -	- - -	21	20	20	21	20	20	20	21	22	22	21	20	—20.7
25	- - -	- - -	21	21.5	19	17.5	18	17	20	18	17.5	17	19	18	—18.6
26	- - -	- - -	18	17	16	15	16	17.5	17	19	19	20	18.5	19	—17.7
27	74 4	66 32	16	16	13	10	9	8	6.5	5	4.5	4	4	4	— 8.3
28	- - -	- - -	4	3	3	2.5	2	1	1	+ 1	+ 2	+ 5	6	7	— 1.8
29	- - -	- - -	9.5	8.5	12	15	16	21	22	24	25	26	28	28	—19.6
30	73 55	66 5	28	28.5	29	29.5	30	32	34	34	33	34	34	34	—31.7
31	- - -	- - -	35	35	35	36	36	36	36	36	36	35	35	35	—35.5
Mean	74.3	67.4	—22.00	—22.23	—21.47	—21.10	—21.00	—21.21	—21.48	—21.45	—21.44	—21.14	—21.86	—22.24	—21.55

Correction to refer mean of 12 to mean of 24 observations = 0°.00.

Temperature of the Air in Shade observed on board the Yacht Fox.

(Expressed in degrees of Fahrenheit's scale.)

January, 1858.

Day of the month.	Lat. north.	Long. west of Green.	2h	4h	6h	8h	10h	Noon.	2h	4h	6h	8h	10h	Midn't.	Mean.
1	- - -	- - -	—36°	—35°	—35°.5	—36°	—35°	—33°.5	—35°	—33°	—32°	—31°.5	—30°	—29°	—33°.5
2	- - -	- - -	29	28	27	26	24	25	27	29	29	30	31.5	31	—28.0
3	- - -	- - -	28	28.5	27	24	23	21.5	20	20.5	22	23.5	24.5	25	—24.0
4	73° 49′	65° 47′	25	25	23	17	15	15	14.5	14	13	11	9.5	9	—15.9
5	- - -	- - -	9	9.5	10	10	9	10	10	10	13	21	22.5	23	—13.1
6	- - -	- - -	21.5	22	20	19	18	17.5	17	17	16.5	16	16	16	—18.0
7	- - -	- - -	16.5	16	15.5	15.5	16	16	15.5	14	15	15	16.5	16	—15.6
8	- - -	- - -	17	17.5	18	18	18	17	18	18.5	18.5	18	18	18.5	—17.9
9	- - -	- - -	16.5	18	19	20	20	19	20	23	24.5	24	24	25	—21.1
10	73 30	64 9	26	26	26	25	24	23	23	22	22	21	20	20	—23.2
11	- - -	- - -	19	18.5	18	18	18	18	18	21	21	24.5	24	26	—20.3
12	73 24	63 54	27	28	27	25	23.5	22	21	26.5	27.5	26	28	26.5	—25.7
13	- - -	- - -	28	27.5	27	25	26	25	26	28	28.5	30	30	31	—27.7
14	- - -	- - -	31	32.5	33	35	36	34	34	33	27.5	22	20	20	—30.0
15	- - -	- - -	17	17	15.5	14	13	9.5	8	8	9	11.5	13	14	—12.4
16	- - -	- - -	14	13	12	12	11	12	14	15	16	17.5	17	17	—14.2
17	- - -	- - -	16	16	19	21	19	22	25	27	29	31	31	33	—24.1
18	73 9	63 25	34	35	35.5	35.5	36	36	36	37	36	35	36	36	—35.7
19	- - -	- - -	36	37	37.5	36.5	35	34	34	32	25	24	18	13	—30.1
20	- - -	- - -	9	8	9	9	9	8.5	9.5	12	12	12	11	11	—10.0
21	- - -	- - -	13	13	14	16.5	16	16	16	16.5	17	17.5	18	18	—16.0
22	- - -	- - -	18.5	19.5	20	25	27	30.5	31	30	29	29	28.5	29	—26.4
23	73 1	62 55	29	28	28	29	30.5	32	32	36	36	36.5	37.5	36	—32.5
24	- - -	- - -	36	36	35	35	35	35	33	32	28	26	24	22.5	—31.5
25	- - -	- - -	22	22	22	23	21	22	24	26	27	27	28	28	—24.3
26	72 48	62 35	26	24.5	24	24	24	24	25	26	26	26	26	27	—25.2
27	- - -	- - -	25	25	24	23.5	26	28	31	31	33	34	35.5	36.5	—29.4
28	- - -	- - -	37	37	38	38.5	39	38	35	37.5	39.5	40	40.5	45.5	—38.4
29	- - -	- - -	39	39	39	39	41	41	45	43	45	46	43	43	—41.9
30	- - -	- - -	41	41	40	37	36.5	36	34.5	35	33.5	32	33	33	—36.0
31	- - -	- - -	33	34	34	34.5	31.5	28	28	24	23	23	23	21.5	—28.2
Mean	73.2	63.7	—25.01	—25.07	—24.92	—24.72	—24.39	—24.16	—24.52	—25.08	—24.97	—25.21	—25.08	—25.00	—24.84

Correction to refer mean of 12 to mean of 24 readings = —0°.03.

February, 1858.

Day of the month.	Lat. north.	Long. west of Green.	2h	4h	6h	8h	10h	Noon.	2h	4h	6h	8h	10h	Midn't.	Mean.
1	- - -	- - -	—22°	—22°	—22°	—19°	—19°	—19°	—21°.5	—22°	—21°	—22°	—23°	—20°	—21°.0
2	72° 28′	61° 10′	20.5	20	17	16	11	10	11	8	12	16	17	19	—14.8
3	- - -	- - -	21.5	22	21.5	22.5	23	22.5	24	25	23	20	21	23	—22.4
4	72 25	61 10	23	21	22	25	25.5	25	26	27	28	29	28	29	—25.7
5	- - -	- - -	30	30	29	27	26	25	25	24	24	21	20	20	—25.1
6	- - -	- - -	21	19	19	18	16.5	15	15.5	15	14	15	17	23	—17.3
7	- - -	- - -	27.5	30	31	32	34	34	32	35	36	34	33.5	35	—32.9
8	72 22	61 26	33	34	36	37	39	39.5	38.5	39.5	38	37	37	35	—37.0
9	- - -	- - -	34	34	33	32	32.5	30	28.5	27.5	26	24	23	23	—28.9
10	- - -	- - -	24	23	20	18	16	15	13	11	10	10	8	6	—14.5
11	- - -	- - -	3	2	4.5	8	10.5	11	11.5	16	18	14	12	10	—10.0
12	- - -	- - -	9	8.5	7.5	6	8.5	7	13	16	17	17	16	16	—11.8
13	71 59	60 26	15	15	17	15	15	14	10	9	10.5	7	7.5	8	—11.8
14	- - -	- - -	8	9	8	7	7	5	5	6	6	6	7	7.5	— 6.8
15	71 38	61 31	8.5	10	10	10.5	9.5	9.5	11	11	11	12	12	11	—10.5
16	71 28	- - -	11	10	9	9.5	8	8	8	9	9	10	11	10	— 9.4
17	71 16	60 45	11	11	12	12	13	13	12	12	13	12	12	12	—12.1
18	71 8	- - -	13	13	13	11	10	9.5	9	10	10	11	11	10	—10.9
19	71 2	60 48	7	7	8	5	3	1	1	1.5	3	4	9	13	— 5.2
20	- - -	- - -	14	15	10	7	5.5	3.5	1	2	1	3	4	5	— 5.9
21	- - -	- - -	5	5	6	7	8	8	7.5	13	19	18	16	15	—10.6
22	- - -	- - -	16	16.5	18.5	17	17	13	13	15	15	15	14	14	—15.2
23	70 39	60 35	15	15	15	15	14.5	13	13	14.5	16	16	16	16	—15.0
24	- - -	- - -	15	13	12	12	13	12.5	12	12	12	13	11	13.5	—12.6
25	- - -	- - -	14	14	13	15	15	15	15	15	16	15	16	16	—14.9
26	- - -	- - -	16	16	16	15.5	12	9	7	10	15	12	13	20	—13.5
27	- - -	- - -	23.5	26	26	25	22	19	14	6.5	6.5	8	15	9	—16.7
28	69 50	59 43	3	+ 8	+ 8.5	+ 8.5	+10	+11	+ 7.5	+ 2	2	0	2	0.5	+ 4.0
Mean	71.5	60.9	—16.55	—16.18	—15.98	—15.55	—15.14	—14.11	—13.95	—14.66	—15.43	—15.04	—15.43	—15.70	—15.31

Correction to refer mean of 12 to mean of 24 observations = —0°.03.

TEMPERATURE OF THE AIR IN SHADE OBSERVED ON BOARD THE YACHT FOX.
(Expressed in degrees of Fahrenheit's scale.)

March, 1858.

Day of the month.	Lat. north.	Long. west of Green.	2h	4h	6h	8h	10h	Noon.	2h	4h	6h	8h	10h	Midn't.	Mean.
1	- - -	- - -	— 2°	— 2°	+ 4°	+ 5°	+ 8°.5	+ 8°.5	+10°	+12°.5	+16°	+15°	+ 6°	+ 3°	+7°.0
2	- - -	- - -	+ 3	+ 1	+ 2	+ 3	+ 3	+ 5	+ 3.5	+ 1.5	+ 0.5	+ 1	0	— 5	+ 1.5
3	- - -	- - -	— 7	— 7	—11	— 4.5	— 5	— 1	— 5	0	+ 3	+ 5	+ 8	+18	— 0.5
4	- - -	- - -	+12	+ 7	+ 4	+ 1	+ 1	0	— 2	— 5	— 7	— 8.5	—11	—12	— 1.7
5	70° 4′	59° 29′	—12.5	—12.5	—10	—12	—12.5	—10	— 8	— 9	—13	—16	—19	—22	—13.0
6	70 1	- - -	—21	—25	—25.5	—23	—18	—16	—14	—15	—18.5	—22.5	—23	—25	—20.5
7	69 55	59 11	—25	—26.5	—25	—22.5	—20	—16	—15	—15	—19	—19.5	—19	—19	—20.1
8	69 49	- - -	—18	—18	—18.5	—18.5	—15	—14.5	—12	—11.5	—17	—20	—19	—17	—16.5
9	- - -	- - -	—17	—17	—15	—12	— 6.5	— 2	+ 3.5	+ 2.5	+ 2	— 1	+ 1	+ 4	— 4.8
10	69 41	- - -	+ 4	+ 2	+ 9	+18	+23.5	+25.5	+22	+21	+20	+18	+20	+26	+17.4
11	- - -	- - -	+25.5	+25.5	+30	+29	+31	+32	+32	+30	+24	+20	+17	+17	+26.1
12	- - -	- - -	+19	+22	+18	+20	+26	+31.5	+27.5	+15	+13	+11	+11	+ 8	+18.5
13	- - -	- - -	+10	+11	+11	+11.5	+10	+13	+10	+12	+ 6	— 6	— 8	—10	+ 5.9
14	69 55	60 5	— 8	— 8	— 9	— 7	— 7	— 6.5	— 4	— 5	—12	—14	—15	—17	— 9.4
15	- - -	- - -	—20	—20	—19	—18	—15.5	—13	—14	—15	—18	—19	—19	—18	—17.4
16	69 38	59 14	—18	—20	—20	—18	—14.5	—12	—10	—10	—11.5	—12	—11	—11	—14.0
17	69 31	- - -	—11.5	—10.5	— 9	— 8.5	— 8.5	— 6	— 3	— 6	— 8.5	—10	—11	—13	— 8.8
18	69 28	58 55	—13	—12	—12	—12	— 7.5	— 5	— 3	— 3	— 5	— 5.5	— 6.5	— 7	— 7.6
19	69 20	- - -	— 8	— 8	— 9	— 8	— 5	— 4	— 2	— 2.5	— 5.5	— 9	—10	— 8	— 6.6
20	69 14	58 43	— 4	— 5	— 9	— 4	— 5	+ 1	+ 3.5	+ 3.5	0	— 3	— 9	—11	— 3.5
21	69 14	- - -	—11.5	—11	—11	—10	— 4	— 3.5	— 1	+ 3	— 6	— 2	0	0	— 4.7
22	- - -	- - -	+ 1	+ 2	+ 4	+ 9	+ 9	+13	+14	+14.5	+17	+19.5	+22	+25	+12.5
23	- - -	- - -	+25	+24	+29	+29.5	+29	+30	+20	+15	+11	+ 9.5	+ 8.5	+ 8	+19.9
24	- - -	- - -	+ 7	+ 7	+ 7	+ 8.5	+10	+10	+ 9.5	+ 8.5	+ 7	+ 6	+ 6	+ 5	+ 7.6
25	69 16	58 50	+ 1	— 1	— 1	+ 3	+ 4	+ 4	+ 5	+ 3.5	+ 1.5	0	0	— 1	+ 1.6
26	68 59	- - -	— 1	— 3	— 5	— 6	— 7	— 7.5	— 7	— 6.5	— 9	—12	—13	—15	— 7.7
27	68 44	58 37	—15.5	—16	—17	—14	—13	—11.5	—11	—11	—12	—14	—16	—17.5	—14.1
28	68 34	- - -	—16.5	—15.5	—14	—11	— 8	— 8.5	— 5	— 4	— 7	— 7	— 9	—12	— 9.8
29	68 27	58 29	—12	—12	—15	— 7	— 7	— 5.5	— 6	— 8	—10	—12	—14	—15	—10.3
30	68 25	58 31	—14	—13.5	—11.5	— 5	+ 3.5	+ 4.5	+ 4	— 2	— 4	—10	—14	—18	— 6.7
31	68 20	- - -	—22	—25	—25.5	—23	—21	—20	—19.5	—18	—19	—20.5	—25.5	—27	—22.2
Mean	69.4	59.1	—5.48	—6.03	—5.60	—3.44	—1.34	+0.47	+0.74	—0.13	—2.49	—4.79	—5.57	—6.01	—3.31

Correction to refer mean of 12 to mean of 24 observations = +0°.02.

April, 1858.

Day of the month.	Lat. north.	Long. west of Green.	2h	4h	6h	8h	10h	Noon.	2h	4h	6h	8h	10h	Midn't.	Mean of 6 obs'ns.	Mean of 12 obs'ns.
1	68°17′	58°15′	—26°	—26°	—26°	—13°	— 8°	— 7°	— 4°.5	— 5°	— 8°.5	—17°	—17°	—17°	—14°.2	—14° 6
2	68 17	- - -	—19	—20	—18	—12	—10.5	— 9.5	— 9	— 9.5	—12	—15	—16	—16	—13.7	—13.9
3	68 9	58 25	—16	—15	—13.5	—10	— 9	— 7.5	— 8	— 9	—11.5	—12	—14	—14	—11.5	—11.6
4	- - -	- - -	—15	—15	—15	—14.5	—13.5	—11	— 8.5	— 8	—10	—11	—11.5	—12.5	—12.0	—12.2
5	- - -	- - -	—12.5	—12	—11	— 6	— 4	— 1	+ 1	— 4	— 7	— 8.5	— 9	—10	— 6.9	— 7.2
6	67 18	58 17	— 8	— 8	— 8	— 4	— 3	0	+ 2	+ 4.5	— 3	— 8	— 9	— 9	— 4.1	— 4.5
7	- - -	- - -	— 8	— 5	— 3	+ 3	+13	+16.5	+15	+ 9	+ 5	+ 4	+ 4	+ 4	+ 5.2	+ 4.8
8	- - -	- - -	+ 4	+ 4	+ 2.5	+ 5	+ 1	+ 5	+ 4	— 1	— 2	— 6	— 7	— 9.5	— 0.4	0.0
9	66 53	58 31	— 9	—10	— 6	— 3.5	0	+ 1	+ 1.5	0	— 2	— 4	— 5	— 6	— 3.7	— 3.6
10	66 45	58 20	— 6	— 7	— 5	— 1	+ 6	+ 9	+10	+ 9	+ 2.5	+ 2	— 1.5	— 1.5	+ 1.7	+ 1.4
11	66 40	- - -	— 2	— 2	— 1	+ 6	+11	+20	+19	+18	+14	+ 5.5	+ 1	+ 4	+ 8.6	+ 7.8
12	66 33	58 8	0	— 1	— 2.5	— 3	— 2.5	— 1	0	— 1.5	— 5.5	— 7.5	— 9	—10	— 4.0	— 3.6
13	66 26	58 12	—10.5	—10	— 5	— 3	+ 1	+ 5	+ 8	+10	+ 8.5	+ 5	+ 1.5	— 2	+ 0.8	+ 0.7
14	66 23	58 4	— 5	— 3	+ 1	+ 6	+10	+12	+12	+11	+ 9	+ 4	+ 1	0	+ 5.0	+ 4.8
15	66 17	57 55	+ 1	+ 1.5	+ 2	+ 2.5	+ 3	+ 5.5	+ 5.5	+ 4.5	+ 4	+ 1.5	0	— 0.5	+ 2.5	+ 2.5
16	65 58	- - -	0	— 1.5	+ 1	+ 4.5	+ 8	+10	+11.5	+14	+16	+ 9	+ 8	+ 8	+ 7.3	+ 7.4
17	65 28	58 24	+ 7	+ 6.5	+ 7	+ 9	+14	+16	+18	+18	+15	+15	+14	+14	+13.1	+12.8
18	64 50	58 35	..	+11	..	+11	..	+19.5	..	+18	..	+17	..	+15	+15.2	+15.1
19	64 16	- - -	..	+14	..	+15.5	..	+16	..	+15	..	+10	..	+ 9	+13.2	+13.1
20	64 22	58 45	..	+ 8	..	+16	..	+16	..	+14	..	+12	..	+10	+12.7	+12.6
21	64 10	58 44	..	+12	..	+13	..	+17	..	+17	..	+ 9.5	..	+ 7	+12.6	+12.4
22	63 51	58 54	..	+ 3	..	+ 5	..	+15	..	+15.5	..	+13	..	+ 7	+ 9.7	+ 9.6
23	63 41	58 59	..	+ 8	..	+12	..	+ 9.5	..	+21	..	+19.5	..	+19	+14.8	+14.7
24	- - -	- - -	..	+17	..	+26	..	+28.5	..	+33	..	+33	..	+30	+27.9	+27.8
25	63 40	58 24	..	+26	..	+30	..	+34	..	+31	..	+25	..	+22	+28.0	+27.8
26	63 47	56 36	..	+23	..	+26.5	..	+30.5	..	+28	..	+25	..	+24	+26.2	+26.1
27	65 14	53 41	..	+28	..	+25	..	+29	..	+30	..	+26	..	+23	+26.8	+26.7
28	66 28	53 30	..	+26	..	+25	..	+29	..	+28	..	+25	..	+25	+26.3	+26.2
29	66 28	53 30	..	+21	..	+23	..	+28	..	+26	..	+25	..	+22	+24.2	+24.0
30	66 28	53 30	..	+27	..	+31	..	+35	..	+38	..	—36	..	+34	+35.5	+33.4
Mean	66.0	57.7	+3.03	+3.35	+4.13	+7.50	+10.14	+12.62	+13.37	+12.45	+10.38	+7.77	+6.14	+5.63	..	+8.04

Correction to refer mean of 12 to mean of 24 daily readings = +0°.02.

TEMPERATURE OF THE AIR IN SHADE OBSERVED ON BOARD THE YACHT FOX.
(Expressed in degrees of Fahrenheit's scale.)

May, 1858.

Day of the month.	Latitude north.	Longitude west of Greenwich.	4h	8h	Noon.	4h	8h	Midn't.	Mean
1	Holsteinborg		33°	34°	34°	28°	27°	25°	+30°.2
2	"		27	. .	34	36.5	31.5	30	31.6
3	"		24	24	24	26	24	21	23.8
4	"		24	26	27	28	28	27	26.7
5	"		27.5	27	21	20	14	13	20.4
6	"		14	16	11.5	18	15	10.5	14.2
7	"		12	16	19	23.5	17	12	16.6
8	"		13	15	29	15	14.5	13	16.6
9	67° 22′	53° 55′	13	13	15	17	17	17	15.3
10	68 10	53 55	15	18	21	21	18	23	19.3
11	Whalefish Islands		24	27	29	29	27.5	28	27.4
12	- - -	- - -	29	30	30	29	28	26	28.7
13	- - -	- - -	29	30	33	34	34	34	32.3
14	- - -	- - -	35	37	39	39.5	37.5	35	37.2
15	- - -	- - -	33	39	39	37	35	31	35.7
16	- - -	- - -	33	35	36	30	29	27	31.7
17	Upernavik Bay		27	29	29.5	30	32.5	30	29.7
18	"	"	29	33	42	45	35	31	35.8
19	"	"	30	31	38	39	34	30	33.7
20	"	"	30	32	39	40	34	30	34.2
21	"	"	26	40	41	40	38	32	36.2
22	"	"	33	34	36	35	35	34	34.5
23	"	"	30	34	37	44	38	36	36.5
24	Godhaven		30	34	39	41	41	31	36.0
25	- - -	- - -	32	35	42	36.5	34	33	35.4
26	Off the coal seam		32	33	35	35	39	35	34.8
27	70 2	52 50	34	37	44	36	37	34	37.0
28	70 32	54 9	35	36	36	42	35	34	36.3
29	71 19	55 37	34	32	32.5	32	32	33	32.6
30	72 1	55 40	35	30	32	31	32	32	32.0
31	Off Upernavik		33	33	36	37	37	32	34.7
Mean	68.7	53.7	+27.60	+29.69	+32.28	+32.10	+30.02	+27.73	+29.90

Correction to refer the mean of 6 to the mean of 24 observations = —0°.07.

June, 1858.

Day of the month.	Latitude north.	Longitude west of Greenwich.	4h	8h	Noon.	4h	8h	Midn't.	Mean.
1	Off Upernavik		38°	39°	42°.5	42°	41°	39°	+40°.3
2	"		38	44	49	50	44	40	44.2
3	"		42.5	38	40	42	41	38	40.3
4	73° 7′	- - -	37	38	37	40	35	33	36.7
5	73 17	56° 23′	32	33	33	40	33	34	34.2
6	73 24	56 20	36	36	40	40.5	44	38	39.1
7	73 27	56 15	41	39	41.5	44	44	36	40.9
8	73 35	56 42	35	35	38	43	38	35	37.3
9	73 51	57 6	34	38	40	41	38	32	37.2
10	73 54	57 5	36	39	37	37	35	35	36.5
11	73 56	57 48	34	34	38	42	36	31	35.8
12	74 3	- - -	35	35	38	36	33	29.5	34.4
13	74 4	- - -	28	30	36	32	32	28	31.0
14	74 10	58 4	29	32	36	35	31	35	33.0
15	74 14	58 14	36	38	38	35	34	32	35.5
16	74 57	60 4	30	35	35	37	37	30	34.0
17	75 17	61 0	32	33	35	33	35	34	33.7
18	75 20	60 19	34	39	40	35	38	31.5	36.2
19	75 35	62 1	35	38	44	38	38	36	38.2
20	75 32	61 50	38	38.5	37	40	35	31	36.6
21	75 34	62 7	30	32	34	34	34	30	32.3
22	75 27	62 2	30	33	35	38	36	32	34.0
23	75 27	62 22	35	35	35	34	35	33	34.5
24	75 36	62 37	34	34	36	38	36	34	35.3
25	75 50	63 27	34	37	36	39	36	36	36.3
26	75 55	65 33	36	36	36	35	37	36	36.0
27	75 55	68 10	35	34	36	34	32	33	34.0
28	75 53	67 50	33	35	38	34	33.5	32	34.2
29	75 54	67 15	36	36	39	34	33	31	34.8
30	75 56	67 28	32.5	34	37	39	35	30.5	34.7
Mean	74.6	60.1	+34.52	+35.92	+37.90	+38.05	+36.32	+33.50	+36.04

Correction to refer mean of 6 to mean of 24 observations = —0°.07.

Temperature of the Air in Shade observed on board the Yacht Fox.

(Expressed in degrees of Fahrenheit's scale.)

July, 1858.

Day of the month.	Latitude north.	Longitude west of Greenwich.	4h	8h	Noon.	4h	8h	Midn't.	Mean.
1	75° 55′	67° 28′	33°	36°	37°	41°	34°	33°	+35°.7
2	75 53	67 11	32	34	41	49	34	31	36.8
3	75 31	70 42	32.5	33	34	34	31.5	31	32.7
4	75 34	70 34	32	32	31	34	31.5	32	32.1
5	75 44	70 28	34	36	36	35	36	37	35.7
6	75 17	73 35	33	32	34	33	31	33	32.7
7	75 25	75 12	34	35	37	36	36	34	35.2
8	75 20	75 37	35	31.5	36	35	36	34	34.6
9	75 17	75 47	33	35	38	36	34	34	35.0
10	75 26	76 58	35	37	39	39	38	36	37.3
11	75 9	78 46	35	37	39	40	35	34	36.7
12	74 41	79 34	33	33	39	35	32	32	34.0
13	74 35	80 40	33	31	33.5	33	35	34	33.2
14	- - -	- - -	35	36	40	38	35	32	36.0
15	74 33	80 57	35	38	37	39	33	36	36.3
16	74 24	81 59	33	36	35.5	38	36	34	35.4
17	74 2	82 0	36	37	44	37	34	33	36.8
18	73 46	79 10	32	38	38	38	32	31	34.8
19	73 49	78 26	32	35	37	38	36	34	35.3
20	73 56	78 32	35	39.5	45	45	39	37	40.1
21	73 58	78 25	36	34	44	43	38	38	38.8
22	74 0	78 5	39	40	45	44	39.5	38	40.9
23	74 5	77 43	34	38	41	39	41	37	38.3
24	73 54	76 54	37	41	43	44	42	39	41.0
25	73 38	77 0	38	40	47.5	42	42	39	41.4
26	73 9	75 49	36	45	49	46	40	37	42.2
27	- - -	- - -	37	38	41	42	42	36	39.3
28	72 50	- - -	35	38	43	38	36	35	37.5
29	72 51	76 13	34	36	35	35	38	34	35.3
30	72 51	76 13	36	38	35	35	35	36	35.8
31	72 37	- - -	37	38	40	36	38	36	37.5
Mean	74.4	76.4	+34.57	+36.39	+39.18	+38.64	+36.14	+34.74	+36.61

Correction to refer mean of 6 to mean of 24 observations = —0°.01.

August, 1858.

Day of the month.	Latitude north.	Longitude west of Greenwich.	4h	8h	Noon.	4h	8h	Midn't.	Mean.
1	72° 47′	77° 9′	34°	37°	38°	40°	39°	33°	+36°.8
2	72 48	76 54	37	38	38	40	36	37	37.7
3	72 45	76 24	36	38	38.5	39	37	36	37.4
4	72 48	- - -	37	37	39.5	40	39	38	38.4
5	72 48	76 39	37	38	40	37	36	36	37.3
6	72 54	75 50	35	39	38	40	37	36	37.5
7	73 40	77 16	38	37	36	36	35	34	36.0
8	73 55	84 22	33	32	35	35	35	35	34.2
9	74 14	87 00	34	36	38	36	34	34	35.3
10	74 18	88 20	36	34	34	35	36	35	35.0
11	- - -	- - -	35	34	38	38	38	38	36.8
12	- -	- - -	38	39	41	44	43	35	40.0
13	- - -	- - -	35	43	40	38	38	38	38.7
14	- - -	- - -	38	40	41	40	38	38	39.2
15	- - -	- - -	39	39	40	38	35	33	37.3
16	- - -	- - -	32	32	33	35	36	34	33.7
17	74 15	94 58	33	34	36	33	32	31.5	33.3
18	74 10	92 26	31.5	31	31	35.5	36	36	33.5
19	Port Leopold		36	32	33	32	33	32	33.0
20	72 41	91 58	32	32	33	33	33	33	32.7
21	72 00	94 9	32	35	33	34	32	31	32.8
22	In Depot Bay		32	31.5	34	35	32	33	32.9
23	In Bellot Straits		33	34	35	35	36	33	34.3
24	71 54	94 26	31	32	32	33	33	34	32.5
25	72 00	94 9	32	35	35	34	30	31	32.8
26	71 54	94 12	30.5	30	32	31	32	32	31.3
27	71 34	93 17	32	35	33	31	30	29	31.7
28	71 50	93 12	30	28	30.5	30	29	30	29.6
29	Depot Bay		32	29	33	32	31	30	31.2
30	72 01	94 14	24.5	26	29	32	31	27	28.2
31	Port Kennedy		28	30	30	30	29	28	29.2
Mean	73.1	88.5	+33.66	+34.44	+35.40	+35.53	+34.55	+33.57	+34.52

The correction to refer mean of 6 to mean of 24 observations becomes zero for this month.

TEMPERATURE OF THE AIR IN SHADE OBSERVED ON BOARD THE YACHT FOX.
(Expressed in degrees of Fahrenheit's scale.)

September, 1858.

Day of the month.	Latitude north.	Longitude west of Greenwich.	4h	8h	Noon.	4h	8h	Midn't.	Mean.
1	Head of Port Kennedy		26°	29°	32°	34°	32°	30°	+30°.5
2	"	"	21	30	30	29	26	26	27.0
3	"	"	25	29	29	29	28	27	27.8
4	"	"	30	30	30	29	27	26	28.7
5	"	"	24	23	27	29	30	29	27.0
6	Near Pemmican Rock		26	27	30	32	34	30	29.8
7	"	"	36	37.5	37	37	36	37	36.7
8	"	"	36	35	36.5	36	31.5	34	34.8
9	71° 58′	95° 10′	33	29	28	29	29	26	29.0
10	71 58	95 10	27	30	33	32	31	29	30.3
11	Port Kennedy		32	30	31.5	31	28	28	30.0
12	72 01	94 14	25	26	27	29	27	25	26.5
13	72 01	94 14	20	22	28.5	27.5	29	26	25.5
14	72 01	94 14	21	19	26	28	26	25	24.2
15	72 01	94 14	23	23.5	24	26	24	20	23.4
16	72 01	94 14	23	22	25	25.5	25	25	24.3
17	72 01	94 14	25	27	29.5	28	28	28	27.6
18	Bellot Straits		29	28	29	26	21	19	25.3
19	- - -	- - -	18.5	17	20	23.5	23	23	20.8
20	- - -	- - -	25	21	20	23	26	27	23.7
21	- - -	- - -	29	31	32	31	30	27	30.0
22	- - -	- - -	19	18	16	18	18	28	19.5
23	- - -	- - -	31	32	32.5	33	26	12	27.8
24	- - -	- - -	11	8	11	14	14	11	11.5
25	- - -	- - -	13	15	16	15	17	15	15.2
26	- - -	- - -	15	19	19.5	18	18.5	15	17.5
27	71 58	- - -	15	16	17	15	12	21	16.0
28	Port Kennedy		23	23.5	26	29	27	27	25.9
29	"		25	21	25	23	20	21	22.5
30	"		21	22	26	26	25	25	24.2
Mean	72.0	94.4	+24.25	+24.68	+26.45	+26.83	+25.63	+24.73	+25.43

Correction to refer mean of 6 to mean of 24 readings = zero.

October, 1858.

Day of the month.	Latitude north.	Longitude west of Greenwich.	4h	8h	Noon.	4h	8h	Midn't.	Mean.
1	Port Kennedy		25°	26°	28°.5	25°	23°	25°	+25°.4
2	72° 01′	94° 14′	27	28	28.5	21	27	25	+26.1
3	Winter Quarters		27	28	26	22	23	29	+25.8
4	"	"	24	25	23	21	20	21	+22.3
5	"	"	22	22	25	24	21	21	+22.5
6	"	"	20	21	27	25	21	19	+22.2
7	"	"	13	14.5	14	14	13	13	+13.6
8	"	"	11	10	15	2	0	0	+ 6.3
9	"	"	— 1	— 2	6	3	— 7	— 6	— 1.2
10	"	"	— 4	— 1	7	8	9	9	+ 4.7
11	"	"	10	12	16	14	14	13	+13.2
12	"	"	14	15	17.5	12	8	4	+11.7
13	"	"	2	— 1.5	— 4	— 2.5	— 1	3	— 0.7
14	"	"	2	2	3	2	— 6	—10	— 1.2
15	"	"	—11	— 9.5	0	11	12	9	+ 1.9
16	"	"	18	19	22	19.5	15.5	17	+18.5
17	"	"	10	8	8	8	5	4	+ 7.2
18	"	"	4	— 2	— 3.5	— 6.5	0	2	— 1.0
19	"	"	5	9	10	9.5	9.5	11	+ 9.0
20	"	"	6	2	0	— 3	— 2	10	+ 2.2
21	"	"	9.5	11	10	7	6	1	+ 7.4
22	"	"	— 1	— 7	— 7	— 9	—10	—11	— 7.5
23	"	"	—10	— 4	0	4	5	10	+ 0.8
24	"	"	14	16	19	19	19	22	+18.2
25	"	"	21	14	8	4	1	—11	+ 6.2
26	"	"	—17	—21	—20	—17	—10	—10	—15.8
27	"	"	—11	—12	— 7	—11	—10	—12.5	—10.6
28	"	"	0	4	1	— 3	— 6	— 8	— 2.0
29	"	"	— 7	— 8	0	0	3	2	— 1.7
30	"	"	2	3	2	9	11	9	+ 6.0
31	"	"	9	7	5	2	1	2	+ 4.3
Mean	72.0	94.2	+7.52	+7.37	+9.03	+7.55	+7.26	+6.53	+7.54

Correction to refer mean of 6 to mean of 24 readings = +0°.05.

TEMPERATURE OF THE AIR IN SHADE OBSERVED ON BOARD THE YACHT FOX.
(Expressed in degrees of Fahrenheit's scale.)

November, 1858.

Day of the month.	Lat. north.	Long. west of Green.	2h	4h	6h	8h	10h	Noon.	2h	4h	6h	8h	10h	Midn't.	Mean.
1	Port Kennedy		+ 4°	+ 5°	+ 5°	+ 8°	+10°	+12°	+12°	+ 9°	+ 2°	+11°	+11°	+11°	+ 8°.3
2	72° 01′	94° 14′	+12	+12	+12	+10	+ 3	— 2	— 8.5	—11	—12	—12	— 8	— 7	— 1.0
3	Winter Quarters		— 5	— 5	— 5	— 5	— 8	—15	—16	— 8	— 4	—15	—15	—15	— 9.7
4	"	"	—14	—14	—14	—14	—13	—14	—11	—11	—11	—11	—10	—11	—12.3
5	"	"	—11	—12	—14	—12	—15.5	—15	—14	—16	—16	—15	—15	—11	—14.0
6	"	"	—10	— 8	— 5	— 2	+ 8	+ 8	+ 8	+ 8	— 4	— 4	— 4	— 2	— 0.6
7	"	"	—15	—16	—16	—16	—15	—15	—14	—12	+ 1	— 8	—12	—12	—12.5
8	"	"	—12	—12	—13	—12	—12	—10	—11	—11	—11	—11	—11	—11	—11.4
9	"	"	—14	—14	—14	—12	—11	— 9	— 8	— 7	— 7	— 7	— 8	—12	—10.3
10	"	"	—12	—14	—16	—17	—16	—17	—20	—21	—18	—17	—17	—17	—16.8
11	"	"	—16	—15	—14	—14	—13	—13	—12	—12	— 9	— 9	— 7	— 7	—11.8
12	"	"	— 7	— 7	—10	—12	—10.5	—12	—14	—13	—13	—13	—15	—15	—12.0
13	"	"	—13	—10	— 9	— 8	— 7	— 7	— 7.5	— 9	—10	—11	—10	— 9	— 9.2
14	"	"	— 7	— 7	—11	— 8	—11	—13	—16	—17	—26	—27	—31	—30	—17.0
15	"	"	—30	—29	—31	—31	—31	—30	—29	—30	—31	—31	—30	—28	—30.1
16	"	"	—26	—26	—22	—22	—20	—20	—18	—18	—16	—14	—12	—11	—18.8
17	"	"	— 5	— 2	+ 1	+ 4	+ 4	+ 2	— 5	— 8	— 4	+ 1	+ 3	+ 5	— 0.3
18	"	"	+ 6	+ 7	+ 9	+11	+11	+10	+ 9	+ 9	+10	+10	+10	+ 7	+ 9.1
19	"	"	+ 8	+ 7	+12	+12	+13	+13	+13	+12	+13	+12	+ 9	+ 8	+11.0
20	"	"	+ 7	+ 9	+11	+10	+12	+12	+ 4	+ 2	— 5	— 3	— 5	— 8	+ 3.8
21	"	"	— 8	— 5	+ 2	— 1	— 2	+ 3	+ 4	+ 4	+ 4	+ 2	— 1	— 5	— 0.3
22	"	"	— 7	—10	—10	—16	—16	—17	—17	—18	—21	—22	—22	—23	—16.6
23	"	"	—21	—22	—21	—20	—19	—21	—23	—23	—22	—25	—21	—25	—21.9
24	"	"	—24	—25	—27	—27	—29	—29	—29	—29	—33	—34	—35	—35	—29.7
25	"	"	—26	—23	—23	—24	—23	—23	—23	—25	—25	—26	—26	—28	—24.6
26	"	"	—26	—26	—26	—26	—28	—28	—28	—27	—27	—27	—26	—26	—26.8
27	"	"	—25	—22	—21	—21	—21	—21.5	—22	—27	—27	—27	—26	—25	—23.8
28	"	"	—25	—25	—22	—20	—20	—20	—19	—19	—17	—16	—16	—16	—19.6
29	"	"	—16	—16	—16	—16	—14	—11	—10	—10	—10	— 9	— 8	— 8	—12.0
30	"	"	— 8	— 9	—10	— 9	— 7	— 7	— 7	— 7	— 7	— 7	— 9	—11	— 8.2
Mean	72.0	94.2	—11.53	—11.20	—10.60	—10.33	—10.03	—10.32	—11.07	—11.57	—11.87	—12.17	—12.23	—12.57	—11.29

Correction = +0°.12.

December, 1858.

Day of the month.	Lat. north.	Long. west of Green.	2h	4h	6h	8h	10h	Noon.	2h	4h	6h	8h	10h	Midn't.	Mean.
1	Port Kennedy		—16°	—18°	—18°.5	—19°	—18°	—17°	—17°	—22°	—21°	—21°	—20°	—20°	—19.°0
2	72° 01′	74° 14′	21	21	23	25	27	28	30	31	33	32	30	28	27.4
3	Winter Quarters		29	27	26	25	26	25	25	28	28	28	28	28	27.0
4	"	"	28	28	30	35	39	40	39	38	37	37	37	37	35.4
5	"	"	36	34	35	32	32	31	32	32.5	30	32	33	31	32.5
6	"	"	28	28	30	32	32	32	32	30	33	31	30	32	30.8
7	"	"	30	30	31	31	31	32	30	31	28	33	33	34	31.2
8	"	"	29	29	29	26	26	26	21	21	27	32	34	34	27.8
9	"	"	33	32	33	37	32	31	29	28	26	23	23	20	29.0
10	"	"	23	23	20	17	17	18	18	21	23	25	27	30	21.8
11	"	"	31	32	32	34	33	33	35	39	41.5	40	40	40	35.9
12	"	"	38	37	37	38	36	36	36	36	36	35	37	36	36.5
13	"	"	38	37	39	39	38	36	37	38	36	37	35	37	37.3
14	"	"	36	36	36	34	35	36	30	33	33	28	28	30	32.8
15	"	"	31	31	33	33	33	32	32	32	37	38	38	39	34.1
16	"	"	39	40	42	43	42	44	43	43	42	41	42	42	41.9
17	"	"	43	43	42	41	38	38	38	38	39	37	32	31	38.3
18	"	"	32	33	32	33	34	34	34	33	35	33	34	34	33.4
19	"	"	35	33	33	33	30	28	28	29	31	35	33	32	31.7
20	"	"	34	34	30	32	27	23	21	18	16	15	16	16	23.5
21	"	"	13	14	19	24	28	29	32	35	33	34	35	36	27.7
22	"	"	37	36	34	32	32	34	35	31	30	29	29	29	32.3
23	"	"	29	30	30	33	33	35	34	35	35	37	35	35	33.4
24	"	"	38	38	39	40	41	43	44	44	44	44	44	45	42.0
25	"	"	44	45	45	45	44	45	44	42	44	45	45.5	47	44.6
26	"	"	47	47	46	44	44	44	45	45	40	36	36	33	42.3
27	"	"	32	32	30	33	32	30	32	32	30	33	32	30	31.5
28	"	"	33	32	29	32	32	31	32	30	30	30	31	31	31.1
29	"	"	29	31	30	36	34	36	37	39	36	35	36	36	34.6
30	"	"	37	37	39	40	36	36	37	38	41	42	43	43	39.1
31	"	"	39	37	38	35	34	34	36	36	36	36	39	36	36.3
Mean	72.0	94.2	—32.52	—32.41	—32.60	—33.32	—32.78	—32.81	—32.74	—33.18	—33.27	—33.35	—33.40	—33.29	—32.97

Correction to refer to mean of 24 observations in a day = 0°.00.

Temperature of the Air in Shade observed on board the Yacht Fox.

(Expressed in degrees of Fahrenheit's scale.)

January, 1859.

Day of the month	Lat. north.	Long. west of Green.	2^h	4^h	6^h	8^h	10^h	Noon.	2^h	4^h	6^h	8^h	10^h	Midn't.	Mean.
1	Port Kennedy		—38°	—37°	—37°	—37°	—38°	—38°	—38°	—37°	—39°	—44°	—44°	—44°	—39°.3
2	72° 01′	94° 14′	44	43	44	44	39.5	40	40	40	38	35	31	33	39.3
3	Winter Quarters		33	33	31	31	32	32	29	29	29	28	28	28	30.3
4	"	"	39	30	33	33	35	37	38	39	39	39	41	43	36.4
5	"	"	45	45	44	41	40	40	40	38	37	39	35	37	40.1
6	"	"	36	40	39	37	32	33	36	37	35	35	35	34	35.8
7	"	"	35	36	37	39	40	40	39.5	39.5	34	33	33	33	36.6
8	"	"	33	33	37	38	35	34	35	35	35	33	34	35	34.8
9	"	"	35	36	26	26	26	27	27	26	30	30	32	31	29.3
10	"	"	34	32	32	36	36	36	36	36	38	40	36	36	35.7
11	"	"	33	29	28	27	26	26	27	24	23	22	22	24	25.9
12	"	"	26	26	24	24	23	21	24	22	20	19	18	20	22.2
13	"	"	21	23	22	20	20	18	18	19	18	16	16.5	17	19.0
14	"	"	16	16	15	15	15	14	19	19	19	23	28	32	19.3
15	"	"	36	37	38	38	39	39	38	38	38	38	38	39	38.0
16	"	"	38	38	38	38	37	36	36	36	36	36	34	33	36.3
17	"	"	32	33	32	32	32	30	28	26	26	26	29	29	29.6
18	"	"	28	26	26	26	28	28	27.5	27.5	29	30	31	32	28.2
19	"	"	35	36	36	35	35	34	36	33	33.5	37	37	39	35.5
20	"	"	39	40	42	43	42	41.5	43	43	43	43	46	45	42.5
21	"	"	46	48	47	43	41	38	40	39	40	41	41	43	42.2
22	"	"	40	42	43	43	44	42	42	43	40	40	39	38	41.3
23	"	"	38	39	39	40	40	41	41	41	40	41	41	40	40.1
24	"	"	40	40	40	40	39	39	40	40	36	38	35	37	38.7
25	"	"	33	36	35	35	34	33	31	30	31	28	30	30	32.2
26	"	"	29	28	26	28	25	33	33	33	33	32	32	32	30.3
27	"	"	30	30	29	29	29	29	24	24	23	21	21	21	25.8
28	"	"	23	24	25	25	25.5	26	28	30	30	33	33	33	28.0
29	"	"	34	35	35	34	36	35	31	28	28	24	27	29	31.3
30	"	"	28	31	32	35	32	33	33	37	36	39	38	39	34.4
31	"	"	39	40	41	41	41	39	42	42	42	43	41	41	41.0
Mean	72.0	94.2	—33.78	—34.26	—33.97	—33.97	—33.52	—33.31	—33.55	—33.26	—32.85	—33.10	—33.11	—33.78	—33.54

Correction to refer to mean of 24 observations = —0°.03.

February, 1859.

Day of the month	Lat. north.	Long. west of Green.	2^h	4^h	6^h	8^h	10^h	Noon.	2^h	4^h	6^h	8^h	10^h	Midn't.	Mean.
1	Port Kennedy		—41°	—41°	—41°	—39°	—38°	—34°	—33°	—32°	—32°	—21°	—22°	—26°	—33°.3
2	72° 01′	94° 14′	27	28	28	27	27	26	24	25	25	23	25	24	25.8
3	Winter Quarters		25	26	25	25	25	24	24	21	20	20	21	18	22.8
4	"	"	16	14	12	17	27	30	30	30	31	32	33	31	25.3
5	"	"	31	32	35	34	35	35	35	34	36	36	37	38	34.8
6	"	"	38	32	30	32	30	29	32	33	33	34	34	39	33.0
7	"	"	38	38	39	39	37.5	38	40	41	40	40	42	43	39.6
8	"	"	45	46	45	44	44	41	43	43	45	45	42	42	43.8
9	"	"	42	43	42	43	44	43	43	43	42	42	43	43	42.8
10	"	"	45	44	44	43	43	42	41	38	38	38	40	39	41.2
11	"	"	39	39	37	36	36	35	34	32	30	30	28	25	33.4
12	"	"	24	21	23	20	21	21	21	22	24	26	25	25	22.8
13	"	"	25	26	27	27	28	29	30	32	35	36	37	38	30.8
14	"	"	40	41	41	41	41	40	41	42	43	45	45	45	42.1
15	"	"	48	46	44	38	37	44	41	40	40	42	41	42	41.9
16	"	"	40	41	42	43	44.5	42	41	41	39	38	38	36	40.5
17	"	"	35	34	34	34	32	31	36	39	40	40	42	42.5	36.6
18	"	"	44	43	44	46	45	45	46	47	48	47	45	45	45.4
19	"	"	45	45	43	43	42	41	39	38	39	44	44	45	42.3
20	"	"	42	39	41	39	37	35	35	37	36	36	37	40	37.8
21	"	"	37	39	43	41	37	30	32	38	39	39	36	38	37.4
22	"	"	36	36	34	33	31	30	29	30	30	28	29	30	31.3
23	"	"	30	33	34	34	33	34	37	38	38	39	39	41	35.8
24	"	"	41	38	36	34	37	37	33	35	36	37	36	38	36.5
25	"	"	36	37	37	37	37	38	37	39	39	38	37	38	37.5
26	"	"	39	38	37	37	36	36	36	38	40	40	40	42	38.2
27	"	"	39	38	37	37	36	36	34	36	41	40	36	37	37.3
28	"	"	38	39	42	44	43	41	40	39	37	34	33	34	38.7
Mean	72.0	94.2	—36.64	—36.32	—36.32	—35.97	—35.86	—35.25	—35.25	—35.82	—36.28	—36.07	—35.96	—36.59	—36.03

Correction to refer mean of 12 to mean of 24 observations = —0°.03.

Temperature of the Air in Shade observed on board the Yacht Fox.

(Expressed in degrees of Fahrenheit's scale.)

March, 1859.

Day of the month.	Lat. north.	Long. west of Green.	2h	4h	6h	8h	10h	Noon.	2h	4h	6h	8h	10h	Midn't.	Mean.	Mean of 6 obs'ns.
1	Port	Kennedy	—31°	—28°	—31°	—33°	—28°	—26°	—26°	—27°	—30°	—29°	—29°	—28°	—28°.8	Derived corr'n to mean of 6 obs. to obtain mean of 12 obs. = —0°.16.
2	72° 01′	94° 14′	29	31	32	35	26	22	23	25	25	23	23	26	—26.7	
3	Winter		25	24	25	24	21	20	20	22	24	25	22	22	—22.8	
4	Quarters		24	26	25	25	18	6	6	11	30	31	32	32	—22.2	
5	"		31	30	27	25	22	9	8	24	31	32	30	30	—24.9	
6	"		29	27	25	23	19	19	19	21	23	22	22	25.5	—22.9	
7	"		24	23	26	27	21	20	21	20	19	16	16	15.5	—20.7	
8	"		11	9	7	4	2	0	+ 2	+ 2	3	2	3	1.5	— 3.2	
9	"		2	4	8	11	6	4	2	8	14	14	13	15	— 8.4	
10	"		20	20	29	24	21	27	14	16	38	26	22	24	—23.4	
11	"		24	26	25	25	24	23	24	25	27	29	29	29	—25.8	
12	"		29	28	25	22	16	13	15	16	21	24	26	29	—22.0	
13	"		29	30	29	28	27	26	24	24	25	26	24	23	—26.3	
14	"		22	24	29	25	13	4.5	12	13	25	30	32	30	—21.6	
15	"		30	26	26	21	19	19	20	21	21	21	21	22	—22.2	
16	"		22	19	17	15	14	11	20	12	11	12	13	13	—14.9	-13°.7
17	"		16	21	24	24	24	24	24	27	26	30	31	33	—25.3	—26.5
18	"		33	32	39	30	26	23	23	24	30	31	32	32	—29.6	—28.7
19	"		32	31	32	31	24	21	21	22	28	29	31	30	—27.7	—27.3
20	"		30	29	28	17	14	12	16	17	25	26	28	28	—22.5	—21.5
21	"		29	29	35	25	20	20	21	22	26	29	27	28	—25.9	—25.5
22	"		29	32	30	28	28	20	19	19	22	22	22	21	—24.3	—23.7
23	"		20	20	20	21	13	10	6	2	+ 1	0	+ 1	+ 4	— 8.8	— 8.2
24	"		+ 4	+ 3	+ 6	+ 9	+12	+11	+ 9	+ 8	+ 6	+ 4	+ 3	+ 3	+ 6.5	+ 6.3
25	"		+ 3	+ 3	+ 4	+ 5	+ 6	+ 9	+ 9	+ 7	+ 4	+ 2	+ 1	+ 1	+ 4.5	+ 4.5
26	"		2	5	5	4	3	3	+ 1	1	1	0	+ 4	10	— 2.4	— 3.8
27	"		10	11	14	11	5	3	3	7	14	19	21	21	—11.6	—12.0
28	"		..	21	..	17	..	5	..	9	..	17	..	22	—15.4	—15.2
29	"		..	19	..	13	..	+ 4	..	1	..	12	..	17	— 9.9	— 9.7
30	"		..	16	..	9	..	+ 1	..	2	..	14	..	18	— 9.9	— 9.7
31	"		..	16	..	10	..	3	..	6	..	11	..	23	—11.7	—11.5
Mean	72.0	94.2	—21.06	—21.00	—21.57	—19.45	—14.79	—11.89	—12.03	—13.77	—18.43	—19.22	—19.52	—20.66	—17.78	

Correction to refer mean to 24 observations = +0°.02.

April, 1859.

Day of the month.	Latitude north.	Longitude west of Greenwich.	5h	8h	Noon.	4h	8h	11h	Mean.
1	Port	Kennedy	—11°	— 9°	— 6	— 8°	—11°	—13°	— 9°.7
2	72° 01′	94° 14′	— 2	+ 2	+ 2	+ 6	+ 2	+ 2	+ 2.0
3	Winter	Quarters	+ 1	+ 4.5	+ 8	+11.5	+ 5	+ 3.5	+ 5.6
4	"	"	+ 5	+ 6	+10	+ 6.5	+ 3	— 2.5	+ 4.7
5	"	"	— 5	— 9	0	— 8	—13	—15	— 8.3
6	"	"	—20	—20	—19	—18	—22.5	—22	—20.3
7	"	"	— 6	— 8	— 2	— 6	—18	—24	—10.7
8	"	"	—23	—11.5	— 8	— 9	—12	—11	—12.4
9	"	"	—11	— 9	— 8	0	— 6	—10	— 7.3
10	"	"	— 6	— 4	—11	—12	—19	—22	—12.3
11	"	"	—21	—14	—13	—16	—23	—27	—19.0
12	"	"	—16	—15	—13	—15	—18	—21	—16.3
13	"	"	—19	—14	—10.5	—12	—17	—18	—15.1
14	"	"	—13	—11	—10	— 9	—10	—12	—10.8
15	"	"	— 9	— 1	+ 8.5	+ 8	— 4	— 9	— 1.1
16	"	"	— 6	— 7	+ 0.5	— 2.5	— 8	— 6	— 4.8
17	"	"	— 6	0	+ 6	+10	+ 5	+ 4	+ 3.2
18	"	"	+14	+15	+20	+22.5	+21	+16	+18.1
19	"	"	+ 6	+ 5	+ 5	+ 0.5	— 3.5	— 4	+ 1.5
20	"	"	— 7	— 7	— 4	— 6	— 8	— 4.5	— 6.1
21	"	"	— 1	+ 2	+ 6	+ 1	— 1	+ 5	+ 2.0
22	"	"	+11	+14	+16	+16	+10.5	+ 0.5	+11.3
23	"	"	0	— 1	0	+ 1	— 1.5	0	— 0.2
24	"	"	— 8	— 9	— 5	0	— 8	—11.5	— 6.9
25	"	"	—12	—10	— 6	— 6	—11	—15	—10.0
26	"	"	— 6	— 4	+ 1	0	— 1	+ 0.5	— 1.6
27	"	"	— 2	+ 2.5	+11	+15	+10	+11	+ 7.7
28	"	"	+12.5	+13.5	+15	+14.5	+12.5	+10.5	+13.1
29	"	"	+11	+12.5	+13	+16	+15.5	+15	+13.8
30	"	"	+18	+18.5	+31	+17	+ 9	+ 5	+16.4
Mean	72.0	94.2	—4.38	—2.27	+1.25	+0.60	—4.07	—5.82	—2.45

Correction to refer observed mean to mean from 24 observations = —0°.17.

Temperature of the Air in Shade observed on board the Yacht Fox.

(Expressed in degrees of Fahrenheit's scale.)

May, 1859.

Day of the month.	Latitude north.	Longitude west of Greenwich.	5^h	8^h	Noon.	4^h	8^h	11^h	Mean.
1	Port Kennedy		0°	1°.5	4°	3°.5	2°	0°	+ 1°.8
2	72° 01′	94° 14′	5	8.5	11	14.5	8.5	1	8.1
3	Winter Quarters		3	5.5	9.5	8	7	1.5	5.7
4	"	"	3	7.5	5.5	8.5	3.5	0	4.7
5	"	"	4	9	19	15.5	6.5	0	9.0
6	"	"	4	9	9	6.5	3.5	—0.5	5.2
7	"	"	3	8	6.5	4	3	0	4.1
8	"	"	5	11.5	14	16	5	3.5	9.2
9	"	"	2	6	9	9	4	0.5	5.1
10	"	"	7	10.5	12	18.5	14.5	8.5	11.8
11	"	"	16	22.5	19	19	14.5	9.5	16.8
12	"	"	14	20.5	14	17	15	15	15.9
13	"	"	10	12	13.5	15.5	14	13	13.0
14	"	"	20	22	25.5	19	18.5	17.5	20.4
15	"	"	17	19.5	24	29	23.5	21.5	22.4
16	"	"	23	24.5	16	15.5	12.5	13	17.4
17	"	"	15.5	19	21.5	20	17	13	17.7
18	"	"	20	22	26	22	14	7	18.5
19	"	"	14	15.5	25	28	19.5	16	19.7
20	"	"	19	22	18	18	14	14	17.5
21	"	"	19	21.5	22.5	20	13	11	17.8
22	"	"	9	9	17	18	15	15	13.8
23	"	"	17.5	19	22	20.5	18	16	18.8
24	"	"	18	22	23	21.5	17	11.5	18.8
25	"	"	16	16	20	17	20	23	18.7
26	"	"	24.5	26	27.5	27.5	22.5	20.5	24.8
27	"	"	19	20	31	29.5	28	20.5	24.7
28	"	"	20	22	35	30.5	24	21	25.4
29	"	"	24	26	33.5	26	20.5	18.5	24.7
30	"	"	21	32.5	25.5	23	21.5	21	24.1
31	"	"	20	21	24.5	24	22.3	21	22.2
Mean	72.0	94.2	+13.34	+16.50	+18.81	+18.21	+14.26	+11.39	+15.42

Correction to refer observed mean to mean from 24 observations = —0°.38.

June, 1859.

Day of the month.	Latitude north.	Longitude west of Greenwich.	5^h	8^h	Noon.	4^h	8^h	11^h	Mean.
1	Port Kennedy		20°	24°	27°.5	25°	24°.5	19°.5	+23°.4
2	72° 01′	94° 14′	19	21	25	28.5	25.5	23	23.7
3	Winter Quarters		31.5	36	45.5	38	36	27.5	35.7
4	"	"	31	38	42.5	38	30	25	34.1
5	"	"	30	33.5	44.5	33	30.5	25.5	32.8
6	"	"	27	34.5	39.5	34	30.5	27.5	32.2
7	"	"	33	36	36	34.5	32	26	32.9
8	"	"	32	37.5	39	37	32.5	31	34.8
9	"	"	34	36.5	40	39.5	31.5	31.5	35.5
10	"	"	33	36	35.5	34.5	33	29.5	33.6
11	"	"	33	33.5	38.5	36	37	34	35.3
12	"	"	36	48	41.5	38	34.5	31	38.2
13	"	"	36	44	41.5	39	34	29.5	37.3
14	"	"	33.5	37	39.5	36	34	30.5	35.1
15	"	"	36	48	45	44.5	38.5	35	41.2
16	"	"	38	39.5	43	42	38	35	39.3
17	"	"	38	47.5	50.5	43	34	33	40.9
18	"	"	34.5	38.5	39.5	36	35	34.5	36.3
19	"	"	36	42.5	37.5	38	34.5	32.5	36.8
20	"	"	34	43	49	38	32.5	33	38.2
21	"	"	36	37.5	47.5	40	37.5	34.5	38.8
22	"	"	35	39	37	37	35.5	33	36.1
23	"	"	33	35.5	37	35	34.5	33	34.7
24	"	"	35	38	39	38.5	35	32.5	36.3
25	"	"	36	41	41	39	34.5	32.5	37.3
26	"	"	35	36.5	39.5	38	37.5	34	36.8
27	"	"	34.5	35	37	36.5	36	33.5	35.4
28	"	"	35	40	39.5	37	35	34.5	36.8
29	"	"	37	40	35.5	37	39	37	37.6
30	"	"	38	44.5	41	37	35.5	34	38.3
Mean	72.0	94.2	+33.33	+38.05	+39.82	+36.92	+33.93	+31.08	+35.52

Correction to refer mean of 6 to mean of 24 observations = —0°.41.

Temperature of the Air in Shade observed on board the Yacht Fox.

(Expressed in degrees of Fahrenheit's scale.)

July, 1859.

Day of the month.	Lat. north.	Long. west of Green.	2^{h}	5^{h} / 4^{h}	6^{h}	8^{h}	10^{h}	Noon.	2^{h}	4^{h}	6^{h}	8^{h}	10^{h}	11^{h} / Midn't.	Mean.	Mean of 6 obs'ns.
1	Port Kennedy		. .	37°.5	. .	43°	. .	43°.5	. .	40°	. .	41°	. .	40°	+40°.6	+40°.8
2	72° 01′	94° 14′	. .	42	. .	50	. .	44	. .	45	. .	43.5	. .	37.5	43.5	43.7
3	Winter		. .	38	. .	40	. .	41.5	. .	38	. .	36	. .	33.5	37.6	37.8
4	Quarters		. .	38	. .	42.5	. .	41.5	. .	40	. .	37.5	. .	35	38.9	39.1
5	"		. .	37	. .	42	. .	44	42°	40.5	39°.5	38	35°	34.5	39.2	
6	"		35°	36	37°	37.5	40°	42	41	38.5	38.5	37	36	36	37.9	
7	"		35.5	38	38	38	40.5	41.5	42.5	41.5	37	36	35	34.5	38.2	
8	"		32	33	32	42	40.5	39.5	36.5	39.5	37	36.5	35	35	36.5	
9	"		34.5	35	36	36	37	43	39.5	38	37.5	36	33.5	34	36.7	
10	"		34	30	32	35.5	40	40	36.5	35.5	35	35	35	36	35.4	
11	"		35	34.5	38	39	39	39	41	41.5	40	37	37	35.5	38.0	
12	"		34	35	36	36.5	38	37	38	39	38	36.5	36	37	36.7	
13	"		37	40	40	40	39	42	38	37	40.5	39	37	35	38.7	
14	"		35.5	36	38	43	43	42	42	39.5	40	39	36.5	35	39.1	
15	"		34	34	34	34	34.5	38	42	38	38	37.5	36	35	36.3	
16	"		35	37	38.5	35	42	42	40	39	37.5	37	36	35	37.8	
17	"		35	36	40	46	44	43	45	42	39	39	36	35	40.0	
18	"		34	33	34	37	37	37	37.5	37	37	37	36	34	35.9	
19	"		34	35	35.5	37	40.5	40.5	39	39	38	37	35	35	37.2	
20	"		33	32	37	42	47.5	42	42	42.5	42	40	38	37.5	39.6	
21	"		37	38	38	38	40	41	40	40	41	41	40	39	39.4	
22	"		39	41	42	45	49	49	49	50	46	45	44	38	44.8	
23	"		44	45	46	48	46.5	47	46	43.5	43	40	37	34	43.3	
24	"		35	39	43	44	49	52	47	47	45	44	42	40.5	44.0	
25	"		38	39	42	44	42	44	42	42	43	41	41	40	41.5	
26	"		39	42	45	44	50	52	49	46	46	46	43	42	45.3	
27	"		40	39	42	42	43	49	41	41	41	40	44	37	41.6	
28	"		38	40	44	49	49	42	42	47	43	43	41	37	42.9	
29	Off Observa-		38	38	38	40	50	55	53	54	55	53	45	41	46.7	
30	tion Point		41	40	42	45	45	48	47	50	49	45	47	49	45.7	
31	"		43	39	45	45	46	46	49	50	46	47	47	41	45.3	
Mean	72.0	94.2	+36.51	+37.24	+39.24	+41.29	+42.90	+43.48	+42.34	+41.98	+41.07	+40.02	+38.56	+36.98	+40.13	

Correction to refer mean of 12 to mean of 24 observations = —0°.01.

August, 1859.

Day of the month.	Latitude north.	Longitude west of Greenwich.	4^{h}	8^{h}	Noon.	4^{h}	8^{h}	Midn't.	Mean.	
1	Port Kennedy		41°	42°	45°	45°	42°	40°	+42°.5	
2	"	"	39	37	36	35	35	35	36.2	
3	"	"	35	34	36	41	40	39	37.5	
4	"	"	39	40	41	41	40	34	39.2	
5	"	"	33	37	39	39	42	39	38.2	
6	"	"	34	39	39	40	40	38	38.3	
7	"	"	36	38	34.5	41	39	33	36.9	
8	"	"	32	35	37	37	34	33	34.7	
9	Long Island		33	34	34	37	36	33	34.5	
10	Adelaide Bay		33	34	36	39	36	33	35.2	
11	- - -	- - -	33	36	39	39	36	40	37.8	
12	- - -	- - -	38	39	40.5	39	39.5	38	39.0	
13	- - -	- - -	38	37	38.5	38.5	41	40	38.8	
14	- - -	- - -	41	41	40	38	38.5	42	40.1	
15	Off Fury Beach		39	38	37	35	34.5	31	35.7	
16	Off Elwin Bay		31	35.5	36	32	33	31	33.1	
17	- - -	- - -	. .	. .	. .	. .	. .	. .	. .	+34°.0
18	72° 55′	87° 16′	32	35	38	34	35	36	35.0	
19	74 00	79 40	32	33	33	33	32	31	32.3	
20	73 12	76 40	32	31	35	34	30	31	32.2	
21	72 43	72 6	33	31	35	31.5	34	34	33.1	
22	73 01	67 17	33	34	34	31	32	31	32.5	
23	73 19	60 15	35	36	38	38	34	36	36.2	
24	72 7	59 8	36	38	38	37	37	37	37.2	
25	70 40	55 57	36	37	39	35	36	36	36.5	
26	69 39	55 30	35	35	38	37	39	37	36.8	
27	Godhaven		33	36	36	37	35	36	35.5	
28	"		31	36	38	40	36	36	36.2	
29	"		37	38	40	42	47	33	39.5	
30	"		32	39	47	44	40	38	40.0	
31	"		36	38	44	42	39	37	39.3	
Mean	71.9	79.8	+34.85	+36.37	+37.97	+37.65	+37.10	+35.52	+36.58	

The correction to refer mean of 6 to mean of 24 observations becomes zero.

Temperature of the Air in Shade observed on board the Yacht Fox.

(Expressed in degrees of Fahrenheit's scale.)

September, 1859.

Day of the month.	Latitude north.	Longitude west of Greenwich.	4h	8h	Noon.	4h	8h	Midn't.	Mean.
1	68° 53′	54° 06′	37°	40°	47°	43°	40°	47°	+42°.3
2	67 20	57 22	38	39	37	40	37	35	37.7
3	64 51	57 05	33	34	35	37	37	34	35.0
4	63 47	56 01	34	39	40	40	40	39	38.7
5	62 38	55 00	42	43	42	42	39	39	41.2
6	62 33	54 56	38	40	39	41	39	38	39.2
7	61 22	53 47	37	38	38	38	37	36	37.3
8	60 20	52 31	36	40	41	40	39	37	38.8
9	58 41	48 21	37	39	41	42	39	39	39.5
10	58 08	44 51	39	42	47	44	42	40	42.3
11	57 27	40 13	42	42	44	45	44	45	43.7
12	56 14	34 19	45	45	48	46	47	46	46.2
13	55 34	31 08	46	52	56	54	54	54	52.7
14	54 25	26 51	55	56	57	54	52	49	53.8
15	53 25	22 30	55	57	59	57	56	55	56.5
16	52 05	18 11	54	59	64	69	59	58	60.5
17	51 18	16 22	58	59	62	61	60	60	60.0
18	50 28	12 30	58	58	59	59	59	60	58.8
Mean	58.9	40.9	+43.6	+45.7	+47.6	+47.3	+45.6	+45.0	+45.79

Correction to refer mean of 6 to mean of 24 readings = zero.

Notes to the preceding Abstract of the Temperature Record.

July, 1857. The column headed "mean" contains the mean daily temperature derived from six equidistant observations; the figures in the next column of "deduced mean" were obtained as follows: Suppose the mean temperature of July 3d be required from the observations at 8 A. M. and 8 P. M., the observations at each of these hours in the *full* series were compared with their respective mean, as given in the preceding column; thus, from 23 values, we find the correction to the 8 A. M. reading, to obtain the mean reading of the day, +0°.8, and in a similar manner, for the 8 P. M. reading, +0°.2. Applying these corrections to 57°.0 and 57°.5 respectively, and taking the mean, we find for July 3d the mean temperature 57°.7. The following table contains these corrections to each observing hour in the month of July, in order to produce the mean of six readings a day, viz:—

For 4 A. M.	+0°.5	For 4 P. M.	—1°.5
" 8 A. M.	+0.8	" 8 P. M.	+0.2
" noon	—0.8	" midnight	+1.0

The means require a further small correction to refer them to what they would be if hourly observations had been made. For this purpose, I have made use of the tables of hourly corrections for periodic variations for Boothia Felix and Drontheim, as given in the Smithsonian collection of meteorological and physical tables by A. Guyot, and also of a similar table given in the discussion of Dr. Kane's meteorological observations for Van Rensselaer Harbor, in Vol. XI. of the Smithsonian Contributions to Knowledge. For these localities, to which has been added Leith, we have, for the month of July, the correction to the mean of six observations at 4^h, 8^h, 12^h, A. M. and P. M., to obtain the daily mean from twenty-four observations:—

	Latitude.	Longitude.	Fahrenheit.
Boothia Felix	69° 59′	92° 1′	0°.00
Drontheim	63 26	—10 25	—0.09
Van Rensselaer	78 37	70 53	—0.06
Leith	55 59	— 3 10	+0.06
Adopted correction			—0.03

The resulting mean temperature for the month of July, in latitude 62° N. and longitude 39°.1 W. is, therefore, +45°.56 —0°.03 = +45°.53, as given in the general table of results. The means for the hours 4, 8, and 12, are derived from the observations between the 6th and the 31st, omitting those on the 19th, and taking 53° for the interpolated value at 4^h A. M. on the 6th.[1] For the sake of uniformity, the quantity +1°.26 has been added to each of these hourly means, so that the mean of all may again produce 45°.56.

The correction to refer the mean from the observations at certain hours of the day to the mean derived from twenty-four readings a day, for the remaining months, has been deduced from the observations at Van Rensselaer Harbor and Boothia Felix. The following table contains these corrections:—

Month.	Year.	Observed Hours.	Correction Deduced.		
			Van Rensselaer Harbor.	Boothia Felix.	Mean.
August	1857, 1858, 1859	4, 8, 12, A. M. and P. M.	—0°.01	0°.00	0°.00
September	"	2, 4, 6, 8, 10, 12, A. M. and P. M.	—0.01	—0.07	—0.04
October	"	" " "	+0.04	0.00	+0.02
November	" 1858	" " "	+0.02	+0.23	+0.12
December	" "	" " "	0.00	+0.01	0.00
January	1858, 1859	" " "	—0.05	—0.01	—0.03
February	" "	" " "	—0.05	—0.01	—0.03
March	" "	" " "	+0.04	0.00	+0.02
April	"	" " "	+0.02	+0.01	+0.02
May	"	4, 8, 12, A. M. and P. M.	—0.13	—0.01	—0.07
June	"	" "	—0.16	+0.01	—0.07
July	"	" "	—0.03	0.00	—0.01
September	"	" "	+0.01	—0.01	0.00
October	"	" "	+0.10	0.00	+0.05
April	1859	5, 8, 12, A. M.; 4, 8, 11, P. M.	—0.26	—0.13*	—0.17
May	"	" " "	—0.42	—0.36*	—0.38
June	"	" " "	—0.44	—0.39*	—0.41

* Indicates that the weight 2 has been given to the correction derived from the Boothia Felix station, as being the nearer one.

August, 1857. The two omissions on the 6th were supplied by 42° and 43°.

September, 1857. The values for the 21st were interpolated as follows: 2 A. M. 12°.0, 6 A. M. 15°.2, and 10 A. M. 21°.2. From the observations between the 21st and 30th, we find that the mean of twelve observations a day is 0°.15 smaller than that derived from six observations a day; the second column of means between the 1st and 21st, therefore, is derived from the preceding column by subtracting

[1] The interpolated value for 8 P. M. on the 21st is 38°.6.

0°.1 and 0°.2 alternately from the successive daily means. The monthly mean temperature at the hours 4, 8, noon, 4, 8, midnight, was first made out (if diminished by the above constant 0°.15, their mean would exactly give 19°.55). To obtain the intermediate values for 2, 6, 10, A. M. and P. M., the observations between the 21st and 30th were used as follows:—

Mean temp. at midnight for last 10 days	12°.30	Same for 30 days, 17°.38
" 2 A. M. " "	11.85	
Difference . . .	—0.45	

which, applied to 17°.38, gives 16°.93; in the same way, we obtain from the following hour, 4 A. M., the value 17°.38. The mean, or 17°.15, has consequently been adopted as the mean monthly temperature at 2 A. M. The remaining values were derived in a similar manner.

February, 1858. On the 11th and some following days, there are occasionally pencil figures inserted between the lines. These are neither used nor explained.

April, 1858. The daily mean from six observations differs from the daily mean from twice this number of observations by 0°.13, as found from the values between the 1st and 17th; a correction of —0°.13 has, therefore, been applied to the deduced means on and after the 18th, in order to refer the same to the result produced by twelve observations. The hourly means at the bottom of the page were obtained in the manner explained in the note to the hourly means of the month of September, 1857, viz: through a comparison of the hourly means of the *full* series, and applying the correction (the mean found from the preceding and following column) to the monthly mean at the hours 4, 8, 12, etc.

May, 1858. The temperature at 8 A. M. on the 2d was assumed to be 30°.5.

March, 1859. The correction to refer the mean from six observations on each of the last four days of the month to the daily mean as resulting from twelve observations, was found by comparison of the respective means on the twelve days preceding; it was found —0°.16. The mean hourly temperature for the hours 2, 6, 8, 10, was obtained by the process applied on two former occasions.

April, 1859. The bar in the column for 4^h and in the column for midnight, indicates that the observations were taken one hour later and one hour earlier, or at 5^h and 11^h respectively. This practice was discontinued on the 5th of July following.

July, 1859. For the temperatures of the 5th, at the hours 2, 4, 6, 10, A. M., I have adopted the interpolated values 36°, 36°.5, 39°, 43°, respectively. The correction to refer the mean of six observations (hours 5, 8, noon, 4, 8, 11) to the mean of twelve observations (hours 4, 8, 12, A. M. and P. M.), was derived from the tables constructed for Van Rensselaer and Boothia Felix; the latter value having the weight 2, it was found = —0°.21, which quantity was applied in the first column of means, July 1st to July 4th inclusive. To obtain the correct hourly means for the month, the numbers in the column for 5^h (first four days) were first referred to the reading at 4^h by subtracting 0.5. The same correction was applied to refer the readings from 11 P. M. to midnight. The monthly means for the hours 4, 8, 12, A. M. and P. M., being known, the means for the intermediate hours were found by comparison of the respective readings on the last twenty-seven days of the month, as has been explained in similar cases.

August, 1859. The value 34°.0 for the mean temperature on the 17th was interpolated, which required a corresponding diminution of 0°.08 for each of the hourly means, in order to produce the same monthly temperature of +36°.58.

September, 1859. The means of this month are of little value, the month being incomplete, and the change in latitude (and longitude) very considerable.

The two following tables contain a recapitulation of the results of the preceding abstracts. Table I exhibits the mean monthly temperature at the locality indicated by its latitude and longitude, also the *relative* maxima and minima, and relative monthly extreme range, as observed in either the bi-hourly or the four-hourly series. The absolute maxima and minima were not recorded. Table II contains the mean monthly temperatures for each observing hour, and is intended to serve as the basis for the discussion of the diurnal variation, while the first table furnishes the means for the discussion of the annual variation of the temperature. The column headed "mean," in Table II, differs from the corresponding column in Table I, for this reason: that, in Table II, no correction has been applied to refer the mean of six or twelve observations in a day (as the case may be) to the reading of twenty-four observations.

TABLE I.—RECAPITULATION OF RESULTS OF MONTHLY MEAN TEMPERATURES OF THE AIR IN SHADE OBSERVED ON BOARD THE YACHT FOX.

(Expressed in degrees of Fahrenheit's scale.)

Year.	Month.	Latitude north.	Longitude west.	Mean temperature.	Relative maxima.	Relative minima.	Relative range.	Correction for index error (to mean temp.).
1857	July	62°.0	39°.1	+45°.53	+61°	+31°	30°	
"	August	74.0	59.8	+34.65	+51	+23	28	
"	September	75.3	65.0	+19.50	+36	— 2	38	
"	October	75.2	67.9	+ 5.73	+32	—13.5	45.5	—0°.07
"	November	74.8	69.1	— 4.76	+31	—32	63	—0.16
"	December	74.3	67.4	—21.55	+ 5	—36	41	—0.20
1858	January	73.2	63.7	—24.87	— 8	—46	38	—0.20
"	February	71.5	60.9	—15.34	+11	—39.5	50.5	—0.19
"	March	69.4	59.1	— 3.29	+32	—27	59	—0.14
"	April	66.0	57.7	+ 8.06	+38	—26	64	—0.05
"	May	68.7	53.7	+29.83	+45	+10.5	34.5	
"	June	74.6	60.1	+35.97	+50	+28	22	
"	July	74.4	76.4	+36.60	+49	+31	18	
"	August	73.1	88.5	+34.52	+44	+24.5	19.5	
"	September	72.0	94.4	+25.43	+37.5	+ 8	29.5	
"	October	72.0	94.2	+ 7.59	+28.5	—21	49.5	—0.15
"	November	72.0	94.2	—11.17	+13	—35	48	—0.43
"	December	72.0	94.2	—32.97	—16	—47	31	—0.66
1859	January	72.0	94.2	—33.57	—14	—48	34	—0.83
"	February	72.0	94.2	—36.06	—12	—48	36	—1.02
"	March	72.0	94.2	—17.76	+12	—39	51	—0.46
"	April	72.0	94.2	— 2.62	+31	—27	58	—0.30
"	May	72.0	94.2	+15.04	+35	— 0.5	35.5	
"	June	72.0	94.2	+35.11	+50.5	+19	31.5	
"	July	72.0	94.2	+40.12	+55	+30	25	
"	August	71.9	79.8	+36.58	+47	+30	17	
"	September	58.9	40.9	+45.79	From 18 days' observations			

TABLE II.—DIURNAL VARIATION OF THE TEMPERATURE OF THE AIR IN SHADE.

Recapitulation of the preceding mean hourly values for each month, and of their monthly mean temperature.

Year.	Month.	Lat. north.	Long. west.	2h	4h	6h	8h	10h	Noon.	2h	4h	6h	8h	10h	Midn't.	Mean.
		°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1857	July	62.0	29.1	..	+44.78	..	+45.24	..	+46.46	..	+47.24	..	+45.36	..	+44.26	+45.56
"	Aug.	74.0	59.8	..	+33.16	..	+33.99	..	+36.39	..	+36.32	..	+34.74	..	+33.31	+34.65
"	Sept.	75.3	65.0	+17.15	+17.23	+16.75	+18.78	+20.42	+22.07	+23.16	+23.10	+20.16	+19.63	+18.63	+17.38	+19.54
"	Oct.	75.2	67.9	+ 4.37	+ 4.31	+ 5.29	+ 6.29	+ 6.86	+ 7.39	+ 7.32	+ 6.55	+ 5.68	+ 5.29	+ 4.81	+ 4.31	+ 5.71
"	Nov.	74.8	69.1	— 4.93	— 4.58	— 4.98	— 4.98	— 4.63	— 4.42	— 4.62	— 4.38	— 4.82	— 5.00	— 5.17	— 6.07	— 4.88
"	Dec.	74.3	67.4	—22.00	—22.23	—21.47	—21.10	—21.00	—21.21	—21.48	—21.45	—21.44	—21.14	—21.86	—22.24	—21.55
1858	Jan.	73.2	63.7	—25.01	—25.07	—24.92	—24.72	—24.39	—24.16	—24.52	—25.08	—24.97	—25.21	—25.08	—25.00	—24.84
"	Feb.	71.5	60.9	—16.55	—16.18	—15.98	—15.55	—15.14	—14.11	—13.95	—14.66	—15.43	—15.04	—15.43	—15.70	—15.31
"	March	69.4	59.1	— 5.43	— 6.03	— 5.60	— 3.44	— 1.34	+ 0.47	+ 0.74	— 0.13	— 2.49	— 4.79	— 5.57	— 6.01	— 3.31
"	April	66.0	57.7	+ 3.03	+ 3.35	+ 4.13	+ 7.50	+10.14	+12.62	+13.37	+12.45	+10.38	+ 7.77	+ 6.14	+ 5.63	+ 8.04
"	May	68.7	53.7	..	+27.60	..	+29.69	..	+32.28	..	+32.10	..	+30.02	..	+27.73	+29.90
"	June	74.6	60.1	..	+34.52	..	+35.92	..	+37.90	..	+38.05	..	+36.32	..	+33.50	+36.04
"	July	74.4	76.4	..	+34.57	..	+36.39	..	+39.18	..	+38.64	..	+36.14	..	+34.74	+36.61
"	Aug.	73.1	88.5	..	+33.66	..	+34.44	..	+35.40	..	+35.53	..	+34.55	..	+33.57	+34.52
"	Sept.	72.0	94.4	..	+24.25	..	+24.68	..	+26.45	..	+26.83	..	+25.63	..	+24.73	+25.43
"	Oct.	72.0	94.2	..	+ 7.52	..	+ 7.37	..	+ 9.03	..	+ 7.55	..	+ 7.26	..	+ 6.53	+ 7.54
"	Nov.	72.0	94.2	—11.53	—11.20	—10.60	—10.33	—10.03	—10.32	—11.07	—11.57	—11.87	—12.17	—12.23	—12.57	—11.29
"	Dec.	72.0	94.2	—32.52	—32.41	—32.60	—33.32	—32.78	—32.81	—32.74	—33.18	—33.27	—33.35	—33.40	—33.29	—32.97
1859	Jan.	72.0	94.2	—33.78	—34.26	—33.97	—33.97	—33.52	—33.31	—33.55	—33.26	—32.85	—33.10	—33.11	—33.78	—33.54
"	Feb.	72.0	94.2	—36.64	—36.32	—36.32	—35.97	—35.86	—35.25	—35.25	—35.82	—36.28	—36.07	—35.96	—36.59	—36.03
"	March	72.0	94.2	—21.96	—21.00	—21.57	—19.45	—14.79	—11.89	—12.03	—13.77	—18.43	—19.22	—19.52	—20.66	—17.78
"	April	72.0	94.2	..	— 3.38	..	— 2.27	..	+ 1.25	..	+ 0.60	..	— 4.07	..	— 5.82	— 2.45
"	May	72.0	94.2	..	+13.34	..	+16.50	..	+18.81	..	+18.21	..	+14.26	..	+11.39	+15.42
"	June	72.0	94.2	..	+33.33	..	+38.05	..	+39.82	..	+36.92	..	+33.93	..	+31.08	+35.52
"	July	72.0	94.2	+36.51	+37.24	+39.24	+41.29	+42.90	+43.48	+42.34	+41.98	+41.07	+40.02	+38.56	+36.98	+40.13
"	Aug.	71.9	79.8	..	+34.85	..	+36.37	..	+37.97	..	+37.65	..	+37.10	..	+35.52	+36.58
"	Sept.	58.9	40.9	..	+43.60	..	+45.70	..	+47.60	..	+47.30	..	+45.60	..	+45.00	+45.80

Discussion of the Annual Variation and of the Temperature at Different Seasons of the Year.

The monthly means brought out in Table I refer to different localities and years, and require to be combined with reference to these changes. The "Fox" remained stationary at the winter quarters for nearly a whole year—between August, 1858, and August, 1859—and we will, therefore, first examine the annual variation, the mean temperature of the seasons and of the whole year, for Port Kennedy, in north latitude 72° 01′, west longitude 94° 14′, near the eastern entrance to Bellot Straits, which separates North Somerset froom Boothia Felix. Our monthly means for August, 1858 and 1859, require to be corrected for difference of position. For this purpose, I have projected on a suitable chart the two isothermal lines for the month of August, constructed by me on the basis of Dove's investigation, and published in the 2d volume, Appendix No. XIII, of Dr. Kane's Narrative of his Arctic Expedition (north of Smith Straits), in the years 1853-'54-'55. By means of these curves, we find that the positions of August, 1858 (viz., latitude 73°.1, longitude 88°.5), and of August, 1859 (viz., latitude 71°.9, longitude 79°.8), can be assumed as lying nearly on the same isotherm, with a temperature of 1°.4 Fahr. relatively colder than the isotherm passing through Port Kennedy in that month; the normal distance between the isotherms differing 4°.5 in temperature being nearly 6° of arc. In the following table, the temperature for the month of August is derived from the mean of the respective observations of 1858 and 1859 increased by 1°.4, in order to refer the value to the locality of Port Kennedy.

TABLE III.—MEAN MONTHLY TEMPERATURE OF THE AIR IN SHADE OBSERVED AT PORT KENNEDY, IN LATITUDE 72° 01′ N., AND LONGITUDE 94° 14′ W., IN THE YEARS 1858 AND 1859.

1858–'9	August	+36°.95	1859	February	−36°.06
1858	September	+25.43	"	March	−17.76
"	October	+ 7.59	"	April	− 2.62
"	November	−11.17	"	May	+15.04
"	December	−32.97	"	June	+35.11
1859	January	−33.57	"	July	+40.12

To express the above and other periodic results in an analytical form, Bessel's formula of interpolation for periodic functions, and depending on the method of least squares,[1] will be made use of throughout the discussion; a practice which has now become almost universal in meteorological and many other physical investigations.

The above numbers will be found represented by the formula—

$$T = +2°.17 + 38°.70 \, sin\,(\theta + 248°\ 4') + 0°.58 \, sin\,(2\theta + 279°\ 57') + 1°.14 \, sin\,(3\theta + 275°\ 53')$$

T representing the monthly values of the annual variation, and the angle θ counting from January 1st at the rate of 30° a month. According to this expression, the mean annual temperature at Port Kennedy is +2°.17 Fahr.

The strict application of Bessel's formula requires the intervals between the successive observations or means to be of equal length, and a small correction, therefore, becomes necessary on account of the unequal length of the months. This correction, generally too small to be noticed in low latitudes, is of sufficient magnitude in very high latitudes not to be neglectable. The following numbers show the quantity, in days and fractions of a day, by which the middle of each actual month differs from the mean of each month of average duration (30.4 days for a common, and 30.5 days for a leap, year), and for which interval a correction, —depending, also, on the magnitude of the variation of the temperature—is to be applied. A positive sign indicates that the middle of the actual month occurs earlier than the middle of the normal month; a negative sign indicates the reverse. Commencing with January, and proceeding in regular order, these intervals are as follows:—[2]

−0d.3	+0.6	+1.5	+1.5	+1.4	+1.3	+1.2	+0.7	+0.6	+0.5	+0.4	+0d.3
−0.2	+0.2	+0.8	+0.8	+0.8	+0.8	+0.8	+0.2	+0.2	+0.2	+0.2	+0.2

The upper line is for a common year, the lower line for a leap year. These numbers suppose the angle θ to be zero for the commencement of the civil year, and that the daily mean temperature, so far as the annual fluctuation is concerned, refers to the middle of the day. The corrections become greatest for the spring and autumn months, when the annual variation is most rapid. To obtain an ap-

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[1] Explained at length by Sir J. Herschel in the article "Meteorology," Vol. XIV, 8th edition of the *Encyclopædia Britannica*.

[2] These numbers were given in my discussion of the meteorological observations of the second Grinnell Expedition, under command of Dr. E. K. Kane. See Vol. XI of the Smithsonian Contributions to Knowledge, 1859.

proximate value for the diurnal change for the middle of each month, the above formula was used, the increase in the value of θ for one day being 59′.2. Multiplying the daily change into the above intervals, we obtain the following mean monthly temperatures corrected for unequal duration, to which numbers the correction for index error has been added, as given in the third column of the table.

PORT KENNEDY. MEAN TEMPERATURE OF THE AIR IN SHADE IN EACH NORMAL MONTH.

Month.	Mean temp.	Corr'd for index.	Month.	Mean temp.	Corr'd for index.
January	—33°.61	—34°.44	July	+39°.98	+39°.98
February	—35.87	—36.89	August	+36.76	+36.76
March	—16.98	—17.44	September	+25.13	+25.13
April	— 1.68	— 1.98	October	+ 7.27	+ 7.12
May	+15.87	+15.87	November	—11.43	—11.86
June	+35.67	+35.67	December	—33.09	—33.75

The maximum corrections for inequality in the length of the month were +0°.94, in April, and —0°.32, in October. The above monthly means, as corrected for index error, will be found represented by the expression (II)—

$$T = +2^\circ.02 + 39^\circ.20 \ sin \ (\theta + 249^\circ \ 5') + 0^\circ.80 \ sin \ (2\theta + 256^\circ \ 56') + 1^\circ.06 \ sin \ (3\theta + 274^\circ \ 43').$$

The numerical coefficients differ but slightly from the corresponding values in the first expression. The observations are represented as follows (the hundredths have been omitted as having no real value):—

Month.	Mean corrected for index error.	Mean corrected for index and inequality.	Same by Form. II.	Difference.	Month.	Mean corrected for index error.	Mean corrected for index and inequality.	Same by Form. II	Difference.
January	—34°.40	—34°.44	—38°.42	+4°.0	July	+40°.12	+39°.98	+40°.92	—0°.9
February	—37.08	—36.89	—33.13	—3.8	August	+36.95	+36.76	+36.81	0.0
March	—18.22	—17.44	—19.74	+2.3	September	+25.43	+25.13	+24.94	+0.2
April	— 2.92	— 1.98	— 2.07	+0.1	October	+ 7.44	+ 7.12	+ 7.65	—0.5
May	+15.04	+15.87	+17.52	—1.6	November	—11.60	—11.86	—13.12	+1.3
June	+35.11	+35.67	+34.01	+1.7	December	—33.63	—33.75	—31.13	—2.6
					Mean	+ 1.85	+ 2.02	+ 2.02	0.0

The differences between the observed and computed mean monthly temperatures are greatest in winter, which is due to the greater fluctuations of the temperature in that season. The same result was found from my reduction of the Van Rensselaer Harbor temperatures, as observed by Dr. Kane. The average probable error of representation of the mean temperature of any one month is accordingly $\pm 2^\circ.1$, and of the result for the mean annual temperature $\pm 0^\circ.6$.

The following table contains the temperature of the several seasons at Port Kennedy; December, January, and February being reckoned as winter months (and so on for the other seasons), in accordance with meteorological usage. The results by Formula II refer to the corrected normal months; the results headed "by observation," are corrected for index error.

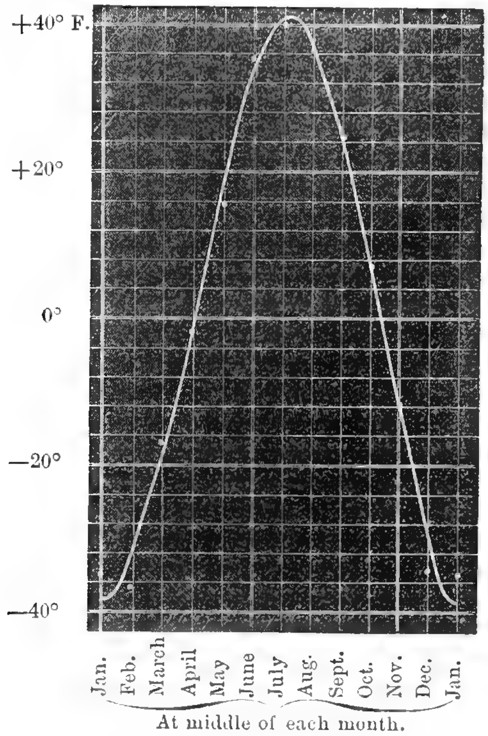
MEAN TEMPERATURES OF THE SEASONS.

At Port Kennedy, Lat. 72° 1′, Long. 94° 14′.				At Van Rensselaer Harbor, Lat. 78° 37′, Long. 70° 53′.			
Seasons.	By observation.	By Form. II.		Seasons.	By observation.	By Form. II.	
Winter	—35°.04	—34°.23		Winter	—28°.59	—29°.1	
Spring	— 2.04	— 1.43		Spring	—10.59	— 8.8	
Summer	+37.40	+37.25		Summer	+33.38	+33.5	
Autumn	+ 7.09	+ 6.49		Autumn	— 4.03	— 4.4	
Year . . .	+ 1.85	+ 2.02	±0°.6	Year . . .	— 2.46	— 2.20	±0°.7

The corresponding values at Van Rensselaer Harbor have been inserted for comparison, and show a remarkable difference in the temperatures of spring and autumn, at which seasons it was much colder at Van Rensselaer Harbor than at Port Kennedy, whereas the mean winter temperature was lowest at Port Kennedy. The observations give the range between the summer and winter mean at Port Kennedy 72°.4, and at Van Rensselaer Harbor 62°.0. According to Formula II, we find, as a close approximation, the warmest day July 20th, with $T = +41°.0$, and the coldest day January 19th, with $T = -38°.4$; hence, the range of the annual fluctuation 79°.4. The mean temperature of the year is reached on April 23d and October 22d.

The annual fluctuation of the temperature, or the observed and computed monthly (normal) means (corrected for index error), are represented in the annexed diagram (A). The curve shows the computed, and the dots the observed, temperature.

(A.) ANNUAL FLUCTUATION OF THE TEMPERATURE OF THE AIR AT PORT KENNEDY.



By means of Table I, we can make the following combinations of mean temperatures of the seasons of the year at different localities, which tabular numbers and combinations may be useful in future investigations of the course of the monthly isothermal lines, and of the isotherms of the several seasons.

Year.	Season.	North latitude.	West longitude.	Mean temperature.	Corrected for index error.
1857	Autumn	75°.1	67°.3	+ 6°.82	+ 6°.74
1857–8	Winter	73.0	64.0	—20.59	—20.79
1858	Spring	68.0	56.8	+11.53	+11.47
1858	Summer	74.0	75.0	+35.70	+35.70

The last three (but one) columns of Table I, exhibit the observed monthly maxima and minima of the temperature, and the extreme monthly range. These numbers are only relative, since the absolute extremes were not found recorded.

The highest temperature observed near Port Kennedy was +55°.0, on July 29th, 1859, and the lowest, —49°.8 (the index correction having been applied), on January 21st, 1859, and February 15th and 18th, 1859. Extreme range recorded at the winter quarters of the "Fox," 104°.8 of Fahrenheit's scale. To compare with the above numbers, Dr. Kane recorded at Van Rensselaer Harbor a maximum temperature of +51°.0, on July 23d, 1854, and a minimum temperature of —66°.4, on February 5th, 1854, and of —65°.5, on January 8th, 1855; observed absolute range 117°.4 Fahr., exceeding the Port Kennedy range by 12°.6.

The monthly range is greatest in March and April and in October and November; its value may be set down as 52° at Port Kennedy. This range is least in December and January and in July and August, when it does not exceed 27°. The extreme monthly range occurred in April, 1858 (viz., 64°), and in August, 1859 (viz., 17°).

Diurnal Variation of the Temperature.

The material collected in Table II furnishes the basis for the discussion of the diurnal fluctuation of the temperature. The hourly means (at certain observing hours) recorded there do not present the true daily fluctuation of the temperature in each month, on account of the disturbing effect of the annual change during the interval of a day, an effect which cannot be neglected in a locality where the annual fluctuation amounts to the excessive quantity of 79°.4. The tabular numbers, therefore, must first be cleared of this disturbing effect. This is best done by computing, by means of our expression for T, the change of the annual variation in a day for the middle of each month, and by correcting the means for the hours 0 A. M. and 12 P. M. by one half of this change, with opposite signs. There is no correction for noon, and a proportional one for the intermediate hours between morning and noon, and between noon and midnight; the signs in the second interval being the reverse from those in the first. The diurnal fluctuation during the long arctic night is so small as to be almost effaced by the overpowering effect of the annual fluctuation during a day.

Confining our attention for the present to the diurnal variation of the temperature in each month at Port Kennedy, we find an anomaly in the table of results in April, May, and June, 1859, when the symmetry of the observing hours is interrupted by observations being taken at 5 A. M. and 11 P. M. To remedy this defect, I have first established an approximate equation of the diurnal variation, and, by means of it, computed the difference between the mean at 4^h and 5^h, and also between 11^h and 12^h. These differences were applied respectively to the mean for 5^h and to the mean for 11^h, which gave the deduced means for 4^h and 12^h.

The maximum corrections for diurnal effect of the annual change occur at midnight, and are as follows:—

In January	0°.00	In July	0.°00
February	—0.15	August	+0.14
March	—0.26	September	+0.25
April	—0.32	October	+0.32
May	—0.30	November	+0.32
June	—0.22	December	+0.20

At 0^h A. M., the corrections are the same with the sign reversed; at noon, they are zero; at intermediate hours, proportional values were applied. The monthly mean is left unchanged (or very nearly so).

For August, I have combined the means of August, 1858 and 1859.

Accordingly, we have the following table of the diurnal variation of the temperature for each month of the year:—

TABLE IV.—DIURNAL VARIATION OF THE TEMPERATURE AT PORT KENNEDY.

	2^h	4^h	6^h	8^h	10^h	Noon.	2^h	4^h	6^h	8^h	10^h	Midn't.
	°	°	°	°	°	°	°	°	°	°	°	°
January	—37.78	—34.26	—33.96	—33.97	—33.52	—33.31	—33.55	—33.26	—32.85	—33.10	—33.11	—33.78
February	—36.52	—36.23	—36.25	—35.93	—35.84	—35.25	—35.27	—35.86	—36.37	—36.16	—36.08	—36.74
March	—20.85	—20.83	—21.44	—19.37	—14.75	—11.89	—12.07	—13.85	—18.56	—19.39	—19.73	—20.92
April	..	— 4.82	..	— 2.17	..	+ 1.25	..	+ 0.50	..	— 4.28	..	— 5.70
May	..	+12.36	..	+16.60	..	+18.81	..	+18.11	..	+14.06	..	+11.05
June	..	+31.94	..	+38.11	..	+39.82	..	+36.86	..	+33.79	..	+30.50
July	+36.51	+37.24	+39.24	+41.29	+42.90	+43.48	+42.34	+41.98	+41.07	+40.02	+38.56	+36.98
August	..	+34.16	..	+35.36	..	+36.68	..	+36.63	..	+35.91	..	+34.68
September	..	+24.08	..	+24.60	..	+26.45	..	+26.91	..	+25.80	..	+24.98
October	..	+ 7.31	..	+ 7.27	..	+ 9.03	..	+ 7.65	..	+ 7.47	..	+ 6.85
November	—11.79	—11.41	—10.76	—10.43	—10.08	—10.32	—11.02	—11.47	—11.71	—11.96	—11.97	—12.25
December	—32.69	—32.54	—32.70	—33.38	—32.81	—32.81	—32.71	—33.12	—33.17	—33.22	—33.23	—33.09

For the purpose of making full use of all the bi-hourly observations, it was thought advisable to express the values for the months of April, May, June, and August, September, October, analytically, and to supply by interpolation values for the hours 2, 6, 10, A. M and P. M. The values thus computed were derived from the following expressions, in which the angle θ counts from midnight, and is reckoned at the rate of 15° an hour:—

For April, $t = -\ 2°.54 + 3°.67 \sin(\theta + 255°) + 0°.70 \sin(2\theta + 27°)$

" May, $t = +15.16 + 4.09 \sin(\theta + 255) + 0.24 \sin(2\theta + 257)$

" June, $t = +35.17 + 4.65 \sin(\theta + 267) + 0.90 \sin(2\theta + 181)$

For August, $t = +35°.57 + 1°.32 \sin(\theta + 228°) + 0°.18 \sin(2\theta + 142°)$

" September, $t = +25.47 + 1.39 \sin(\theta + 213) + 0.31 \sin(2\theta + 55)$

" October, $t = +\ 7.59 + 0.77 \sin(\theta + 258) + 0.35 \sin(2\theta + 80)$

The following table (IV, *b*) contains the interpolated values, by the insertion of which Table IV will be rendered complete :—

TABLE IV (*b*).—ADDITIONAL HOURLY VALUES OF THE DIURNAL FLUCTUATION AT PORT KENNEDY.

	2h A. M.	6h	10h	2h P. M.	6h	10h	Mean.
April	— 5°.40	— 3°.80	— 0°.31	+ 1°.72	— 1°.90	— 5°.53	— 2°.54
May	+11.03	+14.33	+17.59	+18.97	+16.45	+12.59	+15.16
June	+30.23	+34.96	+39.85	+38.53	+35.42	+32.03	+35.17
August	+34.21	+34.58	+36.15	+36.79	+36.34	+35.33	+35.57
September	+24.51	+24.05	+25.51	+26.99	+26.39	+25.37	+25.47
October	+ 7.08	+ 7.10	+ 8.29	+ 8.54	+ 7.40	+ 7.13	+ 7.59

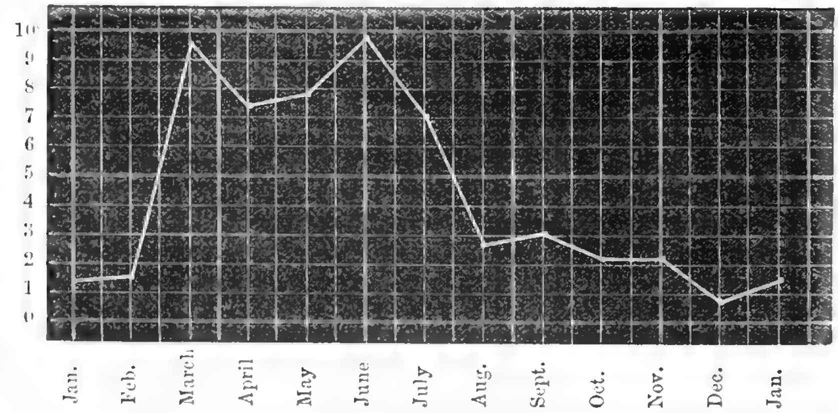
The two preceding tables furnish the following values for the amplitude of the diurnal fluctuation in each month of the year, also in each season, and for the whole year, together with the hours of maximum and minimum temperature, and the hours when the mean temperature is reached, for each of the periods.

TABLE V.—DAILY EXTREMES, RANGE, HOURS OF MAXIMA AND MINIMA, AND CRITICAL INTERVAL, FOR EACH MONTH OF THE YEAR.

Month.	Maximum.	Minimum.	Range.	Hour of max.	Hour of min.	Critical int.
January	—32°.85	—34°.26	1°.41	6 P. M.	4 A. M.	18h
February	—35.25	—36.74	1.49	Noon	Midn't	12
March	—11.89	—21.44	9.55	Noon	6 A. M.	6
April	+ 1.72	— 5.70	7.42	2 P. M.	Midn't	14
May	+18.97	+11.03	7.94	2 P. M.	2 A. M.	12
June	+39.85	+30.25	9.60	10 A. M.	2 A. M.	8
July	+43.48	+36.51	6.97	Noon	2 A. M.	10
August	+36.79	+34.16	2.63	2 P. M.	4 A. M.	10
September	+26.99	+24.05	2.94	2 P. M.	6 A. M.	8
October	+ 9.03	+ 6.85	2.18	Noon	Midn't	12
November	—10.08	—12.25	2.17	10 A. M.	Midn't	10
December	—32.54	—33.38	0.84	4 A. M.	8 A. M.	—4

The annexed diagram (B) exhibits the monthly values of the diurnal range :—

(B.) DIURNAL AMPLITUDE.



The autumn and winter months have a range of less than 3°, whereas the months of March to July exhibit two and a half times that amount. The maximum value was observed in June, amount 9°.60; the minimum value occurred in December, value 0°.14. For comparison, I may add that the corresponding values at Van

Rensselaer Harbor occurred in April, amount 9°.09, and in November, amount 1°.00; showing a correspondence in amount but not in time. The diurnal variation never disappears altogether, and even during the long arctic night there appears to be a daily propagation or existence of a thermal wave producing a range of about 1°. The amount of the amplitude changes tolerably regular from month to month; the high value in March, however, either presents a distinct feature or is due to some anomaly. Altogether, the curve indicates no secondary maximum, such as was found in September at Van Rensselaer Harbor.

On the average, the maximum temperature is reached between noon and 1 P. M., and the minimum between 2 and 3 A. M.; whereas, at Van Rensselaer Harbor, these hours were respectively 2 P. M. and 1 A. M.

The following table contains the hourly values of the diurnal variation for each season and the whole year:—

TABLE VI.—DIURNAL VARIATION IN EACH SEASON.

Season.	2^h	4^h	6^h	8^h	10^h	Noon.	2^h	4^h	6^h	8^h	10^h	Midn't.	Mean.
	°	°	°	°	°	°	°	°	°	°	°	°	°
Winter	—34.33	—34.34	—34.31	—34.43	—34.06	—33.79	—33.84	—34.08	—34.13	—34.16	—34.14	—34.54	—34.18
Spring	— 5.07	— 4.43	— 3.64	— 1.65	+ 0.84	+ 2.72	+ 2.87	+ 1.59	— 1.34	— 3.20	— 4.22	— 5.19	— 1.73
Summer	+33.66	+34.45	+36.29	+38.25	+39.63	+39.99	+39.22	+38.49	+37.61	+36.57	+35.31	+34.05	+36.96
Autumn	+ 6.60	+ 6.66	+ 6.80	+ 7.15	+ 7.91	+ 8.39	+ 8.17	+ 7.70	+ 7.36	+ 7.10	+ 6.84	+ 6.53	+ 7.27
Year	+0.21	+0.58	+1.28	+2.33	+3.58	+4.33	+4.10	+3.42	+2.37	+1.58	+0.95	+0.21	+2.08
Same by formula	+0.10	+0.49	+1.30	+2.42	+3.63	+4.33	+4.08	+3.25	+2.42	+1.72	+0.95	+0.27	+2.08
Differ'ce	+0.11	+0.09	—0.02	—0.09	—0.05	0.00	+0.02	+0.17	+0.05	+0.14	0.00	+0.06	

The computed diurnal variation for the whole year is derived from the expression given below. Comparing the means as stated above with corresponding values derived in the preceding discussion of the mean temperature of the seasons, we may add to each horizontal line the following corrections: to values for winter, —0°.05; for spring, +0°.30; for summer, +0°.29; for autumn, —0°.78; for the year, —0°.06. These differences arise from changes in the observing hours, and consequent necessity of interpolation.

TABLE V (*b*).

Season.	Maximum.	Minimum.	Range.	Hour of max.	Hour of min.	Critical int.
Winter	—33°.79	—34°.54	0°.75	Noon	Midn't	12^h
Spring	+ 2.87	— 5.19	8.06	2 P. M.	Midn't	10
Summer	+39.99	+33.66	6.33	Noon	2 A. M.	14
Autumn	+ 8.39	+ 6.53	1.86	Noon	Midn't	12
Year	+ 4.33	+ 0.21	4.12	Noon	1 A. M.	13
By formula	+ 4.35	+ 0.09	4.26	$0^h\ 28^m$ P. M.	$1^h\ 38^m$ A. M.	$13^h\ 10^m$

The mean temperature of the day is reached at $7^h\ 24^m$ A. M. and at $6^h\ 56^m$ P. M., by formula. The diurnal variation of the temperature during the whole year is represented by the formula:—

$$t = +2°.08 + 2°.02\ sin\ (\theta + 252°\ 57') + 0°.25\ sin\ (2\theta + 117°) + 0°.09\ sin\ (3\theta + 251°).$$

If we supply the constant term, and change the epoch from noon to midnight, as in the above expression, the diurnal variation at Van Rensselaer Harbor has been represented by

$$t = -2^\circ.91 + 1^\circ.85 \, sin \, (\theta + 244^\circ \, 55') + 0^\circ.08 \, sin \, (2\theta + 97^\circ) + 0^\circ.03 \, sin \, (3\theta + 308^\circ),$$

which is here added for comparison.

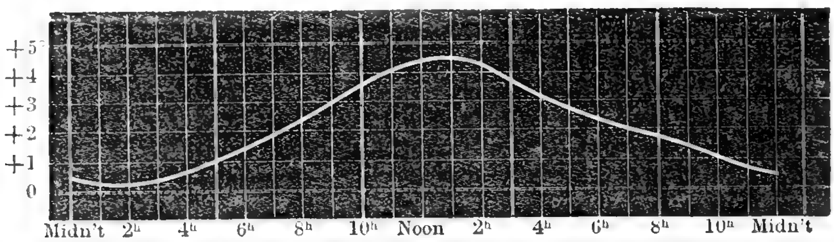
In either expression, the constant term might be omitted, as not essential in the inquiry of the diurnal fluctuation; or the values $+2^\circ.02$ and $-2^\circ.20$, which are the true mean annual temperatures respectively, might be substituted in their place.

The maximum and minimum value is given by the formula:—

$$o = +2^\circ.02 \, cos \, (\theta + 252^\circ \, 57') + 0^\circ.51 \, cos \, (2\theta + 117^\circ) + 0^\circ.28 \, cos \, (3\theta + 251^\circ).$$

The following diagram (C) exhibits the diurnal variation during the whole year:—

(C.) Diurnal Variation.



Hourly Corrections for Periodic Variations.—Under this head, a number of tables have been given by Prof. Guyot in his meteorological and physical tables, prepared for the Smithsonian Institution. These tables furnish the means of correcting other incomplete material at stations in the vicinity. A similar table was prepared by me for Van Rensselaer Harbor. The following table for Port Kennedy is directly derived from the values in Table II, in connection with Tables IV and IV (*b*). For those hours requiring interpolation in the latter case, the small corrections for the effect of the annual change during a day has again been deducted.

Arctic America.—Port Kennedy, Lat. 72° 01′ N., Long. 94° 14′ W. of Greenwich.

Corrections to be applied to any Bi-hourly or set of Bi-hourly Observation to obtain the Mean Temperature of the Day.

Degrees of Fahrenheit's scale.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
2 A. M.	+0.24	+0.61	+3.28	+3.16	+4.41	+5.12	+3.62	+1.23	+0.74	+0.22	+0.24	—0.45	+1.87
4	+0.72	+0.29	+3.22	+2.47	+3.03	+3.39	+2.89	+1.31	+1.21	+0.05	—0.09	—0.56	+1.49
6	+0.43	+0.29	+3.79	+1.45	+1.01	+0.34	+0.89	+0.91	+1.28	+0.31	—0.69	—0.37	+0.80
8	+0.43	—0.12	+1.67	—0.24	—1.31	—2.86	—1.16	+0.16	+0.78	+0.20	—0.96	+0.35	—0.25
10	—0.02	—0.23	—2.99	—2.15	—2.35	—4.61	—2.77	—0.61	—0.09	—0.77	—1.26	—0.19	—1.50
Noon	—0.23	—0.78	—5.89	—3.76	—3.62	—4.63	—3.35	—1.12	—0.99	—1.46	—0.97	—0.16	—2.25
2 P. M.	+0.01	—0.78	—5.75	—4.28	—3.83	—3.38	—2.21	—1.21	—1.49	—0.92	—0.22	—0.23	—2.02
4	—0.28	—0.21	—4.01	—3.11	—3.02	—1.73	—1.85	—1.03	—1.37	+0.02	+0.28	+0.21	—1.34
6	—0.69	+0.25	+0.65	—0.77	—1.41	—0.34	—0.94	—0.71	—0.80	+0.33	+0.58	+0.30	—0.30
8	—0.44	+0.04	+1.44	+1.56	+0.93	+1.26	+0.11	—0.27	—0.17	+0.31	+0.88	+0.38	+0.50
10	—0.43	—0.07	+1.74	+2.75	+2.35	+2.98	+1.57	+0.35	+0.19	+0.71	+0.94	+0.43	+1.13
Midn't	+0.24	+0.56	+2.88	+2.87	+3.84	+4.47	+3.15	+1.02	+0.73	+1.04	+1.28	+0.32	+1.87
6, 6	—0.13	+0.27	+2.22	+0.34	—0.20	0.00	—0.02	+0.10	+0.24	+0.32	—0.05	—0.03	+0.25
8, 8	0.00	—0.04	+1.55	+0.66	—0.19	—0.80	—0.52	—0.05	+0.31	+0.25	—0.04	+0.37	+0.12
10, 15	—0.22	—0.15	—0.62	+0.30	0.00	—0.81	—0.60	—0.13	+0.05	—0.03	—0.16	+0.12	—0.18
6, 2, 10	0.00	—0.19	—0.07	—0.03	—0.16	—0.02	+0.08	+0.02	—0.01	+0.03	+0.01	—0.06	—0.03

Owing to the fact that the observations extend over one year only, the table, in some instances, must necessarily contain some small irregularities. The closest results are obtained from the hours 6, 2, 10, which was also the case at Van Rensselaer Harbor.

Connection of the Lunar Phases with Low Winter Temperatures.

The apparent connection of the lunar phases with the observed temperature of the air during the Arctic winter, the thermometer being below the zero of Fahrenheit's scale, was long ago noticed by Arctic explorers, and was again independently observed by Dr. Kane, in the discussion of whose observations I have attempted an explanation of the phenomenon. In that paper, the connection of the lunar phases with the serenity of the sky and the fall of snow was also discussed; for the observations now on hand, the numerical relations alone will be represented.

Dividing the daily means of the temperature into penthemers (or periods of five days), a table was formed showing the time of full and new moon and the mean temperatures; and, by means of differences of the alternate means at these periods, the amount by which the mean temperature is lower at full moon than at new moon is exhibited in column headed Δ.

FIRST WINTER, 1857–'58.
BAFFIN BAY.
Between lat. 74°.8, long. 69°.6 and lat. 69°.8, long. 59°.8.

Penthemer.	Moon's phase.	Temp.	Alt. means.	Δ
Nov. 23–27		—2°.8		
28–32	1st ○	—27.0	- - -	(—6°.7)
Dec. 3– 7		—25.1		
8–12		—22.4		
13–17	16th ●	—20.3	—25.7	—5.4
18–22		—19.9		
23–27		—15.5		
28–32	30th ○	—24.4	—21.2	—3.2
Jan. 2– 6		—19.8		
7–11		—19.6		
12–16	15th ●	—22.0	—29.6	—7.6
17–21		—23.2		
22–26		—28.0		
27–31	29th ○	—34.8	—16.1	—18.7
Feb. 1– 5		—21.8		
6–10		—26.1		
11–15	13th ●	—10.2	—19.2	—9.0
16–20		— 8.7		
21–25		—13.7		
26–30	27th ○	— 3.5	- - -	(+6.7)

Omitting the first and last (incomplete) values of Δ, we find its average value = —8°.8.

SECOND WINTER, 1858–'59.
PORT KENNEDY, BELLOT STRAIT.
Lat. 72°.0, long. 94°.2.

Penthemer.	Moon's phase.	Temp.	Alt. means.	Δ
Nov. 2– 6	5th ●	—7°.5		
7–11		—12.6		
12–16		—17.0		
17–21	20th ○	+ 4.7	—19.0	+23.7
22–26		—23.9		
27–31		—16.5		
Dec. 2– 6	5th ●	—30.6	—13.1	+17.5
7–11		—29.1		
12–16		—36.5		
17–21	20th ○	—30.9	—33.9	+ 3.0
22–26		—38.9		
27–31		—34.5		
Jan. 1– 5	4th ●	—37.1	—32.7	+ 4.4
6–10		—34.4		
11–15		—24.9		
16–20	18th ○	—34.4	—33.3	— 1.1
21–25		—38.9		
26–30		—29.9		
31–35	3d ●	—29.6	—37.9	— 8.3
Feb. 5– 9		—38.8		
10–14		—34.1		
15–19	17th ○	—41.3	—26.7	—14.6
20–24		—35.8		
25–29		—34.3		
March 2– 6	4th ●	—23.9	—33.8	— 9.9
7–11		—16.3		
12–16		—21.4		
17–21	18th ○	—26.2	—12.5	—13.7
22–26		— 4.9		
27–31		—11.7		
April 1– 5	3d ●	— 1.1	- - -	(—25.1)
6–10		—12.6		

The temperature between Nov. 17–21 is anomalous, and affects also the following value (17.5) of Δ; these values, as well as that of April 1–5, have been omitted in the mean. For the period Nov. 17–21, the wind was N. E.; weather misty, with occasional snow, and variable.

Average Δ, winter 1858–'59 = —5°.7.

The average fall of the temperature for the period from new moon to full moon, from the above comparisons, is $7\frac{1}{4}^\circ$. The separate results may, perhaps, not appear as conclusive as those obtained at Van Rensselaer Harbor (lat. 78°.6); still, the general deduction is confirmed. The following account of the weather for each day, the day preceding and the day following, of the full and new moon, is copied from the record and refers to noon. Beaufort's signification of letters is used.

Full Moon.				New Moon.			
1857 Dec. 1 . . .	b. v.	b. v.	b. v.	1857 Dec. 16 . . .	b. v.	b.	b. m.
Dec. 30 . . .	m. z.	b. v.	b. c.	1858 Jan. 15 . . .	b. c.	m.	m. z.
1858 Jan. 29 . . .	b.	b. c.	b. c.	Feb. 13 . . .	b. c.	b. c.	b. z.
Feb. 27 . . .	o. m. s.	b. c.	b. c.				
1858 Nov. 20 . . .	c. m.	m. o. s.	c. m.	1858 Nov. 5 . . .	b. m. z.	b. m.	b. c. m.
Dec. 20 . . .	b. c. m.	c. m. z.	b. m. z.	Dec. 5 . . .	b. c.	m.	b. c.
1859 Jan. 18 . . .	m. s.	o.	b. m.	1859 Jan. 4 . . .	b. c.	b c. z.	b. m. z.
Feb. 17 . . .	b. m.	m. s.	b. m.	Feb. 3 . . .	m.	b. c.	b. c. z.
Mar. 18 . . .	b. c. z.	b. z.	b. m.	March 4 . . .	m.	b.	b. c.
				April 3 . . .	b.	b. c.	c. s.

b stands for blue sky. c stands for clouds, detached. m stands for misty, hazy.
o " overcast. s " snow. v " visibility, transparency.
z " snow drift.

In the first winter, the weather appears to have been finer and clearer at full moon; whereas, in the second winter, there is little or no difference, a misty weather and snow drifts characterizing the locality; under these circumstances, the lunar effect could hardly be expected to show itself as distinctly as brought out above. Captain McClintock makes the following remark (page ix of the 4th number of meteorological papers published by the Board of Trade): "The dense and continued mist over Bellot Strait, caused by considerably warmer water than the air above it, and the strong local winds, perhaps partly caused by this speedy evaporation and condensation, are special features."

No recurrence of cold was noticed, either in 1858 or in 1859, about May 11th—the period Dove has called attention to.

Temperature of the Winds.—To ascertain the elevating or depressing influence of the various winds on the temperature, the following method of investigation was adopted:—

The normal temperature of each day was made out by taking the mean of the temperature of that day, the two preceding and the two following days. The observed temperature at the hours 6 A. M. and 6 P. M., and at noon and midnight, were then compared with the respective normal temperature (the mean of five days); the differences thus obtained were tabulated according to one of the eight winds (or calm) N., N. E., E., S. E., etc., blowing at the respective hours. The mean difference for each wind, and for a period extending over a season, very nearly indicates the elevating or depressing influence of each wind, and at each season, on the temperature of the air. The + sign indicate warmer, the — sign colder, than the average. The diurnal variation being generally small, and in the absence of any regularity of a certain wind blowing regularly at certain hours, the effect of this variation will disappear in the resulting average values. In the exceptional case when no observations are recorded at 6 A. M. and P. M., the mean of observations at 4 and 8 A. M. and P. M. were substituted. For notes referring to the observations of the winds, see the record or Part II of this discussion. The directions of the wind are "true." This method of investigation is less laborious than that followed by me in a similar discussion of the temperature of the various winds at Van Rensselaer Harbor.

All results in Baffin Bay have been united, and a second group has been formed from the observations at Port Kennedy.

The seasons and localities for Baffin Bay, for which results were deduced, are as follows:—

Season. Months.	Between latitudes		Between longitudes	
Autumn—Sept., Oct., Nov., 1858	75°.3 and	74°.8	65°.0 and	69°.1
Winter—Dec., 1858, Jan., Feb., 1859	74.3	71.5	67.4	60.9
Spring—March, April, May, 1859	69.4	68.7	59.1	53.7
Summer—June, July, August, 1859	74.6	73.1	60.1	88.5
Mean	72°.5 N.		65°.8 W.	

This average position is nearly in the middle of Baffin Bay.

ELEVATING OR DEPRESSING EFFECTS OF THE WINDS ON THE TEMPERATURE OF THE AIR.

+ warmer, — colder, than the mean temperature.

	Calm.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Mean.
Autumn 1857	—2°.8	—0°.2	+3°.1	+1°.6	+4°.1	+0°.7	—2°.6	—1°.2	+0°.3	
Winter 1857–8	—1.9	—0.1	—0.3	—1.0	+0.8	—0.4	—2.4	—0.2	+1.2	
Spring 1858	+0.7	—1.5	+1.0	+1.3	+8.5	+2.5	—0.7	—0.3	—2.9	
Summer 1858	+0.6	0.0	+0.5	—0.5	—0.3	+0.6	0.0	+0.3	—0.5	
Mean	—1.0	—0.5	+1.1	+0.4	+3.3	+0.8	—1.4	—0.4	—0.5	+0°.2
Result for year	—1.2	—0.7	+0.9	+0.2	+3.1	+0.6	—1.6	—0.6	—0.7	

The results in the last line, obtained after deducting 0°.2 from the preceding line, show that the S. E. winds are the warmest, and the S. W. winds the coldest; also, that during calms the temperature is lower. At Van Rensselaer Harbor, the depressing effect of the calms amounted to 3°.4.

The following table shows the results for Port Kennedy:—

	Calm.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Mean.
Autumn 1858	+2°.4	+0°.9	+1°.3	+3°.7	+2°.4	+4°.5	+1°.0	—1°.7	—1°.9	
Winter 1858–9	—0.9	+2.0	—0.5	+2.3	- - -	- - -	+2.2	+0.2	—0.6	
Spring 1859	—0.4	+0.4	+0.3	+0.6	- - -	- - -	- - -	—0.6	—1.2	
Summer 1859	—0.8	—0.4	—0.3	+0.5	—1.2	—1.3	+0.3	+0.5	—0.2	
Mean	+0.1	+0.7	+0.2	+1.8	+0.6	+1.6	+1.2	—0.4	—1.0	+0°.5
Result for year	—0.5	+0.2	—0.3	+1.3	+0.1	+1.0	+0.6	—0.9	—1.5	

The results for winds from the S. E., S., and S. W. are not very reliable, on account of the scarcity of wind from these directions. At Port Kennedy, the E. winds are the warmest and the N. W. the coldest; during calms, the mean temperature is depressed 0°.5. The local configuration of the land, and the peculiar situation of the port, may possibly affect the results deduced.

The following recapitulation of results shows a tolerably fair agreement between the localities—middle of Baffin Bay, Van Rensselaer Harbor,[1] and Port Kennedy.

True direction of wind.	Baffin Bay. Lat. 72°.5 N. Long. 65°.8 W.	Van Rensselaer Harbor. Lat. 78°.6 N. Long. 70°.9 W.	Port Kennedy. Lat. 72°.0 N. Long. 94°.2 W.
N.	—0°.8	—1°.4	+0°.1
N. E.	+0.7	0.0	—0.4
E.	+0.1	—0.1	+1.2
S. E.	+3.0	+0.9	+0.1
S.	+0.4	+0.6	+1.0
S. W.	—1.7	+0.4	+0.5
W.	—0.9	+0.1	—1.0
N. W.	—0.8	—1.4	—1.5

(The positive and negative values have been made to balance, after omitting the value for the calms.)

Counting θ from the north (or belonging to a true north wind), in the direction east, south, etc., to 360°, the above tabular numbers can be expressed by the formulæ—

	Lat.	Long.	
Middle of Baffin Bay,	72°.5	65°.8	$T = +1^\circ.5 \sin(\theta + 338^\circ) + 0^\circ.8 \sin(2\theta + 173^\circ)$
Van Rensselaer Harbor,	78.6	70.9	$T = +1.0 \sin(\theta + 286) + 0.3 \sin(2\theta + 335)$
Port Kennedy,	72.0	94.2	$T = +0.9 \sin(\theta + 320) + 0.4 \sin(2\theta + 26)$

The second terms are of subordinate value; the first, or significant terms, correspond upon the whole very close, considering the peculiarity of each station, in reference to free exposure to the various winds.

From the 4th number of the meteorological papers published by the Board of Trade in 1860, I extract the following remark of Captain McClintock's: "The Danish settlers at Upernavik, in Northwest Greenland, are at times startled by a sudden rise of temperature during the depth of winter, when all nature has been long frozen; rain sometimes falls in torrents. It is called the warm southeast wind." In reference to a warm northwest wind in Upper Baffin Bay, alluded to in the same paper (p. iv), the above table for that locality shows that, although this wind is warm in winter, it is considerably colder in spring, and also colder, on the average, for the whole year.

Temperature of the Soil.—The following is copied from p. 309 of the record: "On 14th September, 1858, as soon as it appeared probable that we should winter at Port Kennedy, I sunk a brass tube two feet two inches vertically in the ground, and inserted a padded thermometer. The ground, at time of sinking the tube, was frozen from six inches below the surface, and it was with great difficulty I could get the tube sufficiently far down. The surface soil was similar to that

[1] See results given on page 111 of my discussion of Dr. Kane's meteorological observations, Vol. XI of the Smithsonian Contributions to Knowledge. As explained elsewhere (and confirmed by Mr. Sonntag and Dr. Hayes), the *true* direction of the wind was actually observed at Van Rensselaer Harbor; hence, the results given in the paper cited above required a corresponding change.

strewn over the land, but from below six inches it was of a yellowish mud. The thermometer used was one of very small bore, with a long stem finely graduated (it had been prepared for taking temperatures of trees). From 18th to 29th September, 1858, no register was made, as the ship was not in port; also from 18th to 28th March, 1859, as I was absent from the ship travelling. The minimum temperature registered was $+0°.5$, on March 10th, 1859; the lowest may be assumed as at zero, on March 16th. The register was continued until June 18th, when water entered the tube, and the thermometer was frozen to the side so that it could not be detached. Column No. 1 gives the register of this thermometer. Column No. 2 gives the depth of overlaying snow, which was always greater than the average on the land. On 17th January, 1859, a tube was placed one foot one inch deep in a mixture of shingle and earth; in this a thermometer was placed. The position of the ground was such that scarcely any snow lay upon it, the strong wind constantly blowing removing it almost as soon as deposited. Column No. 3 is the register of this thermometer. February 12th, 1859, a tube was placed horizontally on the surface of the ground, beneath the snow lying on the ground, where thermometer No. 1 was sunk. The temperature as shown by this thermometer (Column No. 4) was registered until the snow all disappeared. Column No. 5 gives the mean temperature of the air for the day on which the registers of the different thermometers were taken. Column No. 6 gives the mean temperature of the air for the number of days or hours intervening between the registers of the thermometers. All the temperatures of the different thermometers are corrected so as to reduce them to the standard of the air thermometer, comparisons having previously been made as opportunity offered."

(Signed) DAVID WALKER.

Date.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.			
1858		Inches.							
Sept. 30	30°.4	. .	. .	. .	+24°.2				
Oct. 1	29.9	. .	. .	. .	+25.4	Between	Sept. 30	and Oct. 1	= +24°.2
" 4	28.5	3	. .	. .	+22.3	"	Oct. 1	" 4	+25.7
" 7	27.5	5	. .	. .	+13.6	"	" 4	" 7	+22.2
" 9	26.3	5	. .	. .	— 1.2	"	" 7	" 9	+ 9.9
" 13	24.1	7	. .	. .	— 0.7	"	" 9	" 13	+ 7.0
" 16	22.4	7½	. .	. .	+18.5	"	" 13	" 16	0.0
" 19	21.2	8	. .	. .	+ 9.1	"	" 16	" 19	+ 8.2
" 23	20.2	10	. .	. .	— 0.8	"	" 19	" 23	+ 3.2
" 28	19.4	16	. .	. .	— 2.0	"	" 23	" 28	— 0.4
Nov. 6	17.8	42	. .	. .	— 0.6	"	" 28	Nov. 6	— 2.4
" 13	16.3	42	. .	. .	— 9.2	"	Nov. 6	" 13	—10.7
" 20	14.9	55	. .	. .	—13.8	"	" 13	" 20	— 7.9
" 27	14.1	57	. .	. .	—23.8	"	" 20	" 27	—16.5
Dec. 4	13.5	56	. .	. .	—35.4	"	" 27	Dec. 4	—19.4
" 11	12.9	53	. .	. .	—35.9	"	Dec. 4	" 11	—29.8
" 18	10.6	51	. .	. .	—33.4	"	" 11	" 18	—36.7
1859									
Jan. 1	8.1	66	. .	. .	—39.2	"	" 18	Jan. 1	—34.5
" 8	6.9	69	. .	. .	—34.7	"	Jan. 1	" 8	—36.8
" 18	5.4	68	—18°.7	. .	—28.3	"	" 8	" 18	—28.9
" 21	- -	- -	—23.7	. .	—42.2	"	" 18	" 21	—35.4
" 27	4.4	72	—22.2	. .	—25.8	"	" 21	" 27	—37.5
Feb. 1	- -	- -	—24.7	. .	—33.3	"	" 27	Feb. 1	—32.1
" 12	2.9	72	—23.7	. .	—22.7	"	Feb. 1	" 12	—34.1
" 17	- -	- -	—25.2	. .	—36.6	"	" 12	" 17	—35.6
" 26	1.6	68	—25.7	— 3°.0	—38.2	"	" 17	" 26	—37.4
March 4	- -	- -	—22.7	- -	—22.2	"	" 26	Mar. 4	—32.1
" 10	0.5	72	—16.4	— 3.8	—23.4	"	March 4	" 10	—17.0
" 28	0.8	76	—10.9	— 3.7	—15.4	"	" 10	" 28	—17.8
April 2	- -	- -	—12.4	- -	+ 2.0	"	" 28	April 2	—10.9
" 7	1.1	78	—10.9	— 1.2	—10.6	"	April 2	" 7	— 3.5
" 12	- -	- -	—12.9	- -	—16.3	"	" 7	" 12	—12.3
" 15	1.4	77	—11.9	+ 0.6	— 1.1	"	" 12	" 15	—14.1
" 23	1.8	76	— 0.5	+ 1.2	— 0.2	"	" 15	" 23	+ 3.0
" 26	- -	- -	— 5.0	- -	— 1.5	"	" 23	" 26	— 5.7
" 30	2.2	84	— 3.0	+ 2.3	+16.4	"	" 26	" 30	+ 5.5
May 7	2.8	82	— 3.0	+ 3.7	+ 4.1	"	" 30	May 7	+ 5.9
" 10	- -	- -	+ 3.5	- -	+11.8	"	May 7	" 10	+ 7.0
" 14	3.1	72	+ 8.0	+ 4.5	+20.4	"	" 10	" 14	+14.4
" 21	3.6	74	+11.5	+ 5.0	+17.8	"	" 14	" 21	+19.1
" 25	- -	- -	+14.0	- -	+18.7	"	" 21	" 25	+17.1
" 28	4.3	71	+14.5	+ 6.4	+25.4	"	" 25	" 28	+22.7
June 4	4.9	70	+18.0	+ 7.7	+34.1	"	" 28	June 4	+26.5
" 11	10.1	54	+22.1	+31.8	+35.3	"	June 4	" 11	+33.7
" 16	- -	-	+32.3	- -	+39.2	"	" 11	" 16	+37.4
" 18	frozen	26	+33.8	+32.3	+36.3	"	" 16	" 18	+40.1
" 24	frozen	18	+30.3	+32.1	+36.3	"	" 18	" 24	+36.8
July 1	frozen	0	+32.6	+34.8	+40.6	"	" 24	July 1	+36.8

The thermometer sunk two feet two inches, and the ground above covered with snow, gave its lowest indication on March 10th, when it reached +0°.5, and may be assumed as having reached zero about March 16th. The temperature of the air was lowest about January 19th ($T = —38°.4$); hence, the greatest cold of the soil at that depth occurred 57 days later. The thermometer sunk one foot one inch, and the ground free of snow, reached its lowest indication already on February 26th ($T = —25°.7$); hence, 38 days later than the time of the lowest atmospheric temperature.

Temperature of the Surface of the Sea.—Frequent observations (at irregular hours of the day) were made for temperature of the surface of the sea, between July 2d, 1857, and September 12th, 1857. It suffices, however, to give an abstract of these observations, and the following record contains the maximum, minimum, and mean temperature observed each day. The observations were resumed April

18th, 1858, and continued till September 11th, 1858. They were again resumed August 21st, 1859. Some other observations will be given below. For the latitude and longitude, see preceding abstract.

Temperature of the Surface of the Sea.

July, 1857.				August, 1857.				September, 1857.			
Date.	Max.	Min.	Mean.	Date.	Max.	Min.	Mean.	Date.	Max.	Min.	Mean.
1	..	..	..	1	46°	44°	44°.8	1	30°	29°	29°.5
2	..	..	54°	2	46	44	44.2	2	31	29	30
3	..	..	55.5	3	44	42	42.2	3	30	29	29.3
4	..	..	55	4	49	38	42.3	4	32.5	29	29.7
5	..	..	54	5	41	38	39.7	5	30.5	29	29.7
6	58°	55°	56.4	6	43	37	39.5	6	30	28	28.8
7	61	56	57	7	35	31	34	7	30	28	28.5
8	59	56	57.8	8	37	30	32.7	8	30	29	29.2
9	55	53	54	9	36	31	33	9	32	29	30.7
10	54	53	53.2	10	35	30	32.3	10	32	30	31
11	55	51	53	11	35	32	32.5	11	31	29.5	30.6
12	51	47.5	49.9	12	35	29	32.7	12	30	28	28.3
13	47	40	44.3	13	38	32	35	13	..	..	..
14	44	35	38	14	38	33	35.5	14	..	..	..
15	43	42	42.2	15	37	32	33.7	15	..	..	..
16	43	39	41.3	16	36	30	32.7	16	..	..	..
17	38	33	35.6	17	32	29	31	17	..	..	..
18	36	33	34.7	18	35	29	30.7	18	..	..	..
19	..	..	36	19	30	29	29.6	19	..	..	..
20	..	..	..	20	30	29	29.7	20	..	..	..
21	..	..	36	21	32	29	31	21	..	..	..
22	38	36	37.1	22	33	30	31	22	..	..	..
23	34	37	..	23	33	29	31	23	..	..	..
24	40	38	39	24	31	28	29.5	24	..	..	..
25	40	37	38.3	25	32	30	31	25	..	..	..
26	40	37	38.7	26	31	30	30.5	26	..	..	..
27	39	37	38.2	27	33	30	31.2	27	..	..	..
28	40	37	38.5	28	33	31	31.7	28	..	..	..
29	43	38	39.5	29	32	29	31	29	..	..	..
30	43	39	41.5	30	30	29	29.5	30	..	..	..
31	46	42	43.8	31	32	30	30.9				

Notes.—July, 1857.

16th. Pack ice in sight.
17th. Sailing through the ice.
18th. Bergs and pack ice.
23d. In harbor.
28th. Surface temp. 38°, and at 110 fathoms depth 31°.5.
28th–30th. Icebergs in sight.

Notes.—August, 1857.

2d and 3d. Many icebergs in sight.
11th. Fast to a berg.
13th. At 1 P. M., temp. in shade, thermometer freely suspended, 46°; against iceberg, receiving its reflected rays, 53°; against iceberg in the sun, 63°; against a black surface in the sun, 82°.
14th. Deep sea thermometer:—

At 114 fathoms,	30°
" 50 "	29.5
" 25 "	31.5
" surface	38
Fresh water on berg,	32.2

15th. Temp. 3 feet in the iceberg, 29°.15; its surface, 32°.1; temp. of the air 41°.6, at 9 A. M.
16th and 17th. Fast to a floe.

Notes.—September, 1857.

5th. At 10 A. M.—

88 fathoms, temp.	29°.5
50 "	29.0
25 "	29.0
Surface,	28.8

13th. 26 icebergs in sight from aloft.
24th. Temp. of sea at surface, 29°.

NOTES.

1857				
Nov. 9th.	Temp. of sea surface,			28°.0
1858				
Feb. 2d.	Temp. of sea surface,			28.5
" 22d.	"	"		29.0
	Temp. at	5	fath's	29.0
	"	120	"	32.5
March 1st.	"	120	"	34.5
	"	5	"	29.5

1858				
Mar. 10th.	Temp. at	120	fath's	30°.5
	"	100	"	31.0
	"	5	"	29.0
Mar. 20th.	"	90	"	34.0
	"	4	"	29.5
Mar. 29th.	"	120	"	38.0
	"	4	"	30.5
April 7th.	"	110	"	34.0

1858				
April 7th.	Temp. at	4	fath's	30°
April 10th.	"	120	"	34
	"	4	"	30
April 14th.	"	110	"	31
	"	4	"	30.5
April 21st.	"	110	"	31.2
	"	4	"	29.5

Temperature of the Surface of the Sea.

April, 1858.

Date.	Max.	Min.	Mean.
18	. .	. .	29°.0
19	. .	. .	29.0
20	29°	28°.5	28.7
21	29	29	29.0
22	. .	. .	. .
23	. .	. .	29.5
24	. .	. .	. .
25	. .	. .	29.5
26	31	30	30.4
27	31	29.5	30.2
28	32	30	30.9

May, 1858.

Date.	Max.	Min.	Mean.
8	. .	. .	29°.0
9	. .	. .	28.0
10	. .	. .	28.0
11	. .	. .	29.0
29	40°	34°	36.2
30	34	31	32.4
31	33	31	31.8

June, 1858.

Date.	Max.	Min.	Mean.
1	33°	32°	32°.5
2	35	33	33.7
3	32	31	31.7
4	33	32	32.7
5	32.5	31	31.6
6	32	31.5	32.0
7	33	31	32.3
8	33	32	32.7
9	33	30.5	32.2
10	32	31	31.6
11	33	32	32.3
12	32	30	31.6
13	31.5	30	30.8
14	32	30	31.0
15	32	31	31.7
16	32	29	31.0
17	39	31	32.3
18	32	30	31.2
19	33	31	31.8
20	32	31	31.7
21	31	31	31.0
22	32	29	30.8
23	32	30	31.2
24	32	30.5	31.6
25	33	31	32.2
26	33	31	31.8
27	33	31	31.7
28	32.5	32	32.1
29	33	32	32.5
30	32	31	31.7

July, 1858.

Date.	Max.	Min.	Mean.
1	34°	31°	32°.0
2	32	31	31.8
3	33	31	31.8
4	32.2	31.5	31.9
5	33	31	31.8
6	32	30.5	31.2
7	32	31	31.7
8	31	31	31.0
9	34	31	32.2
10	32.5	31	31.9
11	33	32	32.3
12	32	31	31.7
13	32	31	31.2
14	32	31	31.3
15	32	31	31.8
16	32.5	31	31.8
17	32.5	31	32.1
18	32.5	30	31.6
19	32.5	31	31.8
20	35	32	32.9
21	33	32	32.3
22	33	31	32.3
23	34	32	32.9
24	38	32	33.8
25	41	32	35.0
26	38	32	34.0
27	35	32	33.8
28	35	32.5	33.8
29	37	32	33.8
30	34	31	32.8
31	34	32	33.0

August, 1858.

Date.	Max.	Min.	Mean.
1	35°	33°	33°.8
2	35	33	34.0
3	34	32	33.2
4	37	32	33.7
5	35	31	33.2
6	34	32	33.2
7	34	31	32.4
8	. .	. .	32.0
9	. .	. .	29.6
10	32.5	32	32.1
11	33	32	32.7
12	. .	. .	34.0
13	. .	. .	. .
14	. .	. .	. .
15	. .	. .	. .
16	. .	. .	32.5
17	32	31	31.3
18	32	31	31.5
19	31	31	31.0
20	31	31	31.0
21	32	30	30.8
22	33	30	31.2
23	31	30	30.2
24	31	30	30.2
25	32	30	30.4
26	30	30	30.0
27	31	30	30.2
28	30	29	29.5
29	30	29	29.7
30	30	29	29.7
31	29	29	29.0

September, 1858.

Date.	Max.	Min.	Mean.
1	29°	29°	29°.0
2	29	29	29.0
3	30	29	29.2
4	29	29	29.0
5	29	29	29.0
6	30	29	29.5
7	32	30	30.3
8	31	30	30.7
9	30	29	29.5
10	30.5	29	29.6
11	. .	. .	29.2

Sept. 27th. Temp. at 65 fathoms, 31°; surface temp., 28°.

August, 1859.

Date.	8 A. M.	8 P. M.	Mean.
21	. .	39°.8	39°.8
22	39°.5	39.0	39.2
23	36.5	36.8	36.7
24	37.8	38.5	38.1
25	38.2	38.5	38.3
26	38.5	39.8	39.1

September, 1859.

Date.	8 A. M.	8 P. M.	Mean.
2	. .	39° 0	39°.0
3	38°.8	39.8	39.3
4	40.0	41.2	40.6
5	41.0	41.0	41.0
6	41.5	42.0	41.7
7	38.5	40.5	39.5
8	42.5	44.0	43.2
9	43.0	44.5	43.7
10	45.0	46.5	45.7
11	47.5	48.0	47.7
12	. .	51.0	51.0
13	50.5	52.5	51.5
14	. .	54.0	54.0
15	. .	56.0	56.0
16	. .	56.5	56.5
17	. .	58.0	58.0

Table of Mean Results for Temperature of the Surface of the Sea.

Date.	Locality.		Temp. of sea.	Remarks.
	Between N. lat.	Between W. long.		
1857				
July 2—15	58°.3—60°.1	2°.6—48°.3	51°.7	Aberdeen to off Cape Farwel.
" 16—31	60.4—69.2	49.7—53.3	38.5	Off Cape Farewell to Lievely.
Aug. 1—15	69.4—75.1	53.0—59.3	36.9	Lievely to near Melville Bay.
" 16—31	75.1—75.5	59.3—64.1	30.8	" "
Sept. 1—12	75.5—75.5	64.0—65.5	29.6	" "
" 24	75.1	65.3	29.0	" "
Nov. 9	74.8	68.5	28.0	" "
1858				
Feb. 2—22	72.5—70.7	61.2—60.7	28.8	Baffin Bay.
March 1—29	69.8—68.5	59.7—58.5	29.6	Near Davis Strait, at 4½ fathoms depth.
April 7—21	67.0—64.2	58.4—58.7	30.0	Davis Strait 4 fathoms.
" 18—28	64.8—66.5	58.6—53.5	29.6	Davis Strait.
May 8—11	66.8—69.0	53.3—53.3	28.5	Holsteinberg to Whalefish Islands.
" 29—31	71.3—72.8	55.6—55.8	33.5	Omenak Fiord to off Upernavik.
June 1—15	72.8—74.2	55.8—58.2	32.0	Off Upernavik to south of Melville Bay.
" 16—30	75.0—75.9	60.1—67.5	31.6	Melville Bay.
July 1—15	75.9—74.6	67.5—80.9	31.7	Upper Baffin Bay.
" 16—31	74.4—72.6	82.0—76.3	32.4	Baffin Bay.
Aug. 1—12	72.8—74.3	77.2—89.0	32.8	Near Lancaster Sound and Barrow Strait.
" 16—31	74.3—72.0	94.0—94.2	30.5	Prince Regent Inlet, Port Kennedy.
Sept. 1—11	72.0	94.2	29.5	Near Port Kennedy.
" 27	72.0	94.0	28.0	" "
1859				
Aug. 21—26	72.7—69.7	72.1—55.5	38.5	Lower Baffin Bay.
Sept. 2— 9	67.3—58.7	57.3—48.3	41.0	Off South Greenland.
" 10—17	58.1—51.3	44.9—16.4	52.5	

The lowest temperatures of the surface of the sea were observed in November, 1857, near Melville Bay, and in September, 1858, at Port Kennedy (viz., 28°.0); the highest temperature, north of Davis Strait, in May, 1858, off Swarte Hook Peninsula (viz., 33°.5).

The following table of monthly mean temperatures of the air (in shade), expressed in degrees of Fahrenheit's scale, has been prepared by Captain McClintock, and is here appended as forming part of the most valuable material for the construction of the isothermal lines, and for the investigation of the climatic relations of this portion of the Arctic regions. I have added two columns, containing the results from the Second American Grinnell Expedition, under command of Dr. E. K. Kane, from my discussion of the observations, as published by the Smithsonian Institution, and the results for Port Kennedy as made out by me in the preceding discussion. This last column may be substituted for that given by Captain McClintock in his general table.

TABLE OF MEAN MONTHLY TEMPERATURES REGISTERED BY MODERN EXPEDITIONS TO THE AMERICAN ARCTIC REGIONS.

MONTH.	WINTER ISLAND. Lat. 66½° N. 1821–22.	REPULSE BAY. Lat. 66° 32′ N. 1846–47.	IGLOOLIK. Lat. 69⅓° N. 1822–23.	CAMBRIDGE BAY. Lat. 69° 3′ N. H. M. S. Enterprise. 1852–53.	FELIX HARBOR. Lat. 69° 59′ N. 1829–30.	SHERIFF'S HARBOR. Lat. 70° N. 1830–31.	CAMDEN BAY. Lat. 70° 8′ N. H. M. S. Enterprise. 1853–54.	POINT BARROW. Lat. 71° 30′ N. H. M. S. Plover. 1852–53.	POINT BARROW. Lat. 71° 30′ N. H. M. S. Plover. 1853–54.	WALKER BAY. Lat. 71° 36′ N. H. M. S. Enterprise. 1851–52.	PORT KENNEDY. Lat. 72°. Yacht Fox. 1858–59.	PRINCE OF WALES STRAIT. Lat. 72° 47′ N. H. M. S. Investigator. 1850–51.	PORT BOWEN. Lat. 73° 14′ N. 1824–25.	PORT LEOPOLD. Lat. 73° 51′ N. H. M. S. Enterprise. 1848–49.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°
January	—23.13	—29.32	—16.13	—37.75	—27.2	—25.4	—16.19	—24.2	—13.3	—19.29	—33.53	—32.5	—28.9	—31.8
February	—24.01	—26.68	—19.58	—30.73	—29.9	—32.5	—31.80	—17.8	—27.7	—16.89	—36.06	—37.7	—27.3	—31.3
March	—10.78	—28.10	—19.01	—17.58	—20.9	—34.7	—20.00	—12.7	—17.0	—23.29	—17.64	—28.8	—28.4	—19.4
April	+ 6.50	— 3.95	— 0.85	— 3.43	+ 1.4	— 6.4	— 0.90	+ 5.0	+ 2.4	+10.12	— 2.45	— 4.8	— 6.5	—10.1
May	+23.31	+17.88	+25.14	+18.03	+15.3	+16.0	+22.99	+19.3	+20.9	+16.85	+15.41	+18.9	+17.6	+16.4
June	+33.16	+31.38	+32.16	+32.75	+36.8	+31.6	+32.37	+31.9	+32.6	+32.53	+35.50	+36.1	+36.1	+31.7
July	+35.33	+41.46	+38.58	+43.05	+44.6	+37.9	. .	+35.2	+38.4	+41.32	+40.14	+37.5	+37.3	+36.0
August	+36.88	+46.32	+33.88	+36.83	+40.9	+36.5	. .	+43.3	+47.0	+42.63	+37.55	+36.5	+35.8	+33.7
September	+31.62	+28.57	+25.10	+27.52	+29.4	+27.4	. .	+28.9	+23.5	+28.10	+25.43	+20.2	+25.9	+23.2
October	+13.15	+12.56	+13.72	+ 3.95	+ 7.9	+11.0	+ 0.56	+ 4.1	— 0.9	+ 7.56	+ 7.47	+ 0.2	+10.8	+10.0
November	+ 7.80	+ 0.68	—18.66	— 7.17	— 3.6	—11.4	— 9.62	— 9.2	— 7.7	— 5.37	—11.29	—10.2	— 5.0	—12.8
December	—14.24	—19.27	—28.25	—31.27	—23.1	—20.2	—26.04	— 5.6	—21.0	—17.46	—32.98	—23.4	—19.0	—32.5
Mean annual temp.	+ 9.63	+ 5.96	+ 5.51	+ 2.85	+5.97	+2.48	. .	Both years +7.31		+ 8.07	+ 2.29	+1.00	+4.03	+1.09
	Taken from Parry's voyage.	From Rae's Narrative of a winter at Repulse Bay, 46–7.	Parry's voyage.	Only 4 days in Sept. '52, and 10 in Aug. '53, were actually spent in this bay.	Sir John Ross' voyage of the Victory.	Sir John Ross' voyage of the Victory.				Only 15 days in Sep. '51, and 12 days in Aug. '52, actually in this bay.	Only 9 days in Aug. 1859, as the ship then put to sea.	Thermometer not tested or compared.	Parry's voyage.	

MONTH.	MERCY BAY. Lat. 74° 6′ N. H. M. S. Investigator. 1851–52.	MERCY BAY. Lat. 74° 6′ N. H. M. S. Investigator. 1852–53.	GRIFFITH'S ISLAND. Lat. 74° 34′ N. H. M. S. Assistance. 1850–51.	BEECHEY ISLAND. Lat. 74° 43′ N. H. M. S. North Star. 1852–53.	BEECHEY ISLAND. Lat. 74° 43′ N. H. M. S. North Star. 1853–54.	CAPE COCKBURN. Lat. 74° 41′ N. H. M. S. Intrepid. 1853–54.	WINTER HARBOR. Lat. 74° 47′ N., Long. 110° 53′ W. 1819–20.	DEALY ISLAND. Lat. 74° 56′ N. H. M. S. Intrepid. 1852–53.	WELLINGTON CHANNEL. Lat. 75° 31′ N. H. M. S. Pioneer. 1853–54.	WOLSTENHOLM SOUND. Lat. 76½° N. H. M. S. North Star. 1849–50.	NORTHUMBERLAND SOUND. Lat. 76° 52′ N., Long. 97° W. H. M. S. Pioneer. 1852–53.	The following columns are additions to preceding table.	VAN RENSSELAER HARBOR. Lat. 78° 37′ N., Long. 70° 53′ W. Brig Advance. 1853–54–55.	PORT KENNEDY. Lat. 72° 1′ N., Long. 94° 14′ W. Yacht Fox. 1858–59.
	°	°	°	°	°	°	°	°	°	°	°		°	°
January	—27.3	—43.9	—31.90	—35.8	—31.4	—36.71	—32.4	—36.13	—37.4	—25.07	—40.00		—28.26	—34.44
February	—25.8	—38.5	—33.00	—19.0	—34.3	—41.12	—34.9	—30.42	—40.2	—34.02	—29.50		—26.53	—36.89
March	—28.4	—25.4	—25.70	—13.0	—23.0	—31.95	—19.5	—19.18	—30.8	—17.47	—17.71		—33.54	—17.44
April	— 1.4	— 6.5	— 7.03	— 1.8	+ 0.3	— 7.13	— 9.9	— 2.47	— 4.8	— 3.74	— 8.60		— 9.48	— 1.98
May	+10.2	+15.0	+ 9.54	+19.0	+13.9	. .	+16.7	+16.90	+ 9.3	+25.82	+14.70		+14.78	+15.87
June	+31.5	. .	+32.67	+36.8	+30.8	. .	+36.2	+33.04	+27.9	+39.73	+29.80		+30.76	+35.67
July	+36.7	. .	+36.60	+39.4	+37.5	. .	+42.4	+36.42	+38.1	+40.52	+35.70		+38.18	+39.98
August	+37.6	+33.2	+33.70	+34.5	+34.6	. .	+32.7	+33.10	+36.2	+33.67	+33.80		+31.59	+36.76
September	+24.6	+20.1	+20.20	+21.4	+18.5	+17.88	+22.5	+18.80	+17.0	+26.76	+18.63		+13.15	+25.13
October	+ 3.3	— 5.6	— 0.30	+ 5.2	+ 7.4	+ 4.60	— 4.9	— 0.56	+ 9.5	+11.32	— 1.80		— 4.13	+ 7.12
November	—15.2	—16.5	— 6.90	— 3.12	—15.6	—22.27	—22.0	—12.70	—18.3	—18.60	— 6.64		—21.96	—11.86
December	—20.0	—26.1	—22.20	—24.7	—24.1	—31.93	—22.0	—26.50	—28.0	—27.05	—35.50		—31.00	—33.75
Mean annual temp.	+2.15	. .	+ 0.47	Both years +3.06		. .	+0.41	+ 0.86	—1.80	+ 4.32	— 0.59		— 2.20	+ 2.02
	Thermometer not tested or compared.	Same remark; 22 days only, in May, 1853, are taken.		Correction between zero and —20°, add (—1°); —20° and —50°, add (—2°).	Same correction.		Parry's voyage.		Only 23 days in Aug. 1854 are taken (1st to 23d).		Only 4 days of July spent in harbor, the remainder in Wellington Channel.		2d Grinnell Exp'n, E. K. Kane, vol. xi, Smith'n Cont'ns to Knowledge.	L. F. McClintock; results as deduced on preceding pages.

PART II.

WINDS.

RECORD AND DISCUSSION OF THE DIRECTION AND FORCE OF THE WIND.

THE direction and force of the wind was recorded at the same hours as those given in the preceding record of the observations for temperature, and are the same at which all other meteorological observations were made.

In the preface to the journal containing the original record, Captain McClintock states—"The true direction of the wind is given throughout;" and "the force of the wind is indicated according to the Beaufort scale of notation, 0 to 12, see Admiralty's Manual." Comparing the direction of the wind given in the fourth number of Meteorological Papers published by authority of the Board of Trade, 1860, I find that for a part of the cruise the magnetic direction is given, which in Captain McClintock's record is already converted into "true," the magnetic variation having been applied; I have, therefore, added to the record of the wind the observed variation of the needle to show the amount allowed for in the conversion of the directions. The proper reduction of the winds requires a knowledge of the velocity of the air corresponding to each number expressing the force according to Beaufort's scale; this I have derived from the following table:—

Denomination of wind.	Estimated number of force.	Pressure in pounds per square foot.	Velocity in miles per hour.
Calm	0	0.000	0
Light air	1	0.005	1
Gentle breeze	2	0.08	4
Moderate breeze	3	0.9	13
Fresh breeze	4	2.6	23
Strong breeze	5	5.1	32
Fresh gale	6	7.9	40
Strong gale	7	12.0	50
Storm	8	18.0	60
Tempest	9	31.0	80
Hurricane	10	49.0	100

The relation of the tabular numbers of pressure and velocity is in accordance with Smeaton's table, and also agrees with that following from Dr. Bernoulli's formula. By simple proportion, or by means of a diagram, we obtain the following velocity number corresponding to Beaufort's scale, or to a graduation from 0 to 12.

Force according to Beaufort's notation.	Corresponding adopted velocity in miles per hour.	Force according to Beaufort's notation.	Corresponding adopted velocity in miles per hour.
0	0	7	40
1	1	8	48
2	4	9	56
3	10	10	67
4	17	11	82
5	24	12	100
6	32		

The force of the wind being obtained by estimation, a moderate accuracy in the velocity numbers suffices.

Record of the Observations for Direction and force of the Wind.

This record may be divided in two parts; the first part comprising the period from September, 1857, to August, 1858, when the ship was in Baffin's Bay, and the second part between September, 1858, and August, 1859, when she was at Port Kennedy. These two periods will be discussed separately. The daily and mean monthly positions of the Fox are given in the record of the temperatures; those for the several seasons are as follows:—

	Between mean lat's—		and	Mean long's—	
Autumn—Sept., Oct., Nov., 1857 . .	75°.3 and	74°.8 N.		65°.0 and	69°.1 W. of Gr.
Winter—Dec., Jan., Feb., 1857–8 . .	74.3	71.5		67.4	60.9
Spring—March, April, May, 1858 . .	69.4	68.7		59.1	53.7
Summer—June, July, Aug., 1858 . .	74.6	73.1		60.1	88.5
Whole year—average position, Baffin's Bay	72°.5 N.		and	65°.8 W. of Gr.	
Second year—at Port Kennedy . . .	72.0			94.2	

Remarks relating to winds are given in notes.

Direction (true) and Force of the Wind observed on board the yacht Fox.

July, 1857.—Mean position: Lat. 62° N.; long. 39°.1 W. of Greenwich.

DATE.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Varia'n allow'd.	REMARKS.
1	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -		
2	2 S. S. W.	2 W. S. W.	4 S. W.	4 S. by W.	4 S.W. byW.	4 S. S. W.		The variation applied for the 2d, 3d, 4th, and 5th is not given.
3	6 S.	4 S.	5 S. S. W.	1 N. W.	Calm	4 N. E. by N.		
4	5 N. E. by N.	5 N. E. by N.	5 N. E. by N.	6 N. E. by N.	6 N. by E.	7 N. by E.		
5	6 N.	6 N.	4 N.	2 W. N. W.	2 W. N. W.	2 N.W.byW.		
6	2 N.W.byW.	1 S. W.	1 N. W.	1 W. N. W.	1 W. N. W.	1 N. W.	W.	
7	1 E.	Calm	1 E.	1 E.	3 E. S. E.	4 E. S. E.	36°	
8	6 E. S. E.	6 E. S. E.	6 E. S. E.	7 E. by S.	7 E. by S.	7 E. by S.	37	
9	7 E. by S.	7 E. by S.	5 E.	3 E.	2 E.	1 S'ly	42	
10	2 E.	4 E. N. E.	6 E. N. E.	5 E. by N.	1 E. by N.	1 var.	47	
11	1 N. N. E.	4 N. N. E.	5 N. N. E.	5 N. N. E.	6 N. N. E.	7 N. N. E.	51	
12	7 N. N. E.	6 N.	4 N. by W.	4 N. N. E.	4 N. N. E.	2 N.	52	
13	2 N. W.	1 N. W.	1 W. N. W.	1 W. N. W.	1 N'ly	1 N'ly	55	
14	Calm	1 E'ly	2 S. E.	2 E'ly	4 E'ly	4 E. by S.	55	
15	Calm	1 S. E.	4 N. W.	4 W. by N.	5 N. N. W.	1 N. N. W.	55	
16	1 W. by N.	1 S. W.	1 S. W. by S.	1 S. W.	1 S. W.	2 N. N. E.	55	15th. Current N. N. W. 18'.
17	4 N. W.	4 N. W.	5 N. W.	4 N. W.	4 N.W. by N.	2 N.W. by N.	55	
18	2 N.W.byW.	2 N.W. by N.	3 N. W., E.	2 N. N. W.	2 N.W. by N.	2 N.W. by N.	56	
19	2 N.	- - - -	- - - -	4 S. W.	5 S. W.	5 S. S. W.	59	
20	6 S.	6 S.	5 S. by E.	4 S. W.	3 N. W.	3 N. W.		19th. Current N. N. W. 18'; variation applied, between the 19th & 26th not stated.
21	4 N. W.	2 S. W.	2 S. W.	2 N.W.byW.	2 N.W.byW.	2 W.		
22	5 N.W. by N.	5 N.W. by N.	5 N.W. by N.	5 N.W. by N.	3 N.W. by N.	3 N.W. by N.		
23	4 N.W. by N.	4 N.W. by N.	6 N.W. by N.	4 N.W. by N.	2 N.W. by N.	2 N.W. by N.		
24	Calm	4 S. W.	6 S. E. by S.	2 S. W. by S.	1 N. W.	3 N. W.		
25	5 N.	5 N.	1 N. N. W.	2 N. N. W.	1 N.	1 N.		
26	1 N.	1 N.	2 N.	2 N.	2 N.	2 N.		
27	5 N.	4 N.	3 N. by W.	3 N. by W.	5 N. N. W.	4 N. N. W.	62	
28	2 N. N. W.	1 N. N. W.	2 S. S. E.	4 E. S. E.	6 E. S. E.	7 E. S. E.	64	
29	7 E. S. E.	4 E.	4 E.	2 S. S. E.	2 S.	1 S.	70	
30	2 W. N. W.	4 N.W. by N.	5 N.W. by N.	7 N.W. by N.	7 N.W. by N.	2 N.W.byW.	72	
31	2 E. by S.	2 E. N. E.	Calm	Calm	Calm	Calm		

August, 1857.—Mean position: Lat. 74° N.; long. 59°.8 W.

DATE.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Varia'n allow'd.	REMARKS.
1	Calm	Calm	Calm	3 S'ly	4 E. S. E.	5 S. E. by E.	W.	
2	4 S. E. by E.	3 N. E.	1 E'ly	1 E'ly	Calm	Calm	72°	
3	1 E'ly	Calm	Calm	4 E. by S.	4 S. E. by S.	6 S. E. by S.		
4	6 S. E. by S.	2 S. E. by S.	8 S. E. by S.	6 N.W.byW.	4 N.W.byW.	4 W. N. W.		
5	5 W.	5 W.	4 W.	5 W. by S.	5 W. by S.	5 W. by S.	76	4th. Baffling winds with strong gusts.
6	4 S'ly	5 S'ly	6 S. S. E.	6 S. S. E.	8 S. S. E.	4 S. S. E.		
7	1 S. E. by S.	3 W. N. W.	2 N. N. W.	2 N'ly	1 N'ly	3 N'ly	80	
8	3 N. E. by E.	2 N. E. by E.	2 N. E. by E.	4 E. by N.	4 E'ly	5 E'ly		
9	5 S. E.	5 S.	5 S. S. E.	3 S. S. E.	3 S.	3 S. E.	82	
10	3 S. S. E.	3 S. S. E.	3 S. S. E.	1 W. N. W.	2 W'ly	2 N. W.	87	
11	4 N. W.	3 W. N. W.	4 N. W.	3 N. W.	3 N. W.	2 N. W.	90	
12	1 N. W.	1 S. W.	2 S. E.	2 S. E.	Calm	Calm	90	
13	Calm	Calm	Calm	Calm	1 N'ly	1 N. E. by N.	90	
14	Calm	Calm	Calm	Calm	Calm	Calm		
15	Calm	Calm	Calm	3 N. W.	3 N. W.	3 N. W.	87	Var'n observed.
16	1 W'ly	Calm	2 S. S. E.	3 S. S. E.	3 S. S. E.	5 S. S. E.	90	
17	6 S. E.	4 S. E.	2 S. S. E.	4 S. S. E.	4 S. E.	6 S. E.	90	
18	5 S. E.	4 E. S. E.	3 E. S. E.	2 S. E.	1 S. E.	1 S. E.	90	
19	1 E. N. E.	1 E. N. E.	1 E. N. E.	2 S.	3 S. S. E.	5 S'ly	92	
20	6 S. E.	5 E.	4 S. E. by S.	3 S. E. by S.	2 S. E. by S.	2 S. E.	92	
21	1 S. E.	2 S. S. E.	2 S. W. by S.	1 S. W. by S.	1 S. W. by S.	Calm	92	
22	1 N. W.	Calm	Calm	1 S. E.	1 S. E.	1 E. S. E.	92	
23	1 E.	1 E.	4 E. N. E.	3 E.	2 E. N. E.	1 E. N. E.	92	
24	1 N. E.	2 N. by E.	2 N.W. by N.	3 N.W. by N.	3 N.W. by N.	3 N.	92 38'	Var'n observed.
25	3 N.	4 E. by S.	6 E.	6 E. by N.	6 E. by N.	5 E. by N.		
26	2 E. by S.	3 S. by E.	5 E. S. E.	3 E.	5 E. by N.	5 E. by N.	92 38	Var'n observed.
27	5 E.	6 E. S. E.	4 E. N. E.	3 N. E. by E.	2 E. N. E.	2 E. by S.	92 38	
28	Calm	2 E. by S.	1 E. S. E.	1 E. S. E.	1 S. S. E.	2 E. S. E.		
29	1 S. E.	1 S. E.	2 E. S. E.	1 N.W.byW.	4 W. N. W.	4 W. N. W.	92 30	31st. Var'n obs.
30	3 N.	3 N.	5 S. E.	7 E.	7 E. S. E.	8 E. S. E.		Ice stationary, afterwards driving
31	8 S. S. E.	8 S. E.	5 E. N. E.	3 N. N. W.	6 N.W.byW.	6 N.W.byW.	94 12	to N. N. W. & S. E.

Direction (true) and Force of the Wind observed on board the yacht Fox.

September, 1857.—Mean position: Lat. 75°.3 N.; long. 65° W.

Date.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Variation allowed.
1	2 N. W.	2 E.	2 S. W.	1 W. N. W.	2 S. S. W.	3 S. E.	
2	3 S. E.	3 S. by E.	1 E.	Calm	Calm	1 N. W.	
3	1 N. W. by W.	1 N. W. by W.	1 N. W. by W.	1 N. N. W.	1 N. N. W.	1 N. W. by W.	
4	3 S. S. W.	3 S.	3 S. E. by S.	4 S. E.	5 E. S. E.	6 E. by S.	
5	1 N. E.	2 S. E.	2 E. by N.	2 E.	Calm	2 S. E.	W.
6	3 S. S. E.	2 S. E. by E.	3 E.	3 E. N. E.	3 N.	3 N. N. W.	94° 28′
7	5 N. N. W.	5 W. by S.	3 W. S. W.	3 E.	4 N. E.	6 E. S. E.	
8	8 W. S. W.	7 S. S. W.	6 S. E.	7 S. E.	6 S. by W.	6 S. E. by S.	
9	5 S. by E.	5 S. E. by S.	6 S. by E.	5 S. by E.	7 S. by E.	6 S. by E.	
10	5 S. E. by S.	2 S. by E.	3 S. by E.	1 S. by E.	1 W. N. W.	1 W. by S.	
11	2 S. by E.	4 E. by S.	5 S. E.	7 S. E.	6 S. E.	6 S. S W.	
12	4 W. by S.	2 W. by N.	2 W.	2 W. by N.	1 W. by N.	1 W. by N.	
13	4 W. by N.	3 W. N. W.	1 W. by N.	2 N. W.	3 S. S. E.	4 E. by N.	94 4
14	5 E.	4 S. E. by S.	4 S. S. E.	6 S. by E.	6 W. by S.	3 W.	
15	1 W. by S.	2 S. by E.	2 N. N. W.	1 S. E. by S.	1 E. by S.	2 E. N. E.	
16	4 E. by S.	3 E. by S.	4 E. by S.	3 E. by S.	4 E. S. E.	2 E. by N.	
17	2 N. E.	1 N. by W.	1 N. W. by N.	1 N. N. W.	1 N. W.	2 W.	95 16
18	2 N. by E.	2 N. N. W.	3 N. W.	4 N. W.	5 W. N. W.	2 W. N. W.	
19	5 N. E.	3 N. N. W.	1 N.	2 N. E. by W.	2 N. E. by N.	2 N. E.	
20	2 N. W. by N.	2 N. by E.	2 N. E.	3 N. W.	4 N. W. by W.	4 N. W. by W.	
21	4 N. W. by W.	4 N. W. by W.	5 N. W. by W.	6 N. W. by W.	4 N. W.	2 N. N. W.	
22	4 W.	4 N. W. by W.	6 W. N. W.	6 W. N. W.	6 W. by S.	7 W. N. W.	
23	2 W. N. W.	2 N. W.	2 N. N. W.	1 W. N. W.	Calm	Calm	94 14
24	3 E. by S.	5 N. N. E.	6 N. N. E.	3 N. W.	2 N. W.	4 N. W:	
25	6 N. W.	4 N. W.	2 N. W.	2 N. W. by N.	1 N. E.	1 N. E.	
26	2 N. N. E.	2 W. by S.	3 N. W. by W.	3 N. W. by W.	3 N. W. by W.	3 W. N. W.	
27	2 N. W. by W.	3 N. N. W.	4 E. N. E.	4 N. E.	3 E. N. E.	3 N. E. by N.	
28	1 N. N. E.	Calm	2 E.	2 N. N. E.	Calm	Calm	
29	2 N. W. by W.	2 W. N. W.	1 W. N. W.	Calm	1 W. N. W.	1 W. N. W.	
30	Calm	1 N. W. by W.	4 N. N. W.	5 N. W. by W.	5 N. W. by W.	2 W. N. W.	
	2h.	6h.	10h.	2h.	6h.	10h.	
30	Calm	1 N. W.	2 N. W. by W.	4 N. W. by W.	4 N. W. by W.	2 W. N. W.	

Remarks.

1st. Ice driving to S. W., and afterwards to N. W.
2d. " " N. and N. W.
3d. " " S. E. and N. W.
4th. " " E., S. W., and W.
5th. Ice drift to westward.
6th. Var'n observed. Ice drift to S., N. W., & S. W.
7th. Ice drift to S. E. and N. W.
8th. " N. W. and N.
9th. " westward.
10th. " S. W., N. E. and E.
11th. " westward and N. W.
12th. " eastward and westward.
13th. " N. E. and N. W.
14th. " westward.
15th. " northward.
16th. Ice drift to S. W.
17th. " S. W.
18th. " S. W. and S. E.
19th. " N. and S. E.
20th. " S. E.
21st. " S. E.
22d. " S. E.
23d. " S. E., N. E., and S. W.
24th. " S. E.
25th. " S. E. and S.
26th. " S. E.
27th. " S. E. and S. W.
28th. " S. E. and S. W.
29th. " S. E.
30th. " S. E.

Direction (true) and Force of the Wind observed on board the yacht Fox.

October, 1857.—Mean position: Lat. 75°.2 N.; long. 67°.9 W.

DATE.	2h.	4h.	6h.	8h.	10h.	Noon.
1	1 W. N. W.	1 W. N. W.	Calm	2 S. by E.	2 E. N. E.	2 E. N. E.
2	3 E. S. E.	1 E. S. E.	Calm	Calm	1 W.	1 N. W.
3	2 W. N. W.	2 W. N. W.	2 W. N. W.	2 N. W. by W.	2 N. W. by W.	2 N. W. by W.
4	4 N. W. by W.	4 N. W.	3 N. W.	3 N. W. by W.	2 W. N. W.	2 W. N. W.
5	2 N. N. W.	1 N. W.	3 N. W.	5 N. W.	5 N. W.	5 N. W. by W.
6*	2 N. W.	2 N. W.	2 N. by E.	1 N. by E.	1 N. by W.	1 N. by W.
7	Calm	Calm	1 S. by E.	1 S. by E.	1 S. by E.	1 S. S. W.
8	2 W. S. W.	1 W. S. W.	2 S. S. E.	2 S. E. by S.	1 E. by S.	1 E. by S.
9	1 E. by S.	1 E. by S.	1 N. W. by N.	2 N.	4 N. E.	5 N. E.
10	4 W. N. W.	4 W. N. W.	2 W. N. W.	2 W. N. W.	2 W. N. W.	2 W. N. W.
11	2 N. W. by W.	2 N. W. by W.	2 W. N. W.	3 W. N. W.	2 W. N. W.	2 W. N. W.
12	4 W. N. W.	4 W. N. W.	4 W. N. W.	4 N. W.	3 W. by N.	2 W. by N.
13	1 W. by N.	1 W. by N.	1 W.	1 W.	1 E. N. E.	2 E. N. E.
14	8 E. N. E.	9 E. N. E.	8 E. S. E.	8 E. S. E.	8 E. S. E.	8 E. S. E.
15	7 E. S. E.	7 E. S. E.	6 S. E. by E.	6 S. E. by E.	7 S. E.	7 S. E.
16	4 E. S. E.	4 E. S. E.	4 E. S. E.	2 S. E.	2 S. E.	3 E. by S.
17	6 S. S. E.	4 S. S. E.	4 E. by S.	5 E.	6 N. E.	6 N. E.
18	2 E. by S.	1 E. by S.	3 W.	2 W.	3 W. S. W.	3 S. by W.
19	2 N. W.	5 N. W.	5 N. W.	4 N. W.	4 W. N. W.	4 W. N. W.
20	4 E. S. E.	4 E. S. E.	3 S. S. E.	2 S. W. by S.	2 S. W. by S.	2 S. W. by S.
21	6 S. by E.	4 S. by E.	5 S. E. by S.	5 S. E. by S.	4 S. E. by S.	4 S. E.
22	2 N. E. by E.	5 N. E. by E.	8 N. W. by W.	9 N. W. by W.	9 W. by N.	9 W. by N.
23	6 S. W.	4 S. W.	2 S. W.	2 S. W.	2 S. W.	2 S. W.
24	5 W. by N.	6 N. W.	6 N. W.	6 W. N. W.	3 W. N. W.	2 W. N. W.
25	Calm	Calm	1 W.	1 W.	1 E. by N.	1 N. N. W.
26	2 N. W. by W.	2 N. W. by W.	1 W. by S.	1 W. by S.	1 S. W. by W.	1 S. W. by W.
27	1 S. E. by E.	1 S. E. by E.	1 S. E. by E.	1 N. W.	1 W.	3 N. W.
28	8 N. W.	9 N. W.	7 N. W.	6 N. W.	6 N. W.	2 N. W.
29	3 E. by N.	2 E. by N.	1 E. by N.	1 N. W. by W.	1 N. W. by W.	1 N. W. by W.
30	3 N. W.	4 N. W.	4 N. W.	1 N. E. by E.	2 E. N. E.	2 E. N. E.
31	2 N. E. by N.	3 N. E. by N.	4 N. E. by N.	2 N. by E.	3 N. by E.	3 N. by E.

DATE.	2h.	4h.	6h.	8h.	10h.	Midn't.
1	2 S. E. by E.	1 S. E. by E.	6 N. E.	4 E.	5 E. S. E.	4 E. S. E.
2	1 E. by N.	1 S. S. E.	1 W.	1 W.	Calm	3 W.
3	2 N. W.	2 N. W. by N.	2 N. W. by N.	2 N. W. by N.	2 N. W. by W.	3 N. W. by W.
4	2 W. N. W.	2 W. N. W.	2 W. N. W.	1 W. N. W.	2 W. by N.	2 W. by N.
5	3 W. N. W.	3 W. N. W.	2 W. N. W.	1 W. N. W.	3 N. W.	2 N. N. W.
6	1 N. by W.	2 N. W.	2 N. W.	2 W.	2 W.	Calm
7	1 S. W.	1 S. W.	1 S. W.	Calm	Calm	1 S. W.
8	1 E. by S.	1 E. by S.	1 E. by S.	1 E. by S.	Calm	1 E. by S.
9	4 N. E.	4 N. E.	3 N. N. E.	4 N. N. E.	4 N. N. E.	4 N. N. E.
10	2 W. N. W.	2 W.	2 W.	2 W.	2 W.	2 W.
11	2 W. N. W.	3 W. N. W.	3 W. N. W.	2 W. N. W.	3 W. N. W.	2 W. N. W.
12	2 W. by N.	2 W. by N.	1 W. by N.	2 W. by N.	2 W. by N.	2 W. by N.
13	4 E. N. E.	3 E. N. E.	4 E. N. E.	6 E. N. E.	6 E. N. E.	7 E. N. E.
14	7 S. S. E.	6 S. by E.	4 S. by E.	3 S. E. by S.	4 S. E.	7 S. E. by S.
15	3 S. S. E.	3 S. E. by S.	2 S. S. E.	Calm	Calm	Calm
16	3 E. by S.	4 E. by S.	5 E. by S.	6 E.	7 E. by S.	9 S. S. E.
17	5 E. by N.	3 E. by N.	4 E. by N.	3 E. by N.	3 E. by N.	2 E. by S.
18	3 S. S. W.	1 S. by W.	1 S. by W.	Calm	Calm	1 W. N. W.
19	4 W. by N.	3 W. by N.	2 W. by N.	1 W. by N.	2 E. S. E.	2 E. S. E.
20	3 S. E.	5 S. E.	6 E. S. E.	7 S. E. by E.	7 S. by E.	7 S. by E.
21	3 S. E. by E.	2 S. E. by E.	2 N. by W.	5 E. by N.	5 N. E. by E.	4 N. E. by E.
22	9 W. by N.	8 W. by N.	8 W. by N.	7 W.	6 S. W. by W.	6 S. W. by W.
23	2 S. W.	2 S. W.	2 S. W. by W.	2 S. W. by W.	2 S. W. by W.	3 W. by S.
24	1 W.	Calm	1 W. by S.	1 E. by S.	1 E. by S.	1 E. by S.
25	1 E. by S.	Calm	1 W. by S.	1 W. by S.	2 W. by S.	3 N. W. by W.
26	1 S. S. W.	2 S. S. W.	2 S. S. W.	Calm	Calm	Calm
27	3 N. W. by W.	4 N. W. by W.	5 N. W. by W.	7 N. W. by W.	8 N. W. by W.	8 N. W. by W.
28	2 N. W. by W.	1 E.	1 E.	Calm	1 N. E. by N.	1 N. E. by W.
29	2 N. W. by W.	2 N. W. by W.	2 N. W. by W.	4 N. W. by W.	6 N. W. by W.	4 N. W. by W.
30	2 E. N. E.	2 E. by N.	1 E. by N.	2 E. by W.	3 E. by W.	3 E. by N.
31	4 N.	4 N.	5 N.	3 N.	4 E. N. E.	6 E. N. E.

* Variation 92° W.

DIRECTION (TRUE) AND FORCE OF THE WIND OBSERVED ON BOARD THE YACHT FOX.

November, 1857.—Mean position: Lat. 74°.8 N.; long. 69°.1 W.

DATE.	2h.	4h.	6h.	8h.	10h.	Noon.
1	4 E. by N.	4 E. by N.	4 E. by N.	5 E. by N.	4 E. by N.	1 E. by N.
2	4 N. W. by W.	3 N. W. by W.	Calm	Calm	Calm	1 E. S. E.
3	1 E. N. E.	3 E. N. E.	2 N. N. E.	1 S. W. by S.	2 S. W. by S.	3 S. W. by S.
4	1 E. N. E.	5 E. N. E.	4 E. N. E.	2 E. N. E.	3 E. by S.	3 E. by S.
5	3 N. W.	3 N. W.	3 N. W.	2 N. W.	1 N. N. W.	1 N. N. W.
6	3 W. N. W.	3 W. N. W.	3 W. N. W.	3 W. N. W.	2 W. N. W.	3 W. N. W.
7	8 N. W.	9 N. W.	9 N. W.	9 N. W.	8 N. W.	4 N. W.
8	3 W. N. W.	4 W. N. W.	4 W. N. W.	3 W. N. W.	2 W. N. W.	4 W. N. W.
9	6 N. W. by W.	5 N. W. by W.	5 N. W. by W.	5 N. W. by W.	3 N. W. by W.	4 N. W. by W.
10	5 W. by S.	5 W. S. W.	3 S. W. by W.	2 S. S. E.	3 S. by W.	3 S. by W.
11	1 N. E. by N.	2 N. E. by N.	1 W.	2 W. S. W.	2 N. W.	2 N. W.
12	7 N. W. by W.	7 N. W. by W.	5 W. N. W.	4 W. N. W.	3 W.	3 W.
13	Calm	2 W.	2 W.	Calm	2 W. by N.	2 W. by N.
14	4 E.	4 E.	6 E.	7 E. S. E.	7 E. S. E.	7 E. S. E.
15	2 S.	2 S.	4 S.	5 S.	6 E. by N.	5 E. by N.
16	7 E. S. E.	7 E. S. E.	5 E. S. E.	2 E. S. E.	1 E. S. E.	1 E. S. E.
17	8 S.	8 S.	9 W. S. W.	9 W. S. W.	8 S. S. E.	8 S. S. E.
18	Calm	Calm	Calm	1 W.	1 W. N. W.	3 W. N. W.
19	1 W. N. W.	1 W. N. W.	Calm	1 W. N. W.	1 W. N. W.	2 W. N. W.
20	1 S. by W.	1 S. by W.	1 S. by W.	1 S. by W.	1 S. by W.	1 S. by W.
21	4 N. E.	5 N. E.	3 N. E.	2 N. E.	2 S. E. by E.	4 E.
22	9 N. E. by E.	9 N. E. by E.	9 N. E. by E.	9 N. E. by E.	9 N. E. by E.	9 N. E. by E.
23	9 S. S. W.	9 S. S. W.	8 S. S. W.	7 S. S. W.	6 S. S. W.	4 S. S. W.
24	3 S. W.	2 S. W.	1 S. W.	1 S. W.	1 S. W.	Calm
25	2 S. S. E.	4 S. S. E.	5 N. E. by E.	5 N. E. by E.	1 S. E.	1 S. E.
26	7 W.	6 W. N. W.	5 W. N. W.	4 W. N. W.	3 W. N. W.	4 W. N. W.
27	6 N. W.	6 N. W.	6 N. W.	6 N. W.	6 N. W.	5 N. W.
28	5 W. N. W.	6 W. N. W.	6 W. N. W.	5 W. N. W.	5 W. S. W.	5 W. by N.
29	5 W.	6 W.	6 W.	7 W.	7 N. W.	6 N. W.
30	3 W. by N.	2 W. by N.	2 W. by N.	2 N. W.	1 N. W.	1 N. W.

DATE.	2h.	4h.	6h.	8h.	10h.	Midn't.
1	1 E. N. E.	1 E. N. E.	2 E. N. E.	2 N. W.	2 N. W.	4 N. W.
2	1 E. S. E.	1 E. S. E.	1 E. S. E.	1 E. S. E.	2 E. S. E.	Calm
3	3 S. W.	2 S. W.	2 S. W.	1 S. W.	2 N. W. by W.	2 N. W. by W.
4	3 E.	3 E.	2 E.	1 E.	1 E.	1 N. W.
5	2 N. W.	1 N. W.	1 N. W.	Calm	Calm	3 N. W. by W.
6	3 N. W.	3 N. W.	6 N. W.	7 N. W.	7 N. W.	8 N. W.
7	2 N. W. by N.	2 N. W. by N.	3 N. W. by N.	2 N. W. by N.	4 N. W.	4 N. W.
8	4 W. N. W.	5 W. N. W.	4 W. N. W.	3 W. N. W.	2 W. N. W.	1 W. N. W.
9	3 N. W. by W.	5 W.	7 W.	7 W.	7 W.	6 W.
10	2 S. S. W.	2 S. S. W.	2 S. S. W.	1 S.	1 N. E.	1 N. E.
11	2 N. W.	3 N. W.	4 N. W.	5 N. W.	7 N. W.	7 N. W.
12	3 W.	3 W. by N.	5 W. by N.	5 W. by N.	4 W. by N.	1 W. by N.
13	1 S. W.	1 S. W.	2 S. S. E.	3 S. S. E.	2 E. by N.	2 E. by W.
14	7 E. S. E.	5 E. S. E.	5 E. S. E.	6 E. S. E.	1 E. S. E.	1 E. S. E.
15	6 E. by N.	5 E. by N.	4 N. E. by E.	5 N. E. by E.	3 N. E. by E.	4 N. E. by E.
16	1 S. W. by S.	1 S. W. by S.	1 S. W. by S.	3 S. W. by S.	4 S. W. by S.	6 S. W. by S.
17	8 S. S. E.	8 S. S. E.	5 S. S. E.	5 S. S. E.	2 S. S. E.	1 S. S. E.
18	3 W. N. W.	2 W. N. W.	2 W. N. W.	2 W. N. W.	2 W. N. W.	2 W. N. W.
19	2 W. by N.	2 W. by N.	1 W. by N.	Calm	Calm	Calm
20	Calm	Calm	1 N. E.	1 N. E.	1 N. E.	1 N. E.
21	3 S. E.	6 S. E. by E.	6 N. E. by E.	7 N. E. by E.	8 N. E. by E.	8 N. E. by E.
22	9 S. E. by S.	9 S. S. E.	9 S. S. E.	9 S. S. E.	9 S. S. E.	9 S. S. E.
23	4 S. by W.	4 S. by W.	4 S. W. by S.	3 S. W. by S.	4 S. W. by S.	3 S. W. by S.
24	Calm	Calm	Calm	2 S.	3 S.	2 S. S. E.
25	3 N. W. by W.	3 N. W. by W.	5 N. W. by W.	6 S. W. by W.	6 W. S. W.	6 W. by S.
26	7 W. by N.	7 W. by N.	7 W. by N.	6 W. by N.	6 W. by N.	6 W. by N.
27	5 W. by N.	4 W. by N.	5 W. by N.	5 W. by N.	5 W. by N.	5 W. by N.
28	5 W. by N.	4 W. by N.	4 W. by N.	4 W. by N.	5 W. by N.	4 W. by N.
29	6 N. W.	6 N. W.	6 W. by N.	5 W. by N.	2 W. by N.	1 W. by N.
30	1 N. W.	1 N. W.	1 N. W.	1 N. W.	1 N. W.	1 N. W.

Direction (true) and Force of the Wind observed on board the yacht Fox.

December, 1857.—Mean position: Lat. 74°.3 N.; long. 67°.4 W.

DATE.	$2^{h.}$	$4^{h.}$	$6^{h.}$	$8^{h.}$	$10^{h.}$	Noon.	Variation.
1	1 N. W. by W.	1 N. W. by W.	2 N. W. by W.	1 N. W. by W.	1 N. W. by W.	1 N. W. by W.	
2	1 N. W.	1 N. W.	1 N. W.	1 N. W.	1 N. W.	1 N. W.	
3	1 N. W. by N.	1 N. W. by N.	2 N. W. by N.	1 N. W. by N.	1 N. W. by N.	2 W. S. W.	
4	3 S. by W.	3 S. by W.	2 S. by W.	2 S. by W.	3 S. by W.	3 S. by W.	
5	2 S. by E.	2 S. by E.	4 W. by N.	4 W. by N.	5 W. by N.	6 W. by N.	
6	7 N. W. by W.	8 N. W. by W.	8 N. W. by W.	7 N. W. by W.	3 S. S. E.	3 S. S. E.	
7	5 S. S. E.	5 S. S. E.	3 S. S. W.	1 S. S. W.	1 S. S. W.	1 S. S. E.	
8	3 N. E.	2 N. E.	Calm	Calm	1 N. W.	1 N. W.	
9	3 N. W. by W.	1 N. W. by W.	1 N. W. by W.	1 S. S. E.	1 S. E.	1 S. E.	
10	1 N. W.	1 N. W.	1 N. W.	1 N. W.	2 N. N. E.	2 N. N. E.	
11	1 N. W. by N.	1 N. W. by N.	1 N. W. by N.	1 N. W. by N.	2 N. W. by N.	2 N. W. by N.	
12	6 N. E. by E.	6 N. N. W.	8 N. W. by N.	8 N. W. by N.	8 N. W.	9 N. W.	
13	7 W. N. W.	7 W. N. W.	7 N. W. by N.	7 N. W. by N.	7 N. W. by W.	7 N. W. by W.	
14	3 N. W.	2 N. W.	2 W. S. W.	1 W. S. W.	1 W. S. W.	1 S. W.	
15	Calm	Calm	Calm	Calm	Calm	1 W. S. W.	
16	1 W.	1 W.	1 N. E.	1 W. N. W.	1 W. N. W.	1 W. N. W.	
17	2 N. E.	2 N. E.	2 N.	3 N. N. W.	2 N. W.	2 N. W.	
18	3 W.	4 W.	3 W.	3 W.	2 W.	1 W.	
19	Calm	2 S.	2 S.	2 S.	4 W. N. W.	4 W. N. W.	
20	3 N. E.	4 E. by N.	5 W. S. W.	4 S. by W.	4 S. by E.	4 S. by E.	
21	4 S. W.	5 N. W.	6 N. W.	7 N. W.	7 W. N. W.	6 W. N. W.	
22	1 S. W.	2 S. by E.	4 S. by E.	5 S. by E.	4 S. by E.	4 S. by E.	92° W.
23	5 S. S. E.	5 S. S. E.	5 S. S. E.	4 S. S. E.	4 S. S. E.	4 S. S. E.	(about)
24	1 S. E.	1 S. E.	1 N. E.	1 N. N. E.	1 N. N. E.	1 N. N. W.	
25	3 N. N. E.	3 N. N. E.	4 N. N. E.	5 N. by E.	4 N. by E.	4 N. by E.	
26	2 N. by E.	2 N. by E.	2 N. by E.	2 N. by W.	1 N. by W.	1 N. by W.	
27	4 N. by W.	5 N. by W.	4 N. W.	6 N. W.	6 N. W.	6 N. W.	
28	4 N. N. W.	4 N. N. W.	4 N. N. W.	5 N. by W.	4 N. by W.	2 N. W. by N.	
29	6 S. E. by S.	7 S. E. by S.	7 S. E. by S.	6 S. E.	6 S. by E.	5 S. by E.	
30	3 S. by W.	2 S. by W.	1 W. by N.	1 W. by N.	2 N. E.	2 N. E.	91° W.
31	3 W. N. W.	2 W. N. W.	1 W. N. W.	2 S. W. by W.	2 W. by S.	2 W. by S.	(about)

DATE.	$2^{h.}$	$4^{h.}$	$6^{h.}$	$8^{h.}$	$10^{h.}$	Midn't.
1	1 N. W. by W.	1 N. W. by W.	1 N. W. by W.	1 N. W. by W.	1 N. W. by W.	1 N. W. by W.
2	1 N. W. by N.	1 N. W. by N.	1 N. W. by N.	1 N. W. by N.	1 N. W. by N.	1 N. W. by N.
3	3 W. S. W.	3 W. S. W.	2 S. W. by S.	2 S. W. by S.	1 S. W. by S.	2 S. W. by S.
4	3 S.	2 S.	4 S.	2 S.	3 S.	3 S.
5	6 W. by N.	6 W. by N.	7 W. by N.	8 W. by N.	8 N. W.	8 N. W.
6	3 S. E.	4 S. E.	3 S. E.	2 N. E. by N.	2 E'ly	4 E. S. E.
7	5 S. S. E.	5 S. S. E.	4 E. S. E.	1 E. S. E.	1 E. S. E.	1 N. E.
8	1 N. W.	1 N. W.	1 N. W.	1 N. W.	1 N. W.	3 N. W.
9	1 S. E.	1 S. E.	1 S. E.	1 S. E.	1 N. W.	1 N. W.
10	1 N. N. W.	1 N. N. W.	2 N. E.	2 N. E.	1 N. E.	1 N. E.
11	2 N. N. W.	3 N.	3 N.	3 N.	3 N.	4 N. N. E.
12	9 W. N. W.	9 W. N. W.	9 W. N. W.	9 W. N. W.	8 W. N. W.	6 W. N. W.
13	6 N. W. by W.	6 N. W. by W.	4 N. W. by W.	4 N. W. by W.	4 N. W. by W.	2 N. W. by W.
14	1 S. W.	1 S. W.	Calm	Calm	Calm	Calm
15	1 W. S. W.	1 W. S. W.	1 W. S. W.	1 W. S. W.	1 W. S. W.	1 W. S. W.
16	1 W.	1 W.	3 N.	3 N. E.	1 N. E.	1 N. E.
17	1 W. by N.	1 W. by N.	3 W. by N.	3 W. by N.	2 W. by N.	2 W.
18	1 N. W.	1 N. W.	1 N. W.	1 N. W.	1 W. by S.	1 W. by S.
19	2 W.	Calm	1 N. E.	1 N. E.	1 N. E.	3 N. E.
20	3 W. S. W.	3 W. S. W.	2 W. S. W.	2 W. S. W.	Calm	Calm
21	4 W. N. W.	4 W. N. W.	4 W. N. W.	1 W. N. W.	1 S. W.	1 S. W.
22	4 S. S. E.	4 S. S. E.	6 S. S. E.	5 S. S. E.	5 S. S. E.	5 S. S. E.
23	4 S. by E.	4 S. by E.	3 S. by E.	3 S. by E.	2 S. by E.	1 S. by E.
24	1 N. by E.	1 N. by E.	2 N.	1 N.	1 N.	1 N.
25	3 N. by E.	3 N. by E.	3 N. by E.	3 N. by E.	4 N. by E.	4 N. by E.
26	1 N. by W.	1 N. by W.	2 N. by W.	1 N. by W.	2 N.	3 N. by W.
27	6 N. W. by N.	6 N. W. by N.	7 N. N. W.	7 N. N. W.	7 N. N. W.	5 N. N. W.
28*	4 N. N. W.	5 N. N. W.	6 N. N. W.	4 N.	5 S. E. by S.	6 S. E. by S.
29	4 S.	3 S.	3 S.	3 S.	3 S. by W.	3 S. by W.
30	2 N. W.	2 N. W.	2 W. by N.	3 W. by N.	3 W. by N.	3 W.
31	2 W. by S.	2 W. N. W.	2 W. N. W.	1 W. N. W.	1 W. N. W.	1 W. N. W.

* At $8^{h.}$ $45^{m.}$ wind veered from N. by E. to S. E. by S.

Direction (true) and Force of the Wind observed on board the yacht Fox.

January, 1858.—Mean position: Lat. 73°.2 N.; long. 63°.7 W.

Date.	2h.	4h.	6h.	8h.	10h.	Noon.	Variation.
1	2 W. by N.	1 W. by N.	1 N. W.	1 N. W.	1 W. N. W.	1 W. N. W.	91° W.
2	3 W. by N.	4 W. by N.	4 W. by N.	4 W. by N.	4 W. N. W.	3 W. N. W.	(about)
3	4 N. N. W.	4 N. N. W.	4 N. N. W.	4 N. N. W.	5 N. N. W.	6 N. N. W.	
4	3 S. by W.	3 S. by W.	2 S. by E.	2 S. by E.	1 S. by W.	1 S. by W.	
5	5 S. by E.	5 S. S. E.	6 S. by W.	4 S. by W.	2 S. by W.	1 S. by W.	
6	5 N. by W.	4 N. by W.	4 N. by W.	5 N. N. W.	6 N. N. W.	6 N. N. W.	
7	8 N. W.	8 N. W.	7 N. W.	7 N. W.	7 N. W.	7 N. W.	
8	7 N. W.	7 N. W.	7 N. W.	6 N. W.	5 W. by N.	5 W. by N.	
9	7 W.	6 W.	5 W. N. W.	4 W. N. W.	3 W. N. W.	5 W. N. W.	
10	4 N. N. W.	4 N. N. W.	6 N. N. W.	5 N. N. W.	5 N. N. W.	5 N. N. W.	90
11	3 W. N. W.	3 W. N. W.	Calm	Calm	1 S. S. W.	1 S. S. W.	
12	1 S. by E.	1 S. by E.	Calm	Calm	Calm	1 S. E.	
13	4 N. N. W.	4 N. N. W.	5 N. N. W.	5 N. N. W.	3 N. W.	3 N. W.	89
14	2 S. S. W.	1 S. S. W.	1 S. S. E.	2 S. S. E.	2 S. E.	2 E. S. E.	
15	4 N. E.	5 N. E.	5 N. E.	3 N. E. by N.	3 N. E. by N.	3 N. E. by N.	
16	5 N. N. W.	5 N. N. W.	6 N. N. W.	6 N. N. W.	6 N. N. W.	6 N. W.	89
17	4 N. N. W.	4 N. N. W.	4 N. N. W.	4 N. N. W.	3 N. W.	4 N. W.	
18	2 W. by S.	2 W. by S.	1 W.	Calm	1 W.	1 N. N. W.	88
19	1 N. by E.	2 N. by E.	2 N. by E.	1 E. N. E.	1 N. N. W.	1 N. E. by E.	
20	4 E. S. E.	5 E. S. E.	2 E.	2 E.	2 E. by N.	2 E. N. E.	
21	7 N. N. W.	8 N. N. W.	8 N. N. W.	8 N. N. W.	7 N. W.	5 N. W.	88
22	1 N. by W.	1 N. by W.	1 N. by E.	1 N. by E.	1 N. N. E.	1 N. N. E.	87
23	8 N. N. W.	9 N. N. W.	9 W. N. W.	8 W. N. W.	6 W.	6 W.	87
24	Calm	Calm	1 S. W.	1 S. W.	1 S. W.	1 N. N. E.	
25	4 N. by W.	4 N. by W.	2 E. N. E.	2 N. N. E.	1 N. N. E.	1 N. N. E.	
26	3 W. N. W.	3 W. N. W.	4 W. by N.	6 W.	6 W. by N.	6 W. by N.	87
27	6 W.	7 W.	6 W.	4 W. by S.	3 W. S. W.	3 S. W. by W.	
28	1 S. E. by S.	1 S. E. by S.	1 S. E. by S.	1 S. E. by S.	1 S. E. by S.	1 S. E. by S.	
29	1 S. S. E.	Calm	1 W. S. W.	1 S. S. E.	1 E. by S.	1 E. by N.	
30	1 E.	1 E.	2 E. by S.	2 E. by S.	1 E. S. E.	1 E. S. E.	
31	1 S. E.	2 S. E.	1 E. N. E.	1 E. N. E.	3 N. by W.	4 N. by W.	86

Date.	2h.	4h.	6h.	8h.	10h.	Midn't.
1	1 W. N. W.	1 W. N. W.	2 W. N. W.	4 N. W.	2 N. W.	2 N. W.
2	2 W. N. W.	1 W. N. W.	2 N. by E.	2 N. N. W.	2 N. N. W.	3 N. N. W.
3	5 N. N. W.	6 N. W.	3 N. W.	3 N. W.	2 N. W.	2 S. by W.
4	2 S. S. W.	2 S. W.	1 S. by W.	1 S. by W.	1 S. by W.	1 S. by W.
5	1 S. by W.	2 N. by E.	4 N. by E.	3 N. by E.	2 N. by E.	4 N. by E.
6	5 N. W.	6 N. W.	6 N. W.	6 N. W.	7 N. W.	7 N. W.
7	7 N. W.	7 N. W.	6 N. W.	6 N. W.	6 N. W.	6 N. W.
8	5 W.	5 W.	6 W.	5 W.	5 W.	5 W.
9	4 W. N. W.	4 W. N. W.	4 N. W. by N.	5 N. N. W.	4 N. N. W.	4 N. N. W.
10	3 N. N. W.	4 W. N. W.	4 W. N. W.	4 W. N. W.	4 W. N. W.	4 W. N. W.
11	1 S.	1 S.	1 S.	1 S. by E.	1 S. by E.	1 S. by E.
12	1 N. E. by N.	1 N. N. E.	1 N. by E.	1 N. by E.	2 N. by W.	2 N. by W.
13	4 N. W.	4 W. by S.	4 S. S. W.	4 S. S. W.	3 S. S. W.	3 S. S. W.
14	2 E.	3 E.	3 E.	4 E.	3 N. E.	4 N. E.
15	2 N. E. by N.	3 N. E. by N.	3 N. E. by E.	3 N. by W.	5 N. by W.	5 N. N. W.
16	6 N. N. W.	6 N. W. by N.	6 N. W. by N.	4 W. N. W.	4 W. N. W.	4 W. by N.
17	5 N. W.	5 N. W.	6 W.	5 W.	4 W.	2 W.
18	1 N. N. W.	1 N. N. W.	1 N. by E.	1 N. by E.	1 N. by E.	1 N. by E.
19	1 N. N. E.	2 N. E. by E.	3 E. by N.	4 E.	4 E. by S.	4 E. S. E.
20	1 E. N. E.	1 E. N. E.	2 N. N. E.	3 N. N. E.	5 N.	7 N.
21	5 N. W.	5 N. W.	5 W. by N.	4 N. W. by N.	2 N. W. by N.	1 N. W. by N.
22	1 N. N. W.	2 N. N. W.	2 N. N. W.	4 N. N. W.	5 N. N. W.	6 N. N. W.
23	4 W. by N.	2 W. by N.	2 W. by N.	1 W. by N.	1 W. S. W.	1 W. by N.
24	1 N. by W.	1 N. by E.	3 N. by E.	3 N. W.	3 N. W.	3 N. W.
25	1 N. N. E.	1 N. N. E.	1 N.	3 N.	3 N. N. W.	3 N. N. W.
26	6 W. by N.	6 W. by N.	5 W. by N.	6 W.	6 W.	6 W.
27	3 S. by E.	3 S. by E.	3 S. S. E.	2 S. S. E.	2 S. S. E.	1 S. E. by S.
28	2 S. E. by S.	2 S. S. E.	2 S. S. E.	1 S. S. E.	1 S. S. E.	1 S. S. E.
29	1 E. by S.	1 E. by S.	1 E. by S.	2 E. by S.	1 E. by S.	1 E. by S.
30	1 E. S. E.	1 E. S. E.	1 E. S. E.	1 S. E.	1 S. E.	1 S. E.
31	5 N. by W.	5 N. by W.	7 N. by W.	7 N. by W.	7 N.	7 N.

Direction (true) and Force of the Wind observed on board the yacht Fox.

February, 1858.—Mean position: Lat. 71°.5 N.; long. 60°.9 W.

DATE.	2h.	4h.	6h.	8h.	10h.	Noon.	Variation.
1	9 N. N. W.	9 N. N. W.	8 N. N. W.	6 N. N. W.	5 N. N. W.	4 N. N. W.	86° W.
2	4 N. W.	4 N. W.	4 N. W.	4 N. W.	4 N. W.	3 N. W.	85
3	2 N. W.	2 N. W.	2 N. W.	2 N. W.	1 N. W.	1 N. W.	85
4	2 N. N. W.	2 N. N. W.	2 N. N. W.	2 N. N. W.	2 N. by W.	2 N. by E.	84
5	Calm	Calm	1 N.	1 N.	Calm	Calm	84
6	Calm	Calm	1 N. by E.	1 N. N. W.	1 N. N. W.	1 N. N. W.	
7	3 W. by N.	2 W. by N.	2 N. N. W.	3 W.	2 W.	1 W.	84
8	Calm	Calm	Calm	Calm	2 N. by W.	2 N.	85
9	3 N. N. E.	3 N. N. E.	3 N. by W.	3 N. by W.	3 N. by W.	4 N. by W.	85
10	9 N. N. W.	9 N. N. W.	9 N. N. W.	9 N. N. W.	8 N. N. W.	8 N. W. by N.	85
11	1 E. by N.	4 S. E. by S.	6 S. by E.	5 S. S. E.	5 S. S. E.	4 S. S. E.	
12	7 N. W. by N.	8 N. W. by N.	8 N. W. by N.	4 N. W. by N.	3 W. by N.	2 W. by S.	
13	4 N. N. W.	4 N. by W.	2 N. by W.	3 N. by W.	3 N. by W.	3 N. by W.	84
14	7 N. by W.	7 N. by W.	7 N. by W.	7 N. by W.	6 N. by W.	6 N. by W.	
15	8 N.	8 N.	7 N.	6 N. by W.	5 N. by W.	4 N. by W.	83
16	5 N. by W.	6 N. by W.	6 N. by W.	6 N. by W.	6 N. by W.	5 N. by W.	
17	6 N. by W.	9 N. by W.	5 N. by W.	3 N.	4 N.	4 N.	82
18	6 N. N. W.	6 N. N. W.	6 N. by W.	6 N. by W.	6 N. by W.	5 N.	
19	8 N. W.	8 N. W.	8 N. W.	7 N. W.	5 N. W. by N.	4 N. W. by N.	82
20	1 S. W. by S.	2 W. N. W.	2 W. N. W.	3 W. N. W.	4 N. N. W.	5 N. N. W.	
21	6 N. W. by W.	6 N. W. by W.	6 N. W. by W.	5 N. W. by W.	4 N. W. by W.	3 N. W. by W.	
22	1 S. W.	1 W. by S.	Calm	1 N. W. by W.	1 N. by W.	1 N. E. by N.	
23	7 N. N. E.	7 N. N. E.	7 N.	7 N.	7 N. by W.	7 N. by W.	81
24	7 N. by W.	7 N. W. by N.	8 N. W. by N.	9 N. W. by N.	9 N. N. W.	9 N. W. by N.	
25	10 N. W. by N.	10 N. W. by N.	10 N. W. by W.	9 N. W. by W.	9 N. W. by W.	8 N. W. by W.	
26	6 N. W. by W.	5 N. W. by W.	5 N. W. by W.	3 N. W. by W.	1 W. N. W.	1 W. N. W.	
27	3 S. by E.	2 S. by E.	2 S. by E.	2 S. by E.	2 S. by E.	2 S. by E.	
28	7 S. E. by S.	9 S. E. by S.	9 S. E. by S.	8 S. E. by E.	5 S. S. E.	4 S. S. E.	78 ab't

DATE.	2h.	4h.	6h.	8h.	10h.	Midn't.
1	4 N. N. W.	4 N. N. W.	4 N. N. W.	3 N. N. W.	3 N. N. W.	3 N. N. W.
2	4 N. W.	4 N. W.	6 N. W.	6 N. W.	5 N. W.	5 N. W.
3	1 S. W.	2 S. W.	2 S. W.	2 S. W.	1 S. W.	2 W. N. W.
4	2 N. by E.	2 N. by E.	1 N. by E.	1 N. by E.	1 N. by W.	Calm
5	1 S. by E.	1 S. by E.	1 S. by E.	1 S. by E.	1 S. by E.	Calm
6	1 W.	2 W.	4 W. by N.	3 W. by N.	4 W. by N.	3 W. by N.
7	1 W.	2 W.	1 W.	Calm	Calm	Calm
8	1 N. E.	1 N. E.	1 N.	2 N. N. E.	3 N. N. E.	3 N. N. E.
9	6 N. by W.	6 N. by W.	6 N. by W.	9 N. W.	9 N. N. W.	9 N. N. W.
10	8 N. W. by N.	8 N. W. by N.	8 N. W. by N.	5 N. N. W.	3 N. by W.	2 N. by E.
11	2 S. by E.	1 S. by E.	Calm	4 N. by W.	5 N. by W.	7 N. by W.
12	1 W. by S.	3 W. by S.	2 N. W.	2 N. W.	3 N. N. W.	4 N. N. W.
13	3 N. by W.	3 N. by W.	3 N. by W.	4 N. by W.	6 N. by W.	6 N. by W.
14	7 N. by W.	6 N. by W.	6 N.	6 N.	6 N.	6 N.
15	4 N. by W.	4 N. by W.	5 N. by W.	5 N. by W.	6 N. by W.	6 N. by W.
16	6 N. by E.	6 N. by E.	5 N. by E.	6 N.	5 N.	7 N. N. W.
17	4 N.	5 N. by W.	5 N. by W.	5 N. by W.	5 N. by W.	6 N. by E.
18	5 N.	5 N.	6 N.	6 N.	6 N. N. W.	7 N. W. by W.
19	2 N. W. by N.	2 W. N. W.	3 W.	4 W.	3 S. W. by S.	1 S. W. by S.
20	7 N. N. W.	7 N. N. W.	6 N. N. W.	6 N. W. by W.	6 N. W. by W.	6 N. W. by W.
21	3 N. W. by W.	2 W. N. W.	1 N. W. by W.	Calm	Calm	Calm
22	1 N. E. by N.	2 N. E. by N.	3 N. by W.	4 N. N. E.	6 N. N. E.	7 N. N. E.
23	6 N. by W.	5 N. by W.	4 N. W. by N.	6 N. W. by N.	6 N. by W.	7 N. by W.
24	9 N. N. W.	9 N. W. by N.	9 N. W. by N.	10 N. N. W.	10 N. N. W.	10 N. N. W.
25	7 N. W. by W.	6 N. W. by W.	7 N. W. by W.	6 N. W. by W.	7 N. W. by W.	7 N. W. by W.
26	Calm	1 S. E. by E.	1 S. E. by E.	2 S. by W.	2 S. by E.	3 S. by E.
27	2 E. S. E.	3 N. E. by E.	4 E. S. E.	4 S. by W.	4 S. by E.	6 S. E. by S.
28	2 S. E. by S.	1 N. by W.	1 N. E. by N.	1 N. E. by E.	1 N. E. by E.	1 N. E. by E.

Direction (true) and Force of the Wind observed on board the yacht Fox.

March, 1858.—Mean position: Lat. 69°.4 N.; long. 59°.1 W.

Date.	2h.	4h.	6h.	8h.	10h.	Noon.	Variation.
1	2 N. E. by E.	3 N. E. by E.	2 N. E. by E.	1 N. E. by E.	2 N. E. by E.	2 N. E. by E.	
2	7 S. by E.	7 S. by E.	6 S. by E.	2 S. W. by S.	2 S. by W.	1 S. W. by S.	
3	1 W. by N.	1 W. by N.	1 S. W. by W.	1 S. W.	1 N. by W.	1 N. by W.	
4	10 S. S. W.	9 S. S. W.	9 S. by W.	8 S. by W.	8 S. W. by S.	7 S. W. by S.	
5	1 S.	3 S.	1 S. W. by W.	1 S. W. by W.	1 S. W. by W.	1 S. W. by W.	78° W.
6	1 S. W. by W.	2 W. S. W.	4 N. W. by N.	3 N. W.	3 N. W.	3 N. W.	
7	1 N. W. by N.	1 N. W. by N.	3 N. N. W.	4 N. by W.	4 N.	5 N.	76
8	6 N. by W.	6 N. by W.	5 N. by W.	4 N. by W.	4 N. by W.	4 N. by W.	
9	2 N.	2 N. N. E.	2 N. N. E.	1 N. E. by E.	1 E. S. E.	2 E. by S.	
10	2 N. E. by N.	4 N. E. by N.	5 S. E. by S.	6 S. E. by S.	5 E. S. E.	3 E. S. E.	
11	3 S. E. by E.	3 S. E. by E.	6 S. E. by E.	5 S. E. by E.	5 S. E. by E.	5 S. E. by E.	
12	4 S. S. E.	5 S. S. E.	2 E. by S.	2 E. by S.	2 E. by S.	2 S. by W.	
13	2 E. by S.	5 S. by E.	5 S. S. E.	4 S. S. E.	3 S. S. W.	1 S.	
14	3 W.	3 W.	3 W. by N.	4 W. N. W.	3 W. N. W.	3 N. W. by N.	77 30′
15	4 N. W. by N.	4 N. W. by N.	4 N. W. by N.	5 N. W. by N.	5 N. W. by N.	7 N. W. by N.	
16	7 N. W. by N.	6 N. W. by W.	6 N. W. by W.	4 N. W. by W.	4 N. W. by W.	3 W. by N.	
17	4 N. W. by W.	4 N. W. by W.	4 N. N. W.	4 N. N. W.	3 N. N. W.	4 N. N. W.	
18	2 N. by W.	2 N. by W.	2 N. by W.	2 N.	3 N.	3 N.	
19	6 N.	7 N. by W.	6 N. W. by N.	6 N. W. by N.	5 N. W. by N.	5 N. W. by N.	
20	3 N. N. W.	2 N. by E.	1 N. E. by E.	1 E. S. E.	1 N. E. by E.	1 N. E. by E.	75
21	2 N. W. by N.	2 N. W. by N.	1 N.	1 N. E. by E.	1 N. E. by E.	1 N. E. by E.	(about)
22	1 N. E. by E.	1 N. E. by E.	1 E. by S.	1 S. E. by S.	3 E. by S.	3 E. by S.	
23	10 S. E. by E.	10 S. E. by E.	7 S. E. by S.	5 S.	2 S. W. by W.	1 S. by W.	
24	6 N. W. by N.	6 N. W. by N.	6 N.	6 N. by E.	6 N. by E.	6 N. by E.	
25	6 N. by W.	6 N. by W.	9 N. by W.	7 N.	8 N.	8 N.	75
26	8 N. W. by N.	8 N. W. by N.	8 N. N. W.	8 N. W. by N.	8 N. W. by N.	8 N. W. by N.	(about)
27	8 N. N. W.	8 N. N. W.	8 N. N. W.	7 N. N. W.	7 N. N. W.	7 N. N. W.	
28	6 N. N. W.	6 N. N. W.	6 N. N. W.	5 N. N. W.	4 N. N. W.	3 N. N. W.	
29	4 N. N. W.	4 N. N. W.	6 N. N. W.	4 N. N. W.	4 N. W. by N.	4 N. W. by N.	74
30	2 N. E. by E.	2 N. E. by E.	2 E. by N.	2 E.	2 E.	2 S. E. by E.	(about)
31	7 N. by W.	7 N. W. by N.	6 N. W. by N.	5 N. W. by N.	5 N. N. W.	5 W. N. W.	

Date.	2h.	4h.	6h.	8h.	10h.	Midn't.
1	2 E. by N.	4 E. by N.	6 E. by N.	6 S. E. by S.	6 S. by E.	6 S. by E.
2	1 N. W. by W.	1 N. W. by W.	3 N. W. by N.	4 N. W. by N.	3 W. by S.	2 W. by S.
3	2 N. E. by N.	3 N. E. by N.	4 N. E. by N.	7 N. E. by N.	9 N. E. by N.	9 N. E. by E.
4	5 S. W.	2 S. W. by S.	2 S. W. by S.	2 S. W. by S.	Calm	1 S. by E.
5	2 S. W. by W.	4 S. W. by W.	4 S. W. by W.	3 S. W. by W.	1 W. N. W.	1 N. W. by W.
6	3 N. W. by N.	3 N. W. by N.	3 N. W. by N.	3 N. W. by N.	2 N. W. by N.	1 N. W. by N.
7	4 N.	5 N.	4 N.	4 N. by W.	5 N. by W.	6 N. by W.
8	4 N. by W.	4 N. by W.	2 N. N. W.	1 N. N. W.	3 N.	3 N.
9	2 N. E. by E.	2 N. N. E.	2 N. N. E.	2 N. N. E.	2 N. N. E.	1 N. N. E.
10	3 E. S. E.	4 E. by N.	5 E. by N.	2 E. by N.	3 E. by N.	2 E.
11	4 S. E. by S.	3 S. E. by S.	3 S. E. by S.	4 S. E. by S.	4 S. E. by S.	4 S. S. E.
12	2 S. by E.	5 S. by E.	3 S. W. by W.	3 S. W. by W.	2 S. W.	2 S. S. W.
13	2 S.	2 S.	3 S.	2 W. by N.	2 W. by N.	2 W. by N.
14	4 N. W. by N.	3 N. W. by N.	4 N. W. by N.	3 N. W. by N.	3 N. W. by N.	3 N. W. by N.
15	7 N. W. by N.	7 N. W. by N.	7 N. W. by N.	7 N. W. by N.	7 N. W. by N.	7 N. W. by W.
16	3 W. by N.	2 W. by N.	3 N. W. by N.	3 N. W. by N.	5 N. W. by W.	4 N. W. by W.
17	4 N. N. W.	3 N. N. W.	4 N. by W.	3 N. by W.	3 N. by W.	3 N. by W.
18	4 N.	4 N.	4 N.	4 N.	6 N.	5 N.
19	4 N. W. by N.	4 N. W. by N.	3 N. W. by N.	2 N. W. by N.	2 N. W. by N.	2 N. W. by N.
20	1 N. E. by E.	1 N. by E.	2 N. N. E.	2 N. N. E.	2 N. N. E.	2 N. N. E.
21	1 N. E. by E.	1 S. E. by S.	1 N. E. by E.	1 E. by N.	Calm	1 E.
22	5 E. S. E.	5 S. E. by E.	6 E. by S.	7 E. by S.	8 S. E. by E.	9 S. E. by E.
23	3 N. W. by W.	2 N. W. by W.	3 W. by N.	4 W. by N.	4 W. N. W.	6 W. N. W.
24	6 N. by W.	6 N.	5 N. by W.	5 N. by W.	5 N. by W.	6 N. by W.
25	8 N.	9 N.	9 N. W. by N.	9 N. W. by N.	9 N. W. by N.	8 N. W. by N.
26	8 N. W. by N.	8 N. N. W.	8 N. N. W.	8 N. N. W.	8 N. N. W.	8 N. N. W.
27	7 N. N. W.	7 N. N. W.	7 N. N. W.	7 N. N. W.	7 N. N. W.	6 N. N. W.
28	4 N. N. W.	3 N. N. W.	3 N. N. W.	4 N. N. W.	4 N. N. W.	4 N. N. W.
29	3 N. W. by N.	2 N. W. by N.	2 N. W. by N.	2 N.	2 N.	2 N. E. by N.
30	2 S. E. by E.	2 N. N. E.	2 N.	6 N. by W.	7 N. by W.	6 N. by W.
31	5 W. N. W.	5 W. by N.	5 W. N. W.	2 W. N. W.	2 W. N. W.	2 W. by N.

March 4th. Wind shifted from N. E. by E. through E. to S. S. W. between midnight and 1 A. M.

DIRECTION (TRUE) AND FORCE OF THE WIND OBSERVED ON BOARD THE YACHT FOX.

April, 1858.—Mean position: Lat. 66° N.; long. 57°.7 W.

DATE.	2h.	4h.	6h.	8h.	10h.	Noon.	Variation.
1	2 W. by N.	3 W. by N.	4 S. W. by W.	2 S. W. by W.	1 S. W. by W.	1 S. W. by W.	74°W.*
2	3 N. E. by N.	2 N. E. by N.	1 N. E. by E.	1 N. N. E.	3 N. N. E.	3 N. N. E.	73 31′
3	6 N.	6 N.	6 N.	7 N.	7 N.	8 N.	
4	10 N. by W.	10 N. by W.	10 N. by W.	10 N. by W.	10 N. by W.	10 N. by W.	
5	10 N. by W.	8 N. by W.	8 N. by W.	8 N. W. by N.	8 N. W. by N.	8 N. W. by N.	
6	6 N. W. by W.	5 N. W. by W.	5 N. W. by W.	4 W. N. W.	3 W. by S.	3 W. by S.	72
7	3 N. E. by N.	2 N. E. by E.	3 N.	3 N.	2 N.	4 N.	
8	6 N. N. W.	6 N. N. W.	7 N. W. by W.	8 N. W. by N.	8 N. W. by N.	8 N. W. by N.	
9	2 N. N. W.	1 N. N. W.	1 N. N. W.	3 N. N. W.	4 N. N. W.	4 N. N. W.	70 06
10	4 N. N. W.	4 N. N. W.	4 N. N. W.	3 N. N. W.	2 N. N. W.	2 N. N. W.	
11	3 N.	3 N.	3 N.	2 N.	2 N. by E.	2 N. N. W.	
12	4 N. N. W.	5 N. N. W.	5 N. N. W.	5 N.	4 N.	4 N.	69 14
13	2 N. N. E.	2 N. N. E.	6 N. N. E.	6 N. N. E.	2 N. N. E.	2 N. N. E.	
14	2 N. by E.	3 N. E.	2 N. E.	2 N. E.	4 N. E.	4 N. E. by E.	
15	2 N.	3 N.	4 N.	4 N. by E.	5 N. by W.	5 N. by W.	
16	7 N. by W.	7 N. by W.	7 N. by W.	7 N. by W.	8 N. by W.	8 N. by W.	69
17	9 N. by E.	9 N. by E.	9 N. by E.	9 N. by E.	9 N. by E.	9 N. by E.	
18	- - - -	7 N. E.	- - - -	7 N.	- - - -	8 N.	
19	- - - -	7 N.	- - - -	6 N.	- - - -	6 N.	
20	- - - -	5 N. N. W.	- - - -	5 N. N. W.	- - - -	5 N. W.	64
21	- - - -	4 N. N. W.	- - - -	5 N. N. W.	- - - -	5 N. N. W.	
22†	- - - -	6 N. N. W.	- - - -	4 N. N. W.	- - - -	3 N. N. W.	
23	- - - -	3 N. N. W.	- - - -	2 N. W. by W.	- - - -	2 N. W.	62
24	- - - -	2 E. N. E.	- - - -	4 E. S. E.	- - - -	5 E. S. E.	
25	- - - -	4 S. S. W.	- - - -	Calm	- - - -	3 N. N. W.	
26	- - - -	5 W. S. W.	- - - -	6 S. by W.	- - - -	6 S. by W.	
27	- - - -	5 W. S. W.	- - - -	5 W.	- - - -	5 W. N. W.	65
28	- - - -	5 W. S. W.	- - - -	5 S. S. E.	- - - -	4 S. S. E.	68
29	- - - -	3 E. N. E.	- - - -	1 E. S. E.	- - - -	Calm	
30	- - - -	2 E. N. E.	- - - -	3 S. S. W.	- - - -	3 E. N. E.	

DATE.	2h.	4h.	6h.	8h.	10h.	Midn't.
1	2 W. by S.	2 W. by S.	2 W. by S.	1 W. by S.	Calm	1 N. E. by N.
2	3 N. N. E.	4 N. N. E.	3 N. N. E.	4 N. by E.	4 N. by E.	5 N. by E.
3	7 N. by W.	7 N. by W.	8 N. by W.	9 N. by W.	9 N. by W.	10 N. by W.
4	10 N. by W.	10 N. by W.	10 N. by W.	10 N. by W.	10 N. by W.	10 N. by W.
5	7 N. W. by N.	8 N. W. by N.	7 N. W. by N.	6 N. W. by W.	7 N. W. by W.	6 N. W. by W.
6	2 W. by S.	Calm	Calm	Calm	Calm	1 N. E. by N.
7	4 N.	5 N. by W.	5 N. by W.	5 N. by W.	6 N. by W.	6 N. N. W.
8	8 N. W. by N.	7 N. W. by N.	3 N. W. by N.	3 N. W. by N.	2 N. W. by N.	2 N. W. by N.
9	4 N. by W.	4 N. by W.	4 N. by W.	4 N. by W.	4 N. N. W.	4 N. N. W.
10	4 N. by W.	3 N. N. W.	3 N.	2 N.	3 N.	3 N.
11	1 N. W. by W.	1 N. W. by W.	1 N. W. by W.	3 W. N. W.	2 N. W.	4 N. N. W.
12	3 N.	2 N.	3 N.	3 N.	2 N. by W.	2 N. by W.
13	2 N. N. E.	1 N. E. by N.	1 E. by N.	1 N. by E.	1 N. by E.	1 N. by E.
14	5 E. by N.	4 E. by N.	3 E. by N.	3 N. E. by E.	3 N. E. by E.	2 N. by W.
15	5 N. by W.	5 N. by W.	5 N. by W.	5 N. by W.	6 N. by W.	7 N. by W.
16	9 N.	9 N.	9 N. by E.	9 N. by E.	9 N. by E.	9 N. by E.
17	9 N.	9 N.	8 N. by E.	8 N. by E.	7 N. by E.	7 N. by E.
18	- - - -	8 N.	- - - -	8 N.	- - - -	7 N.
19	- - - -	6 N. W. by N.	- - - -	5 N. by E.	- - - -	5 N. by E.
20	- - - -	5 N. W.	- - - -	5 N. W.	- - - -	5 N. W.
21	- - - -	6 N. N. W.	- - - -	7 N. N. W.	- - - -	6 N. N. W.
22	- - - -	3 N. W. by N.	- - - -	2 N. N. W.	- - - -	2 N. N. W.
23	- - - -	2 N. W.	- - - -	2 N. N. W.	- - - -	Calm
24	- - - -	6 E. S. E.	- - - -	6 E. S. E.	- - - -	6 E. S. E.
25	- - - -	4 N. W.	- - - -	4 W. S. W.	- - - -	4 W. S. W.
26	- - - -	5 S. by W.	- - - -	5 W. S. W.	- - - -	6 W. S. W.
27	- - - -	3 W. S. W.	- - - -	5 W. S. W.	- - - -	6 W. S. W.
28	- - - -	2 var.	- - - -	3 W.	- - - -	4 E. N. E.
29	- - - -	2 E. N. E.	- - - -	2 E. N. E.	- - - -	2 E. N. E.
30	- - - -	2 S. S. E.	- - - -	4 S. by E.	- - - -	6 S. E.

* About. † Experienced a S. W. current.

Direction (true) and Force of the Wind observed on board the yacht Fox.

May, 1858.—Mean position: Lat. 68°.7 N.; Long. 53°.7 W.

Date.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Variation.
1	7 S.	2 S.	4 S. S. E.	4 S. S. W.	4 W. S. W.	4 W. S. W.	
2	3 E. N. E.	Calm	3 S. S. W.	4 N. E.	4 E. N. E.	5 N. by E.	
3	2 E. N. E.	4 E. N. E.	4 N. E.	3 N. E.	2 E. N. E.	2 E. N. E.	
4	4 E. N. E.	6 S. S. E.	8 S. S. E.	8 S. S. E.	8 S. S. E.	8 S. by E.	
5	8 S. by E.	8 N. N. W.	9 N. W. by W.	9 N. W.	8 N. W.	5 N. W.	
6	6 N. N. W.	4 N. N. W.	3 N. N. W.	4 N. N. W.	4 N. N. W.	3 N. N. E.	
7	4 N.	3 N. E.	3 N. E.	4 N. N. W.	4 N. N. W.	4 E.	
8	2 S. S. W.	2 E.	6 N.	4 N. N. W.	3 N.	3 N'ly	
9	3 E'ly	4 N'ly	2 N. N. W.	2 Variable	2 E. S. E.	4 Variable	70° W.
10	2 to 5 E. N. E.	5 E.	6 E. by S.	7 E.	7 E.	6 E. S. E.	72
11	6 S. E. by E.	5 S. E.	6 E. N. E.	6 E'ly	5 E. S. E.	4 S. E.	(about)
12	2 E. N. E.	3 N. N. W.	4 S. S. E.	4 S. S. E.	4 S. by W.	4 S. by W.	
13	5 N.	5 N. E. by E.	5 N. E. by N.	5 N. E.	3 N. E.	Calm	
14	2 S.	Calm	2 W. N. W.	2 N. by E.	Calm	2 S. by W.	
15	2 S. S. E.	2 E. N. E.	Calm	Calm	Calm	1 W. S. W.	
16	3 N. N. W.	3 N. E.	1 W. by N.	4 W. N. W.	4 W. N. W.	4 W. S. W.	
17	2 E.	2 E. S. E.	4 N. N. W.	2 W. S. W.	Calm	4 E. N. E.	
18	3 S. S. E.	1 W. N. W.	1 W. N. W.	2 W. N. W.	1 W. N. W.	Calm	
19	5 S. S. E.	2 S. S. E.	Calm	3 W. S. W.	3 W. S. W.	Calm	
20	Calms and	light variable	winds			Calm	
21	Calm	3 E. N. E.	2 E. N. E.	2 W. S. W.	2 W. S. W.	1 W. S. W.	
22	5 E. N. E.	5 E.	5 E.	4 E. N. E.	1 E. S. E.	Calm	
23	Calm	5 E. N. E.	4 E. N. E.	2 W. S. W.	1 W. S. W.	1 W. S. W.	
24	1 S'ly	5 S. S. E.	3 S. S. E.	Calm	Calm	Calm	
25	Calm	2 S. W.	Calm	2 S. E.	2 S. E.	2 S. E.	
26	4 S. E.	4 S. E.	2 E. S. E.	2 S. S. E.	Calm	1 N. N. W.	
27	3 S. S. E.	2 S. E.	Calm	4 N. N. W.	Calm	Calm	73 (ab't)
28	1 W. S. W.	3 S. E.	4 Variable	Calm	Calm	1 E. N. E.	73 30′
29	3 E. N. E.	2 S. S. E.	1 S. S. E.	1 E. S. E.	Calm	1 N. W.	79
30	1 N. W. by W.	Calm	Calm	1 N. W.	3 S'ly	2 S'ly	
31	4 S. S. E.	4 S. S. E.	5 S.	2 S. S. W.	2 N. E.	Calm	

June, 1858.—Mean position: Lat. 74°.6 N.; Long. 60°.1 W.

Date.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Variation.
1	1 N. W.	1 N. W.	2 S. S. W.	1 N. N. W.	1 E. N. E.	1 E. N. E.	
2	2 E. N. E.	2 N. W.	1 N. E.	1 N. E.	Calm	2 S. W. by S.	
3	4 S. by E.	6 S. by E.	6 S. by W.	1 S. W. by S.	Calm	1 N. W. by N.	
4	1 N. W. by N.	3 N. W. by N.	4 N. W. by W.	Calm	7 S. E. by S.	7 S. E. by S.	
5	5 S. E. by S.	4 S. E. by S.	3 S. E. by S.	Calm	4 N.	1 N.	83° W.
6	4 N. N. E.	3 N. W. by N.	3 S. W. by S.	3 N. E.	2 N. E.	Calm	
7	3 N. W. by N.	1 S. E. by S.	Calm	2 S. E. by S.	Calm	Calm	84
8	Calm	1 N. E. by E.	3 N. W. by N.	1 N. W. by N.	Calm	1 N. N. E.	85
9	Calm	Calm	Calm	1 S. E.	Calm	1 S.	
10	1 S. W.	Calm	1 S. W.	Calm	1 S. W.	1 S. W.	
11	1 S. E.	1 N.	1 S. E.	Calm	Calm	1 W.	85
12	Calm	3 W. by S.	3 W.	2 N. by W.	4 N. by W.	5 N. N. W.	(about)
13	5 N. N. W.	5 N. W. by N.	4 N. by W.	4 N. by W.	4 N. W. by N.	4 N. W. by N.	
14	3 N. W.	3 N. N. W.	2 N. N. W.	1 N.	1 N. by E.	2 N. by E.	
15	1 N'ly	1 N'ly	3 N. W.	4 W.	4 W. N. W.	3 W. N. W.	
16	4 W. N. W.	4 N. W.	4 N. W.	3 W. by N.	2 S. W.	2 S. E.	89
17	5 S. E.	4 E. S. E.	3 E. S. E.	2 S. E.	2 E. by S.	1 E. by S.	90
18	1 E. by S.	1 N. E.	2 W. N. W.	2 Variable	Calm	Calm	90 (ab't)
19	2 N. W. by W.	2 N. W.	3 N. W.	3 N. W.	2 W. S. W.	2 S. W.	93
20	2 N. by E.	2 N. W.	4 W. N. W.	3 W. N. W.	1 N. W.	1 S.	(about)
21	Calm	2 N. W.	3 N. by W.	4 W. N. W.	3 N. N. W.	3 N. N. W.	
22	3 N. N. W.	3 N. W. by N.	3 W. N. W.	1 S. E.	Calm	2 N. by E.	93
23	1 N. E.	4 N. E.	5 S. E.	3 E.	4 E. by N.	3 E.	(about)
24	3 N. E.	4 E.	3 E. by N.	2 N. by E.	2 N. by E.	2 N. by E.	94
25	3 N. N. W.	2 N. N. W.	2 N. E.	2 E. by S.	2 E. N. E.	1 E. by S.	
26	Calm	2 N. by W.	1 N. N. W.	3 N. W.	3 N. W.	2 N. E.	94
27	5 E'ly	6 E'ly	6 E. by S.	5 E. by S.	5 E. by S.	5 S. E.	(about)
28	4 E. S. E.	2 S. E.	2 S. E.	2 S. E.	1 S. E.	2 S. E.	
29	1 S. E.	1 S. E.	2 S. E.	3 E. by S.	5 E. by S.	6 E. by S.	
30	5 E. by S.	3 E. by S.	3 S. E. by E.	1 S. E. by E.	2 N. W. by W.	2 N. W. by W.	95

DIRECTION (TRUE) AND FORCE OF THE WIND OBSERVED ON BOARD THE YACHT FOX.

July, 1858.—Mean position: Lat. 74°.4 N.; long. 76°.4 W.

DATE.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Variation.	REMARKS.
1	1 N.W.byW.	Calm	1 S. E.	1 E. by S.	4 W. S. W.	5 W. S. W.	95°	
2	4 S. S. W.	3 W. S. W.	Calm	2 S. E.	4 S. E.	4 S. E'ly	W.	
3	1 S. E.	1 N. W.	2 N. W.	Calm	1 W.	1 S. W.	98	(about)
4	Calm	Calm	2 N.W.byW.	3 N.	3 N.	2 N. E.		
5	4 N. E. by N.	4 E. N. E.	5 N.	4 S. E. by E.	5 N. E.	4 N. E.		
6	6 E.	6 E. by S.	6 E. S. E.	6 N.E. by N.	4 N. E. by E.	3 N. by E.	100	
7	4 N. by E.	4 N. N. W.	3 N.	3 N.	4 N.	5 N. N. W.		
8	4 N.W.byW.	4 N.W.byW.	3 N.W.byW.	3 N.W.byW.	4 N.W.byW.	3 N. W.	102	
9	3 N.W.byW.	2 N.W.byW.	2 N.W.byW.	4 N.W.byW.	4 N.W. by N.	3 N.W.byW.		
10	3 N. W.	4 N.W. by N.	4 N. W.	4 N. W.	3 N.W.byW.	3 N.W.byW.		
11	3 N. N. W.	3 N. N. W.	2 N.W. by N.	1 W'ly	3 W'ly	2 S. E.	105	
12	1 W. S. W.	Calm	1 S. E'ly	6 N. E.	6 N. E.	7 N. E. by N.		
13	8 N. E. by E.	8 N. E. by E.	8 N. E. by N.	5 S. W'ly	6 W. S. W.	4 E. N. E.		At 2 P. M. wind suddenly became light and vari'le.
14	1 N. N. E.	2 W.	2 W.	2 W.	4 W.	4 S. W.		
15	Calm	1 S. W.	2 E'ly	6 E'ly	5 E. N. E.	4 S. E. by E.	106	(about)
16	4 S. E. by E.	2 S. S. E.	1 E'ly	1 W'ly	Calm	1 S. E.	105	
17	Calm	1 E.	1 Variable	2 N. E'ly	2 N. N. E.	2 N. N. E.		
18	Calm	1 N. E'ly	2 E'ly	4 E'ly	2 E'ly	2 E'ly	100	A strong easterly current; the ship drifting with it.
19	2 E. by N.	2 E. by S.	2 E. by N.	5 S. E. by E.	1 S. E. by E.	1 S. E. by E.	99	
20	Calm	1 S'ly	Calm	1 W. by N.	Calm	Calm		
21	1 S. W.	1 S. W.	1 S. W.	2 S. W. by S.	3 S. W. by S.	5 W. S. W.	113½	
22	5 S.W. byW.	2 W. by S.	2 W. by N.	3 W.	3 W. N. W.	3 W. by S.	114	
23	3 W. S. W.	1 N. W.	2 W.	1 W. S. W.	1 W. S. W.	2 W. S. W.		
24	5–3 W. S. W.	3 W.	4 W.	1 S. W.	1 S. S. W.	1 S.		
25	Calm	Calm	Calm	Calm	Calm	3 S. S. E.	110?	
26	2 S. S. E.	2 S. by W.	1 S. S. W.	1 S. W. by S.	2 S. E. by E.	2 S. E. by E.	101	A strong set to the southward.
27	2 E. by S.	Calm	2 N. by W.	Calm	Calm	2 E. by N.	108	
28	1 S. E. by E.	Calm	1 W. by S.	4 N. E. by N.	2 S. E. by E.	1 S. by E.		
29	3 N. E. by N.	1 N. E. by N.	2 S.	Calm	1 E. S. E.	1 E. S. E.		
30	Calm	1 N. W.	7 N. N. W.	5 N.	1 N. E. by E.	6 W. N. W.		
31	7 S.W. byW.	4 W.	4 W. S. W.	4 S. W.	5 S. W.	5 S.		

August, 1858.—Mean position: Lat. 73°.1 N.; long. 88°.5 W.

DATE.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Variation.	REMARKS.
1	3 W.	4 S. W.	5 S.W. byW.	6 S.W. byW.	5 W. by S.	3 W. by S.	108°	
2	7 W. by S.	6 W. by S.	6 W. S. W.	5 W. by S.	2 S. E. by S.	Calm	W.	
3	1 N. E'ly	Calm	Calm	1 E'ly	2 E'ly	Calm		
4	Calm	Calm	Calm	2 S. E.	2 E. S. E.	1 E. S. E.		
5	Calm	Calm	1 E'ly	1 E'ly	Calm	Calm		
6	Calm	Calm	Calm	Calm	1 S. E. by E.	2 S. E. by S.		
7	3 S. E. by S.	4 S. E. by E.	6 S. E. by E.	7 S. E. by S.	7 S. E. by E.	7 S. E. by E.	108	(about)
8	10 E. S. E.	10 E. S. E.	10 E. S. E.	9 E.	9 E.	8 E.	110	A heavy gale.
9	8 E.	7 E.	3 E.	1 E. S. E.	1 E. S. E.	1 E. N. E.		
10	1 E. N. E.	2 E. N. E.	2 E. N. E.	Calm	Calm	1 Variable	115	
11	1 Variable	2 N. W.	Calm	Calm	Calm	Calm	138	(about)
12	Calm	Calm	3 N'ly	4 N. E.	4 E.	4 S. E.		
13	3 E.	4 E.	4 E. S. E.	2 E.	2 E.	2 E.		
14	3 N. N. E.	4 N.	5 N.	6 N. N. W.	5 N.	5 N.		
15	5 N. N. E.	6 N. N. E.	6 N. N. E.	6 N'ly	6 N. N. W.	6 N. N. W.		
16	5 N. N. W.	4 W. N. W.	4 W. S. W.	3 S. W.	5 S. W.	5 S. W.		
17	4 W. S. W.	6 W. by N.	6 W. by N.	5 W.	4 W.	4 S. W.	149	
18	6 S. W.	4 W.	2 W.	2 S'ly	6 S. S. W.	6 W'ly		
19	3 S. S. W.	5 W.	6 W.	2 W.	4 W. S. W.	3 W. S. W.		
20	4 W.	4 W. S. W.	3 W.	6 N. N. W.	7 N. W.	4 W.		
21	5 N. W.	5 N. W.	6 W.	6 W.	5 W.	4 W.		
22	4 W. S. W.	3 W. S. W.	3 S'ly	2 S. S. E.	3 S. S. E.	3 S. S. E.		
23	Calm	2 S. W.	6 W.	6 W.	6 W.	6 W.		
24	5 W.	5 W.	4 W.	2 N. E.	6 N. N. E.	7 N. N. E.		
25	6 N. N. E.	5 N. N. W.	6 N. N. W.	4 N. N. W.	6 W. N. W.	6 W. N. W.		
26	6 N. N. W.	6 N. N. W.	5 N. N. W.	6 N. W.	6 W. N. W.	6 W. N. W.		
27	1 Variable	Calm	6 W. N. W.	6 N. W.	7 N. W.	7 N. W.		
28	6 N. N. W.	6 N. W.	5 N. W.	4 Variable	4 Variable	2 N. E.		
29	3 E. S. E.	3 E. N. E.	3 N. E.	3 E. N. E.	2 E. N. E.	2 N'ly		
30	4 N. E.	3 N. N. W.	2 S.	2 S.	2 S. E.	Calm		
31	1 S. E.	2 S. E.	2 N. E.	2 N. W.	3 W.	3 W.		

DIRECTION (TRUE) AND FORCE OF THE WIND OBSERVED ON BOARD THE YACHT FOX.

September, 1858.—Mean position: Lat. 72° N.; long. 94°.4 W.

DATE.	4h.	8h.	Noon.	4h.	8h.	Midn't.
1	2 N. W.	4 N. N. W.	2 S. W.	3 W.	4 W. N. W.	4 W. N. W.
2	5 N. N. W.	6 W. N. W.	4 S. by W.	4 S. E.	5 W. N. W.	4 W. N. W.
3	5 W. by S.	4 W. by S.	5 W. by S.	4 W. by S.	4 W. by S.	6 W. by S.
4	5 W. by S.	5 W. by S.	5 W. by S.	7 W.	8 W. by N.	8 W. by N.
5	7 W.	6 W.	7 W.	6 W.	6 W.	6 W.
6	4 W.	4 W. S. W.	3 S. W.	4 S. by W.	4 S'ly	4 S'ly
7	3 S'ly	3 S'ly	3 S'ly	4 S. S. E.	4 S. E.	4 S. E.
8	4 S. E.	4 S. E.	4 E. S. E.	4 S. S. E.	4 S. S. E.	4 W. by S.
9	5 S. W.	5 W. by S.	5 W.	5 W.	4 W.	3 W.
10	3 S. W.	2 S. S. W.	2 S. S. W.	Calm	1 N. W.	2 N. W.
11	3 S. S. E.	3 E. S. E.	4 E.	3 N. E.	3 N. E.	3 N. E.
12	3 N. E.	3 N. E.	4 N. E.	4 N. E.	4 N. E.	4 N. E.
13	3 N. N. W.	Calm	2 S'ly	3 S. S. W.	1 W.	Calm
14	2 N. E.	2 N. E.	2 S. W'ly	3 E'ly	3 N. E.	3 N. by E.
15	3 N. by E.	4 N. by E.	3 N. N. E.	5 N. N. E.	6 N'ly	6 N'ly
16	5 N'ly	5 N'ly	5 N. N. W.	5 N. N. W.	5 N. N. W.	5 N. N. W.
17	6 N. N. W.	5 N. N. W.	5 N. N. W.	4 N. N. E.	4 N. N. E.	4 N. N. E.
18	3 N. N. E.	4 N. N. E.	5 N. N. E.	5 N. W.	6 N. W.	6 N. W.
19	6 N. W.	4 N. N. W.	4 W.	4 W.	5 S. W.	5 S. W.
20	4 N. N. W.	4 N. N. W.	4 N. W.	5 W.	6 S. W.	5 S. W.
21	3 S. S. W.	4 S. W.	4 S. S. W.	4 S. W.	5 N. W.	6 N. W.
22	6 N. W.	6 W. by N.	5 W. by N.	3 W. S. W.	7 W. S. W.	7 S. W.
23	4 W. N. W.	3 W.	2 W.	1 W.	7 to 8 N. W.	7 N. W.
24	6 N. W.	6 W.	5 W.	5 W.	1 W.	8 W. S. W.
25	7 W. N. W.	6 W.	6 W.	6 W.	6 W. by S.	6 W. by S.
26	5 W. S. W.	5 W. S. W.	5 W. S. W.	4 S. W.	2 S. W.	2 S. W.
27*	Calm	3 S. W'ly	3 S. E'ly	5 E. S. E.	5 E. S. E.	5 S. E.
28	3 S. E.	5 S. E.	5 S. S. E.	5 S. S. E.	6 S. S. E.	6 S'ly
29	6 S. W.	5 S. W.	3 S. W.	3 W.	2 N.	2 N'ly
30	3 N.	5 N. E.	6 N. E.	5 N. E.	6 N. E.	6 N. E.

October, 1858.—At winter quarters: Lat. 72° N.; long. 94°.2 W.

DATE.	4h.	8h.	Noon.	4h.	8h.	Midn't.
1	6 N. E.	5 N. E.	5 N. E.	6 N. E.	6 N. E.	6 N. E.
2	7 N. E. by E.	7 N. E. by E.	7 N. E. by E.	7 N. E.	7 N. E.	7 N. E.
3	7 N. E.	7 N. E.	6 N. N. E.	7 N. E.	8 N. E.	8 N. E.
4	7 N. E.	5 E. S. E.	6 E. N. E.	6 N. E. by E.	5 N. E.	5 N. E.
5	4 S'ly	3 S. E.	3 S. E.	2 S. S. E.	3 S. E.	2 S. E.
6	2 S. S. E.	2 S. S. E.	1 S. S. E.	2 S.	4 S. W.	6 S. W.
7	3 S. S. W.	3 S. W.	2 W.	2 S. W.	2 S. W.	Calm
8	Calm	Calm	2 W. N. W.	1 W.	1 W. N. W.	1 W. N. W.
9	2 W.	2 W.	2 W.	1 N. E.	1 N. E.	1 E. by S.
10	Calm	4 N. E.	5 E.	7 N. E.	4 E. N. E.	5 E. N. E.
11	4 E. N. E.	3 N. E.	4 N. E. by N.	5 N. E. by N.	5 N. E. by N.	6 N. E.
12	6 N. E.	7 N. N. E.	3 N. E.	2 N. E.	2 N. E.	1 N. E.
13	3 N. E.	2 N. E. by N.	2 N. E.	3 N. E.	5 N. W.	6 W.
14	7 W. N. W.	6 W. N. W.	6 W. N. W.	5 W. N. W.	6 N. W.	2 N. W.
15	2 N. W.	2 N. W.	2 N. W.	3 N. W.	3 N. by W.	4 N. N. E.
16	4 N. W.	5 N. W.	5 N. W.	6 N. W.	6 W. N. W.	8 W. N. W.
17	9 W. N. W.	9 W. N. W.	9 W. N. W.	8 N. W.	9 N. W.	5 N. W.
18	8 N. W.	7 N. W.	7 W. N. W.	4 N. W.	3 N. W.	2 N. W.
19	2 N. N. E.	2 E. N. E.	3 E. N. E.	4 E. N. E.	5 E. N. E.	5 E. N. E.
20	4 N. W.	2 S. S. E.	3 E. N. E.	3 N. N. E.	2 N. E.	2 N. by W.
21	5 N. by E.	6 N. W.	4 N. N. W.	8 N. N. W.	7 N. N. W.	5 N. N. W.
22	5 N. W.	8 N. W.	4 N. W.	3 W. N. W.	3 N. W.	6 N. W.
23	2 N. W.	2 S. E. by S.	2 E. N. E.	2 E. N. E.	4 E. N. E.	1 N. E.
24	1 N. E.	6 S.	6 S.	3 S. S. E.	1 S. S. E.	3 W. by N.
25	3 S. W.	5 N. E.	7 N. E.	8 N. E. by N.	4 N. E. by N.	8 N. N. E.
26	10 N. N. W.	8 W. N. W.	7 W. N. W.	8 N. W.	6 N. W.	10 N. W.
27	10 N. W.	10 N. W.	8 N. W.	7 N. W.	7 N. W.	4 N. W.
28	Calm	2 N. W.	1 N. W.	1 N. E.	2 N. E.	Calm
29	Calm	1 N. W.	1 N. W.	1 N. W.	4 N. W.	6 N. W.
30	7 N. W.	7 N. W.	7 N. W.	5 N. W.	4 N. W.	7 N. W.
31	7 N. W.	4 N. N. W.	4 N. N. W.	4 N. W.	4 N. W.	2 N. W.

* Went into winter quarters, Port Kennedy.

DIRECTION (TRUE) AND FORCE OF THE WIND OBSERVED ON BOARD THE YACHT FOX.

November, 1858.—At winter quarters.

DATE.	2h.	4h.	6h.	8h.	10h.	Noon.
1	2 N. W.	1 N. W.	1 W. N. W.	Calm	Calm	Calm
2	Calm	2 N. W.	2 N. W.	3 N. W.	3 N. W.	3 N. W.
3	9 N. W.	9 N. W.	9 W. N. W.	9 W. N. W.	8 W. N. W.	7 W. N. W.
4	9 W. N. W.	9 W. N. W.	9 W. N. W.	9 W. N. W.	9 W. N. W.	10 W. N. W.
5	9 N. W.	9 N. W.	7 N. W.	6 N. W.	6 N. W.	7 N. W.
6	5 N. W.	5 N. W.	5 N. W.	1 N. W.	4 N. by E.	2 N. by E.
7	7 N. W.	7 N. W.	5 N. W.	4 N. W.	4 N. W.	5 N. W.
8	4 N. W.	5 N. W.	5 N. W.	4 N. W.	4 N. W.	4 N. W.
9	2 N. W.	2 N. W.	1 N. W.	1 N. W.	1 N. W.	1 N. W.
10	2 N. W.	2 N. W.	4 N. W.	4 N. W.	2 N. W.	2 N. W.
11	4 N. W.	5 N. W.	5 N. W.	4 N. W.	4 N. W.	5 N. W.
12	1 N. W.	Calm	Calm	1 N. W.	2 N. W.	2 N. W.
13	1 E. N. E.	2 E.	Calm	2 E. N. E.	1 E. N. E.	2 E. N. E.
14	1 E. N. E.	2 E. N. E.	1 E. N. E.	Calm	4 N. W.	5 N. W.
15	6 N. W.	4 N. W.	5 N. W.	6 N. W.	6 N. W.	6 N. W.
16	Calm	Calm	2 N. E.	2 N. E.	2 N. E.	3 N. E.
17	5 N. E.	4 N. E.	4 E. S. E.	1 E. N. E.	2 E. N. E.	2 E. N. E.
18	3 E. N. E.	4 E. N. E.	4 E. N. E.	2 E. N. E.	Calm	Calm
19	Calm	Calm	2 N. E.	2 N. E.	2 E. N. E.	2 E. N. E.
20	2 N. E.	5 N. N. W.	4 N. N. W.	2 N. N. W.	4 N. E. by E.	3 N. E. by E.
21	2 E. N. E.	3 E. N. E.	1 E. N. E.	1 E. N. E.	1 N. E.	Calm
22	3 N. W.	3 N. W.	5 N. W.	4 N. W.	2 N. W.	2 N. W.
23	2 N. W.	2 N. W.	2 N. W.	2 N. W.	3 N. W.	3 N. W.
24	4 N. W.	2 N. W.	2 N. W.	2 N. W.	1 N. W.	1 N. W.
25	2 N. W.	4 N. W.	6 N. W.	6 N. W.	5 N. W.	6 N. W.
26	6 N. W.	6 N. W.	6 N. W.	6 W. N. W.	6 W. N. W.	6 W. N. W.
27	4 W. N. W.	4 W. N. W.	Calm	Calm	Calm	2 N. E.
28	6 N. E.	8 N. N. E.	8 N. N. W.	8 N. N. W.	8 N. N. W.	8 N. E.
29	9 N. E.	9 N. E.	9 N. E.	8 N. E.	8 N. E.	9 N. E.
30	10 N. E.	10 N. E.	9 N. E.	8 N. E.	6 E. N. E.	6 E. N. E.

DATE.	2h.	4h.	6h.	8h.	10h.	Midn't.
1	Calm	Calm	Calm	1 N. E.	Calm	Calm
2	4 N. W.	6 N. W.	6 N. W.	8 N. W.	8 N. W.	8 N. W.
3	7 W. N. W.	7 W. N. W.	6 W. N. W.	4 W. N. W.	4 W. N. W.	6 W. N. W.
4	9 W. N. W.	8 W. N. W.	9 W. N. W.	9 W. N. W.	7 W. N. W.	4 W. N. W.
5	7 N. W.	7 N. W.	7 N. W.	7 N. W.	7 N. W.	4 N. W.
6	3 N. W.	3 N. W.	4 N. W.	6 N. W.	4 N. W.	4 N. W.
7	3 N. W.	3 N. W.	4 N. W.	4 N. N. W.	4 N. N. W.	4 N. N. W.
8	3 N. W.	3 N. W.	3 N. W.	1 N. W.	1 N. W.	1 N. W.
9	Calm	Calm	Calm	Calm	Calm	Calm
10	2 W.	2 W.	3 N. W.	5 N. W.	3 N. W.	4 N. W.
11	5 N. W.	5 N. W.	4 N. W.	2 N. W.	2 N. W.	2 N. W.
12	2 N. W.	2 N. W.	1 N. W.	1 N. W.	1 N. W.	1 E. N. E.
13	3 E. N. E.	4 E. N. E.	3 E. N. E.	3 E. N. E.	2 E. N. E.	1 E. N. E.
14	6 N. W.	4 N. W.	6 N. W.	6 N. W.	8 N. W.	8 N. W.
15	6 N. W.	6 N. W.	2 N. W.	2 N. W.	3 N. W.	4 N. W.
16	4 N. E.	6 N. E.	6 N. E.	5 N. E.	6 N. E.	5 N. E.
17	1 E. N. E.	2 E. N. E.	4 E. N. E.	4 E. N. E.	4 E. N. E.	3 E. N. E.
18	Calm	Calm	2 N. W.	1 N. W.	1 N. W.	Calm
19	2 E. N. E.	2 E. N. E.	3 N. E.	3 N. E.	3 N. E.	3 N. E.
20	3 E. N. E.	3 E. N. E.	2 E. N. E.	Calm	Calm	1 N. E.
21	1 N. E.	1 N. E.	1 E. N. E.	1 E. N. E.	1 E. N. E.	2 N. W.
22	2 N. W.	2 N. W.	3 N. W.	3 N. W.	5 N. W.	2 N. W.
23	2 N. W.	3 N. W.	3 N. W.	3 N. W.	3 N. W.	3 N. W.
24	2 N. W.	2 N. E.	Calm	Calm	Calm	Calm
25	6 N. W.	7 N. W.	5 N. W.	6 N. W.	5 N. W.	5 N. W.
26	6 W. N. W.	6 W. N. W.	6 W'ly	6 W'ly	4 W'ly	4 W'ly
27	2 N. E.	2 N. E.	2 N. E.	2 N. E.	5 N. E.	6 N. E.
28	7 N. E.	8 N. E.	9 N. E.	8 N. E.	9 N. E.	9 N. E.
29	10 N. E.	10 N. E.	10 N. E.	10 N. E.	10 N. E.	10 N. E.
30	5 E. N. E.	5 E. N. E.	5 E. N. E.	4 E. N. E.	5 N. E.	Calm

Direction (true) and Force of the Wind observed on board the yacht Fox.

December, 1858.—At winter quarters.

Date.	2h.	4h.	6h.	8h.	10h.	Noon.
1	Calm	1 N. W.	1 N. W.	2 N. W.	2 N. N. W.	2 N. W.
2	8 N. W.	6 N. W.	6 N. W.	4 N. W.	4 N. W.	4 N. W.
3	4 N. W.	5 N. W.	5 N. W.	4 N. W.	5 N. W.	5 N. W.
4	8 N. W.	8 N. W.	8 N. W.	6 N. W.	7 N. W.	4 N. W.
5	4 N. N. W.	3 N. N. W.	3 N. N. W.	3 N. W.	4 N. W.	3 N. W.
6	6 N. W.	6 N. W.	6 N. W.	5 N. W.	4 N. W.	4 N. W.
7	6 N. W.	6 N. W.	6 N. W.	3 N. W.	2 N. W.	2 N. W.
8	1 N. W.	1 N. W.	2 N. W.	3 N. W.	2 N. W.	1 Variable
9	3 N. E.	2 N. E.	Calm	2 N. W.	1 N. W.	1 N. W.
10	5 N. W.	5 N. W.	4 N. W.	2 N. W.	3 N. W.	5 N. W.
11	5 N. W.	5 N. W.	4 N. W.	2 N. W.	1 Variable	Calm
12	Calm	1 N. E.	2 N. E.	2 N. E.	2 E. N. E.	3 E. N. E.
13	1 E. N. E.	1 E. N. E.	1 E. N. E.	Calm	2 N. E.	2 N. E.
14	5 E. N. E.	5 E. N. E.	3 E. N. E.	2 N. E.	Variable	Variable
15	6 N. W.	6 N. W.	7 W. N. W.	7 N. W.	5 N. W.	4 N. W.
16	8 N. W.	7 N. W.	5 N. W.	8 N. W.	6 N. W.	7 N. W.
17	5 N. W.	3 N. W.	4 N. W.	3 N. W.	4 N. W.	4 N. W.
18	2 N. E.	2 N. E.	3 N. E.	4 N. E.	4 E. N. E.	4 E. N. E.
19	4 E. N. E.	4 E. N. E.	4 E. N. E.	4 E. N. E.	3 E. N. E.	2 E. N. E.
20	1 E. N. E.	4 N. E.	5 N. E.	6 N. E.	6 E. N. E.	7 E. N. E.
21	2 N. N. W.	4 N. W.	5 N. W.	5 N. W.	6 N. W.	6 N. W.
22	Calm	1 S. W.	2 S. W.	3 S. E.	1 W. by S.	1 S. W.
23	3 S. W.	Calm	1 S. W.	Calm	Calm	Calm
24	Calm	1 N. W.	2 N. W.	4 N. W.	3 N. W.	4 N. W.
25	4 N. W.	4 N. W.	3 N. W.	5 N. W.	3 N. W.	3 W. by N.
26	7 W.	8 W.	6 W.	4 W.	4 W.	5 N. W.
27	3 N. W.	2 N. W.	4 N. W.	6 N. W.	5 N. W.	7 W. S. W.
28	7 W.	4 W.	6 W.	5 W.	4 W.	4 W.
29	2 N. W.	Calm	Calm	Calm	Calm	Calm
30	Calm	Calm	Calm	Calm	1 N. W.	1 N. N. W.
31	Calm	3 N. W.	4 N. W.	4 N. W.	3 N. W.	3 N. W.

Date.	2h.	4h.	6h.	8h.	10h.	Midn't.
1	2 N. W.	4 N. W.	3 N. W.	4 N. W.	4 N. W.	5 N. W.
2	5 N. W.	5 N. W.	5 N. W.	4 N. W.	2 N. W.	Calm
3	4 N. W.	5 N. W.	6 N. W.	7 N. W.	7 N. W.	7 N. W.
4	4 N. W.	4 N. W.	3 N. W.	3 N. W.	4 N. W.	4 N. N. W.
5	3 N. W.	3 N. W.	2 N. W.	1 N. W.	3 N. W.	3 N. W.
6	5 N. W.	6 N. W.	7 N. W.	7 N. W.	6 N. W.	6 N. W.
7	2 N. W.	Calm	Calm	Calm	Calm	Calm
8	3 N. E.	4 N. E.	3 N. E.	4 N. E.	4 N. E.	5 N. E.
9	2 N. W.	3 N. W.	2 N. W.	2 N. W.	3 N. W.	3 N. W.
10	7 N. W.	6 N. W.	6 N. W.	4 N. W.	6 N. W.	5 N. W.
11	Calm	Calm	Calm	Calm	Calm	Calm
12	2 N. E.	2 N. E.	2 N. E.	4 N. E.	2 E. N. E.	1 E. N. E.
13	3 N. E.	4 E. N. E.	4 E. N. E.	3 E. N. E.	3 E. N. E.	4 E. N. E.
14	Calm	Calm	Calm	3 N. W.	6 N. W. by W.	6 N. W. by W.
15	7 N. N. W.	8 N. N. W.	6 N. N. W.	1 N. W.	1 N. W.	2 N. W.
16	5 N. W.	5 N. W.	5 N. W.	4 N. W.	5 N. W.	6 N. W.
17	2 N. W.	1 N. W.	Calm	1 E. N. E.	1 E. N. E.	1 E. N. E.
18	3 E. N. E.	4 E. N. E.	3 E. N. E.	Calm	1 E. N. E.	3 E. N. E.
19	2 E. N. E.	3 E. N. E.	3 E. N. E.	Calm	1 N. E.	2 N. E.
20	6 E. N. E.	5 E. N. E.	4 E. N. E.	1 E. N. E.	3 N. by W.	6 N. N. W.
21	4 N. W.	6 N. W.	4 N. W.	2 N. W.	1 N. W.	Calm
22	2 S. W.	2 S. W.	1 S. W.	1 S. W.	2 S. W.	2 S. W.
23	Calm	1 N. E.	1 N. E.	Calm	Calm	Calm
24	4 N. W.	5 N. W.	4 N. W.	4 N. W.	3 N. W.	5 N. W.
25	3 W. by N.	3 W. S. W.	4 W. S. W.	4 W. S. W.	7 W.	7 W.
26	7 W.	7 W.	7 W.	7 N. W.	8 N. W.	8 N. W.
27	7 W. S. W.	7 W. S. W.	8 N. W.	8 N. W.	7 W.	8 W.
28	4 W.	4 W.	4 W.	6 W.	3 W.	3 W.
29	Calm	Calm	Calm	1 N. E.	Calm	Calm
30	3 N. W.	2 N. W.	Calm	Calm	Calm	Calm
31	4 N. W.	5 W.	6 W.	5 W.	4 N. W.	2 N. W.

Direction (true) and Force of the Wind observed on board the yacht Fox.

January, 1859.—At winter quarters.

DATE.	2h.	4h.	6h.	8h.	10h.	Noon.
1	6 N. W.	4 N. W.	5 N. W.	5 N. W.	1 N. W.	3 N. W.
2	4 N. W.	3 N. W.	4 N. W.	4 N. N. E.	5 N. N. E.	5 N. N. E.
3	4 N. N. W.	4 N.	4 N.	4 N.	5 N.	5 N.
4	3 N.	3 N.	3 N.	4 N. W.	6 N. W.	8 N. W.
5	4 N. W.	3 N. W.	3 N. W.	5 N.	5 N.	4 N.
6	2 N. W.	3 N. W.	3 N. W.	4 N. W.	4 W.	4 W.
7	4 N. W.	4 N. W.	4 N. W.	2 N. W.	6 N. W.	3 N. W.
8	6 N. W.	6 N. W.	8 N. W.	8 N. W.	7 N. W.	6 N. W.
9	Calm	Calm	Calm	2 N. W.	3 N. W.	4 N. W.
10	Calm	1 N. W.	Calm	and variable	air	1 N. E.
11	1 N. E.	2 N. E.	2 N. E.	3 N. E.	3 N. E.	4 N. E.
12	4 E. N. E.	4 E. N. E.	4 E. N. E.	3 E. N. E.	2 N. E.	1 Variable
13	1 E. N. E.	Calm	1 N. E.	1 N. E.	Calm	Calm
14	3 W. N. W.	4 W. N. W.	2 W. N. W.	Calm	3 N. W.	3 N. W.
15	3 N. W.	4 N. W.	6 N. W.	6 N. W.	7 N. W.	7 N. W.
16	6 N. W.	6 N. W.	2 N. W.	2 N. W.	4 N. W.	4 N. W.
17	4 W. N. W.	3 W. N. W.	2 N. W.	4 N. W.	4 N. W.	5 W. N. W.
18	6 N. W.	3 N. W.	3 N. W.	Calm	Calm	1 N. E.
19	3 N. E.	Calm	Calm	1 N. W.	2 N. W.	1 N. W.
20	6 N. W.	7 N. W.	7 N. W.	5 N. W.	3 N. W.	2 N. W.
21	1 N. E.	Calm	1 W. by N.	2 N. W.	1 N. W.	1 N. W.
22	4 N. W.	4 N. W.	5 N. W.	5 N. W.	4 N. W.	5 N. W.
23	5 N. W.	4 N. W.	2 N. W.	2 N. W.	2 N. W.	1 N. W.
24	4 W. N. W.	5 W. N. W.	6 W. N. W.	6 W. N. W.	5 W. N. W.	5 W. N. W.
25	8 N. W.	8 N. W.	7 N. W.	5 N. W.	5 N. W.	4 N. W.
26	5 N. W.	4 N. W.	3 N. W.	2 N. W.	4 N. W.	1 Variable
27	1 N. W.	Calm	Calm	1 N. E.	Calm	Calm
28	6 N. W.	6 N. W.	6 N. W.	6 N. W.	5 N. W.	4 N. W.
29	6 N. W.	5 N. W.	3 N. W.	4 N. W.	2 N. W.	5 N. W.
30	1 N. W.	3 N. W.	4 N. W.	3 N. W.	2 N. W.	1 N. W.
31	2 N. E.	2 N. E.	1 N. E.	1 N. E.	1 N. E.	1 N. E.

DATE.	2h.	4h.	6h.	8h.	10h.	Midn't.
1	4 N. W.	3 N. W.	4 N. W.	4 N. W.	6 N. W.	5 N. W.
2	6 N. E.	5 N.	4 N.	2 N.	3 N.	3 N.
3	5 N.	4 N.	4 N.	4 N.	4 N.	4 N.
4	7 N. W.	8 N. W.	6 N. W.	7 N. W.	6 N. W.	4 N. W.
5	Calm	Calm	1 W.	Calm	3 N. W.	2 N. W.
6	4 W.	6 W.	5 W.	4 W.	6 W.	6 W.
7	4 N. W.	5 N. W.	6 N. W.	4 N. W.	7 N. W.	8 N. W.
8	4 N. W.	3 N. W.	Calm	Calm	Calm	Calm
9	5 N. W.	4 N. W.	3 N. W.	3 W.	2 N. N. W.	3 N. W.
10	1 N. E.	Calm	Calm	Calm	2 N. E.	2 N. E.
11	4 N. E.	4 N. E.	4 N. E.	2 N. E.	2 N. E.	2 N. E.
12	2 N. E.	2 N. E.	3 N. E.	2 E. N. E.	2 E. N. E.	1 E. N. E.
13	Calm	Calm	Calm	3 W. N. W.	4 W. N. W.	3 W. N. W.
14	5 N. W.	6 N. W.	4 N. W.	4 N. W.	4 N. W.	2 N. W.
15	6 N. W.	7 N. W.	7 N. W.	6 N. W.	3 N. W.	3 N. W.
16	4 N. W.	4 N. W.	3 N. W.	3 N. W.	4 N. W.	4 N. W.
17	4 W. N. W.	4 W. N. W.	4 W. N. W.	4 N. W.	5 N. W.	7 N. W.
18	2 N. E.	3 N. E.	3 N. E.	3 N. E.	5 N. E.	5 N. E.
19	4 N. W.	5 N. W.	4 N. W.	3 N. W.	1 N. W.	3 N. W.
20	1 N. W.	Calm	Calm	1 N. E.	Calm	1 N. E.
21	2 N. W.	3 N. W.	3 W. N. W.	4 W. N. W.	4 N. W.	5 N. W.
22	5 N. W.	5 N. W.	2 N. W.	2 N. W.	5 N. W.	4 N. W.
23	3 N. W.	3 N. W.	3 N. W.	3 N. W.	2 N. W.	3 W. N. W.
24	4 W. N. W.	6 N. W.	6 N. W.	9 N. W.	8 N. W.	7 N. W.
25	5 N. W.	5 N. W.	5 N. W.	5 N. W.	6 N. W.	6 N. W.
26	1 N. E.	1 N. E.	1 N. E.	Calm	Calm	Calm
27	3 N. W.	3 N. W.	5 N. W.	2 N. W.	4 N. W.	6 N. W.
28	5 N. W.	4 N. W.	6 N. W.	6 N. W.	6 N. W.	5 N. W.
29	4 N. W.	4 N. W.	3 N. W.	2 N. W.	2 N. W.	1 N. W.
30	1 N. W.	2 N. W.	Calm	Calm	2 N. E.	3 N. E.
31	2 N. E.	1 N. E.	1 N. E.	Calm	Calm	Calm

DIRECTION (TRUE) AND FORCE OF THE WIND OBSERVED ON BOARD THE YACHT FOX.

February, 1859.—At winter quarters.

DATE.	2h.	4h.	6h.	8h.	10h.	Noon.
1	Calm	Calm	Calm	Calm	Calm	Calm
2	4 W. by N.	6 W. N. W.	6 W. N. W.	5 N. W.	1 N. W.	1 N. W.
3	1 E. N. E.	1 E. N. E.	1 E. N. E.	1 E. N. E.	1 E. N. E.	1 E. N. E.
4	1 N. E.	Calm	Calm	2 N. W.	5 N. W.	5 N. W.
5	5 N. W.	3 N. W.	2 N. W.	1 N. W.	2 N. W.	2 N. W.
6	5 N. W.	4 N. W.	6 N. W.	6 N. W.	6 N. W.	5 N. W.
7	8 N. W.	6 N. W.	5 N. W.	2 N. W.	2 N. W.	3 N. W.
8	2 N. W.	Calm	Calm	3 N. W.	5 N. W.	5 N. W.
9	5 N. W.	4 N. W.	3 N. W.	Calm	1 W. N. W.	1 W. N. W.
10	1 N. E.	Calm	Calm	Calm	Calm	2 N. W.
11	6 N. W.	6 N. W.	6 N. W.	7 N. W.	6 N. W.	6 N. W.
12	5 N. W.	3 N. W.	1 N. W.	1 N. W.	1 W.	3 W.
13	4 W. N. W.	3 W. N. W.	2 W. N. W.	4 W. N. W.	3 W. N. W.	2 W. N. W.
14	8 W. N. W.	8 W. N. W.	6 N. W.	4 N. W.	4 N. W.	4 N. W.
15	7 N. W.	7 N. W.	7 N. W.	5 W. N. W.	9 W. N. W.	8 W. N. W.
16	6 W.	5 W.	5 W.	5 W.	6 W.	4 W.
17	2 N. W.	1 N. W.	Calm	1 S. E.	Calm	Calm
18	5 W.	4 W.	5 W.	6 W.	6 W.	1 W.
19	2 W.	5 W.	6 W.	5 W.	5 W.	2 W.
20	Calm	Calm	2 N. E.	2 N. E.	3 N. E.	4 N. E.
21	Calm	Calm	Calm	Calm	Calm	Calm
22	6 N. E.	6 N. E.	5 N. E.	5 N. E.	5 N. E.	4 N. E.
23	3 N. E.	1 N. E.	Calm	Calm	2 W.	1 W.
24	3 N. W.	3 N. W.	3 N. W.	2 W.	3 W.	2 W.
25	6 N. W.	7 N. W.	7 N. W.	7 N. W.	6 W.	4 W.
26	4 N. W.	3 N. W.	5 N. W.	2 N. W.	2 N. W.	1 N. W.
27	2 W.	3 W.	3 W.	4 W.	4 W.	5 W.
28	9 W.	8 W.	8 W.	5 N. W.	6 N. W.	7 N. W.

DATE.	2h.	4h.	6h.	8h.	10h.	Midn't.
1	Calm	1 S.	3 N. W.	3 N. W.	3 W. by N.	5 W. by N.
2	1 N. W.	1 S. E.	1 E. N. E.	2 N. E.	2 E. N. E.	2 E. N. E.
3	1 E. N. E.	1 E. N. E.	1 E. N. E.	1 E. N. E.	1 E. N. E.	1 E. N. E.
4	6 N. W.	4 N. W.	5 N. W.	2 N. W.	3 N. W.	4 N. W.
5	2 N. W.	1 N. W.	3 N. W.	2 N. W.	3 N. W.	4 N. W.
6	4 N. W.	4 N. W.	4 N. W.	2 N. W.	5 N. W.	6 N. W.
7	4 W. N. W.	7 W. N. W.	6 W. N. W.	2 N. W.	1 N. W.	1 N. W.
8	7 N. W.	7 N. W.	6 N. W.	6 N. W.	6 N. W.	4 N. W.
9	1 W. N. W.	Calm	1 N. W.	Calm	Calm	1 N. E.
10	1 N. W.	2 N. W.	2 N. W.	1 N. W.	4 N. W.	4 N. W.
11	4 N. W.	6 N. W.	7 N. W.	4 N. W.	7 N. W.	7 N. W.
12	3 W.	6 W.	4 N. W.	5 W. N. W.	4 W. N. W.	4 W. N. W.
13	2 W. N. W.	2 W. N. W.	4 W. N. W.	3 W. N. W.	3 W. N. W.	3 W. N. W.
14	6 N. W.	4 N. W.	4 N. W.	3 N. W.	5 N. W.	6 N. W.
15	5 W. N. W.	5 W. N. W.	6 W. N. W.	6 W. N. W.	4 W. S. W.	6 W. S. W.
16	6 W.	4 W.	4 N. W.	4 N. W.	4 N. W.	4 N. W.
17	2 W.	2 W.	2 W.	4 W.	5 W.	5 W.
18	2 W.	2 W.	2 W.	3 W.	3 W. N. W.	2 W.
19	2 W.	1 W.	Calm	Calm	Calm	Calm
20	3 N. E.	2 N. E.	2 N. E.	2 N. E.	Calm	Calm
21	Calm	Calm	2 N. E.	2 N. E.	5 N. E.	7 N. E.
22	4 N. E.	4 N. E.	4 N. E.	5 N. E.	5 N. E.	5 N. E.
23	1 W.	1 W.	1 W.	1 W.	Calm	1 N. W.
24	2 W.	2 W.	3 W.	3 N. W.	3 N. W.	4 N. W.
25	4 W.	4 N. W.	4 N. W.	4 N. W.	4 N. W.	4 N. W.
26	1 N. W.	1 N. W.	1 N. W.	1 N. W.	Calm	Calm
27	5 N. W.	5 N. W.	7 W.	5 W.	5 W.	7 W.
28	7 W.	9 N. W.	8 N. W.	6 N. W.	9 N. W.	9 N. W.

Direction (true) and Force of the Wind observed on board the yacht Fox.

March, 1859.—At winter quarters.

DATE.	2h.	4h.	6h.	8h.	10h.	Noon.
1	9 N. W.	8 N. W.	7 N. W.	6 W.	7 W.	6 W.
2	2 W.	2 W.	Calm	Calm	Calm	Calm
3	2 N. E.	2 N. E.	3 N. E.	4 N. E.	4 N. E.	4 N. E.
4	2 N. E.	1 N. E.	2 N. E.	2 N. E.	Calm	Calm
5	Calm	Calm	Calm	Calm	Calm	Calm
6	Calm	Calm	Calm	Calm	Calm	Calm
7	3 N. E.	4 N. E.	4 N. E.	4 N. E.	4 N. E.	4 N. E.
8	3 E. N. E.	3 E. N. E.	3 E. N. E.	3 E. N. E.	3 E. N. E.	3 E. N. E.
9	3 E. N. E.	1 E. N. E.	2 E. N. E.	2 E. N. E.	2 E. N. E.	1 E. N. E.
10	1 N. E.	2 N. E.	Calm	2 N. E.	1 N. W.	1 N. W.
11	5 W. N. W.	7 W. N. W.	7 W. N. W.	7 W. N. W.	7 W. N. W.	7 N. W.
12	9 W. N. W.	9 W. N. W.	9 W. N. W.	7 W. N. W.	8 N. W.	8 N. W.
13	4 N. W.	5 N. W.	5 N. W.	4 N. W.	6 N. W.	3 N. W.
14	4 N. W.	2 N. W.	Calm	Calm	Calm	Calm
15	Calm	2 N. E.	5 N. E.	5 N. E.	5 N. E.	7 N. E.
16	5 N. E.	4 N. E.	3 N. E.	4 N. E.	4 N. E.	4 N. E.
17	3 N. W.	5 N. W.	7 N. W.	7 N. W.	8 N. W.	8 N. W.
18	6 W.	4 W.	8 W.	5 N. W.	5 N. W.	4 N. W.
19	3 N. W.	4 N. W.	3 N. W.	3 N. W.	2 N. W.	2 N. W.
20	Calm	Calm	Calm	Calm	Calm	Calm
21	Calm	Calm	Calm	Calm	Calm	Calm
22	1 N. W.	Calm	Calm	Calm	2 N. E.	1 N. E.
23	3 N. E.	4 N. E.	4 N. E.	2 N. E.	3 N. E.	2 N. E.
24	Calm	Calm	Calm	Calm	1 W.	2 W.
25	1 N. W.	Calm	Calm	1 N. W.	2 N. W.	1 N. W.
26	4 N. E.	3 N. E.	3 N. E.	3 N. E.	5 N. E.	4 N. E.
27	2 N. E.	2 N. E.	4 N. E.	2 N. E.	2 N. E.	Calm
28	- - - -	1 N. E.	- - - -	Calm	- - - -	Calm
29	- - - -	Calm	- - - -	Calm	- - - -	2 N. W.
30	- - - -	2 N. E.	- - - -	1 N. E.	- - - -	1 N. E.
31	- - - -	Calm	- - - -	Calm	- - - -	Calm

DATE.	2h.	4h.	6h.	8h.	10h.	Midn't.
1	5 W.	3 W.	3 W.	2 W.	2 W.	2 W.
2	Calm	Calm	2 N. E.	3 N. E.	4 N. E.	4 N. E.
3	3 N. E.	2 N. E.	1 N. E.	1 N. E.	1 N. E.	3 N. E.
4	Calm	Calm	Calm	Calm	Calm	Calm
5	Calm	Calm	Calm	Calm	Calm	Calm
6	1 N. E.	2 N. E.	2 N. E.	2 N. E.	2 N. E.	2 N. E.
7	5 N. E.	5 N. E.	4 E. N. E.	4 E. N. E.	4 E. N. E.	3 E. N. E.
8	2 E. N. E.	2 E. N. E.	2 E. N. E.	3 E. N. E.	2 E. N. E.	3 E. N. E.
9	1 E. N. E.	2 N. W.	4 N. W.	4 N. W.	2 N. W.	Calm
10	Calm	Calm	1 N. E.	2 N. W.	6 N. W.	4 W. N. W.
11	8 N. W.	9 N. W.	9 N. W.	9 N. W.	9 N. W.	9 W. N. W.
12	7 N. W.	8 N. W.	7 N. W.	7 N. W.	4 N. W.	2 W.
13	6 N. W.	5 N. W.	5 N. W.	4 N. W.	5 N. W.	4 N. W.
14	Calm	Calm	Calm	1 N. E.	Calm	Calm
15	7 N. E.	5 N. E.	4 N. E.	4 N. E.	4 N. E.	4 N. E.
16	3 N. E.	2 N. E.	1 N. E.	1 N. E.	Calm	Calm
17	6 N. W.	6 N. W.	6 N. W.	5 N. W.	3 W.	2 W.
18	3 N. W.	3 N. W.	5 N. W.	4 N. W.	4 N. W.	5 N. W.
19	3 N. W.	2 N. W.	1 N. W.	1 N. W.	1 N. W.	Calm
20	Calm	Calm	Calm	Calm	Calm	Calm
21	Calm	Calm	Calm	1 N. E.	1 N. W.	1 N. W.
22	1 N. E.	2 N. E.	2 N. E.	1 N. E.	1 N. E.	4 N. E.
23	2 N. E.	1 N. E.	Calm	Calm	Calm	2 S. W.
24	2 N. W.	2 N. W.	2 N. W.	2 N. W.	1 N. W.	1 N. W.
25	1 N. W.	1 N. E.	2 N. E.	2 N. E.	4 N. E.	4 N. E.
26	3 N. E.	4 N. E.	2 N. E.	3 N. E.	3 N. E.	3 N. E.
27	1 N. E.	2 N. E.	1 N. E.	Calm	2 N. E.	1 N. E.
28	- - - -	Calm	- - - -	Calm	- - - -	Calm
29	- - - -	2 N. W.	- - - -	2 N. W.	- - - -	Calm
30	- - - -	1 N. E.	- - - -	1 N. E.	- - - -	Calm
31	- - - -	Calm	- - - -	Calm	- - - -	3 N. W.

Direction (true) and Force of the Wind observed on board the yacht Fox.

April, 1859.—At winter quarters.

Date.	5h.	8h.	Noon.	4h.	8h.	11h.
1	4 N. W.	6 N. W.	7 N. W.	5–7 W. S. W.	5 W. S. W.	7–8 W. S. W.
2	8 W. S. W.	2 W. S. W.	4 W.	1 W.	2 W.	3 W.
3	5 W.	2 W.	2 W.	1 W.	Calm	1 N. E.
4	3 E. N. E.	3 N. N. E.	4 N. E.	4 N. E.	2 N.	1 N.
5	4 W'ly	3 W'ly	4 W. N. W.	5 W. N. W.	6 W. N. W.	6 W. N. W.
6	6 W.	5 W. S. W.	7 W. S. W.	4 W.	4 N. W.	3 N. W.
7	2 N.	3 N.	1 N. N. W.	2 N.	Calm	Calm
8	Calm	Calm	3 N. N. E.	3 N. N. E.	3 N. N. E.	2 N. N. E.
9	6 E. N. E.	6 E. N. E.	4 E. N. E.	1 E. N. E.	Calm	Calm
10	Calm	Calm	4 W.	4 W.	2 W.	1 W.
11	Calm	Calm	Calm	Calm	Calm	Calm
12	2 N. W.	2 N. W.	4 W. N. W.	5 W. N. W.	2 W. N. W.	2 W. N. W.
13	Calm	1 Variable	Calm	Calm	2 N. N. E.	3 N. N. E.
14	3 E.	2 E.	4 N. E.	3 N. E.	3 N. E.	4 N. E.
15	1 N. E.	Calm	Calm	Calm	5 E. N. E.	4 E. N. E.
16	4 E. N. E.	4 E. N. E.	3 E. N. E.	4 N. E.	5 N. E.	5 N. E.
17	3 N. E.	5 N. E.	6 N. E.	5 N. E.	4 E. N. E.	6 E. N. E.
18	7 E. N. E.	7 N. E.	8 N. E.	7 N. E.	5 N. E.	1 N. E.
19	1 E. S. E.	4 E. S. E.	2 E. S. E.	2 E. S. E.	2 E. N. E.	3 E. N. E.
20	4 E. N. E.	2 E. N. E.	3 N. E.	4 N. E.	3 N.	4 N. N. E.
21	2 N. N. E.	3 N. N. E.	3 N. N. E.	3 N.	4 N.	5 N.
22	4 N.	1 N.	4 W. N. W.	3 W. N. W.	4 N. N. W.	1 N.
23	3 E. by N.	3 E. by N.	4 N. E.	8 N. E.	8 N. E.	9 N. E.
24	5 E. N. E.	6 E. N. E.	6 E. N. E.	3 E. N. E.	3 E. N. E.	3 N. E. by E.
25	2 E. N. E.	4 E. N. E.	2 E. N. E.	2 N. E. by E.	Calm	Calm
26	Calm	Calm	1 E. N. E.	2 E. N. E.	3 N. E.	4 N. E.
27	4 E. N. E.	4 E. N. E.	6 E. N. E.	3 E. N. E.	2 E. N. E.	2 N. E. by E.
28	Calm	1 N. E.	1 N. E.	Calm	1 N. E.	2 N. E.
29	3 N. E.	2 N. E.	3 N. E.	2 N. E.	4 N. E.	4 N. E.
30	1 N. E.	2 N. E.	Calm	5 W.	8 W.	9 W.

May, 1859.—At winter quarters.

Date.	5h.	8h.	Noon.	4h.	8h.	11h.
1	9 W.	9 W.	9 W.	7 W.	4 W.	4 W.
2	3 W.	3 W.	6 W.	5 W.	5 W.	7–9 W.
3	7 W.	6 W.	6 W.	6–8 W.	4–6 W.	6 W.
4	3 W. N. W.	2 W. N. W.	3 W. N. W.	1 W. N. W.	4 W. N. W.	5 W.
5	4 W.	2 W.	1 W.	3 W.	3 W.	4 W.
6	2 W.	1 W.	2 W.	2 W.	5 W. N. W.	4 W. N. W.
7	2 W.	2 W.	5 W.	6 W.	6–8 W.	8–9 W.
8	4 W.	2 W.	6 W.	5 W.	3 W.	Calm
9	7 N. E.	7 N. E.	6 N. E.	2 N. E.	5 N. N. E.	Calm
10	3 N. W.	5 N. W.	4 N. W.	Calm	Calm	3 W.
11	2 W. by N.	1 W. by N.	5 W. by N.	2 N. E.	3 N. N. W.	2 N. N. W.
12	Calm	Calm	4 N. N. W.	3 N. N. W.	4 N. N. W.	5 N. N. W.
13	3 N. N. W.	3 N. N. W.	3 N. W.	3 N. W.	2 N. W.	Calm
14	Calm	Calm	1 E. N. E.	4 N. N. E.	3 N. N. E.	2 N. N. E.
15	3 N. N. E.	2 N. N. E.	2 N. N. E.	1 N. N. E.	1 N. N. E.	2 N. N. E.
16	Calm	Calm	4 N. W.	7–8 N. W.	5–7 N. W.	8 N. W.
17	4 N. W.	1 N. W.	2 N. W.	3 N. W.	4 N. W.	6 N. N. W.
18	Calm	Calm	Calm	1 N. N. W.	Calm	Calm
19	2 N. E.	Calm	Calm	Calm	1 N. E.	2 N. by E.
20	3 N.	2 N.	6 N. W.	7–9 N. W.	6 N. W.	5 W. N. W.
21	3 W. N. W.	1 W. N. W.	Calm	Calm	Calm	2 N. N. E.
22	3 E. N. E.	2 E. N. E.	1 E. N. E.	2 E. N. E.	1 E. N. E.	2 E. N. E.
23	2 E. N. E.	2 E. N. E.	3 E. N. E.	2 E. N. E.	1 E. N. E.	Calm
24	1 E. N. E.	1 N. by E.	2 N. N. W.	2 N. W.	1 N. W.	2 N. W.
25	6 W. by N.	4–6 W. by N.	3–5 N. W.	5 W. by N.	5 W. by N.	3 N. by E.
26	3 N. E.	3 N. E.	6–8 N. W.	3 N. W.	5 W.	8 W.
27	8 W.	5 W.	5 W.	3 W.	1 W.	2 N. E.
28	1 N. E.	Calm	Calm	1 N.	1 N.	1 N.
29	Calm	Calm	Calm	Calm	Calm	1 N.
30	Calm	Calm	6 N. W.	4–6 N. W.	4 N. N. W.	2 N. N. W.
31	4 N. N. W.	3 N. N. W.	4 N. N. W.	3 N. N. W.	3 N. N. W.	2 N. N. W.

DIRECTION (TRUE) AND FORCE OF THE WIND OBSERVED ON BOARD THE YACHT FOX.

June, 1859.—At winter quarters.

DATE.	5h.	8h.	Noon.	4h.	8h.	11h.
1	4 N. W.	3 N. W.	5–7 N. W.	6–8 N. W.	3 N. N. W.	10 N. N. W.
2	9 N. W.	9 N. W.	9 N. W.	7 N. W.	9 N. W.	9 N. W.
3	4 N. N. W.	1 N.	2 N.	1 N. N. W.	2 N. E.	3 N. E.
4	4 N. E.	4 N. E.	1 N. E.	Calm	2 N. E.	Calm
5	2 N. E.	3 N. E.	Calm	4 N. W.	1 N.	3 N.
6	2 N. E.	3 E. N. E.	2 E. N. E.	Calm	3 N. E.	3 N. E.
7	Calm	3 N. E.	5 N. E. by E.	4 N. E. by E.	2 N. E. by E.	2 N. E. by E.
8	3 N.	4 N.	6 N. W.	7–9 N. W.	7–9 W. by S.	3–7 N. W.
9	3 N.	2 N.	Calm	2 N. E.	1 N. E.	3 N. E.
10	4 N. E.	6 N. E.	6 N. E.	4 N. E.	2 N. E.	Calm
11	6 W. N. W.	6 W.	6 W.	6 N. W.	2–5 N. N. W.	2–5 N. N. W.
12	2 W. by N.	4 W. by N.	6 N. N. E.	5 N. N. E.	4 N. N. E.	3 N. N. E.
13	3 N. E.	2 N. E.	Calm	1 N. W.	3 N. W.	5 N. W.
14	5 N. W.	6 N. W.	5 N. W.	Calm	1 N. W.	1 N. by W.
15	2 W.	2 W.	Calm	Calm	4 N. W.	2 N. W.
16	2 E. N. E.	2 E. N. E.	1 N. E.	1 N. E.	1 N. E.	Calm
17	Calm	Calm	Calm	Calm	Calm	1 N. E.
18	2 E.	1 E.	Calm	5 W.	4 N. W.	3–5 N. N. W.
19	3 W.	2 W.	4 N. E.	4 N. E.	6 N. W.	5 N. W.
20	3 N. W.	2 N. W.	1 N. W.	Calm	2 E.	Calm
21	Calm	1 S. E.	Calm	1 S. S. W.	5 W. N. W.	7 N. W.
22	9 W.	7 W.	5 N. W.	5 N. W.	6 N. W.	5 N. W.
23	6 N. W.	5 N. W.	5 N. W.	6 N. W.	6 N. W.	3–5 N. W.
24	7 N. W.	6 N. W.	7–9 N. W.	5 N. W.	1 N. W.	6 N. W.
25	6 N. W.	5 N. W.	6 N. W.	5 N. W.	7 N. W.	8 N. W.
26	6 N. W.	6 N. W.	5 N. W.	3 N. W.	2 N. W.	Calm
27	1 E. N. E.	1 E. N. E.	2 E. N. E.	3 E. N. E.	1 E. N. E.	3 E. N. E.
28	4 E. N. E.	4 E. N. E.	3 E. N. E.	3 E. N. E.	3 E. N. E.	2 N. E.
29	3 N. E.	1 W.	4 W. N. W.	2 W. N. W.	Calm	1 N. N. W.
30	Calm	2 N. W.	2 N. W.	7 N. W.	7 N. W.	3 N. W.

Direction (true) and Force of the Wind observed on board the yacht Fox.

July, 1859.—At winter quarters.

DATE.	2h.	4h.	5h.	6h.	8h.	10h.	Noon.
1	- - - -	- - - -	8 N. W.	- - - -	7 N. W.	- - - -	6 N. W.
2	- - - -	- - - -	3 N. W.	- - - -	4 N. W.	- - - -	6 N. W.
3	- - - -	- - - -	1 E. N. E.	- - - -	1 E. by N.	- - - -	2 E. S. E.
4	- - - -	- - - -	1 E. N. E.	- - - -	1 E. N. E.	- - - -	2 E. by N.
5	- - - -	- - - -	2 E. N. E.	- - - -	2 E. N. E.	- - - -	2 E. N. E.
6	Calm	Calm	- - - -	3 N. W.	5 N. W.	5 W. N. W.	6 W. N. W.
7	6 W. N. W.	4 W. N. W.	- - - -	3 W. N. W.	2 W. N. W.	2 W. N. W.	1 W. N. W.
8	3 E. N. E.	3 N.	- - - -	2 N.	3 W. N. W.	3 W. N. W.	4 W. N. W.
9	4 S. S. W.	5 S. S. W.	- - - -	5 S. S. W.	2 S. S. W.	Calm	2 W. N. W.
10	5 W. by N.	6 W. by N.	- - - -	5 W. by N.	5 W. by N.	3 W. by N.	6 N. N. W.
11	7 N. E. by N.	9 N. E. by N.	- - - -	9 N. E. by N.	7 N. E. by N.	7 N. E. by N.	7 N. E. by N.
12	3 N. N. W.	3 W. N. W.	- - - -	5 W. N. W.	3 W. N. W.	4 W. N. W.	4 W. N. W.
13	2 W. N. W.	4 W. N. W.	- - - -	5 W. N. W.	6 W. N. W.	6 W. N. W.	5 W. N. W.
14	Calm	Calm	- - - -	4 N. E.	4 N. E.	3 N. W.	3 N. E.
15	4 N. W.	4 N. W.	- - - -	4 N. W.	5 N. W.	4 N. W.	3 N. W.
16	4 N. W.	4 N. W.	- - - -	4 N. W.	4 N. W.	5 N. W.	5 N. W.
17	Calm	Calm	- - - -	2 N. W.	3 N. W.	5 N. W.	5 N. W.
18	6 N. W.	6 W. by N.	- - - -	6 N. W.	6 N. W.	6 N. W.	5 N. W.
19	7 N. W.	7 N. W.	- - - -	3 N. E.	3 N. E.	6 N. E.	6 N. E.
20	5 N. E.	5 N. E.	- - - -	3 N. E.	3 N. N. W.	3 S. W.	2 S. S. W.
21	6 N. E.	5 N. E.	- - - -	5 N. E.	5 N. E.	5 N. E.	5 N. E.
22	5 N. E.	4 N. E.	- - - -	2 N. E.	2 N. E.	2 N. E.	3 N. E.
23	3 N. E.	2 N. E.	- - - -	3 N. E.	3 N. E.	4 E. by N.	3 E. by N.
24	Calm	Calm	- - - -	Calm	Calm	Calm	1 S. W.
25	6 N. W.	6 N. W.	- - - -	6 N. W.	6 N. W.	6 W. S. W.	6 W. S. W.
26	6 W. S. W.	6 W. S. W.	- - - -	5 W. S. W.	5 W. S. W.	1 W. S. W.	1 W. S. W.
27	2 E. by N.	3 E. by N.	- - - -	5 E. by N.	5 E. by S.	4 E. by S.	1 N. E.
28	Calm	Calm	- - - -	Calm	Calm	Calm	Calm
29	1 W. by N.	1 W. by N.	- - - -	2 N. N. E.	2 W. S. W.	2 W. S. W.	2 W. S. W.
30	2 N. W.	3 N. W.	- - - -	3 N. W.	3 N. W.	3 N. W.	2 N. W.
31	2 N. W.	3 N. W.	- - - -	3 S. W.	2 S. W.	3 S. W.	3 W.

DATE.	2h.	4h.	6h.	8h.	10h.	11h.	Midn't.
1	- - - -	2 W. S. W.	- - - -	4 N. W.	- - - -	4 N. W.	- - - -
2	- - - -	2 N. W.	- - - -	2 N. E.	- - - -	2 N. E.	- - - -
3	- - - -	1 E. S. E.	- - - -	1 S. E.	- - - -	1 S. E. by S.	- - - -
4	- - - -	1 E. N. E.	- - - -	1 E. N. E.	- - - -	3 E. N. E.	- - - -
5	1 E. N. E.	3 E.	2 E.	2 E. N. E.	1 E. N. E.	- - - -	1 N. W.
6	6 W. N. W.	6 W. N. W.	6 W. N. W.	6 W. N. W.	5 W. N. W.	- - - -	5 W. N. W.
7	2 W. N. W.	2 W. N. W.	2 W. N. W.	Calm	2 E. N. E.	- - - -	2 E. N. E.
8	5 W. N. W.	6 W. N. W.	6 W. N. W.	5 W. N. W.	3 W. N. W.	- - - -	5 S. S. W.
9	3 W. N. W.	3 W. N. W.	5 W. N. W.	5 W. by N.	5 W. by N.	- - - -	4 W. by N.
10	7 N. N. W.	7 N. N. W.	7 N. N. W.	7 N. N. W.	7 N. E. by N.	- - - -	8 N. E. by N.
11	4 N. E. by N.	3 N. E. by N.	Calm	Calm	Calm	- - - -	Calm
12	5 W. N. W.	5 W. N. W.	5 W. N. W.	4 W. N. W.	6 W. N. W.	- - - -	6 W. N. W.
13	5 N. N. W.	Calm	3 N. W.	3 N. W.	3 W. N. W.	- - - -	Calm
14	2 N. E.	2 N. E.	4 N. by W.	4 N. by W.	3 N. W.	- - - -	2 N. W.
15	5 N. W.	4 N. W.	4 N. W.	4 N. W.	3 N. W.	- - - -	2 N. W.
16	5 N. W.	5 N. W.	3 N. W.	2 N. W.	4 N. W.	- - - -	4 N. W.
17	4 N. W.	4 N. W.	4 N. W.	4 N. W.	5 N. W.	- - - -	6 N. W.
18	5 N. W.	5 N. W.	5 N. W.	5 N. W.	5 N. W.	- - - -	6 N. W.
19	6 N. E.	7 N. E.	6 N. E.	6 N. E.	7 N. E.	- - - -	7 N. E.
20	2 E. by N.	2 E. by N.	5 E. N. E.	5 N. E.	4 N. E.	- - - -	6 N. E.
21	5 N. E. by N.	6 N. E. by N.	6 N. E. by N.	6 N. E. by N.	4 N. E.	- - - -	5 N. E.
22	2 E. N. E.	2 E.	1 E.	Calm	Calm	- - - -	Calm
23	Calm	1 S. W.	1 S. W.	Calm	Calm	- - - -	Calm
24	4 S. W.	4 N. W.	4 N. W.	4 N. W.	5 N. W.	- - - -	5 N. W.
25	6 W. S. W.	6 W. S. W.	5 W. S. W.	6 W. S. W.	6 W. S. W.	- - - -	6 W. S. W.
26	Calm	1 S.	Calm	Calm	1 E.	- - - -	1 E.
27	1 N. W.	2 N. W.	Calm	Calm	4 N. E.	- - - -	Calm
28	Calm	1 S. W.	1 S. W.	Calm	Light	- - - -	Variable
29	1 S. W.	3 W. S. W.	4 W. S. W.	4 N. W.	3 N. W.	- - - -	2 N. W.
30	2 N. W.	3 N. W.	3 N. W.	2 N. E.	2 N. E.	- - - -	3 N. W.
31	3 W. N. W.	3 W. N. W.	2 W. N. W.	3 W. N. W.	5 W. N. W.	- - - -	3 W.

Direction (true) and Force of the Wind observed on board the yacht Fox.

August, 1859.—Mean position: Lat. 71°.9 N.; long. 79°.8 W.

Date.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Variation.
1	3 W.	3 W.	1 W.	1 W.	Calm	1 E. by N.	
2	3 E.	2 E.	1 E. by N.	4 E. N. E.	2 N. E.	2 N. E.	
3	2 N. E.	5 N. E.	6 N. E.	6 N. E.	5 N. E.	5 E. N. E.	
4	6 N. E.	7 N. E.	7 N. E. by E.	6 N. E. by E.	5 N. E. by E.	Calm	
5	Calm	3 N. W.	3 W.	4 W.	2 W.	2 W.	
6	Calm	Calm	2 S. W.	3 N. W.	3 N. W.	2 N. W.	
7	1 W.	2 W.	8 N. W. by W.	4 N. W.	4 N. W.	4 N. W.	
8	5 W.	4 W. N. W.	3 W.	4 W.	4 W.	6 W.	
9*	6 W.	4 W. by S.	5 W. by S.	3 N. N. W.	2 W. N. W.	1 S. E.	
10	C'lm, light var	2 S. E.	1 E.	Calm	Calm	2 E.	
11	3 E. by S.	3 E. by S.	4 E. by S.	5 E. S. E.	6 N. E.	6 N. N. E.	
12	6 E. N. E.	4 E. by S.	6 E. by S.	7 E. by S.	7 E. by S.	7 E. by S.	
13	7 E. by S.	7 E. by S.	6 E. by S.	5 E. by S.	6 E. by S.	7 E. by S.	
14	9 E. by S.	8 E. by S.	6 E. by S.	4 E. by S.	5 E. by S.	5 E. by S.	
15	4 E. by S.	4 W. N. W.	8 N. W.	8 W. N. W.	6 N. W. by W.	6 W. by N.	
16	2–4 N. W. by N.	2 W.	4 S. W.	5 S. by E.	2 S. by E.	3 S.	
17	Calm	2 N. by W.	2 N. E.	3 N. E.	3 Variable	3 N. N. E.	
18	1 N. E.	2 N. W.	3 W. N. W.	5 W. S. W.	5 W.	5 W.	
19	5 W. by S.	5 W. N. W.	6 N. W.	5 W.	5 W.	4 W.	
20	2 W.	Calm	1 N. E.	1 N.	5 N.	4 N. N. E.	
21	6 N. W.	3 S.	5 S. E.	5 S.	5 S. E. by E.	2 E.	
22	1 W.	6 W.	6 W.	6 W.	6 S. S. E.	5 S. E.	90° W.
23	5 S. E.	5 E. S. E.	3 S. E.	5 E. S. E.	3 E. S. E.	1 E. N. E.	90
24	5 N. N. W.	6 N. N. W.	6 N. W. by N.	7 N. N. W.	6 N. N. W.	6 N. N. W.	83
25	4 N. N. W.	Calm	1 N.	1 S.	2 S. W. & var.	3 S. W. & var.	78
26	3 Variable, S.	3 E.	2 E.	5 N. W.	6 N. W.	1 E.	72
27	3 E.	3 E. N. E.	4 E. N. E.	4 E. N. E.	3 E. N. E.	2 E. N. E.	
28	1 E. N. E.	3 E. N. E.	3 E. S. E.	2 E. N. E.	2 E. N. E.	2 E. N. E.	
29	2 E. N. E.	1 E. N. E.	Calm	4 N. N. E.	2 N. E.	Calm	
30	Calm	Calm	5 N. N. W.	2 N. N. W.	Calm	Calm	
31	2 E. N. E.	2 E. N. E.	3 N. E.	1 N. W.	Calm	Calm	

September, 1859.—Mean position: Lat. 58°.9 N.; long. 40°.9 W.

Date.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Variation.
1	2 E. N. E.	4 E. N. E.	2 N. N. E.	2 N.	3 N. W.	5 N. W.	73° W.
2	5 N. N. W.	7 N. N. W.	7 N. W.	6 N. N. W.	6 N. N. W.	7 N. N. W.	72
3	5 N. N. W.	5 N. N. W.	4 N. N. W.	3 N. W.	2 S. S. E.	2 S. W.	65
4	4 S. S. W.	4 S. W.	4 S. W. by S.	5 S. S. W.	5 S.	6 S. by W.	62
5	6 S. E. by S.	7 S. E. by S.	7 S. S. W.	7 S.	3 W. S. W.	2 W. S. W.	60
6	1 S. W. by S.	1 S. W. by S.	5 S. W. by S.	4 S. S. W.	4 S. S. W.	4 S. W. by W.	60
7	3 W.	3 W.	3 W. by N.	5 W.	3 W.	5 W. N. W.	55
8	Calm	2 N. E.	3 N. E.	4 N. E.	5 N. N. E.	7 N.	54
9	7 N. by W.	8 N. N. W.	8 N. W.	6 W. N. W.	6 W. N. W.	4 W. N. W.	53
10	4 W. N. W.	4 W. N. W.	4 W. N. W.	5 W. N. W.	6 W. N. W.	6 W. N. W.	52
11	7 W. N. W.	7 W.	7 W. N. W.	7 W. N. W.	7 W. N. W.	7 W. N. W.	50
12	7 W. S. W.	7 S. W.	6 S. S. W.	5 S. W.	6 W. S. W.	5 W. S. W.	48
13	3 S. S. W.	3 S.	4 S. W.	4 S. W.	6 S. W.	7 S. W.	46
14	7 S. S. W.	6 S. W.	6–7 W. S. W.	7 W.	7 W. N. W.	7 W. N. W.	43
15	7 W. N. W.	8 N. W.	8 N. W.	8 N. W.	8 N. W.	8 N. W.	40
16	7 N. W. by N.	6 N. N. W.	5 N. N. W.	5 N. N. E.	2 N. E.	1 N. E.	35
17	5 S. S. W.	5 S. S. W.	4 S. S. W.	6 S. S. W.	6 S. S. W.	6 S. S. W.	32
18	6 S. S. W.	6 S. W.	2 W.	6 S. W. by S.	6 S. W. by S.	5 W.	

* Steamed out of Port Kennedy.

Method of Reduction.—The method of reduction used is the same as that employed in the discussion of Kane's observations—it is by Lambert's improved formula, so as to include the velocity of the wind, and not the relative frequency alone. It is given in its outline in the article "Meteorology," in the 8th edition of the Encyclopædia Britannica.

Let $\theta_1\ \theta_2\ \theta_3$ . . . . . be the angles which the directions of the wind make with the meridian (true), reckoned round the horizon, according to astronomical usage, from the south, westward to 360°, a direction corresponding to that of the rotation of the winds in the northern hemisphere; and $v_1\ v_2\ v_3$ . . . . . its respective velocities, which may be supposed expressed in miles per hour; and let the observations be made at equal intervals (for instance, hourly). Adding up all velocity-numbers referring to the same wind during a given period (say one month), and representing these quantities by $s_1\ s_2\ s_3$ . . . . ., the number of miles of air transferred bodily over the place of observation by winds *from* the southward is expressed by the formula

$$R_s = s_1 \cos \theta_1 + s_2 \cos \theta_2 + s_3 \cos \theta_3 + \dots$$

And for winds *from* the westward

$$R_w = s_1 \sin \theta_1 + s_2 \sin \theta_2 + s_3 \sin \theta_3 + \dots$$

The resulting quantity R, and the angle ϕ it forms with the meridian, is found by the expressions

$$R = \sqrt{R_s^2 + R_w^2}, \text{ and } \tan \phi = \frac{R_w}{R_s}$$

The general formulæ, in the case of eight principal directions θ, assume the following convenient form:—

$$R_s = (S—N) + (S\,W—N\,E)\sqrt{\tfrac{1}{2}} — (N\,W—S\,E)\sqrt{\tfrac{1}{2}}$$
$$R_w = (W—E) + (S\,W—N\,E)\sqrt{\tfrac{1}{2}} + (N\,W—S\,E)\sqrt{\tfrac{1}{2}}$$

Where the letters S, $S\,W$, W, etc., represent the sum of all velocities during the given period, or the quantity of air moved in the directions S, $S\,W$, W, etc., respectively; R_s represents the total quantity of air transported *to the northward*, and R_w the same transferred *to the eastward*. These formulæ, for practical working, may be put in the following shape:—

$$\text{Put}\quad S—N = a \qquad S\,W—N\,E = c$$
$$W—E = b \qquad N\,W—S\,E = d$$

Then

$$R_s = R \cos \phi = a + 0.707\,(c—d)$$
$$R_w = R \sin \phi = b + 0.707\,(c+d).$$

Since R_s, R_w, R, represents the quantity of air passed over during the given period in the direction 0°, 90°, ϕ°, respectively, we must, in order to find the mean velocity for any resulting direction, divide by n, or by the number of observations during that period; we then have

$$V_s = \frac{R_s}{n}, \quad V_w = \frac{R_w}{n}, \quad \text{and } V = \frac{R}{n}.$$

A particle of air which has left the place of observation at the commencement of the period—of a day, for instance—will be found at its close in a direction 180 + ϕ, and at a distance of R miles, equal to a movement with an average velocity of

$\frac{R}{n}$; this supposes an equal and parallel motion of all particles passing over; the length of the path described by each can be found by the summation of all the *v's* (for each hour) during the period.

The great variability in the direction and force of the atmospheric motion renders the taking of resulting values for short intervals unnecessary, and a subdivision of the reduction into monthly periods has been found convenient.

To include more than eight directions into the discussion would not only render it very tedious, but would give no materially increased accuracy. Observed directions, intermediate of the eight directions, are referred to the nearest principal direction; and if midway, and occurring more than once, they are referred to the nearest preceding and following direction alternately.

The winds observed during July and August, 1857, and in September, 1859, cannot well be combined with the body of the observations, and have, therefore, not been reduced.

To illustrate the process of reduction, the working up of the observations for direction and force of the wind in the month of September, 1857, is here given as an example.

ABSTRACT OF THE QUANTITY OF WIND REFERRED TO THE EIGHT PRINCIPAL DIRECTIONS AND OBSERVED IN THE MONTH OF SEPTEMBER, 1857, BETWEEN LATITUDES 75°.5 AND 75° N., AND LONGITUDES 64°.1 AND 66° W.

Observations at 4, 8, 12, A. M. and P. M.

(The few intermediate observations on the last day of the month were not taken into account.)

True direct'n.	1st.	2d.	3d.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.	12th.	13th.	14th.	15th.
S. . . .	...	10	...	20	...	...	...	72	152	15	36	...	10	66	4
N. . . .	...	...	2	...	...	10	24	...	...	...	...	...	...	...	...
W. . . .	...	...	3	...	...	...	24	48	...	2	...	31	28	42	1
E. . . .	4	1	...	56	8	14	10	...	...	...	17	...	17	24	1
S. W. . .	8	...	...	...	...	...	...	...	...	...	...	...	...	...	...
N. E. . .	...	...	...	...	1	10	17	...	...	...	...	...	...	...	4
N. W. . .	5	1	1	...	...	10	...	...	...	...	...	...	4	...	4
S. E. . .	10	10	...	27	8	10	42	104	24	24	96	...	...	...	1
Sum . . .	27	22	6	103	17	54	117	224	176	41	149	31	59	132	15

True direct'n.	16th.	17th.	18th.	19th.	20th.	21st.	22d.	23d.	24th.	25th.	26th.	27th.	28th.	29th.	30th.	Sums.
S. . . .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	385
N. . . .	...	2	8	9	8	4	...	...	...	...	4	10	5	...	...	86
W. . . .	...	4	28	...	...	90	49	...	...	...	4	...	...	...	...	354
E. . . .	75	...	...	...	...	...	...	...	10	...	...	17	4	...	...	258
S. W. . .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8
N. E. . .	...	4	...	28	4	...	...	...	56	2	...	27	...	...	...	153
N. W. . .	...	2	27	10	44	17	121	13	31	57	40	14	...	11	70	482
S. E. . .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	356
Sum . . .	75	12	63	47	56	111	170	13	97	59	48	68	9	11	70	2082

By preceding formulæ we find—

$c = -145$	$0.7\ (c-d) = -190$	$R_s = +109$
$d = +126$	$0.7\ (c+d) = -\ 13$	$R_{10} = +\ 83$
$c-d = -271$	$a = +299$	$R = +137$
$c+d = -\ 19$	$b = +\ 96$	$\phi = 37°$

equivalent to a resulting direction of the wind S. W. ¾ S.

The following table shows the velocity-numbers for each of the principal eight winds, as well as the resulting direction of the wind, for each month between Sept. 1857, and Aug. 1859, as deduced by application of the preceding formulæ.

1857–'58. True direction.	SEPTEMBER. Mean Lat. 75°.3 Long. 65.0 6 obs. a day.	OCTOBER. Mean Lat. 75°.2 Long. 67.9 12 obs. a day.	NOVEMBER. Mean Lat. 74°.8 Long. 69.1 12 obs. a day.	DECEMBER. Mean Lat. 74°.3 Long. 67.4 12 obs. a day.	JANUARY. Mean Lat. 73°.2 Long. 63.7 12 obs. a day.	FEBRUARY. Mean Lat. 71°.5 Long. 60.9 12 obs. a day.
S.	385	246	220	449	145	124
N.	86	108	0	331	531	2381
W.	354	476	1121	388	993	151
E.	258	377	687	21	118	1
S. W.	8	212	700	135	93	27
N. E.	153	668	417	174	192	233
N. W.	482	1327	1846	2036	2904	3632
S. E.	356	968	1024	660	151	386
ϕ	37°	176°	98°	124°	131°	154°

1858. True direction.	MARCH. Mean Lat. 69°.4 Long. 59.1 12 obs. a day.	APRIL. Mean Lat. 66.°0, Long. 57°.7. From 1st–17th 12 obs. a day.	APRIL. F'm 18th–30th 6 obs. a day.	MAY. Mean Lat. 68°.7 Long. 53.7 6 obs. a day.	JUNE. Mean Lat. 74°.6 Long. 60.1 6 obs. a day.	JULY. Mean Lat. 74°.4 Long. 76.4 6 obs. a day.	AUGUST. Mean Lat. 73°.1 Long. 88.5 6 obs. a day.
S.	395	0	105	221	83	11	22
N.	1465	3366	416	138	126	136	135
W.	137	51	38	1	48	119	785
E.	239	52	0	251	311	154	331
S. W.	361	23	255	131	35	368	331
N. E.	304	246	57	424	82	460	301
N. W.	3112	1135	499	487	457	383	814
S. E.	764	0	215	593	298	165	477
ϕ	149°	165°		264°	224°	172°	114°

PORT KENNEDY. 1858–'59. True direction.	SEPTEMBER. 6 obs. a day.	OCTOBER. 6 obs. a day.	NOVEMBER. 12 obs. a day.	DECEMBER. 12 obs. a day.	JANUARY. 12 obs. a day.	FEBRUARY. 12 obs. a day.
S.	134	85	0	0	0	1
N.	167	38	21	10	369	0
W.	1071	59	106	773	200	1169
E.	27	25	4	0	0	0
S. W.	563	87	0	199	0	49
N. E.	416	1512	2193	780	460	444
N. W.	796	2132	4610	3721	4406	3336
S. E.	369	90	17	10	0	2
ϕ	99°	169°	160°	136°	142°	129°

PORT KENNEDY. 1859. True direction.	MARCH. 12 obs. a day. The numbers for the last 4 days were doubled.	APRIL. 6 obs. a day. The two odd hours were treated like even hours.	MAY. 6 obs. a day. Odd and even hours treated alike.	JUNE. 6 obs. a day. Odd and even hours treated alike.	JULY. 12 obs. a day. Numbers for the first 4½ days were doubled.	AUGUST. 6 obs. a day.
S.	0	0	0	0	1	83
N.	0	103	33	58	48	30
W.	288	308	1245	276	233	509
E.	0	34	0	9	159	685
S. W.	4	212	0	1	563	59
N. E.	1234	1341	282	547	1438	608
N. W.	2152	313	859	1888	3027	715
S. E.	0	26	0	1	14	235
ϕ	159°	196°	117°	146°	151°	197°

The above results for the resulting direction of the wind in each month, when expressed to the nearest half point, are contained in the following table:—

RESULTING DIRECTION OF THE WIND.

First year.			Second year.		
1857	September	S. W. ¾ S.	1858	September	W. ¾ N.
	October	N. ½ W.		October	N. by W.
	November	W. ¾ N.		November	N. N. W. ¼ N.
	December	N. W. by W.		December	N. W.
1858	January	N. W. ½ W.	1859	January	N. W. ¾ N.
	February	N. N. W. ¼ W.		February	N. W. ½ W.
	March	N. N. W. ¾ W.		March	N. N. W.
	April	N. N. W. ¾ N.		April	N. N. E. ½ N.
	May	E. ½ N.		May	W. N. W. ½ N.
	June	N. E.		June	N. W. by N.
	July	N. ¾ W.		July	N. N. W. ½ W.
	August	W. N. W.		August	N. N. E. ½ N.

For the combination of the monthly results to quarterly, half-yearly, and yearly results, we have to double the numbers for R_s and R_w for all months in which but 6 observations a day were taken, in order to make them correspond to the numbers for the other months in which 12 observations a day were recorded; the latter number of observations having been adopted as standard. The numbers in the second column for April, 1858, were doubled and added to the corresponding numbers in column one, before the formula was applied.

The following table contains the resulting values for R_s and R_w as they resulted (or in part were referred to) from bi-hourly observations:—

Month.		R_s	R_w	Month.		R_s	R_w
1857	September	+ 218	+ 166	1858	September	— 458	+2892
	October	— 432	+ 31		October	—4760	+ 932
	November	— 157	+1207		November	—4771	+1782
	December	— 872	+1303		December	—3014	+2964
1858	January	—2382	+2733	1859	January	—3775	+2962
	February	—4673	+2278		February	—2609	+3226
	March	—2674	+1581		March	—2367	+ 933
	April	—5059	+1388		April	—2188	— 630
	May	— 96	—1058		May	—1664	+3298
	June	— 374	— 370		June	—3522	+2412
	July	— 684	+ 106		July	—2769	+1571
	August	— 656	+1422		August	—1334	— 448

RESULTING DIRECTION OF THE WIND IN THE DIFFERENT SEASONS OF THE YEAR.

Season.	ΣR_s	ΣR_w	ϕ Direction.	Mean lat.	Mean long.
1857 Autumn	— 371	+ 1404	105° = W. by N. $\frac{1}{2}$ N.	75°.1 N.	67°.3 W.
1857–'58 Winter	— 7927	+ 6314	142 N. W. $\frac{3}{4}$ N.	73.0	64.0
1858 Spring	— 7829	+ 1911	167 N. by W.	68.0	56.8
" Summer	— 1714	+ 1158	146 N. W. by N.	74.0	75.0
Winter half, November–April . .	—15817	+10490	147° = N. W. by N.	71.5	63.0
Summer half, May–October . .	— 2024	+ 297	172 N. $\frac{3}{4}$ W.	73.4	68.6
1857–'58 Year	—17841	+10787	149° = N. N. W. $\frac{3}{4}$ W.	72.5	65.8
1858 Autumn	— 9989	+ 5606	151° = N. N. W. $\frac{1}{2}$ W.	Port Kennedy,	
1858–'59 Winter	— 9398	+ 9152	136 N. W.	Lat. 72°.0 N.;	
1859 Spring	— 6219	+ 3601	150 N. N. W. $\frac{1}{2}$ W.	Long. 94°.2 W.	
" Summer	— 7625	+ 3535	156 N. N. W.		
Winter half, November–April . .	—18724	+11237	149° = N. N. W. $\frac{3}{4}$ W.		
Summer half, May–October . .	—14507	+10657	144 N. W. by N.		
1858–'59 Year	—33231	+21894	147° = N. W. by N.		

At Port Kennedy, the resulting direction of the wind is remarkably constant for the several seasons, and the differences with the corresponding values for Baffin Bay are also small, the final direction for the two localities being practically identical.

For further comparison, I add a table showing the resulting (true) direction of the wind for Baffin Bay (lat. 72°.5 N., long. 65°.8 W.), Van Rensselaer Harbor[1] (lat. 78°.6 N., long. 70°.9 W.), and Port Kennedy (lat. 72°.0 N., long. 94°.2 W.)

Season.	Baffin Bay.	Van Rensselaer Harbor.	Port Kennedy.
Autumn	105°	22°	151°
Winter	142	351	136
Spring	167	21	150
Summer	146	72	156
Year	149	19	147

These numbers show that the wind at Van Rensselaer Harbor is rather anomalous in its direction when compared with either of the two more southern stations, the resulting directions being S. by W. ¾ W., whereas at Baffin Bay and Port Kennedy, it is N. W. by N. ¼ N.

Average Velocity of the Resulting Wind.—We find the average velocity of the resulting wind by dividing the quantity R by the actual number of observations (exclusive of calms). This velocity, on account of the neutralization of the opposing winds, is necessarily smaller than the average velocity of the winds.

[1] See my discussion of the winds in the Smithsonian Contributions to Knowledge, Vol. XI. Meteorological Observations in the Arctic Seas, by E. K. Kane, U. S. N., p. 77. It is to be remarked that, according to Mr. Sonntag and Dr. Hayes, the *true* direction, and *not* the magnetic direction, was observed at Van Rensselaer Harbor—a statement otherwise confirmed in the discussion of the winds at that station; a corresponding change of the results is therefore to be made. [S.]

Thus, for September, 1857, we found $R = 137$, and n = number of observations (minus calms) = 170, hence $V = 0.8$. The following table contains the quantities for each month, season, and the whole year. The numbers for April, 1858, were changed so as to refer to 12 daily observations throughout. A similar remark applies to March, 1859, and to July, 1859.

MEAN VELOCITY, IN MILES PER HOUR, OF THE RESULTING WIND.

		R	n	V			R	n	V
1857	September	137	170	0.8	1858	September	1464	176	8.3
	October	433	349	1.3		October	2425	179	13.5
	November	1217	338	3.6		November	5093	322	15.8
	December	1568	357	4.4		December	4227	320	13.2
1858	January	3626	363	10.0	1859	January	4798	332	14.4
	February	5199	315	16.5		February	4149	293	14.2
	March	3107	370	8.4		March	2545	260	9.8
	April	5246	349	15.0		April	1139	152	7.5
	May	531	152	3.5		May	1847	154	12.0
	June	263	156	1.7		June	2135	155	13.8
	July	346	161	2.2		July	3184	332	9.6
	August	783	160	4.9		August	704	167	4.2

	Baffin Bay.	Port Kennedy.
V in Autumn	1.9	12.5
" Winter	10.3	13.9
" Spring	9.0	9.8
" Summer	2.9	9.2
V for the year	6.0	11.4

At Van Rensselaer, the annual mean was $V = 4.5$.

Average Velocity of the Winds.—The average velocity with which each of the eight principal winds passes over the place of observation in each month, season, and whole year, is found by dividing the sum of the velocity-numbers of each wind by the number of entries in the period; thus, for the month of September, 1857, we have—

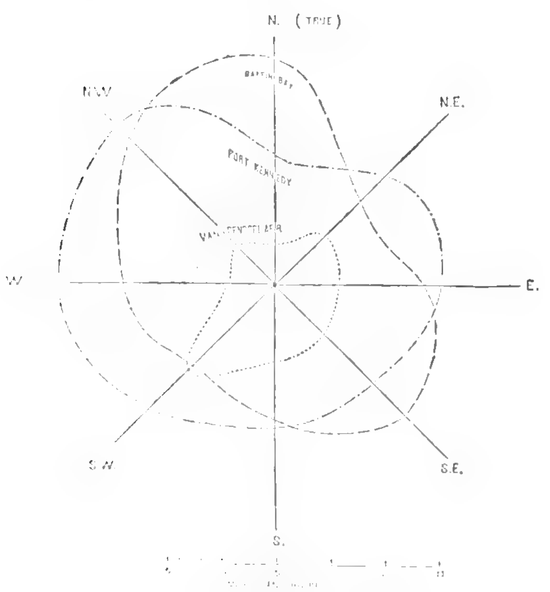
True direction of the wind.	Sum of velocities.	Number of entries.	Mean velocity.
S.	385	20	19.2
S. W.	8	2	4.0
W.	354	29	12.2
N. W.	482	47	10.3
N.	86	18	4.8
N. E.	153	14	10.9
E.	258	22	11.7
S. E.	356	18	19.8
Sum	2082	170	12.3

The following table shows the mean velocity of the winds, expressed in miles per hour, for each month of observation:—

Year.	True direction.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1857–1858	S.	5.4	6.5	18.0	26.2	18.4	16.6	2.2	5.5	19.2	16.4	11.5	11.0	12.5
	S. W.	5.8	3.0	12.9	18.5	6.9	3.2	11.9	17.4	4.0	7.1	16.7	4.5	10.6
	W.	18.4	6.9	6.7	8.1	1.0	9.6	6.7	23.1	12.2	9.9	20.0	10.0	13.9
	N. W.	22.3	29.0	23.4	20.9	16.8	9.3	12.0	26.3	10.3	11.5	16.0	15.2	18.8
	N.	11.8	23.1	21.5	33.2	17.3	6.3	13.6	19.3	4.7	7.7	- -	8.5	20.6
	N. E.	6.0	11.6	7.2	8.4	13.3	4.7	19.3	13.7	11.0	18.1	13.0	5.6	11.0
	E.	5.4	1.0	10.9	13.0	22.8	15.5	9.6	20.7	11.7	8.7	19.6	10.5	13.9
	S. E.	4.1	24.1	21.8	19.5	16.4	10.3	6.0	18.4	19.8	20.2	25.6	16.1	16.8
	Mean	14.1	22.0	18.3	23.6	14.8	9.2	11.2	20.0	12.3	12.5	17.7	11.7	16.0
1858–1859	S.	- -	1.0	- -	- -	- -	- -	1.0	11.9	13.4	21.2	- -	- -	13.2
	S. W.	- -	24.5	4.0	30.3	- -	1.0	15.1	11.8	18.2	12.4	- -	11.7	16.2
	W.	18.1	16.9	15.2	16.2	22.6	21.2	17.9	16.4	23.8	8.4	17.7	25.7	19.6
	N. W.	17.2	19.2	22.2	16.4	15.6	24.8	18.7	21.6	23.4	28.0	22.7	19.2	20.4
	N.	16.8	- -	- -	8.6	3.6	7.3	12.0	7.5	16.7	12.7	10.5	10.0	11.7
	N. E.	12.5	9.9	9.1	15.6	8.1	10.3	18.1	14.8	16.7	22.5	20.3	10.8	14.3
	E.	- -	- -	- -	8.5	- -	3.0	8.2	21.4	13.5	12.5	4.0	- -	15.1
	S. E.	- -	1.0	- -	6.5	- -	1.0	1.7	18.1	18.4	6.9	17.0	10.0	12.8
	Mean	16.5	17.1	14.6	15.4	15.7	18.0	17.1	17.5	20.0	22.5	21.7	17.2	17.8

In the first year, while in Baffin Bay, the velocity of the wind was greatest in the months of February and March, and least in the months of June and July; in the second year, at Port Kennedy, it was greatest in October and November, and least in March and April. In Baffin Bay, during 1857, '58, the N. W. and N. winds blew with the greatest strength, and the S. W. and N. E. with the least; whereas, in the following year, at Port Kennedy, it was the W. and N. W. wind which blew strongest, and the N. and S. E. which blew with the least force. The mean velocity of each of the eight winds is shown in the annexed diagram, which contains also, for comparison, the velocity of the winds as observed at Van Rensselaer Harbor.

Fig. 1.



The velocity of the wind being only estimated at each place, the apparently small velocities at Van Rensselaer Harbor may, in a measure, be due to a different scale of estimating, although the great number of calms seems to point to their reality.

We have next to consider the relative frequency of each wind; for this purpose it is only necessary to refer the number of entries, n, of each wind, as used in the preceding computation for the velocity, to an equal number of hours of observation for each month. This has been done by simple proportion, and the numbers were all referred to twelve observations a day; thus, the numbers of entries, for all months of six observations a day, have all been doubled. The following table contains the relative frequency of each wind:—

	True direction.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1857–1858 Baffin Bay.	S.	27	19	22	8	24	10	10	8	40	15	19	41	243
	S. W.	16	9	28	26	38	22	62	38	4	30	42	30	345
	W.	54	22	20	13	2	10	36	68	58	48	56	39	426
	N. W.	130	125	133	105	58	98	64	62	94	115	115	134	1233
	N.	45	103	68	125	16	40	20	14	36	14	0	39	520
	N. E.	32	20	42	44	64	34	48	44	28	37	32	31	456
	E.	22	1	22	4	22	40	32	32	44	43	35	2	299
	S. E.	37	16	35	22	72	58	48	50	36	48	40	41	503
	Calm	9	21	2	11	70	48	50	52	20	22	21	15	341
Sum and check		372	336	372	358	366	360	370	368	360	372	360	372	4366
1858–1859 Port Kennedy.	S.	0	1	0	0	0	0	1	14	20	8	0	0	44
	S. W.	0	2	0	14	0	2	38	10	62	14	0	17	159
	W.	11	69	19	3	110	26	13	62	90	14	6	30	488
	N. W.	256	174	100	38	110	152	157	66	68	152	203	194	1670
	N.	22	0	0	24	18	16	4	8	20	6	2	1	121
	N. E.	37	45	140	172	70	106	88	82	50	134	108	72	1104
	E.	0	0	0	8	0	6	21	64	4	4	1	0	108
	S. E.	0	2	0	8	0	2	8	26	40	26	1	1	114
	Calm	44	43	112	56	64	50	42	38	6	14	39	53	561
Sum and check		370	336	371	358	372	360	372	370	360	372	360	368	4369

In the above table a few variable winds have not been counted in.

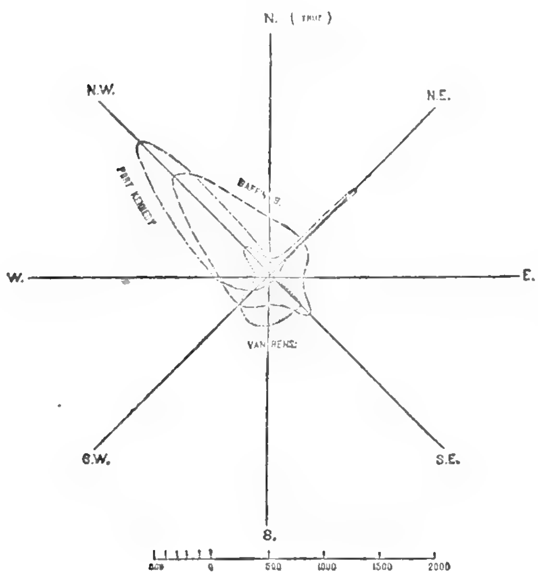
In both localities the N. W. is the most frequent next to this, in Baffin Bay the N. wind, and at Port Kennedy the N. E.; the least frequent wind in both seasons is from the S. and E. The results at Port Kennedy are remarkable for the scarcity of winds from the S., E., and S. E. This is most probably due to the configuration of the surrounding land; the same cause may also explain the scarcity of winds from the north, midway between the most frequent N. W. and N. E. winds. The following diagram exhibits the relative frequency of each wind for the two localities, to which has been added the result obtained at Van Rensselaer Harbor (the numbers for that harbor refer to twenty-four observations a day, and were therefore halfed in order to make them comparable with the numbers deduced above.)

Relative Frequency of the Winds.

True direction.	Baffin Bay.	Van Rensselaer Harbor.	Port Kennedy.
S.	243	410	44
S. W.	345	354	159
W.	426	116	488
N. W.	1233	330	1670
N.	520	144	121
N. E.	456	27	1104
E.	299	56	108
S. E.	503	411	114
Calm	341	2532	561

In Baffin Bay the calms occur less frequently than any of the eight winds; at Port Kennedy they are more frequent; the frequency of the calms at Van Rensselaer exceeds that at Baffin Bay and Port Kennedy in the ratio of nearly 7 and 5 respectively.

Fig. 2.



The preponderance of the N. W. and N. E. winds at Port Kennedy is very striking on the diagram.

The quantity of air which has been transferred over the place of observation in a given period, is directly proportional to the velocity-numbers, or the number of miles travelled over by a particle of air in any direction during the period. The observations not having all been made at regular and equal intervals of two hours, the numbers indicating the relative quantity of air in April, 1858, March and July, 1859, were referred by simple proportion to twelve observations a day, to which all other numbers refer; the number for all months of six observations a day have been doubled.

RELATIVE QUANTITY OF AIR PASSED OVER THE PLACE OF OBSERVATION.

Referring to 12 observations a day.

Year.	True direction.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Sum.
1857–1858 Baffin Bay.	S.	145	124	395	210	442	166	22	44	770	246	220	449	3233
	S. W.	93	27	361	533	262	70	736	662	16	212	700	135	3807
	W.	993	151	137	127	2	96	238	1570	708	476	1121	388	6007
	N. W.	2904	3632	3112	2133	974	914	766	1628	964	1327	1846	2036	22236
	N.	531	2381	1465	4198	276	252	272	270	172	108	0	331	10256
	N. E.	192	233	304	360	848	164	920	602	306	668	417	174	5188
	E.	118	1	239	52	502	622	308	662	516	377	687	21	4105
	S. E.	151	386	764	430	1186	596	330	954	712	968	1024	660	8161
	Sum	5127	6935	6777	8043	4492	2880	3592	6392	4164	4382	6015	4194	62993
1858–1859 Port Kennedy.	S.	0	1	0	0	0	0	1	166	268	170	0	0	606
	S. W.	0	49	4	424	0	2	563	118	1126	174	0	199	2659
	W.	200	1169	288	616	2490	552	233	1018	2142	118	106	773	9705
	N. W.	4406	3336	2152	626	1718	3776	3027	1430	1592	4264	4610	3721	34658
	N.	369	0	0	206	66	116	48	60	334	76	21	10	1306
	N. E.	460	444	1234	2682	564	1094	1438	1216	832	3024	2193	780	15961
	E.	0	0	0	68	0	18	159	1370	54	50	4	0	1723
	S. E.	0	2	0	52	0	2	14	470	738	180	17	10	1485
	Sum	5435	5001	3678	4674	4838	5560	5483	5848	7086	8056	6951	5493	68103

The following table contains the comparative values at Van Rensselaer Harbor with the above, the result at Van R. having first been halfed to refer to twelve observations a day.

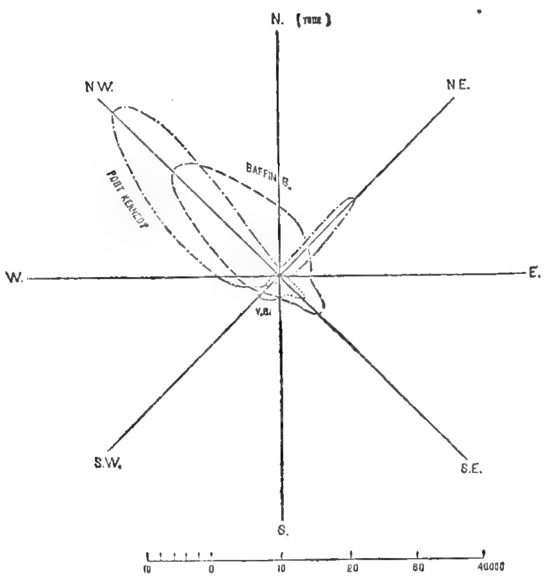
True direction.	Baffin Bay.	Van Rensselaer Harbor.	Port Kennedy.
S.	3233	3060	606
S. W.	3807	4002	2659
W.	6007	481	9705
N. W.	22236	1612	34658
N.	10256	500	1306
N. E.	5188	168	15961
E.	4105	336	1723
S. E.	8161	2600	1485
Sum . .	62993	12759	68103

These results of the relative quantity of air moved over each place are also shown in the annexed diagram.

Owing to the small differences in the velocity of the several winds, the above diagram of the quantity of wind resembles that of the frequency of the winds, at least, in all its characteristics.

It cannot be expected that the relations of the wind within the Arctic Circle should come out with any degree of certainty from but a single year of observation, or even from several years; and before we can arrive at their true characteristics, we must combine results at different stations as well as in different years.

Fig. 3.



Rotation of the Wind.—For the purpose of ascertaining the law of the rotation of the wind, the observations were examined in reference to the number of times the wind arrived at each of the eight principal directions, the motion each time not being less than 45°; and also in reference to the sum total of angular motion, in a direct and retrograde sense. The direction in which the hands of a watch (face up) turn, and which corresponds to the direction of the rotation of the wind, according to Dove, has been assumed as direct, and is indicated by a + sign; the opposite direction is indicated by a — sign.

The following table exhibits the number of changes of the wind, or the number of times it arrived at any one of the principal directions during a given period, and also the amount it shifted, or its angular motion expressed in units of 45°. In making out these numbers for each wind, not only the four-hourly series of observations, but also the intermediate observations in certain months were used. After each calm the counting was commenced anew, and also in cases where the wind shifted suddenly 180°.

Baffin Bay: Mean Lat. 72°.5 N.; Mean Long. 65°.8 W.

Changes to	Autumn, 1857.				Winter, 1857–8.				Spring, 1858.				Summer, 1858.				Year, 1857–8.			
	Direction.		Amount.		Direction.		Amount.		Direction.		Amount.		Direction.		Amount.		Direction.		Amount.	
	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−
N.	3	1	5	2	8	3	16	5	5	4	7	12	5	4	8	8	21	12	36	27
N. E.	6	11	11	20	11	3	36	13	5	5	25	11	9	9	19	22	31	28	91	66
E.	11	11	30	19	0	1	0	2	6	6	17	11	3	6	5	8	20	24	52	40
S. E.	12	7	20	12	2	5	4	16	13	3	42	5	12	6	30	25	39	21	96	58
S.	6	6	12	11	3	4	10	9	2	6	4	10	2	4	9	9	13	20	35	39
S. W.	7	6	17	15	5	4	15	13	10	5	31	16	5	14	9	28	27	29	72	72
W.	3	17	11	35	1	15	1	42	1	4	1	8	9	3	10	17	14	39	23	102
N. W.	17	7	24	19	8	8	15	17	6	10	26	26	6	10	14	19	37	35	79	81
Sum	65	66	130	133	38	43	97	117	48	43	153	99	51	56	104	136	202	208	484	485
Excess	...	1	...	3	...	5	...	20	5	...	54	...	...	5	...	32	...	6	...	1

From the above it appears that the direction of the wind is shifting in spring only direct, in the other seasons it is retrograde; the total amount of angular motion, however, is balanced (within 45°) in the whole year.

Port Kennedy: Lat. 72°.0 N.; Long. 94°.2 W.

Changes to	Autumn, 1858.				Winter, 1858–9.				Spring, 1859.				Summer, 1859.				Year, 1858–9.			
	Direction.		Amount.		Direction.		Amount.		Direction.		Amount.		Direction.		Amount.		Direction.		Amount.	
	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−
N.	2	1	2	5	1	0	1	0	1	1	3	1	3	1	4	1	7	3	10	7
N. E.	10	4	24	13	3	1	6	2	4	2	11	2	11	5	24	8	28	12	65	25
E.	3	0	8	0	1	0	1	0	5	0	7	0	7	2	11	5	16	2	27	5
S. E.	2	4	4	11	0	1	0	2	1	0	2	0	3	2	11	2	6	7	17	15
S.	1	1	3	3	0	0	0	0	0	0	0	0	1	3	1	9	2	4	4	12
S. W.	0	9	0	17	0	5	0	9	0	2	0	4	0	6	0	20	0	22	0	50
W.	5	5	14	8	1	14	3	14	1	9	1	15	0	13	0	18	7	41	18	55
N. W.	9	12	17	28	22	2	28	4	7	6	7	15	12	8	16	26	50	28	68	73
Sum	32	36	72	85	28	23	39	31	19	20	31	37	37	40	67	89	116	119	209	242
Excess	...	4	...	13	5	...	8	...	...	1	...	6	...	3	...	22	...	3	...	33

As might have been expected from the peculiar situation of Port Kennedy, and the results as given on Figs. 2 and 3, the rotation of the wind seems to be greatly affected in this locality; the resulting direction is retrograde, and the amount equals four circumferences.

The following table contains,[1] for comparison, the results of a similar investigation of the rotation of the winds at Van Rensselaer Harbor, from Dr. Kane's observations in 1853, '54, '55. Seventeen months of observations (hourly) were discussed, and the results, by the same months in different years, were united into one mean: the results for September, October, November, December, and January, have double weight, for this reason, when compared with the remaining months.

[1] These results are here published for the first time.

VAN RENSSELAER HARBOR: LAT. 78°.6 N.; LONG. 70°.9 W.																				
Changes to	AUTUMN, 1853-4.				WINTER, 1853, '4, '5.				SPRING, 1854.				SUMMER, 1854.				YEAR, 1853, '4, '5.			
	Direction.		Amount.		Direction.		Amount.		Direction.		Amount.		Direction.		Amount.		Direction.		Amount.	
	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−
N.	10	1	12	2	3	5	3	13	4	0	8	0	11	5	13	8	28	11	36	23
N. E.	2	1	3	3	0	2	0	4	0	1	0	3	4	0	6	0	6	4	9	10
E.	1	6	3	11	1	10	2	21	0	5	0	12	0	3	0	5	2	24	5	49
S. E.	3	18	4	27	10	17	12	33	2	16	2	27	5	4	9	5	20	55	27	92
S.	14	18	18	23	16	20	24	28	15	10	20	17	7	2	8	2	52	50	70	70
S. W.	20	2	27	4	29	6	43	7	12	6	17	16	3	0	4	0	64	14	91	27
W.	6	4	11	6	11	1	28	1	2	2	2	2	2	25	4	26	21	32	45	35
N. W.	4	9	8	13	4	3	8	5	9	5	21	5	18	5	22	6	35	22	59	29
Sum	60	59	86	89	74	64	120	112	44	45	70	82	50	44	66	52	228	212	342	335
Excess	1	...	...	3	10	...	8	...	...	1	...	12	6	...	14	...	116	...	7	...

The result is in favor of the direct motion of not quite a circumference. The result deduced for Baffin Bay agrees with this within the limit of uncertainty of the final value itself, and both indicate that the law of rotation probably does not hold good for these high latitudes.

Occurrence and Duration of Storms.—The following table contains the date, duration, and direction (true), of all storms experienced between the dates of the record. In each case the intensity rises to 8 (of the scale) or beyond it, and there are at least two consecutive entries of this or a higher number; in other words, gusts of wind blowing for less than three hours are not noted.

Date.	Duration.	Direction and changes.
1857, Aug. 30, 31,	12h.	E. S. E. to S. S. E. and S. E.
Oct. 14,	12	E. N. E. to E. S. E.
" 22,	14	N. W. to W.
" 27, 28,	8	N. W.
Nov. 6, 7,	12	N. W.
" 17,	16	S. to S. W., S. E., and S. S. E.
*" 21, 22, 23,	36	N. E. to S. E., S., S. W., and S. S. W.
Dec. 5, 6,	12	W. to N. W.
" 12,	18	N. W. to W. N. W.
1858, Jan. 7,	4	N. W.
" 21,	8	N. N. W.
" 23,	8	N. N. W. to W. N. W.
Feb. 1,	6	N. N. W.
" 9,	24	N. W. to N. N. W. and N. W.
" 15,	4	N.
" 24,	32	N. W. to N. N. W. and N. W.
" 28,	6	S. E.
*March 3, 4,	14	N. E. to S. S. W., S., and S. W.
" 22, 23,	8	S. E.
" 25, 26, 27,	46	N. to N. W. and N. N. W.
April 3, 4, 5,	54	N. to N. W.
" 8,	8	N. W.
" 16, 17, 18,	58	N.
*May 4,	36	S. S. E. to S., N. N. W. and N. W.
July 13,	12	N. E.
Aug. 8,	28	E. S. E. to E.

* Indicates storms in which the direction of the wind is completely reversed; they belong to the rotatory storms or cyclones. Two of these turn from the N. E. to the S. W., and the third from the S. E. to the N. W.

In the year 1857–8 (Baffin Bay), there were 26 storms of an average duration of 19 hours, and from the prevailing quarters, almost to the exclusion of all others, from the N. W. and S. E. (true); at Van Rensselaer Harbor, the prevailing storm quarters were S. W. and S. E. (true), and the average duration was 7 hours; 13 storms were recorded during 17 months.

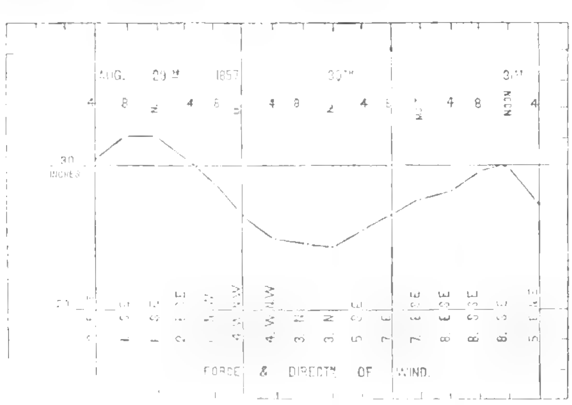
STORMS RECORDED AT PORT KENNEDY IN 1858–59.

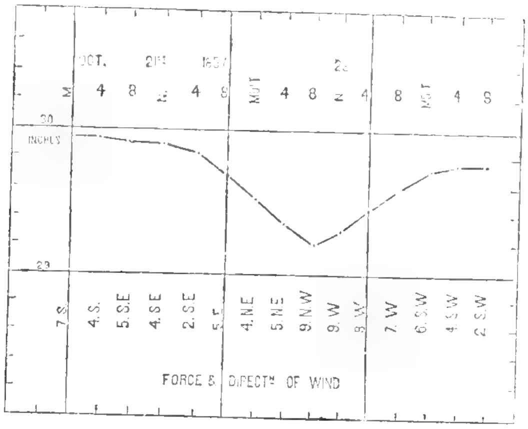
Date.	Duration.	Direction and changes.
1858, Sept. 4,	8h.	W.
Oct. 3,	8	N. E.
" 16, 17,	24	W. N. W. to N. W.
" 25, 26, 27,	48	N. E. to N. N. E., N. N. W., and N. W.
Nov. 2, 3,	16	N. W. to N. N. W.
" 4,	20	W. N. W.
" 5,	4	N. W.
" 14,	4	N. W.
" 28,	54	N. N. E. to N. N. W. and N. E.
Dec. 4,	6	N. W.
" 26,	4	N. W.
" 27,	4	N. W.
1859, Jan. 8,	4	N. W.
" 24, 25,	10	N. W.
Feb. 14,	4	W. N. W.
Feb. 28, and March 1,	28	W. N. W.
March 11,	26	N. W. to W. N. W. and N. W.
" 17,	4	N. W.
April 23,	12	N. E.
April 30, and May 1,	20	W.
June 1, 2,	28	N. N. W. to N. W.
July 11,	4	N. E.

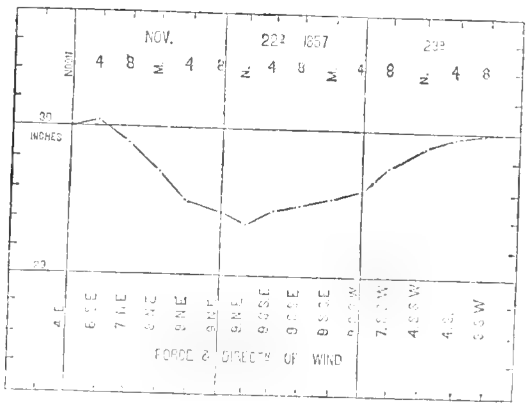
There were 22 storms in the second year, almost all from the N. W., with a few from the N. E., but not a single one from either S. W. or S. E.

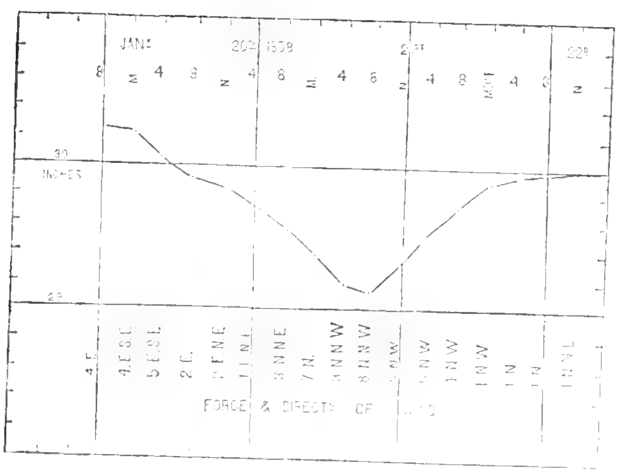
As in Baffin Bay, storms are more frequent in the winter and autumn than in summer.

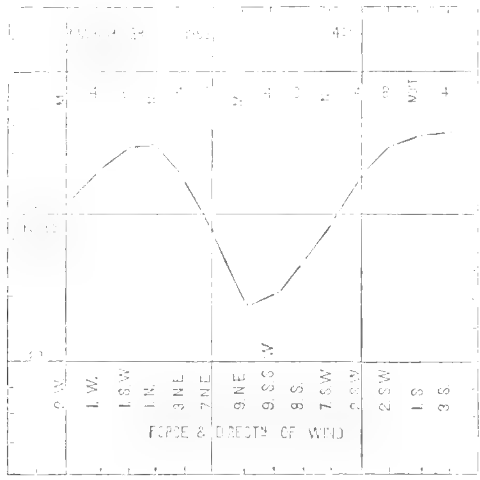
Five of the storms were accompanied by sudden falls of the barometer; they are the more remarkable ones, and have been illustrated by diagrams, showing the hour, direction, and force of wind, and reading of the aneroid barometer. Of these five, the storms of January 21, and March 3, 4, 1858, are perhaps the most interesting; in each case the barometer fell over one inch. During the storm of May 4, 1858, the barometer was not much affected.




OCT.
30
INCHES
29
FORCE & DIRECTN OF WIND


NOV.
22d 1857
23d
30
INCHES
29
FORCE & DIRECTN OF WIND


JANY
20th 1858
30
INCHES



The relation of the different winds to the atmospheric temperatures has already been investigated in the preceding paper; other relations, as those with the atmospheric pressure, will be given on subsequent pages.

PART III.

ATMOSPHERIC PRESSURE.

RECORD AND REDUCTION OF THE OBSERVATIONS FOR ATMOSPHERIC PRESSURE.

INTRODUCTORY REMARKS.

The observing hours are the same as those for the other meteorological observations, that is, in part at equal intervals of two hours, and in part at intervals of four hours. There are two records, one of the aneroid readings, the other of the readings of the mercurial barometer.

The series of observations by the aneroid is continued throughout the cruise; the mercurial barometer was used only between September 20, 1857, and April 16, 1858. The readings in the month of July and August, 1857, and of September, 1859, are given in the record, but are not further introduced in the discussion, since the ship was then rapidly changing her position, not permitting a combination of the daily observations.

The mercurial marine barometer, Adie No. 208, was compared with a standard instrument at Kew both at departure and after return. The comparisons for index correction are as follows (communicated in a letter from Captain McClintock, dated London, December 12th, 1860):—

Corrections to be applied to Barometer by Adie No. 208 (or No. 407, private mark of the makers.)

Before Embarkation in the Fox.		Subsequent to its Return.	
At inches.	Correction.	At inches.	Correction.
30.5	+0.005	30.5	+0.008
30.0	+0.006	30.0	+0.008
29.5	+0.007	29.5	+0.007
29.0	+0.007	29.0	+0.006
28.5	+0.007	28.5	+0.005
28.0	+0.008	28.0	+0.005

This mercurial barometer had been used by Professor Piazzi Smyth at Teneriffe, and is highly thought of by Admiral Fitzroy, in whose office it is now in use.

It is specially stated in the reduction whenever the above correction was applied. Comparisons of the readings of the mercurial and aneroid barometers will be found in the discussion.

The cistern of the mercurial barometer was four feet above the level of the sea (in reference to the position of the aneroid, no statement is given). The barometric readings recorded give the combined pressure of the dry air and aqueous vapor; the latter, however, is very small: no hygrometric observations were found recorded.

The following tables commence with the aneroid readings, and conclude with the readings of the mercurial barometer and its corresponding temperature. A few occasional omissions in the record were supplied by interpolation; such figures are distinguished by being placed between brackets. The mean position of the "Fox" is given for each month (the daily position is already given in the preceding temperature paper).

RECORD OF THE OBSERVATIONS OF THE ATMOSPHERIC PRESSURE MADE ON BOARD THE YACHT "FOX," UNDER COMMAND OF F. L. McCLINTOCK, R. N., IN THE ARCTIC SEAS, IN 1857, '58, '59.

READINGS OF ANEROID BAROMETER 17701 ON BOARD THE YACHT FOX.

July, 1857. 29 Inches +. Mean Lat. 62°.0 N., Long. 39°.1 W. of Greenwich.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Mean.
1	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	Inches.
2	(1.50)	1.50	1.50	1.15	.95	(.92)	1.25
3	(.88)	.85	(.87)	(.89)	.91	(.91)	0.88
4	(.91)	.91	(.94)	(.98)	1.01	(1.05)	0.96
5	(1.08)	1.11	(1.11)	(1.12)	1.12	(1.12)	1.11
6	(1.12)	1.12	1.12	1.17	1.18	1.20	1.15
7	1.20	1.22	1.23	1.22	1.22	1.22	1.22
8	1.16	1.14	1.12	1.08	1.02	.96	1.08
9	.92	.90	.86	.85	.83	.80	0.86
10	.72	.66	.59	.52	.52	.52	0.59
11	.48	.46	.44	.40	.40	.44	0.44
12	.46	.50	.54	.61	.70	.78	0.60
13	.82	.85	.92	.94	.96	.98	0.91
14	.98	.96	.92	.89	.90	.92	0.93
15	.90	.92	.94	.98	.97	.94	0.94
16	.90	.89	.85	.82	.89	.92	0.88
17	.96	.99	.98	.97	.98	.97	0.97
18	.92	.90	.84	.82	.82	.84	0.86
19	.80	(.78)	(.76)	(.74)	(.72)	.70	0.75
20	.74	.74	.74	.74	.74	.80	0.75
21	.82	.82	.84	.82	.88	.88	0.84
22	.86	.82	.80	.82	.84	.84	0.83
23	.86	.86	.84	.85	.84	.84	0.85
24	.84	.76	.73	.76	.80	.90	0.80
25	.96	(.95)	.94	.94	.90	.89	0.93
26	.70	.60	.54	.60	.56	.54	0.59
27	.34	.50	.48	.50	.50	.48	0.47
28	.52	.58	.60	.62	.60	.64	0.59
29	.69	.65	.68	.68	.72	.73	0.69
30	.70	.68	.66	.65	.64	.66	0.66
31	.72	.80	.84	.90	.92	.94	0.85
Mean	29.849	29.847	29.841	29.834	29.834	29.844	29.842

August, 1857. 29 Inches +. Mean Lat. 74.°0 N., Long. 59°.8 W.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Mean.
1	.94	.99	.98	.96	.94	.94	0.96
2	.90	.92	.90	.96	.98	.96	0.94
3	.96	.98	(.94)	(.90)	(.86)	(.82)	0.91
4	.78	.74	.70	.72	.84	.93	0.78
5	1.02	1.12	1.15	1.24	1.24	1.23	1.17
6	1.16	1.08	1.00	.98	.90	.96	1.01
7	.96	1.08	1.10	1.15	1.15	1.15	1.10
8	1.18	1.12	1.02	.94	.86	.80	0.99
9	.75	.76	.81	.88	.90	.90	0.83
10	.92	.92	.94	1.00	1.06	1.04	0.98
11	1.10	1.00	.97	.94	.92	.89	0.95
12	.88	.87	.89	.92	.95	.98	0.91
13	1.00	1.04	1.06	1.02	1.02	1.02	1.03
14	.96	.90	.86	.82	.82	.80	0.86
15	.80	.81	.80	(.73)	(.67)	(.60)	0.74
16	.54	.43	.45	.50	.52	.52	0.49
17	.48	.48	.48	.51	.55	.60	0.52
18	.64	.68	.72	.76	.78	.80	0.73
19	.82	.85	.90	.94	.95	.98	0.91
20	.98	1.00	1.02	1.05	1.06	1.06	1.03
21	1.06	1.04	1.03	1.02	1.00	.98	1.02
22	.96	.96	.94	.96	.98	.94	0.96
23	.92	.92	.90	.90	.88	.84	0.89
24	.78	.71	.61	.56	.54	.54	0.62
25	.56	.61	.62	.61	.62	.54	0.59
26	.51	.54	.64	.68	.67	.62	0.61
27	.62	.65	.65	.62	.62	.66	0.64
28	.76	.82	.92	1.00	1.04	1.10	0.94
29	1.06	1.20	1.20	1.06	.90	.69	1.03
30	.50	.48	.44	.58	.66	.78	0.57
31	.86	.97	.99	.75	.50	.44	0.75
Mean	29.850	29.860	29.858	29.860	29.852	29.842	29.854

Readings of Aneroid Barometer 17701 on board the Yacht Fox.

September, 1857. 29 Inches +. Mean Lat. 75°.3 N., Long. 65°.0 W.

Day.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
1	(0.41)	.41	(0.43)	.44	(.43)	.42	(.40)	.37	(.41)	.46	(.54)	.62	0.44
2	(0.66)	.70	(0.72)	.75	(.78)	.81	(.82)	.84	(.83)	.83	(.83)	.84	0.78
3	(0.83)	.82	(0.84)	.85	(.87)	.90	(.92)	.95	(.97)	1.00	(1.02)	1.04	0.92
4	(1.05)	1.07	(1.09)	1.10	(1.11)	1.12	(1.13)	1.14	(1.14)	1.14	(1.14)	1.14	1.11
5	(1.11)	1.08	(1.07)	1.06	(1.02)	.98	(.96)	.94	(.92)	.91	(.91)	.91	0.99
6	(0.92)	.94	(0.95)	.97	(.96)	.96	(.95)	.94	(.89)	.84	(.77)	.70	0.90
7	(0.61)	.52	(0.50)	.48	(.48)	.49	(.49)	.49	(.45)	.42	(.38)	.34	0.47
8	(0.40)	.46	(0.59)	.72	(.73)	.74	(.71)	.68	(.70)	.72	(.75)	.78	0.66
9	(0.77)	.77	(0.76)	.76	(.81)	.86	(.87)	.88	(.89)	.90	(.91)	.92	0.84
10	(0.84)	.76	(0.75)	.74	(.73)	.72	(.70)	.68	(.70)	.72	(.79)	.86	0.75
11	(0.92)	.98	(1.00)	1.02	(1.02)	1.02	(1.00)	.98	(.96)	.94	(.96)	.99	0.98
12	(1.03)	1.07	(1.10)	1.12	(1.14)	1.16	(1.17)	1.18	(1.19)	1.20	(1.22)	1.24	1.15
13	(1.30)	1.37	(1.41)	1.46	(1.51)	1.56	(1.56)	1.56	(1.51)	1.46	(1.40)	1.34	1.45
14	(1.42)	1.50	(1.48)	1.46	(1.41)	1.38	(1.39)	1.40	(1.36)	1.32	(1.29)	1.26	1.39
15	(1.18)	1.10	(1.09)	1.08	(1.12)	1.16	(1.21)	1.26	(1.32)	1.38	(1.40)	1.42	1.23
16	(1.38)	1.34	(1.32)	1.30	(1.31)	1.32	(1.31)	1.31	(1.33)	1.36	(1.36)	1.36	1.33
17	(1.36)	1.36	(1.28)	1.21	(1.18)	1.15	(1.18)	1.20	(1.21)	1.22	(1.24)	1.26	1.24
18	(1.22)	1.18	(1.12)	1.06	(1.06)	1.06	(.98)	.90	(.85)	.80	(.78)	.77	0.98
19	(0.75)	.74	(0.86)	.98	(0.98)	.97	(1.00)	1.04	(1.10)	1.16	(1.18)	1.21	1.00
20	(1.22)	1.22	(1.25)	1.28	(1.27)	1.26	(1.23)	1.20	(1.15)	1.10	(1.04)	.98	1.18
21	(0.88)	.78	(0.71)	.64	(.62)	.60	.62	.64	.64	.70	.70	.70	0.69
22	.64	.60	.61	.62	.68	.72	.74	.80	.86	.86	.88	.90	0.74
23	.86	.86	.90	.90	.99	1.00	1.06	1.06	1.12	1.14	1.16	1.20	1.02
24	1.19	1.17	1.17	1.16	1.20	1.16	1.12	1.08	1.05	.98	.92	.88	1.09
25	.79	.74	.70	.69	.74	.74	.79	.82	.85	.87	.88	.90	0.79
26	.90	.86	.84	.88	.88	.87	.84	.84	.84	.84	.86	.84	0.86
27	.82	.80	.80	.78	.83	.84	.86	.84	.84	.84	.86	.85	0.83
28	.83	.80	.80	.80	.84	.84	.86	.90	.90	.92	.94	.94	0.86
29	.94	.92	.90	.89	.92	.94	.94	.94	.93	.93	.92	.90	0.92
30	.84	.82	.79	.79	.77	.72	.70	.66	.64	.62	.59	.60	0.71
Mean	0.936	0.925	0.928	0.933	0.946	0.949	0.950	0.951	0.952	0.953	0.954	0.956	29.943

October, 1857. 29 Inches +. Mean Lat. 75°.2 N., Long. 67°.9 W.

Day.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
1	.56	.57	.60	.62	.71	.74	.76	.78	.81	.84	.86	.90	0.73
2	.90	.91	.92	.94	1.00	1.02	1.02	1.07	1.06	1.09	1.10	1.11	1.01
3	1.11	1.13	1.10	1.10	1.16	1.14	1.16	1.18	1.20	1.19	1.18	1.16	1.15
4	1.14	1.12	1.10	1.08	1.08	1.05	1.04	1.04	1.06	1.06	1.06	.99	1.07
5	.95	.92	.90	.88	.88	.86	.78	.76	.74	.72	.70	.69	0.81
6	.67	.68	.68	.74	.80	.80	.81	.87	.87	.90	.90	.90	0.80
7	.88	.89	.89	.89	.91	.92	.92	.94	.95	.96	.96	.97	0.92
8	.96	.94	.95	1.00	1.02	1.04	1.04	1.04	1.08	1.09	1.10	1.12	1.03
9	1.12	1.10	1.10	1.10	1.20	1.24	1.25	1.28	1.29	1.30	1.32	1.32	1.22
10	1.27	1.25	1.20	1.18	1.16	1.12	1.10	1.12	1.12	1.12	1.14	1.16	1.16
11	1.08	1.06	1.05	1.04	1.09	1.08	1.04	1.03	1.00	1.01	.99	.94	1.03
12	.88	.84	.80	.79	.82	.80	.80	.82	.83	.84	.85	.84	0.83
13	.82	.81	.81	.80	.80	.79	.75	.74	.64	.62	.59	.54	0.73
14	.48	.45	.39	.34	.38	.39	.42	.51	.58	.61	.62	.64	0.48
15	.61	.59	.59	.59	.60	.60	.64	.70	.76	.78	.76	.74	0.66
16	.71	.71	.72	.71	.74	.76	.79	.82	.86	.90	.89	.94	0.80
17	1.06	1.10	1.10	1.14	1.12	1.06	1.05	1.05	1.08	1.08	1.06	1.08	1.08
18	1.06	1.04	1.02	1.04	1.06	1.05	1.05	1.02	.98	.96	.90	.85	1.00
19	.78	.73	.68	.68	.70	.68	.69	.74	.74	.75	.76	.76	0.72
20	.74	.74	.76	.81	.86	.88	.90	.90	.91	.94	.94	.95	0.86
21	.96	.94	.90	.94	.92	.92	.87	.81	.75	.68	.60	.51	0.82
22	.43	.34	.26	.20	.24	.28	.37	.43	.53	.60	.64	.70	0.42
23	.73	.74	.75	.77	.80	.82	.83	.83	.80	.78	.74	.74	0.78
24	.74	.76	.82	.92	.99	1.07	1.13	1.20	1.29	1.33	1.34	1.35	1.08
25	1.36	1.36	1.35	1.42	1.46	1.48	1.50	1.56	1.56	1.60	1.60	1.62	1.49
26	1.62	1.63	1.63	1.64	1.70	1.70	1.69	1.70	1.71	1.71	1.70	1.70	1.68
27	1.64	1.58	1.50	1.45	1.44	1.38	1.33	1.26	1.28	1.24	1.19	1.14	1.37
28	1.10	1.08	1.07	1.06	1.13	1.12	1.17	1.18	1.20	1.24	1.23	1.20	1.15
29	1.18	1.18	1.19	1.19	1.22	1.20	1.14	1.13	1.10	1.05	1.00	.96	1.13
30	.88	.83	.78	.76	.80	.83	.86	.88	.85	.86	.89	.88	0.84
31	.86	.82	.80	.81	.86	.88	.88	.88	.90	.92	.92	.88	0.87
Mean	0.944	0.930	0.916	0.924	0.956	0.958	0.961	0.976	0.985	0.993	0.985	0.977	29.959

READINGS OF ANEROID BAROMETER 17701 ON BOARD THE YACHT FOX.

November, 1857. 29 Inches +. Mean Lat. 74°.8 N., Long. 69°.1 W.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
1	.85	.86	.88	.88	.94	.94	.94	.94	.96	.94	.98	.89	0.92
2	.84	.84	.81	.80	.87	.87	.88	.90	.86	.84	.88	.86	0.85
3	.88	.82	.81	.81	.90	.84	.84	.98	1.01	1.04	1.08	1.09	0.92
4	1.08	1.07	1.08	1.09	1.16	1.20	1.22	1.23	1.28	1.29	1.29	1.28	1.19
5	1.25	1.24	1.25	1.24	1.28	1.31	1.32	1.34	1.36	1.37	1.36	1.34	1.30
6	1.30	1.28	1.28	1.28	1.34	1.32	1.29	1.26	1.23	1.20	1.12	1.04	1.25
7	.95	.88	.84	.82	.88	.90	.94	.94	.95	.99	.99	.98	0.92
8	.96	.96	.96	.97	1.00	1.02	1.05	1.12	1.18	1.22	1.26	1.28	1.08
9	1.28	1.29	1.28	1.26	1.26	1.19	1.16	1.10	1.05	1.04	1.03	1.04	1.16
10	1.07	1.10	1.12	1.16	1.20	1.22	1.22	1.23	1.24	1.23	1.24	1.20	1.19
11	1.17	1.09	1.03	.98	.98	.92	.82	.81	.76	.73	.78	.71	0.90
12	.71	.72	.75	.77	.82	.85	.89	.91	.92	.93	.91	.91	0.84
13	.84	.81	.78	.72	.72	.72	.69	.69	.69	.68	.67	.69	0.72
14	.69	.68	.69	.70	.76	.74	.75	.75	.80	.81	.80	.81	0.75
15	.81	.80	.80	.74	.74	.61	.60	.52	.50	.42	.40	.35	0.61
16	.30	.30	.27	.24	.24	.19	.16	.10	.04	.03	.09	.19	0.18
17	.28	.34	.40	.42	.44	.47	.50	.58	.60	.64	.68	.73	0.51
18	.75	.80	.87	.92	1.00	1.06	1.06	1.16	1.20	1.24	1.26	1.26	1.05
19	1.26	1.22	1.16	1.16	1.17	1.16	1.16	1.17	1.20	1.20	1.19	1.17	1.18
20	1.16	1.15	1.16	1.12	1.17	1.17	1.19	1.19	1.19	1.16	1.10	1.05	1.15
21	1.05	1.04	.98	.94	1.00	1.00	1.00	1.01	1.01	.87	.78	.68	0.95
22	.56	.50	.51	.42	.42	.38	.42	.45	.46	.48	.49	.53	0.47
23	.54	.59	.68	.78	.82	.87	.91	.94	.96	.97	.97	.97	0.83
24	.97	.91	.90	.90	.96	.96	.98	1.00	1.08	1.12	1.10	1.05	0.99
25	1.05	.82	.74	.59	.50	.37	.26	.17	.12	.13	.14	.16	0.42
26	.16	.16	.10	.12	.12	.10	.09	.12	.15	.21	.25	.27	0.15
27	.28	.30	.30	.34	.38	.39	.44	.47	.51	.55	.59	.60	0.43
28	.60	.61	.62	.62	.70	.70	.72	.72	.75	.78	.80	.84	0.70
29	.85	.85	.90	.94	1.01	1.04	1.10	1.10	1.18	1.20	1.22	1.23	1.05
30	1.23	1.22	1.24	1.26	1.30	1.32	1.33	1.36	1.39	1.39	1.40	1.41	1.32
Mean	0.857	0.842	0.840	0.833	0.869	0.861	0.864	0.875	0.888	0.890	0.895	0.887	29.866

December, 1857. 29 Inches +. Mean Lat. 74°.3 N., Long. 67°.4 W.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
1	1.41	1.39	1.38	1.39	1.40	1.39	1.38	1.39	1.38	1.35	1.35	1.32	1.38
2	1.28	1.23	1.18	1.15	1.15	1.13	1.12	1.10	1.07	1.07	1 04	1.01	1.13
3	1.00	.95	.92	.88	.88	.90	.83	.80	.80	.77	.75	.73	0.85
4	.72	.70	.70	.69	.66	.66	.67	.68	.70	.69	.67	.64	0.68
5	.62	.60	.55	.54	.52	.47	.43	.42	.40	.35	.30	.29	0.46
6	.26	.23	.22	.21	.25	.29	.34	.35	.41	.44	.49	.55	0.34
7	.58	.62	.67	.74	.82	.86	.90	.92	.98	1.00	1.02	1.04	0.85
8	1.04	1.03	1.02	1.02	1.08	1.08	1.10	1.12	1.16	1.20	1.24	1.22	1.11
9	1.22	1.22	1.23	1.24	1.30	1.28	1.32	1.30	1.30	1.30	1.28	1.28	1.27
10	1.27	1.23	1.23	1.21	1.25	1.26	1.28	1.30	1.28	1.31	1.31	1.33	1.27
11	1.34	1.32	1.32	1.33	1.36	1.36	1.35	1.37	1.34	1.31	1.24	1.18	1.32
12	1.05	.94	.78	.68	.68	.60	.56	.56	.55	.52	.48	.44	0.65
13	.38	.32	.27	.23	.28	.28	.29	.33	.34	.36	.38	.42	0.32
14	.44	.46	.48	.49	.53	.59	.59	.63	.65	.66	.66	.67	0.57
15	.68	.68	.66	.66	.70	.72	.74	.75	.78	.77	.78	.78	0.72
16	.75	.74	.74	.74	.76	.74	.78	.79	.79	.78	.77	.78	0.76
17	.77	.76	.77	.74	.79	.79	.80	.82	.82	.84	.84	.84	0.80
18	.84	.84	.82	.80	.84	.86	.86	.86	.85	.85	.86	.82	0.84
19	.82	.80	.78	.80	.88	.96	1.00	1.06	1.04	1.02	.98	.90	0.92
20	.86	.80	.76	.77	.74	.75	.75	.75	.76	.75	.76	.74	0.77
21	.68	.66	.67	.70	.80	.82	.82	.85	.92	.92	.96	1.01	0.82
22	1.00	1.00	.98	1.04	1.04	1.04	1.02	1.04	1.01	.99	.98	.96	1.01
23	.92	.91	.86	.87	.89	.88	.90	.92	.94	.97	.99	1.01	0.92
24	1.04	1.03	1.02	1.04	1.12	1.10	1.10	1.11	1.11	1.10	1.06	1.03	1.07
25	.95	.88	.80	.76	.76	.73	.71	.70	.71	.70	.70	.68	0.76
26	.66	.68	.71	.64	.54	.54	.54	.54	.53	.51	.48	.42	0.57
27	.36	.30	.24	.20	.19	.18	.13	.12	.09	.09	.08	.09	0.17
28	.10	.10	.08	.04	.05	.04	.01	.00	.00	*.96	*.98	*.98	0.03
29	*.98	*.94	*.94	*.96	.03	.09	.15	.23	.31	.36	.42	.48	0.16
30	.51	.53	.56	.58	.63	.68	.72	.74	.75	.79	.84	.83	0.68
31	.83	.83	.85	.87	.92	.94	.97	.98	.96	.96	.93	.90	0.91
Mean	0.786	0.765	0.748	0.742	0.769	0.775	0.779	0.791	0.798	0.796	0.794	0.786	29.777

* Refers to 28 inches.

Readings of Aneroid Barometer 17701 on board the Yacht Fox.

January, 1858. 29 Inches +. Mean Lat. 73°.2 N., Long. 63°.7 W.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
1	.88	.87	.86	.84	.86	.82	.79	.76	.75	.72	.64	.60	0.78
2	.54	.52	.50	.50	.56	.54	.55	.53	.54	.51	.49	.41	0.52
3	.35	.28	.20	.12	.12	.01	*.96	*.93	*.92	*.89	*.91	*.92	0.05
4	*.92	*.92	*.92	*.94	*.95	*.96	*.98	.01	.04	.11	.13	.20	0.01
5	.22	.24	.24	.26	.31	.32	.30	.28	.28	.26	.26	.23	0.27
6	.19	.18	.14	.12	.12	.12	.13	.14	.12	.12	.10	.09	0.13
7	.09	.07	.07	.09	.14	.17	.20	.22	.28	.29	.30	.31	0.19
8	.30	.28	.27	.26	.26	.26	.26	.27	.26	.26	.26	.24	0.26
9	.24	.21	.21	.22	.26	.29	.30	.31	.33	.36	.37	.37	0.29
10	.38	.38	.38	.40	.45	.48	.51	.54	.58	.60	.61	.66	0.50
11	.67	.68	.67	.67	.71	.73	.75	.80	.82	.83	.83	.85	0.75
12	.84	.82	.81	.80	.84	.84	.84	.85	.84	.83	.81	.77	0.82
13	.72	.71	.67	.68	.72	.80	.90	.99	1.10	1.21	1.32	1.41	0.94
14	1.49	1.54	1.60	1.62	1.69	1.68	1.63	1.57	1.49	1.39	1.32	1.26	1.52
15	1.18	1.13	1.08	1.05	1.06	1.01	1.00	.99	1.00	.96	.96	.96	1.03
16	.92	.90	.87	.82	.81	.79	.76	.77	.80	.83	.84	.88	0.83
17	.88	.90	.90	.90	.91	.91	.90	.90	.99	1.06	1.13	1.21	0.97
18	1.22	1.23	1.23	1.25	1.24	1.26	1.25	1.25	1.26	1.25	1.25	1.20	1.24
19	1.18	1.17	1.16	1.17	1.22	1.24	1.24	1.28	1.26	1.27	1.26	1.21	1.22
20	1.16	1.08	.99	.93	.91	.88	.79	.75	.66	.59	.49	.40	0.80
21	.27	.20	.15	.16	.25	.33	.40	.51	.65	.74	.83	.90	0.45
22	.91	.94	.94	.97	1.02	1.00	.99	.93	.86	.78	.67	.56	0.88
23	.47	.40	.43	.51	.64	.72	.80	.86	.92	.94	.91	.89	0.71
24	.84	.78	.75	.67	.67	.61	.53	.45	.35	.26	.23	.25	0.53
25	.24	.24	.22	.20	.22	.19	.15	.14	.11	.09	.05	.04	0.16
26	.06	.08	.14	.17	.24	.26	.31	.32	.32	.34	.30	.26	0.23
27	.23	.23	.24	.28	.36	.44	.50	.60	.68	.78	.82	.83	0.50
28	.92	.95	.99	1.02	1.06	1.09	1.12	1.14	1.17	1.19	1.21	1.23	1.09
29	1.26	1.28	1.30	1.36	1.45	1.48	1.53	1.59	1.66	1.70	1.73	1.80	1.51
30	1.82	1.84	1.88	1.94	2.00	2.04	2.10	2.14	2.14	2.14	2.14	2.14	2.03
31	2.08	2.03	1.96	1.91	1.86	1.82	1.70	1.62	1.50	1.40	1.32	1.27	1.71
Mean	0.725	0.712	0.702	0.704	0.739	0.745	0.74	0.756	0.764	0.765	0.758	0.753	29.739

February, 1858. 29 Inches +. Mean Lat. 71°.5 N., Long. 60°.9 W.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
1	1.22	1.17	1.15	1.14	1.19	1.19	1.15	1.15	1.12	1.09	1.07	1.00	1.14
2	.93	.90	.86	.84	.85	.84	.81	.81	.81	.80	.81	.80	0.84
3	.76	.76	.75	.72	.75	.72	.74	.73	.72	.72	.70	.70	0.73
4	.66	.64	.64	.68	.69	.69	.68	.71	.73	.75	.79	.80	0.70
5	.80	.78	.76	.76	.78	.75	.74	.74	.72	.70	.68	.64	0.74
6	.56	.53	.51	.48	.48	.47	.47	.47	.47	.48	.48	.51	0.49
7	.51	.53	.56	.59	.64	.68	.72	.78	.81	.83	.86	.88	0.70
8	.91	.90	.91	.93	1.00	1.03	1.05	1.08	1.11	1.11	1.11	1.12	1.02
9	1.08	1.06	1.03	1.02	1.03	1.03	.97	.92	.84	.78	.73	.66	0.93
10	.59	.53	.48	.40	.45	.43	.44	.44	.48	.56	.59	.54	0.49
11	.68	.74	.84	.92	1.06	1.12	1.20	1.23	1.21	1.10	1.02	.94	1.00
12	.91	.90	.98	1.08	1.18	1.22	1.26	1.29	1.35	1.36	1.34	1.34	1.18
13	1.34	1.34	1.41	1.40	1.45	1.46	1.50	1.52	1.50	1.48	1.48	1.44	1.44
14	1.37	1.37	1.32	1.28	1.31	1.29	1.26	1.30	1.29	1.32	1.28	1.26	1.30
15	1.22	1.22	1.21	1.20	1.20	1.20	1.20	1.16	1.14	1.14	1.12	1.08	1.17
16	1.04	1.01	.98	.96	.96	.91	.88	.86	.86	.84	.83	.82	0.91
17	.82	.80	.84	.85	.86	.86	.86	.88	.90	.90	.90	.90	0.86
18	.86	.84	.82	.79	.78	.72	.66	.62	.54	.52	.44	.38	0.66
19	.32	.25	.22	.23	.23	.28	.38	.47	.56	.64	.70	.72	0.42
20	.69	.68	.63	.58	.58	.58	.44	.46	.48	.46	.48	.52	0.55
21	.52	.56	.63	.68	.72	.77	.83	.88	.90	.96	.98	.99	0.78
22	1.02	1.02	1.04	1.06	1.10	1.10	1.06	1.05	1.05	.98	.90	.86	1.02
23	.79	.75	.72	.74	.76	.76	.77	.79	.80	.81	.80	.80	0.77
24	.78	.76	.73	.66	.68	.64	.63	.63	.62	.59	.56	.48	0.65
25	.48	.42	.42	.44	.52	.59	.64	.67	.68	.68	.64	.64	0.57
26	.66	.69	.70	.72	.80	.84	.89	.93	.96	.96	1.01	1.02	0.85
27	1.01	1.01	1.02	1.06	1.10	1.10	1.09	1.11	1.09	1.13	1.16	1.17	1.09
28	1.10	1.06	1.07	1.11	1.18	1.18	1.16	1.16	1.15	1.12	1.10	1.10	1.12
Mean	0.843	0.829	0.830	0.833	0.868	0.871	0.874	0.886	0.889	0.886	0.877	0.861	29.862

* Refers to 28 inches.

READINGS OF ANEROID BAROMETER 17701 ON BOARD THE YACHT FOX.

March, 1858. 29 Inches +. Mean Lat. 69°.4 N., Long. 59°.1 W.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
1	1.04	1.02	.96	.94	.93	.93	.91	.91	.90	.93	.96	.99	0.95
2	1.01	1.03	1.06	1.04	1.07	1.02	.96	.96	.96	.97	1.04	1.12	1.02
3	1.22	1.32	1.36	1.42	1.48	1.46	1.36	1.22	1.05	.83	.59	.35	1.14
4	.42	.49	.54	.66	.83	.91	1.12	1.30	1.40	1.46	1.53	1.54	1.02
5	1.54	1.58	1.62	1.66	1.70	1.72	1.71	1.71	1.66	1.66	1.64	1.64	1.65
6	1.64	1.65	1.64	1.68	1.75	1.79	1.84	1.89	1.94	1.96	1.98	2.00	1.81
7	1.99	1.98	1.95	1.94	1.96	1.90	1.90	1.85	1.82	1.76	1.74	1.67	1.87
8	1.62	1.56	1.56	1.54	1.56	1.55	1.57	1.56	1.57	1.58	1.57	1.58	1.57
9	1.53	1.50	1.46	1.45	1.46	1.40	1.34	1.31	1.22	1.16	1.11	1.04	1.33
10	.99	.94	.86	.82	.82	.72	.58	.44	.29	.20	.05	*.97	0.56
11	*.92	*.89	*.85	*.85	*.88	*.88	*.89	*.94	*.94	*.97	.00	.02	*0.92
12	.02	.03	.04	.06	.13	.16	.19	.30	.38	.44	.49	.48	0.23
13	.48	.48	.49	.50	.54	.54	.54	.53	.54	.55	.56	.58	0.53
14	.58	.57	.58	.60	.69	.70	.73	.79	.80	.80	.84	.83	0.71
15	.80	.80	.80	.82	.88	.89	.93	.97	1.03	1.03	1.04	1.09	0.92
16	1.09	1.09	1.10	1.16	1.20	1.20	1.21	1.22	1.25	1.26	1.26	1.26	1.19
17	1.25	1.25	1.23	1.24	1.26	1.25	1.24	1.25	1.24	1.23	1.20	1.17	1.23
18	1.14	1.09	1.08	1.03	1.01	.96	.92	.90	.88	.88	.84	.82	0.96
19	.80	.78	.78	.77	.80	.80	.80	.82	.86	.88	.88	.90	0.82
20	.90	.88	.88	.88	.89	.85	.83	.82	.79	.76	.75	.71	0.83
21	.68	.68	.68	.70	.74	.72	.72	.70	.68	.66	.66	.62	0.69
22	.59	.56	.56	.56	.60	.58	.56	.56	.55	.54	.51	.48	0.55
23	.50	.52	.60	.68	.79	.89	.98	1.10	1.14	1.24	1.32	1.38	0.93
24	1.40	1.41	1.44	1.44	1.50	1.48	1.48	1.51	1.56	1.56	1.58	1.55	1.49
25	1.49	1.46	1.42	1.42	1.44	1.44	1.44	1.43	1.42	1.47	1.50	1.52	1.45
26	1.53	1.53	1.54	1.58	1.66	1.65	1.66	1.66	1.66	1.68	1.68	1.66	1.62
27	1.64	1.61	1.60	1.64	1.66	1.67	1.67	1.66	1.66	1.65	1.66	1.64	1.65
28	1.60	1.56	1.52	1.52	1.53	1.51	1.49	1.49	1.47	1.48	1.48	1.47	1.50
29	1.47	1.46	1.45	1.53	1.55	1.55	1.59	1.59	1.58	1.60	1.58	1.56	1.54
30	1.50	1.44	1.38	1.37	1.35	1.31	1.29	1.26	1.26	1.28	1.28	1.29	1.33
31	1.27	1.24	1.24	1.26	1.25	1.24	1.23	1.19	1.19	1.20	1.20	1.19	1.22
Mean	1.085	1.077	1.073	1.089	1.120	1.118	1.119	1.124	1.119	1.118	1.114	1.101	30.105

April, 1858. 29 Inches +. Mean Lat. 66°.0 N., Long. 57°.7 W.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
1	1.20	1.19	1.20	1.22	1.22	1.25	1.25	1.26	1.26	1.23	1.22	1.22	1.23
2	1.18	1.12	1.12	1.10	1.10	1.10	1.08	1.08	1.07	1.07	1.04	1.02	1.09
3	1.02	.98	.96	.98	.98	.94	.94	.93	.91	.92	.92	.92	0.95
4	.89	.90	.92	.94	.94	.92	.89	.88	.88	.88	.88	.84	0.90
5	.78	.78	.76	.76	.76	.75	.76	.76	.79	.82	.84	.86	0.78
6	.87	.92	.97	1.09	1.18	1.20	1.26	1.30	1.25	1.33	1.35	1.35	1.17
7	1.32	1.29	1.30	1.30	1.29	1.28	1.26	1.26	1.26	1.25	1.24	1.20	1.27
8	1.14	1.14	1.11	1.09	1.16	1.24	1.32	1.43	1.56	1.64	1.72	1.74	1.36
9	1.74	1.75	1.75	1.74	1.73	1.70	1.68	1.64	1.64	1.62	1.62	1.61	1.68
10	1.54	1.52	1.50	1.54	1.54	1.54	1.54	1.55	1.56	1.56	1.57	1.58	1.55
11	1.56	1.54	1.52	1.53	1.56	1.55	1.54	1.53	1.52	1.53	1.54	1.58	1.54
12	1.62	1.67	1.72	1.79	1.86	1.86	1.87	1.88	1.88	1.88	1.86	1.84	1.81
13	1.74	1.72	1.67	1.67	1.63	1.58	1.52	1.48	1.44	1.42	1.38	1.35	1.55
14	1.30	1.26	1.20	1.18	1.18	1.15	1.12	1.10	1.08	1.08	1.10	1.07	1.15
15	1.02	.97	.93	.93	.96	.96	.96	.96	.98	.98	.95	.95	0.96
16	.90	.90	.90	.91	.90	.89	.90	.90	.92	.93	.93	.89	0.91
17	.86	.82	.80	.77	.76	.73	.69	.74	.72	.71	.68	.65	0.74
18	(.66)	.66	(.66)	.66	(.69)	.72	(.73)	.75	(.74)	.74	(.76)	.77	0.71
19	(.76)	.75	(.77)	.79	(.80)	.82	(.84)	.86	(.90)	.93	(.92)	.92	0.84
20	(.91)	.91	(.93)	.95	(.97)	.90	(.90)	.91	(.91)	.91	(.91)	.91	0.92
21	(.90)	.90	(.91)	.92	(.92)	.92	(.91)	.90	(.93)	.96	(.96)	.97	0.93
22	(.98)	.99	(1.05)	1.10	(1.12)	1.15	(1.17)	1.20	(1.22)	1.25	(1.25)	1.25	1.14
23	(1.22)	1.20	(1.20)	1.20	(1.18)	1.16	(1.13)	1.10	(1.10)	1.11	(1.09)	1.08	1.15
24	(1.02)	.97	(.95)	.93	(.85)	.77	(.74)	(.71)	(.68)	(.65)	(.62)	(.59)	0.79
25	(.56)	.53	(.55)	.56	(.48)	.40	(.41)	.42	(.53)	.64	(.74)	.83	0.55
26	(.90)	.98	(1.03)	1.08	(1.13)	1.19	(1.23)	1.28	(1.35)	1.41	(1.43)	1.46	1.21
27	(1.46)	1.46	(1.50)	1.54	(1.57)	1.60	(1.59)	1.58	(1.59)	1.60	(1.60)	1.60	1.56
28	(1.57)	1.55	(1.57)	1.60	(1.61)	1.62	(1.63)	1.64	(1.65)	1.66	(1.65)	1.64	1.62
29	(1.62)	1.60	(1.60)	1.60	(1.57)	1.55	(1.45)	1.36	(1.35)	1.34	(1.31)	1.28	1.47
30	(1.22)	1.17	(1.07)	.98	(.96)	.94	(.94)	.93	(.94)	.94	(.95)	.96	1.00
Mean	1.149	1.138	1.137	1.148	1.153	1.146	1.142	1.144	1.154	1.166	1.168	1.164	30.151

* Refers to 28 inches.

READINGS OF ANEROID BAROMETER 17701 ON BOARD THE YACHT FOX.

May, 1858. 29 Inches +. Mean Lat. 68°.7 N., Long. 53°.7 W.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Mean.
1	.93	.90	.95	1.04	1.16	1.20	1.03
2	1.16	(1.06)	.96	.79	.73	.74	0.91
3	.77	.88	.96	1.06	1.08	1.10	0.97
4	1.05	1.04	1.02	.99	.96	.94	1.00
5	.84	.85	.87	.98	1.07	1.11	0.95
6	1.11	1.14	1.09	1.11	1.16	1.13	1.12
7	1.12	1.15	1.21	1.21	1.23	1.21	1.19
8	1.16	1.17	1.22	1.24	1.25	1.22	1.21
9	1.18	1.16	1.10	1.08	1.08	1.08	1.11
10	1.10	1.06	1.11	1.13	1.13	1.18	1.12
11	1.14	1.17	1.20	1.19	1.12	1.14	1.16
12	1.13	1.16	1.24	1.38	1.50	1.59	1.33
13	1.58	1.58	1.60	1.64	1.65	1.66	1.62
14	1.64	1.66	1.70	1.68	1.68	1.66	1.67
15	1.65	1.74	1.76	1.70	1.70	1.62	1.70
16	1.56	1.58	1.51	1.50	1.56	1.54	1.54
17	1.50	1.48	1.42	1.40	1.37	1.34	1.42
18	1.34	1.40	1.36	1.35	1.34	1.30	1.35
19	1.30	1.31	1.33	1.26	1.22	1.16	1.26
20	(1.15)	(1.14)	(1.13)	(1.12)	(1.11)	(1.10)	1.12
21	1.08	1.10	1.14	1.18	1.18	1.17	1.14
22	1.18	1.24	1.29	1.26	1.23	1.14	1.22
23	1.19	1.19	1.16	1.16	1.14	1.18	1.17
24	1.20	1.32	1.30	1.25	1.22	1.17	1.24
25	1.15	1.12	1.10	1.08	1.15	1.18	1.13
26	1.24	1.31	1.34	1.36	1.40	1.38	1.34
27	1.39	1.45	1.42	1.44	1.34	1.35	1.40
28	1.30	1.35	1.30	1.10	1.09	1.00	1.19
29	.96	.98	1.00	1.00	1.00	1.01	0.99
30	1.06	1.07	1.10	1.13	1.14	1.16	1.11
31	1.16	1.16	1.20	1.18	1.14	1.12	1.16
Mean	1.204	1.223	1.229	1.225	1.230	1.222	30.222

June, 1858. 29 Inches +. Mean Lat. 74°.6 N., Long. 60°.1 W.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Mean.
1	1.08	1.08	1.09	1.05	1.05	1.05	1.07
2	.99	.92	.90	.85	.88	.89	0.90
3	.99	1.08	1.20	1.18	1.15	1.13	1.12
4	1.00	.94	.92	.92	1.03	1.16	0.99
5	1.20	1.24	1.30	1.32	1.34	1.29	1.28
6	1.21	1.26	1.26	1.26	1.25	1.28	1.25
7	1.24	1.31	1.34	1.28	1.28	1.28	1.29
8	1.28	1.26	1.24	1.20	1.18	1.14	1.22
9	1.12	1.10	1.08	1.05	1.00	.95	1.05
10	.94	.90	.90	.90	.95	.90	0.92
11	.97	.99	1.02	1.06	1.08	1.08	1.03
12	1.10	1.12	1.16	1.22	1.24	1.25	1.18
13	1.23	1.21	1.18	1.18	1.15	1.12	1.18
14	1.12	1.17	1.22	1.24	1.24	1.20	1.20
15	1.18	1.22	1.19	1.18	1 25	1.23	1.21
16	1.18	1.15	1.12	1.04	1.00	.96	1.07
17	.90	.94	.96	.99	1.00	1.04	0.97
18	.99	.99	1.01	.98	.97	.97	0.98
19	.94	.91	.91	.88	.87	.86	0.89
20	.84	.84	.84	.87	.86	.83	0.85
21	.80	.78	.82	.86	.91	.92	0.85
22	.91	.94	1.01	1.06	1.11	1.10	1.02
23	1.10	1.10	1.08	1.16	1.10	1.10	1.11
24	1.08	1.09	1.09	1.07	1.02	.94	1.05
25	.84	.88	.87	.86	.86	.82	0.86
26	.78	.78	.78	.68	.64	.56	0.70
27	.48	.42	.53	.52	.55	.57	0.51
28	.59	.65	.74	.76	.81	.84	0.73
29	.86	.91	1.00	1.06	1.20	1.18	1.03
30	1.20	1.26	1.29	1.29	1.21	1.12	1.23
Mean	30.005	30.015	30.035	30.032	30.039	30.025	30.025

Readings of Aneroid Barometer 17701 on board the Yacht Fox.

July, 1858. 29 Inches +. Mean Lat. 74°.4 N., Long. 76°.4 W.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Mean.
1	1.12	1.17	1.25	1.24	1.21	1.08	1.18
2	1.11	1.09	1.12	1.19	1.20	1.18	1.15
3	1.07	1.10	1.06	1.06	1.07	1.07	1.07
4	1.08	1.11	1.14	1.12	1.13	1.12	1.12
5	1.04	1.00	.94	.92	.86	.78	0.92
6	.72	.81	.86	.89	.90	.91	0.85
7	.84	.84	.86	.82	.80	.80	0.83
8	.75	.76	.76	.77	.77	.74	0.76
9	.74	.74	.70	.66	.69	.64	0.70
10	.64	.68	.69	.70	.71	.67	0.68
11	.70	.69	.69	.70	.72	.70	0.70
12	.68	.70	.69	.79	.72	.62	0.70
13	.58	.57	.56	.62	.66	.62	0.60
14	.64	.63	.68	.68	.72	.73	0.68
15	.74	.74	.72	.66	.69	.66	0.70
16	.60	.61	.64	.68	.73	.74	0.67
17	.79	.79	.84	.89	.98	1.02	0.89
18	1.06	1.22	1.24	1.24	1.27	1.30	1.22
19	1.30	1.35	1.38	1.40	1.44	1.42	1.38
20	1.42	1.44	1.44	1.43	1.48	1.45	1.44
21	1.46	1.48	1.48	1.46	1.48	1.46	1.47
22	1.44	1.47	1.48	1.48	1.45	1.42	1.46
23	1.40	1.37	1.36	1.30	1.28	1.19	1.32
24	1.14	1.20	1.12	1.10	1.04	1.00	1.10
25	.99	.97	.98	.96	.93	.90	0.95
26	.88	.89	.94	.94	.94	.91	0.92
27	.90	.90	.87	.91	.90	.89	0.90
28	.86	.84	.84	.84	.88	.86	0.85
29	.89	.93	.92	.97	.90	.90	0.92
30	.90	.90	.82	.78	.78	.79	0.83
31	.80	.81	.82	.89	.86	.84	0.84
Mean	29.945	29.961	29.965	29.971	29.974	29.949	29.961

August, 1858. 29 Inches +. Mean Lat. 73.°1 N., Long. 88°.5 W.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Mean.
1	.80	.88	.90	.94	1.00	1.05	0.93
2	1.07	1.11	1.13	1.15	1.17	1.19	1.14
3	1.18	1.16	1.16	1.15	1.16	1.12	1.15
4	1.14	1.14	1.14	1.16	1.18	1.18	1.16
5	1.20	1.22	1.24	1.28	1.27	1.26	1.25
6	1.28	1.26	1.24	1.24	1.25	1.20	1.24
7	1.15	1.15	1.00	.86	.80	.73	0.95
8	.58	.54	.55	.58	.59	.62	0.58
9	.60	.66	.76	.78	.78	.80	0.73
10	.82	.82	.88	.90	.90	.89	0.87
11	.82	.92	.89	.85	.85	.89	0.87
12	.89	.89	.87	.87	.89	.83	0.87
13	.87	.92	.84	.83	.74	.74	0.82
14	.72	.70	.70	.72	.72	.74	0.72
15	.74	.76	.80	.95	.98	.98	0.87
16	.98	.98	1.00	1.00	.94	.78	0.95
17	.74	.80	.93	.99	1.04	1.04	0.92
18	.94	.90	.90	.89	.86	.84	0.89
19	.86	.91	.98	.94	1.00	.99	0.95
20	1.01	1.02	1.08	1.14	1.18	1.20	1.10
21	1.19	1.20	1.20	1.20	1.22	1.12	1.19
22	1.04	.94	.90	.86	.90	.88	0.92
23	.87	.88	.86	.85	.80	.67	0.82
24	.60	.60	.58	.60	.60	.64	0.60
25	.68	.69	.76	.81	.81	.78	0.75
26	.78	.84	.88	.90	.92	.88	0.87
27	.78	.70	.74	.98	.98	.92	0.85
28	.98	1.03	1.08	1.11	1.08	1.04	1.05
29	.96	.98	.90	1.05	1.05	1.08	1.00
30	1.07	1.15	1.13	1.14	1.14	1.10	1.12
31	1.10	1.10	1.13	1.14	1.16	1.18	1.13
Mean	29.917	29.931	29.941	29.963	29.966	29.947	29.944

Readings of Aneroid Barometer 17701 on board the Yacht Fox.

September, 1858. 29 Inches +. Mean Lat. 72°.0 N., Long. 94°.4 W.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Mean.
1	1.12	1.12	1.19	1.25	1.26	1.28	1.20
2	1.24	1.25	1.25	1.24	1.35	1.30	1.27
3	1.26	1.30	1.30	1.30	1.34	1.30	1.30
4	1.30	1.29	1.32	1.31	1.30	1.23	1.29
5	1.31	1.30	1.23	1.14	1.18	1.16	1.22
6	1.20	1.10	1.12	(1.06)	(1.00)	(0.94)	1.07
7	.88	.84	.87	.86	.92	.90	0.88
8	.90	.90	.94	.97	.94	.96	0.94
9	.97	1.02	1.10	1.14	1.15	1.18	1.09
10	1.19	1.20	1.20	1.20	1.24	1.22	1.21
11	1.20	1.19	1.20	1.20	1.24	1.24	1.21
12	1.16	1.13	1.17	1.17	1.17	1.15	1.16
13	1.12	1.12	1.16	1.17	1.16	1.21	1.16
14	1.20	1.24	1.28	1.28	1.22	1.22	1.24
15	1.26	1.25	1.29	1.29	1.34	1.37	1.30
16	1.27	1.32	1.31	1.36	1.33	1.29	1.31
17	1.25	1.28	1.23	1.26	1.23	1.19	1.24
18	1.14	1.16	1.12	1.19	1.20	1.12	1.15
19	1.10	1.18	1.18	1.20	1.18	1.09	1.16
20	1.00	1.09	1.06	.98	.94	.80	0.98
21	.72	.72	.74	.72	.78	.84	0.75
22	.88	1.00	1.04	1.03	.90	.68	0.92
23	.52	.33	.32	.28	.48	.69	0.44
24	.75	.90	.88	.98	.98	.96	0.91
25	.90	1.02	1.02	1.08	1.08	1.08	1.03
26	1.10	1.20	1.12	1.24	1.24	1.24	1.19
27	1.20	1.20	1.30	1.31	1.30	1.30	1.27
28	1.15	1.20	1.10	1.04	1.14	1.12	1.12
29	1.10	1.20	1.20	1.24	1.20	1.18	1.19
30	1.12	1.10	1.06	1.04	1.02	.98	1.05
Mean	30.084	30.105	30.110	30.118	30.127	30.107	30.108

October, 1858. 29 Inches +. Mean Lat. 72°.0 N., Long. 94°.2 W.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Mean.
1	.88	.88	.86	.85	.80	.70	0.83
2	.64	.62	.72	.72	.72	.90	0.72
3	.68	.72	.74	.80	.80	.70	0.74
4	.61	.66	.82	.94	.98	1.00	0.83
5	1.10	1.22	1.30	1.38	1.42	1.46	1.31
6	1.46	1.54	1.60	1.62	1.66	1.66	1.59
7	1.64	1.68	1.70	.68	1.63	1.56	1.48
8	1.45	1.45	1.48	1.48	1.50	1.46	1.47
9	1.44	1.44	1.40	1.38	1.37	1.29	1.39
10	1.20	1.16	1.11	.78	.63	.48	0.89
11	.42	.45	.46	.41	.44	.42	0.43
12	.42	.50	.55	.67	.73	.75	0.60
13	.74	.84	.85	.86	.88	.88	0.84
14	.88	.88	1.04	1.08	1.18	1.20	1.04
15	1.18	1.24	1.20	1.11	1.08	.94	1.12
16	.82	.78	.70	.66	.66	.60	0.70
17	.56	.62	.60	.70	.73	.82	0.67
18	.82	.90	.98	.98	.92	.98	0.93
19	.79	.76	.70	.68	.60	.46	0.67
20	.38	.44	.48	.52	.58	.60	0.50
21	.60	.70	.80	.94	1.06	1.14	0.87
22	1.21	1.20	1.32	1.37	1.36	1.36	1.30
23	1.30	1.38	1.35	1.28	1.23	1.14	1.28
24	1.06	1.00	.86	.80	.79	.74	0.87
25	.72	.90	.96	1.04	1.04	1.24	0.98
26	1.26	1.32	1.40	1.38	1.37	1.36	1.35
27	1.34	1.44	1.46	1.46	1.42	1.34	1.41
28	1.24	1.24	1.22	1.18	1.22	1.16	1.21
29	1.10	1.10	1.04	1.04	1.02	1.00	1.05
30	.96	.96	.92	.96	.96	1.04	0.97
31	1.07	1.19	1.20	1.20	1.18	1.12	1.16
Mean	29.967	30.007	30.026	29.998	30.031	30.016	30.007

READINGS OF ANEROID BAROMETER 17701 ON BOARD THE YACHT FOX.

November, 1858. 29 Inches +. Mean Lat. 72°.0 N., Long. 94°.2 W.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
1	1.10	1.08	1.08	1.18	1.15	1.04	1.02	1.02	.98	.97	.94	.94	1.04
2	.86	.86	.85	.93	.96	1.00	1.08	1.14	1.10	1.14	1.16	1.20	1.02
3	1.24	1.26	1.24	1.26	1.36	1.34	1.34	1.34	1.40	1.40	1.36	1.30	1.32
4	1.22	1.22	1.12	1.14	1.18	1.15	1.12	1.22	1.24	1.28	1.20	1.24	1.19
5	1.12	1.16	1.16	1.18	1.23	1.22	1.14	1.18	1.16	1.18	1.18	1.18	1.17
6	1.13	1.16	1.25	1.28	1.26	1.28	1.32	1.34	1.32	1.28	1.34	1.30	1.27
7	1.28	1.28	1.32	1.34	1.38	1.38	1.42	1.46	1.48	1.48	1.50	1.50	1.40
8	1.48	1.48	1.46	1.50	1.50	1.48	1.48	1.50	1.52	1.52	1.52	1.52	1.50
9	1.48	1.48	1.48	1.50	1.50	1.58	1.58	1.60	1.60	1.62	1.60	1.60	1.55
10	1.62	1.62	1.58	1.60	1.64	1.68	1.66	1.66	1.66	1.66	1.66	1.60	1.64
11	1.57	1.52	1.58	1.58	1.52	1.50	1.48	1.46	1.48	1.46	1.46	1.44	1.50
12	1.44	1.44	1.43	1.42	1.50	1.46	1.48	1.48	1.48	1.48	1.48	1.48	1.46
13	1.44	1.40	1.38	1.42	1.38	1.33	1.32	1.32	1.24	1.18	1.15	1.11	1.31
14	1.08	1.04	1.02	1.07	1.08	1.10	1.09	1.18	1.18	1.20	1.22	1.20	1.12
15	1.24	1.24	1.24	1.32	1.34	1.34	1.38	1.38	1.44	1.46	1.50	1.52	1.37
16	1.54	1.54	1.52	1.57	1.56	1.52	1.50	1.45	1.40	1.54	1.30	1.26	1.47
17	1.20	1.14	1.10	1.16	1.19	1.19	1.22	1.22	1.20	1.20	1.15	1.15	1.18
18	1.10	1.06	1.06	1.00	1.12	1.14	1.13	1.15	1.16	1.16	1.18	1.18	1.12
19	1.17	1.17	1.17	1.20	1.18	1.18	1.18	1.18	1.19	1.18	1.14	1.14	1.17
20	1.08	1.06	1.01	1.03	1.00	1.08	.98	.99	1.00	1.02	1.04	1.08	1.03
21	1.10	1.10	1.09	1.14	1.15	1.14	1.12	1.14	1.14	1.12	1.13	1.11	1.12
22	1.12	1.12	1.10	1.19	1.18	1.23	1.24	1.26	1.28	1.30	1.34	1.34	1.23
23	1.33	1.31	1.30	1.36	1.35	1.39	1.39	1.40	1.45	1.49	1.50	1.50	1.40
24	1.50	1.50	1.55	1.65	1.65	1.63	1.64	1.68	1.66	1.66	1.65	1.64	1.62
25	1.60	1.57	1.56	1.58	1.58	1.53	1.54	1.60	1.58	1.56	1.57	1.58	1.57
26	1.56	1.56	1.56	1.60	1.56	1.56	1.54	1.52	1.52	1.44	1.40	1.40	1.52
27	1.35	1.28	1.24	1.26	1.20	1.15	1.05	1.06	1.03	1.02	.94	.91	1.12
28	.86	.80	.73	.75	.74	.74	.72	.70	.68	.68	.68	.69	0.73
29	.66	.65	.64	.72	.76	.74	.72	.74	.78	.80	.81	.81	0.74
30	.82	.84	.90	.97	.98	1.00	1.00	1.02	1.00	1.01	.99	1.00	0.96
Mean	1.243	1.231	1.224	1.263	1.273	1.270	1.263	1.280	1.278	1.283	1.270	1.264	30.261

December, 1858. 29 Inches +. Mean Lat. 72°.0 N., Long. 94°.2 W.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
1	1.00	.99	1.00	1.06	1.08	1.09	1.12	1.16	1.18	1.18	1.20	1.20	1.10
2	1.20	1.18	1.17	1.20	1.20	1.18	1.18	1.16	1.10	1.10	1.04	1.00	1.14
3	.98	.94	.96	1.00	1.03	1.05	1.12	1.02	1.04	1.01	.98	.97	1.08
4	.96	.94	.90	.98	.96	.96	1.00	1.01	1.04	1.05	1.08	1.10	1.00
5	1.10	1.10	1.12	1.12	1.12	1.12	1.12	1.18	1.18	1.18	1.18	1.15	1.14
6	1.16	1.12	1.11	1.16	1.16	1.15	1.12	1.10	1.08	1.05	1.00	.98	1.10
7	.94	.94	.92	.99	1.00	1.01	1.04	1.06	1.06	1.06	1.04	1.03	1.08
8	1.02	1.00	.98	1.00	1.00	1.00	1.00	1.01	1.04	1.08	1.09	1.09	1.03
9	1.09	1.09	1.09	1.12	1.10	1.06	1.04	1.06	1.01	.98	.96	.92	1.04
10	.89	.86	.88	.84	.82	.78	.74	.75	.74	.72	.70	.70	0.78
11	.68	.67	.69	.74	.75	.74	.74	.78	.78	.80	.82	.85	0.75
12	.84	.84	.81	.89	.90	.90	.92	.94	.94	.97	1.00	1.00	0.91
13	1.02	1.04	1.06	1.16	1.20	1.20	1.22	1.26	1.28	1.26	1.26	1.24	1.18
14	1.24	1.22	1.20	1.24	1.26	1.26	1.26	1.28	1.22	1.23	1.24	1.22	1.24
15	1.20	1.20	1.16	1.20	1.22	1.20	1.16	1.18	1.18	1.20	1.20	1.19	1.19
16	1.12	1.10	1.13	1.10	1.12	1.10	1.10	1.12	1.08	1.08	1.08	1.07	1.10
17	1.05	1.04	1.08	1.08	1.08	1.05	1.08	1.08	1.08	1.06	1.06	1.06	1.06
18	1.06	1.06	1.08	1.14	1.14	1.10	1.10	1.12	1.10	1.10	1.08	1.06	1.10
19	1.04	1.04	.98	1.02	1.01	.99	.98	1.00	1.01	1.00	1.00	1.00	1.01
20	.98	.98	.92	.96	.90	.86	.82	.79	.72	.65	.59	.54	0.81
21	.48	.45	.46	.50	.53	.56	.62	.66	.70	.76	.76	.80	0.61
22	.82	.84	.87	.95	.98	1.00	1.03	1.04	1.06	1.08	1.10	1.10	0.99
23	1.08	1.06	1.06	1.12	1.13	1.10	1.08	1.08	1.08	1.06	1.04	1.03	1.08
24	1.02	1.00	1.01	1.00	1.09	1.09	1.09	1.11	1.11	1.12	1.12	1.12	1.08
25	1.12	1.10	1.12	1.14	1.15	1.14	1.16	1.16	1.12	1.13	1.10	1.10	1.13
26	1.09	1.00	1.09	1.08	1.12	1.14	1.16	1.16	1.16	1.16	1.18	1.18	1.13
27	1.20	1.20	1.34	1.30	1.33	1.31	1.38	1.44	1.41	1.50	1.55	1.53	1.37
28	1.54	1.58	1.58	1.70	1.72	1.72	1.75	1.77	1.74	1.70	1.70	1.68	1.68
29	1.64	1.56	1.54	1.54	1.48	1.44	1.40	1.39	1.35	1.32	1.30	1.29	1.44
30	1.22	1.20	1.16	1.20	1.16	1.14	1.15	1.20	1.20	1.21	1.22	1.22	1.19
31	1.20	1.18	1.16	1.18	1.18	1.18	1.18	1.17	1.16	1.12	1.11	1.10	1.16
Mean	1.064	1.049	1.053	1.070	1.094	1.085	1.092	1.105	1.095	1.094	1.090	1.081	30.081

Readings of Aneroid Barometer 17701 on board the Yacht Fox.

January, 1859. 29 Inches +. Mean Lat. 72°.0 N., Long. 94°.2 W.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
1	1.04	1.04	.98	.95	.92	.92	.88	.83	.80	.80	.78	.76	0.89
2	.76	.73	.76	.76	.78	.80	.84	.88	.89	.92	.90	.90	0.83
3	.90	.90	.92	.98	1.02	1.02	1.04	1.06	1.06	1.03	1.04	1.04	1.00
4	1.04	1.00	1.00	1.02	1.03	1.00	.98	1.00	1.04	1.04	1.04	1.03	1.02
5	1.06	1.06	1.06	1.16	1.24	1.28	1.34	1.38	1.44	1.44	1.44	1.46	1.28
6	1.46	1.46	1.46	1.46	1.44	1.42	1.44	1.42	1.37	1.36	1.30	1.28	1.41
7	1.24	1.20	1.17	1.21	1.22	1.22	1.20	1.19	1.20	1.21	1.17	1.14	1.20
8	1.16	1.16	1.15	1.18	1.22	1.22	1.24	1.27	1.28	1.24	1.24	1.22	1.21
9	1.12	1.06	.94	.94	.91	.88	.86	.84	.84	.88	.88	.88	0.92
10	.90	.94	.96	1.08	1.13	1.15	1.20	1.22	1.24	1.26	1.30	1.34	1.14
11	1.32	1.32	1.35	1.38	1.42	1.42	1.40	1.42	1.44	1.44	1.44	1.46	1.40
12	1.44	1.40	1.38	1.32	1.41	1.38	1.38	1.37	1.37	1.36	1.35	1.33	1.37
13	1.32	1.30	1.25	1.26	1.25	1.20	1.20	1.20	1.20	1.18	1.16	1.16	1.22
14	1.13	1.10	1.08	1.12	1.13	1.14	1.16	1.16	1.18	1.20	1.20	1.22	1.15
15	1.24	1.22	1.23	1.26	1.32	1.34	1.36	1.38	1.40	1.40	1.42	1.42	1.33
16	1.41	1.38	1.42	1.38	1.35	1.34	1.34	1.36	1.34	1.34	1.32	1.29	1.36
17	1.28	1.28	1.24	1.26	1.28	1.26	1.27	1.29	1.28	1.26	1.26	1.24	1.27
18	1.21	1.19	1.17	1.21	1.18	1.15	1.12	1.12	1.12	1.10	1.09	1.10	1.15
19	1.10	1.10	1.14	1.20	1.20	1.20	1.19	1.22	1.22	1.23	1.22	1.18	1.18
20	1.09	1.04	.98	.98	.98	.95	.92	.93	.94	.94	.96	.98	0.97
21	1.00	.98	.97	1.02	1.02	1.00	1.00	1.03	1.03	1.00	.96	.96	1.00
22	.90	.88	.88	.92	.90	.87	.88	.89	.88	.89	.87	.88	0.88
23	.86	.86	.84	.90	.94	.94	.96	.99	1.00	1.03	1.02	1.04	0.95
24	1.06	1.04	1.04	1.10	1.15	1.17	1.18	1.18	1.17	1.16	1.15	1.16	1.13
25	1.14	1.15	1.16	1.20	1.22	1.24	1.25	1.26	1.30	1.30	1.30	1.34	1.24
26	1.34	1.32	1.28	1.34	1.34	1.30	1.32	1.33	1.31	1.32	1.30	1.29	1.32
27	1.26	1.24	1.21	1.26	1.32	1.32	1.26	1.26	1.24	1.26	1.26	1.25	1.26
28	1.26	1.26	1.26	1.28	1.31	1.32	1.33	1.35	1.38	1.38	1.40	1.40	1.33
29	1.41	1.42	1.40	1.46	1.46	1.44	1.43	1.44	1.42	1.40	1.40	1.40	1.42
30	1.39	1.38	1.40	1.43	1.46	1.45	1.44	1.50	1.51	1.54	1.52	1.52	1.46
31	1.50	1.50	1.50	1.56	1.56	1.56	1.55	1.52	1.52	1.55	1.54	1.53	1.53
Mean	1.172	1.158	1.148	1.180	1.197	1.190	1.192	1.203	1.207	1.209	1.201	1.200	30.188

February, 1859. 29 Inches +. Mean Lat. 72°.0 N., Long. 94°.2 W.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
1	1.46	1.47	1.46	1.46	1.46	1.42	1.40	1.38	1.38	1.34	1.27	1.25	1.40
2	1.23	1.20	1.16	1.20	1.20	1.18	1.17	1.13	1.08	1.05	.98	.92	1.12
3	.85	.81	.78	.80	.75	.72	.78	.68	.66	.63	.62	.60	0.72
4	.60	.60	.65	.72	.78	.84	.86	.92	.98	1.02	1.06	1.08	0.84
5	1.08	1.10	1.10	1.20	1.19	1.19	1.19	1.22	1.24	1.24	1.24	1.23	1.18
6	1.23	1.21	1.17	1.20	1.22	1.20	1.25	1.25	1.26	1.19	1.28	1.24	1.22
7	1.22	1.22	1.23	1.22	1.23	1.27	1.32	1.30	1.29	1.32	1.32	1.34	1.27
8	1.30	1.30	1.30	1.35	1.34	1.32	1.30	1.30	1.28	1.28	1.26	1.24	1.30
9	1.21	1.22	1.20	1.26	1.24	1.26	1.26	1.27	1.28	1.28	1.28	1.28	1.25
10	1.24	1.22	1.18	1.20	1.22	1.18	1.20	1.20	1.20	1.18	1.17	1.16	1.20
11	1.10	1.06	1.03	1.00	.96	.90	.88	.80	.76	.74	.70	.68	0.88
12	.64	.60	.56	.57	.52	.48	.48	.48	.49	.48	.46	.45	0.52
13	.45	.46	.48	.48	.49	.53	.52	.54	.56	.58	.60	.60	0.52
14	.60	.60	.62	.68	.70	.72	.76	.80	.82	.84	.86	.86	0.74
15	.90	.90	.90	.96	.98	1.00	1.04	1.04	1.00	1.02	1.10	1.05	0.99
16	1.04	1.02	1.02	1.10	1.13	1.12	1.14	1.16	1.18	1.18	1.18	1.19	1.12
17	1.19	1.19	1.21	1.25	1.26	1.26	1.29	1.30	1.31	1.32	1.34	1.35	1.27
18	1.32	1.32	1.38	1.38	1.40	1.46	1.47	1.51	1.51	1.52	1.53	1.54	1.45
19	1.52	1.48	1.46	1.52	1.51	1.50	1.52	1.50	1.50	1.47	1.48	1.44	1.49
20	1.40	1.30	1.25	1.30	1.27	1.26	1.26	1.26	1.26	1.28	1.28	1.28	1.28
21	1.25	1.25	1.25	1.26	1.38	1.38	1.39	1.40	1.43	1.44	1.45	1.44	1.36
22	1.40	1.38	1.38	1.46	1.46	1.48	1.44	1.44	1.44	1.46	1.45	1.45	1.44
23	1.44	1.44	1.44	1.53	1.54	1.55	1.58	1.58	1.60	1.59	1.58	1.57	1.54
24	1.56	1.56	1.55	1.49	1.50	1.48	1.45	1.44	1.44	1.40	1.36	1.32	1.46
25	1.27	1.24	1.20	1.22	1.23	1.24	1.23	1.23	1.24	1.26	1.26	1.25	1.24
26	1.24	1.23	1.21	1.30	1.28	1.28	1.30	1.30	1.31	1.31	1.30	1.26	1.28
27	1.23	1.18	1.16	1.13	1.10	1.06	1.04	.98	.97	.95	.92	.94	1.05
28	.82	.79	.75	.82	.83	.82	.81	.82	.84	.88	.88	.90	0.83
Mean	1.135	1.120	1.110	1.146	1.149	1.146	1.155	1.151	1.154	1.152	1.150	1.140	30.142

Readings of Aneroid Barometer 17701 on board the Yacht Fox.

March, 1859. 29 Inches +. Mean Lat. 72°.0 N., Long. 94°.2 W.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
1	.90	.92	.98	1.10	1.14	1.14	1.15	1.17	1.17	1.18	1.20	1.19	1.10
2	1.20	1.19	1.18	1.22	1.25	1.28	1.27	1.25	1.24	1.22	1.22	1.20	1.23
3	1.18	1.15	1.12	1.18	1.17	1.17	1.15	1.14	1.14	1.14	1.12	1.12	1.15
4	1.12	1.10	1.10	1.16	1.18	1.19	1.22	1.26	1.28	1.29	1.30	1.32	1.21
5	1.32	1.31	1.30	1.37	1.40	1.40	1.45	1.46	1.47	1.46	1.46	1.49	1.41
6	1.47	1.46	1.44	1.50	1.53	1.52	1.53	1.53	1.54	1.53	1.53	1.54	1.51
7	1.50	1.47	1.46	1.48	1.46	1.47	1.46	1.44	1.42	1.39	1.36	1.31	1.44
8	1.26	1.22	1.16	1.18	1.17	1.16	1.16	1.17	1.16	1.16	1.16	1.14	1.18
9	1.10	1.06	1.06	1.10	1.10	1.10	1.09	1.10	1.11	1.14	1.15	1.13	1.10
10	1.11	1.08	1.06	1.08	1.06	1.04	1.04	1.00	.96	.93	.90	.86	1.01
11	.82	.76	.94	.82	.80	.80	.79	.79	.79	.81	.82	.80	0.81
12	.80	.78	.80	.92	.92	.94	1.02	1.05	1.10	1.13	1.17	1.21	0.99
13	1.22	1.20	1.22	1.22	1.32	1.35	1.32	1.38	1.42	1.43	1.40	1.41	1.32
14	1.43	1.44	1.39	1.40	1.45	1.42	1.42	1.44	1.44	1.44	1.44	1.40	1.43
15	1.38	1.34	1.31	1.36	1.32	1.34	1.29	1.30	1.24	1.24	1.23	1.19	1.30
16	1.14	1.10	1.10	1.14	1.12	1.10	1.09	1.09	1.10	1.09	1.08	1.06	1.10
17	1.06	1.04	1.08	1.14	1.14	1.15	1.16	1.22	1.26	1.30	1.32	1.32	1.18
18	1.30	1.31	1.37	1.36	1.38	1.42	1.40	1.44	1.44	1.46	1.48	1.44	1.40
19	1.44	1.44	1.46	1.48	1.48	1.48	1.50	1.52	1.54	1.56	1.58	1.56	1.50
20	1.56	1.59	1.58	1.68	1.68	1.68	1.69	1.72	1.70	1.70	1.72	1.72	1.67
21	1.70	1.70	1.78	1.76	1.76	1.76	1.75	1.78	1.80	1.82	1.81	1.80	1.77
22	1.78	1.78	1.78	1.80	1.82	1.82	1.82	1.79	1.78	1.78	1.78	1.74	1.79
23	1.70	1.66	1.64	1.68	1.64	1.61	1.58	1.56	1.54	1.54	1.54	1.52	1.60
24	1.48	1.42	1.42	1.46	1.46	1.44	1.40	1.40	1.39	1.38	1.38	1.38	1.42
25	1.32	1.30	1.30	1.38	1.40	1.40	1.44	1.46	1.48	1.50	1.54	1.54	1.42
26	1.54	1.53	1.54	1.58	1.58	1.58	1.56	1.58	1.58	1.56	1.58	1.58	1.57
27	1.54	1.50	1.50	1.54	1.58	1.59	1.59	1.62	1.64	1.68	1.68	1.68	1.60
28	(1.69)	(1.70)	(1.71)	1.72	(1.70)	1.68	(1.67)	1.66	(1.68)	1.70	(1.67)	1.64	1.68
29	(1.59)	1.54	(1.56)	1.58	(1.56)	1.54	(1.56)	1.58	(1.59)	1.60	(1.60)	1.61	1.58
30	(1.60)	1.59	(1.62)	1.66	(1.66)	1.66	(1.68)	1.70	(1.70)	1.72	(1.72)	1.74	1.67
31	(1.73)	1.72	(1.73)	1.74	(1.74)	1.75	(1.73)	1.72	(1.71)	1.70	(1.67)	1.64	1.71
Mean	1.354	1.335	1.345	1.380	1.386	1.386	1.386	1.397	1.400	1.406	1.407	1.396	30.382

April, 1859. 29 Inches +. Mean Lat. 72°.0 N., Long. 94°.2 W.

DAY.	5h.	8h.	Noon.	4h.	8h.	11h.	Mean.
1	1.56	1.59	1.52	1.52	1.44	1.40	1.50
2	1.27	1.28	1.22	1.19	1.19	1.16	1.22
3	1.17	1.14	1.08	1.06	.99	.94	1.06
4	.87	.92	.94	1.00	1.03	1.04	0.97
5	1.07	1.09	1.07	1.07	1.09	1.06	1.07
6	1.07	1.09	1.02	1.07	1.06	1.03	1.06
7	.96	1.02	.98	1.00	1.06	1.07	1.01
8	1.07	1.13	1.14	1.19	1.25	1.27	1.17
9	1.37	1.44	1.48	1.52	1.61	1.63	1.51
10	1.67	1.69	1.76	1.80	1.88	1.91	1.78
11	1.96	2.00	2.02	2.07	2.11	2.11	2.05
12	2.16	2.19	2.27	2.24	2.27	2.24	2.23
13	2.17	2.17	2.16	2.14	2.15	2.11	2.15
14	2.04	2.07	2.04	2.01	1.99	1.95	2.02
15	1.87	1.76	1.66	1.59	1.52	1.48	1.65
16	1.37	1.37	1.37	1.30	1.29	1.27	1.33
17	1.26	1.26	1.27	1.37	1.34	1.31	1.30
18	1.17	1.17	1.10	1.11	1.10	1.12	1.13
19	1.27	1.36	1.42	1.46	1.54	1.53	1.43
20	1.57	1.57	1.60	1.62	1.66	1.61	1.60
21	1.57	1.57	1.48	1.40	1.29	1.15	1.41
22	.97	1.07	.99	.97	.93	.98	0.99
23	1.06	1.17	1.16	1.14	1.10	1.03	1.11
24	1.07	1.09	1.16	1.17	1.22	1.22	1.15
25	1.17	1.17	1.16	1.12	1.10	1.04	1.13
26	.97	1.07	1.10	1.17	1.25	1.25	1.14
27	1.27	1.27	1.24	1.23	1.28	1.26	1.26
28	1.37	1.38	1.40	1.47	1.48	1.45	1.43
29	1.47	1.47	1.46	1.46	1.44	1.42	1.45
30	1.37	1.47	1.41	1.43	1.43	1.40	1.42
Mean	1.374 (1.363) At 4h.	1.401	1.389	1.396	1.403	1.381 (1.374) At 12h.	30.391 30.388

READINGS OF ANEROID BAROMETER 17701 ON BOARD THE YACHT FOX.

May, 1859. 29 Inches +. Mean Lat. 72°.0 N., Long. 94°.2 W.

DAY.	5h.	8h.	Noon.	4h.	8h.	11h.	Mean.
1	1.37	1.39	1.40	1.40	1.39	1.37	1.39
2	1.27	1.29	1.37	1.30	1.36	1.31	1.32
3	1.35	1.37	1.39	1.35	1.38	1.33	1.36
4	1.28	1.30	1.28	1.26	1.26	1.24	1.27
5	1.18	1.22	1.25	1.22	1.26	1.22	1.22
6	1.20	1.24	1.26	1.26	1.27	1.26	1.25
7	1.25	1.28	1.30	1.29	1.37	1.32	1.30
8	1.30	1.33	1.30	1.26	1.22	1.18	1.27
9	1.16	1.17	1.26	1.36	1.31	1.29	1.26
10	1.19	1.22	1.22	1.22	1.22	1.18	1.21
11	1.08	1.12	1.09	1.09	1.07	1.05	1.08
12	.96	.97	1.00	1.06	1.07	1.07	1.02
13	1.00	1.02	1.00	.98	1.00	.98	1.00
14	.90	.92	.95	.98	.97	.98	0.95
15	.94	.97	.93	.90	.88	.87	0.92
16	.81	.82	.84	.83	.83	.81	0.82
17	.76	.78	.82	.82	.87	.85	0.82
18	.80	.85	.90	.97	1.02	1.06	0.93
19	1.07	1.09	1.16	1.19	1.24	1.27	1.17
20	1.25	1.29	1.32	1.32	1.34	1.35	1.31
21	1.28	1.28	1.26	1.22	1.22	1.22	1.25
22	1.13	1.15	1.17	1.20	1.23	1.23	1.19
23	1.20	1.23	1.26	1.29	1.31	1.32	1.27
24	1.25	1.28	1.32	1.36	1.38	1.35	1.32
25	1.28	1.29	1.30	1.30	1.28	1.28	1.29
26	1.28	1.28	1.29	1.29	1.30	1.28	1.29
27	1.19	1.19	1.26	1.25	1.25	1.27	1.24
28	1.29	1.29	1.38	1.41	1.42	1.43	1.37
29	1.40	1.42	1.47	1.49	1.54	1.56	1.48
30	1.58	1.58	1.63	1.64	1.65	1.66	1.62
31	1.65	1.65	1.72	1.70	1.70	1.70	1.69
Mean	1.182 (1.175) At 4h.	1.203	1.229	1.233	1.245	1.235 (1.231) At 12h.	30.222 30.219

June, 1859. 29 Inches +. Mean Lat. 72°.0 N., Long. 94°.2 W.

DAY.	5h.	8h.	Noon.	4h.	8h.	11h.	Mean.
1	1.68	1.69	1.70	1.68	1.67	1.55	1.66
2	1.52	1.50	1.44	1.36	1.29	1.21	1.39
3	1.15	1.15	1.23	1.27	1.32	1.33	1.24
4	1.32	1.34	1.38	1.39	1.39	1.40	1.37
5	1.44	1.46	1.51	1.55	1.56	1.58	1.52
6	1.54	1.58	1.60	1.62	1.64	1.62	1.60
7	1.58	1.56	1.56	1.52	1.52	1.45	1.53
8	1.36	1.31	1.29	1.24	1.18	1.16	1.26
9	1.09	1.11	1.13	1.18	1.22	1.22	1.16
10	1.19	1.21	1.24	1.26	1.26	1.22	1.23
11	1.19	1.19	1.20	1.26	1.22	1.22	1.21
12	1.11	1.10	1.09	1.08	1.08	1.06	1.09
13	1.01	1.00	1.02	1.01	1.01	1.02	1.01
14	.98	1.01	1.00	1.00	1.00	.94	0.99
15	.85	.84	.86	.85	.86	.85	0.85
16	.85	.82	.89	.90	.92	.91	0.88
17	.92	.96	.96	.96	.96	.91	0.95
18	.75	.72	.65	.73	.85	.92	0.77
19	1.04	1.06	1.06	1.09	1.14	1.16	1.09
20	1.19	1.21	1.18	1.14	1.07	1.08	1.15
21	1.15	1.16	1.10	1.02	.99	.96	1.06
22	.98	1.02	1.03	1.06	1.06	1.06	1.03
23	1.05	1.02	1.03	1.01	.99	.99	1.01
24	1.00	1.04	1 02	1.06	.98	.92	1.00
25	.86	.88	.86	.88	.84	.84	0.86
26	.78	.78	.81	.79	.77	.77	0.78
27	.74	.78	.80	.85	.83	.84	0.81
28	.88	.91	.98	1.04	1.11	1.10	1.00
29	1.08	1.11	1.04	1.00	1.08	1.08	1.07
30	1.14	1.15	1.15	1.12	1.09	1.06	1.12
Mean	1.114 (1.111) At 4h.	1.122	1.127	1.131	1.130	1.114 (1.109) At 12h.	30.123 30.122

READINGS OF ANEROID BAROMETER 17701 ON BOARD THE YACHT FOX.

July, 1859. 29 Inches +. Mean Lat. 72°.0 N., Long. 94°.2 W.

DAY.	2h.	4h.	5h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	11h.	Midnt.	Mean.
1	(1.00)	(0.96)	.95	(.93)	.90	(.90)	.91	(.93)	.96	(.98)	1.00	(.98)	.97	(.97)	0.95
2	(.96)	(.95)	.95	(.95)	.95	(.95)	.94	(.97)	1.01	(1.03)	1.04	(1.04)	1.05	(1.06)	0.99
3	(1.07)	(1.09)	1.10	(1.11)	1.12	(1.10)	1.07	(1.05)	1.04	(1.02)	1.00	(1.00)	.99	(.99)	1.05
4	(.98)	(.98)	.98	(.98)	.99	(.97)	.95	(.94)	.93	(.92)	.90	(.88)	.86	(.85)	0.94
5	(.83)	(.80)	.79	(.79)	.78	(.77)	.76	.74	.74	.74	.74	.74	(.73)	.72	0.76
6	.70	.70	- - -	.70	.74	.80	.80	.82	.84	.88	.92	.98	- - -	1.00	0.82
7	.98	.99	- - -	1.01	1.02	1.04	1.04	1.04	1.02	.99	.99	.98	- - -	.97	1.00
8	.70	.66	- - -	.67	.76	.76	.76	.74	.72	.68	.67	.62	- - -	.56	0.69
9	.52	.47	- - -	.43	.42	.39	.38	.34	.32	.29	.23	.21	- - -	.20	0.35
10	.20	.20	- - -	.07	.04	.00	.00	*.98	*.98	*.97	*.98	.00	- - -	.02	0.04
11	.04	.09	- - -	.14	.24	.30	.36	.43	.48	.58	.62	.64	- - -	.66	0.38
12	.68	.70	- - -	.72	.79	.82	.83	.85	.88	.88	.89	.84	- - -	.78	0.81
13	.74	.74	- - -	.72	.70	.70	.68	.64	.60	.56	.54	.48	- - -	.48	0.63
14	.50	.53	- - -	.60	.65	.68	.74	.77	.77	.77	.76	.73	- - -	.72	0.68
15	.72	.71	- - -	.70	.70	.70	.70	.78	.78	.74	.72	.72	- - -	.72	0.72
16	.74	.76	- - -	.80	.82	.84	.82	.82	.80	.78	.78	.76	- - -	.76	0.79
17	.76	.79	- - -	.80	.82	.80	.80	.82	.79	.79	.74	.71	- - -	.69	0.78
18	.69	.67	- - -	.68	.66	.67	.66	.68	.70	.76	.74	.75	- - -	.74	0.70
19	.76	.76	- - -	.78	.80	.88	.94	1.02	1.06	1.04	1.03	1.02	- - -	1.02	0.93
20	1.02	1.04	- - -	1.06	1.12	1.14	1.16	1.22	1.17	1.16	1.14	1.12	- - -	1.11	1.12
21	1.10	1.13	- - -	1.14	1.22	1.19	1.26	1.34	1.36	1.34	1.34	1.34	- - -	1.34	1.26
22	1.36	1.36	- - -	1.39	1.46	1.50	1.52	1.58	1.50	1.46	1.53	1.44	- - -	1.43	1.46
23	1.42	1.44	- - -	1.43	1.48	1.48	1.46	1.49	1.40	1.44	1.40	1.39	- - -	1.36	1.43
24	1.36	1.36	- - -	1.36	1.42	1.45	1.44	1.44	1.42	1.36	1.34	1.31	- - -	1.30	1.38
25	1.26	1.28	- - -	1.25	1.26	1.26	1.25	1.26	1.26	1.20	1.18	1.14	- - -	1.14	1.23
26	1.12	1.11	- - -	1.12	1.10	1.12	1.12	1.18	1.14	1.06	1.06	.98	- - -	.94	1.09
27	.92	.98	- - -	.90	.90	.89	.94	.95	.91	.94	.94	.91	- - -	.91	0.92
28	.91	.94	- - -	.95	1.04	1.08	1.12	1.14	1.12	1.08	1.05	1.00	- - -	1.00	1.04
29	1.00	1.01	- - -	1.03	1.06	1.10	1.15	1.13	1.13	1.12	1.12	1.11	- - -	1.08	1.09
30	1.08	1.10	- - -	1.14	1.16	1.20	1.20	1.18	1.20	1.18	1.18	1.17	- - -	1.13	1.16
31	1.12	1.12	- - -	1.14	1.16	1.17	1.15	1.12	1.12	1.10	1.08	1.01	- - -	1.00	1.11
Mean	0.879	0.885	...	0.887	0.912	0.924	0.933	0.948	0.940	0.930	0.924	0.903	...	0.892	29.913

August, 1859. 29 Inches +. Mean Lat. 71.°9 N., Long. 79°.8 W.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Mean.
1	.99	1.08	1.08	1.08	1.10	1.02	1.06
2	1.02	1.02	1.00	.95	.94	.80	0.95
3	.84	.61	.62	.66	.69	.70	0.69
4	.72	.78	.88	.92	.90	.89	0.85
5	.89	.96	.96	.92	.91	.94	0.93
6	.94	.99	.94	.90	.84	.78	0.90
7	.74	.74	.72	.79	.80	.81	0.77
8	.82	.86	.88	.86	.81	.76	0.83
9	.74	.79	.88	.94	.95	.94	0.87
10	.97	1.00	1.06	1.12	1.06	1.06	1.05
11	1.08	1.12	1.11	1.10	1.06	.98	1.08
12	.96	.94	.93	.93	.94	.90	0.93
13	.92	.93	.94	.94	.93	.87	0.92
14	.80	.74	.69	.68	.68	.68	0.71
15	.69	.76	.87	1.02	1.10	1.12	0.93
16	1.16	1.13	1.12	1.12	1.07	1.02	1.10
17	.96	.92	.86	.84	.79	.64	0.84
18	.70	.66	.64	.64	.64	.62	0.65
19	.58	.58	.61	.62	.66	.61	0.61
20	.55	.49	.48	.52	.60	.61	0.54
21	.61	.64	.66	.70	.67	.64	0.65
22	.61	.58	.54	.55	.60	.70	0.60
23	.82	.99	1.12	1.21	1.28	1.30	1.12
24	1.26	1.22	1.20	1.16	1.10	1.04	1.16
25	1.05	1.07	1.10	1.13	1.15	1.13	1.11
26	1.12	1.14	1.15	1.16	1.12	1.10	1.13
27	1.10	1.10	1.12	1.12	1.18	1.20	1.14
28	1.23	1.30	1.36	1.35	1.40	1.49	1.36
29	1.48	1.47	1.46	1.45	1.40	1.46	1.45
30	1.46	1.32	1.27	1.22	1.22	1.22	1.28
31	1.22	1.22	1.23	1.24	1.23	1.24	1.23
Mean	0.936	0.940	0.951	0.963	0.962	0.944	29.950

* Refers to 28 inches.

Readings of Aneroid Barometer 17701 on board the Yacht Fox.
September, 1859. 29 Inches +. Mean Lat. 58°.9 N., Long. 40°.9 W.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midnight.
1	1.24	1.26	1.27	1.26	1.23	1.20
2	1.18	1.18	1.20	1.20	1.20	1.16
3	1.14	1.11	1.08	1.04	.98	.90
4	.80	.78	.77	.80	.81	.80
5	.78	.74	.66	- - - -	- - - -	- - - -
6	.70	.68	.68	.68	.70	.73
7	.78	.82	.85	.87	.88	.90
8	.89	.88	.88	.86	.85	.80
9	.75	.80	.82	.89	.94	.94
10	.81	.82	.90	.86	.88	.82
11	.80	.81	.80	.81	.84	.89
12	.88	.83	.78	.84	.94	.96
13	.93	.92	.91	.98	.96	.94
14	.92	.90	.92	.93	.92	.90
15	.89	.92	.98	1.00	1.01	1.03
16	1.05	1.15	1.19	1.24	1.30	1.30
17	1.30	1.32	1.32	1.30	1.30	1.30
18	1.25	1.26	1.22	1.20	1.18	1.18

Additional Readings of the Marine Mercurial Barometer, between September, 1857, *and April,* 1858.

A description of the Marine Barometer adopted by Her Majesty's government, on the recommendation of the Kew Observatory Committee of the British Association for the Advancement of Science, will be found in the appendix to the fourth number of meteorological papers, published by authority of the Board of Trade. London, 1860.

Readings of the Marine Mercurial Barometer, Adie No. 208, on board the Yacht Fox.
Height of cistern above the level of the sea, 4 feet.
September, 1857. 29 Inches +. Mean Lat. 75°.2 N., Long. 65°.3 W.

DAY.	4h.		8h.		Noon.		4h.		8h.		Midnight.		Mean.		Mean.
	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	At 32°.
	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.
20	(1.033)	(55)	1.093	55	1.106	58	1.048	59	.931	60	.787	62	1.000	58.2	.920
21	(.640)	(62)	.500	62	.453	61	.476	59	.542	62	.549	66	.527	62.0	.439
22	(.421)	(45)	.441	45	.556	52	.673	54	.664	57	.731	63	.581	52.7	.516
23	(.732)	(45)	.772	45	.854	53	.901	55	.967	58	1.049	68	.879	54.0	.812
24	(1.042)	(60)	1.032	60	1.006	56	.927	54	.839	55	.740	59	.931	57.3	.854
25	(.581)	(38)	.531	38	.531	47	.661	49	.702	62	.749	59	.626	48.8	.573
26	(.720)	(48)	.740	48	.728	52	.710	50	.690	51	.680	57	.711	51.0	.651
27	(.640)	(57)	.620	57	.676	51	.698	53	.696	55	.696	59	.671	55.3	.601
28	(.628)	(52)	.628	52	.651	52	.728	56	.702	59	.781	61	.696	55.3	.626
29	(.740)	(46)	.710	46	.789	54	.790	53	.790	56	.769	56	.765	51.8	.703
30	(.666)	(49)	.636	49	.588	47	.513	50	.475	52	.435	51	.552	49.7	.495
Mean	.713	50.6	.700	50.6	.723	53.0	.739	53.8	.733	57.0	.724	60.1	.722	54.2	
At 32	29.656		29.643		29.657		29.672		29.658		29.640		29.654		29.654

The column for $4^{h.}$ A. M. was obtained by interpolation, the difference in the aneroid readings of $4^{h.}$ and $8^{h.}$ was applied to the reading of the marine barometer at $8^{h.}$ to get the value for $4^{h.}$.

The reduction to 32° was effected by means of Table XVII., C., of Guyot's Meteorological Tables (Edition of 1858).

The reading for 4 A. M., between October 1 and 20, being wanting, they were supplied by means of differences of the aneroid readings, as stated above.

Readings of the Marine Mercurial Barometer, Adie No. 208, on board the Yacht Fox.

October, 1857. 29 Inches +. Mean Lat. 75°.2 N., Long. 67°.9 W.

DAY.	4h.		8h.		Noon.		4h.		8h.		Midnight.		Mean.		Mean.
	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	At 32°.
	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.
1	(.422)	(45)	.472	45	.605	50	.663	49	.676	54	.740	58	.596	50	.539
2	(.768)	(46)	.798	46	.860	50	.920	49	.947	53	.980	54	.879	49	.825
3	(1.010)	(51)	.980	51	1.002	47	1.028	52	1.033	58	1.013	56	1.011	52	.948
4	(.954)	(44)	.914	44	.906	49	.909	49	.899	52	.821	52	.900	48	.848
5	(.760)	(45)	.720	45	.716	50	.621	48	.573	52	.556	52	.657	48	.605
6	(.514)	(47)	.594	47	.650	49	.703	49	.739	54	.727	51	.654	50	.597
7	(.700)	(47)	.700	47	.754	45	.788	44	.813	49	.819	54	.762	47	.713
8	(.762)	(49)	.822	49	.850	50	.901	49	.937	51	.950	49	.870	49	.816
9	(.948)	(45)	.948	45	1.079	50	1.138	50	1.161	53	1.181	50	1.075	48	1.023
10	(1.108)	(47)	1.038	47	.980	45	.969	42	.967	49	.930	48	.981	46	.934
11	(.892)	(40)	.872	40	.932	44	.880	44	.866	49	.808	51	.875	44	.834
12	(.716)	(39)	.666	39	.670	44	.680	45	.684	50	.687	50	.684	44	.643
13	(.660)	(47)	.650	47	.618	50	.544	48	.460	56	.400	57	.555	50	.498
14	(.322)	(53)	.212	53	.270	52	.344	51	.440	58	.482	57	.344	54	.277
15	(.452)	(51)	.452	51	.470	53	.539	56	.615	60	.591	59	.520	54	.453
16	(.552)	(51)	.552	51	.602	53	.680	50	.756	58	.787	59	.655	54	.598
17	(.882)	(57)	.922	57	.898	52	.884	51	.900	59	.896	60	.897	55	.827
18	(.858)	(52)	.858	52	.876	58	.846	59	.777	59	.690	59	.818	56	.745
19	(.562)	(53)	.512	53	.536	50	.549	53	.597	57	.604	58	.559	54	.492
20	(.606)	(50)	.676	50	.700	56	.722	54	.761	59	.786	59	.709	54	.642
21	.782	50	.752	52	.750	54	.752	56	.522	58	.350	60	.651	55	.581
22	.178	59	.058	50	.116	55	.278	54	.416	58	.530	56	.264	55	.194
23	.580	50	.598	50	.656	54	.652	58	.620	58	.592	56	.616	54	.549
24	.600	44	.752	45	.906	46	1.030	47	1.136	49	1.201	53	.937	47	.888
25	1.218	40	1.258	42	1.302	44	1.396	50	1.424	50	1.471	53	1.344	46	1.297
26	1.480	42	1.492	42	1.550	43	1.536	47	1.564	51	1.530	55	1.525	46	1.477
27	1.410	43	1.272	44	1.220	44	1.176	52	1.068	55	1.020	50	1.194	48	1.142
28	.966	42	.932	45	.966	48	1.048	54	1.086	59	1.046	51	1.008	49	.953
29	1.010	40	1.042	45	1.060	49	.973	53	.878	55	.770	55	.955	49	.900
30	.670	44	.595	48	.640	51	.650	54	.650	53	.700	56	.650	51	.591
31	.656	43	.652	49	.724	53	.684	56	.726	58	.728	50	.695	51	.636
Mean	.774	47	.766	47	.802	49	.822	50	.828	54	.818	54	.802	50.2	
At 32°	29.724		29.716		29.748		29.764		29.760		29.750		29.744		29.744

November, 1857. 29 Inches +. Mean Lat. 74°.8 N., Long. 69°.1 W.

DAY.	4h.		8h.		Noon.		4h.		8h.		Midnight.		Mean.	
	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.
	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°
1	.702	42	.738	47	.782	49	.778	56	.806	54	.744	50	0.758	49.7
2	.664	48	.654	43	.708	50	.742	58	.696	59	.671	58	0.689	52.7
3	.650	44	.620	46	.680	50	.794	52	.836	57	.912	58	0.749	51.2
4	.920	45	.922	(54)	1.027	62	1.060	57	1.100	61	1.098	58	1.021	56.2
5	1.096	49	1.102	49	1.148	52	1.160	59	1.175	59	1.166	57	1.141	54.2
6	1.096	44	1.070	46	1.138	52	1.065	52	.970	58	.882	58	1.037	51.7
7	.784	45	.732	45	.820	54	.794	53	.848	57	.828	58	0.801	52.0
8	.814	45	.832	49	.866	49	.940	54	1.050	57	1.111	58	0.935	52.0
9	1.110	48	1.128	48	1.020	50	.916	51	.872	55	.882	52	0.988	50.7
10	.932	44	1.012	47	1.044	51	1.038	53	1.038	58	1.002	58	1.011	51.8
11	.880	48	.840	50	.782	55	.658	59	.518	59	.550	55	0.705	54.3
12	.551	45	.600	47	.700	50	.750	58	.760	57	.744	58	0.684	52.5
13	.650	45	.592	48	.552	52	.475	55	.500	55	.528	57	0.550	52.0
14	.526	48	.554	54	.580	54	.600	58	.650	50	.650	58	0.593	53.3
15	.650	47	.614	50	.532	55	.554	55	.274	58	.199	58	0.470	53.8
16	.152	48	.134	48	.074	57	.968	56	.872	59	.012	62	0.369	55.0
17	.162	49	.298	48	.330	56	.448	57	.478	55	.557	55	0.379	53.3
18	.656	47	.762	49	.870	52	.946	56	1.050	57	1.070	61	0.892	53.7
19	1.044	52	1.022	56	1.012	56	1.000	57	1.028	59	1.026	59	1.022	56.5
20	.956	49	.970	51	.996	52	.970	55	.950	56	.880	52	0.954	52.5
21	.848	45	.776	50	.840	56	.836	59	.668	60	.484	57	0.742	54.5
22	.346	46	.270	48	.230	52	.268	57	.294	55	.368	57	0.296	52.5
23	.418	45	.610	50	.700	53	.756	58	.819	55	.816	53	0.687	52.3
24	.734	45	.754	50	.780	55	.824	58	.933	61	.880	54	0.817	53.8
25	.652	48	.442	50	.220	56	.011	56	*.986	57	.004	60	0.219	54.5
26	*.998	49	*.998	51	*.958	52	*.976	54	.028	59	.156	60	0.019	54.2
27	.150	48	.184	54	.220	55	.304	57	.381	59	.444	58	0.281	55.2
28	.450	48	.530	51	.568	56	.580	57	.638	60	.670	59	0.573	55.2
29	.716	49	.811	50	.887	52	.970	57	1.039	59	1.091	59	0.919	54.3
30	1.080	48	1.130	50	1.150	52	1.208	55	1.230	56	1.232	58	1.172	53.2
Mean	0.679	46.8	0.690	49.3	0.707	53.2	0.747	56.0	0.749	57.4	0.722	57.2	0.715	53.3
At 32°	29.631		29.636		29.642		29.674		29.674		29.647		29.650	

* Refers to 28 inches.

READINGS OF THE MARINE MERCURIAL BAROMETER, ADIE No. 208, ON BOARD THE YACHT FOX.

December, 1857. 29 Inches +. Mean Lat. 74°.3 N., Long. 67°.4 W.

DAY.	4h.		8h.		Noon.		4h.		8h.		Midnight.		Mean.	
	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.
	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°
1	1.228	57	1.252	49	1.236	51	1.231	47	1.181	49	1.150	58	1.213	50.2
2	1.094	44	1.008	45	.970	52	.925	51	.902	53	.853	57	0.959	50.3
3	.768	46	.762	49	.766	51	.666	52	.632	52	.598	50	0.699	50.0
4	.570	43	.528	42	.494	47	.526	51	.528	52	.478	47	0.521	47.0
5	.450	37	.410	48	.328	47	.282	53	.182	55	.147	54	0.300	49.0
6	.110	43	.082	41	.140	52	.194	55	.278	51	.374	52	0.196	49.0
7	.459	43	.582	41	.712	48	.775	50	.847	51	.865	51	0.707	47.3
8	.880	45	.868	44	.958	51	.964	54	1.023	56	1.055	59	0.958	51.5
9	1.081	45	1.112	50	1.134	52	1.126	58	1.128	55	1.120	58	1.117	53.0
10	1.050	46	1.022	45	1.096	53	1.128	57	1.128	58	1.150	59	1.096	53.0
11	1.162	45	1.160	48	1.185	50	1.201	56	1.143	55	.999	56	1.142	51.7
12	.760	48	.512	39	.433	50	.398	58	.359	59	.281	59	0.457	52.2
13	.160	48	.090	46	.109	49	.153	55	.199	57	.268	58	0.163	51.7
14	.286	50	.315	48	.421	57	.449	56	.482	56	.508	56	0.410	53.8
15	.519	48	.510	46	.570	54	.597	54	.611	58	.605	60	0.569	53.3
16	.583	49	.582	47	.584	54	.618	58	.636	58	.618	59	0.604	54.2
17	.599	49	.560	46	.628	54	.632	57	.654	59	.652	56	0.621	53.3
18	.631	47	.636	46	.689	58	.682	61	.664	60	.650	61	0.659	55.5
19	.630	51	.642	52	.776	59	.872	60	.878	56	.820	59	0.770	56.2
20	.669	48	.592	50	.565	58	.596	60	.630	61	.590	62	0.607	56.5
21	.521	50	.550	50	.660	56	.703	56	.759	59	.830	59	0.670	55.0
22	.830	48	.838	47	.841	55	.855	60	.822	60	.815	60	0.833	55.0
23	.736	48	.715	52	.732	54	.740	59	.824	59	.868	58	0.769	55.0
24	.869	48	.888	49	.938	57	.940	59	.948	62	.881	63	0.911	56.3
25	.733	51	.616	52	.590	53	.588	60	.554	55	.541	56	0.604	54.5
26	.488	47	.488	49	.388	51	.400	56	.365	56	.282	52	0.402	51.8
27	.156	44	.062	46	.000	54	*.990	59	*.940	59	*.948	61	0.016	53.8
28	*.946	50	*.922	46	*.896	54	*.854	58	*.838	61	*.830	59	*0.881	54.7
29	*.808	48	*.812	45	*.954	56	.098	59	.223	59	.354	64	0.041	55.2
30	.390	50	.472	47	.564	58	.600	60	.644	62	.708	61	0.563	56.3
31	.702	49	.752	46	.774	58	.800	64	.826	61	.774	60	0.771	56.3
Mean	0.609	46.9	0.592	46.8	0.617	53.3	0.632	56.5	0.640	56.8	0.633	57.5	0.620	53.0
At 23°	29.560		29.544		29.552		29.558		29.566		29.556		29.555	

January, 1858. 29 Inches +. Mean Lat. 73°.2 N., Long. 63°.7 W.

DAY.	4h.		8h.		Noon.		4h.		8h.		Midnight.		Mean.	
	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.
	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	In h.	°
1	.746	42	.712	45	.680	59	.638	58	.565	63	.469	62	0.635	54.8
2	.381	48	.380	46	.418	60	.416	60	.376	60	.291	62	0.377	56.0
3	.151	48	*.984	48	*.836	59	*.788	63	*.754	63	*.771	64	*0.881	57.5
4	*.778	51	*.792	45	*.848	60	*.856	58	*.946	59	.030	60	*0.875	55.5
5	.100	49	.142	47	.172	58	.127	60	.080	60	.076	64	0.116	56.3
6	.012	55	*.966	51	*.982	56	*.986	60	*.974	59	*.950	58	*0.978	56.5
7	*.925	47	*.942	44	.020	52	.078	57	.120	60	.160	61	0.041	53.5
8	.140	48	.142	47	.144	52	.127	55	.141	57	.110	58	0.134	52.8
9	.060	48	.098	46	.137	58	.159	61	.191	61	.202	62	0.141	56.0
10	.245	52	.250	50	.331	55	.377	55	.451	56	.495	56	0.358	54.0
11	.513	48	.542	44	.612	52	.631	59	.687	59	.696	60	0.614	53.7
12	.662	48	.674	49	.702	56	.712	58	.704	58	.630	56	0.681	54.2
13	.545	48	.516	48	.626	62	.791	61	1.001	60	1.228	63	0.785	57.0
14	1.360	52	1.432	48	1.510	59	1.420	55	1.254	58	1.098	59	1.346	56.2
15	1.000	48	.896	49	.844	59	.835	58	.818	59	.800	64	0.866	57.4
16	.760	50	.690	48	.654	60	.622	59	.647	62	.691	61	0.677	58.0
17	.706	49	.738	48	.750	59	.762	58	.868	60	1.015	62	0.806	56.0
18	1.037	49	1.062	46	1.093	55	1.098	59	1.081	62	1.038	58	1.068	54.8
19	1.038	47	1.002	45	1.080	58	1.100	59	1.108	59	1.055	61	1.064	54.8
20	.924	48	.798	45	.715	54	.610	58	.449	58	.263	58	0.627	53.5
21	.050	46	.010	44	.151	56	.348	58	.580	58	.727	61	0.311	53.8
22	.770	49	.792	45	.852	54	.765	55	.661	54	.421	53	0.710	51.7
23	.266	43	.406	40	.549	53	.710	55	.790	57	.748	56	0.578	50.7
24	.645	45	.532	43	.448	51	.313	53	.134	50	.095	53	0.361	49.2
25	.098	43	.062	48	.070	50	.008	54	*.947	53	*.912	53	0.016	50.2
26	*.926	44	.032	42	.125	52	.189	52	.186	56	.123	54	0.097	50.0
27	.085	44	.136	42	.300	53	.450	54	.605	55	.720	60	0.383	51.3
28	.792	46	.846	43	.908	52	.957	53	1.015	53	1.048	55	0.928	50.3
29	1.120	44	1.176	42	1.325	51	1.449	57	1.550	54	1.624	58	1.374	51.0
30	1.666	44	1.758	44	1.880	53	1.973	57	1.942	58	1.967	61	1.864	52.8
31	1.896	50	1.722	48	1.620	57	1.422	61	1.238	58	1.130	56	1.505	55.0
Mean	0.561	47.5	0.556	45.8	0.593	55.6	0.604	57.4	0.608	58.0	0.599	59.0	0.587	54.0
At 32°	29.511		29.510		29.521		29.527		29.530		29.519		29.520	

* Refers to 28 inches.

READINGS OF THE MARINE MERCURIAL BAROMETER, ADIE NO. 208, ON BOARD THE YACHT FOX.

February, 1858. 29 Inches +. Mean Lat. 71°.5 N., Long. 60°.9 W.

DAY.	4h.		8h.		Noon.		4h.		8h.		Midnight.		Mean.	
	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.
	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°
1	1.049	45	.980	45	1.042	58	1.010	58	.926	54	.850	52	0.976	52.0
2	.750	44	.698	45	.687	54	.642	58	.674	56	.660	58	0.685	52.5
3	.616	47	.560	49	.617	54	.573	58	.586	59	.548	59	0.573	54.3
4	.507	49	.493	49	.542	55	.576	58	.629	59	.648	62	0.566	55.3
5	.630	52	.608	48	.600	53	.572	59	.502	59	.480	61	0.565	55.3
6	.367	50	.322	50	.333	59	.323	60	.330	61	.348	63	0.337	57.2
7	.370	53	.434	51	.534	56	.639	62	.692	58	.714	61	0.564	56.8
8	.752	49	.772	56	.872	59	.886	61	.962	62	.956	50	0.867	56.2
9	.898	49	.868	62	.884	62	.764	60	.606	61	.523	57	0.757	58.5
10														
11														
12														
13														
14														
15														
16														
17	.642	53	.688	55	.704	56	.734	59	.730	59	.752	63	0.708	57.5
18	.693	52	.652	52	.558	58	.475	59	.370	58	.238	76	0.498	59.2
19	.162	50	.058	52	.140	55	.282	59	.482	58	.566	60	0.282	55.7
20	.530	55	.412	53	.374	58	.311	58	.340	60	.377	58	0.391	57.0
21	.430	55	.492	56	.652	58	.702	66	.801	64	.848	62	0.654	60.2
22	.874	58	.906	59	.924	62	.918	63	.820	62	.732	61	0.862	60.8
23	.606	53	.586	56	.603	61	.629	62	.658	59	.662	60	0.624	58.5
24	.627	54	.514	51	.500	62	.481	61	.438	64	.338	57	0.483	58.2
25	.262	53	.278	51	.448	59	.546	65	.554	61	.513	62	0.434	58.5
26	.530	57	.570	56	.684	58	.773	62	.816	59	.852	63	0.704	59.2
27	.852	51	.864	52	.934	56	.952	61	.974	60	1.027	59	0.934	56.5
28	.930	49	.972	51	1.033	59	1.004	60	.981	55	.923	60	0.974	55.7
Mean	0.623	51.3	0.603	52.3	0.651	57.7	0.657	60.4	0.661	59.4	0.645	60.2	0.640	56.9
At 32°	29.563		29.540		29.574		29.573		29.580		29.562		29.565	

March, 1858. 29 Inches +. Mean Lat. 69.°4 N., Long. 59°.1 W.

DAY.	4h.		8h.		Noon.		4h.		8h.		Midnight.		Mean.	
	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.
	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°
1	.850	48	.764	50	.795	58	.726	59	.770	61	.849	55	0.792	55.2
2	.868	48	.898	58	.874	61	.814	62	.814	63	.962	58	0.872	58.3
3	1.154	48	1.252	53	1.310	59	1.058	58	.690	61	.216	57	0.947	56.0
4	.330	48	.482	52	.846	62	1.146	64	1.380	60	1.380	60	0.927	57.7
5	1.438	53	1.488	54	1.574	58	1.542	58	1.484	59	1.494	63	1.503	57.5
6	1.496	50	1.500	55	.624	60	1.718	59	1.780	62	1.833	63	1.492	58.2
7	1.820	52	1.764	55	1.728	58	1.680	60	1.596	60	1.510	58	1.683	57.2
8	1.412	48	1.374	51	1.418	55	1.426	57	1.412	59	1.430	62	1.412	55.3
9	1.350	50	1.290	51	1.226	53	1.130	59	1.010	57	.904	55	1.152	54.2
10	.786	47	.650	56	.580	52	.346	58	.058	61	*.850	61	0.378	55.8
11	*.762	52	*.718	57	*.752	54	*.800	60	*.836	60	*.898	61	*0.794	57.3
12	*.907	52	*.950	52	.006	62	.148	60	.297	60	.350	60	0.110	57.7
13	.350	50	.352	56	.394	64	.388	60	.399	61	.424	67	0.385	59.7
14	.430	56	.476	53	.526	56	.630	63	.668	60	.686	58	0.569	57.7
15	.642	47	.670	48	.739	54	.829	58	.875	61	.950	64	0.785	55.3
16	.952	50	1.004	57	1.019	58	1.062	58	1.110	58	1.120	61	1.044	57.0
17	1.090	48	1.096	54	1.120	52	1.108	57	1.103	58	1.042	58	1.093	54.5
18	.966	50	.896	54	.808	55	.770	53	.748	56	.674	55	0.810	53.8
19	.628	46	.618	50	.651	53	.668	56	.726	55	.762	59	0.676	53.2
20	.748	47	.718	51	.715	54	.664	59	.619	56	.572	58	0.673	54.2
21	.531	54	.542	54	.552	54	.540	56	.510	56	.462	56	0.523	55.0
22	.436	45	.418	53	.434	57	.440	57	.404	59	.342	58	0.412	54.8
23	.384	50	.554	48	.725	58	.897	60	1.078	63	1.232	62	0.812	56.8
24	1.252	50	1.276	52	1.322	60	1.326	60	1.386	65	1.483	58	1.341	57.5
25	1.282	48	1.242	50	1.280	58	1.271	57	1.322	55	1.358	58	1.292	54.3
26	1.377	47	1.436	55	1.509	52	1.518	53	1.500	53	1.533	52	1.479	52.0
27	1.480	41	1.514	50	1.535	53	1.519	51	1.525	53	1.504	56	1.513	50.7
28	1.422	46	1.342	48	1.376	49	1.320	51	1.328	51	1.316	42	1.351	47.8
29	1.362	52	1.415	52	1.449	51	1.448	55	1.449	53	1.410	55	1.422	53.0
30	1.352	42	1.208	50	1.163	52	1.114	53	1.111	59	1.124	57	1.179	52.2
31	1.102	49	1.099	51	1.120	49	1.062	47	1.064	52	1.075	53	1.087	50.2
Mean	0.934	48.8	0.936	52.3	0.941	55.5	0.971	57.4	0.970	58.3	0.960	58.1	0.952	55.1
At 32°	29.880		29.872		29.869		29.894		29.890		29.881		29.881	

* Refers to 28 inches.

Readings of the Marine Mercurial Barometer, Adie No. 208, on board the Yacht Fox.
April, 1858. 29 Inches +. Mean Lat. 74°.9 N., Long. 68°.8 W.

Day.	4h.		8h.		Noon.		4h.		8h.		Midnight.		Mean.	
	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.
	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°	Inch.	°
1	1.058	47	1.070	53	1.083	54	1.102	55	1.060	54	1.063	58	1.073	53.5
2	.941	48	.974	55	.938	56	.930	56	.934	50	.868	51	0.931	52.7
3	.826	45	.802	52	.790	48	.777	50	.770	53	.764	48	0.788	49.3
4	.730	44	.760	53	.764	53	.758	50	.738	52	.710	52	0.743	50.7
5	.674	48	.594	58	.604	48	.618	48	.658	54	.690	56	0.640	52.0
6	.744	51	.892	50	1.060	51	1.136	49	1.163	52	1.171	56	1.028	51.6
7	1.142	48	1.136	52	1.136	51	1.110	53	1.080	53	1.040	59	1.107	52.7
8	.980	48	.952	53	1.074	58	1.264	53	1.482	59	1.576	58	1.221	54.8
9	1.751	47	1.562	48	1.500	49	1.500	54	1.462	56	1.454	61	1.538	52.5
10	1.370	48	1.394	53	1.386	55	1.386	56	1.388	58	1.390	61	1.386	56.2
11	1.368	50	1.352	56	1.390	56	1.384	58	1.362	58	1.422	62	1.380	56.7
12	1.518	62	1.647	54	1.711	56	1.724	58	1.723	59	1.673	58	1.666	57.8
13	1.568	48	1.486	57	1.435	54	1.325	55	1.258	59	1.202	59	1.379	55.3
14	1.100	48	.980	48	.966	53	.944	59	.932	57	.926	58	0.975	53.8
15	.832	50	.782	56	.786	55	.790	57	.804	62	.817	58	0.802	56.3
16	.742	48	.748	55	.748	55	.738	59	.766	61	.718	61	0.743	56.5
Mean	1.084	48.8	1.071	53.3	1.086	53.3	1.093	54.4	1.099	56.1	1.093	57.3	1.088	53.9
At 32°	30.030		30.004		30.019		30.023		30.025		30.016		30.020	

First Year.—Recapitulation of Mean Readings from the preceding record of the Aneroid Barometer, No. 17701, from September, 1857, to September, 1858.

Average. N. Lat.	Average. W. Long.	1857.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.	Mean.
75.3	65.0	Sept.	29.936	29.925	29.928	29.933	29.946	29.949	29.950	29.951	29.952	29.953	29.954	29.956	29.943
75.2	67.9	Oct.	29.944	29.930	29.916	29.924	29.956	29.958	29.961	29.976	29.985	29.993	29.985	29.977	29.959
74.8	69.1	Nov.	29.857	29.842	29.840	29.833	29.869	29.861	29.864	29.875	29.888	29.890	29.895	29.887	29.866
74.3	67.4	Dec.	29.786	29.765	29.748	29.742	29.769	29.775	29.779	29.791	29.798	29.796	29.794	29.786	29.777
73.2	63.7	'58, Jan.	29.725	29.712	29.702	29.704	29.739	29.745	29.747	29.756	29.764	29.765	29.758	29.753	29.739
71.5	60.9	Feb.	29.843	29.829	29.830	29.833	29.868	29.871	29.874	29.886	29.889	29.886	29.877	29.861	29.862
69.4	59.1	March	30.085	30.077	30.073	30.089	30.120	30.118	30.119	30.124	30.119	30.118	30.114	30.101	30.105
66.0	57.7	April	30.149	30.138	30.137	30.148	30.153	30.146	30.142	30.144	30.154	30.166	30.168	30.164	30.151
68.7	53.7	May		30.204		30.223		30.229		30.225		30.230		30.222	30.222
74.6	60.1	June		30.005		30.015		30.035		30.032		30.039		30.025	30.025
74.4	76.4	July		29.945		29.961		29.965		29.971		29.974		29.949	29.961
73.1	88.5	Aug.		29.917		29.931		29.941		29.963		29.966		29.947	29.944
72.5	65.8		...	...	...	...	...	...	...	...	...	...	...	...	...

Second Year.—Recapitulation of Mean Readings from the preceding record of the Aneroid Barometer, No. 17701, from September, 1858, to September, 1859.
At Port Kennedy: Lat. 72°.0 N., Long. 94°.2 W.

1858.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.	Mean.
Sept.		30.084		30.105		30.110		30.118		30.127		30.107	30.108
Oct.		29.967		30.007		30.026		29.998		30.031		30.016	30.007
Nov.	30.243	30.231	30.224	30.263	30.273	30.270	30.263	30.280	30.278	30.283	30.270	30.264	30.261
Dec.	30.064	30.049	30.053	30.070	30.094	30.085	30.092	30.105	30.095	30.094	30.090	30.081	30.081
1859, Jan.	30.172	30.158	30.148	30.180	30.197	30.190	30.192	30.203	30.207	30.209	30.201	30.200	30.188
Feb.	30.135	30.120	30.110	30.146	30.149	30.146	30.155	30.151	30.154	30.152	30.150	30.140	30.142
March	30.354	30.335	30.345	30.380	30.386	30.386	30.386	30.397	30.400	30.406	30.407	30.396	30.382
April		30.363		30.401		30.389		30.396		30.403		30.374	30.388
May		30.175		30.203		30.229		30.233		30.245		30.231	30.219
June		30.111		30.122		30.127		30.131		30.130		30.109	30.122
July	29.879	29.885	29.887	29.912	29.924	29.933	29.948	29.940	29.930	29.924	29.903	29.892	29.913
Aug.		29.936		29.940		29.951		29.963		29.962		29.944	29.950
	...	...	...	...	...	...	...	...	...	...	...	...	...

RECAPITULATION OF MEAN READINGS FROM THE PRECEDING RECORD OF THE MARINE MERCURIAL BAROMETER, ADIE NO. 208, ON BOARD THE YACHT FOX.

The readings are reduced to the temperature 32°. The cistern is 4 feet above the level of the sea.

Average.		1857.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Mean.
N. Lat.	W. Long.								
			Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
[1]75°.2	65°.3	September	29.656	29.643	29.657	29.672	29.658	29.640	29.654
75.2	67.9	October	29.724	29.716	29.748	29.764	29.760	29.750	29.744
74.8	69.1	November	29.631	29.636	29.642	29.674	29.674	29.647	29.650
74.3	67.4	December	29.560	29.544	29.552	29.558	29.566	29.556	29.555
73.2	63.7	1858, January	29.511	29.510	29.521	29.527	29.530	29.519	29.520
[2]71.5	60.9	February	29.563	29.540	29.574	29.573	29.580	29.562	29.565
69.4	59.1	March	29.880	29.872	29.869	29.894	29.890	29.881	29.881
[3]74.9	68.8	April	30.030	30.004	30.019	30.023	30.025	30.016	30.020

Comparison of the Readings of the Aneroid and Mercurial Barometers.

The preceding tabular results furnish the means of comparing the two barometers, and of deducing a correction to the indications of the aneroid barometer, in order to give the readings obtained from the mercurial barometer, referred to 32° of temperature. This correction is necessarily independent of the temperature, there being no thermometric readings in connection with the aneroid: any constant correction for difference of level between the two instruments is included. The following table contains the corresponding readings at the *same* days and hours, each being the mean of six observations a day.

Table of comparison of corresponding mean readings of the mercurial and the aneroid barometer, and resulting correction to the latter.

Date.	Mercurial.	Aneroid.	$M-A$ Δ
	Inches.	Inches.	Inch.
1857, September	29.654	29.878	—0.224
October	29.744	29.959	—0.215
November	29.650	29.865	—0.215
December	29.555	29.776	—0.221
1858, January	29.520	29.739	—0.219
February	29.565	29.792	—0.227
March	29.881	30.105	—0.224
April	30.020	30.245	—0.225
Mean	...	$\Delta =$	—0.221

These differences appear remarkably regular, and show that the mean monthly readings of the aneroid may be relied on to one-hundredth of an inch. There appears to be no tendency of a change of Δ depending on the higher or lower reading of the barometer, nor is there any variation due to changes in temperature. The correction to the aneroid readings to refer them to the corresponding readings

[1] The mean of 11 days, from Sept. 20th to 30th.

[2] The mean of 21 days, from Feb. 1st to 9th, and from Feb. 17th to 28th.

[3] The mean of 16 days, from April 1st to 16th.

of the mercurial barometer is, therefore, — 0.22 inches. This quantity, strictly speaking, is composed of two parts; the first, the true index error of the aneroid, and the second, the specific difference of the two instruments in different latitudes, the mercurial barometer (weighing a mass of mercury against a mass of air) being independent of a change of gravity, whereas the aneroid barometer is sensible to any increase of gravity as we proceed to the northern high latitudes. Within the limits of latitudes 66°.0 N. and 75°.3 N. this variation amounts to 0.014 inches; and its greatest difference from the mean, say in latitude 72°.0 N., is, therefore, $\pm$ 0.008 inches. This quantity being smaller than the uncertainty of the results by the aneroid, I have considered it as a correction that can safely be neglected. The formula $b = b_{45}\ (1 - 0.0026 \cos 2\ \phi)$ shows the variation for any latitude ϕ.

North of latitude 45° the aneroid gives the higher readings.

Resulting mean 4-hourly and mean monthly readings of the mercurial barometer in the months of September, 1857, *and February and April*, 1858.—The results for these months, given above, require a small correction to refer them from part of the month to the whole month; this was obtained by means of the known aneroid readings for the interval when the mercurial barometer was not read, the index correction — $0^{in.}.22$ having first been applied. We find—

Referred mean readings of the mercurial barometer for the full months of September, February, and April, of the first year:—

Average.		Month.	4h.	8h.	Noon.	4h.	8h.	Midn't.	Mean.
N. Lat.	W. Long.								
75°.3	65°.0	1857, September	29.707	29.715	29.727	29.732	29.728	29.728	29.723
71.5	60.9	1858, February	29.621	29.609	29.648	29.653	29.658	29.632	29.637
66.0	57.7	1858, April	29.930	29.922	29.923	29.922	29.939	29.936	29.929

The following comparisons were made for the purpose of ascertaining how near the mean of 6 and 12 observations a day approximate to the true daily mean as derived from hourly observations. The following mean hourly readings, taken for 15 days between January 6 and January 22, 1858, are taken from the record; also the means for 7 days in January, 1859, and for 15 days in July, 1859. (Of these observations I find only the results recorded.)

JANUARY, 1858. FOR 15 DAYS.

Hour A. M.	Bar.	Hour A. M.	Bar.	Hour P. M.	Bar.	Hour P. M.	Bar.
1	29.746	7	29.697	1	29.738	7	29.782
2	.733	8	.695	2	.742	8	.787
3	.724	9	.705	3	.748	9	.790
4	.718	10	.722	4	.758	10	.792
5	.710	11	.731	5	.774	11	.796
6	.700	Noon	.737	6	.778	Midn't	.795

Mean of 24 observations a day . . . . 29in..746
" " 12 " " . . . . .746 From the even hours,
" " 6 " " . . . . .748 " " " " including noon and midnight, and at equal intervals.

JANUARY, 1859. FOR 7 DAYS.

Hour A. M.	Bar.	Hour A. M.	Bar.	Hour P. M.	Bar.	Hour P. M.	Bar.
1	30.037	7	30.020	1	30.040	7	30.051
2	.029	8	.047	2	.036	8	.050
3	.020	9	.059	3	.043	9	.049
4	.013	10	.053	4	.051	10	.039
5	.006	11	.050	5	.053	11	.040
6	.003	Noon	.040	6	.051	Midn't	.043

Mean of 24 observations a day . . . . 30in..038
" " 12 " " . . . . .038 From the even hours,
" " 6 " " . . . . .041 " " " " and at equal intervals.

JULY, 1859. FOR 15 DAYS.

Hour A. M.	Bar.	Hour A. M.	Bar.	Hour P. M.	Bar.	Hour P. M.	Bar.
1	30.012	7	30.040	1	30.087	7	30.056
2	.012	8	.061	2	.098	8	.046
3	.011	9	.071	3	.094	9	.035
4	.018	10	.072	4	.080	10	.026
5	.021	11	.073	5	.071	11	.022
6	.026	Noon	.066	6	.065	Midn't	.013

Mean of 24 observations a day . . . . 30in..049
" " 12 " " . . . . .049 From the even hours,
" " 6 " " . . . . .047 " " " " and at equal intervals.

The results show conclusively that the hourly and bi-hourly series give the same mean, and that the mean, deduced from six observations a day, does not materially differ from either; no correction need therefore be applied to daily means derived from readings at intervals of two and four hours.

Diurnal Variation of the Atmospheric Pressure.

The diurnal variation, which is almost vanishing in the higher latitudes of the Arctic regions, can only be satisfactorily traced by means of a combination of a great number of observations; it is also frequently masked by the great irregular fluctuations in the atmospheric pressure. The observations were, therefore, grouped, the first part comprising the results in Baffin Bay, from September, 1857, to August, 1858, inclusive, and the second part, the results at Port Kennedy, from September, 1858, to August, 1859, inclusive.

For greater convenience the results by the aneroid have been reduced to the results by the mercurial barometer, by the application of the correction — $0^{in.}.221$.

The readings for the hours 4, 8, 12, A. M. and P. M., for the first eight months between Sept. and April, were taken from the preceding abstract of the mercurial barometer (the readings in Sept. February, and April from the table containing the referred means). All tabular numbers for the same eight months, at the hours 2, 6, 10, A. M. and P. M., are derived from the readings of the aneroid barometer by interpolation by means of differences; thus to obtain the reading at 10 A. M., in September, we have—

Aneroid reading at 10 A. M. 0.013 greater than at 8 A. M. Mercurial barometer reading at 8 A. M. = 29.715, hence at 10 A. M. = 29.728; again, aneroid at 10 A. M. 0.003 smaller than at noon. Mercurial barometer at noon 29.727, hence at 10 A. M. = 29.724, and the resulting mean from the comparison of the preceding and following hour becomes 29.726 as given in the table.

The annual mean for the hours 2, 6, 10, A. M. and P. M. is obtained in a similar manner; thus, for 10 A. M. we have: From 8 months, Sept. to April, mean at 10 A. M., the reading 0.020 greater than at 8 A. M. or = 29.731 + 0.020; it is also 0.006 greater than at noon or = 29.743 + 0.006; the mean of the two values is 29.750 as given in the table.

Diurnal variation of the atmospheric pressure during the year from September, 1857, to August, 1858, in mean latitude 72°.5 N., and mean longitude 65°.8 W.; nearly in the centre of Baffin Bay. 29 inches is to be added to the tabular numbers.

Month.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.
1857, Sept.	.713	.707	.710	.715	.726	.727	.730	.732	.730	.728	.727	.728
Oct.	.727	.724	.709	.716	.747	.748	.750	.764	.762	.760	.755	.750
Nov.	.632	.631	.636	.636	.661	.642	.654	.674	.680	.674	.667	.647
Dec.	.568	.560	.547	.544	.558	.552	.551	.558	.566	.566	.566	.556
1858, Jan.	.507	.511	.504	.510	.530	.521	.520	.527	.532	.530	.524	.519
Feb.	.625	.621	.614	.609	.644	.648	.646	.653	.658	.658	.648	.632
Mar.	.876	.880	.866	.872	.887	.869	.880	.894	.890	.890	.890	.881
April	.931	.930	.920	.922	.928	.923	.920	.922	.925	.939	.940	.936
May		.984		1.003		1.009		1.005		1.010		1.002
June		.785		.795		.815		.812		.819		.805
July		.725		.741		.745		.751		.754		.729
Aug.		.697		.711		.721		.743		.746		.727
Mean		.730		.731		.743		.753		.756		.743
Completed mean	.733		.726		.750		.745		.756		.753	

The table of bi-hourly means for the second group was obtained from the general recapitulation of result, by subtracting 0.221 from each mean to reduce it to the reading of the standard marine barometer, and by referring the incomplete means at the hours 2, 6, 8, A. M. and P. M., to their corresponding value for a complete series of 12 values by a process similar to that explained in case of the preceding table.

Diurnal variation of the atmospheric pressure during the year from September, 1858, to August, 1859, at Port Kennedy, in latitude 72°.0 N., and longitude 94°.2 W. 29 inches is to be added to the tabular numbers, which, as well as the preceding tabular numbers for 1857–8, should be considered as reduced to the temperature 32° (Fahr.).

Month.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Midn't.
1858, Sept.		.863		.884		.889		.897		.906		.886
Oct.		.746		.786		.805		.777		.810		.795
Nov.	1.022	1.010	1.003	1.042	1.052	1.049	1.042	1.059	1.057	1.062	1.049	1.043
Dec.	.843	.828	.832	.849	.873	.864	.871	.884	.874	.873	.869	.860
1859, Jan.	.951	.937	.927	.959	.976	.969	.971	.982	.986	.988	.980	.979
Feb.	.914	.899	.889	.925	.928	.925	.934	.930	.933	.931	.929	.919
Mar.	1.133	1.114	1.124	1.159	1.165	1.165	1.165	1.176	1.179	1.185	1.186	1.175
April		1.142		1.180		1.168		1.175		1.182		1.153
May		.954		.982		1.008		1.012		1.024		1.010
June		.890		.901		.906		.910		.909		.888
July	.658	.664	.666	.691	.703	.712	.727	.719	.709	.703	.682	.671
Aug.		.715		.719		.730		.742		.741		.723
Mean		.897		.923		.933		.939		.943		.925
Completed Mean	.906		.894		.935		.936		.940		.934	

These results, when expressed analytically by means of Bessel's form of periodic functions with application of the method of least squares, become—

1. For Baffin Bay, 1857–1858—

Inches.

$$b = 29.743 + 0.013 \sin (\theta + 5°) + 0.004 \sin (2\theta + 159°)$$

2. For Port Kennedy, 1858–1859—

Inches.

$$b = 29.925 + 0.021 \sin (\theta + 22°) + 0.009 \sin (2\theta + 150°)$$

3. For Van Rensselaer Harbor, 1853–54–55, for comparison—

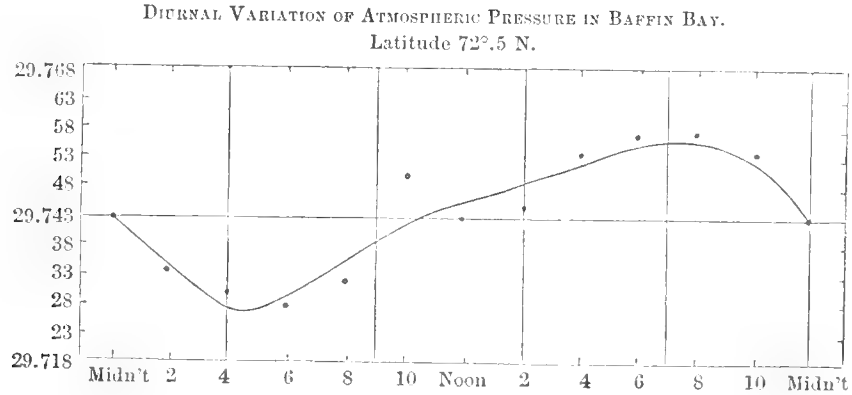
Inches.

$$b = 29.765 + 0.003 \sin (\theta + 290°) + 0.002 \sin (2\theta + 204°)$$

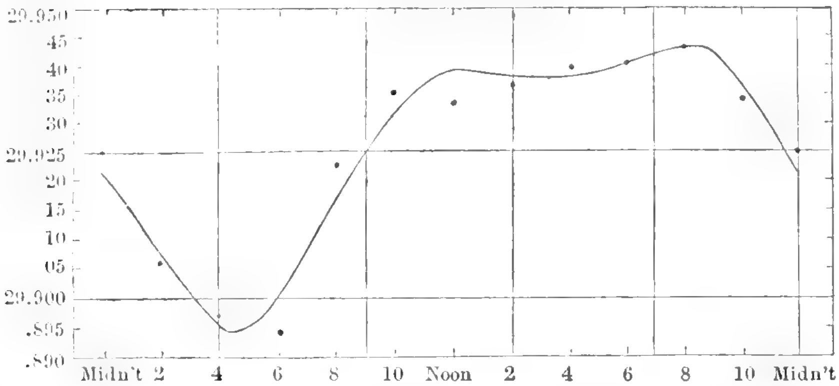
In which expressions the angle θ counts from noon at the rate of 15° an hour.

The comparison of the observations with the values deduced by the formulæ is shown in the following two diagrams, in which the observed values are indicated by dots.

Diurnal Variation of Atmospheric Pressure in Baffin Bay.
Latitude 72°.5 N.



Diurnal Variation of Atmospheric Pressure at Port Kennedy.
Latitude 72°.0 N.



These curves have in common a maximum at about 7½ P. M., and a minimum at about 4½ A. M.; the hour of maximum at Van Rensselaer Harbor was 10 P. M., whereas a minimum at 4 A. M. is hardly perceptible at this place. A secondary maximum is plainly indicated at Port Kennedy about noon, and a secondary minimum about 2½ P. M., which secondary minimum seems to correspond with the principal minimum at Van Rensselaer Harbor at 1½ P. M.

The range of the diurnal fluctuation of the barometer is as follows:—

1. In Baffin Bay	0.028 inches.
2. At Port Kennedy	0.048 "
3. At Van Rensselaer Harbor . . .	0.010 "

Hence, between latitudes 72°.2 and 78°.6, there is a diminution in range of 0.028 inches; at this rate, the diurnal fluctuation would become insensible (be less than 0.001) in about 81° north latitude.

The following table of observed bi-hourly means is added for convenience of reference and for comparison:—

Hour.	Baffin Bay. Lat. 72°.5.	Port Kennedy. Lat. 72°.0.	Van Rensselaer. Lat. 78°.6.
2	29.733	29.906	29.765
4	.730	.897	.766
6	.726	.894	.766
8	.731	.923	.762
10	.750	.935	.764
Noon	.743	.933	.763
2	.745	.936	.759
4	.753	.939	.763
6	.756	.940	.767
8	.756	.943	.769
10	.753	.934	.771
Midn't	.743	.925	.768
Mean	29.743	29.925	29.765

Annual Variation of the Atmospheric Pressure.

The mean monthly height of the barometer is obtained directly from the preceding tables, showing the diurnal fluctuation, by applying to the monthly mean the correction for index, +0.007, and the reduction to the level of the sea, +0.005. To the table I have added for comparison the values for Van Rensselaer Harbor (also referred to the level of the sea by applying +0.005).

MONTHLY MEAN READINGS OF THE BAROMETER AT THE LEVEL OF THE SEA, AND AT 32° FAHR.

Month.	1857–8. Baffin Bay. Lat. 72°.5.	1858–9. Port Kennedy. Lat. 72°.0.	1853, '54, '55. Van Rensselaer. Lat. 78°.6.
January	29.532	29.979	29.778
February	29.649	29.933	.848
March	29.893	30.173	.750
April	29.940	*30.179	.903
May	*30.014	30.010	*.942
June	29.817	29.913	.719
July	29.753	29.704	.741
August	29.736	29.741	.694
September	29.735	29.899	.658
October	29.756	29.798	.755
November	29.665	30.052	.758
December	29.570	29.872	29.753
Mean	29.755	29.938	29.775

It should be remembered that the monthly means in the first column were obtained while the ship was drifting and sailing in Baffin Bay, on which account the annual fluctuation may not appear as plainly as if the ship had been stationary in the middle latitude 72°.5 N.

The maximum in each series has been marked with an asterisk (*); it occurs either in April or May. The occurrence of the minimum does not agree at these stations; in Baffin Bay it occurred in January, at Port Kennedy in July, and at Van Rensselaer Harbor in September—showing plainly that more observations are required to fix the season or month in which it takes place on the average.

The preceding monthly values are represented by the formulæ:—

1. For Baffin Bay, 1857–8—

$$B = 29.755 + 0.155 \sin(\theta + 304°) + 0.113 \sin(2\theta + 236°)$$

(Greatest difference between an observed and computed value = 0.04 inches).

2. For Port Kennedy, 1858–59—

$$B = 29.938 + 0.137 \sin(\theta + 17°) + 0.106 \sin(2\theta + 232°)$$

(Greatest difference between observed and computed values; in October, —0.13, in November, +0.11).

3. For Van Rensselaer, 1853, '54, '55—

$$B = 29.775 + 0.079 \sin(\theta + 4°) + 0.044 \sin(2\theta + 194°)$$

Expressed in inches, and θ counting from January 1st, and at a rate of 30° a month.

The computed annual range, or the difference between the highest and lowest monthly mean, is as follows:—

Baffin Bay	0.44 inches.
Port Kennedy	0.41 "
Van Rensselaer	0.21 "

Taking the mean of the expressions for the three stations, the following formulæ furnish the type-curve for lat. 74°.4 N., and long. 77°.0 W., for the *diurnal* and *annual* variation of the atmospheric pressure:—

Inches.

$$b = 29.823 + 0.012\ sin\ (\theta + 346°) + 0.005\ sin\ (2\theta + 171°)$$
$$B = 29.823 + 0.124\ sin\ (\theta + 348°) + 0.088\ sin\ (2\theta + 221°)$$

Diurnal Extremes.

The irregular oscillations from day to day are subject to an annual variation, as exhibited in the following table of average differences in the atmospheric pressure on consecutive days. The daily changes were made out, irrespective of sign, and were obtained from the comparison of the daily means of the aneroid readings.

To the two localities—Baffin Bay and Port Kennedy, I have added, for comparison, Van Rensselaer Harbor, and also a column for a mean of the three localities.

	1857–8. Baffin Bay. 72°.5 N. Lat.	1858–9. Port Kennedy. 72°.0 N. Lat.	1853, '54, '55. Van Rensselaer. 78°.6 N. Lat.	Mean.
September	0.17 inches.	0.12 inches.	0.11 inches.	0.13 inches.
October	0.19	0.21	0.15	0.18
November	0.22	0.14	0.17	0.18
December	0.21	0.12	0.26	0.20
January	0.26	0.11	0.17	0.18
February	0.20	0.16	0.26	0.21
March	0.22	0.12	0.17	0.17
April	0.19	0.16	0.12	0.16
May	0.10	0.07	0.14	0.10
June	0.12	0.10	0.10	0.10
July	0.08	0.14	0.09	0.10
August	0.11	0.12	0.10	0.10
Mean	0.17	0.13	0.15	0.15

In Baffin Bay the progression is more regular than at Port Kennedy; the mean from the two stations compares very favorably with the result deduced from Dr. Kane's observations. The oscillations in the winter months are twice as great as those in the summer months.

The larger variations in the atmospheric pressure have already been noticed in the discussion of particular storms in the preceding part of the paper.

Monthly and Annual Extremes.

The following table contains the observed maxima and minima of the atmospheric pressure in each month, as observed by or referred to the mercurial marine barometer. (At 32° Fahr.)

Month.	Baffin Bay, 1857–58.			Port Kennedy, 1858–59.			For comparison: Van Rensselaer Harbor, 1853, '54, '55.		
	Max.	Min.	Range.	Max.	Min.	Range.	Max.	Min.	Range.
September	30.34	29.12	1.22	30.12	29.06	1.06	30.15	29.04	1.11
October	30.50	28.98	1.52	30.48	29.16	1.32	30.33	29.05	1.28
November	30.19	28.81	1.38	30.46	29.42	1.04	30.33	29.03	1.30
December	30.19	28.72	1.47	30.55	29.23	1.32	30.43	28.95	1.48
January	30.92	28.67	2.25	30.34	29.51	0.83	30.44	29.08	1.36
February	30.30	29.00	1.30	30.38	29.23	1.15	30.45	28.84	1.61
March	30.78	28.63	2.15	30.60	29.57	1.03	30.49	29.18	1.31
April	30.66	29.18	1.48	31.05	29.65	1.40	30.37	29.28	1.09
May	30.54	29.51	1.03	30.50	29.54	0.96	30.49	29.19	1.30
June	30.12	29.20	0.92	30.48	29.43	1.05	30.19	29.41	0.78
July	30.26	29.34	0.92	30.36	28.75	1.61	29.97	29.40	0.57
August	30.06	29.32	0.74	30.27	29.26	1.01	30.05	29.22	0.83
Mean	30.40	29.04	1.36	30.47	29.32	1.15	30.31	29.14	1.17

The monthly range is greatest in winter and least in summer in Baffin Bay and at Van Rensselaer Harbor; at Port Kennedy the amount of range is rather irregularly distributed over the year.

Absolute observed maxima and minima and extreme range (corrected for index error and referred to the level of the sea by the addition of 0.01).

Locality.	Max.	Date.	Min.	Date.	Range.
Baffin Bay	30.93	Jan. 30, '58.	28.64	Mar. 11, '58	2.29
Port Kennedy	31.06	April 12, '59.	28.76	July 10, '59.	2.30
Van Rensselaer Harbor.	30.97	Jan. 22, '55.	28.84	Feb. 19, '54.	2.13

Relation of the Atmospheric Pressure to the Direction of the Wind.

In this investigation the aneroid readings alone have been employed. For this purpose the daily readings at the hours 6 A. M. and 6 P. M., and at noon and midnight, were compared with the corresponding mean of five days (two days before and two days after the day in question). This substitution of the penthemers for the monthly means, as normals, was considered a desirable improvement. Each difference was inserted in the column for the respective wind (eight in all with a column for calms). In the exceptional case, where no observation was made at one or the other of the above hours, the observation at the nearest hour adjacent was substituted. A + sign indicates a pressure higher than the mean, a — sign a pressure lower than the mean. The following table contains the results arranged for two localities of one years' observations for each (commencing with September); the results at Port Kennedy for the S. E., S., and S. W. winds, are contracted in one mean on account of the scarcity of wind from these directions. The results for Van Rensselaer[1] have been added for comparison.

[1] Exchanging the magnetic for the true direction, on page 111 of Dr. Kane's meteorological record and discussion; a correction already referred to before.

Direction (true) of the wind.	1857–58. Baffin Bay. Lat. 72°.5.	1858–59. Port Kennedy. Lat. 72°.0.	1853–4–5. Van Rensselaer. Lat. 78°.6.
N.	+ 0.031 inches.	+ 0.004 inches.	— 0.022 inches.
N. E.	+ 0.009	— 0.024	— 0.014 (N. E. and E.)
E.	+ 0.007	— 0.016	
S. E.	— 0.036		0.000
S.	— 0.005	+ 0.015 (S. E., S. and S. W.)	+ 0.038
S. W.	— 0.007		+ 0.045
W.	— 0.010	+ 0.005	— 0.031
N. W.	— 0.022	+ 0.003	— 0.031
Calm	+ 0.035	+ 0.012	+ 0.005

The maximum effect of any one wind (or calm) does not exceed 0.04 of an inch, and, considering the short period of observation, and the probable irregularity in the phenomenon itself, the above figures for any one locality show a tolerable degree of progression. During calms the barometer is higher on the average 0.017 inch.

The above tabular quantities (after omitting the calms and making the algebraic sum of the results for each place equal zero) are contained in the expressions—

Inches.

For Baffin Bay $\beta = + 0.015 \, sin \, (\theta + 27°)$

For Fort Kennedy $\beta = + 0.015 \, sin \, (\theta + 181)$

For Van Rensselaer $\beta = + 0.018 \, sin \, (\theta + 246)$,

The angle θ counting from the north. These expressions give nearly the same amount (0.016 inches) of elevating and depressing effect of the winds on the average, but do not correspond in the direction; thus, in Baffin Bay, according to the above, the barometer is higher with the wind from the N., N. E., and E., and lower with the wind from the S. W., W., and N. W.; whereas, at Port Kennedy, where the wind is much subject to local influences, nearly the opposite law would hold good.

The changes in the atmospheric pressure during the more violent storms have already been noticed, and were illustrated with diagrams.

APPENDIX.

APPENDIX.

RECORD OF THE WEATHER KEPT ON BOARD THE YACHT "FOX," FROM JULY 2, 1857, TO SEPTEMBER 18, 1859; WITH NOTES ON THE SPECIFIC GRAVITY OF SEA WATER, ON THE STATE OF THE ICE, APPEARANCE OF ANIMALS, ETC. ETC.; ON THE AURORA BOREALIS AND ATMOSPHERIC PHENOMENA.

THE state of the weather is indicated by the following letters (Beaufort's notation):—

b Blue sky.
c Clouds (detached).
d Drizzling rain.
f Foggy.
g Gloomy.
h Hail.
l Lightning.
m Misty (hazy).
o Overcast.
p Passing showers.
q Squally.
r Rain.
s Snow.
t Thunder.
u Ugly (threatening) appearance.
v Visibility, objects at a distance unusually visible.
w Wet (dew).
z Snow drift.

A bar (—) or a dot (.) under any letter augments its signification.

The sign ("), in the record of the state of the weather, indicates the same entry as that of the hour immediately preceding.

The position of the vessel is given in the preceding record. The specific gravity of sea water was determined by Twaddel's hydrometer, that of distilled water being 1.000. The temperature of sea water and atmospheric pressure have already been stated.

The specific gravity of sea water, in the last column, is given in units of the fourth place of decimals, as indicated by the heading of the table.

For reasons stated by A. Mitchell, A. M., M. D., in the July number, 1860, of the Edinburgh New Philosophical Journal, it has not been deemed advisable to publish the observations for amount of ozone in the atmosphere. It is evident that the amount of discoloration of the papers exposed depends, in a great measure, on the air passed over, and, therefore, presents the combined effect of the quantity of ozone and the strength of the wind.

July, 1857. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midnight.	Specific Grav. of Sea Water, 1.0.
1	b	"	"	"	c	"	...
2	c	"	"	"	"	"	285
3	c	"	"	"	"	"	295
4	c	"	"	"	"	"	297
5	c	"	b c	"	"	"	292
6	c	b c	c	b c	"	"	295
7	b c	"	b	b c	"	"	292
8	c	"	c o	"	c	c m p	...
9	p	c m p	c m	m o	"	f	294
10	d m	m o r	o r	"	c m	b m	295
11	b	m	m o	r	c d	o q	295
12	m o q	b c	b	b c	"	"	300
13	b	"	"	c	"	b c	...
14	b m	f	c m	o	d	c	300
15	r	d	m f	m	b c	f	302
16	m	c d	m o	m	"	f	300
17	d	f	"	"	"	"	...
18	f	"	"	"	c	b c	302
19	b	- - -	- - -	q r	"	"	...
20	r	c	b c	m	"	"	...
21	m	"	b m	"	f	"	...
22	f	"	"	"	b	"	302
23	b	"	"	"	"	"	...
24	b	c	"	f	g	c	300
25	b c	"	"	"	"	b	310
26	b	"	b c	"	"	"	300
27	b	g	"	c	o	c	280
28	g	c	"	g	"	o r	300
29	o r	r	o	c m	c	"	295
30	b c	"	"	"	"	"	295
31	b c	c	"	"	"	"	285

NOTES TO JULY RECORD.

1st. Aberdeen.

7th. Porpoises going east; a shearwater and two loons seen; fulmar petrels constantly in sight.

8th. A shearwater, an Arctic tern, and several fulmar petrels seen.

9th. A whale seen.

11th. Fulmar petrels constantly in sight.

13th. Mountains of South Greenland seen; Cape Farewell, N. 66°, W. 74′; fulmar petrels, kittiwake gulls, also strange petrels in sight.

14th. Fulmar and strange petrels, and kittiwakes in sight; several hours in sight of the ice.

16th. Loons are not uncommon.

17th. Sailing through heavy pack ice.

18th. Sailing through heavy pack ice.

19th. At noon in harbor of Frederickshaab.

23d. Anchored at 1h. 30m. P. M. in Fiskernaes Harbor.

25th. Hove to off Goodhaab 8 A. M.

26th. One rorqual seen, mollymauks, and an occasional skua gull.

27th. Mollymauks as usual.

28th. A skua gull shot; considerable number seen; one black whale seen. Specific gravity of water in 110 fathoms 1.0275, temperature 31°.5; at surface 1.0275, temperature 37°.0.

31st. In Lievely Harbor.

August, 1857. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midnight.	Specific Grav. of Sea Water, 1.0.
1	*c*	"	"	*b c*	"	*c*	280
2	*c*	"	"	*o c*	*c*	*o c*	285
[1]3	*f*	*o*	"	*b c*	*c*	"	*285
4	*c*	*c q r*	*p c g*	*g r*	*g g*	*b c q*	285
5	*b c*	"	"	"	*c*	"	285
6	*c*	"	"	"	*c o*	*g*	280
7	*o r*	*o*	*f*	*b c*	"	*f*	275
8	*f*	"	*o r*	*o*	*c m*	*c*	275
9	*b c*	*o*	*o r*	*c*	*o*	*o r*	*270
[2]10	*c*	*b c*	*o*	*m r*	*f*	"	*208
11	*f*	*b*	"	"	"	"	- - - -
12	*b*	"	"	"	"	"	225
13	*b*	"	"	*b c*	"	"	240
[3]14	*b c*	"	"	"	*b*	"	230
15	*b c*	"	"	"	"	"	*240
16	*b c*	"	"	"	*f*	"	*250
17	*f*	"	"	*m d*	"	*o s*	260
18	*o*	*m o*	*c m*	"	"	"	260
19	*c m*	"	"	"	*m s*	*c*	*260
20	*c m*	*c*	*s*	*c m*	*m s*	*c*	*260
21	*c*	"	*f*	*g o*	*f*	*m o*	*260
22	*m o*	*m*	*b c*	*d*	"	*c*	*260
23	*c o*	*o*	"	"	*c*	*b c*	262
24	*b c*	*b*	"	*b c*	"	*c*	*260
25	*c*	"	*m o s*	*m o r*	*r*	*d*	*262
26	*d*	*b c*	*m*	*f*	*c*	*o*	*261
[4]27	*c*	*o c*	*c*	*b c*	*c*	"	*262
28	*c*	*f*	"	*m o*	*o*	*g*	*262
29	*b c*	"	*b*	*b m*	*b*	"	*260
30	*b c*	"	*o c g*	*f*	*g m o*	"	*262
31	*o s*	*s*	*c*	*b*	"	"	*260

NOTES TO AUGUST RECORD.

1st. In Disco Fiord; eider ducks abundant.
2d. One black whale and several rorquals seen.
3d. Off Issung Point; immense flocks of ducks.
4th. At Rittenbenk.
5th. A few rotchies seen.
6th. Off Upernavik; took on board six dogs at Proven, and fourteen at Upernavik.
7th. Several rotchies seen.
8th. Sailing amongst loose ice.
10th. Off the Devil's Thumb.
12th. Steaming through ice.
13th. Specific gravity of fresh water on the iceberg, 1.001.
14th. At midnight (14th to 15th) fast to a berg south of Brown's Island.
16th. Running through lanes in the pack.
17th. Running through lanes in the pack and beset.
18th. Beset in Melville Bay.

[1] Specific gravity of sea water marked with an asterisk (*), taken from the fourth number of Meteorological Papers, published by the Board of Trade. London, 1860. At 8 P. M. at anchor in 7 fathoms water, one-third of a mile off shore; bad holding ground; coaling at Rittenbenk.

[2] The specific gravity of the surface water fell from 1.0270 on the 9th, to 1.0208 on the 10th. The yacht is said to have been off the glacier, and was surrounded by bergs, the fresh water from which probably caused the diminution in the specific gravity at the surface. The specific gravity of the fresh water on a berg was 1.0010.

[3] Specific gravity in 111 fathoms	1.028	Temperature	30°.0
" " " 50 "	1.025	"	29.5
" " " 25 "	1.024	"	31.5

[4] Cape Walker, N. 60° E. (true); Cape Melville, N. 14° W. (true).

20th. Three seals seen.
21st. Two seals shot.
24th. One seal shot.
26th. Two glaucous gulls shot.
27th. Three seals and a turnstone shot; warping through the ice; ship nipped.
28th. Two seals shot.
29th. Cape Melville N. 8° 19′ W. (true).
30th. Cape Melville N. 10° 30′ W. (true).

September, 1857. Record of the Weather kept on board the Yacht Fox, with general remarks.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midnight.	Specific Grav. of Sea Water, 1.0.
1	*b*	*b c*	"	"	"	*c*	
2	*f*	"	"	"	"	"	*260[1]
3	*f*	*b f*	*f*	*f o*	*m o*	*f*	*261[1]
4	*f*	*m o*	"	*o*	"	*f*	*260[1]
[2]5	*o*	*f*	*c o*	*c*	*o*	*c*	*260[1]
[3]6	*f*	*o s*	*o*	*c*	*b c*	*c*	*288[1]
7	*c*	*c o*	"	*o s*	*s*	"	
[4]8	*o s*	*c o*	*s*	*f*	*c*	*o*	
[5]9	*f*	*f s*	*r s*	"	"	*f r s*	
[6]10	*s*	*f*	"	*o*	*m o*	*s*	
[7]11	*o s*	*m*	*r s*	*f s*	*s*	*f*	
12	*f*	*m*	*b c*	*f*	"	"	
13	*b c*	"	"	"	*f o*	*f*	
14	*g o*	*f*	*s*	"	"	*b*	
15	*b c*	"	"	"	"	"	
[8]16	*o*	*c*	*c o*	*o*	"	*c*	
17	*b*	"	"	"	"	"	
18	*b*	"	"	"	"	"	
19	*b*	"	"	"	"	"	
20	*b*	"	"	"	"	"	
21	*b*	"	"	"	*b c*	"	
22	*c*	"	*b c*	*o*	*b c*	*c*	
23	*f*	*b c*	*b*	*b c*	*c*	"	
24	*b*	*b c*	*b*	"	*b c*	*b*	
25	*c*	*b*	*b c*	*b*	*f*	*m*	
26	*b*	"	"	"	"	"	
27	*v*	*m*	*b c*	"	"	*f*	
28	*f*	*b c*	*o*	*c*	"	*c*	
29	*f*	"	*b c m*	*c*	*f*	"	
30	*f*	*c*	*c m*	*c*	"	*b c*	

NOTES TO SEPTEMBER RECORD.

1st. Four seals shot; beset in Melville Bay.
2d. Three seals shot.
3d. Three seals shot.
4th. Two seals shot.

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[1] Specific gravity of sea water, from record in fourth number of Meteorologicals, Board of Trade.

[2] Specific gravity of sea, at surface . . . . . 1.0265 Temperature 28.8
" " " " in 25 fathoms . . . . 1.0290 " 29.0
" " " " " 50 " . . . . 1.0292 " 29.0
" " " " " 88 " . . . . 1.0302 " 29.0

[3] Cape Melville, N. 10° 48′ E. (true); two black whales seen; four seals shot.

[4] A slight swell perceptible; a sea snipe shot; a young burgomaster and a kitchie seen; also several mollymauks.

[5] Two burgomaster gulls shot; a white falcon seen.

[6] At 9 A. M., dry bulb, 23°.0, wet, 22°.5; five seals and a burgomaster shot; at 10 P. M., dry bulb, 32°.5, wet bulb, 32°.5.

[7] Snow buntings seen; a ring dotterel shot.

[8] Lower deck, wet bulb, 58°, dry bulb, 64°; at 9 A. M., dry bulb, 20°.0, wet bulb, 20°.0; a seal and a burgomaster shot.

5th. A black whale seen; sounded in 88 fathoms; yellowish mud; six seals obtained.
6th. Soundings in 88 fathoms; yellowish mud.
7th. A *Tringa* shot.
8th. Soundings in 86 fathoms; same bottom.
9th. Soundings in 94 fathoms; mud, shells, and stones.
10th. Soundings in 83½ fathoms; stones and mud.
11th. Soundings in 83 fathoms; stones and mud.
12th. Soundings in 80 fathoms; soft mud.
13th. Strong refraction in N. W.; three ravens, one burgomaster, and one turnstone seen.
14th. Soundings in 78 fathoms; a sea snipe shot; dry bulb 29°.0, wet 28°.8 at 9 A. M.
15th. Soundings in 79 fathoms; two ravens, a few snow buntings, and a burgomaster seen.
16th. Soundings in 69 fathoms; stones.
17th. Soundings in 94 fathoms; mud.
18th. Longitude by Jupiter's first satellite 65° 5′ W.
19th. Faint aurora at 2 A. M.; sounded in 114 fathoms; stones and mud.
21st. No bottom with 120 fathoms; wet bulb 25.5, dry bulb 26.5.
22d. Sounded in 135 fathoms; mud and sand; two bears seen.
23d. Sounded in 130 fathoms; soft mud.
24th. Specific gravity of surface of sea 1.0250, at 29° temperature; two bears seen; faint aurora in the S. E.
25th. Faint aurora from N. N. W. to S. S. W; two seals and a glaucous gull seen.
26th. A raven shot.
27th. A raven seen; at 2 A. M. a slight aurora in the E. S. E.
28th. No bottom with 140 fathoms.
29th. Two bears seen.
30th. Many shooting stars at midnight (30th to 1st).

October, 1857. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.
1	*v*	"	*f*	"	"	*m o*	*c*	- - -	*s*	"	*o*	"
2	*s*	"	"	"	*c*	*o*	*m o*	*f*	"	"	"	"
3	*f*	"	"	"	*b c*	*b c m*	*b*	"	"	"	*v*	"
4	*b*	"	"	*c*	"	"	"	"	*o*	"	*c*	*b c*
5	*c*	"	*b c*	"	"	"	*b*	"	"	"	"	"
6	*b*	"	*c*	"	*b c*	"	*c*	"	*b c*	*v*	*b c v*	*b*
7	"	"	"	*b m*	*b c m*	"	*b c*	*o*	*f*	"	*c*	"
8	*b c*	*o*	*f*	"	*c m*	*m*	"	*c*	"	"	*f*	*c*
9	*v*	"	*o*	*s*	*o*	"	*s*	"	*c*	*b c*	*b*	"
10	*b v*	"	"	*b m*	*b*	"	"	*f*	"	*m*	*f*	"
11	*f*	"	"	*b m*	"	"	*b c*	"	"	*b*	*m*	*c m*
12	*t*	*o*	*b*	- - -	*m o*	"	*c*	*s*	"	"	*b m*	*f*
13	*f*	*m*	*o*	"	"	*m o*	*f*	*o*	*m*	*s z*	"	"
14	*s z*	"	"	"	*z m*	"	*m*	*b c m*	*o*	*b m*	*m o*	*m*
15	*o*	*o z*	"	"	"	"	*o*	"	"	*s*	"	"
16	*s*	"	"	*o*	"	"	"	"	*m*	*c*	*c z*	"
17	*v*	"	*b*	*b c*	*c*	*b c*	"	*c*	*s*	"	"	*o*
18	*s*	"	"	*m*	"	*m o*	*m*	"	"	"	"	"
19	*m*	"	"	*s*	"	"	"	*f*	"	"	"	"
20	*s*	*m*	*s*	*m*	*s*	"	"	*z*	"	"	"	"
21	*f*	"	*s*	*o*	*b c*	*g. m*	*s*	*m*	"	*s*	"	"
22	*m*	*s*	*z*	"	"	"	"	"	"	"	"	*m*
23	*m*	*c*	"	*m*	*b c*	"	"	"	"	"	*b*	*s*
24	*m*	"	"	*s*	*m*	"	"	"	*o*	*c*	*b c*	"
25	*v*	"	*b c*	*o*	*m*	*c m*	"	"	*v*	"	*s*	*m*
26	*m*	"	"	*c*	*b c*	"	"	"	*m*	"	*o*	*m*
27	"	*c*	"	"	*b c*	"	"	"	"	*b z*	"	"
28	*b z*	"	"	"	"	"	*b c*	"	"	*v*	*c*	*b c*
29	*v*	"	"	"	"	"	*c*	*m*	*c*	*b*	"	"
30	*b c*	"	*v*	"	*b c*	"	"	"	*b*	*v*	"	"
31	*o*	"	*c*	"	*b c*	"	"	"	"	*c*	"	"

NOTES TO OCTOBER RECORD.

1st. Ice drift N. W.; a ptarmigan caught by the dogs; a flock of eider-ducks and a raven seen.

2d. Dusk at 7h.

3d. Dawn at 5h. 10m., dusk at 7h.

4th. Dusk at 6h. 30m.; at 11 P. M. an aurora in W. N. W.

5th. Dawn at 5h. 30m., dusk at 6h. 30m.; at midnight longitude by chronometer and Jupiter 65° 45′ W.

6th. Dawn at 5h. 20m.; tried for soundings with 140 fathoms; dusk at 6h. 30m.

7th. Dawn at 5h. 35m., dusk at 6h. 25m.; two bear tracks near the ship.

8th. Dawn at 5h. 35m., dusk at 6h. 10m.

9th. 2 A. M. aurora seen from S. S. E. to E. S. E.; dawn at 5h. 30m.; a raven seen; dusk at 6h. 0m.

10th. Dawn at 5h. 35m., dusk at 5h. 55m.

11th. Dawn at 6h. 0m., dusk at 5h. 10m.

12th. Dawn at 5h. 30m., dusk at 5h. 40m.; a flock of eider-ducks passed to the southward; fox and bear tracks seen; between 8 and 10 P. M. some shooting stars.

13th. Dawn at 5h. 35m., dusk at 5h. 30m.

14th. Dawn at 6h. 0m., dusk at 5h. 30m.; the young ice opened for some miles in length; a slight swell observed.

15th.[1] Dawn at 5h. 30m., dusk at 5h. 30m.

16th. Dawn at 6h. 30m., dusk at 5h. 30m.; seals in the lane of water; tried for soundings with 165 fathoms.

17th. Dawn at 6h. 15m., dusk at 5h. 15m.; high land seen from north to N. E. by E. (true); seals in the lane of water, also narwhals; thickness of young ice one month old, 1 foot 3.8 inches; overlying snow, 2½ inches.

18th. Dawn at 6h. 30m., dusk at 5h. 0m.

19th. Dawn at 6h. 45m., dusk at 4h. 30m.

20th. Dawn at 6h. 50m., dusk at 4h. 25m.

21st. Dawn at 6h. 50m., dusk at 4h. 15m.; distant land bearing E. N. E., true; a large seal seen.

22d. Dawn at 6h. 45m., dusk at 4h. 10m.

23d. Dawn at 7h. 50m., dusk at 4h. 35m.; a fox track near the ship, and a seal seen.

24th. Dawn at 7h. 0m., dusk at 4h. 30m.

25th. Dawn at 6h. 35m., dusk at 4h. 20m.

26th. Dawn at 7h. 50m., dusk at 4h. 15m.; Cape York N. 3° E. (true); Cape Dudley Digges N. 50° E. (true).

27th. Dawn at 7h. 0m., dusk at 4h. 30m.

28th. Dawn at 7h. 10m., dusk at 4h. 15m.; the ice opening and in motion near the ship.

29th. Daylight at 7h. 20m.; a lane of water crossing the bows and distant two hundred yards; a long lane on port beam distant one mile, and extending east and west two or three miles; dusk at 4h.

30th. Ice movement and pressure all preceding night within two hundred yards of the ship; at 4h. 30m. A. M. slight aurora from S. to S. S. E. (true); dawn at 7h. 15m., dusk at 4h. 0m.; at 10 P. M. ice in motion.

31st. Dawn at 7h. 20m.; wide lane of water, covered with thin bay ice in all directions; dusk at 3h. 40m.; ice in motion and water space increasing.

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[1] Thickness of snow falling during three or four weeks, 2½ inches; thickness of ice one month old, 15.8 inches.

November, 1857. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.
1	c	“	b c	“	b c m	m s	g	c	“	“	“	b
2	m	“	c	b c	“	m	“	“	b c	m	“	c
3	b c	b	v	c	“	v	o	“	m	“	“	“
4	m	“	“	“	“	m o	m	“	“	“	“	c m
5	c	b c	“	“	c	“	“	“	“	“	“	“
6	c	“	c m	b c	“	“	m	“	m z	“	“	“
7	m z	“	“	“	b z	b c	“	“	m	“	c	“
8	m	“	m o	“	c m o	c	“	c m	c	m	“	m o
9	m o	“	“	“	m	c m	m	c	“	“	“	b c
10	v	c	o	“	m	“	“	c	“	m	c	“
11	m	f	m	“	b c	“	“	“	“	c	v	m
12	m	“	c	b c	“	“	“	b	m	“	b	m
13	m	“	m o	“	“	“	m	“	c m o	m o	“	c m
14	m o	“	c o	“	c o z	“	“	m o	“	“	m o s	“
15	m o s	“	“	“	m	c o	c	“	“	m	“	“
16	s z	“	m o	“	s	“	“	m o	s	“	s z	“
17	s z	“	“	“	c z	“	“	“	c m	“	m	“
18	m o	“	“	b c	v	“	m o	“	“	“	m	“
19	m	“	f	b c	“	c	m	“	“	“	“	“
20	m s	s	“	m	c	c m	b c	m	“	“	“	“
21	m	“	“	s	c	“	b c	c m	“	o z	“	“
22	m o z	m z	“	“	m o z	“	“	“	“	“	“	“
23	o z	“	b c	“	“	“	c	“	b c	b	b c	“
24	c	m	c	s	b c	“	“	“	b	m	b	b c
25	b c	“	m	“	c	“	b c	m	b z	“	“	“
26	b z	b c	“	“	c	b c	b z	“	“	“	“	b m
27	b z	“	b c	“	“	“	“	b	b v	“	“	b c
28	c	“	c m	“	b c	“	“	“	b	v	“	“
29	v z	“	b z	“	“	“	b	“	b c	c	b	“
30	b o	“	“	“	“	“	“	“	“	“	“	“

NOTES TO NOVEMBER RECORD.

1st. Dawn at $7^{h.}$ $30^{m.}$, dusk at $2^{h.}$ $50^{m.}$

2d. Dawn at $7^{h.}$ $40^{m.}$, dusk at $3^{h.}$ $30^{m.}$; 8 P. M. a bear came to the ship and was shot; length 7 feet 3 inches.

3d. Dawn at $7^{h.}$ $30^{m.}$, dusk at $3^{h.}$ $30^{m.}$

4th. Dawn at $8^{h.}$ $0^{m.}$, dusk at $3^{h.}$ $15^{m.}$

5th. Dawn at $7^{h.}$ 30^{m}, dusk at $3^{h.}$ $15^{m.}$

6th. Dawn at $7^{h.}$ $45^{m.}$, dusk at $3^{h.}$ $15^{m.}$; ice in motion; lanes of water in the S. W. and N. W.; two seals seen.

7th.[1] Dawn at $7^{h.}$ $45^{m.}$, dusk at $3^{h.}$ $15^{m.}$; lanes of water in all directions; two dovekies shot; slight streak of aurora near horizon in the S. E. after 6 P. M.

8th. Dawn at $8^{h.}$ $10^{m.}$, dusk at $3^{h.}$ $0^{m.}$; several seals seen; 8 P. M. faint aurora in the W. N. W.

9th.[2] Dawn at $8^{h.}$ $30^{m.}$, dusk at $2^{h.}$ $55^{m.}$; ice in motion, opening and closing; several seals seen; at 10 P. M. several shooting stars, and a faint lunar rainbow.

10th. 2 A. M. faint streaks of aurora from south to west, near horizon; dawn at $8^{h.}$ $30^{m.}$, dusk at $2^{h.}$ $55^{m.}$; several seals seen.

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[1] Notices of auroras inclosed within brackets were taken from the fourth number of Meteorological Papers of the Board of Trade.

[7th, midnight. Faint in S. W. (true) horizon, 25′ in breadth, and about 28° in extent, of a pale yellow color at times, oscillating and decreasing in extent to 14°; again on following night in N. N. W. horizon.]

[2] [9th, midnight. In south to east (true) pale yellow to pale green, with rays streaming towards the zenith, about 7° above horizon, and rising apparently just above a bank of fog, which gradually overcame and obscured it. There were no vibrations or scintillations, but at times it appeared broken up in detached pieces. It continued for an hour and a quarter.]

11th.[1] A dovekie seen; two seals shot; dusk at 2h. 50m.; 8 P. M. slight aurora in S. W.; several falling stars.

12th. Dawn at 8h. 20m., dusk at 2h. 40m.; a dovekie seen; three seals shot.

13th. Dawn at 8h. 45m., dusk at 2h. 35m.; motion perceptible in the ice; a few seals and a dovekie seen.

14th. Dawn at 8h. 30m.; ice in motion, the old ice crushing up the new ice; dusk at 2h. 23m.

15th. Dawn at 8h. 45m.; ice moving; several large pools of water; a narwhal and many seals seen, one shot; dusk at 2h. 30m.

16th. Dawn at 9h. 15m.; a seal shot and a dovekie seen; dusk at 2h. 15m.

17th. Dawn at 9h. 30m., dusk at 2h. 0m.

18th. Dawn at 9h. 35m., dusk at 2h. 5m.; a few seals and narwhals seen.

19th. Dawn at 9h. 30m., dusk at 2h. 0m.; two or three seals seen.

20th. Dawn at 9h. 45m., dusk at 2h. 0m.; one seal seen.

21st. Dawn at 9h. 45m., dusk at 2h. 15m.

22d. Dawn at 9h. 50m., dusk at 1h. 50m.

23d.[2] Dawn at 9h. 45m.; one seal seen; 8 P. M. aurora near the horizon in the S. E.; at midnight, aurora from N. W. to S. W. and S. E.

24th. 2 A. M. aurora at the S. E. horizon; dusk at 1h. 45m.

25th. Dawn at 9h. 50m., dusk at 1h. 40m.; a small lane of water near the ship; only one seal seen.

26th. Dawn at 9h. 50m., dusk at 1h. 35m.

27th. Dawn at 10h. 0m., dusk at 1h. 50m.

28th. Dawn at 10h. 5m., dusk at 1h. 35m.

29th. Dawn at 10h. 0m., dusk at 1h. 35m.

30th. Dawn at 10h. 15m., dusk at 1h. 10m.

December, 1857. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.
1	*b v*	"	"	"	"	"	"	"	"	"	"	"
2	*b v*	"	"	"	"	"	"	"	"	"	"	"
3	*b v*	"	"	"	*m*	"	*c o*	*m*	"	"	"	*b v*
4	*b v*	"	"	"	"	*c*	*m*	"	"	"	"	*m c*
5	*b v*	"	"	"	"	"	*b z*	"	*m z*	"	"	"
6	*m z*	"	*c m z*	"	*c m*	"	"	"	"	"	"	"
7	*c m*	"	"	"	*c*	"	*b c*	"	"	*b v*	"	"
8	*b v*	*b c*	*c m*	"	*c*	*b c*	*c*	*c m*	"	"	*b v*	"
9	*b v*	"	"	*b c*	"	"	*b*	*b v*	"	"	*c*	*b c*
10	*b*	*b v*	"	"	*b c*	*b*	*m*	"	"	*b v*	*b m*	*m*
11	*m*	"	"	"	*b c*	"	*b c*	*b*	*b c*	*b*	"	*b v*
12	*m*	"	*c z*	"	"	"	"	*m z*	"	"	"	*m*
13	*m z*	"	"	"	"	*b m z*	*b m*	*b*	"	"	*b c*	*c*
14	*c*	*c m*	*m*	"	*b*	*b v*	*c*	*b*	"	"	"	"
15	*c*	"	*b*	"	*b v*	"	"	"	"	"	"	"
16	*m*	"	*c*	*b*	"	"	*c*	*m*	"	"	"	"
17	*m*	"	"	*b m*	"	"	*b c*	*c*	"	*b v*	"	*b c*
18	*b c*	*c*	"	*b v*	"	*b c*	"	"	*b*	*b v*	"	"
19	*b v*	*m*	"	"	*c*	"	*b c*	*b v*	"	"	*m*	"
20	*m*	"	"	*s*	"	"	*m*	"	"	"	*m s*	"
21	*s*	*s z*	*m z*	"	*m*	"	"	"	"	"	*b v*	"
22	*m*	"	"	"	"	*c*	*m*	"	*m z*	"	"	"
23	*m*	"	"	"	"	*m s*	*s*	"	*m*	*c*	"	*m*
24	*m*	"	*c*	*m*	*c m*	"	*m*	*b v*	"	*b c*	*c*	"
25	*m*	"	"	"	"	*b m*	*c m*	*b m*	*b v*	"	"	*m*
26	*b v*	*m*	"	"	*b c*	"	"	"	"	"	*b v*	*b m*
27	*m*	"	"	"	*m z*	"	*m o z*	"	"	"	*s z*	"
28	*m*	"	*m s*	"	"	"	"	*c s*	*b c*	*m s*	*c*	*m s*
29	*m s*	*s z*	*m z*	"	"	"	*b*	*m*	*b v*	"	*b c*	"
30	*m*	"	*b v*	"	"	"	*b c*	*b c v*	"	*b v*	"	"
31	*b v*	*b c*	*b*	"	*b v*	*b c*	"	*b v*	"	"	"	"

[1] [11th, midnight. Slight in S. E. (true).]

[2] [23d, midnight. Very bright till 2 A. M. in N. W. to S. E. (true).]

[On the 16th, thickness of ice 2 feet ½ inch; increase since last month, 8 inches.—*B. of T. Papers.*]

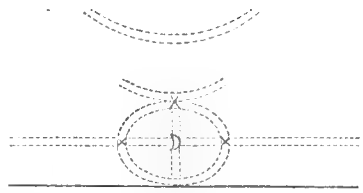
NOTES TO DECEMBER RECORD.

1st. Dawn at $10^{h.}$ $30^{m.}$, dusk at $1^{h.}$ $5^{m.}$; ice crushing up at the edges of the floe.

2d. Dawn at $10^{h.}$ $30^{m.}$, dusk at $1^{h.}$ $10^{m.}$

3d. Dawn at $10^{h.}$ $30^{m.}$, dusk at $1^{h.}$ $0^{m.}$

4th. Dawn at $11^{h.}$ $0^{m.}$; a well-marked halo and several paraselenæ, $7^{h.}$ to $10^{h.}$ P. M., consisting of five false moons, three arcs of halos, and a horizontal belt of light round the heaven and passing through the moon.



5th. Dawn at $10^{h.}$ $30^{m.}$, dusk at $0^{h.}$ $50^{m.}$

6th. Unable to read by light of the sky.

7th. Dawn at $11^{h.}$ $0^{m.}$; several cracks near the ship; one seal seen.

8th. Dawn at $11^{h.}$ $0^{m.}$; dusk at $0^{h.}$ $30^{m.}$; the cracks nearly closed.

9th. Dawn at $11^{h.}$ $5^{m.}$; dusk at $0^{h.}$ $45^{m.}$; midnight (9th to 10th), aurora from E. N. E. to E. S. E. (true), also several shooting stars.

10th. Dawn at $11^{h.}$ $0^{m.}$, dusk at $1^{h.}$ $30^{m.}$; 9 P. M., faint aurora in the south, streaming towards the zenith.

11th. Dawn at $11^{h.}$ $30^{m.}$, dusk at $0^{h.}$ $30^{m.}$

12th. Dawn at $11^{h.}$ $15^{m.}$, dusk at $0^{h.}$ $20^{m.}$; [2 A. M., slight aurora to southward;] 10 P. M., faint aurora in N. W.

13th. Dawn at $11^{h.}$ $0^{m.}$, dusk at $0^{h.}$ $50^{m.}$; 6 P. M., bright aurora in S. E.; 10 P. M., aurora from the S. E. to N. E. [part of an arc], with rays shooting up towards the zenith.

14th. 2 A. M., faint aurora towards the southern horizon; dawn at $11^{h.}$ $10^{m.}$, dusk at $0^{h.}$ $15^{m.}$; found a perceptible divergence in the gold leaves of an electrometer when attached to a masthead wire and passed down to the sea; 8 P. M., faint aurora in the N. E. (true).

15th. Dawn at $11^{h.}$ $10^{m.}$, dusk at $0^{h.}$ $30^{m.}$; several shooting stars between 5 and 6 P. M.; midnight (15th to 16th), faint aurora to southward. [Thickness of ice 3 feet 0 inches; increase since last month 11½ inches.—*B. of T. Papers.*[1]]

16th. No daylight. [6 P. M., aurora slight from E. to N. E., and at 10 P. M. bright from S. to N. E., continuing till 10 A. M. next day, at 6 P. M. again for one hour, across the zenith from E. to W. and N. W.; the electrometer was sensibly affected.]

17th. Dawn at $11^{h.}$ $30^{m.}$, dusk at $0^{h.}$ $30^{m.}$; 6 P. M., slight aurora E. to N., 10 P. M., bright aurora S. to N. E.

18th. Thickness of September ice 3 feet 0 inches, overlying closely packed snow 6½ inches; 4 A. M. aurora still visible, $9^{h.}$ $45^{m.}$ A. M. aurora disappeared; dawn at $11^{h.}$ $15^{m.}$, dusk at $0^{h.}$ $30^{m.}$; 4 P. M., faint aurora from E. to W. and N. W., passed through the zenith; 10 P. M., aurora S. S. E. to S. S. W., near horizon.

19th. Dawn at $11^{h.}$ $45^{m.}$, dusk at $0^{h.}$ $35^{m.}$; a wide crack, N. W. and S. E., half a mile from the ship.

20th. No daylight.

21st. Daylight at $11^{h.}$ $45^{m.}$, dusk at $0^{h.}$ $15^{m.}$

22d. No daylight.

23d. No daylight.

24th. Dawn at $11^{h.}$ $45^{m.}$, dusk at $0^{h.}$ $20^{m.}$; narrow lane of water recently opened to the S. W. and N. W. of the ship, and distant from one-quarter to one mile.

25th, 26th, 27th. No daylight.

28th. Dawn at $11^{h.}$ $25^{m.}$, dusk at $0^{h.}$ $45^{m.}$

29th. Dawn at $11^{h.}$ $0^{m.}$, dusk at $11^{h.}$ $45^{m.}$; small lanes of water, and several fresh cracks near the ship.

30th. Dawn at $11^{h.}$ $15^{m.}$, dusk at $0^{h.}$ $45^{m.}$

31st. Dawn at $10^{h.}$ $30^{m.}$, dusk at $0^{h.}$ $50^{m.}$ [No birds seen and only one seal.—*B. of T. Papers.*]

[1] Hard packed snow 6½ inches thick.

January, 1858. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.
1	b v	"	"	"	"	"	"	"	"	"	"	b
2	b c	"	"	"	b c	"	"	"	b v	"	"	"
3	b c	"	"	"	b z	"	b v	"	"	"	"	"
4	b v	"	m	"	"	"	"	m c	"	"	m	"
5	m z	"	"	m o	"	"	c m	"	b c	b	"	b c
6	c m	b	b v	b c	b	b z	b c	"	"	"	"	b z
7	b c z	"	"	"	"	"	"	m z	"	"	"	"
8	m z	"	m	"	"	"	"	"	"	"	"	"
9	m z	"	"	"	b m	b c m	c m	b c	"	"	"	"
10	b c	"	"	"	"	"	"	b v	b c	b c m	m	"
11	m	"	m s	"	m	b c	m s	"	m	b v	"	"
12	m	"	"	"	m s	"	b c	"	"	"	"	"
13	m	"	"	b c	"	"	"	"	"	"	"	"
14	b c	"	"	b v	b c	"	"	"	m	"	"	"
15	m s	"	"	"	m	"	"	"	"	b c	m	"
16	m s	"	"	"	m z	"	"	"	"	m	"	"
17	m s	"	"	"	m	b c	b c z	"	"	"	"	"
18	b c	"	"	v	b c	"	"	"	b	"	"	"
19	b c	"	"	"	c	"	b c	"	"	"	m s	"
20	m s	"	"	"	"	"	"	m	m s	"	m z	"
21	m z	"	"	"	"	m s z	m z	"	"	"	m	"
22	m	"	"	b c	"	"	"	"	b v	"	"	b s
23	m s	- - -	m s z	m z	"	"	"	b c	b	"	"	"
24	b c	"	m	b c	"	"	"	"	"	m	"	"
25	m	"	m s	"	"	m	"	"	b c	m s	m	"
26	m	"	"	m z	"	"	m	"	m z	"	"	"
27	m s	"	"	"	b c	"	"	"	"	b v	"	"
28	b v	"	b	"	b c	b	b c	"	"	"	"	"
29	b c	"	"	"	"	"	"	"	b v	b c	"	"
30	b c	"	"	"	"	"	"	"	"	"	"	"
31	b c	"	b v	b c	b v	"	b c	"	b z	"	"	"

NOTES TO JANUARY RECORD.

1st. Dawn at $10^{h.}$ $45^{m.}$, dusk at $1^{h.}$ $0^{m.}$; temperature in snow-hut —16°.

2d. Dawn at $10^{h.}$ $30^{m.}$, dusk at $1^{h.}$ $30^{m.}$

3d. Dawn at $11^{h.}$ $10^{m.}$

4th. Dawn at $11^{h.}$ $10^{m.}$, dusk at $0^{h.}$ $35^{m.}$

5th. Dawn at $11^{h.}$ $15^{m.}$, dusk at $1^{h.}$ $15^{m.}$; a lane of water in the west extending N. E. and S. W. (true); one seal seen.

6th. Dawn at $10^{h.}$ $45^{m.}$, dusk at $1^{h.}$ 15^{m}

7th. Dawn at $10^{h.}$ $45^{m.}$, dusk at $1^{h.}$ $30^{m.}$

8th. Dawn at $10^{h.}$ $35^{m.}$, dusk at $1^{h.}$ $30^{m.}$

9th. Dawn at $10^{h.}$ $15^{m.}$; at 8 P. M. bright aurora from west to east (magnetic) passing through west; 10 P. M., slight aurora occasionally visible round the horizon; 11 P. M., same.

10th. Dawn at $10^{h.}$ $5^{m.}$, dusk at $1^{h.}$ $15^{m.}$

11th. Dawn at $10^{h.}$ $30^{m.}$, dusk at $2^{h.}$ $30^{m.}$; aurora near the S. W. horizon at 9 P. M.

12th. Dawn at $10^{h.}$ $30^{m.}$, dusk at $1^{h.}$ $45^{m.}$; at 8 P. M. a patch of aurora 8° above horizon S. by E. (true).

13th. Dawn at $9^{h.}$ $50^{m.}$, dusk at $2^{h.}$ $10^{m.}$

14th. Daylight at $9^{h.}$ $40^{m.}$, dusk at $2^{h.}$ $5^{m.}$

15th. Dawn at $10^{h.}$ $15^{m.}$, dusk at $2^{h.}$ $10^{m.}$

16th. Dawn at $10^{h.}$ $0^{m.}$, dusk at $2^{h.}$ $0^{m.}$

17th. Dawn at $9^{h.}$ $50^{m.}$, dusk at $2^{h.}$ $30^{m.}$; a bear supposed to have alarmed the dogs; 8 P. M., aurora near horizon being S. and E. from 8 until midnight.

18th. Dawn at $9^{h.}$ $15^{m.}$, dusk at $2^{h.}$ $40^{m.}$

19th. Dawn at $9^{h.}$ $40^{m.}$, dusk at $2^{h.}$ $45^{m.}$

20th. Dawn at $9^{h.}$ $30^{m.}$, dusk at $2^{h.}$ $45^{m.}$; temperature in snow-hut, 6 hours after it was built, 7° above the external temperature; these huts were built by 8 men in 45 minutes.

21st. Dawn at $9^{h.}$ $30^{m.}$, dusk at $3^{h.}$ $0^{m.}$

22d. Dawn at $9^{h.}$ $10^{m.}$, dusk at $3^{h.}$ $15^{m.}$; much refraction in the S. E.

23d. Dawn at $9^{h.}$ $30^{m.}$, dusk at $3^{h.}$ $0^{m.}$

24th. Dawn at $9^{h.}$ $0^{m.}$, dusk at $3^{h.}$ $15^{m.}$

25th. Dawn at $9^{h.}$ $0^{m.}$, dusk at $3^{h.}$ $15^{m.}$; a halo round the moon at $7^{h.}$ P. M.

26th. Dawn at $9^{h.}$ $0^{m.}$, dusk at $3^{h.}$ $30^{m.}$

27th. Dawn at $8^{h.}$ $45^{m.}$, dusk at $3^{h.}$ $20^{m.}$

28th. Dawn at $8^{h.}$ $25^{m.}$; sun's upper limb appeared at $11^{h.}$ $25^{m.}$; refraction 59′ 55″, neglecting the height of the eye (5 feet); sun's upper limb disappeared at $1^{h.}$ $0^{m.}$ m. t.; dusk at $3^{h.}$ $45^{m.}$

29th. Dawn at $8^{h.}$ $15^{m.}$; sun's upper limb appeared at $11^{h.}$ $10^{m.}$ m. t., disappeared $1^{h.}$ $25^{m.}$; dusk at $3^{h.}$ $45^{m.}$; 10 men built two houses in 30 minutes; mercury froze at about —41°.

30th. Dawn at $8^{h.}$ $30^{m.}$; sun's upper limb appeared at $10^{h.}$ $30^{m.}$, disappeared at $1^{h.}$ $50^{m.}$; dusk at $3^{h.}$ $50^{m.}$. two seals and a dovekie seen in a large crack three or four miles east of the ship.

31st. Dawn at $8^{h.}$ $15^{m.}$; sun's upper limb appeared at $10^{h.}$ $40^{m.}$; a seal and several dovekies seen in a lane of water; sun's upper limb disappeared at $2^{h.}$ $0^{m.}$; dusk at $4^{h.}$ $0^{m.}$

February, 1858. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.
1	*b z*	"	"	"	"	*b c*	*b z*	*b c*	"	"	"	"
2	*b c*	"	"	"	"	"	"	*m s*	*m z*	"	*b m*	"
3	*b c*	"	"	"	"	"	"	"	"	*b m*	"	*b v*
4	*b m*	*m*	"	*b c*	"	"	"	"	*b*	*b v*	"	"
5	*b v*	"	*b c*	"	"	"	"	"	"	*m*	"	"
6	*m*	"	*m s*	"	"	"	"	"	"	"	"	*m*
7	*b c*	"	*b*	*b c*	"	"	"	"	"	"	"	"
8	*m*	"	*b c*	"	*b v*	"	"	"	"	"	*b m*	"
9	*b m*	"	*b c*	"	"	"	*b c z*	*b m z*	"	"	*b c z*	"
10	*b m z*	"	"	"	"	"	*c m z*	"	"	*m z*	*c m*	*m*
11	*m*	*c m*	*b c z*	*b c*	*b c z*	*b c*	"	"	"	*c m z*	"	"
12	*c m z*	*c z*	"	*c m*	*b c*	"	"	"	*b*	*b m*	"	"
13	*b m*	"	*b c*	"	"	"	"	"	*b m*	*b c*	*b m z*	"
14	*b z*	"	"	"	"	"	*b c z*	"	"	"	"	"
15	*b c z*	"	"	*b z*	"	"	*b c*	*b c z*	"	"	"	"
16	*b c*	*b c z*	"	"	"	"	*b z*	"	"	"	*b c z*	"
17	*b z*	"	*b c*	"	*b c z*	"	"	"	"	"	"	"
18	*b c z*	"	"	*b z*	"	"	*b c z*	"	"	"	"	"
19	*m z*	*b c z*	"	*c o*	"	"	"	*m s*	"	"	*b c*	"
20	*b c*	"	"	"	*m o*	*m z*	*c o z*	"	*b c z*	"	*c m z*	*m s*
21	*m s z*	"	*m z*	"	*c o*	*b c*	"	"	"	"	"	"
22	*b c*	"	"	"	"	"	"	"	"	"	*b c z*	"
23	*b c z*	"	"	"	"	"	"	"	"	"	"	"
24	*b c z*	"	"	"	"	"	"	- - -	- - -	*o m z*	*o q m z*	"
25	*o q m z*	"	"	*o m z*	"	"	*c m z*	"	"	"	*b c z*	*o z*
26	*c m z*	"	"	*o m z*	*o m s*	"	"	"	*m o*	"	*b c*	*b*
27	*b c*	"	"	*v*	*b c*	"	"	*m s*	*b c s*	*b c*	*c s*	*m s*
28	*m s*	*m s z*	"	"	*c o*	*b c*	"	"	*o*	*b c*	*o*	"

NOTES TO FEBRUARY RECORD.

1st. Dawn at $8^{h.}$ $0^{m.}$; sun's upper limb appeared at $10^{h.}$ $25^{m.}$ m. t.; a sooty fox shot, small and fat, weight 7 lbs.; sunset at $2^{h.}$ $5^{m.}$, dusk at $4^{h.}$ $10^{m.}$

2d. Dawn at $8^{h.}$ $0^{m.}$; sun's upper limb appeared at $10^{h.}$ $10^{m.}$; no sounding with 170 fathoms; several new cracks; cirro-stratus moving to S. E.; dusk at $4^{h.}$ $10^{m.}$; 9 P. M. aurora faint in the S. E. horizon for about ten minutes; 10 P. M. an auroral arch in the S. E., visible for one hour, faint from S. E. to E. N. E., the extremities of the arch touching the horizon; the S. E. extremity was the brightest, with an occasional stream towards the zenith.

3d. Dawn at $7^{h.}$ $50^{m.}$; sun's upper limb appeared at $10^{h.}$ $5^{m.}$; dusk at $4^{h.}$ $20^{m.}$; at 11 P. M. an arch of an aurora from S. E. (true) horizon to the zenith; ice in motion.

4th. Dawn at $7^{h.}$ $50^{m.}$; the ice has opened in several places; some seals and dovekies seen; dusk at $4^{h.}$ $30^{m.}$; 8 until 12 P. M. ice in motion near the ship.

5th. Dawn at $7^{h.}$ $50^{m.}$; sun's upper limb appeared at $10^{h.}$ $5^{m.}$ m. t.; six dovekies shot, a few seals seen; at 2 P. M. the floe cracked ten yards astern of the ship, many cracks running N. E. and S. W., and considerable motion in the ice; built snow huts in $40^{m.}$

6th. Dawn at $7^{h.}$ $45^{m.}$, dusk at $4^{h.}$ $20^{m.}$; 11 P. M. a slight aurora in the N. E. [Thickness of old floe ice 4 feet 6 inches.]

7th. Dawn at $7^{h.}$ $30^{m.}$; sun's upper limb disappeared at $2^{h.}$ $40^{m.}$; dusk at $4^{h.}$ $30^{m.}$; $11^{h.}$ $15^{m.}$ P. M. until midnight pale streaks and patches of aurora near horizon between S. S. E. and north (true).

8th. Dawn at $7^{h.}$ $30^{m.}$, dusk at $4^{h.}$ $40^{m.}$

9th. Dawn at $7^{h.}$ $25^{m.}$, dusk at $4^{h.}$ $40^{m.}$; at 11 A. M. a faint parhelion; 10 P. M. aurora from N. E. to S. E.

10th. 2 A. M. slight aurora from N. to S., passing through the zenith; dawn at $7^{h.}$ $30^{m.}$, dusk at $4^{h.}$ $45^{m.}$

11th. Dawn at $7^{h.}$ $20^{m.}$, dusk at $4^{h.}$ $50^{m.}$; a broad line of water one mile astern of the ship running E. N. E. and W. S. W.

12th. Dawn at $7^{h.}$ $20^{m.}$, dusk at $5^{h.}$ $0^{m.}$

13th. 4 A. M. a slight aurora in the west; dawn at $7^{h.}$ $15^{m.}$; prismatic halo round the sun; several seals seen; dusk at $5^{h.}$ $10^{m.}$; 11 P. M. aurora near horizon between S. S. E. and E., with vertical rays or streamers half way up to the zenith, arch about 14° above the horizon.

14th. Dawn at $7^{h.}$ $5^{m.}$; two dovekies seen; $1^{h.}$ $30^{m.}$ P. M. an ill-defined halo about 18° diameter, its extremities at the horizon prismatic; ice opening in a lane two miles N. W. from ship; dusk at $5^{h.}$ $20^{m.}$

15th. Dawn $7^{h.}$ $20^{m.}$; an imperfect double halo around the sun, diameter about 18° and 36°; dusk at $5^{h.}$ $20^{m.}$; $7^{h.}$ to $9^{h.}$ P. M. pale aurora near horizon between S. S. E. and E. N. E., with vertical rays towards the zenith, arch 4° above horizon.

16th. Dawn $6^{h.}$ $50^{m.}$; an imperfect halo slightly prismatic; dusk at $5^{h.}$ $20^{m.}$; at 8 P. M. bright, pale yellow aurora along the horizon between S. E. and N. N. E., with vertical streamers towards zenith, forming at times an arc, double and even treble, from 6° to 8° above horizon.

17th. Aurora continues until 2 A. M., when it disappeared; thickness of ice 3 feet 9 inches, of snow 9¼ inches; dawn at $6^{h.}$ $45^{m.}$; at noon imperfect prismatic halo, diameter 45°, luminous spots at horizon 45° E. and W. of the sun; several seals seen; dusk at $5^{h.}$ $20^{m.}$; halo round the moon, diameter 46°; 10 P. M. aurora near the south horizon, arc from S. S. W. to N. N. E. about 4° above horizon.

18th. Midnight until 4 A. M. aurora between S. W. and E.; dawn at $6^{h.}$ $50^{m.}$, dusk at $5^{h.}$ $20^{m.}$; $8^{h.}$ $30^{m.}$ P. M. auroral arch about 15° above horizon, between S. S. E. and E.; 10 P. M. aurora ceased.

19th. Dawn at $6^{h.}$ $40^{m.}$, dusk at $5^{h.}$ $35^{m.}$; at midnight (19th—20th) arch of aurora 9° above horizon, between S. S. E. and N. E.

20th. Dawn at $6^{h.}$ $40^{m.}$; a wide lane of water two miles north from the ship, and extending E. N. E. and W. S. W., the terminations not visible; 6 P. M. prismatic halo round the moon, diameter 4° 20′.

21st. Dawn at $6^{h.}$ $30^{m.}$, dusk at $5^{h.}$ $30^{m.}$

22d. Dawn at $6^{h.}$ $30^{m.}$; tried for soundings with 180 fathoms; several seals and dovekies seen in wide lane to the north of the ship, also a bear; dusk at $5^{h.}$ $40^{m.}$; at midnight (22d—23d) halo round the moon.

23d. Dawn at $6^{h.}$ $15^{m.}$, dusk at $6^{h.}$ $0^{m.}$

24th. Dawn at $6^{h.}$ $10^{m.}$, dusk at $5^{h.}$ $0^{m.}$

25th. Dawn at $6^{h.}$ $0^{m.}$, dusk at $6^{h.}$ $0^{m.}$

26th. Dawn at $6^{h.}$ $0^{m.}$, dusk at $6^{h.}$ $10^{m.}$

27th. Dawn at $5^{h.}$ $55^{m.}$ dusk at $6^{h.}$ $15^{m.}$; snow melted against ship's side in the sun at 9 A. M., temperature in shade —22°; a seal shot; dovekies seen; at noon black bulb thermometer —7°, in shade —17°.5.

28th. Dawn at $6^{h.}$ $0^{m.}$; no water in sight; dusk at $6^{h.}$ $15^{m.}$; midnight (28th—1st) halo round the moon, diameter 43°; altitude of moon 19¾°.

March, 1858. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.
1	*o*	"	*c o*	"	*b c*	"	"	*o*	*m s*	"	*b c z*	"
2	*c z*	*b c z*	*m s*	"	*c o*	"	*v*	*b c*	*c*	*b c*	"	"
3	*b c*	"	"	"	*m o*	*m*	"	"	*c o*	*m o z*	"	*h m o z*
4	*m z*	*b c z*	*m z*	"	"	*b c z*	"	*b c*	"	"	*b*	"
5	*b c*	"	"	"	"	*b*	*b c*	"	"	*b*	*b v*	"
6	*b c*	"	"	*b*	"	"	*v*	*b c*	"	"	"	"
7	*b v*	"	"	"	*b v*	*b m*	*b c*	*b*	*b c*	*b*	*b c*	"
8	*b c*	"	"	"	"	"	"	"	"	"	"	"
9	*b c*	"	"	"	*c o*	"	*b c*	"	"	"	"	"
10	*o*	*b c*	*m s*	"	"	"	*c o*	"	*c*	*m s*	"	"
11	*m s*	"	"	*m*	*m s*	"	*m*	*c m*	*b c*	"	"	*m*
12	*b c*	*c m*	*b c*	*c o*	*o s*	*o*	*c o*	*c m s*	*m s*	*o*	*m s*	"
13	*m s*	"	"	"	*b c*	*c o*	*m s*	"	*b c*	"	"	"
14	*b c*	*b*	*b c*	"	"	"	"	"	"	"	"	"
15	*b*	*b c*	"	"	"	*b c z*	"	"	"	"	"	"
16	*b c z*	"	*b c*	"	"	"	"	"	"	"	"	"
17	*b c*	"	"	"	"	*c*	*b c*	*c*	"	*b c*	*b v*	*b c*
18	*b c*	"	"	*b*	"	"	"	"	"	"	"	*b c*
19	*b c*	"	"	"	*b*	"	"	"	"	"	"	"
20	*b c*	"	*o*	*f s*	"	*f*	*o*	*b c*	"	"	"	*b*
21	*b*	"	*b c*	"	*b m*	"	*b c*	*m*	*f*	"	"	"
22	*f*	*c o*	*o*	*m*	*c o*	"	"	*f*	*f s*	*f z*	*m z*	"
23	*m z*	"	"	"	*m s*	"	"	"	*s*	*m s*	"	"
24	*m*	"	*m c*	*m o*	*c o*	*m s*	"	*b c*	"	"	*m z*	*b c z*
25	*b c z*	"	"	"	*c z*	*b c z*	"	"	*c z*	"	"	"
26	*c z*	*m z*	*b c z*	"	"	"	"	"	"	"	"	"
27	*b z*	"	"	"	"	"	"	"	"	"	"	"
28	*b z*	*b c z*	"	*b c*	"	"	"	"	"	"	"	"
29	*b*	*b c*	*b c z*	*b*	*b c*	"	"	"	"	"	"	*m s*
30	*c m s*	"	"	"	"	"	"	"	"	*m z*	*b c z*	"
31	*b c z*	"	"	*b z*	*b*	"	"	"	*b c z*	*b c*	*b*	"

NOTES TO MARCH RECORD.

1st. Noon tried for soundings with 180 fathoms.

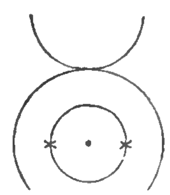
2d. A large lane of water opened E. N. E. and W. S. W. about one mile south of the ship; several seals seen and four shot; aurora visible between S. W. by S. and east from 10.30 P. M. until $2^{h.}$ $30^{m.}$ A. M. (3d) [patches, arches and streamers].

3d. Several lanes and cracks in the ice north of the ship, in which some narwhals and dovekies and several seals were seen; hail fell from 10 P. M. until 11.

4th. 10 P. M. Auroral arch in the N. E. at a low altitude. [A broad arch reaching nearly to the zenith.]

5th. At noon, black bulb thermometer in the sun zero, temperature in shade, —10°; at 2 P. M. the ice suddenly detached itself from the ship's bows and sides allowing her to rise eleven inches forward. 9 P. M. Aurora in clouds and streamers between N. W. and S., visible throughout the night; the sound of crushing or cracking ice distinctly heard during the night.

6th. 8 P. M., bright aurora between S. S. W. and E. from 8° to 50° above horizon, ceased at $10^{h.}$ $30^{m.}$. [Bands and arches with streamers towards the zenith.]



7th. 6 A. M., appearance of high land supposed to be Disco bearing east (true); from 11 A. M. until 2 P. M. a double prismatic halo (red external) about the sun, diameters 45° and 90° nearly; occasional parhelia or inner halo in same altitude as the sun; a portion of inverted arch above outer halo; sun's altitude 16°.

8th. At daylight appearance of land bearing E. by N.; a lane of water northwest of the ship in which seals and narwhals were seen; 10 P. M., faint aurora in S. E.

9th. A bear passed near the ship; many seals, some dovekies, and a black whale seen.

10th. Two small seals shot and some narwhals seen; several lanes and pools of water in the northward.

11th. Ice much broken up, also lanes and small pools of water northward of the ship.

12th. Water in lanes and pools in sight all around; a slight swell perceptible in the lanes and cracks.

13th. A seal shot.

14th. Several small lanes and pools to the northward.

15th. At $10^{h.}$ $30^{m.}$ P. M. a bank of aurora between S. and S. E. (true) about 8° elevation, with occasional vertical streamers ascending.

16th. Ice 4 feet $3\frac{1}{2}$ inches thick, increase for the month $6\frac{1}{2}$ inches; snow $9\frac{1}{2}$ inches, no increase; ice opened 120 yards west of the ship and a wide lane of water formed, extending N. and S.; its extremes not visible; 8 P. M., aurora from S. W. to N. E. near the horizon and with vertical streamers [lasted till midnight].

17th. Several seals seen, three dovekies shot; the ice much broken up and wide lanes of water running N. and S.; 10 P. M., bright aurora between S. W. and E. N. E.

18th. A seal shot; the ice closing; the tracks of three bears seen; $4^{h.}$ $30^{m.}$ P. M. ice crushing up with great force, that in which the ship is frozen appears setting southward of the western ice; 11 P. M., aurora between S. with E. N. E. [10° above horizon with streamers towards zenith]; the ice opening.

19th. Several seals and dovekies seen; at noon, a faint halo with parhelia; 6 P. M. ice in motion, afterwards stationary.

20th. Sounded in 150 fathoms, soft mud.

21st. Noon, the lane opened to the westward of the ship.

22d. A seal shot; six dovekies shot; $10^{h.}$ $30^{m.}$ P. M., the ice detached itself from the ship and she heeled over to the gale.

23d. A seal and a dovekie shot; a large pool of water 68 yards west of the ship; much water in sight to the southward; many narwhals seen swimming northward.

24th. The ice apparently drifting southward and opening in different directions; 10 P. M., ice in motion and pressing against the floe edge 70 yards west of the ship.

25th. $1^{h.}$ $45^{m.}$ A. M., ice slacked off and the crack opened; from 6 until 8 P. M. the ice in motion and crushing up with great pressure in the crack W. of the ship.

26th. 9 P. M., halo around the moon, diameter about 44°; altitude moon's centre 28°; slight motion in the ice.

27th. 8 P. M., ice opened in lane W. 50 yards from ship.

29th. 8 A. M., got bottom with 180 fathoms, mud, supposed depth 170 fathoms.

30th. Two seals and two dovekies shot; 11 P. M., Paraselena on each side and above the moon, distant about 23°, moon's altitude 11°.

31st. Three seals shot; a fresh bear track close to the ship.

April, 1858. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.
1	*b c*	"	"	"	*b*	"	"	"	"	"	"	"
2	*b*	"	"	"	*b c*	"	"	"	"	*b*	"	"
3	*b c*	"	*b c z*	*c m z*	*b m z*	"	*m z*	"	*c m z*	"	*m z*	"
4	*q m z*	"	*m z*	"	"	"	*q m z*	"	"	"	"	"
5	*q m z*	"	"	"	"	"	"	"	"	*m z*	"	"
6	*m z*	*m s*	"	*b c*	"	"	"	"	"	*b*	*b c*	*c o*
7	*c*	*b c*	*m s*	"	"	*m*	*b c*	*c m*	*m s*	"	*m s z*	"
8	*m s z*	"	"	"	*q m s z*	"	"	*b c m z*	*b*	"	"	"
9	*b*	*b c*	*b*	*b c*	"	"	"	"	"	"	"	"
10	*b c*	"	"	"	"	"	"	"	"	"	"	"
11	*b c*	"	"	"	"	"	"	"	"	"	*o s*	*b c*
12	*b c*	"	"	"	"	"	"	"	"	"	"	"
13	*b c*	"	"	"	"	"	"	"	"	"	"	"
14	*b c*	"	"	"	"	"	"	"	"	"	"	"
15	*b c*	"	"	"	"	"	"	"	"	"	"	"
16	*b c z*	"	"	"	"	*b z*	*b c z*	"	"	*b q z*	"	"
17	*b q z*	"	"	"	"	"	"	"	*b c q*	"	"	"
18	- - -	*b m q*	- - -	*b q s*	- - -	"	- - -	"	- - -	*c o s*	- - -	"
19	- - -	*m o s*	- - -	"	- - -	"	- - -	*m s*	- - -	*b c*	- - -	*b c m*
20	- - -	*b c*	- - -	"	- - -	"	- - -	"	- - -	"	- - -	"
21	- - -	*b c*	- - -	"	- - -	"	- - -	"	- - -	*b v*	- - -	"
22	- - -	*b v*	- - -	"	- - -	"	- - -	"	- - -	"	- - -	*b*
23	- - -	*b c*	- - -	*b v*	- - -	"	- - -	*b m*	- - -	"	- - -	*c o*
24	- - -	*c*	- - -	*c o*	- - -	"	- - -	*m o s*	- - -	"	- - -	*c o*
25	- - -	*b c*	- - -	*c o s*	- - -	*b m s*	- - -	*m s*	- - -	*c o*	- - -	*c*
26	- - -	*b m*	- - -	*m s*	- - -	*b c*	- - -	"	- - -	"	- - -	"
27	- - -	*c o*	- - -	*c*	- - -	"	- - -	*c o*	- - -	*m s*	- - -	*c o*
28	- - -	*c*	- - -	"	- - -	"	- - -	"	- - -	*o s*	- - -	*c*
29	- - -	*b c*	- - -	*b*	- - -	"	- - -	*b c*	- - -	"	- - -	*c o*
30	- - -	*o*	- - -	*c o*	- - -	"	- - -	"	- - -	*m s*	- - -	*m o s*

NOTES TO APRIL RECORD.

1st. A wide lane opening two miles N. E. of the ship; 9 P. M. a streak of aurora 8° above horizon between S. S. E. and S. W., with streamers towards the zenith.

2d. Two black whales seen.

4th. At noon our old floe cracked in a N. N. E. and S. S. W. line about thirty yards from the ship; it widens to about sixty yards.

5th. At 2h. 20m. the old floe cracked in line with ship, that on the port side drifted off about fifty yards; secured ship to fast ice, head to wind.

6th. A whale and many narwhals seen; four seals shot.

7th. Tried for soundings with 170 fathoms.

8th. Ice quiet, but drifting rapidly before the wind.

9th. A walrus seen; before sunset the western land became visible, supposed Cape Dyer, S. 88° W. (true); 11 P. M. aurora between E. and N., and from 10° elevation stretching up to the zenith.

10th. A large iceberg bearing E. (true); tried for soundings with 180 fathoms; Cape Dyer visible S. 89° W.; another cape S. 83° W.; midnight faint aurora from S. to E. (true).

11th. A bear's track within eighty yards of the ship; a fog bank in S. E.; 9 to 12 P. M. a pale aurora between E. and S. E.

12th. A lane of water opened astern in the direction of a large berg in the E. N. E.; much mist and vapor in the S. E.; eight dovekies shot; 11 P. M. aurora to the southward between E. and W. S. W. [about 15° above horizon, with streamers towards zenith, and numerous nebular spots of light at intervals in arch].

13th. 6 P. M. distant land seen bearing S. W. $\frac{1}{2}$ W. (true); 11 P. M. aurora similar to last night.

14th. A large flock of ducks flying N. W.; tried for soundings with 170 fathoms; 10 P. M. a bright aurora in the east (true); midnight, faint to the southward at 18° elevation.

15th. 1h. 30m. A. M. a bear came close to the ship; thickness of ice 3 feet 11 inches, decrease for the month 1 foot $2\frac{1}{2}$ inches; snow $10\frac{1}{2}$ inches, increase $1\frac{1}{2}$; a number of mollymauks seen; 10h. 30m. P. M. aurora to the southward, appearing over a fog bank [afterwards forming an arch from E. to S., disappeared at midnight].

16th. At 3 P. M. ice cracked and opened alongside; secured ship by the stern with three hawsers.

17th. Pieces of our floe began to break off, and at 11 A. M. the ship went adrift with them; 3 P. M. shipped rudder and stood to the eastward under double reefed mainsail and flying staysail.

18th. The ice closed about the ship at 3 A. M.; sludge and bay ice only visible; several bergs in sight; at 6 P. M. ship fast in young ice; many mollymauks about, and a snow bunting seen.

19th. Three bears seen; several bergs in sight.

20th. A considerable swell; unshipped rudder at 3 A. M.; the lofty clouds going to the westward at P. M.; a bear and a seal killed; several small bergs in sight.

21st. Tried for soundings with 170 fathoms.

22d. Many small bergs near; they change rapidly their bearings, as if the ship and pack were drifting past them to the S. W.; experienced a S. W. current.

23d. A large black whale seen, also a seal; experienced a westerly set; several large seals lying on the ice.

24th. 8 P. M. a swell from the S. E., and ice commenced to break up.

25th. Swell rapidly increasing; ice striking against the ship; proceeded under sail and steam to the eastward: noon, swell ten feet high; ship receiving very violent and frequent shocks, and proceeding, head to swell, through close heavy ice; 6 P. M. swell thirteen feet high, ice less close, shocks still more violent; 8 P. M. cleared the ice, stopped engine, and made sail.

26th. Mollymauks and kittiwakes abundant.

27th. 7 A. M. saw the land about Sukkertoppan N. E. by N. (true).

28th. Anchored at Holsteinberg at 7h. 30m. P. M. in seventeen fathoms water, moored with hawsers to the rocks.

29th and 30th. In the harbor of Holsteinberg.

[Specific gravity of sea-water:—

On the 7th, in 110 fathoms, 1.0295 (temp. 34°); in 5 fathoms, 1.0275 (temp. 30°).
“ 10th, “ 120 “ 1.0290 “ 34°; “ 4 “ 1.0275 “ 30°.
“ 14th, “ 110 “ 1.0310 “ 31°; “ 4 “ 1.0278 “ 30.5°.
“ 21st, “ 110 “ 1.0280 “ 31.5°.]

May, 1858. Record of the Weather kept on board the Yacht Fox, with general remarks.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midnight.
1	*m o s*	“	“	“	“	*c o*
2	*c*	“	*b c*	“	“	“
3	*b c*	“	“	“	“	“
4	*o*	*c*	*m s*	“	“	“
5	*m o s*	“	“	*b c*	“	“
6	*m s*	*b c*	“	“	“	“
7	*m s*	*b c*	“	“	“	“
8	*b c*	“	*c q s*	*c*	*c m*	“
9	*c m*	- - -	*b c*	*m s*	*o m s*	“
10	*b c*	*b m*	*b m s*	*m s*	*m o s*	“
11	*m o s*	*m s*	*b c m*	*b c*	“	*c*
12	*b c*	“	*m s*	*c o*	“	“
13	*b c*	“	“	“	“	“
14	*b*	“	“	“	“	“
15	*b*	*b f*	*f*	“	*b f*	*b m*
16	*b*	“	“	*b c*	*f*	“
17	*f s*	*m*	*b m*	“	*f*	*b*
18	*f*	*b m*	*b c*	*b*	“	“
19	*f*	“	*b m*	*b*	“	“
20	*b m*	*b*	“	“	“	“
21	*b*	“	“	*b c*	“	“
22	*b c*	“	*c o*	“	*b c*	“
23	*b*	*b c*	“	“	*b*	*b c*
24	*b c*	*c*	“	*b c*	“	“
25	*b*	“	“	*b c*	*b*	*c o*
26	*c o*	“	*b c*	“	“	*b*
27	*c*	*b c*	“	*b*	“	“
28	*b*	“	“	“	“	“
29	*b c*	“	*b*	*b c*	“	*b m*
30	*f*	“	“	“	*b m*	*f*
31	*m s*	“	“	*c o*	“	*b c*

NOTES TO MAY RECORD.

1st. At Holsteinburg.

8th. Sailed from Holsteinburg at 7h. A. M.

9th. Much ice about; white whale seen; specific gravity of sea water, surface, 1.0270.

10th. Midnight (9th—10th) off Northstrom Fiord; icebergs and ice about; noon, off Rifcal; at 7h. 15m., when 8 miles from Godhavn, stopped by ice extending in to the land; thick fog and snow came on; very narrowly escaped running on the N. W. of the Whalefish Islands. [Passed more than 500 bergs.]

11th. Anchored at Whalefish Islands in 12½ fathoms.

15th. 6 P. M., prismatic halo around sun about 45° diameter, two lateral parhelia, some polarization; also an arch 15° above horizon, apparently of a circle of same diameter as halo, opposite the sun.

16th. Godhavn Harbor and entrance filled with packed ice.

17th. 7h. 30m. P. M., anchored in Upernavik, Back Bay, in 10½ fathoms.

24th. Left Upernavik, and steamed to Godhavn.

25th. Steamed out of Godhavn at 4h. 30m. A. M.

26th. 6 A. M., entered the Waigat; 4h. 30m., anchored off the coal seam in 7 fathoms; one-third of a mile off shore.

27th. Proceeded under steam northward at 11h. 50m. P. M.

28th. Passed out of the Waigat, steering for Black Hook.

29th. At 5h. 30m. P. M. off Black Hook, Sanderson's Hope ahead; many bergs in sight.

31st. 7 A. M., hove to off Sanderson's Hope; 10h. 30m. A. M., bore up for Upernavik.

June, 1858. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midnight.	Specific Grav. of Sea Water, 1.0.
1	*b c*	*c o*	*c*	*b c*	"	"	
2	*b c*	"	"	"	"	"	
3	*c*	*c o*	"	"	*b c*	"	
4	*b*	*b c*	"	*m*	*c m o*	*m o s*	
5	*m o s*	*c o*	*c*	*c o*	*c*	"	
6	*b c*	"	*m s*	*c*	*c o*	"	
7	*b c*	*c*	*c o*	*b c*	*b*	*b c*	
8	*b c*	*b*	"	*b c*	"	"	
9	*b*	"	*b v*	*b c*	"	"	
10	*b*	*f*	"	*m*	*f s*	"	
11	*f s*	"	"	*c*	"	"	
12	*c*	*c f*	*c m*	*b m*	*f*	"	
13	*f*	"	"	"	*b c f*	*b c*	
14	*b c*	*b*	"	"	*b c*	"	
15	*c*	*b c*	"	"	*b*	"	
16	*b*	*b f*	"	*b c*	"	"	285
17	*f*	"	*d f*	*f*	"	*c o*	280
18	*c o*	*c*	*c o*	*f*	"	*m*	275
19	*b c*	"	*b*	*b c*	"	*b*	275
20	*b*	"	"	"	"	*f*	280
21	*f*	"	*b m*	*b c*	*b*	"	285
22	*b*	"	"	*b c*	*c*	"	[1]170
23	*c o*	"	"	*c*	*c o*	*c*	275
24	*c o*	"	*s*	*c*	*b c*	"	280
25	*b c*	*b*	"	"	*b c*	"	275
26	*o r*	*o*	"	"	*c d*	*g r*	275
27	*o r*	*c q r*	*m o*	*f o*	"	*m o*	270
28	*o*	*f s*	*o m*	"	*b c m*	*m o*	
29	*f*	"	*c m*	*c o*	"	*o s*	275
30	*f*	*c o*	*c*	*b c*	*f*	"	280

[1] At 1½ fathoms, 275.

NOTES TO JUNE RECORD.

4th. Started under steam at $5^{h.}$ $30^{m.}$ A. M.; west point of Great Dane Island (Narsak), north one and a half mile; $3^{h.}$ $30^{m.}$ P. M., made fast to land ice in a bay on south side of Upernavik Island; the ice closed in and beset the ship.

6th. Started under steam at $5^{h.}$ $50^{m.}$ A. M.; at $10^{h.}$ $20^{m.}$ made fast to a grounded berg in 25 fathoms, half a mile west of a rugged island having a large cairn on the summit of its S. W. extreme; Buchan Island west three and a half or four miles.

7th. Passed south of Buchan Island, and close along its west side; at $8^{h.}$ $30^{m.}$ A. M. struck and remained fast on a reef of rocks, tide falling; extremes of Buchan Island S. 36° W. and S. 18° E., distant about one mile; at $1^{h.}$ $30^{m.}$ P. M. low water.

8th. At $11^{h.}$ $40^{m.}$ A. M. observed a rock above water bearing from noon position S. 28° E. (true) three miles; passed inside Horse's Head; $2^{h.}$ $40^{m.}$ passed another rock; Horse's Head S. 15° E; Cape Shackleton (North Bluff) N. 46° E. (true).

9th. Steamed at intervals for about three hours.

11th. Made fast one mile N. of the Duck Islands.

12th. Tried to reach a lead close to Cape Wilcox but failed and returned; new moon at 2 P. M., high water at $11^{h.}$ $6^{m.}$ A. M.; rise 3 feet 8 inches; flood sets N. N. W., ebb sets S. S. E., about 2′ an hour between the islands.

13th. At $10^{h.}$ $40^{m.}$ P. M. steamed to the northward, and made fast to land ice; 4′ N. ½ W. from Eastern Duck Island.

17th. 4 P. M. saw the Sabine Islands bearing N. E. (true), and distant seven miles.

18th. Passed through and steamed along the land ice.

19th. Made fast at a nip; four bears seen, many seals and birds; 10 A. M., until $3^{h.}$ $30^{m.}$ P. M., under sail, working to westward; unable to distinguish the land ice from the loose ice.

22d. Advanced one mile to the N. W.; progress impeded by nips.

23d. At 9 P. M. got through the nip and made sail to the N. W.; three bears seen.

24th. At 11 A. M. came up to a nip and made fast; about 500 little auks shot.

25th. Nip opened; proceeded under steam and sail; two bears seen; at $4^{h.}$ $30^{m.}$ P. M. stopped at a nip; 5′ S. E. of Bushnan Island.

26th. 7 P. M. made fast to land ice; Cape York N. W. 4′; 9 P. M. proceeded to the westward; shot a walrus.

27th. Blowing strong and very thick; $2^{h.}$ $15^{m.}$ P. M. made fast to a floe; when clear saw Conical Island N. W. 18′ or 20′; off shore six miles.

28th. Find this floe is held fast by grounded bergs near us; 42 fathoms; mud and stones; shot rotchies; many rotchies' eggs picked up.

29th. The ship in a large space of water; no lead visible; considerable movement in the loose ice caused by current and wind.

30th. 8 A. M. tying to a floe three miles off shore.

[The specific gravity of the surface water is copied from the fourth number of the *Board of Trade Papers*.]

July, 1858. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midnight.	Specific Grav. of Sea Water, 1.0.
1	*f*	"	*f o*	*b c*	*f*	*b m*	285
2	*b c*	*b c m*	*b m*	*f*	*b m*	*c o*	275
3	*m o*	"	*f o*	*f*	"	"	270
4	*f*	"	"	"	"	*b c*	270
5	*b c*	"	"	*c o*	"	*o r*	275
6	*o s*	"	*o c*	"	*c*	*f*	275
7	*o*	*c*	*m*	*c o*	*b c*	"	
8	*b*	*b c*	"	"	"	"	
9	*b*	"	"	*b c*	"	"	270
10	*b*	*b c*	"	"	"	"	
11	*b*	*b c*	"	"	"	"	270
12	*b*	*b c*	*c o*	"	"	"	
13	*o q s*	"	*c o s*	*c o*	*o s*	"	
14	*o s*	*c o*	*c*	*o s*	*c o*	"	275
15	*c*	*c o*	"	*c q r*	*r*	*c*	
16	*c*	*c o*	*c f*	*b c*	*f*	*b c*	270
17	*c*	*b*	"	*b c*	*b*	"	275
18	*f*	*b c*	*b*	*b c*	*f*	"	
19	*f*	*b*	"	*b c*	"	"	
20	*b*	"	"	*b c*	"	*b*	
21	*b c*	*b*	"	*b c*	*b*	*b c*	275
22	*b c*	"	"	*b*	"	"	
23	*b c*	"	"	"	"	*c*	
24	*b c*	"	"	"	"	"	225
25	*b c*	"	"	"	"	"	205
26	*b c*	"	"	*f*	*b c*	*c*	
27	*b c*	"	"	"	"	"	
28	*b c*	"	"	"	*c o*	*b c*	
29	*c o*	*o r*	"	*c o*	*b c*	"	230
30	*m o*	*f r*	*r*	*m r*	*c m*	"	
31	*c m q*	*c o*	*m o r*	*c o*	"	*o r*	

NOTES TO JULY RECORD.

1st. Noon, the ship received a considerable nip, the floes being checked by a grounded berg; rudder damaged.

2d. Several large seals on the ice; 4 P. M., water visible, started under steam and reached at 8 P. M.; made all sail; midnight lost sight of the pack.

3d. Passing through loose ice; a seal shot.

4th. At midnight (4th–5th) fog cleared off, the pack close to leeward of us.

5th. Sailing along the pack edge. 9 P. M., about 15 miles from Conical Island; bore up through lane in the pack.

6th. Sailing through heavy ice, thick fog at midnight.

7th. Lying fast to a large floe in a confined space of water; Cobourg Island visible to the northward.

8th. Noon, steamed about four miles to the west; land visible from E. N. E. to N. ½ W. (magnetic.)

9th. From 2 P. M. until 7 P. M. working through nips.

10th. Noon, Cobourg Island in the N. W. 15′ or 18′; a seal shot.

11th. 2 A. M., reached a large space of water with ice in shore; no ice in sight towards Jones' Sound; found the pack to rest against the land; a black whale seen; 11 P. M., rounded Cape Horsburg two miles off shore.

12th. Made fast to land ice off DeRos Island and communicated with natives; proceeded four miles further into a large space of water; found ice all around; kept ship between the pack and the land westward of Cape Osborne.

13th. At 2h. 20m. A. M., made fast to land ice ½ mile off shore in seven fathoms water; the pack fast driving up the sound and closing in.

14th. The pack in the offing moving with the wind and tide; found a high water mark, a piece of an oaken ship's timber 7 × 8 inches, with three nails and an iron bolt through it, much bleached.

15th. Proceeded to Cape Warrander; ice all round.

16th. Lying to in a space of water off Cape Warrander.

17th. The ice is very loose; stopped when within four miles of Cape Hay; many narwhals and two black whales seen.

20th. Commenced boring through the pack to the S. E.

21st. Attempted to bore through the pack; a seal shot.

22d. Attempted to bore through the pack; a very large bear shot.

24th. Steaming through loose ice from 7 until 10 P. M; 8 P. M., off Possession Bay.

25th. Made fast to the land ice; a bear seen.

26th. 4 A. M., ship drifted to a loose floe in order to drift to the southward with it.

27th. Made fast to land ice off Button Point; at noon one mile off shore; shooting party brings back 312 loons.

28th. Captain and interpreter left the ship to visit the natives up the inlet; shooting party returns with 301 loons.

29th. The ice in the inlet broke up; shifted ship to the land ice 1½ mile N. E. of Button Point; Captain and party returned.

30th. 9 P. M., commenced steaming up Pond's Inlet with two natives on board.

31st. 8 A. M., came to fast ice 17 miles up the inlet, found it too weak to make fast to; a strong lea current.

(Numerous unicorns were seen this month.)

[Notes on specific gravity of sea water are from the 4th paper of the Board of Trade.]

August, 1858. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midnight.	Specific Grav. of Sea Water, 1.0.
1	*o r*	*c*	"	*c o*	*b c q*	*b c*	
2	*c o q*	*b c*	"	"	"	"	
3	*b c*	*b*	"	*b c*	"	"	
4	*c*	*c o*	*b c*	"	"	*c r*	
5	*b c*	*c*	"	"	*b c*	"	
6	*b*	"	"	"	*b c*	*b*	
7	*b*	*b c*	"	*b c q*	*o q*	*m q r*	
8	*m o q*	"	*m o r*	*m o q*	*c o q*	*c o*	
9	*m o*	"	*o*	*m o*	"	"	
10	*o s*	*f*	*m o*	"	*f*	"	235
11	*f*	*o*	"	*b c*	"	"	
12	*b c*	"	"	*c*	"	"	
13	*c*	*b c*	"	*c*	"	"	235
14	*c o*	*c*	*b c*	"	"	"	
15	*c*	"	"	"	*b c*	"	240
16	*c*	*b m*	*b f*	*b m*	*f r*	*f r*	
17	*f r*	*b c*	*b m*	*b c*	*c o*	"	200
18	*c m*	*c*	*o c*	*b c*	*c o r*	*c o m*	230
19	*c o*	*b c*	"	"	*c*	*c o*	220
20	*c s*	"	*c s o*	*b c*	*b c s*	*c*	210
21	*b c*	"	"	"	*c o*	"	
22	*c o*	"	"	*o s*	*s*	*o s*	
23	*f*	"	*c o*	"	"	"	
24	*c o*	*s*	*b c*	*c s*	*b c*	"	
25	*b c*	"	"	*s*	*o s*	"	
26	*c q*	*b c q*	*b c*	*c o*	"	"	
27	*s*	*o s*	*c*	*c o*	"	*c o s*	225
28	*c o*	"	"	"	"	"	
29	*c f s*	*m o*	*b c*	*c o*	"	"	
30	*c o*	*o*	*b c*	"	"	*o*	
31	*c o*	"	*o*	"	"	"	

NOTES TO AUGUST RECORD.

1st. $5^{h.}$ $45^{m.}$ A. M., Captain and party left the ship to visit the natives at Kaparotolik; many seals were seen; ice broke adrift; got the ship clear when within her own length of a rock.

2d. Beating to the westward through drifting ice; 6 P. M., Captain and party returned; bore up to the eastward.

3d. Midnight (2–3) four natives came on board; endeavoring to beat out of Pond's Bay.

4th. Found the current to set westward along the north shore; whales seen.

5th. Steaming from 4 until 7 P. M.; then made fast to land ice, three miles southeast of Cape Graham shore; whale seen.

7th. A bear shot.

8th. A heavy gale with very heavy sea.

10th. Many walrus seen; passed through a few streams of ice; 9 P. M., rounded Cape Hurd in thick fog; grounded in the mouth of Rigby Bay; floated off; a bear shot.

11th. A bear shot; anchored inside Cape Riley and commenced taking on board coals.

12th. Loose ice in motion with the tide; coaling from C. Riley and receiving stores from Beechey Island.

14th. Proceeded to Beechey Island; anchored off the house in five fathoms.

16th. Sailed for Cape Hotham at 6 A. M., at $7^{h.}$ $30^{m.}$ off Cape Hotham depot, landed and brought off two whale boats; proceeded to the westward.

17th. Steered for Peal Sound 9 P. M., Cape Granite N. 73° E., and Cape Lyons N. 56° W.; observed fast ice extending across the straits from about Cape Briggs to McClure Bay; bore up for Narrow Straits.

18th. At $2^{h.}$ $15^{m.}$ A. M., passed Limestone Island; 4 P. M., off Cape McClintock; 9 P. M., steaming against a head-wind round N. E. cape; midnight anchored in Port Leopold in seven fathoms; 1′ N. N. W. of Whaler Point.

19th. Examining stores on Whaler Point; $5^{h.}$ $30^{m.}$ P. M. made sail to the southward.

20th. $10^{h.}$ $30^{m.}$ A. M., passed Fury Point in a snow shower; 4 P. M., off Cape Garry; $8^{h.}$ $30^{m.}$, rounded the north point of Brentford Bay; observed a small cairn upon it; $10^{h.}$ $15^{m.}$, anchored in a bay four miles further west.

21st. A bear shot; made an attempt to pass through Bellot Straits, found it full of loose ice in rapid motion with a very strong tide; returned to Depot Bay; erected a cairn and landed a depot of 15 days provisions.

22d. A bearded seal shot.

23d. Made another attempt to pass through Bellot Straits, found it choked; ran to the southward until stopped by fast ice; anchored in a harbor on east side of Levesque Island at 4 P. M; a herd of reindeer seen on north shore of Bellot Straits, and two seen on shore here.

24th. Made another attempt to penetrate Bellot Straits; anchored in a small bay on the north shore, about half way through at $11^{h.}$ $15^{m.}$ P. M., a very unsafe position.

25th. At $3^{h.}$ $30^{m.}$ A. M., left anchorage and steamed west 4′, but being unable to get further returned to Depot Bay and anchored there at 8 P. M.

26th. At 9 A. M., ran to the southward, anchored in Stillwell Bay? 7 fathoms soft mud; landed 120 rations in casks in lat. 71° 21′ N.; heavy streams of ice in the offing.

27th. 9 A. M., made sail for Depot Bay; working to windward between the streams of ice in the offing and the land.

28th. Very little ice seen this day.

29th. Noon, anchored in Depot Bay in 10 fathoms water.

30th. At 5 A. M. steamed into Bellot Straits, finding it still full of loose ice; anchored in a harbor at the head of Port Kennedy at $10^{h.}$ $30^{m.}$ A. M. in 11 fathoms; at 6 P. M. Captain and boat party left the ship to examine the ice in Victoria Strait from the western hills; a herd of deer seen and a bearded seal shot.

31st. Several deer seen inland.

[Several Brent geese and Peregrine falcons shot on the 23d and 29th; from the 1st to the 5th whales were very numerous.—*B. of T. Papers.*]

September, 1858. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midnight.
1	*b*	*b c*	*b*	"	*b c*	"
2	*b c*	"	"	"	*b*	"
3	*m*	*c*	*b c*	"	"	"
4	*c*	*o*	*b c*	"	"	"
5	*b c*	*c*	"	*b c*	"	"
6	*c*	*c o*	"	"	"	"
7	*c o*	"	"	*r*	*c o*	"
8	*c o*	"	"	*r*	*o r*	*r*
9	*o r*	*c*	*b c*	"	"	*b*
10	*c o*	*c*	*b c*	*c s*	*c*	"
11	*c s*	*b c m*	"	*o*	*o s*	"
12	*c*	"	*o*	*c*	"	"
13	*b c*	*b*	"	"	*b c*	*b*
14	*b c*	"	"	"	"	"
15	*o*	*o s*	*c*	*o*	*o s*	*b c*
16	*c o*	*c*	"	"	"	"
17	*o s*	"	*c*	*c o*	"	*o*
18	*c*	*b c*	*o*	*c o*	*c*	"
19	*c*	"	"	"	"	"
20	*f s*	*c*	"	*c o*	*o s*	"
21	*o s*	"	"	"	"	*c o*
22	*c o*	"	*b c*	"	*s*	"
23	*s*	"	"	*o s*	"	*b*
24	*c*	*b c*	"	*c*	*b c*	*c o*
25	*c s z*	"	"	"	"	"
26	*o s*	"	"	"	*c o*	*o*
27	*b c*	"	"	*c*	*m s*	*c*
28	*c*	"	"	"	"	*c s*
29	*c*	*c o*	"	*o*	*c*	"
30	*c*	*c o s*	*c s*	*o s*	"	"

NOTES TO SEPTEMBER RECORD.

1st. One reindeer shot.

2d. Captain Young and boat party left to explore the S. W. part of Brentford Bay.

5th. Party returned; several deer seen.

6th. 6 A. M. steamed into Bellot Straits; high water at 11h. A. M.; flood tide running east; 1h. 30m. P. M. passed into the western sea; found the main pack resting upon Capes Bird and Hopkins, and extending as far west as visible; made fast to the edge of the ice; 1′ south of Cape Bird.

10th. Two seals shot.

11th. Returned to Port Kennedy and anchored in the entrance in 10 fathoms; a few deer seen, and a hare shot.

12th. A hare shot.

13th. [Observed a comet.]

18th. Steamed through Bellot Straits and made fast to the ice near Pemmican Rock; sent an officer and dog-sledge to examine the ice between us and Separation Island.

20th. At 8h. 15m P. M. a vivid flash of sheet lightning was observed.

21st. Dogs and parties carrying provisions to the southward.

23d. 8 P. M. observed the comet, increased in brilliancy.

25th. Lieut. Hobson and parties started with thirteen days' provisions to carry out southern depots; placed a boat and gear upon Pemmican Rock.

27th. Placed a depot of 100 rations on Pemmican Rock; cast off at noon and steamed for Port Kennedy; when 4½ miles within western end of Bellot's Straits, sounded in 75 fathoms; rock and sand; tide about to commence setting west; boring through young ice, and sledge ran into the fast ice in the entrance of Port Kennedy at 10 P. M., and, being unable to penetrate further, made fast; 13 fathoms water; off shore one-fourth of a mile; 12 fathoms at Winter Quarters.

29th. Two reindeer shot; their weights, exclusive of the entrails, are 354 and 139 lbs.

30th. Reindeer seen.

[Specific gravity of sea water 7th, 1.0215; on the 27th, 1.0230; at 65 fathoms, 1.0270; temp. 31°. —*B. of T. Papers.*]

October, 1858. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midnight.
1	*c*	"	"	*s*	"	"
2	*o s*	*c o*	"	"	*m s*	*o*
3	*s*	*m s*	*o m s*	*c o*	*q s*	"
4	*o q s*	*c o*	*o s*	*m s*	"	"
5	*m s*	*c*	"	*o*	*m o*	*o*
6	*c o*	*c*	*o*	"	*c*	"
7	*c*	*c m*	*b c*	*o s*	*s*	*m*
8	*b c*	*b*	"	"	"	"
9	*b*	"	"	"	"	"
10	*b*	*f*	"	*f s*	*s*	"
11	*s*	*m s*	*o m s*	*m s*	"	"
12	*m o*	*c*	*b c*	*b*	*b c*	*b*
13	*b c*	"	"	"	"	"
14	*b c*	"	"	"	"	"
15	*b c*	"	"	"	"	"
16	*m o s*	*o s*	"	*o s z*	"	*o z*
17	*o z*	"	"	"	"	"
18	*o z*	*o*	*b c*	"	"	"
19	*m s*	*o s*	"	"	"	"
20	*s*	*c*	*b c*	*b*	"	"
21	*m s*	*b c z*	*m s z*	*m z*	*c s*	*b c*
22	*b z*	"	"	*b c*	"	"
23	*b m*	*o m s*	*m s*	"	"	*o s*
24	*o*	*o*	*o s*	*m o*	*o s*	"
25	*m*	*b c*	*b z*	"	"	"
26	*b m z*	"	"	*b c s z*	*b c z*	"
27	*b z*	"	"	"	"	"
28	*b*	"	"	"	"	"
29	*b c*	"	"	"	"	"
30	*b c*	*m z*	*m*	*m s z*	*m s*	*m s z*
31	*m z*	"	"	*m o*	"	"

NOTES TO OCTOBER RECORD.

1st. Four reindeer seen; 8 P. M., the crack running up the harbor widened; hove the ship eighty yards further ahead.

2d. Two small herds of deer seen.

3d. 10h. 30m. P. M. lightning observed.

4th. Three ptarmigan seen.

5th. Two herds of deer seen.

6th. Reindeer seen.

7th. A few reindeer and ptarmigan seen.

8th. A reindeer shot; 10 P. M. comet visible.

9th. 10 P. M. comet visible.

10th. Four reindeer seen.

12th. One reindeer seen.

13th. Built an ice-house for magnetic observatory.

15th. Thickness of ice formed since the third, $9\frac{3}{4}$ inches.

19th. Lieut. Hobson and party started to carry depot down the west coast of Boothia at 8 A. M.

20th. A hare shot; many seals seen in the open water in the straits; 8 P. M. halo round the moon, diameter about 45°.

22d. 8 P. M. Prismatic halo around the moon.

28th. 8 P. M. aurora in the S. E. [about 20° above the horizon].

29th. From 8 P. M. until midnight, faint aurora between S. and N. W. [about 25° above the horizon, the extremities being joined by a narrow band stretching across the zenith.—*B. of T. Papers.*]

30th. A hare shot, two deer seen; 8 P. M. faint aurora in the S. W.

31st. Two ptarmigan shot; 10 P. M. faint aurora in the N. W.

November, 1858. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL
REMARKS.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.
1	*m s*	“	*m o*	*o*	“	“	“	“	*b c*	*m*	“	“
2	*m*	*m s*	*m o*	*b c*	“	“	“	*b c z*	“	“	“	“
3	*b c z*	“	“	“	“	“	“	“	*b c*	“	“	*b c z*
4	*b z*	“	“	“	“	*b m z*	“	*m z*	*b m z*	“	*b m*	“
5	*b m*	“	“	“	“	“	*b m z*	“	“	*b m*	“	“
6	*b m*	“	“	“	*b c m*	“	“	“	*o s*	*m o*	“	“
7	*m o*	“	“	“	“	“	*b m*	“	“	“	“	“
8	*b c*	“	“	“	“	“	*b c s*	*b c*	“	“	“	“
9	*b c m*	“	“	“	“	“	“	“	“	*b*	“	“
10	*b*	“	*b c m*	*b*	*b m*	“	“	“	“	“	“	“
11	*b m*	“	*b c*	*o s*	*b c*	*o*	“	“	“	*b c m*	“	*b m*
12	*b m*	“	“	“	“	“	“	“	“	“	*b*	“
13	*b*	*b m*	*b c*	*o s*	“	“	*s*	*m s*	“	“	“	“
14	*m s*	“	“	*m*	*m s*	“	*m z*	“	*b c z*	*b m z*	*m z*	“
15	*m z*	*b m z*	“	“	“	“	*b c*	“	*b m*	“	*b c m*	“
16	*b c m*	“	“	“	“	*m s*	“	*m s z*	*m z*	“	*m s z*	“
17	*m s*	“	“	*b*	“	“	*b*	“	*b c*	*m s*	*m o s*	“
18	*m o s*	“	“	“	“	“	*m o*	*c o*	*b c*	“	*b c m*	“
19	*b c m*	“	*m o*	*c m*	“	“	“	“	“	*c m s*	*b c m*	“
20	*b c m*	“	“	*m o*	*s*	*m o s*	*m*	“	*m o*	*b m*	“	“
21	*m o*	“	“	“	*m o s*	*c m*	*b c m*	*c m*	“	“	*c m s*	*c m*
22	*b c m*	“	“	“	“	“	“	“	“	*b m*	“	“
23	*b m*	“	*b c m*	“	“	“	“	“	*b m*	*b*	“	*b m*
24	*b m*	“	“	*b c m*	“	“	“	*b*	*b c*	“	“	“
25	*b*	*b c m*	*b m*	*m z*	“	*b m z*	“	“	*b z*	“	“	“
26	*b z*	“	“	“	“	“	“	“	“	*b m z*	“	“
27	*m z*	*b c*	“	*m s*	*b c*	“	“	“	“	“	“	“
28	*m z*	“	“	“	“	“	“	“	“	“	*b m z*	“
29	*b m z*	“	“	“	“	“	“	“	“	“	“	“
30	*m o z*	“	“	“	“	“	“	“	*b m z*	*b m*	“	*b c*

NOTES TO NOVEMBER RECORD.

6th. Lieut. Hobson and party returned; a recent deer track seen.
9th. [10 P. M. faint aurora from S. by E. to W. S. W.]
7th. and 8th. [10 P. M. aurora faint in S. W.]
9th. Faint aurora between S. and W. 10° above horizon, 10 P. M.
12th. 10 P. M. a pale streak from the northern horizon to the zenith.
14th. 10 P. M. faint aurora between S. W. and W. N. W.
16th. A deer came near the ship; three ptarmigan seen; [thickness of ice 1 foot 9½ inches.]
21st. A ptarmigan seen.
23d. 10 P. M. a halo around the moon.
24th. Three ptarmigan seen.
26th. 8 P. M. several willow grouse seen; two deer seen.

December, 1858. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.
1	*b c*	“	“	“	*b*	“	“	“	“	“	“	“
2	*b c*	“	“	“	“	*b m*	“	- - -	*b c*	“	*b*	“
3	*b*	*b c*	“	“	*m z*	“	*b m z*	“	“	“	“	“
4	*b m z*	“	“	“	*b c*	“	“	“	“	“	“	“
5	*b c*	“	“	“	“	*m*	*b c*	“	“	*b*	“	“
6	*b c*	“	“	“	“	“	“	*b*	“	*b m z*	“	“
7	*b c z*	“	*m*	*b*	“	“	“	“	“	“	“	“
8	*b*	“	“	“	“	“	*b m*	*m*	*m z*	*b m z*	“	“
9	*b m*	“	“	“	*b*	“	*b m*	“	“	“	“	“
10	*b c*	*b c m*	“	*c m*	*b c m*	*b m z*	“	“	“	“	“	*m s*
11	*m*	*b m*	“	“	“	“	“	“	“	“	“	“
12	*b c*	“	*b m*	*b c*	“	“	“	“	*b c s*	“	*b m*	“
13	*b*	“	“	“	“	“	*b z*	*b m z*	“	“	“	“
14	*b*	“	“	“	“	“	“	“	“	*b c*	*b z*	“
15	*b c z*	“	“	*b z*	*m z*	“	*b z*	*b m z*	“	*b m*	“	“
16	*b m z*	“	“	“	“	*b c z*	“	“	“	*b c*	“	“
17	*b*	*b c*	*b m*	“	*m*	- - -	*b c*	“	*b m*	“	“	“
18	*m*	*c m*	“	“	“	“	*b c*	“	“	“	“	“
19	*b c*	“	“	*m z*	*m*	*b c m*	“	“	“	*b*	“	“
20	*b c*	“	“	*b c z*	*c m z*	“	“	“	“	“	*m s*	“
21	*m s*	“	*b m z*	“	“	“	*s*	*m*	“	*b m*	“	*b*
22	*m s*	“	*m*	“	“	“	“	“	*m s*	*m*	*m s*	“
23	*m s*	“	“	*g m*	“	“	“	*b m*	“	“	“	“
24	*b c*	“	“	“	*b c m*	*c m*	*b z*	“	“	*b c m*	“	“
25	*b c*	“	“	*b z*	*b c*	*b m*	“	*m*	*b m q*	“	*b m z*	“
26	*m z*	“	*m*	*m z*	*b z*	“	“	“	*b c z*	*m z*	“	*b m z*
27	*m z*	“	“	“	“	“	“	*b m z*	“	“	“	“
28	*b c z*	*b m z*	“	“	*b m*	“	“	“	“	*b m z*	“	“
29	*b*	“	*b c*	“	*b m*	*b c*	“	“	“	*b*	“	“
30	*b c*	“	*b*	“	*b m*	*b c*	“	*b m*	*b c*	“	“	“
31	*b c*	“	“	“	“	“	*m*	*b m z*	“	“	*m z*	“

NOTES TO DECEMBER RECORD.

1st. Four ptarmigan seen.

3d. 11 P. M., pale aurora in S. W. (true), about 18° above horizon.

4th. 10 P. M., aurora in S. W. [Bright from E. to W. N. W. (through south), about 25° above the horizon.—*B. of T. Papers.*]

5th. A ptarmigan seen; from 8 P. M. until midnight aurora from horizon between S. E. and W., extending upwards nearly to the zenith. [6 to 7h. 30m. P. M., flashing from S. E. to N. W. across the zenith; at 10 P. M. faint in the westward, and at midnight in W. N. W. and across zenith from N. W. to S. E.—*B. of T. Papers.*]

6th. 8 until 9 P. M., pale aurora between W. and S. E., about 35° above horizon.

8th. A fox caught; 8 P. M., aurora in the S. E. [about 40° above horizon].

9th. A fox caught.

10th. A fox caught.

11th. 10 P. M., several shooting stars.

12th. 5 to 7 P. M., bright aurora between E. by S. and N. W. [Bright from N. W. to S. E. (through S.) about 60° above horizon.—*B. of T. Papers.*]

13th. 6 to 7 A. M., light aurora between S. E. and N.; 9 P. M., aurora from S. S. E. to W. N. W., about 20° above the horizon [and continuing until midnight]; several ptarmigan seen.

14th. 4 A. M., bright aurora from S. W. through E. to N. W.; 10 P. M., aurora between S. E. and S. W. near the horizon. [20° above horizon.—*B. of T. Papers.*] Ptarmigan seen.

15th. 5 to 8 A. M.; bright aurora from E. through S. to N. W. [30° above horizon.—*B. of T. Papers.*]

18th. 6 P. M., a lunar halo, diameter about 45°. [Thickness of ice, 3 feet 1 inch.]

19th. A covey of ptarmigan seen.

20th. 8 P. M., a lunar halo, diameter 45°.

23d. A ptarmigan seen.

24th. 11 P. M., bright aurora all over the heavens [causing the magnetometer to oscillate considerably.—*B. of T. Papers*].

28th. Aurora between S. S. E. and W. by N., about 20° above the horizon.

29th. A ptarmigan, and the recent track of a deer, and one or two hares seen.

30th. 5 P. M., aurora to the southward, about 35° above the horizon.

31st. A ptarmigan seen.

January, 1859. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.
1	*m z*	*b m*	*b*	“	*b c*	“	*b c z*	*b c*	*b m z*	*b m*	*b c z*	*b c*
2	*b m*	*m z*	“	*c z*	“	“	*b c z*	“	“	*b c*	*b*	“
3	*b c*	“	“	“	“	“	*b m c*	*b c*	“	“	“	“
4	*b c*	“	*b*	“	*b z*	*b c z*	“	“	“	“	“	*b c*
5	*b c*	“	*b m*	*b m z*	“	“	*b*	“	*b m*	*b*	*b m*	“
6	*b m*	*b c*	*b m*	“	*m*	*b m*	“	*b m z*	“	“	“	“
7	*b m z*	*b c*	“	*m*	“	*b m*	“	*b m z*	“	*b*	*b m z*	“
8	*b m z*	“	“	“	“	“	*b m*	“	*b*	“	“	“
9	*b*	*b m*	“	“	*b c*	“	*m*	“	*b c*	*b*	“	“
10	*b*	“	“	“	“	“	“	“	“	“	“	“
11	*b*	“	“	“	*m s*	“	*m*	“	*m s*	“	*b m*	“
12	*m*	“	*b m*	“	“	“	*b c*	“	“	*b m s*	*c m*	*b c*
13	*b c*	“	*c*	*c m*	*c m s*	“	*m s*	“	“	“	“	“
14	*m s*	“	“	“	*b m*	*m z*	“	“	*m s*	*m*	*b c*	“
15	*b*	“	*b c z*	“	“	“	“	*m z*	*b m z*	*b m*	“	“
16	*b m z*	“	*b*	“	*b m*	*b c*	“	“	“	*b c m*	“	“
17	*b m*	“	*b c*	“	*c m s*	*m s*	*c m*	“	“	*b c m*	*b c m z*	“
18	*b m z*	*m*	“	“	*o*	“	*m o*	“	“	*b c m*	“	“
19	*b c*	“	*b m*	*b*	*b m*	“	*b*	“	*b m*	“	“	“
20	*m z*	“	“	*b m z*	*b*	*b c*	“	“	*b m*	*m*	*b*	“
21	*b*	“	*b m*	“	“	“	“	“	“	“	“	“
22	*b m*	“	“	“	*m*	*m z*	“	*m*	“	“	“	“
23	*b m*	“	“	*b c*	*m*	*b m*	“	“	*b*	*b c*	“	“
24	*b*	“	*b z*	*b m z*	“	“	“	“	“	“	“	“
25	*b m z*	“	“	“	“	“	“	“	“	“	“	“
26	*b m z*	“	“	“	“	*b*	“	“	“	“	“	“
27	*b*	“	“	*b m*	“	“	“	“	*b m z*	*m*	“	*m z*
28	*b m z*	“	“	*b m*	*b m z*	*m z*	“	*b m z*	“	“	*b z*	“
29	*b m z*	“	*b m*	“	*b*	*b m*	“	“	“	“	“	*b*
30	*b*	*b m*	“	“	“	“	“	“	*b*	“	“	“
31	*b*	“	“	“	“	“	“	“	“	“	*b m*	“

NOTES TO JANUARY RECORD.

1st. 8 P. M. aurora from S. to W. about 40° above the horizon.

2d. 8 P. M. faint aurora in the S. W. about 40° above horizon, just above fog bank.

3d. 5 P. M. faint aurora in the east from horizon to zenith; 11 P. M. narrow band of aurora from E. S. E. to zenith.

8th. 10 P. M. faint aurora between S. E. and W. S. W. near the horizon.

9th. 6 to 7 A. M. bright aurora between W. and N. W; 10h. 30m. P. M. a narrow band of aurora from S. to W., passing through the zenith.

10th. 5 to 7 A. M. slight aurora from S. E. through S. to N. W.; 8 P. M. until midnight, strong auroral bands from S. to N. through the zenith.

11th. 9 P. M. until midnight, aurora between S. E. and W. about 15° above horizon.

12th. Some ptarmigan seen.

13th. A ptarmigan seen.

14th. 10 P. M. a lunar halo, diameter 45°.

16th. A ptarmigan shot.

17th. A fox caught; 6 P. M. a lunar halo.

18th. A fox caught; 6 P. M. a bear's track seen in Depot Bay.

19th. A hare shot; 10 P. M. a halo round the moon.

21st. A ptarmigan shot, and a hare seen.

22d. A raven seen.

26th. Sun's upper limb appeared at 11 A. M.; fresh tracks of two reindeer seen.

30th. Three ptarmigan shot, 3 A. M.

31st. 3 A. M. bright aurora between S. E. and N. W., passed through S. W.; 6 P. M. pencils of auroral rays from horizon to zenith between S. E. and W.; electrometer strongly affected; two ptarmigan shot.

February, 1859. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.
1	*b*	"	"	"	"	"	"	"	*b m*	*b*	"	*b z*
2	*b m z*	"	"	"	*m*	"	"	"	"	*m s*	*m*	"
3	*m*	"	*b c*	"	*b c s*	*b c*	"	*b m s*	*b m*	*b m s*	"	"
4	*m s*	"	"	*m*	*b z*	*b c z*	*b c m z*	"	*m z*	*b*	*b m*	"
5	*b m z*	*b m*	"	"	*m*	*b m*	*b*	*b m*	"	"	"	"
6	*b m z*	*b m*	*b m z*	"	"	"	*m z*	"	*b m*	"	*b m z*	"
7	*b z*	"	*b c*	"	"	*b c z*	*b c*	*b c z*	*b m z*	*b c*	*b*	"
8	*b*	"	"	*b m*	"	"	*b z*	"	*b m*	*b z*	"	*b*
9	*b z*	*b m*	"	*b c*	"	*b*	*m*	"	"	"	"	"
10	*b m*	*m*	"	"	*m s*	*b m*	*b c*	*b m*	*b*	"	*b m*	"
11	*b z*	"	"	"	*b c z*	*b z*	*b*	*b z*	"	*b c*	*b z*	"
12	*b*	"	"	*b c*	"	*c m*	*m z*	*m*	*b c*	"	*b*	"
13	*b*	"	*b c*	*b c m*	*b m*	"	"	"	"	"	*b c*	"
14	*b z*	"	"	*b m*	*b c g*	"	*b c m*	*b c*	*b m*	"	"	*b*
15	*b m*	*b z*	"	*m z*	*b c z*	"	*b m z*	"	"	*b m*	"	*b m z*
16	*b c*	*b m*	"	"	*b m z*	*b m*	*b m z*	"	*b m*	"	"	"
17	*b*	*b m*	*m s*	"	"	"	*b m*	*b c*	*b m*	"	"	*b c q*
18	*b z*	*b m*	*m z*	"	*b z*	*b m*	"	*m*	"	*b m*	*m*	*b m*
19	*b m*	*m g*	*m z*	*b m z*	"	*b m*	"	*m*	"	*c*	"	"
20	*b c*	"	"	*b m*	*b c*	*b c z*	*b z*	*b*	"	"	*b m*	"
21	*m*	"	*b*	*b m*	*b*	"	"	"	"	"	*b z*	"
22	*b z*	*b m z*	*b z*	"	"	"	*b c z*	"	"	*b z*	"	"
23	*b*	"	"	*b m*	"	*b c*	*b m*	"	"	"	"	"
24	*m*	*b m*	*m*	*m s*	*b m*	"	*m*	"	"	"	*b*	*b m*
25	*b m z*	*m z*	*b m z*	"	*m z*	"	*m z*	"	"	*b m*	"	"
26	*b m*	"	*m z*	*b m*	"	"	"	"	*b c m*	*b m*	"	*b*
27	*b*	"	"	*b m z*	"	"	"	"	"	"	*b z*	*b m z*
28	*m z*	"	*b m z*	"	"	*b z*	"	"	"	"	*b q z*	"

NOTES TO FEBRUARY RECORD.

1st. 3 A. M. aurora between S. E. and N. W., passing through south.

2d. A ptarmigan shot.

3d. Two reindeer seen; ascertained the water space in Bellot Straits for one mile east and west.

4th. A seal and a dovekie seen in the open water.

8th. 8 P. M. aurora in the S. W.

9th. Some ptarmigan seen.

12th. Two reindeer and several ptarmigan seen; a sooty fox caught; halo round the moon.

13th. Two ptarmigan seen; halo round the moon.

17th. 8 A. M. the early travelling parties left the ship; fifteen ptarmigan shot.

19th. 10 P. M. aurora from south to north through the zenith.

20th. Nine ptarmigan shot; 11 P. M. faint aurora from south to zenith.

21st. Thermometer against a black surface exposed to the sun showed zero; [exposed against the ship's side, —0.5°.]

23d. 2 A. M. very bright aurora from N. E. to S. W.; at 4 A. M. slight aurora in the east; four ptarmigan shot; one white fox caught.

24th. Two white foxes caught.

25th. A white fox caught.

26th. A hare seen; 11 P. M. until midnight, aurora from north to south through zenith.

27th. A fox caught.

March, 1859. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.
1	*b z*	"	"	"	*m z*	"	*b m z*	*b*	*b c*	*b m*	"	*b*
2	*b*	*b c*	"	"	"	"	"	"	"	"	*m s*	"
3	*m s*	"	"	"	*m z*	*m*	*m z*	*b m*	*b c*	"	*b m*	*b s*
4	*b c*	"	*b*	"	*b c*	*b*	"	"	"	"	"	"
5	*b*	*b c*	"	"	"	"	*b*	*b c*	"	"	*b*	"
6	*b*	"	*b c*	"	*o m*	"	*m s*	*b m*	*b c m*	"	*b*	"
7	*b*	"	*b c*	"	*b m*	*m z*	"	"	"	*m s*	"	"
8	*m s*	"	"	"	"	"	*b m c*	"	*m s*	"	"	"
9	*m s*	"	*b c*	"	*o m s*	"	"	*m s*	*b c*	*b m*	"	*c m*
10	*b c*	"	"	*b m*	*b*	"	"	"	*b c*	"	*b*	"
11	*b z*	"	*m z*	*b m z*	"	*b z*	"	"	*b m z*	*b m z s*	*b m z*	*b c m z q*
12	*b m z q*	"	"	"	"	"	"	"	"	"	"	*b m q*
13	*b c q*	"	"	"	*b c z*	*b c q*	*b c z*	"	"	*b m*	*b*	"
14	*b*	"	"	*b c*	"	"	*b*	"	"	"	"	"
15	*b*	"	*b c z*	*o z*	"	"	"	"	*b m z*	"	"	*b m*
16	*b m s*	"	*b c*	*o m s*	"	"	*m s*	*b m*	*b m s*	*b m*	*c s*	"
17	*b c*	*b c z*	*m z*	"	*b c z*	"	*b c z*	"	"	"	*b c*	*b m c*
18	*b m z*	"	"	*b z*	"	"	*b m z*	"	"	"	*b m*	"
19	*b m*	"	"	"	"	"	*b*	"	"	"		"
20	*b*	"	*b c*	*b*	*b m*	"	"	"	"	"	"	"
21	*b m*	*b c*	*b*	"	"	"	"	"	"	"	"	"
22	*b*	"	"	"	"	"	"	*b c*	"	"	"	*b m*
23	*b m*	*m s*	"	*b c*	*b*	"	*b c*	"	"	*o c*	"	"
24	*o c*	"	"	"	*c*	"	"	*b m*	*b c*	"	*b m*	"
25	*b m*	*m s*	"	"	"	"	*o s*	"	"	"	*m s*	"
26	*m s*	"	"	"	*m*	"	*b c*	"	"	*m*	*b c*	"
27	*b c*	"	*c*	*b c*	"	"	*b m*	"	*b c*	"	"	"
28	- - -	*b c*	- - -	*b*	- - -	"	- - -	*b c*	- - -	*f*	- - -	*b*
29	- - -	*m*	- - -	*b c*	- - -	"	- - -	"	- - -	"	- - -	*b*
30	- - -	"	- - -	"	- - -	"	- - -	"	- - -	"	- - -	"
31	- - -	"	- - -	"	- - -	"	- - -	"	- - -	"	- - -	"

NOTES TO MARCH RECORD.

2d. Seven ptarmigan and one hare shot.

3d. Noon, Captain Young and party returned.

4th. Twelve ptarmigan shot.

5th. Frost smoke in Prince Regent's Inlet.

6th. A white fox caught, a reindeer seen, a ptarmigan shot; 9 P. M. a narrow band of aurora from N. N. W. to S. S. E. through zenith—a well-marked divergence of leaves of gold electrometer.

10th. Nine ptarmigan shot; one hare seen.

14th. Noon, Captain McClintock and party returned.

15th. 2 A. M. a lunar halo; two ptarmigan shot.

18th. 9 A. M. Captain Young with two dog sledges left for Fury Beach; 1 P. M. Dr. Walker with a party started to bring in depot from Cape Airy.

19th. Two bears seen, and two ptarmigan shot.

20th. A hare seen; a white fox caught.

21st. A hare seen.

22d. A hare seen and a white fox caught; several ptarmigan seen.

23d. A hare seen and a ptarmigan shot; a lemming caught; Bellot's Straits entirely free from vapor.

24th. A ptarmigan shot; a white fox caught; a bear seen.

25th. 10 A. M. Dr. Walker and party returned.

26th. Two hares seen.

28th. A hare and a ptarmigan shot; 8 P. M. Captain Young and party returned from Fury Beach.

30th. A parhelion on each side of the sun; a ptarmigan shot and a hare seen; at midnight aurora seen between land to W. and S. W. and observer.

31st. 11 P. M. aurora in west seen between land and observer.

April, 1859. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	5h.	8h.	Noon.	4h.	8h.	11h.
1	*b c*	"	*b z*	*b c z*	*b g z*	"
2	*b q z*	*b z*	*b*	"	"	"
3	*b s*	*b*	*b c*	*c*	*c m s*	"
4	*c m s*	*c s*	"	*c*	"	*b c*
5	*c m*	"	*b c*	*b*	"	*b c*
6	*b z*	*b c*	*b c z q*	*b c*	"	"
7	*b c*	"	"	*b*	"	"
8	*b v*	*b*	"	*b c*	"	*b*
9	*o*	*g o*	*b c*	"	*o s*	"
10	*c*	*b c*	*b z*	*b c z*	*b c*	*b*
11	*b*	"	"	"	"	"
12	*b*	"	"	"	"	"
13	*b*	"	"	"	"	"
14	*o c*	"	*b c*	"	*b*	*b c*
15	*b c*	"	"	"	"	*b*
16	*b*	"	"	"	*b c*	*o*
17	*o*	"	*o c z*	"	*o c*	*o z*
18	*o z*	*o s z*	*o c s z*	*o s z*	*b c s z*	*o s*
19	*o*	*o z*	*b c*	*b*	*o c*	"
20	*o c*	*b*	*b c*	"	"	*o z*
21	*o*	"	"	*b c*	*b c z*	*o z*
22	*o*	*b*	*o s*	"	"	*b*
23	*o*	*b*	*b c*	*b z*	*b c z*	*b m z*
24	*b z*	"	*o s z*	*o*	*b c*	*b m*
25	*b m*	*b z*	*b*	*b v*	"	"
26	*o*	"	"	*b*	*b o c*	*o c*
27	*b*	*o c*	*b c*	*o*	*o c s*	*o s*
28	*o s*	"	*o c*	*b c*	*o c s*	*o s*
29	*b c*	*b*	*b c*	"	*o c s*	*o*
30	*o s*	"	"	"	*m o s z*	"

NOTES TO APRIL RECORD.

1st. A fox caught; $10^{h.}$ $20^{m.}$ P. M.; Captain McClintock and party left the ship, also Lieutenant Hobson and party for long spring journey to the southward.

4th. A white wolf prowling about the ship.

6th. Travelling party detained by weather.

7th. A hare seen; 9 A. M.; Captain Young and party left ship for search of Prince of Wales' land; a lemming caught.

8th. A hare seen; Bellot Straits quite free from vapor; two ptarmigan shot.

9th. Noticed a second space of water in Bellot Straits, smaller and about two miles further west than first.

10th. A hare seen.

11th. A hare seen; thickness of ice formed since Oct. 3d, 6 feet 2 inches.

13th. A raven seen.

15th. Bellot Straits entirely free from vapor throughout the day.

20th. A hare seen.

21st. A hare seen; prismatic parhelion and part of halo on each side of the sun distant about 22° 30′.

23d. A raven seen.

26th. Two hares seen.

27th. A hare seen.

28th. A bear and two cubs seen.

[No aurora reported.]

May, 1859. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	5h.	8h.	Noon.	4h.	8h.	11h.
1	*b z*	"	*o c m z*	*b c z*	*b z*	*b c*
2	*b c z*	*b m z*	"	*m o s z q*	*b z q*	"
3	*o z*	"	*b c z*	*b c z q*	*b c m*	*o m s*
4	*o m*	"	*b*	*b v*	*b v*	*b*
5	*m o z*	*o m*	*o c m s*	*o s*	*b c*	"
6	*o*	"	*o m s*	*b c s*	*b c*	*b*
7	*m o*	"	*o c*	*b c*	*b q*	*b q z*
8	*o*	"	*o z*	*o s z*	*o s*	"
9	*o z*	"	*b c z*	*b c*	*b c*	"
10	*b c*	"	*b o*	*b o c*	*b o*	"
11	*b*	"	"	*b o*	"	*b*
12	*b*	"	"	*o c*	*o*	"
13	*b*	"	*b c*	*o*	"	"
14	*o s*	"	*o*	*o s*	*o s*	*o s*
15	*b*	"	*b c o*	*o*	*o c*	"
16	*b*	"	*b c*	*b z q*	*b c z q*	*b c q*
17	*b*	"	*b v*	*b c v*	*b*	"
18	*o s*	"	"	"	*b*	"
19	*o s*	*b*	*b c*	"	*o s*	*o*
20	*o s*	"	*b c z*	*b c z q*	*b c z*	*o c s*
21	*o s*	"	*b*	"	"	*b c*
22	*o m*	"	*b c*	*o c*	"	*o s*
23	*o s*	"	"	*o*	*o s*	"
24	*o s*	*o*	*o c s*	*o s*	"	*b c*
25	*b z*	*b q*	*o c q*	*o q*	*o*	*b c*
26	*b*	*o*	*b c q*	*b c*	"	*o*
27	*o*	"	"	"	"	"
28	*o*	*o s*	"	*o c*	*b c*	*o s*
29	*o s*	"	*b c*	"	"	"
30	*b c*	"	"	"	"	"
31	*o s*	*o s m*	"	*o s*	*b c*	"

NOTES TO MAY RECORD.

1st. Prismatic parhelion and part of halo on each side of the sun, distant about 23°.

3d. Two ravens seen. The water space in Bellot Strait much increased in extent.

4th. A white wolf seen.

5th. Parhelion and part of halo on each side of sun.

6th. Prismatic parhelion and part of halo on each side of sun distant 22° 20′ (observed).

9th. Two hares seen; also recent tracks of a small herd of deer.

10th. Five hares seen.

11th. Ice formed since Oct. 3d, 1858, 5 feet 4 inches; several hares seen.

12th. Four hares seen. Two small pools of water noticed in the strait between Fox Island and south shore.

13th. Two hares seen; 8 P. M., fine snow falling.

14th. A young bear shot; tip to tip 6 feet 1 inch.

15th. Two hares seen.

16th. Two hares seen; part of Captain Young's party returned.

17th. Two hares seen and two snow buntings shot.

18th. Two hares and some buntings seen.

19th. Three seals and one wolf seen.

21st. A snow bunting seen; a long lane of water seen to the E. N. E. in Regent's Inlet.

22d. Ice loosened from ship's sides, allowing her to rise 2 feet 4 inches forward and 3 inches aft; two hares seen; also recent tracks of seven deer going northward.

28th. A deer seen; two others crossing ice to northward.

29th. A fox seen; also several buntings shot; three burgomasters seen flying north.

30th. One bunting seen, one finch shot; four men and sledge started for Pemmican Rock to join Captain Young.

June, 1859. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	5h.	8h.	Noon.	4h.	8h.	11h.
1	*o m s*	"	*m o s z*	"	*b c m*	*b c m z*
2	"	*m o z*	*b c z*	"	"	*o c*
3	*o c*	"	*b c*	"	"	"
4	*b c*	"	"	*b*	*b c*	"
5	*o*	"	*b c*	*b*	"	"
6	*o*	*b c*	*o c*	*b c*	*b o*	"
7	*b o*	*b*	*o c*	"	*o*	*b v*
8	*b c*	"	"	"	*o c q*	*m o q*
9	*b c*	*o*	*b c*	*o c*	*m o r*	*b c*
10	*b c*	"	"	"	*b*	"
11	*b c*	"	"	"	*b c q*	*b c v q*
12	*b*	"	*b v*	"	"	*b*
13	*b*	"	*b v*	*b*	"	"
14	*b*	"	"	"	"	"
15	*b*	"	"	"	*o c*	*m o r*
16	*o*	"	"	"	"	*b c*
17	*b*	"	*b c*	*b*	*o f*	"
18	*o*	*o r*	*c r*	"	*m o c*	*b c*
19	*b c*	"	*o c*	*o f r*	*b c*	"
20	*o*	"	*b c*	*o r*	"	"
21	*o*	"	"	*c*	*m o c*	*c*
22	*b c*	"	*o c*	*b c*	"	*o c*
23	*o c*	*b c*	*m o s*	"	*o*	*b c s*
24	*b c*	*o m*	*b c*	"	"	*o c*
25	*b c*	"	"	"	"	"
26	*b c*	"	"	"	"	"
27	*o s*	*o*	"	*b c*	"	"
28	*b c*	"	*b*	"	"	"
29	*b c*	*o*	*o c s*	*o c*	*b c*	"
30	*b c*	"	"	"	"	"

NOTES TO JUNE RECORD.

2d. A bunting seen.

3d. Some gulls, a bunting, and a raven seen; black bulb thermometer in sun's rays, 93° in maximo.

4th. Some geese, gulls, and bunting seen; a bear came near the ship; a fox shot alongside.

5th. Some bunting and a gull seen; some small pools of water to eastward of Fox Island, in the course of current of straits; several pools of water to E. N. E. and N. E. in Regent's Inlet.

6th. Measured height of mountain ahead of harbor—1120 feet (aneroid); a small cairn on top.

7th. Captain Young returned on board; a raven, several ducks, and bunting seen; three reindeer crossing the ice to northward; remainder of Captain Young's party returned.

9th. A deer, a hare, and a fox seen; also some buntings and sandpipers.

10th. A deer, some gulls, buntings, and sandpiper seen; some buntings and sandpiper shot; Captain Young and party left the ship.

11th. Several buntings and gulls seen.

12th. Two sandpipers shot.

13th. First plant in flower (*Saxifraga oppositifolia*); a fox caught, and some buntings shot; a deer, a hare, some geese, gulls, and duck seen; ice formed since Oct. 3, 4 feet 6 inches.

14th. Lieut. Hobson and party returned on board, bringing documents and relics of Franklin's expedition from west side of King William's Land; some duck and sandpipers seen.

15th. Maximum, black bulb thermometer in sun's rays, 96°.5; three sandpipers shot; some gulls seen.

16th. Two long-tailed ducks and two sandpipers shot; some ducks and gulls seen.

17th. Many ducks and gulls seen, also one seal; one king and two long-tailed ducks shot.

18th. Several ducks and one seal seen.

19th. Captain McClintock and party returned on board, bringing relics of Franklin's expedition obtained from natives on east coast of King William's Land, and picked up on Montreal Island and south shore of King William's Land; a bear, seal, and some duck seen.

20th. Two ducks shot.
21st. One seal shot.
22d. Twelve ducks and one hare shot; seal seen.
23d. Five ducks and one red-throated diver shot; a seal seen.
24th. Four ducks and four deer seen.
25th. One duck and one diver shot.
26th. One duck shot.
27th. One duck and one plover shot; two deer seen.
28th. Four plover shot.
29th. One deer seen; two ducks shot; one ermine caught.
30th. Several geese seen, and a duck shot.

July, 1859. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	2h.	4h.	6h.	8h.	10h.	Noon.	2h.	4h.	6h.	8h.	10h.	Mid't.
1	- - -	o m	- - -	o c	- - -	b c	- - -	"	- - -	b	- - -	b c
2	- - -	b c	- - -	"	- - -	"	- - -	b	- - -	b c	- - -	"
3	- - -	o	- - -	b c	- - -	"	- - -	b	- - -	"	- - -	"
4	- - -	b	- - -	b c	- - -	"	- - -	b	- - -	"	- - -	"
5	- - -	o m	- - -	b c	- - -	"	"	"	"	c	"	"
6	c	o r	o c	"	c	b c	"	o r	o c	o c r	b c	"
7	b c	o c	"	"	"	"	b c	"	o c r	o m r	o s	"
8	o m s	"	o c	b c	o c	"	c	o c	o r	"	o c	o r
9	o r	o c	"	r	o c	b c	"	"	"	"	"	"
10	c	"	o c	"	"	o c q	o c q r	"	"	"	"	"
11	o c r	b c	"	o c	"	"	"	"	"	b c	"	"
12	b c	"	"	"	"	o c	"	"	"	o c	o m r	o c
13	b c	"	o c	"	"	c	o c	"	"	"	"	r
14	r	b c	"	"	"	"	"	"	"	"	o c	"
15	b c	"	o c	"	"	"	b c	"	"	"	"	"
16	b c	"	"	"	b c s	b c	"	"	"	"	"	"
17	b c	"	"	"	"	"	"	"	"	c	b c	"
18	b c	c	o c	"	o c q r	o m s	o c	"	"	b c	"	o c r
19	o m r q	o c q	o c	"	b c	"	"	"	b	b c	"	"
20	b c	c	b c	"	"	"	b	b c	"	"	b	b c
21	b c	"	"	"	"	"	"	"	"	"	b	"
22	b	"	"	"	"	"	"	"	"	"	"	"
23	b	"	"	b m	"	"	"	"	"	"	"	"
24	b c	b	b m	b	"	"	b c	"	"	"	"	"
25	b c	b	"	"	b c	"	b	"	"	b c	"	"
26	b c	"	"	"	"	"	"	"	c	r	"	"
27	c	c r	b c	"	"	"	"	"	"	"	"	"
28	b c	"	"	"	"	b	"	"	b c	"	"	"
29	b c	"	"	"	"	"	"	"	"	"	"	"
30	b c	"	"	"	b	"	b c	"	"	b	b c	"
31	b c	"	b	"	b c	"	"	"	c	"	"	m c

NOTES TO JULY RECORD.

2d. Two ducks and two divers shot.
3d. Four ducks and two gulls shot.
4th. Three ducks and one seal shot.
5th. Commenced tide observations; one duck, one diver, and a silvery gull shot; an ermine seen.
6th. Two hares seen.
7th. A gull shot and lemming caught; several seals seen on the ice.
11th. A seal and a duck shot; the water has much increased in Bellot Straits.
12th. Several lanes of water seen in Regent's Inlet; two seals shot.
13th. One seal shot.
14th. One hare shot, and an ermine seen.
15th. Three seals shot.
16th. Two ducks shot.

17th. A fox seen.

18th. A seal shot, and another taken from a bear; a gull and a duck shot.

24th. An usuk seen.

25th. Several flocks of ducks flying eastward.

26th. Bellot Straits clear of ice as far as Western Head.

27th. Ice breaking up around the ship; 11 gulls shot.

28th. A large extent of harbor ice commenced driving out.

29th. Drifted with harbor ice, to which the ship is attached, between the Fox Island and the main, until 2 A. M., when the ice was brought up by the land and shoals; 4 A. M., western current ceased; 5 A. M., ice commenced drifting eastward; 9 A. M., made sail to a light S. W. breeze; $9^{h.}$ $45^{m.}$ got clear of the ice, and proceeded into Port Kennedy; 11 A. M., anchored in 6½ fathoms off Observation Point.

30th. Ice breaking away from head of harbor; outer harbor almost clear; $11^{h.}$ $30^{m.}$, harbor ice drifted foul of the ship; several gulls shot.

31st. Two gulls and one duck shot.

August, 1859. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	$4^{h.}$	$8^{h.}$	Noon.	$4^{h.}$	$8^{h.}$	Midnight.
1	*m c*	"	*o*	"	"	"
2	*c o*	*o r*	*o m r*	*m r*	*m*	*o r*
3	*o r*	*r*	*o c*	"	"	*b c*
4	*o c*	*b c*	"	"	"	*b*
5	*b*	"	*o c*	"	*b c*	*b*
6	*b c*	*b*	*b c*	"	"	*c*
7	*o c*	*c*	*o c*	*b c*	"	"
8	*o c*	"	"	"	"	*m*
9	*m s*	"	*b s*	*b c m*	"	*m s*
10	*o c s*	*c*	*o m*	*b c*	"	*o c*
11	*c*	*o*	*o c*	*c*	*o c*	*o c r*
12	*o c r*	"	*b c*	*o c q r*	*o r*	"
13	*o r q*	*o q*	"	"	"	*o r q*
14	*o r*	*o r*	"	*m r*	*f*	*m r*
15	*m*	*m r q*	*o c q*	*b c q*	"	*b q*
16	*b*	*c*	*b c*	*f*	*m c*	*f*
17	*f*	*b*	"	"	"	"
18	*b*	"	"	*f*	*b m*	*b*
19	*b m*	*b c*	"	*b*	*b m*	"
20	*o c*	*b c*	"	*f c*	*m c*	"
21	*o c*	"	*c*	*o c*	*o m*	*o s*
22	*o c*	*c*	"	*b c*	"	"
23	*b c*	"	"	"	"	"
24	*b c*	"	"	*b m*	*c s*	*m r s*
25	*b c*	"	"	*c*	*o m r*	*o c s*
26	*o s*	*o c*	*b c*	"	*b*	"
27	*b*	"	"	"	*b c*	"
28	*b c*	*b*	"	*b c*	"	"
29	*b c*	"	"	"	*b*	"
30	*b*	"	*b c*	"	*b*	"
31	*b*	"	"	"	"	"

NOTES TO AUGUST RECORD.

1st. One seal and fifteen ducks shot; also two gulls.

3d. $4^{h.}$ $30^{m.}$ A. M., thunder.

4th. Bellot Straits and Port Kennedy clear of ice.

5th. A seal shot.

6th. A deer and two seals shot.

7th. Harbor full of drift ice.

8th. Ice stationary; 8 P. M., ice setting into the harbor.

9th. 10h. 30m. A. M., weighed and proceeded out of the harbor under sail and steam; noon, passing south end of Long Island; 1h., passed between Brown's Island and off Lying Islet southeastward; 2h. 30m., off Hazard Inlet; 8h., off Mt. Oliver; 8 to 12, steering between pack and land.

10th. 4 A. M., steaming past Cape Garry; Creswell Bay clear of ice; 11h. 25m. A. M., made fast to grounded ice in 3 fathoms, 3 cable lengths off shore of Adelaide Bay; Fury Point 2′ E. by N. (true); a seal and several dovekies shot; white whales, ducks, and mollymauks seen; pack closing in; low water 3 P. M.; ebb sets to S. W. along land; high water near midnight; rise 7½ feet.

11th. A white whale shot, 13 feet 2 inches long; pack closing in Cresswell Bay.

12th. Ice driving to southwestward; no water visible in Cresswell Bay or in N. E.; a seal seen; tide flowed until midnight; water rose 10 feet.

13th. Pack in offing driving southwestward; (4 A. M.) no water visible from mast-head, except inside the space into which we are lying; a small seal and some dovekies shot; many king ducks flying northward; high water at 12h. 30m.

14th. 4 A. M., pack driving to southwestward; many ducks flying northward.

15th. Tide flowed until about 1h. 20m. A. M.; at 5h. 45m. P. M. Fury Beach bore W. (true) three miles distant.

16th. 2h. 45m. A. M., off Batty Bay, free from ice; 9 A. M., off Elwin Bay; 3h. 30m. P. M., Cape Sepping N. W. ½ W., distant 6′; ice seen extending from Leopold Island eastward.

17th. A black whale and some narwhals seen; Barrow Strait clear of ice as far as visible; 8 P. M., passed a small sheet of ice.

18th. Many narwhals about the ship; passing stream of loose ice; 9h. 30m P. M., passing Admiralty Inlet; some pack or stream ice seen in shore.

19th. 4 A. M., two miles off Wollaston Island; running among loose ice; midnight (19–20), passing round Cape Byam Martin, distant 4′.

20th. Noon, off Cape Burney, distant 1½′; a bear and two cups shot; 6 P. M., off Cape Graham Moore.

21st. No floe ice visible.

22d. Some rotchies seen; passed several bergs.

23d. 75 bergs in sight; saw some stream ice in eastward.

24th. A few bergs in sight; 9 P. M., saw the land about Swarte Hook.

25th. A finback whale seen; rotchies seen.

26th. Saw the land about Mellem Fiord; 4 P. M., off Disco Fiord.

27th. 2 A. M., anchored in Godhavn Harbor in 7½ fathoms.

Specific gravity of sea water—

21st. 1.0278.	24th. 1.0270.
22d. 1.0275.	25th. 1.0265.
23d. 1.0262.	26th. 1.0275.

31st. [Aurora slight in S. W. (true) at 11 P. M.—*B. of T. Papers.*]

September, 1859. RECORD OF THE WEATHER KEPT ON BOARD THE YACHT FOX, WITH GENERAL REMARKS.

DAY.	4h.	8h.	Noon.	4h.	8h.	Midnight.	Specific Grav. of Sea Water, 1.0
1	*b c*	"	*b*	*b c*	"	*c*	
2	*o c*	*c*	*b c*	"	"	"	280
3	*o c*	*c*	*b c*	*o c*	*o m*	*o c*	272
4	*o*	*o c*	"	*o c*	"	"	268
5	*b c*	*o c*	"	"	*b c*	*b*	268
6	*c m*	*o c*	*o c r*	*o c q*	*b c*	"	282
7	*p*	"	"	*b c*	"	"	282
8	*b c*	"	"	"	*c*	*b c*	285
9	*o c h*	*c*	*b c*	*c*	*b c*	"	300
10	*b c h*	"	"	"	*b c*	"	300
11	*b c*	*b c h*	"	"	*b c*	*b*	290
12	*o r*	*o r q*	"	*o m*	"	*b c*	275
13	*o f*	*o f r*	*f*	*f r*	*o f r*	*f r*	275
14	*o f r*	"	"	*o m*	"	*c m*	275
15	*o c*	*c*	*b c*	*o c*	*o c q*	*b c*	285
16	*b c q*	*b c*	*o c*	*b c*	*c*	*b c*	290
17	*o m*	*o c*	"	"	*c*	*o c*	
18	*o r*	*o r*	"	*o m r*	*o r q*	*o c*	

NOTES TO SEPTEMBER RECORD.

1st. Proceeded out of Godhavn; two whales seen.
2d. Passed several bergs.
3d. Bergs seen.
4th to 5th. Midnight; six bottle-nosed whales seen.
6th. Bergs in sight; passed a drift pine log; midnight, slight aurora in S. E.
7th. Bergs passed; a finner seen; midnight, aurora in S. W.
8th. Bottle-nosed whale seen.
9th. Passed piece of drift pine.
10th. [Aurora, 10 P. M., in N. E.—*B. of T. Papers.*]
15th. Porpoises seen.
18th. 8 P. M., sounded in 86 fathoms.

TABULATION OF AURORAS, WITH OBSERVATIONS AND NOTES, BY DR. DAVID WALKER.
(Copied from the log-book.)

DATE.	True Direction of Aurora.	DATE.	True Direction of Aurora.	DATE.	True Direction of Aurora.
		1858.		1858.	
1857.		March 2	* S. W. by S. to E.	Dec. 8	S. E'd.
Oct. 30	S. to S. S. E.	4	S. to W. N. W.	12	* N. W. to S. E. through S.
Nov. 7	* S. E.	5	S. W. by S. to N. W.		
8	N. N. E. to N. N. W.	6	S. S. W. to E.	13	* S. S. E. to W. S. W.
9	* E. to S.	8	S. E.	14	* E. S. E. to N. W.
9	S. E.	16	* S. by W. to N. E.	15	N. W. through S. to E.
11	* N. W. to S. E.	17	* S. W. to E. N. E.	24	All over the heavens.
Dec. 9	E. N. E. to E. S. E.	18	* S. by E. to E. N. E.	28	* W. by N. to S. S. E.
10	S. to zenith.	April 9	* E. to N.	30	S'd.
12	N. W.	10	* S. to E.	1859.	
13	N. E. to S. E.	11	* E. to S. E.	Jan. 1	* W. to S.
14	E. to N. E.	12	* E. by S. to W. S. W.	2	* S. W'd.
15	S'd.	13	* E. to W. S. W.	3	S. E'd.
17	* S. to N. E. and E. to N.	14	* E. to S.	8	W. S. W. to S. E.
18	E. to W.	15	* E. to S.	9	* W. to N. W.
1858.				9	N. to S. through zenith.
Jan. 9	N. W. to S. E. and all round horizon.	Oct. 28	* S. to W.	10	* N. W. to S. E. by S.
		29	* S. S. E. to W. N. W.	10	N. to S. through zenith.
11	S. W.	30	* S. W'd.	11	* S. E. to W.
12	S. to E.	31	* N. W'd.	31	* N. W. to S. E. by S.
17	S. to E.	Nov. 6	S. by E. to W. S. W.	31	W. to S. E. to zenith.
Feb. 2	* S. E. to E. N. E.	7	* S. W.	Feb. 1	* N. W. to S. E. by S.
3	S. E. to zenith.	8	* S. W.	8	* S. W'd.
7	* S. S. E. to N.	9	* S. to W.	19	N. to S. through zenith.
9	* N. E. to S. E.	12	N. to zenith.	20	S. to zenith.
13	S. S. E. to E.	14	* S. W. to W. N. W.	23	N. E. to S. W.
15	S. S. E. to E. N. E.	Dec. 3	* S. W'd.	26	N. to S. through zenith.
16	S. E. to N. N. E.	4	E. through S. to W. N. W.	March 6	N. N. W. to S. S. E. through zenith.
17	S. S. W. to S. S E.				
18	S. S. E. to E.	5	* S. E. to N. W.	30	* W. to S. W.
19	S. S. E. to N. E.	6	* S. E. to W.	31	* W.

"During our drift down Baffin's Bay and Davis' Straits (1857–'8) the aurora was noticed on 43 nights; of these, 18—marked with an asterisk—were observed in a direction where water or water sky had been seen during the day. The general direction of the remainder was between N. E. and S. E. None were particularly bright but two or three, and even these scarcely equalled the brilliancy of those seen at times in the north of Scotland. On some occasions the aurora was from horizon to zenith, but generally from 10° to 40° above the horizon, with occasional streamers; these latter were generally present towards the zenith, but only sometimes reaching so far. At times pulsations were noticed in the patches and bands of light; these were often contrary to the surface wind. On the whole stars of all magnitudes were dimmed when viewed through the aurora, but only those of small magnitude were rendered invisible. Once only was there noticed a connection between cirrous clouds and the aurora.

"Of the 42 auroras observed during our winter at Port Kennedy (1858–'9) 24—marked with an asterisk—were in a direction of a space of water, open throughout the winter, or of the vapor rising from it. More than this number might be traced to it, but of these 24 I am certain. On the nights of the 30th and 31st March, 1859, I noticed the aurora between myself and the land; the patches of light could plainly be seen a few feet above the small mass of vapor arising from the water. The opposite land was from two and a half to three miles distant, and I am confident, if this land had been sufficiently high, the most of these 24 auroras would have been seen suspended but a short distance above the surface of the water or ice. On five occasions the aurora was observed to cause agitation of the magnectic needle; on one of these, Dec. 24, 1858, I noticed a vibration of 15°; on the other four times the vibration was not much more than a degree; four of these five occurred when the aurora was from south to north, passing through the zenith. A fine wire was attached to the fore yard-arm by insulated supports and led to a snow house with a connection through the floe to the water beneath. Here the gold leaf electroscope was at times applied, and I was enabled to observe the presence of the electricity in the atmosphere and also the influence of the aurora on the instrument. There appeared to occur two periods of minimum electric intensity about 9 P. M. and noon; the instrument not being sufficiently delicate I could not be satisfied about the time of the maximum. On the whole there seemed to be more fur electricity present in the air at Port Kennedy than Baffin's Bay or Davis' Strait. On six occasions in 1857–'8 I observed a well-marked effect on the electroscope by the presence of aurora, the gold leaves diverging with greater force and remaining so for a longer time than usual. On three occasions at Port Kennedy, when the aurora was from horizon to zenith, the electroscope was strongly affected; on all these occasions the electricity was positive."

[D. W.]

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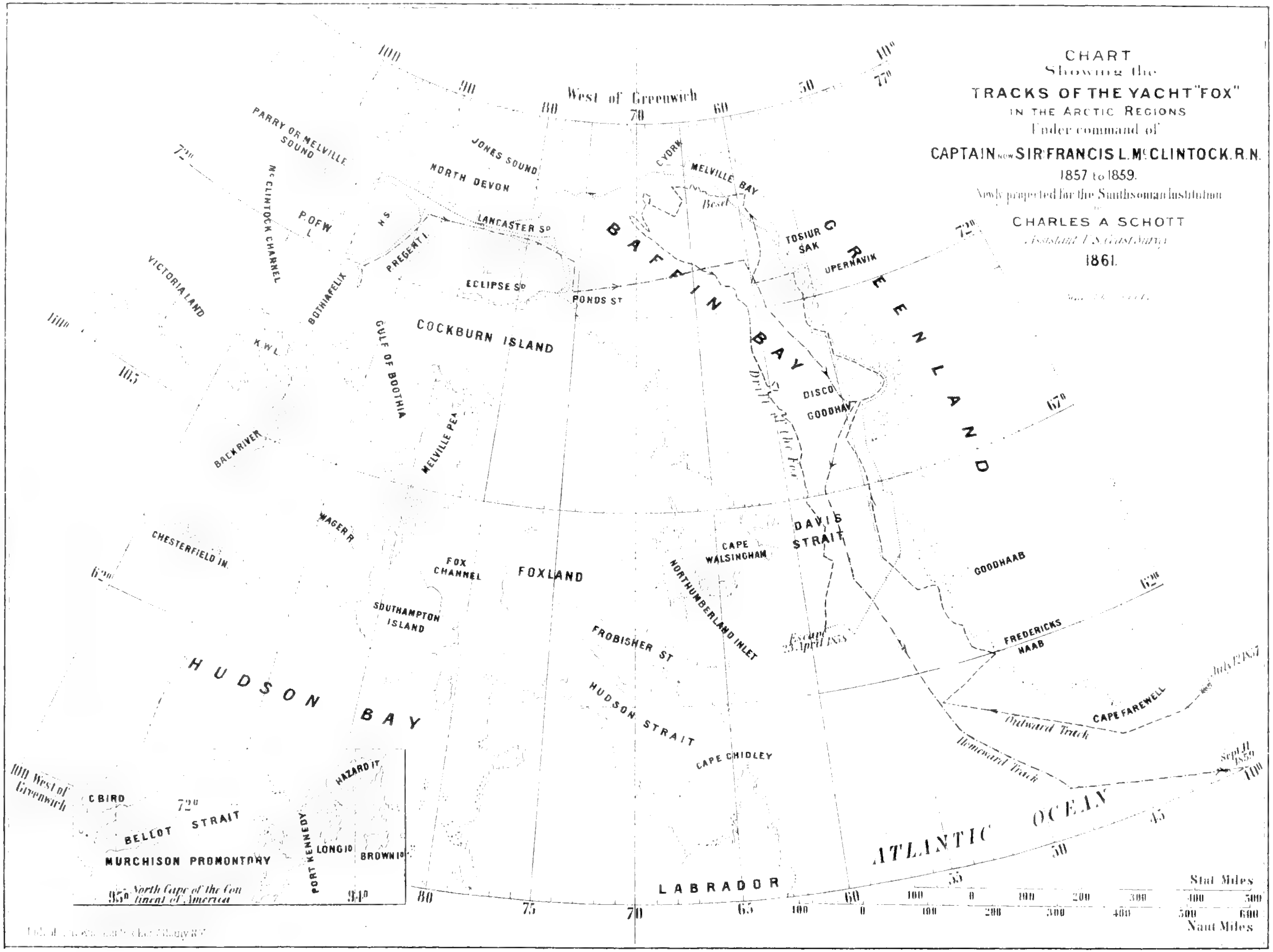
CHART
Showing the
TRACKS OF THE YACHT "FOX"
IN THE ARCTIC REGIONS
Under command of
CAPTAIN now SIR FRANCIS L. McCLINTOCK R.N.
1857 to 1859.
Newly projected for the Smithsonian Institution
by
CHARLES A SCHOTT
Assistant U.S. Coast Survey
1861.



SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

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ANCIENT MINING

ON THE

SHORES OF LAKE SUPERIOR.

BY

CHARLES WHITTLESEY.

[ACCEPTED FOR PUBLICATION, APRIL, 1862.]

COMMISSION

TO WHICH THIS PAPER HAS BEEN REFERRED.

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ANCIENT MINING ON THE SHORES OF LAKE SUPERIOR.

PRELIMINARY REMARKS.

The evidences of ancient mining operations within the mineral region of Lake Superior were first brought to public notice in the winter of 1847–8. Although the Jesuit fathers frequently mention the existence of copper, and even use the term *mines*, it is clear, from the general tenor of their narratives, that they neither saw nor knew of any actual *mining* in the technical sense of that word. They announced as early as the year 1636 the presence of native copper, and refer to it as having been taken from the "mines." This was prior to the time when they had themselves visited the Great Lake, and their information was derived from Indians. At the same time they speak with equal certainty of mines of gold, *rubies, and steel;* but it must be borne in remembrance that the French word is not equivalent to our English *mines*, but may be more correctly rendered veins or deposits of metals or ores.

In the "Relacions" for 1659–60, after missions had been established on Lake Superior, the region is reported to be "enriched in all its borders by mines of lead almost pure and of copper all refined in pieces as large as the fist, and great rocks which have whole veins of torquoise." It is probable that these accounts are second hand and such as the Chippeways gave when they exhibited to the fathers specimens of native metal in the shape of water-worn pieces and small boulders.

Boucher, in the "Histoire veritable," &c., in 1640, asserts that "there are in this region, mines of copper, tin, antimony, and lead." He speaks of a great island fifty leagues in circumference, which is doubtless the one now called Michipicoten, where "there is a very beautiful mine of copper." Copper was also found in other places in large masses "all refined;" in one instance an ingot of copper was discovered which weighed more than 800 pounds, and from which the Indians cut off pieces with their axes after having softened it by fire. All this information Boucher obtained from some French traders, and not from his own observation. Such is the tenor of the historical accounts from the time of Lagarde in 1636 to Charlevoix in 1721.

Detached and water-worn lumps of copper have been found in great numbers in the gravel, clay, and loose materials that cover the rocks, from the days of the Catholic fathers to this time, not only in the mineral region but over a large space to the southward of it. All these pieces were originally from veins, but have probably been separated by the same cause that gave rise to that formation which geologists call the "drift."

The agent, whatever it was, that broke off fragments from the rocks, not only on Lake Superior but further north, and transported them in the shape of boulders, sand, and gravel, as far south as the valley of the Ohio, also bore along the contents of the mineral veins which those rocks contained. Pieces of native copper are well calculated to resist the severe attrition to which transported materials are subjected. Masses of it have been found not far removed from the mineral range, weighing 3000 lbs., and others at a greater distance have been taken from the beds of rivers and from the beach of the lake weighing 1500 and 800 pounds. Others again of less size have been recovered from the gravel of the Menominee River, near the shores of Green Bay, and at Sheboygan Falls near the town of Sheboygan on Lake Michigan. Professor J. Brainard, of Cleveland, has a piece weighing five or six pounds which was found five feet beneath the surface in the drift gravel of Rocky River, Medina County, Ohio.

Had the Indians, the French, or the Jesuits of early times, discovered copper on the shores of Lake Michigan or of Lake Erie, not knowing or supposing the metal could exist except in *mines*, they would probably have spoken of it as having been found in a mine. The attention of the fathers was not particularly called to the subject of mineralogy, and although they were learned men, their knowledge of geology must have been very limited, for this science had not at that time assumed a place in the schools.

As to the accounts given by savages, every one who has had much intercourse with them, knows that great allowance must be made for their want of knowledge and their tendency to embellishment and exaggeration. I have listened to many wonderful tales concerning distant mineral riches. An aged Chippeway, by the name of Kundickan, whom I met on the Ontonagon in 1845, stated that as he was one day sailing along the western shore of the Gogebic (or Akogebe) Lake, at the head of the west branch of that river, he heard an explosion on the face of a rocky cliff that overlooked the water, and saw pieces of something fall at a distance from him, both in the lake and on the beach. When he had found some of them, they proved to be a white metal, like "Shuneaw" (money), which the white man gives to the Indians at La Pointe. There are good reasons why the old missionaries should have had greater confidence in such stories than we have, and thus have given them a place in their reports to the Propaganda. But with all the influence possessed by them over the Indians, and the closeness of the ties that could not fail to exist between a priest and his converts, no instance is referred to where they were shown mining operations upon the rocks or veins.

There is nothing to show that the Indians wrought copper in mines at that time. They had no implements proper for the purpose; nor did they produce samples of metal taken from its position *in sitû*. The Indians had neither copper kettles nor axes when the French came among them; but only rudely fashioned copper knives, that were evidently beaten out from small boulders. Instead of viewing copper as an object of every day use, they regarded it as a sacred Manitou, and carefully preserved pieces of it wrapped up in skin in their lodges for many years; and this custom has been continued to modern times. I am well aware that they have a superstitious dread of showing a mineral mass or locality to a white man, believing that the Manitous will visit them with some calamity if they do so.

The missionaries, however, frequently overcame this feeling in regard to copper boulders, and could as easily have done so in regard to mines, if any such had really existed. If the Chippeways had been cognizant of the ancient works that have been recently discovered, they would have communicated this fact to their spiritual fathers, who would not have suffered so interesting a fact to be lost.

If the Indians possessed traditions from their ancestors relating to ancient mines, or the people who worked them, those must also have come to the ears of the Jesuits. With the exception of an old Chippeway chief who resided some years since at Fon du Lac (Lake Superior), I have known of no one pretending to such knowledge. The story he gives is sufficiently imaginative, and relates to mines wrought by his tribe on Isle Royale, in times long past, when his fathers were much happier, and had larger canoes than his cotemporaries have now. I place his narrative in the same category with those above noticed, as having reference to boulder copper, and not to that obtained from mining *in sitû*.

From evidences which I shall give, in describing the works in detail, it will appear that they were abandoned several hundred years before the French became acquainted with the northern tribes; no mines having been found that could have been wrought as late as the time of the earliest Jesuit. If such were wrought by Indians, it must have been at a period very remote, such as Loons Foot describes. But could the natives have lost the recollection of such a state of things? Had they ever worked mines, they must have possessed the skill to fashion the metal extracted from them into various useful forms, without which it would be of no value. Neither the skill nor the implements themselves would have been lost in a few hundred years, by a people having the same wants, and residing in the same country.

It also seems to be highly improbable that their ancestors either knew of ancient mines, not worked by themselves, or the people who wrought them. Tradition is the only history of savage nations, and the fault of this species of knowledge is not in the absence, but in the excess of materials such as they are.

Among thousands of legends which the Indians have related, nothing positive or consistent has come to my knowledge respecting the people who preceded the present Aborigines, except a tradition communicated to Major Long, in 1819, upon the Great Miami River, by an Indian chief, during his Expedition to the Sources of the Mississippi. Aside from this, I have heard of nothing coming from the Western tribes concerning the origin of the tumuli and earthworks that are so conspicuous in Ohio, Kentucky, and other Western States. As a people, if we may judge by their silence on a subject on which they may be supposed inclined to be communicative, if they had anything to tell, the aborigines have no traditionary knowledge of their predecessors, the race of the "mound builders." Neither do we find in the record of English travellers who succeeded the French in 1763 any notice of ancient mines.

Description of the Locality of the Remains of Ancient Mining Operations, &c.

In casting the eye over a map of Lake Superior, a remarkable projection, in the form of an immense horn, will be observed jutting out from the south shore, and curving to the northeast until it ends in an irregular point.

This peninsula, which is called Keweenaw Point, is about eighty miles in length, and at the place where it joins the main land forty-five miles in width. Through the whole extent of this projection a belt of metalliferous trap formation extends, differing at various points in structure, and in the character of its contents. Along this belt, which is designated on the map by dotted lines, there are exhibited, throughout nearly its whole extent, a disturbance of the strata, and upheavals comprising a series of bluffs, rising abruptly from the two streams, Eagle and Montreal Rivers.

Within this belt, all the mining operations, ancient and modern, have been chiefly confined. The most remarkable feature of the district is the character of its metalliferous products, which occur, not in the condition of an ore of copper, but exclusively as native metal. This is met with in immense masses, in veins of smaller size, and in rounded nodules. The cutting of the masses is a tedious and costly process, and in some instances, even with all the appliances of modern art, requires several months before a single mass is entirely removed from the mine. The metal is sometimes almost entirely free from foreign matter, yielding when melted down in the furnace from 90 to 95 per cent. of copper.

The first actual mining operations, within historic times, were commenced near the forks of the Ontonagon, in 1761, by Alexander Henry, but under the peculiar circumstances they proved entirely abortive. In 1841, Dr. Douglas Houghton made a report to the Legislature of Michigan, in which the earliest definite information in regard to the occurrence of native copper on Lake Superior was given to the public. Shortly after this, mining operations were commenced in this region, explorers and speculators flocked to it from all quarters, and in 1845 the shores of Keweenaw Point were whitened with their tents.

In 1846 the excitement reached its climax, after which a reaction took place, and finally only half a dozen companies out of all that had been formed continued the operation of mining in good earnest.

The first public announcement, so far as we are aware, of the remains of ancient mines in the copper region is that by Mr. S. O. Knapp, agent of the Minnesota Mining Company, in 1848. Dr. Chas. T. Jackson brought forward the subject in his Geological Report to the United States Government, in 1849, and gave some interesting details of what had been discovered up to that time. Further mention of it was made by Messrs. Foster and Whitney, in their report in 1850, and several illustrations were given. Since then our knowledge of the subject has been much enlarged by the prosecution of mining operations on the very sites of the ancient works.

It must not, however, be supposed that our information is now complete. It is by no means an easy task to discover remains buried, as those of the ancient mines of

Lake Superior are, in extensive and dense forests, where the explorer can only see a few rods, or, perhaps, yards around him, and where there is seldom anything which rises sufficiently high above the surface to attract the eye.

They are, for the most part, merely irregular depressions in the soil, trenches, pits, and cavities; sometimes not exceeding one foot in depth, and a few feet in diameter. Thousands of persons had seen the depressions prior to 1848, who never suspected that they had any connection with the arts of man; the hollows, made by large trees overturned by the wind, being frequently as well marked as the ancient excavations. Besides this, there are natural depressions in the rocks on the outcrop of veins, formed by the decomposition of the minerals, that resemble the troughs of the ancient miners, as they appear after the lapse of centuries. There is not always a mound or ridge along the side of the pits, for most of the broken rock was thrown behind, nearly filling up the trenches. A mound of earth is as nearly imperishable as any structure we can form. Some of the tumuli of the west retain their form, and even the perfection of their edges at this day. But mere pits in the earth are rapidly filled up by natural processes. Some of those which have been reopened, and found to have been originally ten feet deep, are now scarcely visible. Others that have a rim of earth around the borders, or a slight mound at the side, and were at first very shallow, are more conspicuous at present than deep ones without a border.

There are, however, pits of such size as could not fail to surprise one at first view, were not the effect destroyed by the close timber and underwood with which they are surrounded. A basin-shaped cavity, 15 feet deep and 120 feet in diameter, would immediately attract the eye of the explorer were it properly exposed. But it is not unusual to find ten and twelve feet of decayed leaves and sticks, filling a trench, and no broken rock or gravel. In such cases a fine red clay has formed towards the bottom, a deposit from water, which indicates the long period of time since the excavation was made.

From the accompanying map it will be seen that the positions of the principal ancient mines correspond to those which are worked at present. There are three groups or centres of operation in both cases, one a little below the forks of the Ontonagon River, another at Portage Lake, and a third on the waters of Eagle River. Other works are known to exist, and more will probably be found; but we have probably discovered the most important ones within the district embraced by the map.

Although the old works are not always situated upon what would be considered good veins, yet they are regarded by practical miners as pretty sure guides to valuable lodes.

In the opening of our principal mines, we have followed in the path of our predecessors, but with much better means of penetrating the earth to great depths. The old miners performed the part of surface explorers.

In giving detailed descriptions of the antiquities of the mining country, we shall commence with those most easterly, near the extremity of Point Keweenaw, and proceed along the mineral range in the order of position to the southwest. There are, however, ancient works found over a much greater space than is included in the map.

The veins on Isle Royale, and near the north shore, opposite Point Keweenaw, were extensively wrought in olden times.

In the other direction, sixty and eighty miles to the southeast, in the iron region near Marquette are remains that are also ancient, and which will be noticed hereafter.

No doubt future examinations will bring others to notice on the continuation of the mineral range to the southwest, as it extends in that direction into Wisconsin.

DESCRIPTION OF THE SEVERAL WORKS.

1st Group.

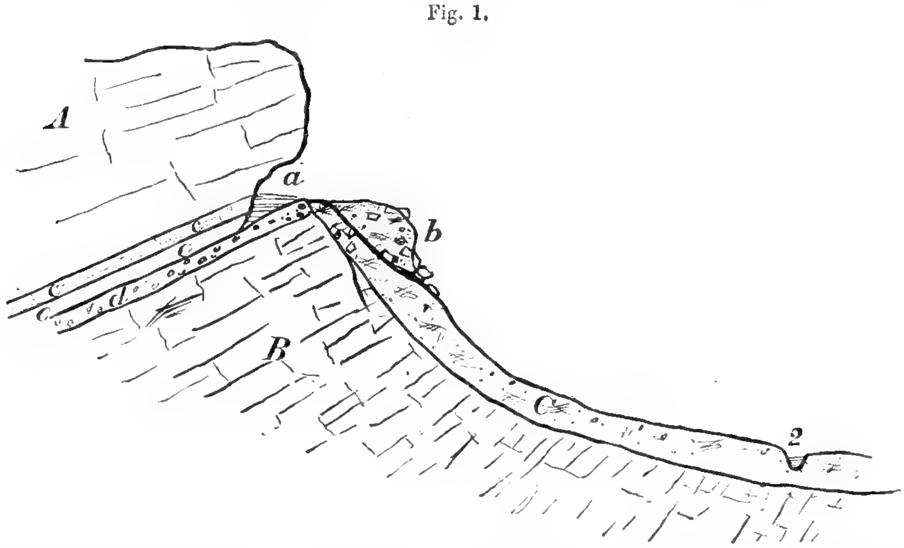
The Agate Harbor Company has an extensive property on the range south of Agate Harbor, on which there are reported to be *Indian diggings*, as these excavations are frequently called by the miners. They are well developed at the works of the Native Copper Company, on the northern slope of the range, and on the Northwest Company's grounds at their mines, south of the "Greenstone" cliffs. The same veins extend across both these locations, a distance of a mile and a half, indicated by the presence of old works.

At the Northwest Mine the pits are conspicuous, showing on the surface the position of *three* veins that have since been wrought. Stone mauls were abundant in them. Some of the pits had been made in a band of red conglomerate, which lies between the strata of greenstone (or crystalline) and amygdaloid trap. This conglomerate is composed of pebbles and boulders principally of red trap, cemented by argillaceous red sand, forming a very compact stratum, twelve to twenty feet thick. It here carries copper in small grains or pieces, near the veins; also crystallized calcareous spar and epidote.

The ancients did not neglect the most trifling indications of metal, but appear to have instituted a thorough investigation as to whether the copper existed in true veins, in metalliferous bands, or in detached nests. There is nothing remarkable in their operations at the "Native" Copper and the "Northwest" mines, except this closeness of pursuit, through all the veins and branches to their most minute extremities.

Waterbury Mine.—The works of this Company are situated about one mile and a half west of the Northwest Mine. A person passing to the interior from Eagle Harbor or anywhere along the northern shore of Point Keweenaw, and crossing the mineral range to the valley of the Little Montreal, witnesses everywhere the same topographical features. The mountain range rises from the lake level, in the distance of a mile, to an elevation of 500 and 600 feet; in the next mile the ascent is less precipitous, but the ground continues to rise from one to two hundred feet more. From the summit of the range there is along the whole line, from the extremity of the point to the Albion location, two miles west of the Cliff Mine, a vertical wall of naked trap rudely columnar, the upper edge, or *crest*, of which forms the summit of the range. This mineral front has the appearance of a vast upheaval from two to three hundred feet high facing the south, and about thirty miles in length. The ground from the bottom of this wall rises gradually to the south until it reaches another range of about the same elevation, thus forming a long narrow valley, through which flow, in opposite directions, the Montreal and Eagle Rivers. From the summit of the perpendicular cliff at the Waterbury Mine this valley presents a view extremely picturesque, and such as is seldom seen by the traveller in other regions. The general contour of the valley is curvilinear, so that the eye, placed at the middle of an arc in the position above mentioned, takes in the boundary ridge on each side as well as the whole inclosure. At the Waterbury Mine, which is situated near the middle of the length of the valley, there is in the face of the vertical bluff an ancient artificial recess or cavern, which is twenty-five feet in horizontal length, fifteen feet high, and twelve feet in depth. In front of it is a pile of the excavated rock, on which are now standing, in full size, the forest trees common to this region. Some of the blocks of stone which were removed from the recess would probably weigh two or three tons, and must have required the use of levers to dislodge them from their original position. Beneath the surface rubbish the remains of a gutter or trough composed of cedar bark were discovered, the object of which was clearly to conduct off the water which was baled from the mines by wooden bowls, of which mention will be made hereafter. Portions of fine or pulverized copper scales remained in the upper end of this trough. After removing the water and decayed leaves at the bottom of the excavation a piece of white cedar timber was found, one end of which exhibited the marks of a cutting instrument like those of a narrow axe.

Fig. 1.



WATERBURY MINE, artificial cavern.—*A.* Crystalline or greenstone trap, dipping *N.* 28°.—*B.* Amygdaloid trap.—*C.* Talus of the bluff and drift.—*a.* Ancient rock excavation.—*b.* Rubbish thrown out of *a.*— *d.* Conglomerate bed.—*c c.* Jointed chloritic bed.—*e e.* Inclined shaft of Waterbury Company.—2. Little Montreal River or creek.

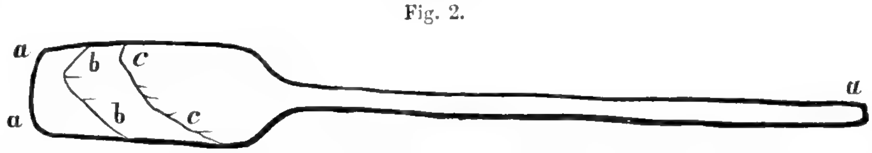
The above profile is made at right angles to the bluff, and shows the geological structure as seen from the western side. It would answer equally well for the *North*, *West*, *North Western*, *Eagle River*, *Cliff*, or any mine situated on the southern face of the coast range of Point Keweenaw.

The copper bearing amygdaloid (*B*) is separated from the crystalline or "Greenstone" trap (*A*) by a parting of conglomerate (*d*), which is however sometimes wanting, and its place supplied by a thin bed of red clay called "*flucan*" overlaid by a layer of quartz carrying specks of copper. This parting, whether it be of red conglomerate or of flucan and quartz, is known as the "slide," and sometimes (though improperly) is called a cross-course. The beds all dip northerly and at an angle of 28°. Resting immediately on the slide, and composing the inferior face of the greenstone stratum, is a bed of blackish-green chloritic rock (*c c*) very much jointed, which contains between its joints, in a leafy state and in its mass in a state more solid, scales, particles, and lumps of copper. This chloritic bed is from 12 to 15 feet thick, and in it the ancients worked forming this cavern. They did not operate on a vein at this place.

The Waterbury Company, encouraged by the labors of their predecessors, followed from the bottom of "*a*" along the surface of the conglomerate by an inclined shaft "*E E*" to a depth of 300 feet, measuring on the slide.

In removing a part of the old burrow *B*, Dr. Blake discovered several shovels, of white cedar, resembling the paddles in form now used by the Chippeway Indians in propelling their canoes. Had these been found elsewhere, they would have been regarded as ordinary paddles, but in this place they had evidently been used as shovels. This is also evident from the manner in which the blades are worn, as shown by the lines *a a*, *b b*, *c c*, in the annexed sketch.

Fig. 2.



WOODEN SHOVEL, 3½ feet long—Waterbury Mine.—*a a a*. Original form.—*b b*. Partially worn.—*c c*. Worn obliquely.

The blades are more worn on the under side than the upper, as if the mineral had been scraped together and then shovelled out, as is the practice of the miners of the present day. The shovels which were found beneath the water level were sound in appearance, and the strokes of the tool by which they were formed remained perfectly distinct, but on being dried they shrunk very much, opening in long cracks, the wood retaining little of its original strength or hardness.

A birch tree, two feet in diameter, grew directly over one of these paddles.

A portion of a wooden scoop, or bowl, was found in the pit, evidently intended to dip up and to pass water. Its edge had been worn, like the shovels, by scraping over the rock; but it was so much decayed that it fell to pieces when it was taken out.

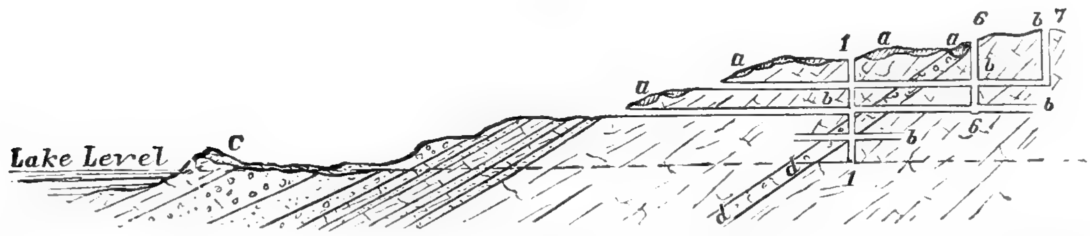
I examined the walls of this cavern minutely, hoping to find the marks of some tool of metal. The effects of blows of stone mauls were visible, and such is the hardness of the rock, that if drills or picks had been used upon it, I think the marks would be easily seen, particularly on that part which was protected from the atmosphere by water.

At one place something resembling the impression made by the point of a light sharp pick was discernible, but not very plain, and only in a single instance.

In the Porcupine Mountains I have seen works made by the English miners in the years 1769 and '70, where an adit or open cut made in the face of a cliff has been always exposed to the frost and rains. But here the marks of picks and drills appear as fresh and as perfect as if they had been recently made, although in some places the sides of the cut are covered by old lichens and mosses.

Copper Falls Location.—The ancient miners made very extensive excavations on the property of the Copper Falls Mining Company, both upon veins and metalliferous bands, which run parallel with the formations. By the profile and explanations here given the geological structure of the place will be well understood.

Fig. 3.



SECTION ON THE COPPER FALLS VEIN. *Explanations.*— Trap rock. Conglomerate beds. Sandstone.—*a a a.* Ancient pits on the vein.—*b b b.* Shafts and galleries of the mine.—*c.* Sand dunes.—*d d.* Copper bearing bed of trap.

Scale—horizontal and vertical—2 inches to the mile. 1, 6, 7, Nos. of the shafts.

This sketch illustrates the geology of the northern part of the range, or of all mines described under the head of Copper Falls Location.

From this it will also appear that when we use the term extensive, as applied to "Indian diggings," it is only in a comparative sense, and in reference to other works of the old miners. The levels and shafts constructed by the Copper Falls Mining Company, since 1851, cause the mining of the ancients to appear like mere exploratory pits.

On looking at the map, the pits will be seen to occupy a total length of several miles on this location; but none have been reopened that had a greater depth than twenty-four feet, while the modern shaft has already descended more than 250 feet, and the mine has rock galleries of greater total length than all the old trenches of the ancients. In the profile their pits are shaded, and represented at *a a a*, occupying about half a mile on the "East Vein," or as it is sometimes called, the "Copper Falls Vein." Before they were obliterated, as they are in part now, the surface appearance was that of an irregular channel or trough ascending the mountain from the edge of the sandstone beds to the band *d d*, which carries copper. Here a system of basin-shaped cavities, broad, circular, and deep, crossed those made on the vein. They are denoted by heavy black dots on the map.

The first named series were from two to five feet deep and five to ten broad, and the latter five to eighteen deep, with a diameter of twenty to 120 feet. Forest trees and underbrush stood alike within and without them.

There is a heavy vein half a mile west of the East Vein, which is styled the West or the "Hill Vein," where the old works are similar in all respects to those above noticed and sketched on the East Vein. Those on the "Owl Creek" Vein are not so extensive, because the creek occupies the "back" of the lode. Still further east other veins are seen with pits, not only on this location, but on that of the Eagle Harbor Mining Company. Broken stone mauls are common in all of them. About the point where the Owl Creek crosses the "scoriaceous" or metal bearing bed *d d*, the excavations on that bed near the creek are very marked. Here is something similar to the cave on the Waterbury Location.

A very large pit to the east of Owl Creek was partially explored by S. W. Hill, Esq., the Superintendent of the mine, in 1852. By running in an adit on a level eighteen feet below the edge of the depression, after passing some distance in the gravel, rock was met in place; cutting through this at a distance of 100 feet, the miners discovered loose fragments and rubbish that had been handled, and pieces of timber still in good preservation. The adit was not deep enough to drain the pit to its bottom, and its depth was not ascertained. I have in my possession a portion of a pine tree from the end of this adit, in complete preservation, except a part which was charred by fire. The adjacent rock contained sheet copper, and small lumps, being a part of the metalliferous band.

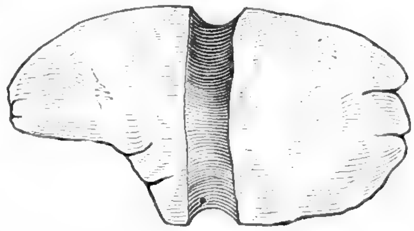
By examining the section, it will be seen that the order of succession in the strata is as follows:—

Beginning at the shore of the lake first, a bed of trap, that dips northerly. It rests upon a stratum of *red conglomerate* of great thickness, dipping conformably under the trap, and is succeeded by conformable and alternating beds of trap and red sandstone, known by the geologist as the "Potsdam" red.

In these beds the mineral veins are not rich enough for working; a fact which the ancients knew full well, for it was only on the regular and uniform strata of trap underlying the variable beds that they expended their labor.

On clearing out some of the old pits, Mr. Hill found wooden shovels like those at the Waterbury Mine, more or less worn and of the same size and shape. In the bottom of trenches, and among the rubbish, the workmen saw continually ashes and charcoal, with other traces of the presence of fire. They threw out frequently broken hammers or "mauls," with a groove around the middle. These mauls weigh from five to fifteen pounds, and are merely oblong water-worn boulders of hard, tough rocks. Nature has done everything in fashioning them, except the groove, which was chiselled around the middle. They were collected from the smooth boulders of the lake shore, and from banks of coarse gravel that abound in the country. Most of them are trap; but the hornblende, sienitic and granitic rocks furnish some. The ring or groove appears to have been cut for the purpose of attaching a withe, to be used as a handle, wherewith to swing the maul. In one of the trenches on the Cliff Mine, north of the upper engine, one was found with a root of cedar still twisted in the groove, but so much decayed that it fell to pieces and was not brought away. Dr. M. D. Senter, of the Cliff Mine, states that he saw it before being disturbed, and it was evidently the intention of the operators to use the twisted root or withe for a handle.

Fig. 4.

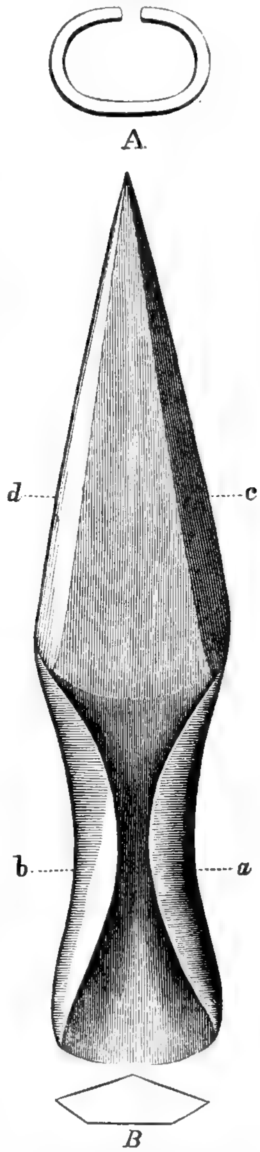


STONE HAMMER OR MAUL, with one groove, and broken by use; length 7 inches. Copper Falls Mine.

Most of these hammers are fractured at *both ends*, and the peculiar sharp cut character of the fracture in many cases indicates that the implement had been used to drive metallic wedges, such as quarrymen call a "gad." Copper gads of this kind have been found in old pits at the Minnesota Mine. It will be seen also that there are heavier mauls with *double* grooves, probably to be handled by two men.

In the description of works at the Central Mine, a class of hammers will be noticed without a groove. The one here figured was taken from a pit near Shaft No. 1 of the section above given. Not far to the south of the same shaft was found a copper spear or javelin head, in the rubbish near the bottom. Three others were found by Mr. Hill on the surface. One of them was so much corroded that the socket was nearly gone. The other I have sketched of natural size and thickness, from the original in the possession of Mr. Hill. It was evidently formed by beating the metal while cold, probably between stones, having a rough and not a polished exterior; it is not much decayed. The section of the blade *B* shows that its two faces were not symmetrical. A piece of decayed wood was found in the socket of one of them, being apparently the remnant of the shaft, by which it was hurled. As the edges of the "shank" or socket are not soldered together, but only bent around the shaft, it was probably wound with some ligament to give it strength. It is too large and heavy for an arrow-head; neither has it the shape proper for that purpose.

Fig. 5.



COPPER SPEAR-HEAD—Copper Falls Mine.—*B*. Section of blade at *c d*. *A*. Section of shank at *a b*. Scale, full size.

The description here given of the pits of the east vein will answer for almost all others.

In working the surface of the vein, or of the copper-bearing bed, the ancient operators must have wrought open to the day. They no doubt commenced as low down the slope of the range as the copper appeared to them worth being taken out, and worked upwards towards the south, in order to keep their drainage. From their rude and tedious method it was of the highest consequence to cause the water to flow away behind them, without the necessity of baling.

The "attle," or broken rock, was generally thrown back into the vacant space whence it had been taken: but little of it was cast out to right and left along the margin of the vein, which explains why the pits are so shallow at the present time.

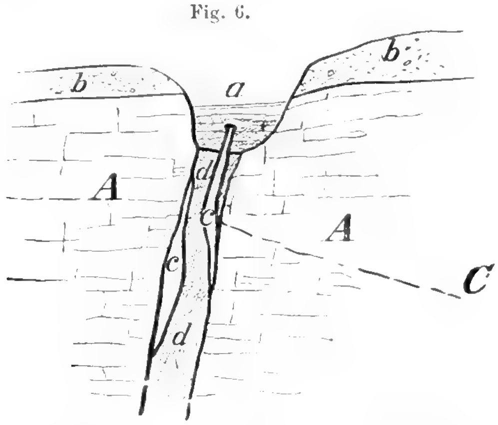
In many places on this location, the vein is wide enough to allow men to work between its walls.

Thin sheets of copper were left standing at the bottom of the ancient excavation, which might readily have been extracted, and it seems singular that they were not.

Central Mine.—Near the road from the "North Western" to the "Winthrop" Mine, in an open grove of sugar trees, a depression was observed about five feet deep and thirty feet in length. It was generally free from water, and differed so little from cavities that are not artificial, but which are due to geological causes, that it did not attract much attention.

Mr. John Slawson, the agent of the North Western Mine, after a careful surface examination, concluded that this pit was not wholly due to nature, and the tract was on that account purchased for mining, in the fall of 1854.

Fig. 6.



CENTRAL MINE. Section of the vein and old pit. East and west.—*A A*. Trap rock wall of the vein *d d*.—*a*. Ancient excavation partly filled.—*c c*. Masses of native copper in the vein.—*b b*. Drift gravel covering the rocks.

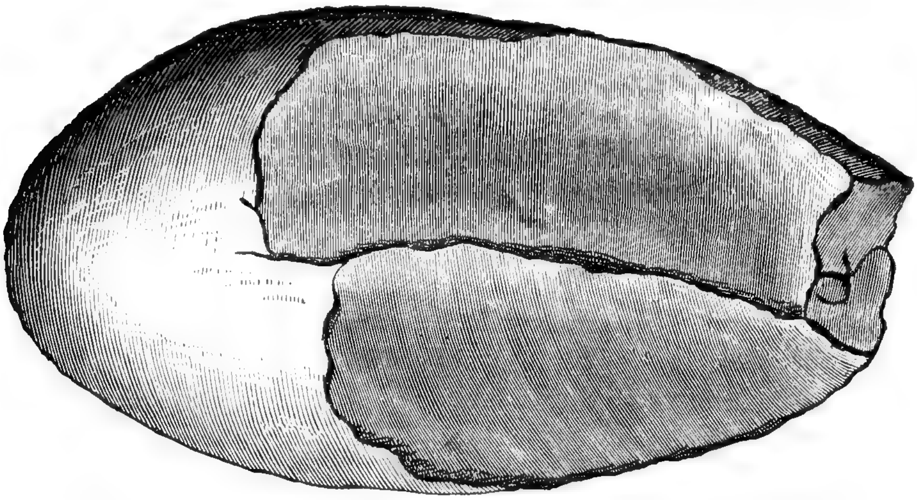
The Central Mining Company having been organized, a drain was constructed to take off the water, which was no sooner done than all doubts were removed; about five feet in depth of leaves and rotten sticks had accumulated at the bottom, among which a hard substance could be felt with a stick.

This proved to be a flat piece of native copper C, from five to nine inches thick, and nine feet in length, forming part of a large vein *d d*, as shown in the profile. The vein material had been worked away from one foot to eighteen inches along side of it, and it extended forward as well as downward in the vein. Its upper edge had been beaten by the stone mauls so severely, that a lip, or projecting *rim*, had been formed, which was bent downwards, over the sides. A large number of broken mauls were found in the place, and around it on the surface, all of them without grooves, of which the annexed woodcut is an illustration.

I have seen similar ones on the Humboldt Location, next west of Copper Falls. Where this class of stone hammers is found, those with grooves are wanting. The grooveless ones appear to have been used for percussion only at *one end*, as though the manner of holding them was such that a blow was not given on the other.

The Peruvians have a copper axe without an eye, or a groove, to which, however, they attach a handle in the form of a split stick, bound with thongs. The ancient miners, probably, had some such mode of tying a handle to these smooth oblong stones. Different parties of men may have preferred tools of different kinds, which would account for mauls, which are seen at one mine, being among themselves alike, but dissimilar to those at other places.

Fig. 7.



BROKEN MAUL, CENTRAL MINE.—Without groove, ½ size, weight 8½ lbs.

The usual remains were here thrown out, consisting of charcoal, ashes, and broken wall rock.

The general bearing of the vein is 10° or 12° west of north. The section is made across it, east and west, looking south, and is vertical.

As the labor of uncovering the mass of copper progressed, another one was met with, overlapping the first, and adhering to the east wall. Further on, in the adit, a third mass was found, attached to the western wall, partly overlapping the one which the ancients had left.

By stoping out a space about sixty feet in length by twenty deep, on the vein, the Company took out fifty-three tons of mass copper. Such unwieldy pieces appear to have been beyond the control of the old miners. Their object seems to have been to secure small lumps, such as could be fashioned without melting. Whatever pieces might have been detached, by diligent pounding with their stone mauls, were broken off, and the remainder was abandoned.

It was impossible for them to cut into pieces, reduce by melting, raise from the pit, or transport blocks of metal weighing many tons. There are neither marks of a cutting tool upon them, nor of the action of fire. It is quite singular that they had not discovered the art of melting copper, which can be effected so easily in an open fire made of wood, but no evidences have fallen under our notice that this was done by that ancient race.

2d Group.

Portage Lake Region.

Quincy and Pewabic Mines.—Portage Lake resembles in form the long, narrow, and crooked Scottish lochs. Like them its quiet surface reflects the outlines of most exquisite scenery.

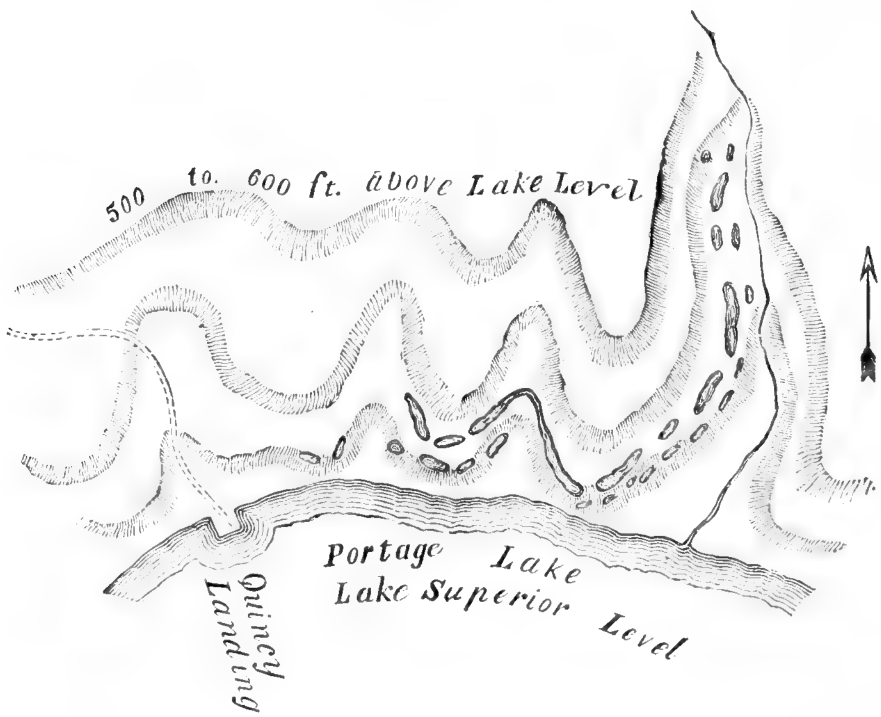
It connects with Lake Superior through the channel of Sturgeon River, which has so little descent below the point of junction, that all material changes in the level of the great lake are felt throughout this inland water.

The *Quincy* landing is situated on the north side of Portage Lake, about twenty miles from Keweenaw Bay. The northern shore, which is nearly east and west at the landing, does not show rocks at the water level.

A succession of drift, knolls, points, and headlands, rising about 200 feet above the surface, overlook this shore. Above this elevation, and attaining a height of 500 to 600 feet, are seen projecting ledges and bluffs of trap rock, inclosing mineral veins. This rock is also visible at the heads of ravines where rivulets fall over low precipices forming small cataracts.

The first signs of ancient excavations occur near the lake level, and what is remarkable, are not in the rock, but in the *sand* and *boulder* "drift."

Fig. 8.



Ancient Pits in the Boulder Drift or Gravel, Quincy Location.

The most capacious of these gravel pits, however, occur on a line nearly level and about 100 feet above the surface of the water.

They are partly upon the land of the Quincy Mining Company and in part on the Pewabic, a short distance east of the landing, as shown in the sketch. Those constituting the upper series are even, broad, deep, and regular, having the appearance of old fortifications. They extend around the headlands of gravel, connecting adjacent ravines, as though the object was to bring water from the rivulets along the face of the bluff.

At the points of the ridges they are much broader and deeper than they are at the heads of the ravines. The resemblance to a race way, or "sluice" for running water, is such that it required much examination to convince me that they had not been used for that purpose. There are, however, no openings at the extremities, such as would have been the case in sluices, to admit and discharge water. A bench, or narrow terrace, breaking into the slope of the hill, forms a regular plateau for the uppermost group; the other groups being scattered along the slope at irregular intervals. Some of them extend down the declivity nearly to the water's edge. Pits of a peculiar shape are occasionally seen to the westward of the landing, particularly at the distance of about a mile. Here is a group of small ones covering several acres on a piece of level land, which is elevated about 200 feet above the lake, constituting one of the upper drift terraces.

There are no doubt many others, large and small, concealed by the thick brush wood with which the ground is covered. Mr. C. C. Douglass, formerly an assistant of Dr. Houghton, in the geological survey of the Upper Peninsula, and since for many years the superintendent of the Quincy and Isle Royale Mining Companies, states that lumps of water-rolled copper and small masses are frequently found on both sides of the lake in this drift gravel. In digging cellars, constructing roads, and exploring trenches, such pieces are so common, that it has been thought that they would pay for their collection by washing the earth. One mass of 1500 pounds weight was found in digging a cellar where there is no rock visible in place.

To obtain this transported mineral, Mr. Douglass conjectures to have been the object which the ancients pursued in their gravel trenches, and at the same time, that they selected from the water-worn boulders of the coarse drift such stones as had the proper size and shape for mauls, to be used in the adjacent rock excavations.

The earth from the trenches near the landing, on the slopes, was principally thrown out over the *lower* side, forming embankments with an extreme height of fifteen feet above the bottom of the ditch as it remains now after the lapse of centuries.

Some of the ditches are fifty feet wide at the present time.

The beds of trap, constituting the mineral range, at this place, have a total thickness of about a mile and a half, presenting the ends of the strata towards the lake. To reach the rock excavation of the ancients, it is necessary to follow a road from the landing up the mountain three-quarters of a mile to the north-east. Here the copper bearing rocks protrude from the soil in ledges; the intervals where no rock is seen being covered to a slight depth with earth. The veins of this part of the range have a direction different from those before described on Point Keweenaw. They have run with the formation, and not at right angles to it, like those at the Cliff, Copper Falls, Northwest, and other neighboring mines. The true lodes of the Quincy, Pewabic, Isle Royale, Portage, Huron, and other companies adjacent to Portage Lake, are called "*parallels*," while those further east belong to the system of "transverse" veins.

In the winter of 1854–5, after the land had been explored and worked ten years, a line of depressions was discovered on the summit of the range that attracted immediate attention. On this elevated ground the old operators had discovered and worked a rich deposit of copper which was nowhere visible upon the surface. The direction of the line of pits is northeast and southwest, corresponding with the range.

The mines now in operation on this lode are among the richest of Lake Superior. At first view the excavations appeared to be irregular, like those in the gravel at the foot of the bluffs, but after clearing away the growing timber, they assumed an allignment such as I have given on the map. There are also veins in the vicinity that have a bearing different from the general course of the pits.

When the cavities came to be opened, it was evident that a deposit of great richness had been worked there in past times. Lumps of copper were found plentifully in the bottom of the old works, and with them the usual evidences of ancient mining. The pits are broad and deep, extending not far from half a mile.

Isle Royale Location.—This is on the south side of Portage Lake. Here the ground does not rise so high as on the north side, but is equally abrupt. The first escarpment on this side is rocky, its crest being reached by an ascent of 300 feet. The mining companies which have penetrated the rocky strata to a depth of at least 250 feet, are the Isle Royale, Portage, Huron, and Albion; all of them on the same vein, and situated near the south-easterly edge of the mineral range. The beds in which these companies have worked are, therefore, geologically, nearly a *mile* lower than those of the Quincy and Pewabic, which are near the westerly or north-westerly side of the range. It was, therefore, in different ground that the ancients sought for copper on the southerly side of the lake.

After having attained the summit of the lake front on this shore, we find the land nearly level for the distance of a mile, and the rocks covered with a shallow depth of earth. On this plateau the ancients discovered a rich lode that did not show itself on the surface.

In the autumn of 1851, Mr. Douglass informed me that there were indistinct signs of old works, half a mile from the lake on the northwest quarter of Section 1, T. 53, R. 34, owned by the Isle Royale Mining Company. At the request of the directors of the company, a close reconnoissance of the ground was immediately made by myself. It required some assistance of the imagination to conceive that the slight and irregular depressions, which were dimly visible among the trees, were the works of men. Applying a compass to such of them as could be seen at one view, and carrying this line forward, it passed over or near the successive pits for a distance of one-third of a mile. We then set men to work to cut down a cross trench through one of them, and in a few hours reached the bottom. The vein and its walls were distinctly visible, having been worked out to a depth of ten feet, but the space was filled with rubbish nearly to the surface. Further examination, and cross trenching, disclosed the vein along a distance of three quarters of a mile, in places very broad, with a bearing coincident to that of the formation.

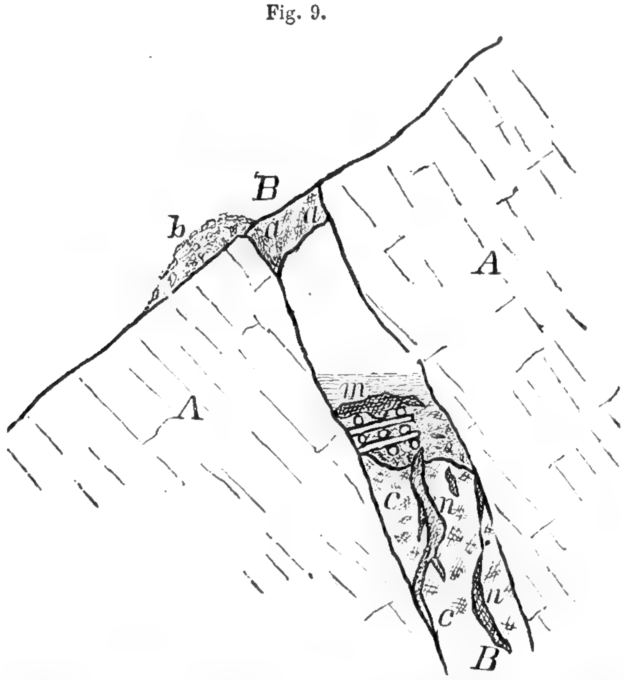
It has now been worked to a depth of 250 feet, producing copper in rich masses, over a space twenty feet in thickness. In these wide places or pockets the early miners enlarged their pits to correspond, and carried their works to greater depths. Charcoal, broken mauls, and ashes are mixed with the black earth and rocky fragments of the pits.

3d Group.

Minnesota Mine.—As I have before stated, it was upon this location that the existence of mines, long since wrought, on Lake Superior was first made known to us. It is here, also, that the most extensive and interesting works of that kind are to be found.

The Minnesota lodes have a direction like those at Portage Lake, and different from those at Point Keweenaw. The veins about the forks of the Ontonagon, embracing a district of forty-five miles in length, on the mineral range, from the Douglass Houghton Mine, on the east, to the Akogebe Lake, on the west, run *with* the range, and not across it. Their bearing is, therefore, north-easterly and south-westerly, or about N. 54° East.

Fig. 9.



Minnesota Mine. Section across the Vein, looking from the easterly quarter. N. 30° W.—*B B.* Mineral vein dipping north.—*A A.* Wall rock of compact trap.—*a. a.* Left standing a part of the original surface support to the hanging wall.—*m.* Mass of copper sustained by timbers.—*b.* Ancient burrow or spoil bank.—*c c.* Vein matter embracing masses of copper *n n.*

On the Minnesota there is a group of veins nearly parallel among themselves, four in number, and on all these the ancients labored. The surface presents a corresponding group of rude trenches, showing the position of the veins, for more than two miles. The ground rises gradually to a height of 637 feet above the lake, but on the south drops suddenly off into a deep valley. The Ontonagon River cuts the range two and a half miles west of the mine, being navigable for batteaux to the landing.

In the above section, across the main lode, I have grouped together several remarkable objects, that were seen near each other, though not strictly in contact. The descriptions and sketches are in part due to Mr. Knapp, partly to Messrs. Foster and Whitney, and also to my personal examinations.

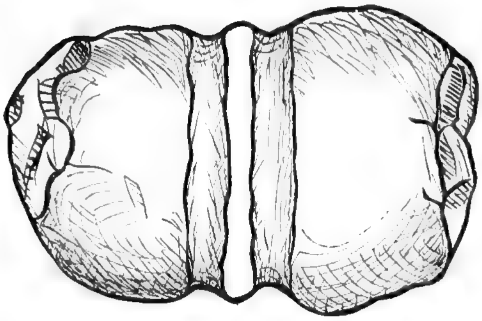
The vein *B B* has a variable thickness from one to nine feet, dipping northerly, at an angle of about 60° with the horizon. This is somewhat steeper than the dip of the strata, or wall rock, *A A*. On some of the veins, the excavations extend eastward, out of the Minnesota, into the grounds of the Rockland Mining Company, where they are very distinct. Being upon the southerly slope of the mountain, the ditches have become very much filled up by washing from the surface. The greatest depth of the ancient excavation is thirty feet. At the place of the above section the vein had been removed to a depth of twenty-six feet.

Not far below the apparent bottom of a trough-like cavity where shaft No. *one* is now situated, among a mass of leaves, sticks, and water, Mr. Knapp discovered a detached mass of copper weighing nearly six tons. It lay upon a cob work of round logs or skids six to eight inches in diameter, the ends of which showed plainly the strokes of a small axe or cutting tool about 2½ inches wide. These marks were perfectly distinct. A piece of this wood which I took from the mine in 1849 proved to be a species of oak, the only species known upon the range, and by some called the Spanish oak. It shrunk on drying to about two-thirds of its size, cracking open in deep gashes, and possessed little strength. Its appearance was that of water-soaked timber not rotted, preserving its original form.

The mass of copper had been raised several feet along the foot wall of the lode, on the timbers, by means of wedges. Its upper surface and edges were beaten and pounded smooth, all the irregularities taken off, and around the outside a rim or lip was formed, bending downwards. This work had apparently been done after the miners had concluded to abandon the mass. Such copper as could be separated by their tools was thus broken off. The beaten surface was smooth and polished, not rough. Near it were found, as the excavation advanced, other masses, *n n*, imbedded in the vein. After several years, this vein has been found by the modern miners uncommonly rich and valuable for the size and number of its masses of copper.

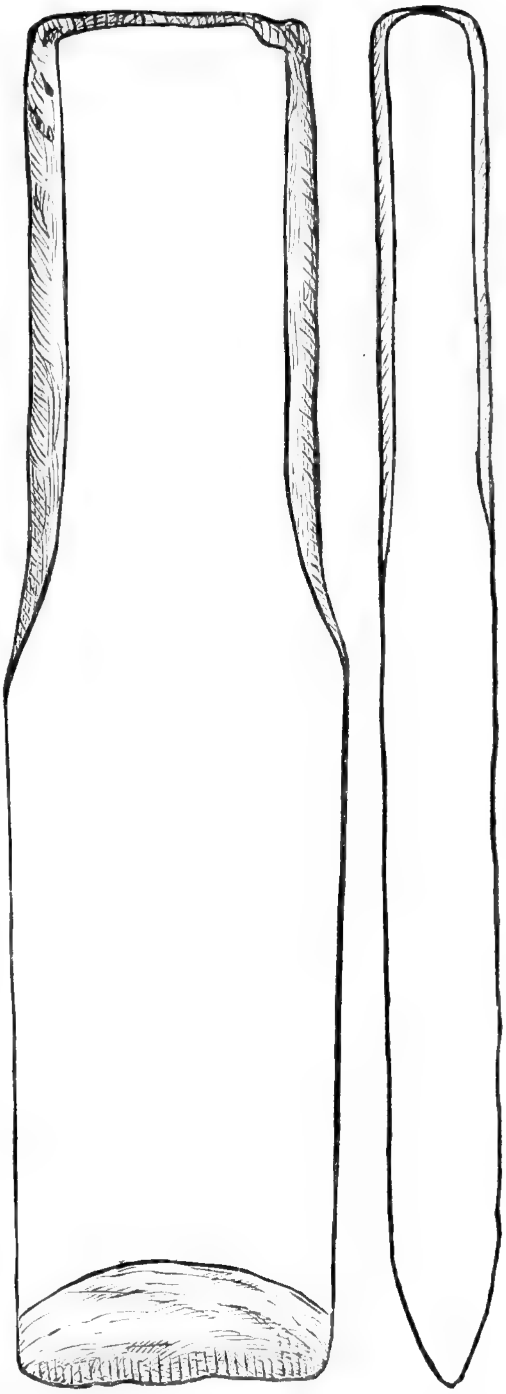
Not far to the west of this spot a portion of the vein *a a* had been left like a pillar as a support to the hanging wall, while they excavated beneath. It is cut or bruised quite smooth, but shows no marks of other tools than the mauls. This rocky support is about four feet in thickness, and is high enough above the present bottom of the trench to allow a person to pass under it. The marks of fire on the rocks of the walls are still evident. Charcoal, ashes, and stone mauls are found in all of the pits hitherto cleaned out. One of the heaviest mauls yet seen, weighing thirty-six pounds, came from this location. It has a *double* groove, as shown in the annexed figure, which is not usual, and it was intended, no doubt, to be used by two men.

Fig. 10.



STONE MAUL, with double grooves.—Weight 36 lbs. Minnesota Mine.

Fig. 11.



COPPER CHISEL. Full size.—Length $7\frac{1}{4}$ in.; breadth $1\frac{3}{4}$ in.; thickness $\frac{5}{8}$ in. Minnesota Mine.

View edgewise.

In one of the pits a rude ladder was found, formed of an oak tree trimmed so as to leave the stumps of the branches projecting, on which men could readily descend or ascend to or from their work. Wooden levers are also found among the rubbish, preserved by water, which covered them continually.

On the edge of the excavation in which the mass *m* was found there stood an aged hemlock, the roots of which extended across the ditch. I counted the rings of annual growth on its stump, and found them to be two hundred and ninety. Mr. Knapp mentions another tree which had three hundred and ninety-five. The fallen and decayed trunks of trees of a previous generation were seen lying across the pits. >

Near the place where the detached mass *m* was found Mr. Hill discovered a tool of which the following is a sketch, and near it a copper maul or sledge weighing from twenty to twenty-five pounds. Like all the other implements found this maul had been fashioned by pounding in a cold state. Originally the mass appeared to have had the shape of the letter T, the cross head at the top being about an inch thick and two or three inches broad, tapering towards each end. These two prongs had been folded over each other and beaten into a shape rudely resembling a man's fist, but larger. This lump of copper had evidently been battered either by pounding, to make it more compact, or by use as a maul. The handle of the maul was eight or nine inches long.

The chisel above figured was somewhat bruised at the upper end, as though it had been used. Towards the upper end the corners are taken off, apparently for the purpose of being held in one hand, while it was struck by a mallet with the other. It has a rough surface, common to these relics, but is symmetrical in form, with a bevel at the cutting edge on both sides. None of the tools show signs of having been ground to an edge on stone, but are beaten down roughly by hammers.

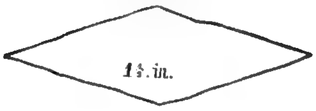
Artificial Caverns.—On the Aztec, Ohio, Adventure, and Ridge locations, in addition to the pits which are so common along the range, there are cavities in the mural faces of trap at various elevations, which are ancient and belong to the old copper works.

The bluffs are sometimes as high as three hundred feet above the valley. There are also breaks or gaps in the range formed by dislocations of the strata or faults, enlarged by the wearing action of the drift forces. The ends of different beds of trap are thus presented to view, rising on either side of the gorges, with precipitous fronts of different heights. One of the strata, and perhaps more than one, is metalliferous, like the scoriaceous bed worked at Copper Falls and at Phœnix Mines, on Point Keweenaw. At the Adventure the metal bearing stratum is very thick and highly charged with copper, disseminated irregularly through it. The ancients wrought upon it extensively, seeking with assiduity for the rich portions, no matter how difficult of access. Some of their excavations on the side of the bluff are scarcely large enough to shelter a bear. Others are more extensive, formed in all conceivable shapes, extending wherever indications of minerals were apparent. The agents of the Adventure Mine have followed the example of their predecessors, but on a larger scale, pursuing the strings and bunches of copper in all directions, till they disappear. When the mineral fails, like the ancients they strike off at random, and seldom proceed far without encountering other lumps or small masses.

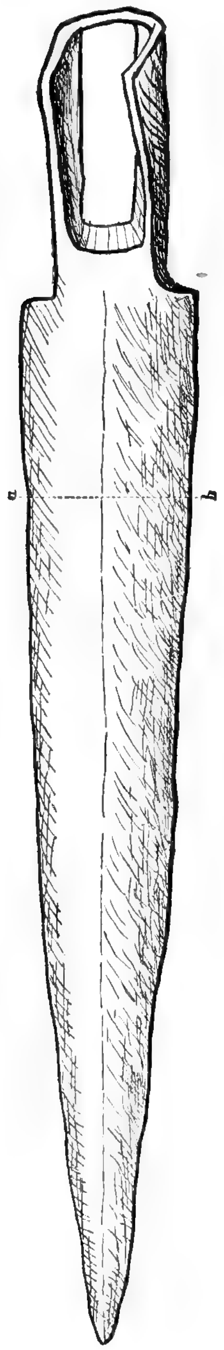
Hitherto the true veins near the copper bearing stratum have not proved profitable. The ancients, exercising their usual skill, expended very little labor upon them. They showed in this very considerable knowledge respecting the different systems of veins, and also in regard to those anomalous deposits in which the caves are situated.

Forest Mine, Evergreen Bluffs.—On the ground known by the name of the Evergreen Bluffs ancient pits have been opened southeasterly of the Minnesota works. Some prominent ones have recently (1855) been cleared out on the "Johnson preëmption," which disclosed in a few days several tons of copper. Masses had been partly uncovered in the vein, as at the Central Mine, and thus left. On the Nebraska location and on the Rockland, the old excavations are numerous, and wherever they are reopened valuable lodes are exposed. They are not wanting on the west of the river. At the Forest Mine the present works were commenced upon the site of earlier and ancient operations. A wooden bowl was found near the bottom of one of them, that had been used for baling. Doubtless many others in the vicinity of the Ontonagon exist that are not yet discovered.

Fig. 12.

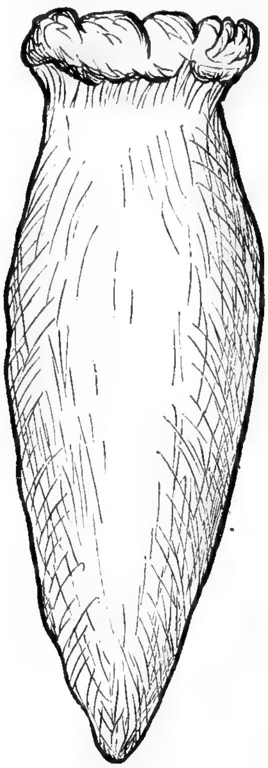


Section on *a b*, full size.



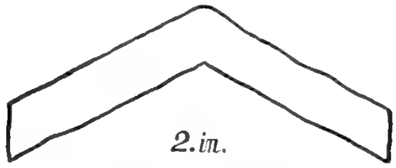
SPEAR HEAD.—Half size. 14 inches long. Ontonagon. From drawings of John F. Mullowney, Esq., Surveyor.

Fig. 13.

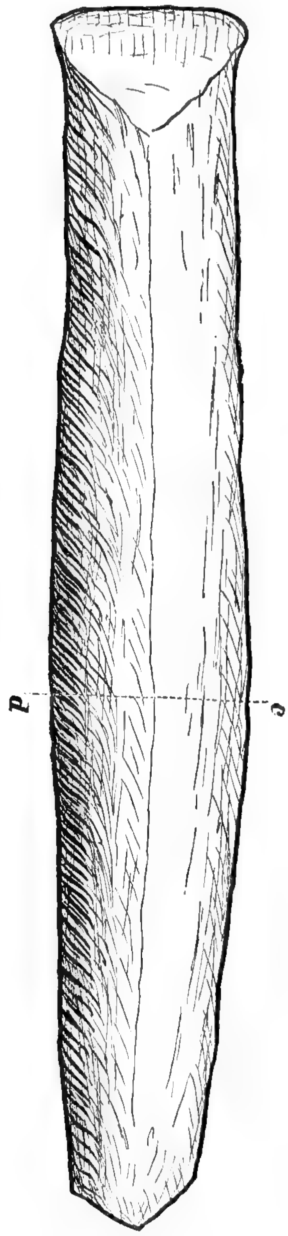


COPPER GAD, full size. Minnesota Mine.

Fig. 14.



Section on *c d*, full size.



CHISEL.—Half size. 13 inches long. Ontonagon.

Copper Implements, Ontonagon.—Some laborers in the employ of Mr. Greenfield were levelling the ground for a brick yard on the east bank of the Ontonagon River, half a mile above the village, in the year 1854, when they perceived some pieces of copper, which were well fashioned implements. They are said to have been found upon a bed of clay in a ravine, and covered about two feet with alluvial earth, a large cedar tree growing nearly over the spot. They consist of two implements, which may be described as spear or javelin heads, though more probably designed as miners' tools; and two cutting instruments that may properly be called chisels, as shown in the annexed sketches. These show the form and size better than any written description. The socket of the spear is small, and not of the best shape to give a good fastening to a staff, which may perhaps favor the idea that it was a weapon for the use of one hand, like a dirk. The blade is symmetrical and strong; it apparently had not been much bruised or injured by use. If it was to be thrown like a javelin, the stock or staff must have been fitted on around the shank and driven down over the blade some distance, to make the wooden attachment proportionally strong with the metal part.

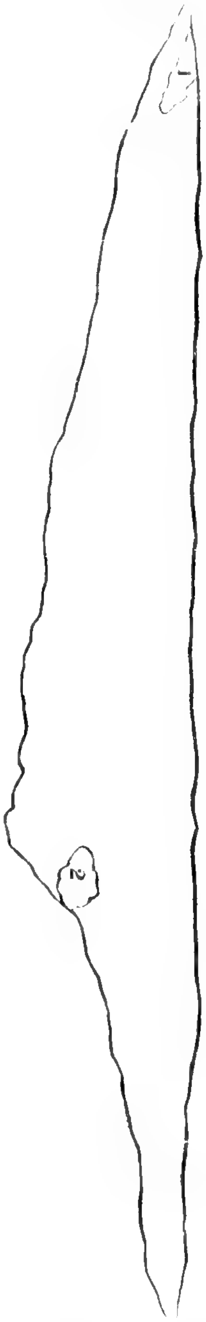
The chisel also had not been used, since neither the cutting edge nor the head is battered. It is bent up longitudinally from near each end in the manner shown by the cross section in *c d*. The object in giving it this form must have been to stiffen it and thus save metal. This contrivance speaks well for the ingenuity of the maker. Those instruments have better proportions than similar ones found in Ohio. They were probably fresh from the hands of the workman when they were lost upon the banks of the river. Although I have myself examined these implements, I am indebted to Messrs. Emerson, Coburn, and Mullowney for facts respecting them. Both are represented to be more hard and less malleable than the native copper of the mines, from which it has been inferred that they have undergone a hardening process. Like those found at Marquette and elsewhere, I suppose the hardness is due only to prolonged hammering, by which the density is increased. The copper of the ancient inhabitants of Europe was hardened by alloying it with tin.

Copper Implements, Carp River. (Not on the Map.)—In August, 1854, while workmen were engaged for Mr. John Burt in making a dam across the Carp River near Marquette, signs of copper were discovered in gravel. They were wheeling earth from the banks of the stream, and did not at first preserve the remains that were visible in the form of spots of green carbonate, which on examination presented a core of unoxidized metal. Mr. Burt states that there were numerous thin chips of copper not entirely decayed, which appeared to have been cut from a piece of native metal by a sharp and thin tool. There was also found a rude copper knife, the shank two and a half inches, and the blade four and a half in length, making seven inches. The blade resembles in shape a short butcher knife very much worn. It has spots of native silver imbedded in it like those frequently seen in Lake Superior specimens of copper.

Another tool resembles a bodkin, with a socket for the insertion of a wooden handle. There were also arrow or spear heads of copper, which were probably made upon the spot. These relics were lying upon a bed of water-washed gravel, which Mr. Burt conjectures once formed the bed of the river, but the channel of this time is ten feet lower. Soil had accumulated over the tools to a depth of two feet, and on it were pine trees, considered to be at least one hundred years of age.

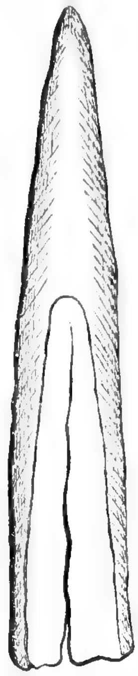
The knife was harder than the chips, and does not bend so easily. This hardness is probably due to the process of hammering which the mass underwent while it was in a cold state, and not to any tempering. If the bodkin-like implement had not been of this parcel the others might have been referred to the present race of Indians. They possessed knives and other implements made of copper when the French came among them, but these were very rude. Mr. Baily, of Eagle Harbor, has one which resembles somewhat the semilunar knife used by saddlers. There is a notch in the middle by which to attach a handle. Mr. B. thinks it was used in dressing and working skins. It was found in the gravel within the pickets at Fort Wilkins, Copper Harbor.

Fig. 15.



Rude Copper Knife.—Full size. Carp River. 1, 2. Spots of silver.

Fig. 16.

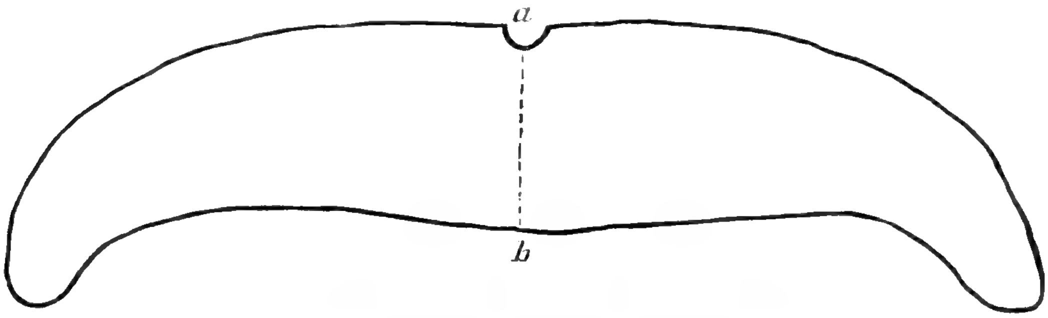


Pointed Tool with a Socket.—Full size. Carp River.

Near the mouth of Carp River there are remains of cabins, placed in a row like the houses of a village. This is shown by a line of heaps of stone and clay, like the remains of chimneys, and connected with them slight ridges of clay, resembling the low embankments around a log building after the timber has decayed. They may have been formed of clay which was used to daub the chinks. A forest of ancient growth covered these ruins. Although I know of no historical evidence illustrating the point, I should hesitate to give them a greater antiquity than the early French adventurers. It is about two hundred years since the Jesuits established themselves on Lake Superior. Traders may have preceded them thirty years, and constructed cabins at places not mentioned by the Jesuits.

I have seen the ruins of buildings on the west fork of the Ontonagon, near the old Copper Rock, the history of which has reached us, and which were erected in 1769. In 1845, eighty-four years afterwards, all the logs except such as were of cedar, had disappeared. Near a cabin which was used for a blacksmith shop, the outlines of a forge were quite distinct, with cinders, charcoal, and pieces of rusty iron lying upon it. There were also several pounds of corroded steel and brass, mostly the locks and guards of muskets, and

Fig. 17.



Copper Instrument.—Full size. Fort Wilkins.

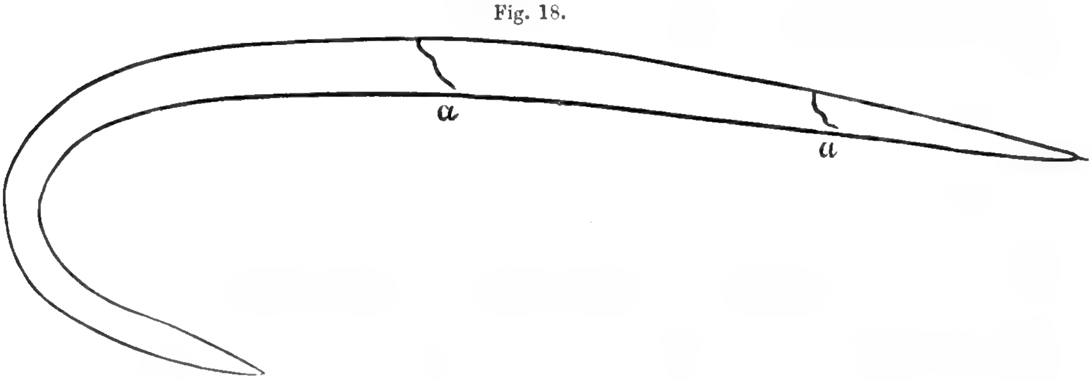
Section through *a b*.

one gun barrel. On the forge a pine tree had established itself, which we cut down, and counted upon the stump sixty-one layers of annual growth.

In regard to the implements found at the mill on Carp River, I incline to the belief that they are not as ancient as the old mines. Mr. Henry, who has furnished us the account of the explorations just referred to on the Ontonagon River, and on the north shore, made by the English soon after the Treaty of Paris, says that the Indians beat out pieces of copper into bracelets and spoons. None of their implements are shown to have been so difficult to form as the chisels and spear-heads, which are found in the old pits. These required a state of mechanical skill apparently above the reach of Indians.

Mr. Burt has also furnished the following sketch of a *copper hook* found by himself in the excavation of the St. Mary's Canal.

Fig. 18.

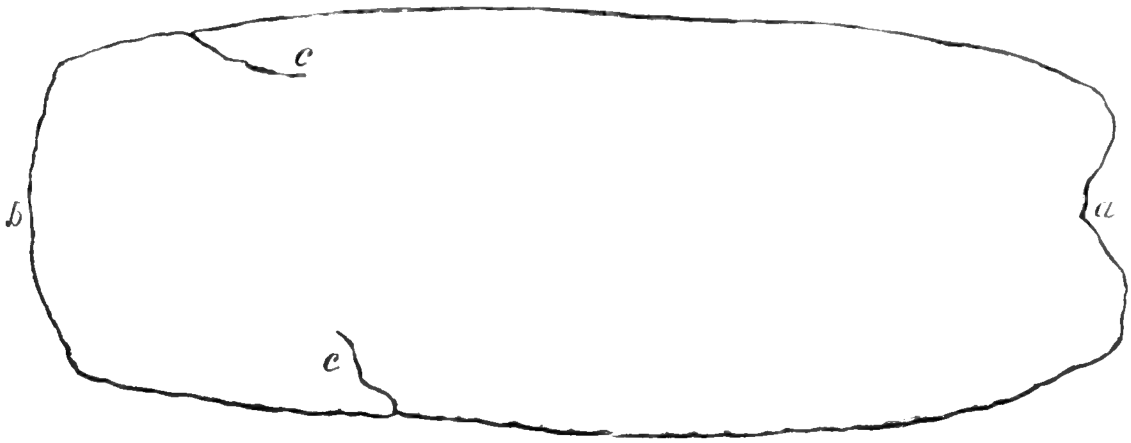


Copper Hook.—Full size. *a a*. Flaws in the metal. Sault St. Mary's.

It has the usual flaws which cold wrought articles exhibit, and doubtless belongs to the class of recently made implements.

On the Canada shore of the St. Mary's River, at Garden River, twelve miles below the Sault, an implement was discovered in the soil by a half-breed and presented to Mr. Burt. The horizontal and side views are sufficiently shown in the

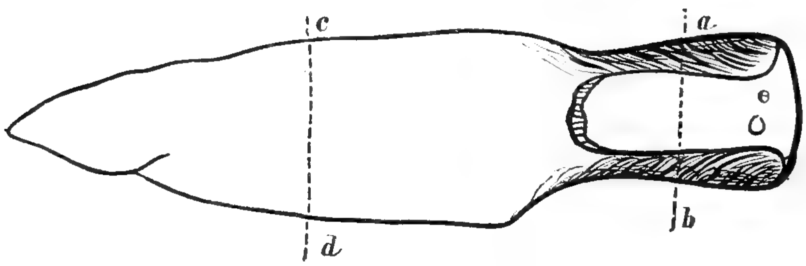
Fig. 19.



OUTLINE OF A COPPER TOOL. Full size. Garden River, Canada.—*a*. The head.—*b*. The edge.—*c c*. Flaws in the metal.

Longitudinal section.

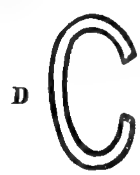
Fig. 20.



COPPER SPEAR-HEAD. Full size. Downward view.—*e*. Hole in back of shank. Oak Orchard. Oconto County, Wisconsin.

Side view.

Section of blade through *c d*.

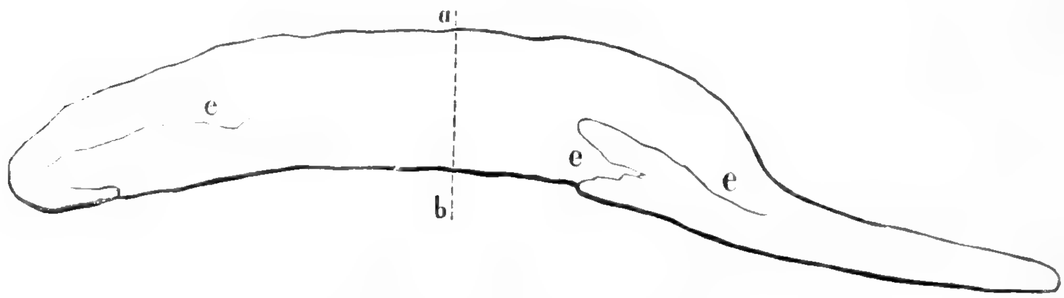


Section of shank through *a b*.

sketch to indicate its use, which was that of a cutting instrument like a chisel. Its bruised head shows the effect of blows from a mallet of wood or stone.

A rude knife and spear-head of copper were recently picked up by Mr. William Windross, at Oak Orchard, Oconto County, Wisconsin, on the western shore of Green Bay. They are in the possession of Lyman C. Draper, Esq., of Madison, Wisconsin, to whom they were presented by the Hon. C. D. Robinson, of Green

Fig. 21.



COPPER KNIFE. Natural size.—*e e e.* Flaws.

Section of blade from *a* to *b*.

Bay. The spear or arrow-head differs from those of Lake Superior principally in the state of finish, and in having a hole *e* in the shank to fasten it to a handle or shaft. Both these specimens are roughly forged and apparently ground to a blunt edge. They are, with little doubt, recent, the work of some half-breed or Frenchman.

By whom were the ancient mines wrought?—I have already given reasons going to show that it was not the present Indian race by whom these mines were worked.

As yet no remains of cities, graves, domicils, or highways have been found in the copper region. As the race appears to have been farther advanced in civilization than their successors, whom we call the aborigines, they probably had better means of transportation than the bark canoe. They might thus carry provisions a great distance by water. Their mine-works are open cuts exposed to the day, which in the winter in this country, where snow lies from three to five feet in depth, could not be occupied comfortably without shelter. No remains of such coverings have been discovered, nor is it probable that any traces of such should now be recoverable. On the upland the thermometer descends to minus 38°. This would not render these trenches absolutely untenable, but would present great difficulties in working them. Even in modern shafts and galleries, that are closed by self-shutting doors, frost penetrates to a depth of twenty and thirty fathoms. It is frequently necessary to put stoves in the upper levels in order to prevent their being filled with ice. It would therefore be barely possible, by no means profitable, to work in open trenches during winter. The miners could readily bring with them in the spring supplies for three months, and before these were exhausted the same craft might return for additional supplies. After spending the months of summer, the miners could return to their homes for winter, carrying with them the mineral obtained during the season.

In relation to their dead, it may have been a custom, perhaps a part of their religion, to restore the bodies to their friends. If the number of operators was not great, and the mortality was no greater than it is now, this would not have been a great burden. In case there were no women and children the proportional number of deaths would be less than at present. It is now, for the season of navigation, not far from five in 1000, including females and children, and including also those killed by accident.

All the ancient excavations hitherto examined could have been made, with our means of working, at less expense than has been incurred during the last ten years. But we must allow much for the imperfect modes of operating, and thus increase the number of men required to do the same work; we must also, on the other hand, conclude that the old mines were wrought a great length of time, and infer that a less mining force was kept up than we have in our times.

In the prosecution of mining in this remote region, not only would the deaths be few, but among them such distinguished persons as were entitled to sepulchral mounds or monuments would not be found in great numbers. The absence of artificial mounds, therefore, need not excite surprise.

The Mound Builders consumed large quantities of copper. Axes, adzes, chisels, and ornamental rings are so common among the relics in Ohio as to leave no doubt on this subject. We know of no copper bearing veins so accessible as those of Lake Superior to a people residing on the waters of the Ohio. Neither are there any others now known that produce *native metal* in quantities to serve as an article of commerce. Specimens of pure copper are found in other mines of North America, but not as a predominant part of the lode. The implements and ornaments found in the mounds are made of metal that has not been melted. They have been brought into shape *cold wrought*, or at least without heat enough to liquefy the metal, and were therefore produced from native copper. In the Lake Superior veins spots of *native silver* are frequently seen studding the surface of the copper, united or welded to it, but not alloyed with it. This is not known of any other mines, and seems to mark a Lake Superior specimen wherever it is found. It also proves conclusively that such pieces have not undergone fusion, for then the pure white spots would disappear, forming a weak alloy. Copper with blotches of native silver has been taken from the mounds. Dr. John Locke, of Cincinnati, possessed a flattened piece of copper weighing several pounds, which was found in the earthworks at Colerain, Hamilton County, Ohio, having a spot of silver as large as a pea forming a part of the mass.

At the first view of the logs which supported the mass *m* of the Minnesota vein, the marks of the tool by which they were cut brought to mind the old copper axes I had seen in Ohio, figured by Mr. Squier. The cut was about an inch and three-tenths wide, not smooth like that of a perfectly sharp edge, and not deep enough for a modern axe or hatchet. No such axes have been found on Lake Superior. Those of Ohio may have been used as a chisel, although Mr. Squier thinks a handle was attached to them. The difference between the axe and chisel is principally in the taper of the axe towards the head. No groove or eye has been noticed by which to insert a handle, but the Peruvians had means of fastening a handle to a similar instrument without either. There are also chisel-like tools from the Ohio mounds almost identical with those I have already figured. James McBride, Esq., of Hamilton, Butler County, Ohio, has in his possession four of them, found in 1855 near that place, that may be regarded either as chisels, axes, or adzes.

How much time has passed since these mines were wrought, or since they were abandoned, is a question of great interest. The timber found in some of the ancient mines is in a better state of preservation than that of the Ohio mounds; but it does not follow that it is more recent. Most of the pieces exhumed were covered by water, or wet earth. In a northern climate the decay of wood is slower than in warmer regions. The timber itself is mostly resinous, which assists in its preservation. The wooden cobwork that remains in the Ohio tumuli, hitherto examined, always lies above water, and the loamy earth in which it was buried does not wholly exclude the atmosphere.

In the Grave Creek mound the timber was very much decayed, but the chambers inclosing the skeletons were elevated above the natural surface, and the surrounding earth was dry. These circumstances being considered, it does not follow that the wood work of the mounds is the most ancient because it is the most decayed.

The living trees now standing, with their roots entwined among the mauls, skids, and shovels of the old miners, are reliable witnesses as to the least space of time since the mines were abandoned. The age of such trees varies from 300 to 350 years. Beneath the shade of these patriarchs of the forest are the prostrate and rotten trunks of a preceding generation.

General Harrison, in a discourse before the Historical Society of Ohio, adds another score to the tally of ages that have passed since the earthworks were evacuated. When ground that has been cleared of its timber is abandoned, the second growth differs from the first in kind. It is not until several generations of trees have disappeared, that such places produce the varieties which constituted the original forest. The same thing is observed on Point Keweenaw; where a sweeping fire has consumed or deadened the resinous trees of the mountains, the first succeeding growth is that of birch and aspen.

In process of time, however, the balsam, cedar, pine, and hemlock, resume their ancient domain, overshadowing and obscuring the deciduous trees. On the ancient burrows, and in the old pits of Lake Superior, the same kinds of timber flourish now as are observed in the surrounding forest. These works could not have been carried on without destroying the growth of timber of that day. Before the pines, and other evergreens that now occupy these places, overcame the birch and aspen trees, one or two generations must have passed away.

Is it going too far, on the strength of this evidence, to place the *abandonment* of the mines at a distance of 500 to 600 years from our times?

There may have been inhabitants covering large territories for long periods who have disappeared without leaving any monumental evidences of their occupation.

If the North American Indians had been destroyed by a general pestilence before Pamphilo de Narvaez landed in Florida, what traces of them should we be able to find? They have left no distinctive marks of their existence impressed upon the soil. Some faint signs of cultivation in the shape of little hillocks or hills of corn, not entirely obliterated as yet, are the sole vestiges of centuries. But avoiding all mere conjectural speculations, the following conclusions may be drawn with reasonable certainty:—

An ancient people extracted copper from the veins of Lake Superior of whom history gives no account.

They did it in a rude way, by means of fire and the use of copper wedges or gads, and by stone mauls.

They had only the simplest mechanical contrivances, and consequently penetrated the earth but a short distance.[1]

They do not appear to have acquired any skill in the art of metallurgy or of cutting masses of copper.

For cutting tools they had chisels, and probably adzes or axes of copper. These tools are of pure copper, and hardened only by condensation or beating when cold.

They sought chiefly for small masses and lumps, and not for large masses.

No sepulchral mounds, defences, domicils, roads or canals are known to have been made by them. No evidences have been discovered of the cultivation of the soil.

They had weapons of defence or of the chase, such as darts, spears, and daggers of copper.

They must have been numerous, industrious, and persevering, and have occupied the country a long time.

EAGLE RIVER, May 1, 1856.

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[1] Their deepest works are about the same as that of the old tin mines of Cornwall, which were wrought before the conquest of Britain by the Romans.

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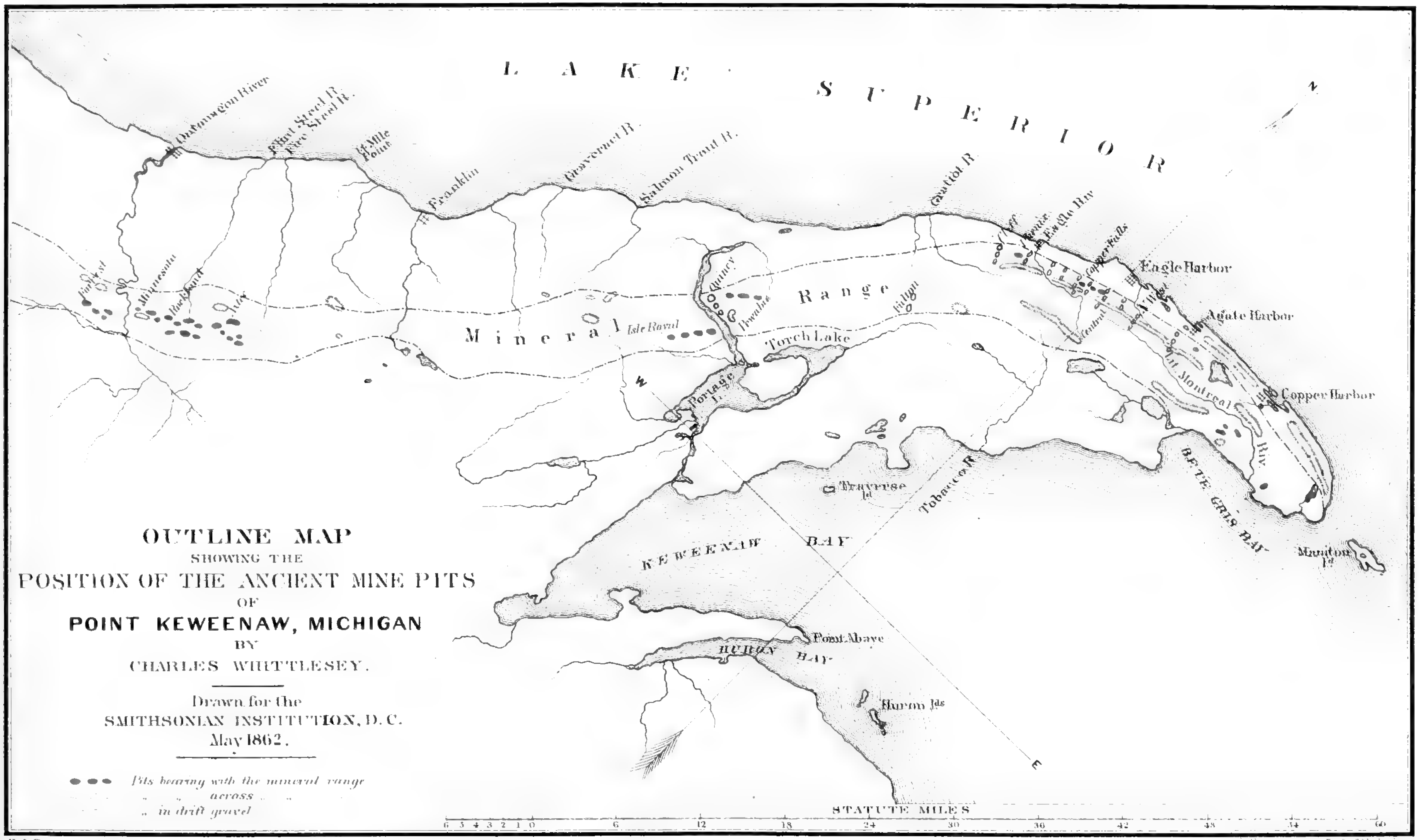
OUTLINE MAP
SHOWING THE
POSITION OF THE ANCIENT MINE PITS
OF
POINT KEWEENAW, MICHIGAN
BY
CHARLES WHITTLESEY.
Drawn for the
SMITHSONIAN INSTITUTION, D.C.
May 1862.
Pits bearing with the mineral range
" " across " "
" in drift gravel
LAKE SUPERIOR
Ontonagon River
Flint Steel R.
Fire Steel R.
Ft. Mile Point
Franklin
Graverat R.
Salmon Trout R.
Gratiot R.
Eagle Harbor
Agate Harbor
Copper Harbor
Eagle Riv.
Mineral Range
Isle Royal
Torch Lake
Portage L.
Minnesota
Quincy
Mt. Montreal
KEWEENAW BAY
HURON BAY
Point Abaye
Huron Ids
Traverse Id
Tobacco R.
BETE GRIS BAY
Manitou Id
STATUTE MILES
6 5 4 3 2 1 0 6 12 18 24 30 36 42 48 54 60
N
S
E
W
C.A.S.

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

DISCUSSION

OF THE

MAGNETIC AND METEOROLOGICAL OBSERVATIONS

MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA,
IN 1840, 1841, 1842, 1843, 1844, AND 1845.

PART II.

INVESTIGATION OF THE SOLAR DIURNAL VARIATION IN THE MAGNETIC DECLINATION AND ITS ANNUAL INEQUALITY.

BY

A. D. BACHE, LL. D.

[ACCEPTED FOR PUBLICATION, SEPTEMBER, 1860.]

COLLINS, PRINTER.
PHILADELPHIA.

INVESTIGATION

OF THE

SOLAR-DIURNAL VARIATION OF THE MAGNETIC DECLINATION, AND ITS ANNUAL INEQUALITY.

HAVING discussed, in Part I, the eleven-year period in the amplitude of the solar-diurnal variation, as well as in the disturbances of the magnetic declination, I now proceed to the analysis of the annual inequality of the solar-diurnal variation.

To obviate the difficulty which would occur in cases of months of unusal disturbance, if the crude observations were used, the normals or means freed from the disturbances have been employed in the discussion. This mode of proceeding not only obviates the necessity for rejecting the observations of particular months, but brings out the most consistent results which the observations can furnish, for both diurnal and annual variation. It is the course adopted by General Sabine in the third volume of his discussion of the Toronto observations.[1]

Returning, then, to the hourly normals, they are rearranged in the tables which follow, according to the different months of the year. The normals for 1840 are corrected for the index error by the addition of 93.3 scale divisions. All corrections for referring the partial monthly readings to the annual mean are, of course, omitted.

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[1] Table LXVI, of this volume, exhibits the solar-diurnal variation of the declination after the separation and omission of the larger disturbances; whereas Table VII, of the preceding volume, similar in form, differs from the latter, being derived from all the observations including the disturbances.

HOURLY DECLINATION. NORMALS FOR JANUARY.[1]

Observations 19½ minutes later than indicated. Value of one scale division = 0′.453.
Increase of scale readings corresponds to a decrease of westerly declination.

YEAR.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	...	...	...	...	...	...	...	...	...	...	...	...
1841	579.3	...	577.0	...	578.6	...	576.9	...	580.7	...	581.9	...
1842	564.3	...	563.8	...	565.3	...	565.9	...	570.9	...	566.4	...
1843	...	...	...	...	...	...	...	...	...	...	...	...
1844	558.6	558.2	558.4	559.2	558.9	558.8	559.7	561.2	562.9	563.3	559.1	555.9
1845	530.9	531.3	531.1	531.5	533.0	531.6	532.9	535.2	535.8	533.8	530.2	526.7
Mean[2]	558.28	...	557.57	...	558.95	...	558.85	...	562.57	...	559.40	...
Same refer'd to its mean epoch[3]	565.25	564.80	564.35	565.62	565.70	564.66	565.47	567.74	569.27	569.51	566.65	561.88

YEAR.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	...	...	...	...	...	...	...	...	...	...	...	...
1841	570.0	...	568.8	...	570.3	...	574.2	...	578.0	...	580.1	...
1842	556.7	...	556.0	...	562.9	...	563.2	...	566.1	...	567.8	...
1843	...	...	555.4	...	...	...	...	...	...	...	...	...
1844	552.9	552.4	553.2	554.1	556.3	556.9	557.8	559.2	559.5	560.9	560.8	559.6
1845	524.2	525.2	526.2	528.0	530.1	531.8	532.7	532.8	533.3	533.0	532.4	532.0
Mean[2]	550.95	...	551.92	...	554.90	...	556.97	...	559.22	...	560.27	...
Same refer'd to its mean epoch[3]	557.72	557.31	557.55	558.97	561.20	562.41	563.38	564.82	565.90	567.00	567.20	566.35

[1] The hours refer to mean local time, reckoned from midnight to 24 hours.

[2] The mean given is the simple mean of the four readings, and at 14h. of five readings, and is here inserted for comparison with the corrected mean in the line below, which would have been obtained if there had been no omissions in the observations.

[3] To obtain the normals referring to January of the mean year, the readings for the defective years 1840 and 1843 have been interpolated in the following manner: 1. *For the even hours.*—The normals for any two consecutive years differ simply by the annual effect of the secular change, which may be regarded as uniform when the same hours and months are compared, as in the present case. The values derived from the comparison of the several months of any two years differ, however, by the accidental errors of the observations; thus, taking the difference of the normals for 1840 and 1841, we obtain for the several months the values—

June	+15d.7	September	+21d.9	December	+20d.0
July	20.5	October	12.7		
August	18.5	November	17.5	Mean	16.86

Which mean corresponds exactly to the difference of the constant terms in Part I, for 1840 and 1841. By adding, therefore, 16.9 scale divisions to the normals for 1841, we obtain interpolated values for 1840. The values from January to May, 1840, were thus supplied. The normals for 1843 were supplied in a different manner, by making use of the readings at 2 P. M., which were taken for the purpose of keeping up the continuity of the series. Subtracting 0.6 scale division from the hourly readings of 1842, we obtain those for 1843—this being the difference at 14h ; in like manner, adding 2.2 scale divisions to the readings of 1844, we obtain a second value for the normals of 1843. The mean of these two independent determinations has been used in supplying the readings for 1843. The normals for 1840 and 1843 being thus supplied, the figures in the last line of the preceding table are obtained by simply taking the mean of the six readings at each even hour. 2. *For the odd hours.*—The difference in the mean readings for any given odd hour, in 1844 and 1845, from the two adjacent even hours, was applied to the normals of these hours, and the mean taken as the normal of the intermediate odd hour. Thus, the mean reading at noon of 1844 and 1845 is 538.55, at 13h , 538.80, difference +0.25; which, added to the noon normal 557.72, gives 557.97 ; and, in like manner, by comparison with 14h., the correction to its normal is —0.90, and the normal for 13h. becomes 556.65. The mean of the two results, 557.31, is the resulting normal for this hour as given in the table.

The same principle of interpolation was applied throughout the tables. Due attention must be paid, in the deductions, for the unequal weight of the normals for the even and odd hours ; these weights being generally as 5 : 2, or proportional to the number of separate readings. The application of a nearly constant quantity to refer means from a defective number of years to the mean epoch of all the years, is not of much consequence in regard to the diurnal and annual inequalities, which depend mainly on differences of readings, but it is essential that no changes should have occurred in the zero of the scale during any interval under discussion.

Hourly Declination. Normals for February.

Observations 19½ minutes later than indicated. One division of scale = 0'.453.

YEAR.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	...	...	...	...	...	...	...	...	...	...	...	...
1841	575.0	...	573.2	...	575.6	...	577.8	...	582.1	...	579.5	...
1842	564.5	...	564.3	...	563.8	...	565.2	...	567.8	...	565.5	...
1843	...	...	...	...	...	...	...	...	...	...	...	...
1844	559.1	558.5	559.1	559.2	559.9	561.1	560.8	562.1	562.2	560.7	557.3	554.5
1845	531.6	531.1	531.0	532.4	532.3	533.1	534.7	535.9	535.7	535.4	533.0	528.6
Mean	557.55	...	556.90	...	557.90	...	559.62	...	561.95	...	558.82	...
Same refer'd to its mean epoch	563 88	563.10	563.13	563.90	564.23	565.25	565.93	567.88	568.53	567.97	565.42	561.47

YEAR.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	...	...	...	...	...	...	...	...	...	...	...	...
1841	569.5	...	566.0	...	569.5	...	572.4	...	574.4	...	575.8	...
1842	558.2	...	559.9	...	558.0	...	561.9	...	565.3	...	565.5	...
1843	...	...	555.9	...	...	...	...	...	...	...	...	...
1844	551.1	551.1	553.0	554.7	556.4	556.6	557.6	558.4	559.9	559.4	560.1	559.0
1845	524.4	523.0	525.3	527.5	529.7	530.4	532.4	531.3	533.6	534.4	532.3	531.9
Mean	550.80	...	552.02	...	553.40	...	556.07	...	558.30	...	558.42	...
Same refer'd to its mean epoch	557 33	555.85	557.17	558.30	559.43	560.25	562.13	562.25	564.42	565.02	564.77	564.00

Hourly Declination. Normals for March.

Observations 19½ minutes later than indicated. One division of scale = 0'.453.

YEAR.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	...	...	...	...	...	...	...	...	...	...	...	...
1841	577.1	...	577.6	...	580.9	...	582.9	...	586.8	...	578.9	...
1842	564.8	...	564.1	...	565.4	...	566.1	...	571.8	...	565.9	...
1843	...	...	...	...	...	...	...	...	...	...	...	...
1844	558.0	559.0	559.2	557.9	559.8	560.2	561.3	563.6	564.8	564.1	560.3	554.9
1845	532.9	532.7	533.7	533.6	535.0	533.9	536.0	538.8	539.4	538.6	534.5	529.4
Mean	558.20	...	558.65	...	560.27	...	561.58	...	565.70	...	559.90	...
Same refer'd to its mean epoch	565.60	565.72	566.03	565.75	567.82	567.53	569.20	572.11	573.37	571.95	567.32	562.02

YEAR.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	...	...	...	...	...	...	...	...	...	...	...	...
1841	569.4	...	567.7	...	571.8	...	576.4	...	577.4	...	577.7	...
1842	555.6	...	553.9	...	556.4	...	560.3	...	564.5	...	564.9	...
1843	...	...	557.2	...	...	...	...	...	...	...	...	...
1844	550.6	549.4	549.6	551.7	553.0	555.2	556.6	558.0	558.4	558.2	558.6	559.7
1845	524.8	522.5	522.8	524.8	527.8	529.7	531.6	533.0	533.0	533.8	533.5	534.0
Mean	550.10	...	550.24	...	552.25	...	556.22	...	558.32	...	558.67	...
Same refer'd to its mean epoch	557 52	555.75	555.97	557.75	559.63	561.85	563.68	565.31	565.75	566.04	566.08	566.94

Hourly Declination. Normals for April.

Observations 19½ minutes later than indicated. One division of scale = 0′.453.

YEAR.	0h	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	...	...	...	...	...	...	...	...	...	...	...	...
1841	580.0	...	581.9	...	582.9	...	585.6	...	587.6	...	579.4	...
1842	563.3	...	565.4	...	566.1	...	568.5	...	569.7	...	563.6	...
1843	569.7	...	570.0	...	571.0	...	574.7	...	576.2	...	566.2	...
1844	556.6	557.0	557 2	556.9	557.5	558.4	561.7	558.5	564.4	561.8	557.1	552.0
1845	529.1	528.8	529.0	529.2	529.8	531.7	534.0	535.6	537 5	535.4	528.5	522.5
Mean	559.74	...	560.70	...	561.46	...	564.90	...	567.08	...	558.96	...
Same refer'd to its mean epoch	565 93	566.42	567.05	567.12	567.85	568.31	571.17	569.90	373.32	570.98	565.18	559.76

YEAR.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	...	...	...	...	...	...	...	...	...	...	...	...
1841	568.8	...	566.1	...	571.7	...	576.9	...	578.0	...	579.1	...
1842	554.0	...	552.5	...	555.1	...	560.6	...	561.3	...	563.0	...
1843	557.8	...	555.7	...	562.6	...	564.8	...	568.5	...	568.7	...
1844	547.4	545.7	546.2	547.6	549.6	553.4	553.4	553.8	556.2	555.1	555.7	559.3
1845	517.8	513.9	514.0	517.2	521.5	525.8	527.8	527.9	528.1	528.5	528.0	529.4
Mean	549.16	...	546.90	...	552.10	...	556.70	...	558.42	...	558.90	...
Same refer'd to its mean epoch	555 25	552.54	552.92	555.13	558.18	562.05	562.88	563.16	564.50	564.59	565.08	567.50

Hourly Declination. Normals for May.

Observations 19½ minutes later than indicated. One division of scale = 0′.453.

YEAR.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	...	...	...	...	...	...	...	...	...	...	...	...
1841	579.1	...	579.8	...	581.9	...	587.4	...	589.1	...	578.6	...
1842	563.3	...	564.3	...	566.0	...	571.2	...	569.5	...	560.0	...
1843	567.0	...	567.3	...	569.6	...	574.6	...	575.6	...	565.7	...
1844	548.4	548.7	547.8	547.0	549.3	552.5	555.8	556.8	555.1	552.3	546.7	542.2
1845	529.9	531.3	529.7	531.7	533.2	536.3	539.3	541.9	540.7	536.0	528.0	522.6
Mean	557.54	...	557.78	...	560.00	...	565.66	...	566.00	...	555.80	...
Same refer'd to its mean epoch	563 95	565.16	564.27	564.72	566.47	569.28	572.10	574.01	572.67	569.07	562.42	557.72

YEAR.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	...	...	...	...	...	...	...	...	...	...	...	...
1841	569.4	...	567.9	...	573.6	...	577.4	...	578.5	...	580.1	...
1842	552.6	...	552.3	...	557.7	...	560.8	...	561.8	...	562.3	...
1843	556.0	...	556.2	...	562.2	...	566.4	...	566.9	...	567.3	...
1844	538.3	535.8	536.5	538.9	542.1	545.1	545.2	546.5	546.3	547.3	547.3	547.8
1845	517.1	516.8	518.9	522.1	526.7	529.3	529.6	530.4	529.7	530.3	530.5	530.3
Mean	54[illegible].68	...	546.36	...	552.46	...	555.88	...	556.64	...	557.50	...
Same refer'd to its mean epoch	553 28	551.62	552.77	555.23	558.80	561.94	562.28	563.44	563.10	563.94	564.09	564.04

Hourly Declination. Normals for June.

Observations 19½ minutes later than indicated. One division of scale = 0′.453.

YEAR.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	587.7	...	588.3	...	590.8	...	597.3	...	596.0	...	587.1	...
1841	571.7	...	572.2	...	574.7	...	583.3	...	582.6	...	571.1	...
1842	564.6	...	563.7	...	567.2	...	573.7	...	573.0	...	565.2	...
1843	566.0	...	565.6	...	568.4	...	574.1	...	573.9	...	564.8	...
1844	548.7	549.0	549.3	549.1	551.6	553.9	557.6	559.1	558.2	554.3	547.9	541.8
1845	531.5	531.7	531.6	532.0	534.8	537.9	541.9	543.5	542.5	538.6	532.2	524.9
Mean	561.70	...	561.78	...	564.58	...	571.32	...	571.03	...	561.38	...
Same refer'd to its mean epoch	...	561.81	...	561.91	...	567.38	...	572.42	...	567.46	...	555.22

YEAR.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	578.8	...	576.7	...	581.2	...	586.1	...	585.8	...	586.9	...
1841	561.6	...	560.3	...	565.0	...	570.1	...	570.9	...	570.8	...
1842	555.1	...	552.5	...	558.3	...	561.8	...	563.7	...	564.1	...
1843	556.4	...	556 0	...	561.1	...	564.3	...	564.0	...	565.6	...
1844	537.4	535.0	537.3	540.0	542.4	545.2	545.6	546.2	546.5	546.8	548.0	548.5
1845	521.3	519.6	520.0	522.1	525.4	528.9	530.3	530.7	530.1	530.7	530.3	531.4
Mean	551.77	...	550.47	...	555.57	...	559.70	...	560.17	...	560.95	...
Same refer'd to its mean epoch	...	549.42	...	552.80	...	558.76	...	560.26	...	560.58	...	561.65

Hourly Declination. Normals for July.

Observations 19½ minutes later than indicated. One division of scale = 0′.453.

YEAR.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	590.6	...	590.5	...	592.2	...	598.0	...	598.8	...	588.7	...
1841	569.9	...	568.5	...	571.6	...	578.4	...	581.2	...	571.8	...
1842	566.0	...	566.0	...	568.4	...	576.6	...	576.4	...	565.8	...
1843	566.9	...	565.9	...	568.2	...	574.2	...	574.6	...	564.5	...
1844	549.0	550.5	548.4	549.4	551.0	554.3	556.9	559.8	558.6	554.8	548.0	540.8
1845	...	...	...	...	...	...	...	...	...	...	...	...
Mean	568.48	...	567.86	...	570.28	...	576.82	...	577.92	...	567.76	...
Same refer'd to its mean epoch	561.77	563.26	561.15	562.07	563.60	567.16	570.02	572.67	571.23	567.61	561.00	535.47

YEAR.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	577.8	...	577.3	...	582.0	...	586.6	...	588.8	...	589.6	...
1841	558.9	...	557.3	...	562.3	...	567.2	...	568.8	...	568.6	...
1842	556.3	...	553.8	...	558.5	...	562.4	...	564.2	...	567.1	...
1843	555.1	...	554.1	...	559.5	...	563.6	...	563.8	...	565.6	...
1841	538.3	535.5	536.3	538.8	541.9	544.5	545.8	546.2	546.6	547.4	548.8	549.3
1845	...	...	...	...	...	...	...	...	...	...	...	...
Mean	557.28	...	555.76	...	560.84	...	565.12	...	566.44	...	567.94	...
Same refer'd to its mean epoch	550 65	548.05	549.05	551.33	554.22	556.98	558.43	559.05	559.67	560.18	561.28	561.97

Hourly Declination. Normals for August.

Observations 19½ minutes later than indicated. One division of scale = 0′.453.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	588.6	...	589.0	...	592.1	...	599.7	...	602.4	...	582.7	...
1841	568.4	...	570.3	...	571.6	...	580.1	...	583.9	...	568.9	...
1842	564.8	...	566.0	...	568.5	...	573.7	...	575.0	...	560.0	...
1843	564.2	...	564.5	...	267.2	...	573.5	...	572.7	...	560.5	...
1844	548.6	547.8	547.3	547.4	550.9	552.4	557.5	560.3	558.2	551.8	543.3	536.4
1845	...	...	...	...	...	...	...	...	...	...	...	...
Mean	566.92	...	567.42	...	570.06	...	576.90	...	578.44	...	563.08	...
Same refer'd to its mean epoch	560.40	559.85	560.60	560.80	563.40	565.00	570.20	573.35	571.60	565.01	556.32	549.14

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	573.8	...	575.2	...	581.5	...	586.5	...	588.2	...	589.4	...
1841	558.3	...	556.9	...	564.0	...	566.8	...	568.6	...	568.9	...
1842	552.3	...	553.7	...	561.5	...	562.2	...	564.1	...	564.5	...
1843	555.1	...	554.6	...	561.2	...	563.6	...	562.3	...	564.2	...
1844	531.8	532.0	534.3	538.7	542.1	544.3	546.0	546.5	546.7	546.6	547.8	547.7
1845	...	...	...	...	...	...	...	...	...	...	...	...
Mean	554.26	...	554.94	...	562.06	...	565.02	...	565.98	...	566.96	...
Same refer'd to its mean epoch	547 05	546.49	548.03	552.15	555.27	557.12	558.38	558.99	559.30	559.15	560.30	559.85

Hourly Declination Normals for September.

Observations 19½ minutes later than indicated. One division of scale = 0′.453.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	585.8	...	588.5	...	590.2	...	596.5	...	595.8	...	584.1	...
1841	565.1	...	564.5	...	565.5	...	569.4	...	571.1	...	564.1	...
1842	567.4	...	567.8	...	570.0	...	576.8	...	574.9	...	561.2	...
1843	560.4	...	560.4	...	560.3	...	565.7	...	566.6	...	554.6	...
1844	543.3	543.1	544.1	546.0	546.5	547.1	550.0	552.9	552.4	545.8	538.3	532.5
1845	...	...	...	...	...	...	...	...	...	...	...	...
Mean	564.40	...	565.06	...	566.50	...	571.68	...	572.16	...	560.46	...
Same refer'd to its mean epoch	557 42	557.16	558.10	559.60	559.70	561.00	564.60	566.70	565.40	559.80	553.30	547.47

Year.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	570.6	...	572.8	...	581.7	...	583.2	...	586.6	...	585.9	...
1841	553.6	...	554.5	...	559.5	...	562.9	...	563.8	...	564.0	...
1842	556.0	...	555.4	...	562.0	...	565.7	...	566.7	...	566.6	...
1843	547.5	...	550.5	...	556.8	...	558.0	...	560.0	...	558.7	...
1844	529.3	530.0	534.1	538.3	539.4	541.9	542.4	541.9	543.0	544.6	543.7	543.3
1845	...	...	...	...	...	...	...	...	...	...	...	...
Mean	551.40	...	553.46	...	559.88	...	562.44	...	564.02	...	563.78	...
Same refer'd to its mean epoch	544.25	543.81	546.77	551.44	553.00	555.31	555.63	556.04	557.05	558.26	556.97	557.00

Hourly Declination. Normals for October.

Observations 19½ minutes later than indicated. One division of scale = 0′.453.

YEAR.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	585.8	...	583.7	...	584.4	...	582.4	...	582.5	...	577.4	...
1841	566.8	...	566.3	...	565.5	...	567.6	...	569.4	...	568.2	...
1842	563.1	...	563.1	...	564.4	...	566.0	...	568.8	...	564.0	...
1843	559.6	560.2	559.6	559.1	559.9	560.6	562.1	565.1	566.0	565.0	560.8	556.5
1844	545.1	545.3	544.2	546.1	545.8	544.4	548.6	550.9	551.5	548.7	545.3	540.8
1845	...	...	...	...	...	...	...	...	...	...	...	...
Mean	564.08	...	563.38	...	564.00	...	565.34	...	567.64	...	563.14	...
Same refer'd to its mean epoch	557 45	557.71	556.72	557.33	557.50	556.67	559.08	561.23	561.48	560.04	556.70	552.36

YEAR.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	571.7	...	570.6	...	575.2	...	579.6	...	579.0	...	586.4	...
1841	564.0	...	562.3	...	564.7	...	573.5	...	568.6	...	569.3	...
1842	556.0	...	555.0	...	558.2	...	564.3	...	565.0	...	565.3	...
1843	553.6	552.6	552.7	554.2	556.2	557.0	558.2	559.7	560.1	561.1	559.7	560.7
1844	541.1	539.5	541.4	544.0	545.7	545.4	545.6	545.0	544.9	544.6	544.5	544.6
1845	...	...	...	...	...	...	...	...	...	...	...	...
Mean	557.28	...	556.40	...	560.00	...	564.24	...	563.56	...	565.04	...
Same refer'd to its mean epoch	551.12	549.62	550.43	552.39	554.15	555.68	557.67	557.47	556.98	558.12	558.15	558.22

Hourly Declination. Normals for November.

Observations 19½ minutes later than indicated. One division of scale = 0′.453.

YEAR.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	574.4	...	573.9	...	576.2	...	577.0	...	579.7	...	575.0	...
1841	557.2	...	558.5	...	558.5	...	557.6	...	561.7	...	557.1	...
1842	564.2	...	563.8	...	565.6	...	566.9	...	569.2	...	563.3	...
1843	556.3	556.7	556.6	556.6	557.4	557.4	559.1	561.8	561.3	560.1	556.2	552.6
1844	546.8	546.8	548.3	548.6	547.4	548.5	551.5	549.2	548.4	547.9	546.2	542.8
1845	...	...	...	...	...	...	...	...	...	...	...	...
Mean	559.78	...	560.22	...	561.02	...	562.42	...	564.06	...	559.56	...
Same refer'd to its mean epoch	554.15	554.21	554.77	555.20	555.28	555.30	557.13	557.98	557.98	556.90	553.87	550.00

YEAR.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	567.5	...	565.8	...	570.8	...	574.1	...	576.9	...	576.0	...
1841	551.8	...	549.9	...	553.4	...	554.9	...	558.0	...	558.6	...
1842	556.6	...	557.3	...	561.2	...	564.0	...	565.5	...	565.0	...
1843	550.4	550.0	551.1	552.6	553.8	554.9	556.3	557.5	557.5	557.7	557.3	557.4
1844	542.8	541.7	544.5	546.1	545.6	547.9	548.8	548.2	548.3	549.6	548.0	548.0
1845	...	...	...	...	...	...	...	...	...	...	...	...
Mean	553.82	...	553.72	...	556.96	...	559.62	...	561.24	...	560.98	...
Same refer'd to its mean epoch	548 52	547.32	548.72	550.76	551.60	553.25	554.35	555.26	555.62	556.36	555.35	555.35

HOURLY DECLINATION. NORMALS FOR DECEMBER.

Observations 19½ minutes later than indicated. One division of scale = 0′.453.

YEAR.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	571.2	...	568.5	...	573.1	...	572.8	...	573.8	...	573.9	...
1841	560.1	...	559.3	...	560.5	...	559.6	...	560.1	...	558.1	...
1842	561.7	...	560.7	...	562.1	...	562.7	...	565.5	...	564.2	...
1843	559.0	558.1	557.4	558.2	557 8	558.8	560.0	560.8	561.2	561.9	559.9	556.7
1844	536.1	535.8	535.4	535.9	536.8	537.3	537.2	536.8	537.9	539.3	536.1	532.9
1845	...	...	...	...	...	...	...	...	...	...	...	...
Mean	557.62	...	556.26	...	558.06	...	558.46	...	559.70	...	558.44	...
Same refer'd to its mean epoch	550 57	549.92	549.32	550.38	551.05	551.35	551.45	551.75	552.60	553.75	551.25	547.78

YEAR.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	564.0	...	564.9	...	566.0	...	571.8	...	572.3	...	574.5	...
1841	552.9	...	551.7	...	555.8	...	559.6	...	563.3	...	561.6	...
1842	556.6	...	556.2	...	560.1	...	562.0	...	563.5	...	563.8	...
1843	552.9	551.4	550.9	553.1	554.6	557.5	558.2	558.9	559.6	560.0	559.9	559.5
1844	530.6	529.3	529.4	532.1	533.2	534.8	535.9	537.0	536.8	537.4	537.8	537.1
1845	...	...	...	...	...	...	...	...	...	...	...	...
Mean	551.40	...	550.62	...	553.94	...	557.50	...	559.10	...	559.52	...
Same refer'd to its mean epoch	544.47	543.45	543.62	546.35	547.02	549.40	550.43	551.50	551.92	552.35	552.43	551.60

The following table contains the recapitulation of the monthly normals for each hour of the day, and for the mean epoch 1842 to 1843, and forms the basis for the discussion of the diurnal variation and its annual inequality. The table exhibits at one view the mean hourly readings for each month, unaffected by the larger disturbances.

RECAPITULATION.—MONTHLY DECLINATION-NORMALS FOR EACH HOUR OF THE DAY, AND FOR THE MEAN EPOCH 1842–43.

Increasing scale divisions denote an easterly movement of the north end of the magnet. The readings belong to an hour 19½ minutes later than indicated by the figures at the head of the columns. Value of a scale division = 0′.453. Readings derived from five years of observation between 1840 and 1845.

PHILADELPHIA MEAN TIME.

MEAN EPOCH 1842–43.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
January	565.25	564.80	564.35	565.62	565.70	564.66	565.47	567.74	569.27	569.51	566.65	561.88
February	563.88	563.10	563.13	563.90	564.23	565.25	565.93	567.88	568.53	567.97	565.42	561.47
March	565.60	565.72	566.03	565.75	567.82	567.53	569.20	572.11	573.37	571.95	567.32	562.02
April	565.93	566.42	567.05	567.12	567.85	568.31	571.17	569.90	573.32	570.98	565.18	559.76
May	563.95	565.16	564.27	564.72	566.47	569.28	572.10	574.01	572.67	569.07	562.42	557.72
June	561.70	561.81	561.78	561.91	564.58	567.38	571.32	572.42	571.03	567.46	561.38	555.22
July	561.77	563.26	561.15	562.07	563.60	567.16	570.02	572.67	571.23	567.61	561.00	553.47
August	560.40	559.85	560.60	560.80	563.40	565.00	570.20	573.35	571.60	565.01	556.32	549.14
September	557.42	557.16	558.10	559.60	559.70	561.00	564.60	566.70	565.40	559.80	553.30	547.47
October	557.45	557.71	556.72	557.33	557.50	556.67	559.08	561.23	561.48	560.04	556.70	552.36
November	554.15	554.21	454.77	555.20	555.28	555.30	557.13	557.98	557.98	556.90	553.87	550.00
December	550.57	549.92	549.32	550.38	551.05	551.35	551.45	551.75	552.60	553.75	551.25	547.78

MEAN EPOCH 1842–43.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mean.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
January	557.72	557.31	557.55	558.97	561.20	562.41	563.38	564.82	565.90	567.00	567.20	566.35	564.20
February	557.33	555.85	557.17	558.30	559.43	560.25	562.13	562.25	564.42	565.02	564.77	564.00	562.98
March	557.52	555.75	555.97	557.75	559.63	561.85	563.68	565.31	565.75	566.04	566.08	566.94	564.86
April	555.25	552.54	552.92	555.13	558.18	562.05	562.88	563.16	564.50	564.59	565.08	567.50	564.03
May	553.28	551.62	552.77	555.23	558.80	561.94	562.28	563.44	563.10	563.94	564.09	564.04	563.18
June	551.77	549.42	550.47	552.80	555.57	558.76	559.70	560.26	560.17	560.58	560.95	561.65	560.84
July	550.65	548.05	549.05	551.33	554.22	556.98	558.43	559.05	559.67	560.18	561.28	561.97	560.24
August	547.05	546.49	548.03	552.15	555.27	557.12	558.38	558.99	559.30	559.15	560.30	559.85	559.07
September	544.25	543.81	546.77	551.44	553.00	555.31	555.63	556.04	557.05	558.26	556.97	557.00	556.07
October	551.12	549.62	550.43	552.39	554.15	555.68	557.67	557.47	556.98	558.12	558.15	558.22	556.43
November	548.52	547.32	548.72	550.76	551.60	553.25	554.35	555.26	555.62	556.36	555.35	555.35	553.97
December	544.47	543.45	543.62	546.35	547.02	549.40	550.43	551.50	551.92	552.35	552.43	551.60	549.82
Mean	...	...	...	...	...	...	...	...	...	...	...	...	559.64

This table shows plainly the relation of the mean hourly position of the magnet of each month to its general mean position, after the separation of the larger disturbances, and also, by running the eye along any horizontal line, the solar-diurnal variation for each month. It does not, however, show distinctly the annual inequality, on account of the changes in the numbers by the secular change. To eliminate the effect of this change, each hourly normal has been compared, in the following table, with the corresponding mean monthly value, as given in the last right-hand column; the sign + indicating a westerly direction, and — an easterly direction,[1] of the north end of the magnet from the mean monthly position. The scale divisions have been converted into minutes of arc.

[1] The sign + being generally taken to signify west declination, it has been retained to indicate a movement of the north end of the magnet to the west.

TABLE OF THE SOLAR DIURNAL VARIATION OF THE MAGNETIC DECLINATION FOR EACH MONTH OF THE YEAR, SHOWING THE ANNUAL INEQUALITY.

Observations 19½ minutes later than indicated in the headings.

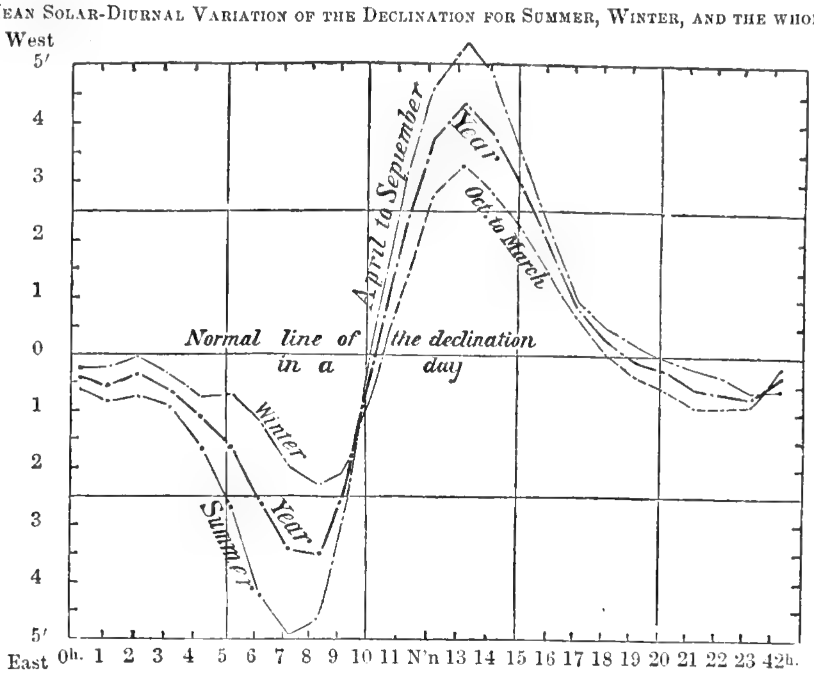
PHILADELPHIA MEAN TIME.

MEAN EPOCH 1842–43.	0h.	1h.	2h	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
January	—0′.47	—0′.27	—0′.07	—0′.64	—0′.68	—0′.21	—0′.57	—1′.61	—2′.29	—2′.40	—1′.11	+1′.06
February	—0.41	—0.06	—0.07	—0.42	—0.56	—1.03	—1.34	—2.22	—2.51	—2.26	—1.11	+0.68
March	—0.34	—0.39	—0.53	—0.40	—1.35	—1.21	—1.97	—3.28	—3.85	—3.21	—1.12	+1.29
April	—0.86	—1.09	—1.37	—1.40	—1.73	—1.94	—3.24	—2.65	—4.21	—3.15	—0.50	+1.93
May	—0.35	—0.90	—0.49	—0.70	—1.49	—2.77	—4.04	—4.90	—4.30	—2.66	+0.35	+2.47
June	—0.39	—0.44	—0.43	—0.48	—1.70	—2.97	—4.75	—5.25	—4.62	—3.00	—0.25	+2.54
July	—0.68	—1.37	—0.41	—0.82	—1.53	—3.18	—4.44	—5.63	—4.98	—3.34	—0.35	+3.07
August	—0.60	—0.36	—0.69	—0.78	—1.96	—2.68	—5.03	—6.47	—5.68	—2.69	+1.25	+4.50
September	—0.61	—0.49	—0.92	—1.60	—1.64	—2.23	—3.86	—4.81	—4.23	—1.69	+1.26	+3.89
October	—0.46	—0.58	—0.13	—0.41	—0.48	—0.10	—1.20	—2.17	—2.28	—1.63	—0.12	+1.84
November	—0.09	—0.11	—0.36	—0.55	—0.59	—0.60	—1.44	—1.81	—1.81	—1.33	+0.05	+1.80
December	—0.34	—0.05	+0.23	—0.26	—0.55	—0.69	—0.73	—0.87	—1.27	—1.78	—0.64	+0.93
Summer	—0.58	—0.78	—0.72	—0.96	—1.68	—2.63	—4.23	—4.95	—4.67	—2.76	+0.29	+3.07
Winter	—0.35	—0.24	—0.16	—0.45	—0.70	—0.64	—1.22	—1.99	—2.33	—2.10	—0.67	+1.27
Year	—0.47	—0.51	—0.44	—0.71	—1.19	—1.64	—2.72	—3.47	—3.50	—2.43	—0.19	+2.17

MEAN EPOCH 1842–43.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
January	+2′.94	+3′.12	+3′.01	+2′.36	+1′.36	+0′.81	+0′.37	—0′.28	—0′.77	—1′.27	—1′.36	—0′.98
February	+2.55	+3.23	+2.62	+2.12	+1.61	+1.24	+0.38	+0.33	—0.65	—0.93	—0.81	—0.46
March	+3.33	+4.13	+3.02	+3.22	+2.36	+1.36	+0.53	—0.20	—0.40	—0.54	—0.55	—0.95
April	+3.98	+5.20	+5.02	+4.03	+2.64	+0.90	+0.52	+0.39	—0.21	—0.26	—0.47	—1.57
May	+4.49	+5.24	+4.71	+3.60	+1.99	+0.56	+0.41	—0.12	+0.04	—0.35	—0.41	—0.39
June	+4.11	+5.16	+4.70	+3.64	+2.38	+0.95	+0.51	+0.27	+0.30	+0.12	—0.05	—0.36
July	+4.35	+5.53	+5.07	+4.03	+2.73	+1.47	+0.81	+0.53	+0.26	+0.03	—0.47	—0.78
August	+5.45	+5.71	+5.00	+3.14	+1.72	+0.88	+0.32	+0.04	—0.10	—0.04	—0.56	—0.36
September	+5.35	+5.56	+4.17	+2.09	+1.39	+0.35	+0.20	+0.01	—0.45	—1.00	—0.41	—0.42
October	+2.40	+3.08	+2.72	+1.83	+1.04	+0.35	—0.56	—0.47	—0.25	—0.76	—0.78	—0.81
November	+2.46	+3.01	+2.37	+1.45	+1.08	+0.33	—0.18	—0.59	—0.74	—1.09	—0.63	—0.63
December	+2.42	+2.89	+2.81	+1.57	+1.27	+0.19	—0.27	—0.76	—0.96	—1.15	—1.18	—0.81
Summer	+4.62	+5.40	+4.78	+3.42	+2.14	+0.85	+0.46	+0.19	—0.03	—0.25	—0.40	—0.65
Winter	+2.68	+3.24	+2.76	+2.09	+1.46	+0.71	+0.05	—0.33	—0.63	—0.95	—0.88	—0.77
Year	+3.65	+4.32	+3.77	+2.76	+1.80	+0.78	+0.25	—0.07	—0.33	—0.60	—0.64	—0.71

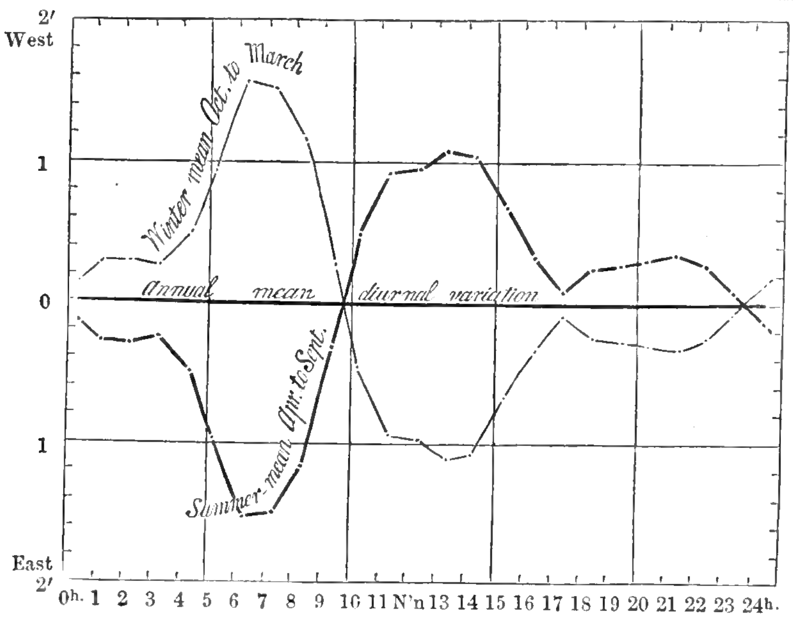
The distinctive features of the above table are next to be considered analytically as well as graphically. The inequality in the diurnal variation is most conspicuous when the tabular numbers in the horizontal lines for the months of February and August are compared. The annual variation appears plainest by carrying the eye over the vertical column at the hours 6 or 7 A. M. The annual variation depends on the earth's position in its orbit; the diurnal variation being subject to an inequality depending on the sun's declination. The diurnal range is greater when the sun has north declination, and smaller when south declination; the phenomenon passing from one state to the other about the time of the equinoxes. To show the diurnal variation at these periods, the summer and winter means, as well as the annual means, were tabulated. The months from April to September (inclusive) comprise the summer period, and from October to March (inclusive) the winter period. The first diagram (A) shows this variation, and contains the type curves for these half yearly periods. We find for the summer months a diurnal range of nearly 10½ minutes, and for the winter months of but 5½ minutes. These and other curves will be further analyzed hereafter.

(A).—Mean Solar-Diurnal Variation of the Declination for Summer, Winter, and the whole Year.



The second diagram (B) exhibits the same phenomenon in a different way; the yearly curve of the first diagram being straightened out and forming the axis of the second diagram, which thus shows the deviations from the annual mean value for the two seasons when the sun has north and south declination. The ordinates are obtained by subtracting the annual mean from either the summer or winter mean in the preceding table. This diagram exhibits, in quite a characteristic manner, the course of the annual variation at the different hours of the day, at

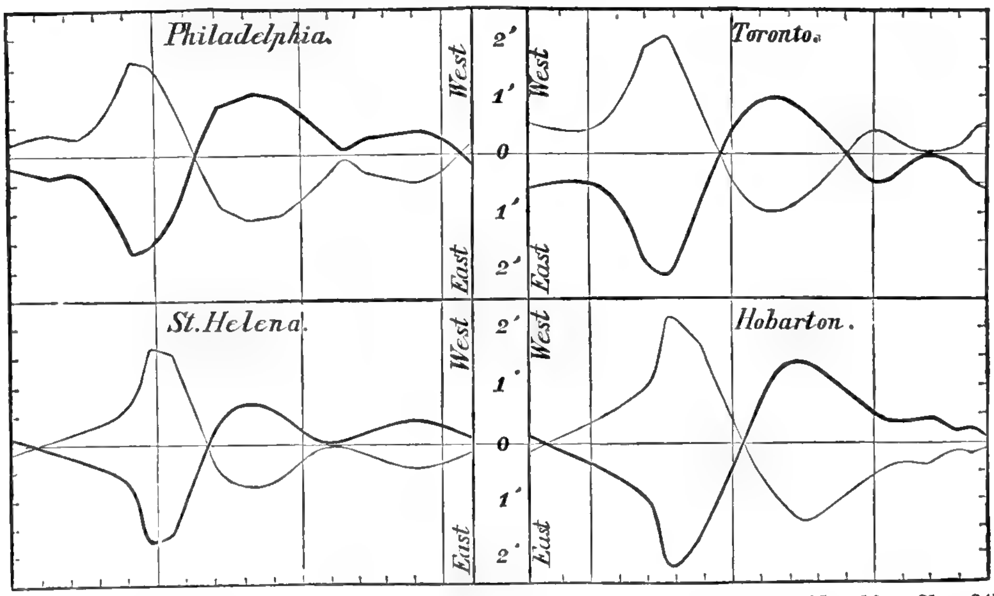
(B).—Semi-Annual Irregularities of the Solar-Diurnal Variation of the Declination.



the season for which the diagram is constructed. Thus, at the hour of 6 or 7 in the morning, the annual variation is a maximum, disappearing at a quarter before 10 A. M., and reaching a second (secondary) maximum value at 1 P. M. It almost disappears soon after 5 P. M., and a third still smaller maximum is reached after 9 P. M. Half an hour before midnight, the annual variation again disappears. At (and before and after) the principal maximum, between 6 and 7 in the morning, the annual variation causes the north end of the magnet to be deflected to the east in summer and to the west in winter; at 1 P. M., the deflections are to the west in summer and to the east in winter. The range of the diurnal motion is thus increased in summer and diminished in winter; the magnet being deflected in summer more to the east in the morning hours, and more to the west in the afternoon hours, or having greater elongations than it would have if the sun moved in the equator. In winter, the converse is the case. The range of the annual variation from summer to winter is about 3′.0, and its daily range about 2′.6 at Philadelphia.

(C).—COMPARATIVE DIAGRAM OF THE SEMI-ANNUAL DEFLECTION OF THE SOLAR-DIURNAL VARIATION.

Sun { north / south } of the equator { —— / —— }



The next diagram (C) has been projected in order to illustrate the semi-annual inequality of the diurnal variation at four principal magnetic stations.[1] The general features of the Philadelphia curve most nearly resemble those exhibited in the St. Helena curve; and, relatively, the Toronto and Hobarton curves appear to represent rather extreme than normal shapes. The Philadelphia and St. Helena

[1] The annual variation of the diurnal motion has been made the subject of a particular discussion by General Sabine, in papers presented to the British Association and the Royal Society. See Reports of the British Association, 1854, pp. 355–368, and Transactions of Royal Society, May 18, 1854, pp. 67–82; also, article XXVIII, Philosophical Transactions, 1851.

curves have another feature in common: the amplitude at its maximum value, shortly after 6 A. M., is less than the amplitude at Toronto and Hobarton; and, upon the whole, the Philadelphia type confirms the idea that all forms partake of the same general character, more or less affected by incidental irregularities.

In reference to the annual variation, General Sabine, in the "rectifications and additions" to the last volume of Humboldt's *Cosmos*, expresses himself as follows: "Thus, in each hemisphere, the semi-annual deflections concur with those of the mean annual variation for half the year, and consequently augment them, and oppose and diminish them in the other half. At the magnetic equator, there is no mean diurnal variation, but in each half year the alternate phases of the sun's annual inequality constitutes a diurnal variation, of which the range in each day is about 3′ or 4′, taking place every day in the year except about the equinoxes; the march of this diurnal variation being from east in the forenoon to west in the afternoon, when the sun has north declination, and the reverse when south declination." According to the same authority, the *annual* variation is the *same* in both hemispheres, the north end of the magnet being deflected to the east in the forenoon, the sun having north declination; when in the *diurnal* variation, the north end of the magnet at that time of the day is deflected to the east in the northern hemisphere and to the west in the southern hemisphere. In other words, in regard to direction, the law of the annual variation is the same, and that of the diurnal variation the opposite, in passing from the northern to the southern magnetic hemisphere.

I next proceed to consider more in detail the annual variation at the hours of 6 and 7 in the morning and of 1 and 2 in the afternoon, these being the hours of the principal and secondary maxima respectively. By subtracting the annual mean from each monthly value at the respective hours, we obtain from the preceding general table the following columns:—

Annual Variation at the Hours of the Principal and Secondary Maxima of Range.

$\left.\begin{matrix}+\\-\end{matrix}\right\}$ indicates $\left\{\begin{matrix}\text{west}\\\text{east}\end{matrix}\right\}$ deflection from the mean annual position.

	6h. A. M.	7h. A. M.	Mean.	1h. P. M.	2h. P. M.	Mean.
January	+2′.15	+1′.86	+2′.01	−1′.20	−0′.76	−0′.98
February	+1.38	+1.25	+1.31	−1.09	−1.15	−1.12
March	+0.75	+0.19	+0.47	−0.19	−0.75	−0.47
April	−0.52	+0.82	+0.15	+0.88	+1.25	+1.06
May	−1.32	−1.43	−1.38	+0.92	+0.94	+0.93
June	−2.03	−1.78	−1.90	+0.84	+0.93	+0.89
July	−1.72	−2.16	−1.94	+1.21	+1.30	+1.25
August	−2.31	−3.00	−2.66	+1.39	+1.23	+1.31
September	−1.14	−1.34	−1.24	+1.24	+0.40	+0.82
October	+1.52	+1.30	+1.41	−1.24	−1.05	−1.14
November	+1.28	+1.66	+1.47	−1.31	−1.40	−1.35
December	+1.99	+2.60	+2.30	−1.43	−0.96	−1.20
	Maximum range at the above hours, 5′.0; the easterly deflection being greater by 0′.4 than the westerly.			Range at the hours 1 and 2 P. M., 2′.7; the eastern and western deflections being equal.		

A general inspection of the above columns containing the mean values shows that, approximately, the solstices are the turning epochs of this annual variation, the signs changing at the time of the equinoxes. To ascertain how nearly this is true, and in order to obtain a more precise expression, the means of the two columns (after changing the signs in the second) for each month respectively, were put into an analytical form, using Bessel's well-known formula for periodic functions—

$$\Delta_a = +1'.78\ sin\ (\theta + 90°) + 0'.32\ sin\ (2\theta + 180°);$$

$$\text{or, } \Delta_a = +1'.78\ cos\ \theta - 0'.32\ sin\ 2\theta;$$

the angle θ counting from January 1st.

The maximum values will occur on the first of January and the first of July; and the transition from a positive to a negative value, and the reverse, will take place on the first of April and the first of October, the equation $1.78\ cos\ \theta = 0.32\ sin\ 2\ \theta$, being only satisfied for $\theta = 90°$ and $270°$. That the angles C_1 and C_2 should be exactly 90° and 180° is remarkable. The monthly values are satisfied as follows:—

Middle of	By observation.	By calculation.
January	+1'.50	+1'.56
February	+1.22	+0.94
March	+0.47	+0.30
April	—0.46	—0.30
May	—1.16	—0.94
June	—1.40	—1.56
July	—1.59	—1.56
August	—2.00	—0.94
September	—1.03	—0.30
October	+1.28	+0.30
November	+1.41	+0.94
December	+1.76	+1.56

The regular progression of the monthly values is a feature of the annual variation deserving particular notice. There is no sudden transition from the positive to the negative side, or *vice versâ*, at or near the time of the equinoxes (certainly not at the vernal equinox); on the contrary, the annual variation seems to be regular in its progressive changes. The method here pursued is entirely different from that employed by General Sabine for the same end, but the results are, nevertheless, in close accordance. He remarks (in the British Association report above cited): "When a mean is taken corresponding to the 10th or 11th day after the equinox, the transition from the character of the preceding six months has already commenced and advanced very far towards its completion, and, by the middle of October, is quite complete; apparently, the progress of the change is somewhat more tardy in the March than in the September equinox." From the above analysis, we have found that the transition took place *ten* days after either equinox, and also that the turning points occur ten days after the solstices.

For the more precise determination of the law of the phenomenon, and in order to render the results of similar investigations comparable with one another, the *regular* solar-diurnal variation is now to be expressed as a function of the time. The preceding tabular values, given in minutes of arc, when treated as required by Bessel's[1] periodic function, furnish the following expressions for each month of the year:—

[1] For another development of the formula, see Rev. Dr. H. Lloyd, "On the Mean Results of Observations," Transactions Royal Irish Academy, 1848, Vol. XXII, Part I. Dublin, 1849.

For January, $\Delta_d = +1'.423 \sin(15n + 225^\circ\,09') + 1'.491 \sin(30n + 16^\circ\,38')$
$+0'.579 \sin(45n + 220^\circ\,23') + 0'.548 \sin(60n + 53^\circ\ldots)$

For February, $\Delta_d = +1'.469 \sin(15n + 211^\circ\,09') + 1'.456 \sin(30n + 20^\circ\,50')$
$+0'.472 \sin(45n + 231^\circ\,59') + 0'.352 \sin(60n + 60^\circ\ldots)$

For March, $\Delta_d = +2'.098 \sin(15n + 206^\circ\,46') + 1'.827 \sin(30n + 26^\circ\,34')$
$+0'.693 \sin(45n + 230^\circ\,10') + 0'.413 \sin(60n + 84^\circ\ldots)$

For April, $\Delta_d = +2'.906 \sin(15n + 213^\circ\,21') + 2'.001 \sin(30n + 34^\circ\,01')$
$+0'.926 \sin(45n + 223^\circ\,29') + 0'.245 \sin(60n + 80^\circ\ldots)$

For May, $\Delta_d = +2'.746 \sin(15n + 210^\circ\,38') + 2'.377 \sin(30n + 45^\circ\,50')$
$+0'.970 \sin(45n + 251^\circ\,57') + 0'.100 \sin(60n + 161^\circ\ldots)$

For June, $\Delta_d = +2'.883 \sin(15n + 204^\circ\,09') + 2'.438 \sin(30n + 44^\circ\,15')$
$+0'.941 \sin(45n + 254^\circ\,03') + 0'.216 \sin(60n + 114^\circ\ldots)$

For July, $\Delta_d = +3'.310 \sin(15n + 204^\circ\,19') + 2'.465 \sin(30n + 38^\circ\,48')$
$+1'.047 \sin(45n + 251^\circ\,38') + 0'.092 \sin(60n + 176^\circ\ldots)$

For August, $\Delta_d = +3'.161 \sin(15n + 211^\circ\,37') + 2'.849 \sin(30n + 52^\circ\,16')$
$+1'.375 \sin(45n + 265^\circ\,49') + 0'.201 \sin(60n + 51^\circ\ldots)$

For September, $\Delta_d = +2'.706 \sin(15n + 220^\circ\,05') + 2'.372 \sin(30n + 55^\circ\,54')$
$+1'.126 \sin(45n + 261^\circ\,14') + 0'.414 \sin(60n + 115^\circ\ldots)$

For October, $\Delta_d = +1'.271 \sin(15n + 226^\circ\,29') + 1'.325 \sin(30n + 33^\circ\,12')$
$+0'.727 \sin(45n + 230^\circ\,52') + 0'.150 \sin(60n + 47^\circ\ldots)$

For November, $\Delta_d = +1'.259 \sin(15n + 229^\circ\,06') + 1'.257 \sin(30n + 39^\circ\,15')$
$+0'.390 \sin(45n + 236^\circ\,30') + 0'.242 \sin(60n + 87^\circ\ldots)$

For December, $\Delta_d = +1'.212 \sin(15n + 231^\circ\,46') + 1'.321 \sin(30n + 23^\circ\,34')$
$+0'.367 \sin(45n + 205^\circ\,46') + 0'.418 \sin(60n + 32^\circ\ldots)$

In like manner, we obtain for the summer half-year (from April to September inclusive), for the winter half-year (from October to March inclusive), and for the whole year, the following expressions for the diurnal variation:—

For summer half-year, $\Delta_d = +2'.936 \sin(15n + 210^\circ\,36') + 2'.404 \sin(30n + 46^\circ\,07')$
$+1'.031 \sin(45n + 253^\circ\,37') + 0'.178 \sin(60n + 132^\circ\,20')$

For winter half-year, $\Delta_d = +1'.420 \sin(15n + 220^\circ\,41') + 1'.399 \sin(30n + 26^\circ\,39')$
$+0'.520 \sin(45n + 227^\circ\,26') + 0'.310 \sin(60n + 61^\circ\,17')$

For the whole year,[1] $\Delta_d = +2'.167 \sin(15n + 213^\circ\,55') + 1'.875 \sin(30n + 38^\circ\,52')$
$+0'.759 \sin(45n + 244^\circ\,40') + 0'.198 \sin(60n + 83^\circ\,05')$

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[1] For the purpose of showing the correspondence when the above equation is deduced *independently*, from the observations at the even and odd hours, I add here the values for the two cases:—

From even hours, $\Delta_d = +2'.170 \sin(15n + 213^\circ\,27') + 1'.888 \sin(30n + 38^\circ\,59')$
$+0'.729 \sin(45n + 244^\circ\,57') + 0'.183 \sin(60n + 83^\circ\,26')$

From odd hours, $\Delta_d = +2'.159 \sin(15n + 215^\circ\,19') + 1'.835 \sin(30n + 38^\circ\,31')$
$+0'.848 \sin(45n + 243^\circ\,49') + 0'.242 \sin(60n + 82^\circ\,01')$

The relative weights of the results by the even hours and the odd hours are as 3 : 1.

If, for the purpose of comparison with the previous results in Part I of this discussion, and with other similar expressions, we change the angles C_1, C_2, C_3, C_4, by 180°, which is equivalent to an easterly deviation from the mean for positive results and to a westerly deviation for negative results, we find—

For Philadelphia, $\Delta_d = +2'.167 \sin(\theta + 33^\circ\,55') + 1'.875 \sin(2\theta + 218^\circ\,52')$
$+0'.759 \sin(3\theta + 64^\circ\,40') + 0'.198 \sin(4\theta + 263^\circ\,05')$

For Dublin, $\Delta_d = +3'.519 \sin(\theta + 64^\circ\,18') + 2'.127 \sin(2\theta + 225^\circ\,22')$
$+0'.688 \sin(3\theta + 70^\circ\,40') + 0'.322 \sin(4\theta + 242^\circ\,27')$

This latter expression is copied from the Rev. H. Lloyd's discussion of the Dublin observations in 1840–'43.

For a comparison of the monthly equations, the reader may also consult similar expressions obtained

In determining the least square coefficients in these equations, allowance has been made for the different weights due to the readings at the even and odd hours. θ is reckoned from midnight at the rate of 15° an hour. To compare the numerical quantities of the angles C_1, C_2, C_3, C_4, in the general expression—

$$\Delta_d = B_1 \, sin \, (\theta + C_1) + B_2 \, sin \, (2\theta + C_2) + B_3 \, sin \, (3\theta + C_3) + B_4 \, sin \, (4\theta + C_4),$$

with the same quantities in the formula of the diurnal variation (pp. 8 and 9 of Part I), 180° must first be added or subtracted from each angle given there; since, in the discussion of Part I, *increasing* numbers correspond to a *decrease* of western declination, the scale being thus graduated, whereas, in the *present* case, *increasing* positive numbers correspond to an *increase* of western declination, as stated above.

The following table exhibits the close correspondence of the computed and observed mean annual value of the regular solar-diurnal variation:—

Philadelphia mean time.	Diurnal Variation.		C—O.	Philadelphia mean time.	Diurnal Variation.		C—O.
	Computed.	Observed.			Computed.	Observed.	
0h. 19½m.	—0′.49	—0′.47	—0′.02	Noon 19½m.	+3′.69	+3′.65	+0′.04
1 19½	—0.48	—0.51	+0.03	13h. 19½	+4.28	+4.32	—0.04
2 19½	—0.51	—0.44	—0.07	14 19½	+3.81	+3.77	+0.04
3 19½	—0.67	—0.71	+0.04	15 19½	+2.77	+2.76	+0.01
4 19½	—1.09	—1.19	+0.10	16 19½	+1.71	+1.80	—0.09
5 19½	—1.82	—1.64	—0.18	17 19½	+0.88	+0.78	+0.10
6 19½	—2.77	—2.72	—0.05	18 19½	+0.33	+0.25	+0.08
7 19½	—3.49	—3.47	—0.02	19 19½	—0.07	—0.07	0.00
8 19½	—3.44	—3.50	+0.06	20 19½	—0.38	—0.33	—0.05
9 19½	—2.29	—2.43	+0.14	21 19½	—0.57	—0.60	+0.03
10 19½	—0.24	—0.19	—0.05	22 19½	—0.62	—0.64	+0.02
11 19½	+2.03	+2.17	—0.14	23 19½	—0.57	—0.71	+0.14

The maximum difference at any one hour is less than 11″, and the probable error of any single hourly result is $\pm 0'.05$. The probable error of any single computed value from a monthly expression is $\pm 0'.19$.

By means of the preceding equations, the hourly values of the diurnal variation for each month of the year have been computed; and the results, projected in curves, are given in Diagrams D and E. The first contains the curves for the six months of the summer half-year, and the second those of the winter half-year. Positive ordinates correspond to a westerly movement, and negative ordinates to an easterly movement, of the north end of the magnet. The diagram following (F) contains the type curves for summer, winter, and the whole year, all being upon the same scale.

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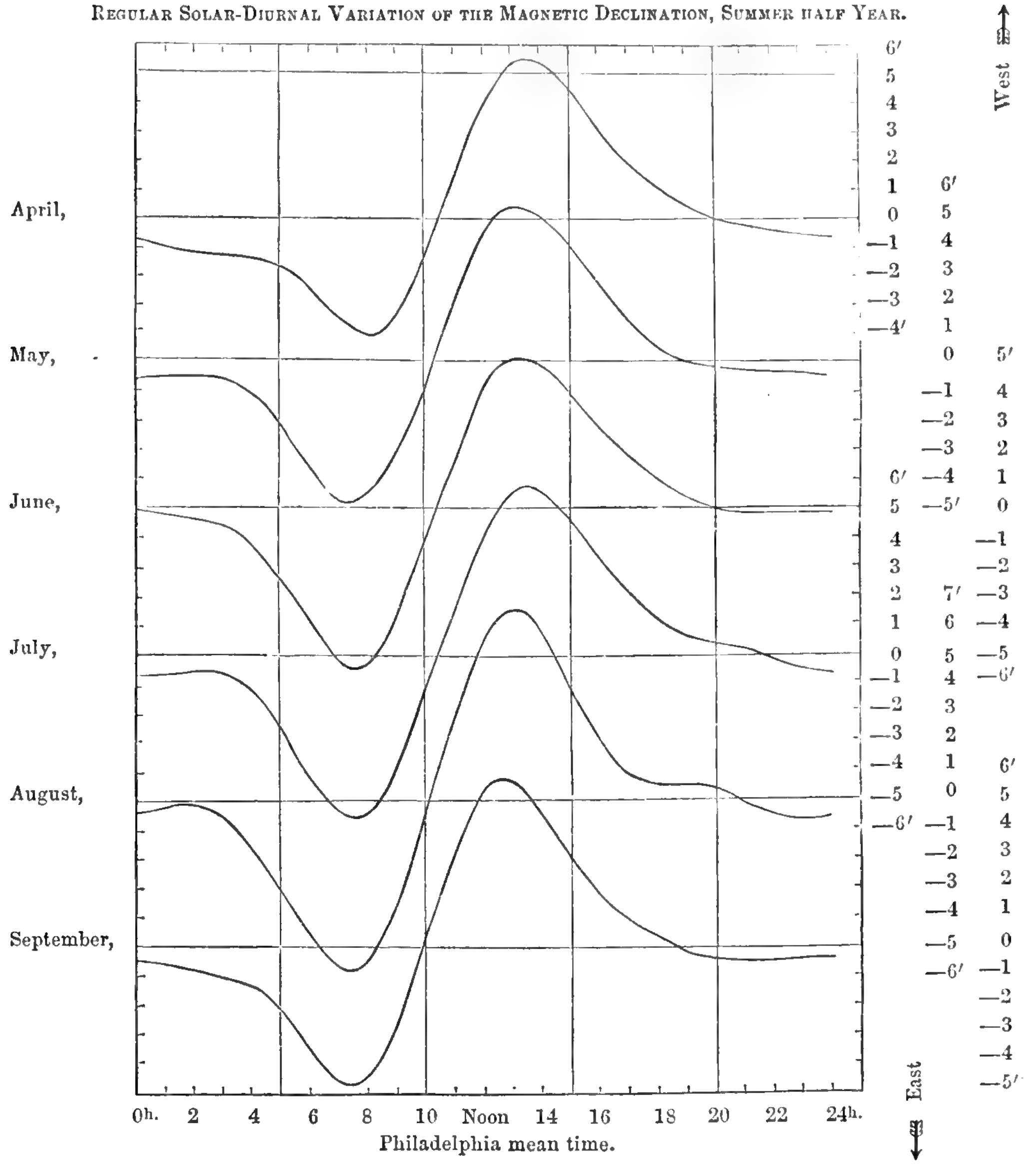
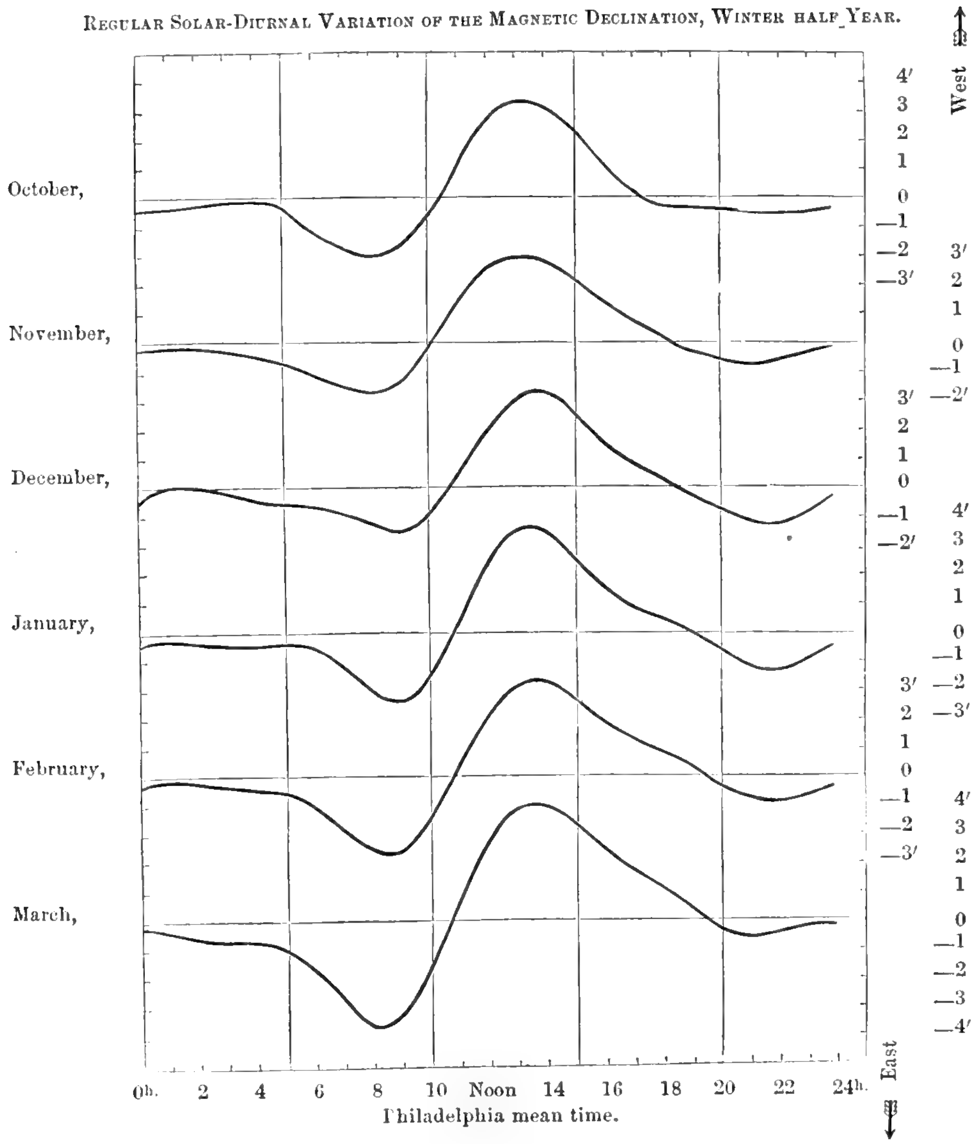
by Mr. Karl Kreil from his discussion of declinometer observations at Prague, extending over ten consecutive years (1840–'49), and selected from a thirteen years' series, in order to obtain mean results *unaffected* by the smaller inequality of the ten or eleven year period with which our results are still affected. Part I of the present discussion, however, affords ready means of changing slightly the numerical values of the coefficients B_1, B_2, B_3, B_4, in our equations, in order to obtain the values we would have obtained, had we discussed a consecutive eleven year series of observations or one extending over a series of years corresponding to the actual length of the solar period then observed. Mr. Kreil's discussion will be found in Vol. VIII of the proceedings of the mathematical and physical section of the Imperial Academy of Sciences at Vienna (1854).

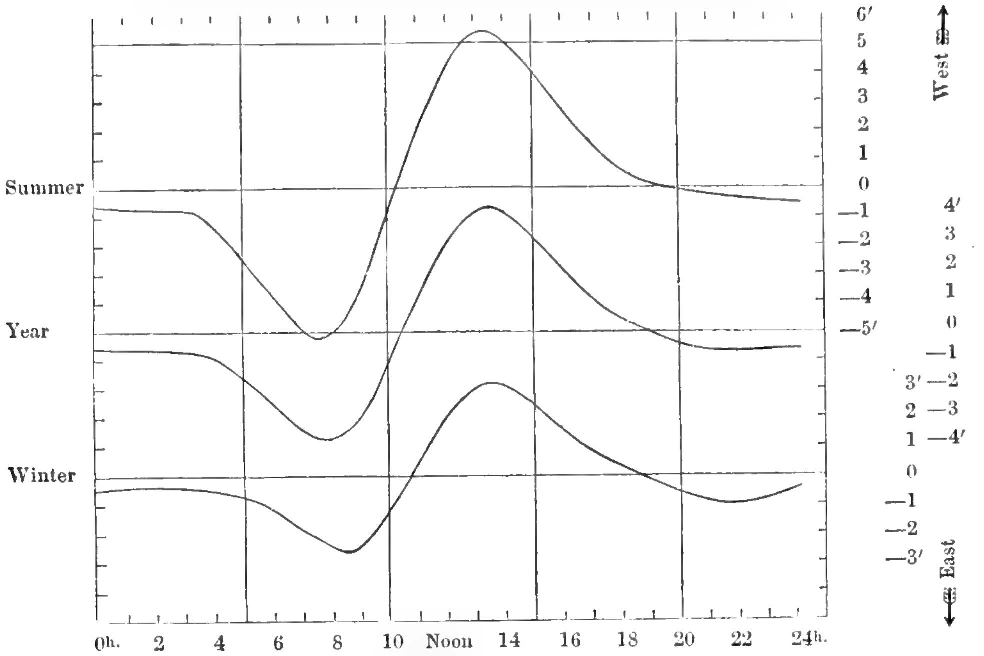
Regular Solar-Diurnal Variation of the Magnetic Declination, Summer half Year.



REGULAR SOLAR-DIURNAL VARIATION OF THE MAGNETIC DECLINATION, WINTER HALF YEAR.



TYPE-CURVES OF THE REGULAR SOLAR-DIURNAL VARIATION OF THE DECLINATION.



REGULAR SOLAR-DIURNAL VARIATION OF THE MAGNETIC DECLINATION, COMPUTED FOR EVERY MONTH OF THE YEAR, AND FOR THE PRINCIPAL SEASONS.

MEAN EPOCH 1842–43.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
January	—0′.52	—0′.24	—0′.30	—0′.48	—0′.48	—0′.38	—0′.55	—1′.24	—2′.12	—2′.45	—1′.59	+0′.26
February	—0.30	—0.09	—0.14	—0.32	—0.49	—0.71	—1.18	—1.90	—2.52	—2.49	—1.49	+0.24
March	—0.25	—0.32	—0.55	—0.71	—0.81	—1.09	—1.84	—2.93	—3.67	—3.40	—1.81	+0.55
April	—0.88	—1.14	—1.34	—1.44	—1.54	—1.88	—2.64	—3.55	—4.02	—3.42	—1.54	+1.11
May	—0.58	—0.59	—0.50	—0.59	—1.18	—2.32	—3.75	—4.74	—4.66	—3.24	—0.81	+1.93
June	—0.19	—0.28	—0.41	—0.69	—1.32	—2.45	—3.87	—5.02	—5.13	—3.80	—1.23	+1.69
July	—0.80	—0.82	—0.67	—0.72	—1.34	—2.62	—4.22	—5.42	—5.45	—4.04	—1.47	+1.47
August	—0.62	—0.33	—0.21	—0.59	—1.60	—3.09	—4.68	—5.71	—5.48	—3.67	—0.58	+2.87
September	—0.52	—0.72	—0.90	—1.06	—1.42	—2.23	—3.51	—4.55	—4.50	—2.84	+0.11	+3.18
October	—0.44	—0.52	—0.30	—0.20	—0.16	—0.45	—1.33	—1.72	—2.19	—1.92	—0.79	+0.77
November	—0.23	—0.21	—0.32	—0.44	—0.56	—0.75	—1.18	—1.68	—1.91	—1.50	—0.37	+1.11
December	—0.36	+0.01	—0.02	—0.34	—0.60	—0.67	—0.73	—1.00	—1.44	—1.64	—1.09	+0.26
Summer	—0.63	—0.71	—0.71	—0.81	—1.33	—2.43	—3.84	—4.92	—4.91	—3.43	—0.83	+2.12
Winter	—0.41	—0.26	—0.29	—0.42	—0.50	—0.68	—1.09	—1.73	—2.25	—2.15	—1.12	+0.56
Year	—0.49	—0.48	—0.55	—0.62	—0.94	—1.54	—2.41	—3.31	—3.54	—2.80	—1.02	+1.32

MEAN EPOCH 1842–43.	Noon.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
January	+2′.26	+3′.40	+3′.34	+2′.46	+1′.52	+0′.92	+0′.57	+0′.08	—0′.64	—1′.29	—1′.45	—1′.08
February	+1.96	+2.97	+3.02	+2.42	+1.71	+1.17	+0.76	+0.26	—0.36	—0.85	—0.97	—0.70
March	+2.71	+3.86	+3.85	+3.17	+2.33	+1.65	+1.02	+0.35	—0.31	—0.70	—0.67	—0.43
April	+3.60	+5.06	+5.18	+4.28	+2.98	+1.76	+0.88	+0.27	—0.14	—0.38	—0.54	—0.67
May	+4.06	+5.07	+4.88	+3.85	+2.48	+1.22	+0.39	—0.02	—0.12	—0.14	—0.21	—0.43
June	+3.99	+5.00	+4.79	+3.79	+2.60	+1.59	+0.87	+0.38	+0.07	—0.10	—0.13	—0.15
July	+3.90	+5.26	+5.37	+4.54	+3.28	+2.04	+1.16	+0.66	+0.39	+0.18	—0.15	—0.53
August	+5.44	+6.35	+5.55	+3.75	+1.98	+0.87	+0.50	+0.45	+0.26	—0.13	—0.56	—0.77
September	+5.18	+5.54	+4.48	+2.99	+1.68	+0.85	+0.33	—0.11	—0.44	—0.56	—0.55	—0.44
October	+2.60	+3.17	+3.00	+2.20	+1.08	+0.25	—0.39	—0.36	—0.39	—0.52	—0.69	—0.69
November	+2.31	+2.81	+2.58	+1.90	+1.18	+0.57	+0.06	—0.40	—0.59	—0.92	—0.77	—0.49
December	+1.86	+2.95	+3.04	+2.32	+1.34	+0.57	+0.11	—0.28	—0.78	—1.22	—1.33	—0.96
Summer	+4.35	+5.29	+4.99	+3.89	+2.57	+1.43	+0.64	+0.18	—0.05	—0.17	—0.33	—0.44
Winter	+2.21	+3.12	+3.09	+2.38	+1.52	+0.84	+0.37	—0.09	—0.55	—0.89	—0.94	—0.72
Year	+3.25	+4.22	+4.09	+3.14	+2.06	+1.12	+0.45	+0.05	—0.32	—0.52	—0.58	—0.58

In the above table + signifies westerly and — easterly deflection; it may be compared with similar tables constructed for Toronto,[1] Dublin,[2] and Prague.[3] It will be observed that the preceding table, which gives the observed variation, refers to an epoch 19½ minutes later than the exact local hour (that is, to an exact Göttingen hour), whereas the computed table refers to the exact Philadelphia hours.

From the computed tabular values, aided by the diagrams, we can now deduce some of the general features of the diurnal variation and its annual inequality.

The general character of the diurnal motion (see type-curves) is nearly the same throughout the year; the most eastern deflection is reached a quarter before 8 o'clock in the morning (about a quarter of an hour earlier in summer, and half an hour later in winter); near this hour the declination is a minimum; the north end of the magnet then begins to move westward, and reaches its western elongation about a quarter after one o'clock in the afternoon (a few minutes earlier in summer). At this time the declination attains its maximum value. The diurnal curve presents but a single wave, slightly interrupted by a deviation occurring during the hours near midnight (from about 10 P. M. to 1 A. M.), when the magnet has a direct or westerly motion; shortly after 1 A. M. the magnet again assumes a retrograde motion, and completes the cycle by arriving at its eastern elongation shortly before 8 o'clock in the morning. This nocturnal deflection is well-marked in winter, vanishes in the summer months, and is hardly perceptible in the annual curve. According to the investigations of General Sabine, it is probable that, if we had the means of entirely obliterating the effect of disturbances, this small oscillation would almost disappear. In summer, when it has no existence, the magnet remains nearly stationary between the hours of 8 P. M. and 3 A. M., a feature which is also shown by the annual type-curve.

The two preceding plates show a close general resemblance in the diurnal curves for the six months when the sun has north declination, and a similar resemblance in the other six months when it has south declination.

The analytical expressions give the epoch and amount of variation with greater precision. The hours of minimum and maximum deflection are obtained from the equation $\frac{d\,\Delta_d}{d\,n} = o$; and the hours of the mean declination, when the curves cross the axis of abscissæ, from the condition $\Delta_d = o$. The following table contains these results for each month and the two principal seasons of the year, also the critical interval between the two adjacent hours of the mean position.

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[1] Vol. III., Table LXVI; compare also with Table VII. of Vol. II.

[2] Trans. Royal Irish Academy, Vol. XXII., Part I., Table III.

[3] Academy of Sciences at Vienna, Vol. VIII. of Math. Section, Table II.

Month.	Eastern elongation A. M.	Western elongation P. M.	Critical interval from minimum to maximum.	Epoch of Mean Declination. A. M.	Epoch of Mean Declination. P. M.	Critical interval.
January	8h. 58m.	1h. 27m.	4h. 29m.	10h. 52m.	7h. 08m.	8h. 16m.
February	8 34	1 32	4 58	10 52	7 26	8 34
March	8 07	1 34	5 27	10 46	7 32	8 46
April	8 12	1 27	5 15	10 34	7 40	8 56
May	7 29	1 21	5 52	10 19	6 57	8 38
June	7 33	1 20	5 47	10 25	8 26	10 01
July	7 36	1 28	5 52	10 30	9 32	11 02
August	7 18	1 05	5 47	10 10	8 40	10 30
September	7 30	0 45	5 15	9 58	6 45	8 47
October	8 00	1 17	5 17	10 30	5 23	6 53
November	7 54	1 08	5 14	10 16	6 08	7 52
December	8 54	1 40	4 46	10 50	6 17	7 27
Summer	7h. 33m.	1h. 8m.	5h. 35m.	10h. 17m.	7h. 43m.	9h. 26m.
Winter	8 24	1 25	5 01	10 40	6 49	8 09
Year	7 48	1 16	5 28	10 26	7 08	8 42

We likewise obtain:

Secondary minimum of eastern deflection in winter	9h. 42m. P. M.	Amount —0′.97
" maximum of western " " "	1 15 A. M.	" —0 .26
Differences:	3h. 33m.	0′.71

and

Secondary minimum of eastern deflection for the year	10h. 11m. P. M.	Amount —0′.62
" maximum of western " " "	1 13 A. M.	" —0 .47
Differences:	3h. 02m.	0′.15

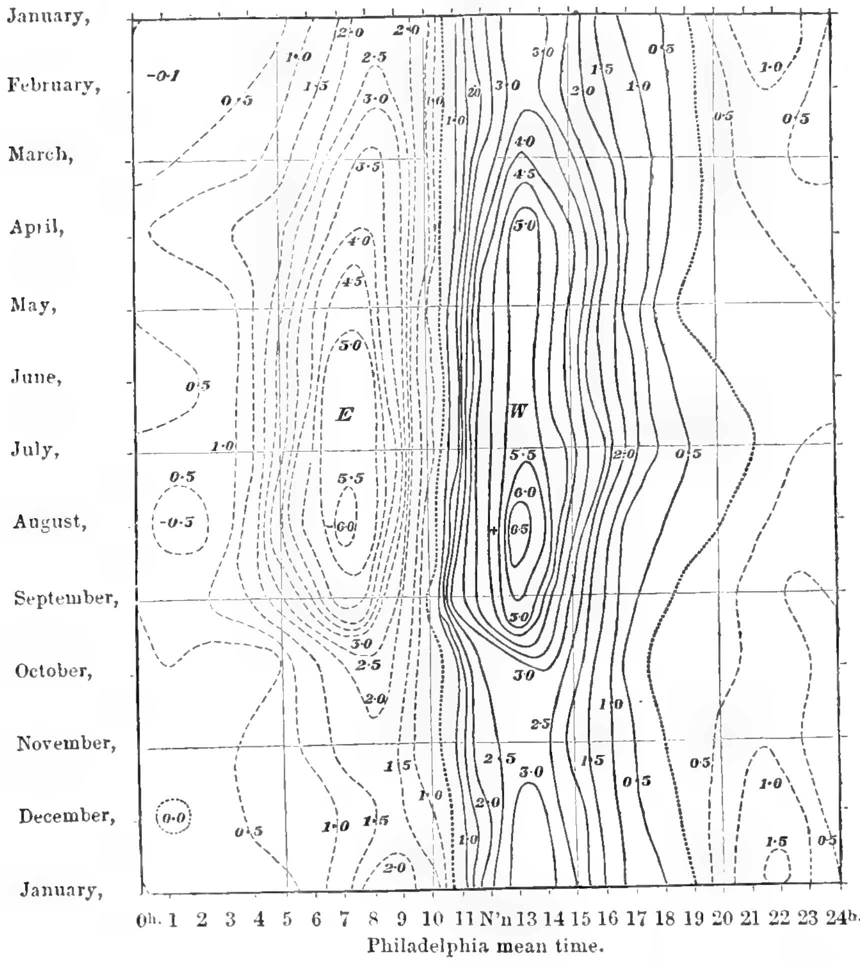
The effect of the seasons on the critical hours is well marked in the above table. The eastern elongation occurs earliest between the summer solstice and the autumnal equinox, and latest about the winter solstice. The western elongation occurs earliest about the autumnal equinox, and latest about the winter solstice; and the same holds good for the morning epoch of the mean declination. The afternoon epoch, however, occurs earliest, shortly after the autumnal equinox, and latest, shortly after the summer solstice.

The critical hours which vary least during the year are those of the western elongation and those of the morning mean declination. The extreme difference between the value for any month and the mean annual value is 31 minutes in the former and 28 minutes in the latter.

The following graphical representation of three variables (Diagram G) will serve to show at a glance the various features of the diurnal variation and its annual inequality: The magnetic surface is formed by contour lines, 0.′5 apart; the dotted curves are lines of mean position, the curves represented by dashes correspond to eastern, and the full curves to western deflection from the normal position. This diagram, as well as the computed tabular values from which it has been constructed, serve equally to furnish the correction necessary to reduce any single observation taken at any hour of the day and month to its mean value. It also enables us in a measure to dispense with developing the annual variability of the coefficients B_1 B_2 B_3 ... and C_1 C_2 C_3 .... (or rather the equivalents a_1 b_1 a_2 b_2 a_3 b_3 .... from which they are derived) in the general expression $A + B_1 \sin(\theta + C_1) +$ etc. In most cases either a tabular or graphical interpolation between the two adjacent monthly values will fully answer the purpose. The diagram also distinctly exhibits the diurnal minima and maxima, the former represented by a valley, the latter by a ridge in the magnetic surface.

The magnitude of the diurnal range is next to be considered.

DIAGRAM SHOWING THE DEFLECTION (IN MINUTES OF ARC) OF THE NORTH END OF THE MAGNET FROM ITS MONTHLY NORMAL POSITION FOR EVERY HOUR OF THE DAY AND MONTH OF THE YEAR, DERIVED FROM THE DECLINOMETER OBSERVATIONS AT PHILADELPHIA BETWEEN 1840 AND 1845.



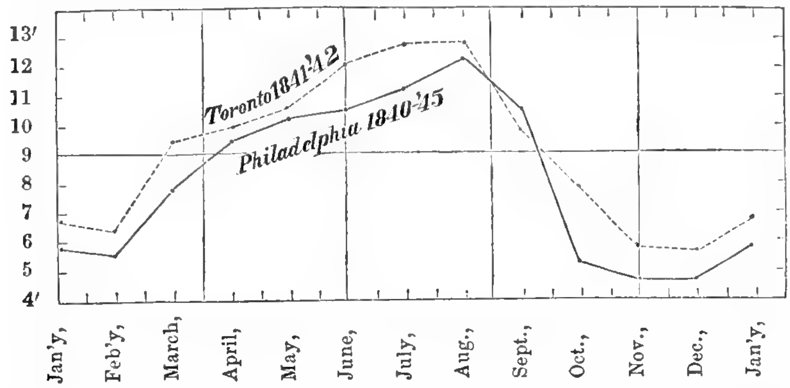
The following table contains the amount of the deflection at the eastern and western elongations and the diurnal amplitude of the declination for each month of the year, derived from the preceding equations:—

	Deflection at		Diurnal range.		Deflection at		Diurnal range.
	E. Elong.	W. Elong.			E. Elong.	W. Elong.	
January	—2'.46	+3'.52	5'.98	July	—5'.58	+5'.46	11'.04
February . . .	—2.64	+3.11	5.75	August	—5.79	+6.36	12.15
March	—3.73	+4.03	7.76	September . . .	—4.71	+5.60	10.31
April	—4.02	+5.28	9.30	October	—2.18	+3.23	5.41
May	—4.89	+5.16	10.05	November . . .	—1.92	+2.85	4.77
June	—5.26	+5.06	10.32	December . . .	—1.65	+3.14	4.79

The diurnal range for the summer months is 10'.45, for the winter months 5'.56, and for the whole year 7′.89; all corresponding to an epoch removed about one year and a half from the epoch of a minimum of the solar period.

The numbers expressing the diurnal range exhibit three remarkable features, viz., the maximum value in the month of August, the sudden falling off in the months of September and October (see the graphical representation), and the

DIURNAL RANGE OF THE DECLINATION.



minimum value in November or December. Otherwise the progression is regular; the curve is *single-crested*, a feature equally true for the *eastern* as well as for the *western* deflection when viewed separately. This latter circumstance is of special importance, since it is probable that it is mostly by the interference of these two separate curves that we observe at other stations the curve of the diurnal range at some stations apparently to be a double-crested one. The curves for Milan, Munich, Göttingen, Brussels, Greenwich, Dublin, etc., for instance, exhibit two maxima, one after the vernal equinox, and a second, generally the smaller one, about the summer solstice, with more or less regularity. The system to which Philadelphia belongs is exemplified by the annual curve of the diurnal range at Prague and at some Russian stations, especially at Nertschinsk, but principally at Toronto, for which last station the curve is shown in the diagram. Neither station appears to have a tendency to a secondary maximum about the month of April, leaving the maximum about a month and a half after the summer solstice, a well-marked North American feature.

Annual Variation of the Declination.—In connection with the preceding discussion the annual inequality in the magnetic declination next claims attention.

This subject presents greater difficulty, inherent in the observations, than the diurnal inequality; not so much on account of the length of the period as on account of the difficulty of keeping the instrument in precisely the same condition of adjustment throughout the year. In the first part of this discussion I have already had occasion to refer to this circumstance while investigating the annual effect of the secular change, and it was there shown that the Philadelphia observations share in this respect the difficulties of those of other stations,[1] in consequence of which the results must be received with caution.

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[1] It may be proper to give here, in full, Dr. Lloyd's instructive note on this subject, in his discussion of the Dublin observations: "The determination of the annual variation is much more difficult than that

Returning to the last vertical column in the table, headed "mean," we have there the monthly values of the declinometer readings (in scale divisions), and in their differences when compared month for month, the joint effect of the secular change, and of the annual inequality. To eliminate the effect of the secular change, we determine its annual amount as follows: Subtracting the mean annual reading 559.64, corresponding to July 1, from each monthly mean, and putting $x =$ monthly effect of the secular change (considered as uniform), each monthly mean reading furnishes an equation for the determination of x, thus: for

January	$4.56 = 5.5\,x$
February	$3.34 = 4.5\,x$
March	$5.22 = 3.5\,x$
April	$4.39 = 2.5\,x$, etc.,

which, when combined by least squares, give $x = 1^{d.}.227$, hence the annual change $14^{d.}.7$ or 6′.7 of *increasing westerly* declination.[1]

Deducting the effect of the secular change, and comparing the monthly remainders with their mean values, we obtain the annual inequality of the declination as follows:—

MONTH.	Mean reading.	Reduction for sec. change.	Reduced reading.	Annual inequality.	MONTH.	Mean reading.	Reduction for sec. change.	Reduced reading.	Annual inequality.
	d.	d.	d.	d.		d.	d.	d.	d.
January . . .	564.20	—6.75	557.45	+2.2	July	560.24	+0.61	560.85	—1.2
February . .	562.98	—5.52	557.46	+2.2	August . . .	559.07	+1.84	560.91	—1.3
March . . .	564.86	—4.29	560.57	—0.9	September . .	556.07	+3.07	559.14	+0.5
April	564.03	—3.07	560.96	—1.3	October . . .	556.43	+4.29	560.72	—1.1
May	563.18	—1.84	561.34	—1.7	November . .	553.97	+5.52	559.49	+0.2
June	560.84	—0.61	560.23	—0.6	December . .	549.82	+6.75	556.57	+3.1

The sign { — / + } in the annual inequality indicates an { *easterly* / *westerly* } deflection.

According to these results the magnet (north end) is deflected to the east of its mean annual position in summer, and to the west in winter. It is, however, desirable to test the result by submitting the first and the second $2\frac{1}{2}$ years of observations separately to the same process of investigation. The first 31 months in the years 1840, '41, and '42, give a result almost identical with that just deduced;

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of the diurnal, both on account of the much smaller frequency of the period, and the difficulty of preserving the instrument in the same unchanged condition during the much longer time, or of determining and allowing for its changes when they do occur. Accordingly, although the annual period may be traced in the observations of Gilpin and is decidedly displayed in those of Bowditch, it has evaded the researches of recent observers. There is but a faint indication of its existence in the Göttingen observations, which were made at the hours of 8 A. M. and 1 P. M., and Professor Gauss and Dr. Goldschmidt find, in their analysis of these observations, no important fluctuation dependent on season. A similar negative result is deduced by Dr. Lamont from the Munich observations, which were made twelve times in the day."

[1] This value (+6′.7), as resulting from a different combination of observed and partly interpolated values, may not be preferable to that (+4′.5) deduced in Part I. of this discussion, but must necessarily be employed in the present investigation. The most reliable value, +5′.0, was deduced from independent observations, as already remarked, and lies between the two.

the remaining 27 months in the years 1843, '44, and '45, when discussed in the same manner, give a rather different result.

Some improvements, however, can be made in the preceding investigation by omitting the December mean of 1844, which is obviously about 12 scale divisions too small; the observed value is $535^{d}.2$, and the interpolated value $547^{d}.0$. An examination of the first series shows a defect in the monthly means of 1841, between May and June, requiring a constant correction of + 8.0 scale divisions for the remaining months after May, as may be seen by the following table:—

Year.	May.	June.	Diff. May–June.	
1841	578.5	571.2?	....	Computed value for June, 579.2
1842	561.8	563.6	—1.8	
1843	566.2	565.0	+1.2	
1844	546.5	547.5	—1.0	
1845	529.7	531.0	—1.3	
Mean			—0.7	

The following values then remain for the discussion, and they should be considered as forming the basis from which the legitimate results are to be deduced. The numbers marked with an asterisk have been increased by $8^{d}.0$. Interpolated values are between brackets, and were obtained by comparing the means of the remaining months of the year with the corresponding means of every other year; by this process several values are obtained for each interpolated number; the resulting mean is given in the table. The high value of 1841, and the low value of 1844, for the month of May, in some measure compensate.

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
1840	(586.9)	(585.9)	(586.3)	(586.4)	(584.1)	586.9	588.4	587.4	585.2	579.9	573.9	570.5
1841	576.3	574.3	577.0	578.1	578.5	*579.2	*576.7	*576.9	*571.1	*575.2	*564.4	*567.4
1842	564.1	563.3	562.0	561.9	561.8	563.6	565.2	563.8	566.7	562.7	563.5	561.6
1843	(566.5)	(565.6)	(565.9)	567.2	566.2	565.0	564.7	563.6	558.3	559.0	556.1	557.6
1844	558.0	558.0	557.6	555.2	546.5	547.5	547.5	546.2	542.2	545.3	547.2	(547.0)
1845	531.0	531.3	532.0	527.1	529.7	531.0	(529.9)	(529.0)	(527.0)	(526.2)	(522.7)	(522.1)
Means	563.8	563.1	563.5	562.6	561.1	562.2	562.1	561.2	558.4	558.1	554.6	554.4
	560.4											
Correct'n for sec. changes	—4.4	—3.6	—2.8	—2.0	—1.2	—0.4	+0.4	+1.2	+2.0	+2.8	+3.6	+4.4
Corrected means	559.4	559.5	560.7	560.6	559.9	561.8	562.5	562.4	560.4	560.9	558.2	558.8
Annual variation	+1.0	+0.9	—0.3	—0.2	+0.5	—1.4	—2.1	—2.0	—0.0	—0.5	+2.2	+1.6
(in arc)	+0′.5	+0′.4	—0′.1	—0′.1	+0′.2	—0′.6	—1′.0	—0′.9	—0′.0	—0′.2	+0′.9	+0′.7

This last result accords in general with that before deduced, but is much to be preferred.

From June to October the north end of the magnet is accordingly to the eastward of the mean annual position (after the elimination of the secular change), and in the remaining months of the year it is to the westward of this position. From the vernal equinox till after the summer solstice the motion is to the eastward or

4

retrograde in regard to the advance of the secular change (to the westward); this is in conformity with the law as given by Dr. Lloyd in the Dublin discussion, where the motion of the magnet is to the westward at this period of the year, or the reverse of the Philadelphia deflection, but the secular change is likewise reversed, the west declination diminishing at Dublin (at the same time or more accurately between 1840 and '43).

For further comparison I give here the results deduced from seven years' observation at Toronto between the years 1845 and '51, a previous working up of a three years' series (middle year 1846) not being deemed sufficiently distinctive in its results. The secular change is here 2'.0 per annum, increasing westerly declination, whereas it was 4'.4 per annum at Philadelphia in 1843; as in the above result + indicates west, — east deflection.

Annual Variation at Toronto between 1845 and 1851.

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
+0'.1	—0'.5	—0'.2	0'.0	—0'.1	—0'.5	—0'.8	—0'.2	+0'.7	+1'.0	+0'.3	+0'.3

In regard to the amount of the inequality, the two stations agree remarkably well, the range remaining slightly below 2' of arc. It has been supposed that this range at the same station is increasing or diminishing as the secular change increases or diminishes.

It may further be remarked that the general mean resulting from the above discussion at Philadelphia, viz., 560.4, is identical with the value given in Part I. of the discussion, there deduced by an entirely different combination. The annual effect of the secular change, + 4'.4, is likewise in very close conformity with the value given in Part I., as found by a very different process.

The monthly values of the annual variation may serve to give the corrections to observed declinations in any month of the year needed to refer the same to the mean declination of the year, and may also be used in the more refined discussion of the secular change, in both cases, only, when the greatest accuracy is required.

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

DISCUSSION

OF THE

MAGNETIC AND METEOROLOGICAL OBSERVATIONS

MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA,
IN 1840, 1841, 1842, 1843, 1844, AND 1845.

PART III.

INVESTIGATION OF THE INFLUENCE OF THE MOON ON THE MAGNETIC DECLINATION.

BY

A. D. BACHE, LL. D.

[ACCEPTED FOR PUBLICATION, SEPTEMBER, 1860.]

INVESTIGATION

OF THE

INFLUENCE OF THE MOON ON THE MAGNETIC DECLINATION.

THE existence of a sensible lunar effect on the magnetic declination has already been established by the labors of Broun, Kreil, Sabine, and others. It is nevertheless important to add the weight of new numerical results to those already obtained.

In the discussions of the Philadelphia observations of magnetic declination, already presented to the Association, I have shown how the influence of magnetic disturbances, of the eleven year period of the solar diurnal variation and its annual inequality, of the secular change, and of the annual variation may be severally eliminated, leaving residuals from which the lunar influence is to be studied. Each observation was marked with its corresponding lunar hour and the hourly normals used for comparison.

This method of treatment of the subject is that followed by General Sabine in his discussion of the results of the British observations.[1]

The details of the method will be better understood by an example.

The time of the moon's passage over the meridian of Philadelphia (upper transit) was obtained from the American Almanac, the small correction for the difference

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[1] In reference to methods and results, in general, on this subject, the following papers may be consulted: Observations in Magnetism and Meteorology made at Makerstown, in Scotland, in the observatory of General Sir Thomas M. Brisbane, Bart., in 1845 and 1846, forming vol. xix., part i. of the Trans. Royal Society of Edinburgh. By John Allan Broun. Edinburgh, 1849; also vol. xix. part ii., containing the general results (1850).

Einfluss des Mondes auf die magnetische Declination by Carl Kreil. Vol. iii. of the Proceedings of the Mathematical and Physical Section of the Imperial Academy of Sciences of Vienna, 1852; also, vol. v., ibid., 1853.

Philosophical Trans. Royal Society, art. xix., 1853: On the Influence of the Moon on the Magnetic Declination at Toronto, St. Helena, and Hobarton. By Col. E. Sabine.

Phil. Trans. Royal Society, art. xxii., 1856: On the Lunar-diurnal Magnetic Variation at Toronto. By Major General E. Sabine. And—

Phil. Trans. Royal Society, art. i., 1857: On the evidence of the Existence of the Decennial Inequality in the Solar-diurnal Magnetic Variations and its Non-existence in the Lunar-diurnal Variation, of the Declination at Hobarton. By Major General E. Sabine.

of longitude being neglected. The observation nearest to the local mean solar time of the moon's transit was marked with a zero, signifying $0^{h.}$ of lunar time. The time of the inferior transit was next obtained; and the observation nearest to it in time was marked 12^{h}. The greatest difference in interval between the moon's transit and the time of observation could in no instance exceed half an hour. In the bi-hourly series, the observations nearest the moon's transit, or to either hour angle, one hour before or one hour after the transit was marked. The mean of a number of differences for the same hours thus gave a result corresponding nearly enough with the hour. The number of observations intermediate between those marked $0^{h.}$ and $12^{h.}$ were marked with the corresponding hour angle by interpolation, care being taken to note the nearest full hour against each observation in the bi-hourly series. The hourly series begins with October, 1843. In the case of thirteen observations within twelve lunar hours, the one nearest midway between the two consecutive lunar hours was omitted.

In the month of March, 1842, which is selected as an example of the details of working the bi-hourly series, the number of observations available is 298, of which 148 correspond to western and 150 to eastern hour angles. In the abstract which follows + indicates a deviation of the north end of the magnet to the west, and — a deviation to the east of the respective normal position for the hour. The hourly normals are given in the first part of the discussion. No difference exceeds eight divisions, this being the limit in number indicated by the criterion.

Lunar-Diurnal Variation from Observations at Philadelphia in March, 1842.
Differences from the hourly normals.

☽'s Upper transit. Western hour-angles.

	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	+4.1	+6.1	—0.1	—5.0	+1.3	—0.9	—0.1	+1.0	+2.5	+3.1	+0.9	—4.1
	—2.5	—4.2	+2.0	+1.0	+7.2	+0.2	+7.8	0.0	+1.2	—2.0	+2.1	—1.8
	+3.1	—1.4	+4.6	+6.1	+1.4	+0.9	—0.6	—0.5	+4.2	—2.7	+1.6	—6.8
	—4.3	+4.3	—0.7	+1.8	+0.3	+1.2	+2.3	—3.0	+1.0	+5.2	—0.4	—2.0
	—1.9	—0.5	+3.9	—1.3	—0.6	—2.9	—0.5	+1.4	+0.7	—1.8	—1.1	—5.2
	+6.4	+1.0	+3.6	+1.9	—4.8	+1.3	—0.1	+2.1	—3.3	+7.0	+1.7	+5.6
	+1.7	+3.3	+1.6	—0.9	+3.1	—2.3	—1.6	—6.2	+2.3	—1.1	+6.5	+6.6
	—0.7	+0.2	—3.2	—0.9	+2.9	—3.8	—3.8	—3.1	—4.5	—5.5	—1.9	—1.8
	+0.8	—5.1	+3.0	0.0		—7.2	—6.3	—5.9	—2.9	—3.0	+2.6	+1.1
	+2.9	—2.7	+3.1	+1.8		—3.7	—2.4	—4.6	—0.8	+4.4	—1.7	+0.7
	—1.7	+2.8		—3.0		+0.5	+0.5	—5.1	—0.9	—2.2	—0.9	—1.6
		—1.3		—1.9		+2.9	—0.2	—4.6		—1.6	—0.5	
		+2.2		—1.4			—5.9	—4.2		—1.9	—2.9	
				+2.9			+3.5	—1.6		—1.9		
				+2.1				+2.0				
				+1.6								
Means	+0d.72	+0.38	+1.78	+0.30	+1.35	—1.15	—0.53	—2.15	—0.05	—0.29	+0.46	—0d.84

☽'s Lower transit. Eastern hour-angles.

	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	—2.7	—0.5	—2.9	+0.5	+5.6	+0.5	+0.6	—4.1	+1.6	—4.9	+4.4	—4.2
	—0.2	—2.4	—1.9	—0.4	—3.4	—1.7	—2.8	+1.3	+6.5	—5.4	—0.3	+0.6
	—1.7	+3.0	+2.9	—0.6	—2.0	—0.6	—1.6	+2.5	—5.1	—0.4	+6.9	—3.1
	—1.0	—0.6	+0.5	—7.2	—1.4	—3.2	—1.0	—0.6	—0.6	+0.4	—0.9	—0.1
	+3.2	—0.2	—5.2	—0.5	—2.3	—0.4	—6.0	+0.3	+0.6	+0.7	+1.6	+1.2
	+0.9	+2.7	+3.4	—1.1	+1.4	+2.2	—3.3	—4.2	+0.2	+0.1	—1.1	+1.7
	+2.4	+2.6	+4.5	+3.4	+1.0	+1.4	—3.8	—3.3	—0.7	—0.4	—2.8	+1.6
	+1.9	+4.9	+5.4	+4.7	—1.0	+2.3	+2.9	—0.3	—3.6	—2.2	—1.5	—3.5
	+7.4	—0.7	—1.1	+7.6	+5.8	—0.1	—0.7	—2.0	+5.9	+1.5	+1.4	—4.0
	+0.3	—4.6	+6.4	+3.4	+3.0	—0.5	—3.0	+3.6	—1.0	+1.2	+3.0	—3.3
	+5.3	—3.5	+1.6	—0.1	—0.3	—3.0	+2.5	—6.6	—1.6	—0.8	—0.4	+0.6
	—1.2	—0.3	+1.5		—1.1	—1.0	—0.7	—3.7	+3.4	+5.6	—3.4	+5.1
					+3.7		+4.9				—6.5	+2.8
					—1.5							
					+0.6							
					—1.1							
Means	+1d.22	+0.20	+1.25	+0.88	+0.44	—0.34	—0.92	—1.43	+0.47	—0.39	+0.03	—0d.35

Number of observations or differences at western hour-angles . . 148
" " " " eastern " . . 150

Total 298

The following table contains the number of observations used in the discussion of the lunar-diurnal variation:—

	1840.	1841.	1842.	1843.	1844.	1845.
January	...	168	265	...	577	591
February	...	263	257	...	571	535
March	...	293	298	...	551	575
April	...	283	278	276	522	561
May	...	276	285	309	596	603
June	300	276	280	300	566	542
July	272	292	267	290	593	...
August	269	262	254	244	541	...
September	253	250	247	283	522	...
October	223	214	221	571	517	...
November	271	230	289	590	517	...
December	237	268	316	595	549	...
Sum	1825	3075	3257	3458	6622	3407
Total sum	21644					

If divided into western and eastern hour-angles, the annual numbers stand as follows:—

	Western hour-angles.	Eastern hour-angles.
1840	916	909
1841	1523	1552
1842	1618	1639
1843	1724	1734
1844	3288	3334
1845	1700	1707
Sum	10769	10875

The preceding mean results will be found inserted in their proper place in the following abstract of the mean monthly values for each observing month between 1840 and 1845.

Proceeding in this way the following results are obtained for the different months discussed.

☽'s Upper transit. Moon's hour-angle.

1840.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
June[1]	—0.23	—0.25	—1.28	+0.95	—1.09	+0.11	—0.21	+0.30	—1.12	+1.60	—0.02	+0.55
July[2]	+0.52	+1.87	—0.56	+2.04	—1.98	+1.60	—1.34	+0.40	—0.21	+0.47	+0.11	+0.75
August	—0.71	—0.10	+1.41	+0.73	+1.05	+1.20	—0.50	—0.44	+0.10	+0.86	+0.20	+0.75
September[3]	+1.74	—0.52	+1.05	—0.87	—0.40	—2.05	—0.67	—1.18	+0.49	+0.28	+0.52	+1.53
October	+0.77	—1.13	+0.37	+0.98	+0.25	+1.23	—0.01	+0.71	—0.78	—0.63	—0.68	—3.61
November[4]	+1.11	+1.04	+1.21	+0.77	+1.07	+1.44	—0.39	—0.53	—1.44	—2.03	—0.08	—1.61
December	—1.43	+1.14	+0.37	+0.37	+0.16	—0.90	—0.73	—1.44	—1.03	+1.01	—0.81	+1.24

☽'s Lower transit.

1840.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
June[1]	+0.50	+0.75	+0.38	+0.86	+0.19	+1.65	—0.72	+0.68	—1.35	+0.69	—2.30	+0.98
July[2]	+1.15	—1.08	—0.41	+0.32	—1.71	+1.03	+0.15	—0.18	—0.37	+1.00	—1.38	—0.03
August	+0.18	—1.56	—0.91	—0.65	—1.15	—0.03	+0.06	—2.61	+1.50	—1.30	—1.27	—0.50
September[3]	+0.64	+0.38	+0.63	+2.25	+0.84	+1.26	—0.61	—0.01	—1.05	—0.61	—0.23	+0.20
October	+0.53	—0.59	+0.30	+1.18	—1.19	+0.63	—0.31	—0.99	—0.40	—0.40	+1.51	+1.05
November[1]	+0.75	—0.62	+0.02	—0.82	—0.49	+0.01	—0.02	+1.09	+0.88	+0.57	+0.14	+0.18
December	+0.91	—0.78	—0.67	—1.82	—0.06	—0.70	—2.57	+1.21	+0.63	+0.86	+0.64	+1.48

[1] The tabular values for this month are expressed in parts of the new or observatory scale, the quantities having been converted from parts of the old or college scale into parts of the new scale.

[2] The tabular numbers refer to the new scale, the values for the first eighteen days of the month having been converted as above.

[3] Attention was paid to the half-monthly normals for the hour $8^{h.}\ 19\frac{1}{2}^{m.}$ (mean observatory time).

[4] The index correction, on and after the twenty-third day of the month, was applied before the differences were taken.

☽'s Upper transit. Moon's hour-angle.

1841.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
January	+0.86	—1.07	+0.54	+1.39	+0.50	—2.01	+0.89	—0.11	—1.52	+0.48	—0.12	—1.10
February	+1.48	—2.17	+1.12	+0.49	+0.49	+0.10	—0.10	—0.57	—0.38	+0.32	+0.92	+1.40
March	+1.67	+0.82	+0.64	+1.00	+0.61	+0.40	—0.39	—1.07	—1.21	+0.69	—0.65	—0.91
April	+1.57	+1.01	+0.45	+0.97	+0.20	+0.12	+0.39	+1.40	—0.27	—1.52	+0.48	—1.43
May	+0.19	+2.11	+0.69	+1.94	—0.05	+0.92	—0.39	—0.60	—0.73	—0.20	—0.94	+1.21
June	—0.56	+1.77	+0.07	+0.45	+2.18	+1.25	—1.15	—0.59	—2.40	—1.13	—0.42	—1.24
July	+0.84	+1.86	+0.46	—1.06	—0.62	—1.52	—0.80	—0.55	—0.88	—1.71	—0.24	+1.63
August	+1.95	+1.31	+1.73	+1.42	—1.17	—1.46	—1.48	—1.39	—2.06	—2.24	—1.72	+0.60
September	+1.05	+0.10	—0.45	—0.17	—3.50	—0.54	—0.55	—0.83	—1.47	+0.86	+1.29	+0.03
October[1]	—1.15	+0.26	—0.77	—0.06	—1.31	—0.82	—0.66	—0.61	—1.73	+1.73	+0.22	+1.09
November	+0.01	—0.08	+0.02	+0.54	+0.23	—1.08	+1.54	+0.52	+1.39	+0.02	—0.24	—0.06
December	—0.41	+0.10	+0.45	—0.71	—0.94	+0.55	—0.51	+1.09	+0.62	—0.47	+0.48	+0.08

☽'s Lower transit.

1841.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
January	+1.33	+0.57	—0.04	—0.51	—0.50	+0.21	+0.25	—2.10	—0.21	—1.32	—0.07	0.00
February	—0.03	—1.30	—0.78	—0.30	—1.23	—2.01	—1.12	—1.08	+0.60	+1.30	+0.56	+1.07
March	+0.15	+0.18	+1.05	+0.23	—0.15	—0.59	—0.23	—0.93	—0.47	—0.98	+1.89	+0.35
April	+1.35	—1.05	—0.09	+0.90	—0.02	—1.13	—0.32	—1.67	—0.89	—0.13	—0.63	+0.02
May	+0.42	+1.44	+0.56	+0.24	—1.21	—0.89	—2.64	—0.85	—2.20	—1.09	+0.96	+0.90
June	+0.11	—1.42	—0.13	+0.67	+1.18	—0.53	+0.62	—1.14	+1.79	+0.01	—0.22	+0.80
July	+1.26	+1.50	+1.09	+1.76	+0.32	+0.45	—0.80	+0.01	—0.95	+0.27	—0.87	+0.44
August	+2.28	+0.51	+1.97	+1.19	+0.62	—1.81	—0.50	—1.07	—0.59	+1.66	+0.06	+1.20
September	+0.37	+0.41	+1.21	+0.95	—1.66	—0.44	—0.25	—0.45	+0.45	+0.19	+0.85	+0.44
October[1]	—1.73	+1.04	+0.76	+0.34	+0.18	+1.60	+0.97	+3.14	+1.30	+3.10	—0.61	—1.54
November	+1.01	+0.03	—1.20	—0.30	—1.89	—1.33	—0.72	—0.49	+0.50	—1.89	+0.79	—0.27
December	+0.73	—0.59	+0.80	—0.49	+0.71	—0.92	—0.67	—1.27	+0.12	+1.21	+1.76	+0.83

☽'s Upper transit. Moon's hour-angle.

1842.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
January	—0.30	+0.64	—0.53	+0.02	+0.66	—0.61	+0.14	—1.48	+0.44	—1.20	+0.26	—1.84
February	—0.73	+0.88	+0.36	—0.13	—0.83	+0.67	+0.18	—1.80	—0.92	—0.73	—0.27	+0.04
March	+0.72	+0.38	+1.78	+0.30	+1.35	—1.15	—0.53	—2.15	—0.05	—0.29	+0.46	—0.84
April	—0.77	+0.92	+0.53	+0.37	—0.07	—0.39	—0.20	—1.65	+0.27	—0.42	+1.21	+0.10
May	—0.57	+1.78	+0.01	—0.16	+0.18	—1.01	—1.41	—0.97	—0.92	+0.08	—0.43	+0.42
June	+0.38	+0.69	—0.95	+1.64	—0.18	+0.77	—0.25	—0.32	+0.76	+1.18	+0.38	—0.74
July	+0.78	+0.16	+0.69	—0.07	+0.60	—0.76	—2.08	+0.08	—1.65	+0.87	—1.04	+3.03
August	+0.88	+0.82	—0.08	—1.03	+1.17	—0.91	—0.95	+0.67	+0.72	—1.24	—0.17	+1.65
September	+0.71	—0.52	—0.13	—0.95	+0.67	+0.96	—0.82	+0.34	+0.82	+0.35	+0.62	+1.36
October	+3.46	+0.38	+0.77	—0.29	+0.06	+0.02	—0.25	—2.21	—0.98	—1.39	+0.52	—1.09
November	—0.05	+0.38	—1.07	—0.48	—0.36	—1.10	—0.53	+0.43	—0.95	+0.54	+0.14	+0.29
December	—0.59	—0.36	—0.34	—1.15	—0.75	+0.26	—0.57	+0.24	+0.39	+0.64	+0.87	+0.16

☽'s Lower transit.

1842.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
January	—0.18	—1.19	—0.11	—2.13	+0.17	—0.61	+0.45	+1.05	+0.72	+0.66	—0.12	+0.62
February	—0.91	+0.71	+0.52	+0.40	—0.97	—0.86	—1.11	+0.44	—0.12	+0.14	+0.08	+0.84
March	+1.22	+0.20	+1.25	+0.88	+0.44	—0.34	—0.92	—1.43	+0.47	—0.39	+0.03	—0.35
April	+3.28	—0.86	+0.13	—0.12	—1.05	—1.34	—1.36	+0.15	—1.22	+0.19	—0.94	+1.11
May	+1.13	+1.78	+1.59	+1.10	—0.59	—0.52	—0.68	—1.47	—1.05	+0.15	—0.70	+1.01
June	+0.20	—0.82	+1.45	+0.33	+1.73	—1.19	+0.05	—1.36	—1.04	—1.43	—1.35	—1.37
July	—0.32	+1.84	—0.86	—0.72	+0.59	—0.95	—0.27	+0.03	—1.22	+0.09	—0.58	+0.68
August	—0.68	+2.50	—1.34	+0.59	—1.41	—0.67	—0.79	—0.58	—0.96	—0.26	+1.68	+0.81
September	+0.46	+1.11	—1.94	+0.25	+0.99	—0.45	—1.64	+0.10	—1.70	+2.14	+1.50	+0.96
October	+1.31	+1.68	—0.62	+0.74	—1.87	—0.14	+1.08	+0.43	—0.16	—0.25	+0.71	—0.56
November	+0.47	+0.40	+0.91	—1.13	+0.02	+0.11	—0.22	—1.46	+0.05	+0.68	+0.94	+1.58
December	+0.53	+0.35	+0.12	—0.45	—1.12	+0.15	+0.35	+0.54	+0.40	+0.57	+0.21	+0.07

[1] At $14^{h.}\ 19\frac{1}{2}^{m.}$ (observatory time) the difference from the half-monthly normals was used.

☽'s Upper transit. Moon's hour-angle.

1843.[1]	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
April	+0.87	+1.47	+1.66	+0.39	−0.42	−1.30	−2.64	−1.72	−1.99	−0.12	−1.63	−0.48
May	+0.94	+0.89	+1.54	+0.45	+0.27	+0.38	+0.23	−1.02	−0.79	−1.01	+0.47	+1.08
June	−0.13	−1.58	+0.18	−0.81	+0.67	+1.21	−0.31	+0.83	+0.16	+0.61	−0.10	+1.30
July	+2.10	+0.91	−0.71	+0.65	+0.69	+0.54	−0.62	+0.56	−0.39	−2.29	+1.05	−0.16
August[2]	−1.56	−0.81	−2.28	+1.17	−0.05	−1.12	+0.32	−1.24	+0.26	−0.22	−0.69	+0.46
September	−0.71	+0.26	−0.58	−0.85	−1.08	−0.23	−0.30	+1.74	−0.74	+0.37	−0.42	+0.58
October[3]	+1.05	+0.14	+0.28	+0.17	−0.03	−0.93	+0.19	−0.52	−1.16	+0.27	+0.33	+0.33
November	+0.52	+0.16	−0.72	−0.47	−0.80	−0.84	−0.57	−0.72	−0.02	+0.23	−0.17	+0.72
December	−0.41	−0.24	−0.64	−1.15	−0.88	−0.41	+0.07	+0.08	+0.39	+0.99	+1.09	+1.28

☽'s Lower transit.

1843.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
April	+0.79	+1.92	+0.72	−0.06	+0.53	+0.05	−1.10	−1.05	−0.22	−1.06	−0.56	+1.58
May	+0.67	+0.74	+1.01	−0.58	−1.01	−1.03	−1.43	−0.27	−0.52	−0.49	+0.70	+0.08
June	+0.94	+1.46	−0.55	+0.29	−0.99	−0.05	−0.63	+0.07	−0.38	−0.22	+0.74	−0.20
July	−0.25	+0.61	+0.66	+0.66	−0.43	−1.10	−2.00	−1.05	−0.20	−0.06	−0.54	+1.73
August[2]	+0.91	−0.59	−0.77	+0.59	−1.85	+0.01	−1.00	+1.37	−0.92	+0.74	+0.49	+0.06
September	+1.63	+1.85	+0.78	+2.32	+1.15	−0.29	−0.86	+1.08	+0.65	−0.37	−0.90	−0.78
October[3]	+0.76	+1.50	+1.30	+0.53	−0.71	−0.92	−1.76	−0.70	−0.08	+0.50	−0.37	+0.78
November	+0.67	+0.45	−0.33	−0.25	−0.54	+0.04	−0.24	+0.17	+1.06	+1.00	+0.27	+0.50
December	+0.83	+0.51	+0.60	+0.62	+0.28	−1.14	−0.59	−0.74	−0.46	+0.46	+0.24	−0.42

☽'s Upper transit. Moon's hour-angle.

1844.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
January[4]	−0.79	−0.18	−0.26	+0.07	+0.20	+0.94	+0.58	+0.19	+0.22	+0.37	−0.46	+0.43
February	+1.43	+0.87	+0.67	−0.52	−0.69	−0.82	−0.56	−0.74	−0.29	+0.77	+1.03	+0.96
March	+1.10	+1.06	+0.42	+0.04	−0.72	−0.55	−0.69	−0.16	+1.18	+0.05	+0.93	−0.02
April	−0.52	+0.08	+0.23	+0.54	+0.09	+0.35	−0.49	−0.12	−0.55	−0.41	+0.16	−0.04
May	+0.76	+1.17	+0.88	+0.27	+0.02	−0.49	−0.18	−0.60	−0.35	−0.10	+0.14	+0.27
June	+1.11	+0.68	+1.07	+0.44	+0.09	−0.64	−0.24	−1.33	−1.58	−1.47	−0.40	+0.22
July	+1.09	+1.27	+0.78	+0.97	+0.18	−0.73	−1.05	−1.77	−0.17	−0.13	+0.68	+0.37
August	+2.30	+0.93	+0.19	−0.14	−0.16	−1.55	−0.78	−0.69	−0.38	−0.66	+0.45	+0.45
September	+1.13	+1.47	−0.21	−0.05	−0.61	−1.15	−0.31	+1.05	+1.10	−0.18	+0.12	−0.34
October	−0.22	+0.42	−0.02	+0.22	−0.41	−0.59	−0.78	+0.38	−0.02	+1.04	+1.10	+1.01
November	−0.91	−1.12	−0.71	−0.57	−0.76	+0.03	−0.01	+0.45	−0.77	+0.06	+0.62	+2.57
December[5]	−0.26	−0.74	−0.21	−0.44	−1.14	−0.33	−0.41	−0.18	+0.14	+0.33	+0.36	+0.60

☽'s Lower transit.

1844.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
January[4]	+0.32	+0.10	+0.31	−0.09	−0.61	−0.17	+0.84	+0.95	+0.32	−0.10	−0.80	−0.48
February	+0.44	0.00	+0.54	−0.26	−1.10	−0.49	−1.13	−0.39	−0.02	−0.05	−0.02	+0.84
March	+1.33	+0.52	−0.50	−0.21	−0.21	−0.68	−1.60	−0.50	−0.31	−0.48	+0.35	−0.10
April	+0.87	+0.70	+0.37	+0.64	−0.22	−0.54	−0.50	+0.05	−0.66	−0.42	−0.02	−1.63
May	+0.46	+0.09	+0.74	+0.43	+0.62	+0.06	−0.19	−1.10	−0.85	−1.17	+0.10	+0.06
June	+0.19	+0.48	−0.30	−0.36	−0.01	+0.35	+0.31	+0.29	+0.25	+0.20	+0.11	0.00
July	+1.27	+0.36	+0.46	−0.70	−0.51	−0.70	−1.03	−0.13	−0.31	−0.57	−0.12	+0.78
August	+0.50	+0.22	+0.84	−0.30	−0.19	−0.77	−1.06	−0.75	−0.34	−0.14	−0.43	+0.76
September	+0.25	+0.04	+0.73	−0.20	−0.03	−1.20	−1.89	−1.27	−1.33	−0.62	+0.13	+1.15
October	+0.56	+1.19	+0.78	−0.10	−0.36	−0.32	−0.03	−0.83	−0.58	−0.55	+0.06	+0.06
November	+0.36	+1.09	+0.67	+0.43	+0.05	+0.40	+0.07	−0.77	−0.68	+0.41	+0.15	−0.11
December[5]	+0.48	+0.64	+1.06	−0.12	−0.12	−0.64	−0.22	+0.23	+0.26	+0.68	+0.17	+0.42

[1] There are no observations in January, February, and March, of this year.
[2] Attention was paid to the shifting of the zero of the scale between the 9th and 10th.
[3] Commencement of the hourly series of observations.
[4] Proper attention was paid to the change in the zero of divisions after the 10th.
[5] The half-monthly normals were used.

☽'s Upper transit. Moon's hour-angle.

1845.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
January	—0.46	—1.65	—1.52	—1.65	—1.63	—0.24	+0.11	+1.41	+0.96	+1.83	+0.91	+1.11
February	—0.13	+0.48	—0.26	—1.15	—0.56	—0.81	—0.39	—0.28	+0.18	+1.03	+0.98	+1.28
March	—0.42	—0.47	—0.26	—0.48	—0.25	—0.75	—0.81	—0.25	+0.20	+0.39	+0.79	+0.91
April	+0.45	+0.54	+0.07	+0.52	—0.21	—0.47	—0.27	—0.07	—0.25	—0.03	+0.27	+1.08
May	+0.53	+0.49	+0.01	+0.16	—0.21	—0.22	—0.66	—0.25	—0.88	+0.04	+0.92	+0.43
June	+1.77	+1.63	+0.90	+1.24	+0.86	+0.54	—0.66	—1.09	—0.75	—0.93	—0.83	—0.31

☽'s Lower transit.

1845.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
January	+0.02	—0.28	—1.07	—0.60	—0.30	+0.14	+1.09	+0.29	+0.86	+0.34	+0.39	+0.38
February	+1.70	+0.67	—0.13	+0.40	+0.03	—0.76	—0.92	—1.26	—0.46	+0.17	—0.05	—0.09
March	+1.15	+0.95	+1.79	+0.35	+0.86	—0.08	—0.83	—1.27	—0.56	+0.37	—0.39	—0.73
April	+0.54	+0.56	0.00	+0.76	+1.01	—0.30	—1.00	—1.67	—1.62	—0.97	+0.37	—0.78
May	+0.53	+0.03	—0.63	—0.01	—0.24	—0.48	—0.70	—0.30	—0.40	—0.53	+1.16	+0.63
June	+0.01	+0.86	+0.30	+0.18	—0.33	—1.27	—0.82	—0.59	—0.92	+0.05	+0.74	+0.64

Value of a scale division 0'.453.

One of the first questions to determine is how many of these residuals must be used to give a definite result, and another one is whether numbers deduced from different parts of the series would give harmonious results. To test both of these the observations were formed into three groups—one containing 4,900 in 19 months of 1840, '41; another, 6,715 results in 21 months of 1842, '43; and a third, 10,029 results in 18 months of 1844, '45. In all, 21,644 results.

The following table contains the result for each group. Group II includes three months of the hourly series of observations treated as if only equal in weight to the bi-hourly series.

The sign Σ indicates the algebraic sum of the values in the preceding tables for the months comprised in each group, and for every hour-angle of the moon. The lines headed I, II, III, contain the preceding values divided by their respective number of months and expressed in minutes of arc, or the lunar diurnal variation.

☽'s Upper transit. Moon's hour-angle.

	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
Σ of group I	+10.27	+8.07	+7.52	+11.17	—4.32	—1.46	— 7.06	— 5.49	—14.63	—1.61	—1.70	+ 0.30
Σ " II	+ 6.59	+7.35	—0.23	— 2.38	+0.87	—5.95	—10.90	—10.83	— 6.35	—2.78	+2.48	+ 7.65
Σ " III	+ 7.96	+6.93	+1.77	— 0.53	—5.91	—7.48	— 7.60	— 4.05	— 2.01	+2.00	+7.77	+10.98
I	+0'.24	+0'.19	+0'.18	+0'.27	—0'.10	—0'.04	—0'.17	—0'.13	—0'.35	—0'.04	—0'.04	+0'.01
II	+0.14	+0.16	+0.00	—0.05	+0 02	—0.13	—0.24	—0.23	—0.14	—0.06	+0.05	+0.16
III	+0.20	+0.17	+0.05	—0.02	—0.15	—0.19	—0.20	—0.10	—0.05	+0.05	+0.20	+0.28

☽'s Lower transit. Moon's hour-angle.

	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
Σ of group I	+11.91	— 2.18	+4.54	+6.00	—7.22	— 3.54	— 9.43	—8.71	—0.71	+3.14	+1.58	+7.60
Σ " II	+13.46	+16.15	+4.52	+3.86	—6.64	—11.24	—14.67	—4.68	—6.90	+2.79	+1.53	+8.73
Σ " III	+10.98	+ 8.22	+5.96	+0.24	—1.66	— 7.45	— 9.61	—9.02	—7.35	—3.38	+1.90	+1.80
I	+0'.29	—0'.05	+0'.11	+0'.14	—0'.17	—0'.09	—0'.23	—0'.21	—0'.04	+0'.08	+0.04	+0'.18
II	+0.29	+0.35	+0.10	+0.08	—0.14	—0.24	—0.32	—0.10	—0.14	+0.06	+0.03	+0.19
III	+0.28	+0.21	+0.15	0.00	—0.04	—0.19	—0.24	—0.23	—0.19	—0.08	+0.05	+0.05

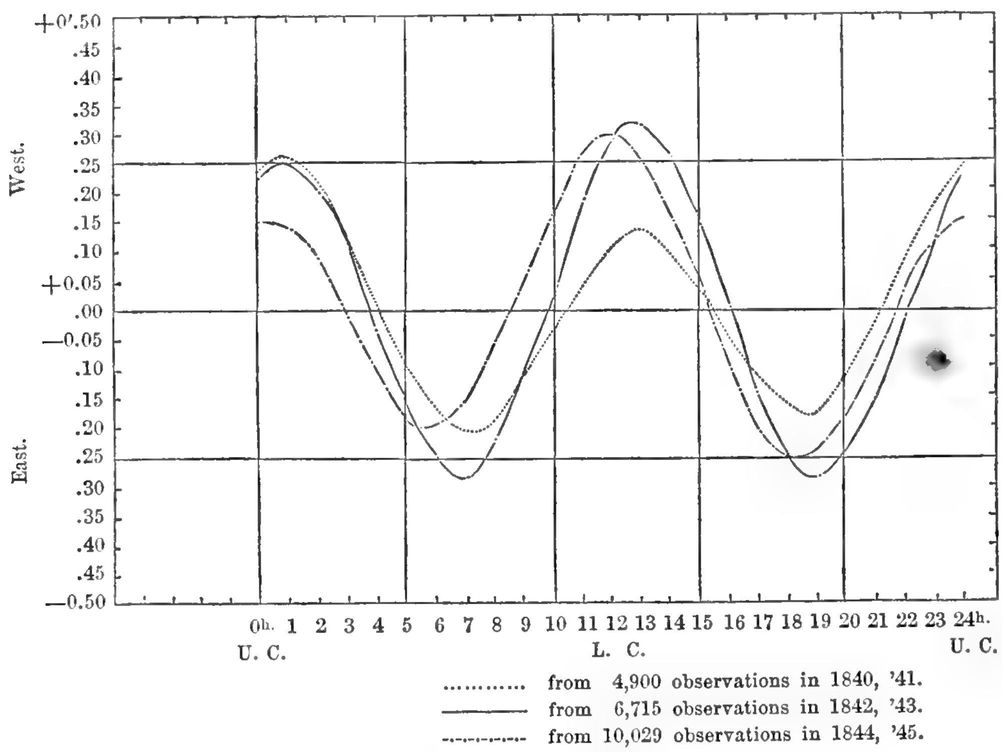
+ indicates west, — east, deflection from the normal position.

These results, I, II, III, when expressed analytically by means of Bessel's form of periodic functions, and when treated by the method of least squares, are represented by the following equations, in which the moon's hour-angle θ is reckoned from the upper transit westwards at the rate of 15° to each hour. $\Delta_{☾}$ represents the lunar diurnal variation.

Group I, 1840–'41. $\Delta_{☾} = +0'.003 + 0'.063 \sin. (\theta + 92°) + 0'.189 \sin. (2\theta + 67°)$
" II, 1842–'43. $\Delta_{☾} = -0'.006 + 0'.030 \sin. (\theta + 263°) + 0'.282 \sin. (2\theta + 63°)$
" III, 1844–'45. $\Delta_{☾} = 0'.000 + 0'.075 \sin. (\theta + 292°) + 0'.219 \sin. (2\theta + 88°)$

The numerical results from these equations are presented graphically on the following diagram.

Lunar-Diurnal Variation of the Magnetic Declination.



The curves all agree in their distinctive characters, and show two east and two west deflections in a lunar day, the maxima W. and E. occurring about the upper and lower culminations, and the minima at the intermediate six hours. The total range hardly reaches 0'.5. These results agree generally with those obtained for Toronto and Prague.

From 8,000 to 10,000 observations seem to be required to bring out the results satisfactorily, and the best results are derived from the use of all the groups.

The following table contains annual sums of deflections for each hour, and the resulting lunar-diurnal variation from the 21,644 observations available for the purpose :—

Upper curve. Westerly hour-angles.

YEAR.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
Σ for 1840	+1.77	+2.05	+2.57	+4.97	—0.94	+2.63	—3.85	—2.18	—3.99	+1.56	—0.76	—0.40
" 1841	+8.50	+6.02	+4.95	+6.20	—3.38	—4.09	—3.21	—3.31	—10.64	—3.17	—0.94	+0.70
" 1842	+3.92	+6.15	+1.04	—1.93	+2.50	—3.25	—7.27	—8.82	—2.07	—1.61	+2.55	+2.54
" 1843 (*a*)	+1.51	+1.14	—0.19	+1.00	+0.08	—0.52	—3.32	—0.85	—3.49	—2.66	—1.32	+2.78
" 1843 (*b*)	+1.16	+0.06	—1.08	—1.45	—1.71	—2.18	—0.31	—1.16	—0.79	+1.49	+1.25	+2.33
" 1844	+6.22	+5.91	+2.83	+0.83	—3.91	—5.53	—4.92	—3.52	—1.47	—0.33	+4.73	+6.48
" 1845	+1.74	+1.02	—1.06	—1.36	—2.00	—1.95	—2.68	—0.53	—0.54	+2.33	+3.04	+4.50
Mean $\frac{\Sigma}{79}$	+0.43	+0.37	+0.12	+0.08	—0.21	—0.31	—0.42	—0.32	—0.33	+0.01	+0.23	+0.41
Same in arc	+0′.19	+0.17	+0.05	+0.04	—0.10	—0.14	—0.19	—0.14	—0.15	+0.01	+0.10	+0′.19

Lower curve. Easterly hour-angles.

YEAR.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mos.
	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	
Σ for 1840	+4.66	—3.50	—0.66	+1.32	—3.57	+3.85	—4.02	—0.81	—0.16	+0.81	—2.89	+3.36	7
" 1841	+7.25	+1.32	+5.20	+4.68	—3.65	—7.39	—5.41	—7.90	—0.55	+2.33	+4.47	+4.24	12
" 1842	+6.51	+7.70	+1.10	—0.26	—3.07	—6.81	—5.06	—3.56	—5.83	+2.29	+1.46	+5.40	12
" 1843 (*a*)	+4.69	+5.99	+1.85	+3.22	—2.60	—2.41	—7.02	+0.15	—1.59	—1.46	—0.07	+2.47	6
" 1843 (*b*)	+2.26	+2.46	+1.57	+0.90	—0.97	—2.02	—2.59	—1.27	+0.52	+1.96	+0.14	+0.86	3
" 1844	+7.03	+5.43	+5.70	—0.84	—2.69	—4.70	—6.43	—4.22	—4.25	—2.81	—0.32	+1.75	12
" 1845	+3.95	+2.79	+0.26	+1.08	+1.03	—2.75	—3.18	—4.80	—3.10	—0.57	+2.22	+0.05	6
Mean $\frac{\Sigma}{79}$	+0.63	+0.42	+0.29	+0.14	—0.23	—0.40	—0.58	—0.42	—0.27	+0.01	+0.09	+0.26	37 21
Same in arc	+0′.29	+0.19	+0.13	+0.06	—0.10	—0.18	—0.26	—0.19	—0.12	+0.01	+0.04	+0′.12	21
													79

The two values for 1843, marked (*a*) and (*b*), exhibit the separate sums for the bi-hourly and the hourly observations, and were required to give proper weights to each. There are 37 months of bi-hourly, and 21 months of hourly observations —the latter having double weight, as found from a consideration of the probable errors derived respectively from all the results of the years 1842 and 1844. The probable error of any single monthly mean for any hour in the year 1842 was found $= \pm 0^{d}.60$, and the same for the year 1844 was $= \pm 0^{d}.40$. Hence the weights for a resulting value in the bi-hourly series is to the weight for a value in the hourly series nearly as 1 : 2, or the weights are nearly proportional to the number of observations—a result which indicates that no constant errors influence the result. The accordance among themselves of the values for the easterly hour-angles is somewhat better than the corresponding values for the westerly hour-angles—a circumstance which seems to connect itself with another phenomenon to be mentioned presently. Giving, therefore, double weight to months of the hourly series, the lunar-diurnal variation resulted as given above. When expressed analytically, it takes the form

$$\triangle_{☾} = +0'.001 + 0'.029 \sin(\theta + 295°) + 0'.207 \sin(2\theta + 85°)$$

which may also be written

$$\triangle_{☾} = 0''.0 + 1''.7 \sin(15n + 295°) + 12''.4 \sin(30n + 85°)$$

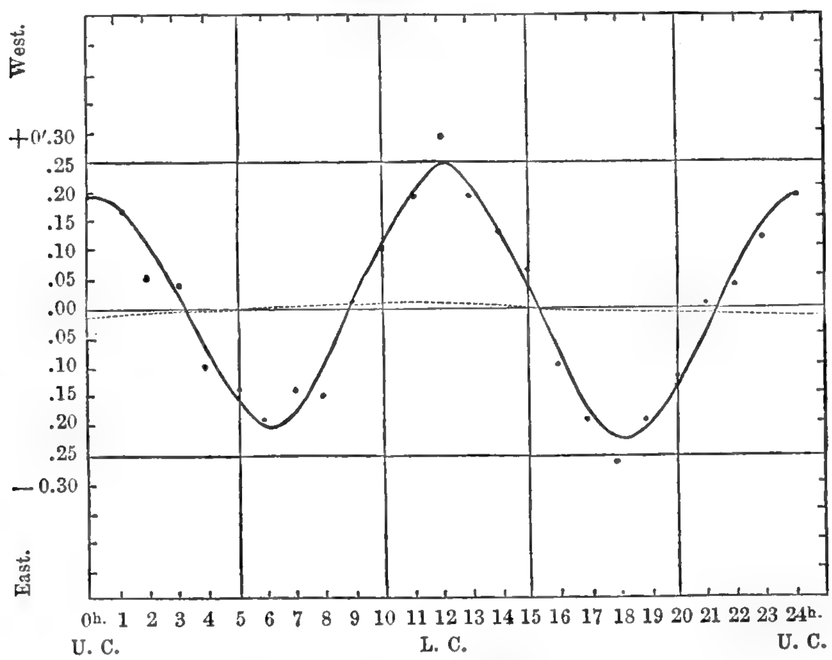
where θ represents the moon's hour-angle, reckoned from the upper culmination, or n the number of hours after the same epoch: + indicates west, and — east deflection.

The constant in Bessel's formula comes out zero, and hence it is inferred that the moon has no specific action in deflecting the magnet by a constant quantity. The coefficient of the first term of the formula is small, and it is from the second term that the distinctive features of the double-crested curve result. These results are all represented by curves.

Both the east and west deflections are well marked, those occurring when the moon is east of the meridian being greater than those when west.

It is not at all necessary to take in the third or higher terms. The progression of the hourly values is systematic, and the agreement between the computed and observed values is deemed satisfactory. The following diagram represents the curve resulting from the above equation, the observed values being indicated by dots.

Lunar-Diurnal Variation.



From 21,644 observations at Philadelphia, from 1840 to 1845.

The principal western maximum occurs 6 minutes after the lower culmination of the moon, and amounts to 0′.23. The secondary maximum occurs 14 minutes after the upper culmination, and amounts to 0′.18. The principal minimum occurs at $6^{h.}\ 17^{m.}$ after the lower culmination, the easterly deflection being 0′.22. The secondary minimum at $6^{d.}\ 03^{m.}$ after the upper culmination, with a deflection of 0′.19. The greatest range is 27″, and the secondary 22″. The epochs of the maxima and minima are found from the formula to be at a mean 10 minutes after culmination. The probable error of a single computed value of the lunar declination is $\pm$ 1″.32. The Toronto observations gave $\pm$ 1″.37 from more than twice the number of observations, so that the Philadelphia results are worthy of every confidence.

At Toronto, from the second investigation, embracing about 44,000 observations, the western and eastern deflections balanced, giving for the range 38″.3. The

Prague observations also confirm the nearly equal deflections (mean) to the west and east. The epochs of the maxima and minima were found from the four roots of the equation $0 = 0.029 \cos(\theta + 295^\circ) + 0.414 \cos(2\theta + 85^\circ)$, which gave 10 minutes as the mean time elapsed between the moon's passing the meridian, and the time of maxima deflections. If we take the four phases into account, the lunar action seems to be retarded 10 minutes, which quantity may be termed the *lunar-magnetic interval* for the Philadelphia station. At Toronto the intervals are not so regular.

The secondary range exists at Toronto, and is a marked feature in the Prague result.

The following table contains the observed and computed values and their differences:—

Upper Curve.				Lower Curve.			
	Observed.	Computed.	Difference.		Observed.	Computed.	Difference.
0h.	+0′.19	+0′.18	+0′.01	12h.	+0′.29	+0′.23	+0′.06
1	+0.17	+0.17	0.00	13	+0.19	+0.21	—0.02
2	+0.05	+0.10	—0.05	14	+0.13	+0.13	0.00
3	+0.04	+0.01	+0.03	15	+0.06	+0.03	+0.03
4	—0.10	—0.09	—0.01	16	—0.10	—0.08	—0.02
5	—0.14	—0.16	+0.02	17	—0.18	—0.18	0.00
6	—0.19	—0.19	0.00	18	—0.26	—0.22	—0.04
7	—0.14	—0.17	+0.03	19	—0.19	—0.21	+0.02
8	—0.15	—0.09	—0.06	20	—0.12	—0.14	+0.02
9	+0.01	+0.01	0.00	21	+0.01	—0.05	+0.06
10	+0.10	+0.12	—0.02	22	+0.04	+0.06	—0.02
11	+0.19	+0.20	—0.01	23	+0.12	+0.14	—0.02

The formula or curve enables us to divide the observed curve so as to show the diurnal and semi-diurnal part of the observed variations. The decomposition of the curve is made on the diagram where the resulting curve for the diurnal period is given.

The lunar-diurnal variation seems to be subject to an inequality depending on the solar year, for the investigation of which the preceding results were rearranged in two groups, one containing the hourly values for the summer months (April to September), the other the values for the winter months (October to March). For the summer season we have 11,087 observations, and for the winter 10,557.

Hourly Sums of the Lunar Variation for the Summer Season.

Moon's hour-angle.

	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	
Σ 1840–3	+9.29	+14.15	+3.45	+7.20	—2.93	—2.23	—15.73	—6.18	—12.04	—4.57	—1.49	+12.38	
Σ 1844–5	+8.62	+8.26	+3.92	+3.95	+0.05	—4.36	—4.64	—4.87	—3.81	—3.87	+1.51	+2.13	
$\frac{\Sigma}{40}$	+0.66	+0.77	+0.28	+0.38	—0.07	—0.27	—0.63	—0.40	—0.49	—0.31	+0.04	+0.42	
Same in arc	+0′.30	+0.35	+0.13	+0.17	—0.03	—0.13	—0.28	—0.18	—0.22	—0.14	+0.02	+0.19	
	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Mo's.
Σ 1840–3	+17.02	+11.44	+5.18	+13.14	—4.94	—7.97	—16.72	—10.27	—12.44	+0.11	—5.49	+10.12	22
Σ 1844–5	+4.62	+3.32	+2.51	+0.44	+0.10	—4.85	—6.88	—5.47	—6.18	—4.17	+2.04	+1.61	9
$\frac{\Sigma}{40}$	+0.66	+0.45	+0.26	+0.35	—0.12	—0.44	—0.76	—0.53	—0.62	—0.21	—0.04	+0.33	
Same in arc	+0′.30	+0.20	+0.12	+0.16	—0.05	—0.20	—0.34	—0.24	—0.28	—0.09	—0.02	+0.15	

HOURLY SUMS OF THE LUNAR VARIATION FOR THE WINTER SEASON.

Moon's hour-angle.

	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	
Σ 1840–2	+6.42	+1.21	+4.92	+3.04	+1.19	—3.00	—1.92	—8.98	—8.15	—1.31	+1.02	—6.76	
Σ 1843–5	+0.50	—1.27	—3.23	—5.93	—7.67	—5.30	—3.27	—0.34	+1.02	+7.36	+7.51	+11.18	
$\frac{\Sigma}{39}$	+0.19	—0.04	—0.04	—0.23	—0.36	—0.35	—0.22	—0.25	—0.16	+0.35	+0.41	+0.40	
Same in arc	+0′.09	—0.02	—0.02	—0.10	—0.16	—0.16	—0.10	—0.11	—0.07	+0.16	+0.18	+0.18	
	12h.	**13h.**	**14h.**	**15h.**	**16h.**	**17h.**	**18h.**	**19h.**	**20h.**	**21h.**	**22h.**	**23h.**	**Mo's.**
Σ 1840–2	+6.09	+0.09	+2.31	—4.18	—7.95	—4.79	—4.79	—1.85	+4.31	+3.86	+8.46	+5.35	15
Σ 1843–5	+8.62	+7.34	+5.02	+0.70	—2.73	—4.62	—5.32	—4.82	—0.65	+2.75	0.00	+1.05	12
$\frac{\Sigma}{39}$	+0.60	+0.38	+0.32	—0.07	—0.35	—0.37	—0.40	—0.29	+0.08	+0.25	+0.22	+0.19	
Same in arc	+0′.27	+0.17	+0.14	—0.03	—0.16	—0.17	—0.18	—0.13	+0.04	+0.11	+0.10	+0.09	

Expressed analytically, the lunar-diurnal variation in the two seasons is as follows :—

In summer,

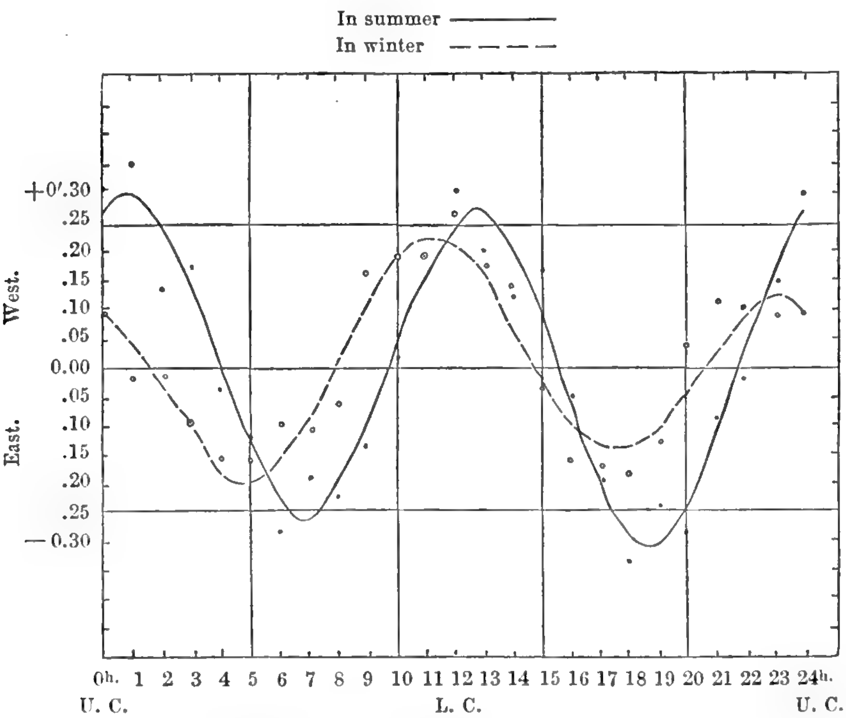
$$\triangle_{☾} = -0'.006 + 0'.028 \sin(\theta + 18°) + 0'.278 (2\theta + 67°)$$

In winter,

$$\triangle_{☾} = +0'.005 + 0'.058 \sin(\theta + 264°) + 0'.173 (2\theta + 115°)$$

The characteristic feature of the annual inequality in the lunar-diurnal variation is, therefore, a much smaller amplitude in winter than in summer. Kreil, indeed,

LUNAR-DIURNAL VARIATION.



Summer curve from 11,087 observations (.)
Winter " " 10,557 " (°)

inferred from the ten-year series of the Prague observations, that in winter the lunar-diurnal variation either disappears, or is entirely concealed by irregular fluctuations, requiring a long series for their diminution. The method of reduction which he employed was, however, less perfect than that now used. The second characteristic of the inequality consists in the earlier occurrence of the maxima and minima in winter than in summer. The winter curve precedes the summer curve by about one and three-quarter hours. Both these features are well expressed in the above diagram. At Toronto, the same shifting in the maxima and minima epochs was noticed, but the other inequality in the amount of deflection is not exhibited. It seems probable that the Philadelphia results are more typical in form than those either of Prague or Toronto. It is also apparent that the smaller deflection at the upper culmination in the annual mean, when compared with the deflection at the lower culmination, is entirely produced by the feeble lunar action in winter. The maximum west deflection in summer occurs actually near the upper culmination. At the same season the maximum east deflection is still retained (as in the annual curve) about six hours after the lower culmination. In the winter season this last mentioned maximum east deflection is actually the smaller of the two. We have—

Maximum summer range	35″.4,	Secondary,	31″.8
" winter "	25 .2,	"	15 .6
Difference	10 .2,		16 .2

At Prague the maximum summer range was 44″.

Next I proceed to examine whether the phases of the moon, the declination, or parallax, have any sensible effect upon the magnetic declination. Mr. Kreil found, from a ten years' series of observations at Prague, that there was no specific change in the position of the magnet depending upon the moon's phases and parallax, but that the declination was 6″.8 greater when the moon was at the greatest northern declination than when at the greatest southern declination. On the contrary, Mr. Broun, from the Makerstoun observations, a much shorter series than the one at Prague, inferred that there was a maximum of declination two days after the full moon. He also found a maximum corresponding to the greatest northern declination of the moon, but does not appear to have investigated the effect of distance. The residuals which we have been treating enable us at once to examine these several points.

Beginning with the lunar phases, the daily means for the day of full and new moon, and for two succeeding days, were compared with the monthly mean declination. In case any of the hours were disturbed, the monthly normal for the hour was substituted for the disturbed observation before the mean was taken. If one-half or more of the hourly readings were disturbed, the daily mean was altogether omitted. Accidental omissions of hourly observations were supplied by the hourly normal. The half-monthly normals were then compared with the half-monthly means. In the table of differences thus formed, equal weight is given to the bi-hourly and hourly observations. The daily mean having been subtracted from the monthly mean, the positive sign indicates a western deflection, and the negative sign an eastern one, as compared with the normal position. The following table contains the result:—

	Sum of deflections.	Number.	Deflection.		
Full moon ⊙	+11.6	52	$+0^{d}.22$	+0′.10	±0′.07
1st day after	—7.1	51	—0.14	—0.06	
2d day after	—9.3	48	—0.19	—0.08	
New moon ●	—11.5	43	—0.27	—0.12	±0′.09
1st day after	+1.5	47	+0.03	+0.01	
2d day after	+4.4	49	+0.09	+0.04	

The effect is very small, scarcely much beyond the probable error, but the table indicates that the north end of the magnet is deflected to the westward 0′.1 at the full, and as much to the eastward at the change day, the range between full and new moon being 0′.2. A more definite result could hardly be expected from a series of observations extending over but five years.

Treating the subject of the effect of the moon's variation in declination in precisely the same manner, we obtain the following result:—

	Mean deflection.	
One day before	—0′.20	from 54 days of observation.
At moon's max. declination . .	—0.10	" 53 " "
One day after	—0.09	" 55 " "
Mean . . .	—0′.13	" 162 " "
One day before	—0′.04	" 54 " "
At moon's min. declination . .	—0.07	" 52 " "
One day after	+0.14	" 52 " "
Mean . . .	+0′.01	" 158 " "

These results do not positively fix a deflection of the magnet as depending on the moon's greatest north and south declination, the amount resulting from the comparisons being of nearly the same magnitude as its probable error.

A similar investigation, with respect to the moon's distance from the earth, gives the following results:—

	Mean deflection.	
One day before	—0′.18	from 50 days of observation.
At moon's perigee	—0.18	" 41 " "
One day after	0.00	" 59 " "
Mean . . .	—0′.12	" 150 " "
One day before	—0′.02	" 55 " "
At moon's apogee	—0.20	" 53 " "
One day after	—0.13	" 47 " "
Mean . . .	—0′.12	" 155 " "

The differences being of the same order of magnitude as the probable errors, no conclusion as to the effect of distance can be drawn from them.

I propose hereafter to extend the discussion of the moon's effect on the declination to the effect on the earth's magnetic force.

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

DISCUSSION

OF THE

MAGNETIC AND METEOROLOGICAL OBSERVATIONS

MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA,
IN 1840, 1841, 1842, 1843, 1844, AND 1845.

SECOND SECTION,

COMPRISING PARTS IV, V, AND VI. HORIZONTAL FORCE.

INVESTIGATION OF THE ELEVEN (OR TEN) YEAR PERIOD AND OF THE DISTURBANCES OF THE HORIZONTAL COMPONENT OF THE MAGNETIC FORCE, WITH AN INVESTIGATION OF THE SOLAR DIURNAL VARIATION, AND OF THE ANNUAL INEQUALITY OF THE HORIZONTAL FORCE; AND OF THE LUNAR EFFECT ON THE SAME.

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PART IV.

INVESTIGATION

OF THE

ELEVEN (OR TEN) YEAR PERIOD AND OF THE DISTURBANCES OF THE HORIZONTAL COMPONENT OF THE MAGNETIC FORCE.

INVESTIGATION

OF THE

ELEVEN (OR TEN) YEAR PERIOD, AND OF THE DISTURBANCES OF THE HORIZONTAL COMPONENT OF THE MAGNETIC FORCE.

VOLUME XI of the Smithsonian Contributions to Knowledge contained a discussion, in three parts, of the observations for magnetic declination. The first part referring to the eleven (or ten) year period in the amplitude of the solar diurnal variation, and of the disturbances of the magnetic declination; the second, to the annual inequality of the solar diurnal variation, and the third, to the influence of the moon on the magnetic declination. The present discussion refers to the changes of horizontal force, and will be carried on in the same order as the former, so as to dispense with explanations in the mode of treatment, unless in those portions involving the peculiarities of the horizontal force instrument and record. Charles A. Schott, Esq., has rendered me the same assistance in this work, stated in the introduction to Part I.

The horizontal force instrument was one of Gauss's large bifilar magnetometers, made by Meyerstein, of Göttingen, the weight of the magnetic bar being about twenty-five pounds, and its length being thirty-six inches and five-eighths. The suspension wires were slightly inclined, the smaller distances between them being above the larger. The value of one division of the scale in parts of the horizontal force was determined to be:—

in May, 1840, ...	0.000035
in June, 1841, ...	0.000038

The mean, or 0.0000365 is the value used throughout the series. The sensibility of the instrument was thus very considerable. The instrument having been properly adjusted with the bar at right angles to the mean magnetic meridian, the torsion angle Z was found to be 71° 43′. The relation $k = a \; cotan. \; Z$ expresses the value of one scale division k in parts of the horizonal force, a being the value of a scale division in parts of the radius, or $0.00011 = 0'.38$, and Z the angle of torsion. Increase of readings on the scale corresponded to decrease of horizontal force.

The instruments were placed in position by the equations deduced by Professor Lloyd, for the case of the declinometer in equilibrium with the horizontal and vertical force magnetometers, the position of instable equilibrium being taken necessarily from the form and position of the observatory. The effect of the small vertical force bar at first used, upon the bifilar was quite insensible, and that of the declinometer bar affected the value of the scale but slightly, the effect of both instruments changing the value of the scale divisions only in the ratio of 1 to 0.9956.

A thermometer, by Francis, of Philadelphia, divided to half degrees of Fahrenheit's scale, and easily read to tenths, was placed in the box of the horizontal force magnetometer and as near as practicable to the bar.

After the bifilar was set up, a motion commenced in the direction indicating decrease of force; it was progressive though not steadily so. After a time an extra scale was required on occasions of auroral, or other disturbances, and finally the ordinary readings were upon this extra scale. On the occasion of the change of the vertical force magnetometer, in January, 1841, by the substitution of Saxton's balance magnetometer for Lloyd's, the magnetism of the horizontal force bar was examined and found to have sensibly decreased; its force amounted to 0.9601 of its original force, in May, 1840. The experiments were made by means of deflections with a subsidiary declinometer bar, the only means then available. A further experiment of the loss of force was made in June, 1841, when the instrument was accidentally disturbed by one of the observers. The loss of magnetism then found, by means of a new determination of the angle Z, was 0.0314 of its amount in January, 1841. To ascertain the change of magnetism of the bars of the magnetometers, vibrations were also made use of, but they led to no satisfactory result. The progressive change of the scale readings from the change of the horizontal force and loss of magnetism of the bar, will be investigated further on.

The observations, between June, 1840, and September, 1843, were made bi-hourly, and from October, 1843, to the close of the series, hourly. The series extending over five years is not quite continuous; no observations were made on eleven days in January, 1841, on the occasion of the introduction of a new vertical force magnetometer, and the consequent necessity of readjusting the instruments; in January, February, and March, 1843, the work was reduced to but a single reading a day, by circumstances elsewhere stated; there are also some minor disturbances at other times when the difference in the readings, however, were ascertained and allowed for. Full statements bearing on the continuity of the series will be given in subsequent pages.

The reduction proper, necessarily commences with the operation of bringing all the readings to the same standard temperature, to render them comparable among themselves.

Correction of the Readings of the Bifilar Magnetometer for Changes of Temperature.

The care bestowed on the experiments to ascertain the effect of the temperature on the instrument, and the perseverance with which they were carried out were not rewarded with a corresponding degree of agreement in the results obtained, by the various processes employed. This it will be recollected was also the case at other observatories. The subject of the co-efficient of temperature for the bifilar magnet is fully treated in the preface to the three volumes containing the record, and it will, therefore, in this place only be necessary to recapitulate in general the results and to state the nature of the experiments there described.

The first observations for the temperature co-efficient were made on July 16, 1840. Oscillations were observed alternately at the ordinary temperature and near the freezing point, obtained by surrounding the box containing the magnet with ice; at the same time comparative oscillations of a bar in another building were observed to furnish the necessary data to correct the bifilar results for any change in the horizontal force during the progress of the experiments. The value deduced was 2.8 scale divisions for a change of 1° Fahrenheit. No reliance was placed on this result on account of the comparatively rude indications of the subsidiary instrument, and also on account of an irregularity at a certain point in the curve representing the connection of change of force with change of temperature.

The method of deflections was tried, and abandoned on account of the small amount of deflection at a distance sufficiently great to prevent the chance of permanent changes from the mutual action of the bars.

On the 22d of February, 1841, comparisons by vibrations were again resorted to, but with no better success, the correction for change of force during the interval being unsatisfactory. The result deduced was 3.0 scale divisions for 1° Fahr.

Applying the results to the readings of the bar when mounted on the bifilar suspension wires in the observatory, they were so little satisfactory that it was determined to get the change of intensity of the bar by heating and cooling the observatory while the bar remained in situ.

In January and February, 1842, a continuous series of observations was made by allowing the observatory to attain the winter temperature on one day, and obtaining thus a result by comparison with the preceding and succeeding days, when the room was artificially warmed. The value found was 1.55 scale divisions for 1° Fahr. At this time the observatory was warmed by a soap-stone stove with copper fixtures.

About the close of the year 1842 an efficient set of subsidiary instruments was mounted in one of the College buildings, the bifilar magnet being about nine inches in length. After the relative value of the scales of the instruments had been ascertained, comparative observations were made, six each day, in the morning and afternoon. These observations and results are given in a table extending over eleven months, in 1843, and over eleven months, in 1844. The results were fluctuating, and the discrepancies proved conclusively, that other causes were at work which would not be accounted for. The changes in the force were generally small. In the course of these experiments I found, beyond a doubt, that instruments of the same dimensions were required to give comparative results. During an aurora the small instrument in the College gave by no means the same results as the large instrument in the observatory; there were numerous comparisons determining this. I had reason also to believe that the large bar had its induced magnetism easily disturbed, and not regularly renewing itself, so that the correction for temperature may be supposed compound, one part permanent and one part temporary. The following results were obtained:—

Observations between	February and June, 1843,	2.50 scale divisions
" "	July and December, 1843,	2.28 " "
" "	January and June, 1844,	1.94 " "
" "	July and December, 1844,	2.00 " "

for 1° Fahr. It may also be stated that no reasonable supposition in regard to differences of temperature between the indications of the thermometer and magnetic bar, or to changes in the co-efficient varying with the temperature, will explain all the cases of discrepancies. In these comparisons, always near each other in time, small differences in intensity, as shown by the subsidiary instrument, were allowed for, but the corrections for temperature of this latter instrument were neglected, as the changes of temperature in the building where it was placed were small.

Another method, not quite so unobjectionable as the preceding one, was tried; it consisted in taking the results corresponding to the highest temperatures during each winter, and comparing them with those corresponding to the lowest temperatures, a correction being made to reduce the changes of force by means of the secondary instrument. These comparisons were liable to be affected by the unequal distribution of the results used over the different parts of the month. The result was: for combinations and comparisons, from

January, 1844, to June, 1844,	2.03
July, 1844, to December, 1844,	2.29

scale divisions for each degree of Fahrenheit's scale.

The mean value of all the results obtained by the various processes explained, is 2.6 scale divisions, and as a preliminary measure, it was supposed that the co-efficient was changeable, and hence a correction for change of temperature was applied, varying from 3.2 scale divisions, in 1840, to 2.0 scale divisions, in 1844.

On resuming the discussion it was thought desirable to deduce a value for this co-efficient directly from the entire mass of observations, as this could not fail to satisfy the whole series. For this purpose it was indispensable to make the series of observations continuous, or, in other words, to refer the readings, extending over five consecutive years, to the same initial division of the scale. This is, therefore, a proper place for stating all cases when the instrument suffered any disturbance and the amount of scale correction required. All necessary explanations are given in the record.

The first break in the series occurred August 27, 1840, at $12^h\ 22^m$ (Philadelphia time), when the mirror was accidentally deranged. The observed numbers from this date to September 22, at $12^h\ 22^m$ have been brought to comparison with former numbers by the mean position of the bar for six previous days (in some cases seven) and by the hours, from $0^h\ 22^m$ to $22^h\ 22^m$ inclusive. This correction is already applied in the record, its probable error is given as 3.3 scale divisions.

On September 22, 1840, the instrument was readjusted.

An interruption of eleven days occurred, in January, 1841, owing to the introduction of a reflecting vertical force magnetometer, and requiring a new arrangement of the instruments. The horizontal force magnetometer was left in its place. The mean values for January, viz., 944.6 divisions for the bifilar, and 36°.5 for the corresponding temperature, as given in volume I of the record, may be reduced to the true mean by the interpolation of values, between December 31 and January 12. The daily mean (at 32°), on December 31, was 842.3, and on January 12, 913.0, hence, omitting the readings for January 3d, and 10th, as Sundays, the complete monthly mean should be 18.6 divisions less or equal 926.0.

The observations were resumed on the 12th, and continued to February 8th at $22^h\ 49\frac{1}{2}^m$, when the wires were found to have been slightly deranged, two days previously, February 6, $18^h\ 22^m$ (Philadelphia time), a great change in the position was noticed; on re-arranging the instrument it did not return to its former readings. A correction of + 116 has been applied (in the record) to the previous *mean* readings only in this month, and in consequence + 116 divisions should be added to each individual reading from the commencement of the series; but on account of another disturbance of the instrument, on the 22d, at $16^h\ 22^m$ (Philadelphia time), a further correction of + 92.8 scale divisions should be applied. The total correction is therefore + 208.8. Besides these corrections the readings on the 22d from $0^h\ 22^m$ (Philadelphia time) to $10^h\ 22^m$ (Philadelphia time), inclusive, should be increased by + 25.1 divisions, the alhidade of the instrument having been disturbed.[1]

On the 2d of June, 1841, the suspension wires were struck accidentally, deranging the instrument; the readings were then near the end of the subsidiary scale, and in rearranging the instrument the new readings were brought near the middle of the scale. The total difference between the old and new scale readings, the latter commencing with the first of the month, is 900 scale divisions. The means between June 1st and 5th are already corrected in the record, but the individual bi-hourly readings require a correction of + 213[2] scale divisions to produce these means. It was thought best not to apply this correction of — 900 divisions to the observations between June, 1840, and June, 1841, but simply to state the quantity since it can be applied easily to any result hereafter.

At the close of 1842 the regular observations were discontinued for three months, during January, February, and March, 1843; a daily reading was taken at $14^h\ 22^m$ (Philadelphia time), in order to keep up a continuity in the series. By means of the reduced readings in the same months in the other years, it was found that a correction of $-\ 3^d.4$ $-\ 3^d.7$ and $+\ 1^d.5$ for January, February, and March, respectively, was required to refer the mean at $14^h\ 22^m$ to the mean of a complete bi-hourly daily series. Applying these corrections, the corrected monthly means become:—

[1] The corrected daily means for the month of February, 1841, should, therefore, read as follows:—

1st	1163.5	10th	1131.1	19th	1127.9
2d	1144.8	11th	1103.8	20th	1130.0
3d	1141.9	12th	1082.5	22d	1182.9
4th	1133.0	13th	1083.5	23d	1182.6
5th	1138.1	15th	1100.0	24th	1128.0
6th	1138.6	16th	1122.1	25th	1107.7
8th	1181.2	17th	1139.7	26th	1144.6
9th	1150.6	18th	1137.0	27th	1162.3
Mean					1135.7

[2] For the first day only + 142, according to the mean in the record.

For January, 1843, ...	$803^d.7$ at $59^\circ.2$
For February, 1843, ...	$798^d.9$ at $51^\circ.9$
For March, 1843, ...	$815^d.1$ at $48^\circ.7$

On the 15th of April, 1843, the instrument was carefully examined and found in adjustment.

At 6^h 50^m on May 4, 1843, the bifilar was disturbed, but readjusted on May 5, before the regular observation at 2^h 21^m P. M. A correction of — 16 divisions during the interval is to be applied to the readings. After this date the instrument remained undisturbed.

We have, therefore, for discussion the following continuous series of monthly means of the readings of the bifilar magnetometer with its corresponding mean temperature. The series extends over five years and one month. To obtain a better view of the series, the correction of — 900 divisions for the first twelve months has been applied, it gives a negative value to the June mean of 1840.

TABLE I.—RECAPITULATION OF MONTHLY MEAN READINGS OF THE BIFILAR MAGNETOMETER, CORRECTED SO AS TO PRESENT A CONTINUOUS SERIES.

	1840–41.	1841–42.	1842–43.	1843–44.	1844–45.
June	— 85.4	+432.3	+663.5	+901.0	+1092.0
July	+ 90.1	463.9	710.2	946.5	1126.6
August . . .	146.2	511.6	718.1	956.3	1149.5
September . .	162.1	537.9	740.3	985.4	1124.8
October . . .	149.4	515.6	768.8	988.6	1140.7
November . .	136.8	503.1	777.8	983.7	1135.1
December . .	156.0	535.4	775.9	986.1	1191.3
January . . .	234.8	561.0	803.7	988.3	1227.2
February . . .	235.7	576.4	798.9	1018.1	1221.6
March	248.9	572.1	815.1	1052.1	1235.3
April	266.5	606.7	869.5	1067.6	1257.3
May	307.8	625.1	873.6	1072.4	1250.8
June	...	...	...	...	1291.7
			Temperature of the bifilar magnet.		
June	$+72^\circ.1$	$+74^\circ.1$	$+71^\circ.3$	+75.1	+72.9
July	75.6	77.3	76.8	76.8	77.8
August . . .	75.5	75.4	74.7	77.2	75.8
September . .	65.0	70.6	72.5	73.1	71.5
October . . .	58.7	53.7	67.9	66.3	68.8
November . .	47.4	47.1	61.8	60.5	61.5
December . .	35.7	55.4	57.3	57.7	57.4
January . . .	36.5	61.5	59.2	51.7	58.8
February . . .	34.7	60.5	51.9	54.6	53.6
March	43.5	64.1	48.7	62.8	58.2
April	50.5	65.5	67.4	63.8	64.1
May	60.3	68.3	68.4	68.9	64.3
June	...	...	...	...	74.8

Under the supposition of a uniform progression in the change of the mean monthly readings (due to change in the horizontal force and loss of magnetism of the bar) the bifilar readings for a given period may be represented by the form:—

$$B = B_m + \triangle e\, x + \triangle t\, y$$

where B_m a mean bifilar reading for the period.

x the change during a period.

y the change in the reading due to a change of 1° Fahr.

$\Delta e =$ difference between any single period and the mean epoch.

$\Delta t =$ " " any temperature and the mean temperature.

The formula was first applied to the monthly means resulting from five years of observation; it gave $y = + 1.0$ scale division; but the remaining differences showed that the irregular changes between June and July, and December and January, of the years 1840–41, had an undue effect on the result, the first year's observations were, therefore, omitted, and the process repeated for the remaining four years. The twelve conditional equations gave the normal equations:—

$$+ 2143.15 = + 143x - 200.4\,y.$$
$$- 2549.73 = - 200.4x + 711.1\,y.$$

whence $x =$ monthly effect of the progression $= + 16.5$ scale divisions.

$y =$ temperature correction for 1° Fahr. $= + 1.8$ " "

An examination of the observed and computed values showed that the introduction of a term $\Delta e^2 z$ would improve the agreement, solving the three normal equations we found

$$x = + 17.6$$
$$y = + \ 1.62$$
$$z = - \ 0.31$$

The following table shows the comparison of the observed and computed monthly mean readings of the bifilar:—

1841–1845.	Mean temperature.	Mean observed bifilar reading.	Mean computed.	Difference c. — o.	C. — o + 3.5
June	73.3	772.2	779.2	+ 7.0	+10.5
July	77.2	811.8	806.2	— 5.6	— 2.1
August . . .	76.5	833.9	824.7	— 9.2	— 5.7
September . .	71.9	847.1	837.0	—10.1	— 6.6
October . . .	64.2	853.4	843.3	—10.1	— 6.6
November . .	57.7	849.9	851.4	+ 1.5	+ 5.0
December. . .	57.0	872.2	867.8	— 4.4	— 0.9
January . . .	57.8	895.0	886.0	— 9.0	— 5.5
February . . .	55.2	903.8	897.9	— 5.9	— 2.4
March	58.5	918.6	919.3	+ 0.7	+ 4.2
April	65.2	950.3	945.4	— 4.9	— 1.4
May	67.5	955.5	963.5	+ 8.0	+11.5
Mean	65.17	872.0			

Adding + 3.5 scale divisions to the mean value of B_m the above differences will balance. According to the above results, the annual progressive change is $+ 17.6 \times 12 = 211.2$ scale divisions, and the change in magnetic moment of the bar for a change of 1° Fahr. in the temperature, or $q = + 1.62 \times 0.0000365 = 0.0000591$. This agrees with the best direct determination, being the one in which the observatory was alternately heated and cooled.

To test these results, a combination of the six warmest months with the six coldest months, by alternate means furnished several values for q depending merely on the assumption of a gradual regular progressive change during each year and a half, for which separate results were deduced; this series commences with May, 1841, and ends with April, 1845, and contains, therefore, the same number of months as the first combination, excluding at the same time the two defective portions noticed above. This combination also possesses the advantage of showing the variations in the values of q.

Combination by Alternate Means of the Warmer Months, from May to October inclusive, with the Colder Months, from November to April inclusive.

	Bifilar.	Temperature.	Alternate Means.		Δd	Δt	q in scale divisions.
May, 1841 to Oct., 1841	461.5	68.57					
Nov., 1841 to April, 1842	559.1	59.05	582.9	70.25	23.8	11.20	+2.1
May, 1842 to Oct., 1842	704.3	71.92	683.0	58.38	21.3	13.54	+1.6
Nov., 1842 to April, 1843	806.8	57.72	823.1	72.37	16.3	14.65	+1.1
May, 1843 to Oct., 1843	941.9	72.82	911.4	58.12	30.5	14.70	+2.1
Nov., 1843 to April, 1844	1016.0	58.52	1029.8	72.72	13.8	14.20	+1.0
May, 1844 to Oct., 1844	1117.7	72.62	1113.6	58.72	4.1	13.90	+0.3
Nov., 1844 to April, 1845	1211.3	58.93					
				Sum	109.8	82.19	+1.3

The result from this combination + 1.3 confirms the preceding value, the result, according to weight or + 1.5 scale divisions or q=0.0000548 in parts of the horizontal force has, therefore, been adopted in the reduction of the bifilar readings to a standard temperature, for which + 63°.0 Fahr. has been determined upon as the mean temperature of the magnetic bar during the five years series of observations.

The difference in the resulting value for q, when obtained from deflections or vibrations, and from combinations of the bifilar readings themselves, has been remarked before, and no satisfactory explanation has as yet been given of it. Thus, for instance, at Toronto, the two respective values were 2.69 and 1.63 scale divisions, as shown in General Sabine's remarks (Vol. III.) The existence of a similar discrepancy in the case of the Makerstoun bifilar has been detected by Mr. Broun. Whatever may be the cause of the difference, there can be no hesitation in saying that the result derived from the bifilar observations themselves is the one to be preferred. At St. Helena (Vol. II., London, 1860), the two values were 1.45 and 0.98, the half yearly comparisons at this station even show a less value, viz., 0.88 scale divisions; 0.98 (for convenience 1.0) was adopted in the reduction. Dr. Lamont, in his Handbook of Terrestrial Magnetism (p. 206, edition of 1849), says: "It deserves to be remarked that the value obtained by comparing monthly mean readings of the bifilar at high and low temperatures is smaller than that obtained by direct observation."

In the present discussion the value $\frac{q}{k} = \frac{0.0000548}{0.0000365} = 1.5$ has been adopted. At Toronto this value was $\frac{q}{k} = \frac{0.000142}{0.000087} = 1.63$, and at St. Helena $\frac{q}{k} = \frac{0.00019}{0.00019} = 1.0$.

It will be seen from these values that the Philadelphia bifilar magnetometer was very sensitive; its scale value in parts of the horizontal force is but four-tenths of the Toronto value, and only two-tenths of that of the St. Helena instrument.

In the computations which follow the tenths of scale readings have been omitted (keeping only the nearest unit) as contributing nothing to the accuracy of the results, and merely increasing the labor of reduction. The uncertainty in the readings arising from the uncertainty in the value of q probably affects the units, and the same may be said of the declination changes, so that in extreme (individual) cases the next higher figure may be affected.

The next step of the reduction consisted in transcribing the whole body of the observations after correcting them individually for differences of temperature; the adopted standard temperature being 63° Fahr.

The following table contains the monthly means of the bifilar readings reduced to the standard temperature; the series has been made continuous by the application of certain corrections explained before.

The readings are in scale divisions of 0.0000365 parts of the horizontal force; increasing numbers denote decrease of force. The time is Observatory mean time, counted to twenty-four hours for convenience sake.

TABLE II.—MONTHLY MEANS OF THE BIFILAR READINGS TAKEN AT INTERVALS OF TWO HOURS AND REDUCED TO THE STANDARD TEMPERATURE 63° FAHRENHEIT.

Philadelphia time (A. M.)							(P. M.)					
	$0^h 22^m$	$2^h 22^m$	$4^h 22^m$	$6^h 22^m$	$8^h 22^m$	$10^h 22^m$	$12^h 22^m$	$14^h 22^m$	$16^h 22^m$	$18^h 22^m$	$20^h 22^m$	$22^h 22^m$
1840.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.
June	—96	—98	—101	—113	—102	— 79	— 94	—115	—117	— 96	— 88	— 90
July	+74	+67	+ 63	+ 60	+ 86	+100	+ 81	+ 52	+ 41	+ 74	+ 79	+ 79
August	129	117	117	113	145	157	137	113	110	129	126	133
Sept.	158	147	143	138	169	201	183	157	152	153	157	153
October	155	149	137	140	153	179	177	161	155	157	158	152
Nov.	160	157	149	141	153	171	179	165	167	159	160	164
Dec.	203	192	184	178	184	210	218	206	192	196	202	202
1841.	$0^h 22^m$	$2^h 22^m$	$4^h 22^m$	$6^h 22^m$	$8^h 22^m$	$10^h 22^m$	$12^h 22^m$	$14^h 22^m$	$16^h 22^m$	$18^h 22^m$	$20^h 22^m$	$22^h 22^m$
*January	296	287	286	276	272	294	322	306	289	298	294	298
Feb.	279	270	265	256	261	286	303	295	276	283	289	275
March	276	273	267	260	272	298	299	272	279	281	282	280
April	285	278	268	265	287	312	314	282	273	280	289	286
May	311	312	311	303	318	335	323	304	298	307	312	315
June	420	417	414	405	418	427	406	402	408	416	426	427
July	444	440	435	436	447	457	449	429	430	442	453	448
August	490	490	485	481	499	515	500	479	481	496	501	497
Sept.	517	520	517	514	534	561	538	522	521	528	523	524
October	528	520	517	518	532	540	545	535	529	530	531	530
Nov.	528	529	522	515	525	535	539	525	523	525	528	529
Dec.	545	541	537	534	539	551	562	550	547	553	553	551
1842.	$0^h 21\frac{1}{2}^m$	$2^h 21\frac{1}{2}^m$	$4^h 21\frac{1}{2}^m$	$6^h 21\frac{1}{2}^m$	$8^h 21\frac{1}{2}^m$	$10^h 21\frac{1}{2}^m$	$12^h 21\frac{1}{2}^m$	$14^h 21\frac{1}{2}^m$	$16^h 21\frac{1}{2}^m$	$18^h 21\frac{1}{2}^m$	$20^h 21\frac{1}{2}^m$	$22^h 21\frac{1}{2}^m$
January	560	558	557	554	553	575	579	564	559	568	565	565
Feb.	582	576	574	568	570	580	593	582	578	583	589	582
March	573	564	561	561	567	580	577	567	568	574	576	577
April	605	599	598	593	601	618	612	596	592	605	607	607
May	618	614	609	609	624	632	622	607	609	618	620	622
June	652	655	649	641	652	664	654	642	639	652	655	656
July	684	689	682	683	695	710	698	681	674	687	693	697
August	702	695	695	693	712	722	703	689	690	700	704	703
Sept.	721	723	719	712	732	746	734	722	718	729	730	727
October	757	750	747	747	755	774	778	772	766	764	765	762
Nov.	780	774	772	769	778	791	786	782	778	778	781	785
Dec.	783	780	778	776	779	793	800	791	780	781	784	785
1843.	$0^h 21\frac{1}{2}^m$	$2^h 21\frac{1}{2}^m$	$4^h 21\frac{1}{2}^m$	$6^h 21\frac{1}{2}^m$	$8^h 21\frac{1}{2}^m$	$10^h 21\frac{1}{2}^m$	$12^h 21\frac{1}{2}^m$	$14^h 21\frac{1}{2}^m$	$16^h 21\frac{1}{2}^m$	$18^h 21\frac{1}{2}^m$	$20^h 21\frac{1}{2}^m$	$22^h 21\frac{1}{2}^m$
January								813				
Feb.								819				
March								835				
April	860	859	853	853	867	880	875	860	859	863	866	859
May	866	864	862	860	875	877	862	855	856	863	873	870
June	884	883	879	876	886	895	887	873	873	884	887	888
July	924	921	921	920	933	940	932	920	916	921	931	929
August	932	931	931	928	950	957	944	924	925	930	936	935
Sept.	968	967	962	957	977	990	981	966	968	970	970	966

Hourly Series.												
	0h 21½m	1h 21½m	2h 21½m	3h 21½m	4h 21½m	5h 21½m	6h 21½m	7h 21½m	8h 21½m	9h 21½m	10h 21½m	11h 21½m
1843.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.
October	983	978	980	978	976	978	977	980	984	987	991	992
Nov.	988	987	986	984	983	981	981	984	988	992	994	994
Dec.	996	994	993	992	990	988	988	988	992	992	993	998
	12h 21½m	13h 21½m	14h 21½m	15h 21½m	16h 21½m	17h 21½m	18h 21½m	19h 21½m	20h 21½m	21h 21½m	22h 21½m	23h 21½m
October	991	989	985	983	983	983	985	985	985	984	983	984
Nov.	992	990	988	987	985	986	987	987	988	988	989	989
Dec.	1000	999	997	994	992	991	993	996	996	996	998	999
1844.	0h 21½m	1h 21½m	2h 21½m	3h 21½m	4h 21½m	5h 21½m	6h 21½m	7h 21½m	8h 21½m	9h 21½m	10h 21½m	11h 21½m
January	1009	1007	1006	1004	1002	1002	1001	1001	1004	1007	1010	1013
Feb.	1031	1031	1031	1029	1026	1026	1026	1028	1029	1030	1034	1036
March	1050	1048	1047	1046	1045	1044	1045	1046	1051	1058	1060	1062
April	1067	1066	1065	1062	1059	1059	1062	1062	1067	1075	1079	1079
May	1066	1066	1064	1063	1063	1062	1062	1065	1069	1075	1076	1071
June	1080	1079	1078	1079	1079	1077	1075	1079	1082	1084	1086	1083
July	1103	1104	1106	1107	1107	1106	1105	1105	1110	1117	1119	1115
August	1129	1130	1130	1130	1129	1127	1126	1131	1139	1148	1149	1143
Sept.	1108	1108	1108	1109	1105	1107	1106	1113	1123	1129	1133	1129
October	1132	1128	1127	1123	1122	1124	1125	1130	1137	1143	1146	1141
Nov.	1136	1135	1133	1132	1131	1127	1128	1129	1134	1141	1147	1149
Dec.	1203	1201	1198	1196	1194	1192	1188	1191	1192	1196	1207	1215
	12h 21½m	13h 21½m	14h 21½m	15h 21½m	16h 21½m	17h 21½m	18h 21½m	19h 21½m	20h 21½m	21h 21½m	22h 21½m	23h 21½m
January	1011	1008	1005	1001	1000	1002	1004	1005	1005	1006	1007	1009
Feb.	1035	1032	1028	1028	1032	1031	1032	1033	1034	1033	1034	1033
March	1067	1063	1056	1049	1052	1054	1054	1053	1051	1052	1052	1051
April	1074	1069	1063	1059	1061	1059	1065	1067	1068	1069	1066	1069
May	1065	1058	1054	1054	1052	1055	1060	1064	1065	1065	1064	1064
June	1079	1074	1069	1067	1067	1069	1073	1075	1077	1079	1079	1080
July	1107	1101	1097	1094	1093	1094	1097	1100	1102	1103	1104	1105
August	1134	1125	1117	1115	1117	1123	1130	1131	1132	1131	1132	1131
Sept.	1119	1108	1102	1100	1101	1105	1108	1110	1111	1111	1112	1116
October	1139	1134	1128	1129	1128	1132	1133	1133	1135	1132	1133	1130
Nov.	1146	1145	1139	1137	1138	1138	1138	1143	1141	1138	1135	1139
Dec.	1215	1210	1205	1200	1195	1196	1197	1197	1197	1201	1201	1201
1845.	0h 21½m	1h 21½m	2h 21½m	3h 21½m	4h 21½m	5h 21½m	6h 21½m	7h 21½m	8h 21½m	9h 21½m	10h 21½m	11h 21½m
January	1233	1230	1231	1229	1227	1225	1224	1226	1230	1238	1244	1248
Feb.	1232	1234	1232	1230	1230	1227	1224	1228	1234	1238	1246	1249
March	1237	1237	1235	1236	1235	1235	1231	1234	1242	1250	1256	1262
April	1253	1250	1249	1247	1245	1243	1241	1247	1255	1270	1280	1279
May	1249	1248	1246	1245	1241	1238	1235	1242	1254	1264	1265	1263
June	1274	1274	1274	1273	1268	1267	1262	1266	1273	1284	1290	1289
	12h 21½m	13h 21½m	14h 21½m	15h 21½m	16h 21½m	17h 21½m	18h 21½m	19h 21½m	20h 21½m	21h 21½m	22h 21½m	23h 21½m
January	1245	1241	1238	1235	1233	1236	1237	1233	1232	1231	1231	1229
Feb.	1251	1247	1240	1236	1235	1233	1234	1236	1236	1232	1232	1233
March	1261	1254	1246	1240	1241	1243	1245	1242	1241	1238	1241	1240
April	1271	1267	1255	1253	1249	1251	1254	1257	1257	1254	1251	1252
May	1256	1248	1242	1242	1242	1246	1251	1251	1251	1253	1251	1245
June	1282	1278	1269	1267	1266	1269	1274	1278	1277	1276	1275	1275

The monthly means are contained in the following table:—

TABLE III.—MONTHLY MEANS OF THE PRECEDING BIFILAR READINGS REDUCED TO THE STANDARD TEMPERATURE 63° FAHRENHEIT.

	1840–41.	1841–42.	1842–43.	1843–44.	1844–45.
	Div's.	Div's.	Div's.	Div's.	Div's.
June	— 99				
July	+ 71	443	689	926	1104
August . . .	127	493	701	935	1130
September . .	159	527	726	970	1112
October . . .	156	530	761	984	1132
November . .	160	527	780	987	1138
December . .	197	547	784	994	1199
January . . .	[1]274	563	[3]808	1005	1233
February . . .	278	580	[3]814	1031	1235
March	278	570	[3]835	1052	1243
April	285	603	863	10 6	1255
May	312	617	865	10 4	1249
June	[2]415	651	883	10.7	1274

Correction for progressive change in the readings.—The observations having been referred to a uniform temperature, still require a correction for the effect of the progressive change during each month before Peirce's criterion can be applied for the purpose of separating the disturbances. We have seen that the mean monthly value of this change due to loss of magnetism of the bar and to change in the horizontal force itself, was 17.6 scale divisions; on the average, therefore, a correction must be applied to the observations on the first and last day of each month of + 8.8 and — 8.8 scale divisions, and in proportion for the intermediate days. At Toronto, also, the progressive change in some months was so great as to present a practical difficulty by its interference with the proper comparability of the observations, and in these cases new means at shorter intervals than a month were taken.

[1] The actual mean of 17 days was 293; to reduce this to the mean of 27 days, 19 scale divisions were subtracted, resulting from an interpolation between January 1st and January 12th; the mean of 7 days preceding and following the gap was made use of.

[2] Owing to causes already explained, the means of May and June differ so much as to affect the continuity of the series; the same is to be said of the differences between June and July, 1840, and between December, 1840, and January, 1841; the corresponding differences between the same months in the other four years furnish us with the means of correcting the series for the first year, as will be seen hereafter; it also appeared advisable to omit the readings in June, 1840, altogether, the instrument not having then been in stable adjustment.

[3] The numbers in table II have been slightly changed, to refer the mean of the hour of observation to the mean resulting from observation of 12 hours a day. Comparing the mean at 14^h 22^m in each month with the respective monthly means in the other four years, the above corrections became —5, —5 and 0 for January, February, and March.

The bar between September and October, 1843, separates the means from the bi-hourly and the hourly series.

In the application of the reduction for temperature no attempt whatever has been made at interpolation in the magnetic series, but whenever a temperature reading was accidentally omitted, it has been supplied by comparison with the observed temperature immediately preceding and following. No magnetic reading can be supplied by interpolation, however short the interval, as long as the law of the occurrence of the disturbances remains unknown.

At Philadelphia the progressive change is so large as to require a systematic correction throughout the series. In the manuscript tables used for the preparation of the monthly normals and containing the observations reduced to 63° Fahr., the readings corrected for progressive change were written in blue ink underneath each observation. If the monthly differences are taken from Table No. III., it is apparent that the change is irregular, and in three cases at least it is certain that other causes were in operation, which produced larger monthly differences than could be attributed to the gradual loss of magnetism. These cases are the following (already noticed in the preceding temperature discussion): between June and July, 1840, a difference of 170 divisions; between December and January, 1840–41, a difference of 77; and between May and June, 1841, a difference of 103 divisions. They require separate treatment, as will be presently explained. For the correction of the progressive change the mean reading from *one* month's series was made out for the first, middle, and last of each month. By this process of taking the mean from 14 days preceding and 14 days following each of the epochs the lunar effect on the solar variation is practically eliminated from the resulting mean value.[1] These means corresponding in time to the beginning, the middle, and the end of each month, furnish the *rate* of change for the first and second half of the month, and by simple interpolation give the correction for progressive change for each day. If the rates for the first and second half of the month are different, the monthly means of each hour (from the blue figures) will differ by a small but *constant* quantity from the former monthly means. Thus, for instance, for the month of June, 1842, the monthly mean is 651 divisions, corresponding in time to the middle of the month, the mean of the readings (at 63°) for the second half of May and the first half of June is 641, corresponding in time to the first of June, and the mean of the readings (at 63°) of the second half of June and the first half of July is 673, corresponding in time to the last of June; the correction applied to the bi-hourly readings (at 63°) on June 1st was + 10, and to the readings on June 30th was — 22 divisions. At the middle of the month the correction is zero, and for the intermediate days it is in proportion to their respective distances from the middle. The algebraic sum of the daily corrections divided by the number of days of observation is — 3, which gives the new monthly mean 648, as corrected for irregularity in the progressive change. In the exceptional case of a break, or beginning and termination, the required rate of change for half the month was found by a similar process, using half monthly and quarterly means.

The following table, No. IV., contains the monthly means of the bi-hourly and hourly readings of the bifilar magnetometer referred to a uniform temperature (63° Fahr.), and corrected for irregularity in the progressive change. It is here inserted for the purpose of comparing it with the monthly normals, showing the change produced by the exclusion of the disturbances. The means in the month of June, 1840, are suppressed, and the readings between June 1 and June 5, 1841, were not used.

[1] In connection with this subject, the first part of an interesting paper by Mr. Broun may be consulted, viz.: "On the lunar diurnal variation of the magnetic declination at the magnetic equator."—*Proceedings Royal Society*, vol. X., No. 39, 1860.

TABLE IV.—MONTHLY MEANS OF THE BI-HOURLY AND HOURLY READINGS OF THE BIFILAR MAGNETOMETER, REDUCED TO A UNIFORM TEMPERATURE AND CORRECTED FOR IRREGULARITY IN THE PROGRESSIVE CHANGE.

Philadelphia time (A. M.)						(P. M.)						
	$0^h 22^m$	$2^h 22^m$	$4^h 22^m$	$6^h 22^m$	$8^h 22^m$	$10^h 22^m$	$12^h 22^m$	$14^h 22^m$	$16^h 22^m$	$18^h 22^m$	$20^h 22^m$	$22^h 22^m$
1840.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.
July	90	83	79	76	102	116	97	68	57	90	95	95
August	130	118	118	114	147	158	139	115	112	130	127	134
Sept.	161	150	146	141	172	204	186	160	155	156	160	156
October	153	147	135	138	151	177	175	159	153	155	156	150
Nov.	155	152	144	136	148	166	174	160	162	154	155	159
Dec.	202	191	183	177	183	209	217	205	191	195	201	201
1841.	$0^h 22^m$	$2^h 22^m$	$4^h 22^m$	$6^h 22^m$	$8^h 22^m$	$10^h 22^m$	$12^h 22^m$	$14^h 22^m$	$16^h 22^m$	$18^h 22^m$	$20^h 22^m$	$22^h 22^m$
[1]January	300	291	290	280	276	298	326	310	293	302	298	302
Feb.	279	270	265	256	261	286	303	295	276	2[illegible]3	289	275
March	276	273	267	269	272	298	299	272	279	281	282	280
April	283	275	265	262	284	309	311	279	270	277	286	283
May	307	308	307	299	314	331	319	300	294	303	308	312
[2]June	392	390	389	383	400	406	390	380	386	392	402	400
July	445	441	436	437	448	458	450	430	431	443	454	449
August	492	492	487	483	501	517	502	481	483	498	503	499
Sept.	519	522	519	516	536	562	540	524	523	530	525	526
October	527	519	516	517	531	539	544	534	528	529	530	529
Nov.	525	526	519	512	522	532	536	522	520	522	525	526
Dec.	546	542	538	535	540	552	563	551	548	554	554	552
1842.	$0^h 21\frac{1}{2}^m$	$2^h 21\frac{1}{2}^m$	$4^h 21\frac{1}{2}^m$	$6^h 21\frac{1}{2}^m$	$8^h 21\frac{1}{2}^m$	$10^h 21\frac{1}{2}^m$	$12^h 21\frac{1}{2}^m$	$14^h 21\frac{1}{2}^m$	$16^h 21\frac{1}{2}^m$	$18^h 21\frac{1}{2}^m$	$20^h 21\frac{1}{2}^m$	$22^h 21\frac{1}{2}^m$
January	558	556	555	552	551	573	577	562	557	566	563	563
Feb.	585	579	577	571	573	583	596	585	581	586	592	585
March	569	560	557	557	563	576	573	563	564	570	572	573
April	610	604	603	598	606	623	617	601	597	610	612	612
May	614	610	606	605	621	629	618	604	606	615	617	619
June	649	652	645	638	649	661	651	639	636	649	652	653
July	687	692	685	686	698	713	700	684	677	690	696	700
August	701	694	695	692	711	721	702	688	689	699	703	702
Sept.	723	725	720	713	734	748	736	724	720	731	732	729
October	761	754	751	751	759	778	782	776	770	768	769	766
Nov.	779	773	771	768	777	790	785	781	777	777	780	784
Dec.	780	777	775	773	776	790	797	788	777	778	781	782
1843.	$0^h 21\frac{1}{2}^m$	$2^h 21\frac{1}{2}^m$	$4^h 21\frac{1}{2}^m$	$6^h 21\frac{1}{2}^m$	$8^h 21\frac{1}{2}^m$	$10^h 21\frac{1}{2}^m$	$12^h 21\frac{1}{2}^m$	$14^h 21\frac{1}{2}^m$	$16^h 21\frac{1}{2}^m$	$18^h 21\frac{1}{2}^m$	$20^h 21\frac{1}{2}^m$	$22^h 21\frac{1}{2}^m$
January								818				
Feb.								819				
March								831				
April	863	862	856	856	870	883	878	863	862	866	869	862
May	865	863	861	859	874	876	861	854	855	862	872	869
June	881	880	876	873	883	892	884	870	870	881	884	885
July	927	924	924	923	936	943	935	923	919	924	934	932
August	931	930	930	927	949	956	943	923	924	929	935	934
Sept.	971	970	965	960	980	993	984	969	971	973	973	969

[1] The mean of 17 days is given; to refer it to a complete month subtract 19 divisions.
[2] The mean of 19 days is given; to refer it to a complete month add 8 divisions.

Hourly Series.

1843.	$0^h 21\frac{1}{2}^m$	$1^h 21\frac{1}{2}^m$	$2^h 21\frac{1}{2}^m$	$3^h 21\frac{1}{2}^m$	$4^h 21\frac{1}{2}^m$	$5^h 21\frac{1}{2}^m$	$6^h 21\frac{1}{2}^m$	$7^h 21\frac{1}{2}^m$	$8^h 21\frac{1}{2}^m$	$9^h 21\frac{1}{2}^m$	$10^h 21\frac{1}{2}^m$	$11^h 21\frac{1}{2}^m$
	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.
October	983	978	980	978	976	978	977	980	984	987	991	992
Nov.	987	986	985	983	982	980	980	983	987	991	993	993
Dec.	995	993	992	991	989	987	987	987	991	991	992	997
	$12^h 21\frac{1}{2}^m$	$13^h 21\frac{1}{2}^m$	$14^h 21\frac{1}{2}^m$	$15^h 21\frac{1}{2}^m$	$16^h 21\frac{1}{2}^m$	$17^h 21\frac{1}{2}^m$	$18^h 21\frac{1}{2}^m$	$19^h 21\frac{1}{2}^m$	$20^h 21\frac{1}{2}^m$	$21^h 21\frac{1}{2}^m$	$22^h 21\frac{1}{2}^m$	$23^h 21\frac{1}{2}^m$
October	991	989	985	983	983	983	985	985	985	984	983	984
Nov.	991	989	987	986	984	985	986	986	987	987	988	988
Dec.	999	998	996	993	991	990	992	995	995	995	997	998
1844.	$0^h 21\frac{1}{2}^m$	$1^h 21\frac{1}{2}^m$	$2^h 21\frac{1}{2}^m$	$3^h 21\frac{1}{2}^m$	$4^h 21\frac{1}{2}^m$	$5^h 21\frac{1}{2}^m$	$6^h 21\frac{1}{2}^m$	$7^h 21\frac{1}{2}^m$	$8^h 21\frac{1}{2}^m$	$9^h 21\frac{1}{2}^m$	$10^h 21\frac{1}{2}^m$	$11^h 21\frac{1}{2}^m$
January	1007	1005	1004	1002	1000	1000	999	999	1002	1005	1008	1011
Feb.	1031	1031	1031	1029	1026	1026	1026	1028	1029	1030	1034	1036
March	1051	1049	1048	1047	1046	1045	1046	1047	1052	1059	1061	1063
April	1070	1069	1068	1065	1062	1062	1065	1065	1070	1078	1082	1082
May	1065	1065	1063	1062	1062	1061	1061	1064	1068	1074	1075	1070
June	1078	1077	1076	1077	1077	1075	1073	1077	1080	1082	1084	1081
July	1102	1103	1105	1106	1106	1105	1104	1104	1109	1116	1118	1114
August	1133	1134	1134	1134	1133	1131	1130	1135	1143	1152	1153	1147
Sept.	1102	1102	1102	1103	1099	1101	1100	1107	1117	1123	1127	1123
October	1136	1132	1131	1127	1126	1128	1129	1134	1141	1147	1150	1145
Nov.	1132	1131	1129	1128	1127	1123	1124	1125	1130	1137	1143	1145
Dec.	1205	1203	1200	1198	1196	1194	1190	1193	1194	1198	1209	1217
	$12^h 21\frac{1}{2}^m$	$13^h 21\frac{1}{2}^m$	$14^h 21\frac{1}{2}^m$	$15^h 21\frac{1}{2}^m$	$16^h 21\frac{1}{2}^m$	$17^h 21\frac{1}{2}^m$	$18^h 21\frac{1}{2}^m$	$19^h 21\frac{1}{2}^m$	$20^h 21\frac{1}{2}^m$	$21^h 21\frac{1}{2}^m$	$22^h 21\frac{1}{2}^m$	$23^h 21\frac{1}{2}^m$
January	1009	1006	1003	999	998	1000	1002	1003	1003	1004	1005	1007
Feb.	1035	1032	1028	1028	1032	1031	1032	1033	1034	1033	1034	1033
March	1068	1064	1057	1050	1053	1055	1055	1054	1052	1053	1053	1052
April	1077	1072	1066	1062	1064	1062	1068	1070	1071	1072	1069	1072
May	1064	1057	1053	1053	1051	1054	1059	1063	1064	1064	1063	1063
June	1077	1072	1067	1065	1065	1067	1071	1073	1075	1077	1077	1078
July	1106	1100	1096	1093	1092	1093	1096	1099	1101	1102	1103	1104
August	1138	1129	1121	1119	1121	1127	1134	1135	1136	1135	1136	1135
Sept.	1113	1102	1096	1094	1095	1099	1102	1104	1105	1105	1106	1110
October	1143	1138	1132	1133	1132	1136	1137	1137	1139	1136	1137	1134
Nov.	1142	1141	1135	1133	1134	1134	1134	1139	1137	1134	1131	1135
Dec.	1217	1212	1207	1202	1197	1198	1199	1199	1199	1203	1203	1203
1845.	$0^h 21\frac{1}{2}^m$	$1^h 21\frac{1}{2}^m$	$2^h 21\frac{1}{2}^m$	$3^h 21\frac{1}{2}^m$	$4^h 21\frac{1}{2}^m$	$5^h 21\frac{1}{2}^m$	$6^h 21\frac{1}{2}^m$	$7^h 21\frac{1}{2}^m$	$8^h 21\frac{1}{2}^m$	$9^h 21\frac{1}{2}^m$	$10^h 21\frac{1}{2}^m$	$11^h 21\frac{1}{2}^m$
January	1234	1231	1232	1230	1228	1226	1225	1227	1231	1239	1245	1249
Feb.	1231	1233	1231	1229	1229	1226	1223	1227	1233	1237	1245	1248
March	1236	1236	1234	1235	1234	1234	1230	1233	1241	1249	1255	1261
April	1255	1252	1251	1249	1247	1245	1243	1249	1257	1272	1282	1281
May	1244	1243	1241	1240	1236	1233	1230	1237	1249	1259	1260	1258
June	1281	1281	1281	1280	1275	1274	1269	1273	1280	1291	1297	1296
	$12^h 21\frac{1}{2}^m$	$13^h 21\frac{1}{2}^m$	$14^h 21\frac{1}{2}^m$	$15^h 21\frac{1}{2}^m$	$16^h 21\frac{1}{2}^m$	$17^h 21\frac{1}{2}^m$	$18^h 21\frac{1}{2}^m$	$19^h 21\frac{1}{2}^m$	$20^h 21\frac{1}{2}^m$	$21^h 21\frac{1}{2}^m$	$22^h 21\frac{1}{2}^m$	$23^h 21\frac{1}{2}^m$
January	1246	1242	1239	1236	1234	1237	1238	1234	1233	1232	1232	1230
Feb.	1250	1246	1239	1235	1234	1232	1233	1235	1235	1231	1231	1232
March	1260	1253	1245	1239	1240	1242	1244	1241	1240	1237	1240	1239
April	1273	1269	1257	1255	1251	1253	1256	1259	1259	1256	1253	1254
May	1251	1243	1237	1237	1237	1241	1246	1246	1246	1248	1246	1240
June	1289	1285	1276	1274	1273	1276	1281	1285	1284	1283	1282	1282

TABLE V.—MONTHLY MEANS OF THE PRECEDING BIFILAR READINGS REFERRED TO A UNIFORM TEMPERATURE AND CORRECTED FOR IRREGULARITY IN THE PROGRESSIVE CHANGE.

The column 1840–41 contains a double set of figures, the first are the monthly means directly obtained from Table IV, the second contains the means when the series is made continuous for the two breaks already noticed. The mean difference between May and June (from four years) is 25 scale divisions, and between December and January it is 22 scale divisions; these corrections were applied in the second set of figures.

	1840–1841		1841–1842	1842–1843	1843–1844	1844–1845	Monthly Means of Series.
	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	
July	87	215	444	692	929	1103	677
August	128	256	495	700	934	1134	704
September	162	290	529	728	973	1106	725
October	154	282	529	765	984	1136	739
November	155	283	524	779	986	1134	741
December	196	324	548	781	993	1201	769
January	297—19	346	561	813	1003	1234	791
February	278	346	583	814	1031	1234	802
March	278	346	566	831	1053	1242	808
April	282	350	608	866	1069	1257	830
May	308	376	614	864	1063	1244	832
June	393+8	401	648	880	1075	1281	857
Annual Means		318	554	793	1008	1192	773

The differences in the successive annual means indicate that the progressive change may be assumed to have been uniform from year to year, and applying the usual method we find an annual progressive change of 220 scale divisions.

Introduction of the Horizontal Intensity in absolute measure and separation of the effect of the loss of Magnetism of the Bifilar bar from the effect due to the secular change of the Horizontal Intensity.—Although some experiments were made to determine the gradual loss of magnetism of the bar, as, for instance, in January, 1841, when the amount was found to be 0.9601 of the force in May, 1840, and again in June, 1841, when the amount was 0.9686 of its amount in January, 1841, yet the experiments do not extend over the whole period of observation, and consequently we are obliged to deduce the effect of the secular change of the horizontal intensity from other independent means, and, after converting it into scale divisions, we can assign the proper proportion of what is due to secular change and to loss of magnetism, in the whole progressive change of 220 scale divisions in a year.

In connection with the operations of the U. S. Coast Survey, Assistant Schott has investigated[1] the secular change of the horizontal intensity at a number of stations on the Atlantic and Pacific coasts. At several stations the results were subsequently improved by a discussion of my observations for intensity, made in part in connection with a magnetic survey of Pennsylvania, and also extending into adjoining States, and, in one of the journeys, into Canada. From the complete material the values in the following table of observed horizontal and total intensities have been collected. The horizontal intensity X and the total intensity ϕ are expressed in absolute measure (grains and feet).

[1] Report to Superintendent, dated January 19, 1861.

No.	Year.	Observer.	Reference from which the values were derived or taken.	X.	θ.
1	1835.0	Bache and Courtenay.	Trans. Amer. Phil. Soc., Vol. V, 1837.	4.195	13.58
2	1836.7	Bache.		4.159	13.46
3	1839.5	Loomis.	Trans. Amer. Phil. Soc., Vol. VIII.	4.149	13.41
4	1840.9	Bache.		......	13.41
5	1841.5	Locke.	Phil. Trans. Roy. Soc., 1846.	4.172	13.51
6	1841.8	Bache.		......	13.46
7	1842.5	Locke.	Phil. Trans. Roy. Soc., 1846.	4.174	13.52
8	1842.8	Lefroy.	" " " " "	4.176	13.50
9	1843.6	Bache.		4.172	13.46
10	1844.5	Locke.	Phil. Trans. Roy. Soc., 1846.	4.162	13.47
11	1846.4	Locke.	U. S. Coast Survey Records.	4.143	13.42
12	1855.7	Schott.	" " " "	4.226	13.89
[1]13	1862.6	Schott.	" " " "	4.088	13.30

The first three observations were not made at the Girard College grounds; and it appears from Prof. Loomis' observation when compared with Dr. Locke's, that a correction of 0.023 in the value of X should be added to these; to the twelfth observation I have assigned only half weight; it was probably made during a disturbance. From the general discussion an annual diminution in the horizontal force of 0.0011 parts was deduced for a number of stations on the Atlantic coast. At Toronto (vol. III of General Sabine's Discussion) the annual decrease was found 0.0010 in parts of the horizontal force. Being somewhat guided by these results, after several trials, the following combination of the results in the table has been adopted, as perhaps best representing the values for the time during which the Girard College observations were made, these latter being merely of a differential character:—

Combination.	Mean epoch.	Mean horiz'l int. X.
1, 2, 3	1837.1	4.191
5, 7, 8, 9	1842.6	4.174
10, 11, 12, 13	1852.3	4.145

The annual diminution of X is 0.0030, or, when expressed in parts of the horizontal force, = 0.0007; its equivalent in scale divisions is 19.2. The total annual change was found to be 220 scale divisions; hence, 200.8 scale divisions of annual change is due to loss of magnetism of the bar.

The mean epoch is 1844.0, and the corresponding mean X = 4.170; the mean epoch of the observation taken at the Girard College, is January, 1843, for which, therefore, the mean value of X = 4.173. This value has been adopted whenever it was desirable to introduce the horizontal force in absolute measure.

Separation of the Larger Disturbances.—The observations having been referred to a uniform temperature, and corrected for progressive change, Peirce's criterion was applied separately to each month. For this purpose, a systematic application was made extending over the whole series of observations, commencing with the hour 0 and the month of July, next with the hour 2 and August, followed by hour 4 and September, and so on in regular progression. This process eliminates from the result the diurnal variation and the annual variation of the disturbances themselves. The value for 0^h in July, 1840, was omitted as affected by two very large disturbances. The following table shows the limiting value of difference from the

[1] Added while this paper is passing through the press.

mean (the monthly mean for the respective hour), also the number of observations in each year subjected to the process:—

LIMITS OF REJECTION BY PEIRCE'S CRITERION.

		Div's.		
1840–41	cx =	53		n = 241
1841–42	"	44		312
1842–43	"	37		309
1843–44	"	28		313
1844–45	"	33		313
Mean value		39	Sum	1488

The limiting value derived from nearly 1,500 observations is 39 scale divisions, and the separate annual values show plainly the effect of the eleven (ten ?) year period, the year 1843–4 being a minimum year. Certain limits in the adoption of a separating value are allowable, and upon trial as to the actual number of disturbances separated, the value 33 scale divisions was finally adopted. Any observation differing 33 divisions or more from its respective monthly mean, was therefore marked and excluded from the mean. 33 divisions equal 0.0012 parts of the horizontal force, and in the value of the absolute scale it amounts to 0.005. At Toronto the limiting value was 14 divisions, = 0.0012 parts of the horizontal force, equal to 0.004 in the absolute scale. (Vol. III of the Toronto Obser's.)

TABLE VI.—SHOWS THE NUMBER OF OBSERVATIONS AND THE NUMBER OF THE LARGER DISTURBANCES SEPARATED BY THE VALUE 33, AS THE LIMIT, FOR EACH MONTH, YEAR, AND THE WHOLE PERIOD.

MONTH.	1840—1841.		1841—1842.		1842—1843.		1843—1844.		1844—1845.	
	Obser's.	Dist's.	Obser's.	Dist's.	Obser's.	Dist's.	Obser's.	Dist's.	Obser's.	Dist's.
July	323	165	323	26	308	24	312	15	648	0
August . . .	308	73	312	17	321	3	324	11	648	4
September . .	312	54	310	41	308	44	312	16	600	27
October . . .	323	68	308	28	310	53	624	3	648	32
November . .	293	49	312	32	312	15	624	1	624	42
December . .	321	120	323	26	323	5	624	0	624	46
January . . .	201[1]	23	311	14	26[3]	0	646	3	648	27
February . .	288	50	287	37	24[4]	1	600	5	576	18
March . . .	320	62	323	26	27[5]	1	624	29	624	3
April	309	48	309	38	300	14	624	16	624	33
May	310	46	300	29	324	25	648	3	648	19
June	225[2]	13	311	16	312	4	600	0	600	56
Sums	3533	770	3729	330	2895	189	6562	102	7512	307
Ratio	1 dist. in 4.6 ob's.		1 dist. in 11.3 ob's.		1 dist. in 15.3 ob's.		1 dist. in 64.3 ob's.		1 dist. in 24.4 ob's.	

Total number of observations	24,231
Total number of disturbances	1,698

The limiting value separated, therefore, one in every 14.3 observations. At Toronto one in every 12.5 was marked as a disturbance.

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[1] In 17 days.
[2] In 19 days.
[3] One observation a day.
[4] One observation a day.
[5] One observation a day.

The larger disturbances having been excluded, new monthly means were taken, and the process was repeated several times, when required, until all readings differing 33 scale divisions or more had been excluded; the final means constitute the normals as given in the following table:—

TABLE VII.—MONTHLY NORMAL OF THE BI-HOURLY AND HOURLY READINGS OF THE BIFILAR MAGNETOMETER REDUCED TO A NORMAL TEMPERATURE AND CORRECTED FOR IRREGULARITY IN THE PROGRESSIVE CHANGE.

Philadelphia time (A. M.)						(P. M.)						
	$0^h 22^m$	$2^h 22^m$	$4^h 22^m$	$6^h 22^m$	$8^h 22^m$	$10^h 22^m$	$12^h 22^m$	$14^h 22^m$	$16^h 22^m$	$18^h 22^m$	$20^h 22^m$	$22^h 22^m$
1840.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.
July	113	97	89	50	112	116	94	59	52	92	93	108
August	108	112	117	106	138	153	134	103	111	114	121	126
September	155	147	139	141	180	202	177	155	153	158	157	150
October	142	137	122	138	153	166	159	158	148	146	148	151
November	155	150	144	133	144	154	175	157	151	148	144	160
December	196	188	176	166	178	208	217	193	182	185	200	194
1841.	$0^h 22^m$	$2^h 22^m$	$4^h 22^m$	$6^h 22^m$	$8^h 22^m$	$10^h 22^m$	$12^h 22^m$	$14^h 22^m$	$16^h 22^m$	$18^h 22^m$	$20^h 22^m$	$22^h 22^m$
January[1]	298	300	294	284	281	302	326	311	289	296	301	302
February	269	261	264	257	265	288	297	289	275	274	275	272
March	268	272	267	257	271	294	286	267	266	282	264	272
April	273	271	262	262	283	317	315	279	268	271	283	280
May	311	305	306	297	306	323	313	301	294	306	309	313
June[2]	392	390	392	386	400	401	395	382	385	392	402	392
July	442	442	435	435	447	458	449	428	430	444	448	439
August	490	494	487	482	501	518	502	483	483	497	500	495
September	510	514	515	508	531	542	537	516	519	520	515	515
October	521	517	518	514	526	537	547	530	525	527	529	528
November	519	517	515	509	518	529	531	514	518	513	516	518
December	546	541	538	535	537	548	562	549	545	547	550	552
1842.	$0^h 21\frac{1}{2}^m$	$2^h 22\frac{1}{2}^m$	$4^h 21\frac{1}{2}^m$	$6^h 21\frac{1}{2}^m$	$8^h 21\frac{1}{2}^m$	$10^h 21\frac{1}{2}^m$	$12^h 21\frac{1}{2}^m$	$14^h 21\frac{1}{2}^m$	$16^h 21\frac{1}{2}^m$	$18^h 21\frac{1}{2}^m$	$20^h 21\frac{1}{2}^m$	$22^h 21\frac{1}{2}^m$
January	561	556	555	558	553	573	577	559	554	564	563	564
February	580	573	572	567	568	582	589	578	578	580	590	578
March	565	559	557	554	563	574	575	561	565	571	567	566
April	595	598	597	594	604	620	618	603	598	607	608	611
May	614	610	611	605	621	630	622	606	607	615	618	619
June	649	652	646	638	649	659	650	639	638	649	648	650
July	692	686	682	678	695	708	700	680	677	690	694	700
August	699	694	695	692	711	721	700	688	689	701	703	702
September	726	733	722	717	739	750	737	730	727	737	737	734
October	764	759	757	757	764	781	783	776	776	768	769	764
November	774	770	771	768	777	789	787	781	778	775	776	776
December	780	777	775	773	776	790	795	786	773	776	781	782
1843.	$0^h 21\frac{1}{2}^m$	$2^h 21\frac{1}{2}^m$	$4^h 21\frac{1}{2}^m$	$6^h 21\frac{1}{2}^m$	$8^h 21\frac{1}{2}^m$	$10^h 21\frac{1}{2}^m$	$12^h 21\frac{1}{2}^m$	$14^h 21\frac{1}{2}^m$	$16^h 21\frac{1}{2}^m$	$18^h 21\frac{1}{2}^m$	$20^h 21\frac{1}{2}^m$	$22^h 21\frac{1}{2}^m$
January								818				
February								817				
March								829				
April	861	861	854	854	868	883	878	863	860	861	865	859
May	864	862	858	857	875	872	864	855	856	862	867	863
June	881	879	876	873	883	894	884	870	870	881	881	885
July	927	924	924	923	935	941	934	923	916	221	928	931
August	931	930	931	927	947	954	938	921	924	929	932	933
September	974	967	965	960	980	992	985	972	972	975	974	973

[1] The mean of 17 days.

[2] The mean of 19 days.

Hourly Series.

	$0^h\,21\frac{1}{2}^m$	$1^h\,21\frac{1}{2}^m$	$2^h\,21\frac{1}{2}^m$	$3^h\,21\frac{1}{2}^m$	$4^h\,21\frac{1}{2}^m$	$5^h\,21\frac{1}{2}^m$	$6^h\,21\frac{1}{2}^m$	$7^h\,21\frac{1}{2}^m$	$8^h\,21\frac{1}{2}^m$	$9^h\,21\frac{1}{2}^m$	$10^h\,21\frac{1}{2}^m$	$11^h\,21\frac{1}{2}^m$
1843.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.
October	983	978	983	978	976	978	977	980	983	987	991	992
November	987	986	985	983	982	980	980	983	987	991	992	993
December	995	993	992	991	989	987	987	987	991	991	992	997
	$12^h\,21\frac{1}{2}^m$	$13^h\,21\frac{1}{2}^m$	$14^h\,21\frac{1}{2}^m$	$15^h\,21\frac{1}{2}^m$	$16^h\,21\frac{1}{2}^m$	$17^h\,21\frac{1}{2}^m$	$18^h\,21\frac{1}{2}^m$	$19^h\,21\frac{1}{2}^m$	$20^h\,21\frac{1}{2}^m$	$21^h\,21\frac{1}{2}^m$	$22^h\,21\frac{1}{2}^m$	$23^h\,21\frac{1}{2}^m$
October	991	989	985	983	983	983	985	985	985	986	983	984
November	991	989	987	986	984	985	986	986	987	987	988	988
December	999	998	996	993	991	990	992	995	995	995	997	998
1844.	$0^h\,21\frac{1}{2}^m$	$1^h\,21\frac{1}{2}^m$	$2^h\,21\frac{1}{2}^m$	$3^h\,21\frac{1}{2}^m$	$4^h\,21\frac{1}{2}^m$	$5^h\,21\frac{1}{2}^m$	$6^h\,21\frac{1}{2}^m$	$7^h\,21\frac{1}{2}^m$	$8^h\,21\frac{1}{2}^m$	$9^h\,21\frac{1}{2}^m$	$10^h\,21\frac{1}{2}^m$	$11^h\,21\frac{1}{2}^m$
January	1006	1005	1004	1002	1000	1000	999	999	1002	1005	1008	1011
February	1031	1031	1031	1029	1026	1026	1026	1028	1029	1030	1034	1034
March	1048	1047	1046	1046	1046	1043	1043	1047	1050	1054	1057	1063
April	1070	1069	1068	1065	1063	1062	1064	1061	1067	1074	1078	1078
May	1065	1065	1063	1062	1062	1061	1061	1064	1068	1076	1077	1070
June	1078	1077	1076	1077	1077	1075	1073	1077	1080	1082	1084	1081
July	1102	1103	1105	1106	1106	1105	1104	1104	1109	1116	1118	1114
August	1133	1134	1134	1133	1133	1131	1130	1135	1143	1152	1153	1147
September	1106	1104	1107	1105	1101	1101	1100	1107	1117	1125	1128	1125
October	1133	1132	1131	1127	1124	1125	1129	1134	1141	1149	1152	1145
November	1131	1130	1127	1126	1125	1123	1122	1125	1130	1135	1138	1142
December	1213	1202	1200	1198	1196	1194	1190	1193	1194	1197	1209	1217
	$12^h\,21\frac{1}{2}^m$	$13^h\,21\frac{1}{2}^m$	$14^h\,21\frac{1}{2}^m$	$15^h\,21\frac{1}{2}^m$	$16^h\,21\frac{1}{2}^m$	$17^h\,21\frac{1}{2}^m$	$18^h\,21\frac{1}{2}^m$	$19^h\,21\frac{1}{2}^m$	$20^h\,21\frac{1}{2}^m$	$21^h\,21\frac{1}{2}^m$	$22^h\,21\frac{1}{2}^m$	$23^h\,21\frac{1}{2}^m$
January	1009	1006	1003	999	998	1000	1002	1003	1003	1004	1004	1005
February	1035	1032	1028	1028	1030	1031	1032	1033	1034	1033	1032	1030
March	1063	1061	1057	1050	1051	1050	1050	1052	1050	1048	1050	1048
April	1077	1071	1066	1062	1064	1062	1068	1068	1071	1071	1068	1069
May	1064	1057	1053	1053	1051	1054	1059	1063	1064	1064	1065	1063
June	1077	1072	1067	1065	1065	1067	1071	1073	1075	1077	1077	1078
July	1106	1100	1096	1093	1092	1093	1096	1099	1101	1102	1103	1104
August	1138	1129	1121	1119	1121	1127	1134	1135	1135	1134	1135	1135
September	1115	1104	1097	1095	1095	1100	1102	1104	1104	1108	1107	1108
October	1145	1137	1134	1130	1132	1134	1135	1137	1138	1134	1137	1135
November	1136	1133	1129	1127	1124	1131	1128	1129	1130	1130	1131	1131
December	1220	1212	1209	1202	1201	1201	1203	1198	1200	1204	1206	1206
1845.	$0^h\,21\frac{1}{2}^m$	$1^h\,21\frac{1}{2}^m$	$2^h\,21\frac{1}{2}^m$	$3^h\,21\frac{1}{2}^m$	$4^h\,21\frac{1}{2}^m$	$5^h\,21\frac{1}{2}^m$	$6^h\,21\frac{1}{2}^m$	$7^h\,21\frac{1}{2}^m$	$8^h\,21\frac{1}{2}^m$	$9^h\,21\frac{1}{2}^m$	$10^h\,21\frac{1}{2}^m$	$11^h\,21\frac{1}{2}^m$
January	1233	1228	1231	1230	1228	1226	1225	1226	1231	1241	1248	1252
February	1230	1230	1231	1229	1229	1226	1223	1227	1231	1236	1243	1244
March	1236	1236	1234	1235	1234	1234	1231	1233	1241	1249	1255	1261
April	1252	1250	1249	1247	1245	1243	1241	1244	1253	1268	1278	1281
May	1244	1243	1241	1239	1236	1233	1229	1236	1251	1261	1262	1258
June	1280	1281	1281	1281	1275	1271	1266	1273	1282	1293	1295	1292
	$12^h\,21\frac{1}{2}^m$	$13^h\,21\frac{1}{2}^m$	$14^h\,21\frac{1}{2}^m$	$15^h\,21\frac{1}{2}^m$	$16^h\,21\frac{1}{2}^m$	$17^h\,21\frac{1}{2}^m$	$18^h\,21\frac{1}{2}^m$	$19^h\,21\frac{1}{2}^m$	$20^h\,21\frac{1}{2}^m$	$21^h\,21\frac{1}{2}^m$	$22^h\,21\frac{1}{2}^m$	$23^h\,21\frac{1}{2}^m$
January	1249	1242	1239	1233	1229	1230	1233	1231	1230	1230	1229	1229
February	1250	1242	1238	1231	1233	1229	1231	1233	1235	1231	1231	1232
March	1260	1253	1245	1239	1240	1242	1244	1240	1239	1237	1240	1239
April	1268	1267	1255	1252	1248	1253	1256	1254	1254	1253	1250	1254
May	1253	1244	1238	1236	1237	1239	1245	1246	1246	1248	1247	1242
June	1286	1280	1272	1269	1269	1273	1278	1281	1280	1277	1279	1280

Increase of scale readings corresponds to decrease of force. Value of one division of the scale = 0.0000365 parts of the horizontal force, or in the absolute scale equal to 0.0001523.

Investigation of the Eleven Year (also called Ten Year) Period, as shown in the Changes of the Amplitude of the Solar Diurnal Variation of the Horizontal Force.— The variation in the amplitude of the diurnal motion of the horizontal force is subject to the same inequality of about eleven years as the declination, and the means of investigation will be analogous to those used in Part I of this discussion. For greater convenience, the preceding monthly normals were united into annual means and the results put into an analytical form, using Bessel's function applicable to periodical phenomena, and determining the numerical quantity by the application of the method of least squares.

In the following table of the regular solar diurnal variation of the horizontal force the means for 1842–43 depend only on nine months of observation; the correction given to refer them to twelve months of observation depends on the mean difference between the results of the same nine months and twelve months of the preceding and following year; this correction is nearly constant and the same within one scale division for the adjacent years. In the second corrected column for 1842–43 the effect of the annual inequality is thus eliminated. In the year 1843–44 the results from nine months of observation at the odd hours were reduced to twelve months by means of corresponding differences in the series of even hours; thus (omitting the minutes) at hour 2, mean of 12 months = 1006, mean of 9 months = 1028; at hour 3 for the same 9 months, mean = 1026, or 2 divisions less; at hour 3 for 12 months the mean is therefore 1004, and the same result is found by comparing with the following hour 4; the mean is given in case of a difference in the two results.

TABLE VIII.—REGULAR SOLAR DIURNAL VARIATION OF THE HORIZONTAL FORCE FOR EACH YEAR OF OBSERVATION EXPRESSED IN SCALE DIVISIONS.

Increased numbers indicate decrease of force. The minutes at the head of each column are to be added to the hours given in the first vertical column. Each year commences with the month of July.

Hour of the day.	1840–41. 22^m	1841–42. $21\frac{3}{4}^m$	1842–43 (9 m'ths). $21\frac{1}{2}^m$	Correction.	1842–43. $21\frac{1}{2}^m$	1843–44. $21\frac{1}{2}^m$	1844–45. $21\frac{1}{2}^m$
	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.	Div's.
0 (A. M.)	223	549	782	+6	788	1008	1191
1						1007	1189
2	219	548	780	+6	786	1006	1189
3						1004	1188
4	214	545	777	+6	783	1003	1186
5						1002	1184
6	206	542	774	+6	780	1002	1182
7						1005	1186
8	226	552	788	+5	793	1010	1194
9						1013	1202
10	244	564	799	+5	804	1017	1206
11						1016	1207
12 (P. M.)	241	563	792	+6	798	1014	1202
13						1010	1195
14	221	547	781	+7	788	1005	1189
15						1002	1186
16	215	547	778	+7	785	1002	1185
17						1004	1188
18	222	553	783	+7	790	1006	1190
19						1008	1191
20	225	554	786	+7	793	1008	1191
21						1009	1191
22	227	553	785	+6	791	1008	1191
23						1008	1191
Mean.	223.5	551.5			789.9	1007.4	1191.4

(Philadelphia local time, counted from midnight to midnight, 24 hours.)

The preceding mean diurnal variations were put in the following analytical form, in which the angle θ counts from midnight at the rate of 15° an hour.

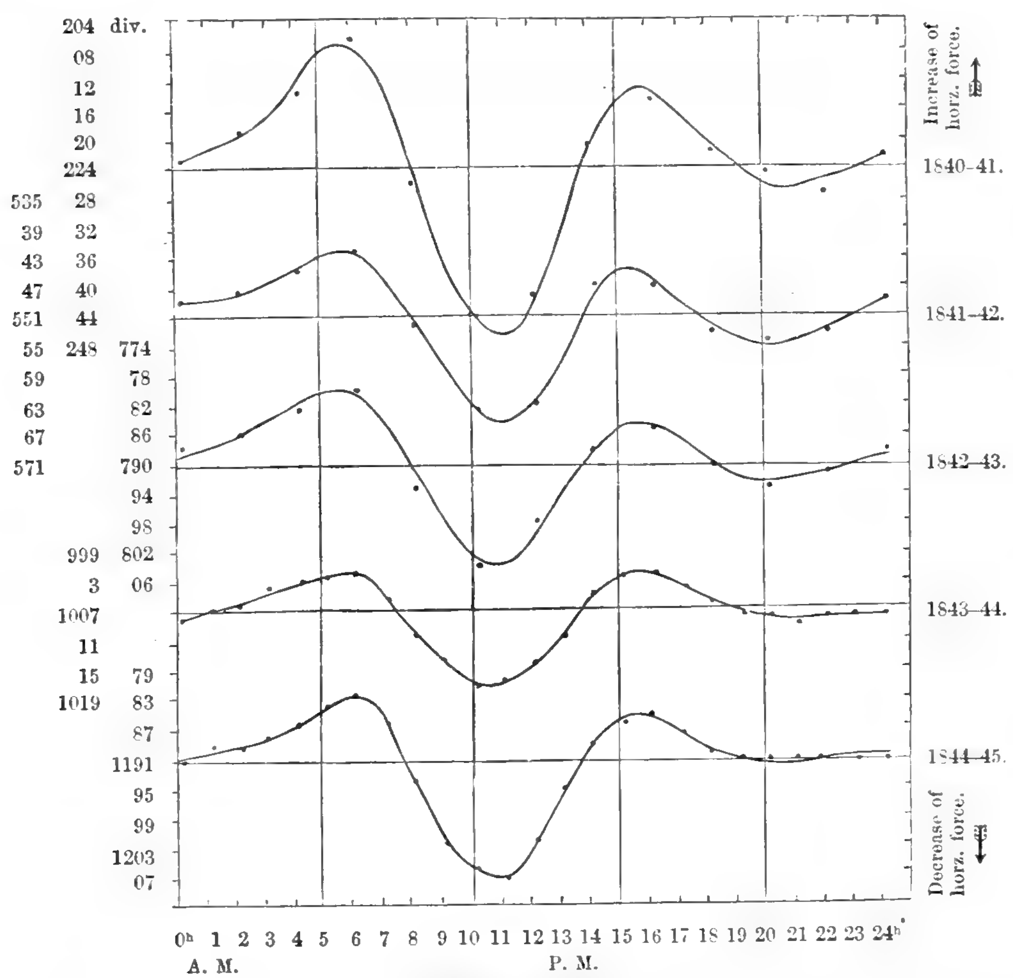
Year 1840–41 $H = 223^d.5 + 5^d.98 \sin(\theta + 252° 14') + 11^d.68 \sin(2\theta + 121° 16') + 5^d.89 \sin(3\theta + 314° 42')$
" 1841–42 $H = 551.5 + 4.03 \sin(\theta + 244\ 07) + 6.58 \sin(2\theta + 131\ 32) + 4.48 \sin(3\theta + 312\ 19)$
" 1842–43 $H = 789.9 + 4.14 \sin(\theta + 250\ 06) + 7.07 \sin(2\theta + 132\ 24) + 3.74 \sin(3\theta + 323\ 06)$
" 1843–44 $H = 1007.4 + 2.14 \sin(\theta + 273\ 55) + 5.09 \sin(2\theta + 128\ 58) + 2.35 \sin(3\theta + 317\ 58)$
" 1844–45 $H = 1191.4 + 4.40 \sin(\theta + 271\ 13) + 6.86 \sin(2\theta + 123\ 25) + 4.11 \sin(3\theta + 321\ 26)$

To show the degree of correspondence in the formulæ when deduced from the observations of the even and odd hours separately, the results for the last year have been added, viz:—

Even hours $H = 1191^d.3 + 4^d.20 \sin(\theta + 271° 28') + 6^d.98 \sin(2\theta + 122° 36') + 4^d.11 \sin(3\theta + 322° 35')$
Odd hours $H = 1191.5 + 4.60 \sin(\theta + 270\ 59) + 6.73 \sin(2\theta + 124\ 13) + 4.12 \sin(3\theta + 320\ 17)$

The close agreement between the observed and computed values is shown generally in the annexed diagram.

(A).—Inequality in the Diurnal Variation of the Horizontal Intensity.



The following table exhibits the differences for the year 1842–43, as an example of the numerical correspondence.

A. M.	Computed.	Observed.	C—O.	P. M.	Computed.	Observed.	C—O.
$0^h\ 21\frac{1}{2}^m$	788.7	788	+0.7	$12^m\ 21\frac{1}{2}^h$	799.5	798	+1.5
2 "	786.6	786	+0.6	14 "	787.6	788	—0.4
4 "	781.3	783	—1.7	16 "	784.5	785	—0.5
6 "	781.2	780	+1.2	18 "	790.2	790	+0.2
8 "	792.5	793	—0.5	20 "	792.9	793	—0.1
10 "	803.3	804	—0.7	22 "	720.5	791	—0 5

The differences, using three terms in the equations, are within the uncertainty of the observed values. The probable error of a single representation is ± 0.6 scale divisions, or ± 0.00009 in the absolute scale.

The curves show a double progression in the daily motion, with a principal maximum of horizontal force in the morning, a principal minimum before noon, and a secondary maximum in the afternoon; the precise epochs (to the nearest five minutes) and extreme values were computed by means of the preceding formulæ.

Year. From July to July.	Principal A. M. Maximum of hor. force.		Principal A. M. minimum of hor. force.		Diurnal range in			Secondary P. M. maximum of hor. force.		Less than A. M max. by div's.
	Epoch.	Amount. Div's.	Epoch.	Amount. Div's.	Scale div's.	Parts of horizontal force.	Value in absol. scale.	Epochs.	Amount. Div's.	
1840–41	$5^h\ 45^m$	207.3	$11^h\ 0^m$	246.1	38.8	0.00142	0.0059	$4^h\ 05^m$	213.5	6.2
1841–42	5 50	541.7	11 5	565.5	23.8	0.00087	0.0036	3 50	545.1	3.4
1842–43	5 30	779.8	10 55	803.9	24.1	0.00088	0.0037	3 50	784.0	4.2
1843–44	5 40	1001.7	10 50	1016.9	15.2	0.00055	0.0023	4 0	1002.0	0.3
1844–45	5 40	1182.4	10 50	1206.6	24.2	0.00088	0.0037	4 0	1184.8	2.4
Mean	5 41		10 56				0.0038	3 57		

The secondary maximum is reached about $8^h\ 30^m$ P. M. with a comparatively small range.

The mean value of the force is attained about $7^h\ 55^m$ A. M., and again about $1^h\ 55^m$ P. M., with considerable regularity; it is again reached at $6\frac{3}{4}^h$ and $11\frac{1}{2}^h$ P. M., though with less regularity.

At Toronto (see Vol. II. of the Toronto Observations) the diurnal variation of the horizontal force has a principal maximum at a little after 4 P. M., and a principal minimum at 10 or 11 A. M.; the secondary maximum occurs about 6 A. M. There is, therefore, this specific difference in the diurnal motion at these two stations: in that at Philadelphia the morning maximum is the higher of the two, while at Toronto it is the afternoon maximum. The difference between the two maxima, as shown above, is almost nothing in the minimum year 1843–44, but increases before (and after) this epoch in proportion to the interval. At Toronto the daily range seems to be slightly greater. The secondary minimum at Toronto occurs about 2 or 3 A. M., or about six hours later than at Philadelphia; this is a second though less significant point of difference.

The minimum daily range occurs in 1843–44; its value is then less than one-half what it was in 1840–41.

The following equation expresses the mean diurnal range in scale divisions:—

$$R = +\ 19.68 - 3.78\ (t - 1843) + 2.77\ (t - 1843)^2.$$

It represents the observed values as follows:—

	Observed range.	Computed range.
January, 1841	38.8	38.3
" 1842	23.8	26.2
" 1843	24.1	19.7
" 1844	15.2	18.7
" 1845	24.2	23.2

The minimum range as given by the formula is in September, 1843. In Part I. of the discussion we found the minimum range of the declination in May, 1843, and the minimum from the disturbances of the declination in August, 1843.

Before proceeding to the discussion of the disturbances in the horizontal force, the formulæ given for the diurnal variation require to be put in a different form for future use and for convenience of comparison with other places.

The scale divisions were multiplied by the value of one division of the scale (0.0000365), and again by the value of X found for the year; the numerical constant was replaced by X and the angular quantities were changed by 180° so as to make increasing numbers correspond to increase of force; we then obtain in absolute measure the following expressions for the regular solar-diurnal variation of the horizontal force at the Girard College:—

Year 1840–41 $H = 4.178 + 0.00091 \sin(\theta + 72°14') + 0.00178 \sin(2\theta + 301°16') + 0.00090 \sin(3\theta + 134°42')$

" 1841–42 $H = 4.175 + 0.00061 \sin(\theta + 64\ 07) + 0.00100 \sin(2\theta + 311\ 32) + 0.00069 \sin(3\theta + 132\ 19)$

" 1842–43 $H = 4.173 + 0.00063 \sin(\theta + 70\ 06) + 0.00108 \sin(2\theta + 312\ 24) + 0.00057 \sin(3\theta + 143\ 06)$

" 1843–44 $H = 4.170 + 0.00033 \sin(\theta + 93\ 55) + 0.00078 \sin(2\theta + 308\ 58) + 0.00036 \sin(3\theta + 137\ 58)$

" 1844–45 $H = 4.168 + 0.00067 \sin(\theta + 91\ 13) + 0.00104 \sin(2\theta + 303\ 25) + 0.00063 \sin(3\theta + 141\ 26)$

The angle θ counts from midnight; the middle epoch to which each equation refers is January.

Investigation of the Eleven (Ten?) Year Inequality in the Disturbances of the Horizontal Magnetic Force.—In Table VI. the number of disturbances in each month has been given as found from the observations; these numbers are, however, not directly comparable with one another, first, on account of some omissions in the record, and secondly, on account of the change from a bi-hourly to an hourly series. For any incomplete month the number of disturbances for the whole month is obtained by simple proportion from the number during the part of the month recorded; for January, 1841, the total number becomes 35, for June, 1841 the total number is 18. For January, February, and March, 1843, the mean total number of the disturbances, as found in the same months in the preceding and following year, was substituted; this mean gave 8, 20, and 20, respectively. The number of disturbances after October, 1843, were halved to make them comparable with the bi-hourly series. There were two anomalous months, July and December, 1840, in which the disturbances amount to 165 and 120, with an annual mean of 64, whereas in the same months in the following year they only amount to 26 and 26 respectively, with an annual mean of 27; the mean annual difference 37 was applied to the numbers found in 1841, which give 63 and 63 as a substitute for the anomalous values in July and December, 1840. This anomaly does not exist in the phenomenon itself, but is unquestionably due to the irregularity in the progressive change.

Table IX. contains the number of disturbances as distributed over the several years and months, all referred to a uniform series of bi-hourly observations. To this table the monthly means and their ratio, when compared with the annual mean, have been added; also, for comparison, the corresponding ratios found in Part I. of the discussion of the disturbances of the declination.

MONTH.	1840–41.	1841–42.	1842–43.	1843–44.	1844–45.	Mean.	Hor. force. Ratio.	Declination. Ratio.
July	(63)	26	24	15	0	26	1.09	0.86
August	73	17	3	11	2	21	0.89	1.59
September	54	41	44	16	13	34	1.43*	1.36
October	68	28	53	2	16	33	1.39	2.12*
November	49	32	15	0	21	24	1.00	1.08
December	(63)	26	5	0	23	23	0.97	1.00
January	35	14	8	1	13	14	0.59	0.77
February	50	37	20	3	9	24	1.00	0.52
March	61	25	20	14	2	25	1.06	0.68
April	48	38	14	8	16	25	1.06	0.91
May	46	30	25	2	10	23	0.97	0.58
June	18	16	4	0	28	13	0.55*	0.53*
Sums	628	330	235	72	153	285	12.00	12.00
Mean	52	28	20	6	13	24		

In the columns of ratios the principal maxima and minima are indicated by an asterisk.

The annual means exhibit plainly the eleven year inequality; they have been represented by the formula:—

$$N = + 14.4 - 10.2 (t - 1843) + 4.8 (t - 1843)^2.$$

	Observed N.	Computed N.
January, 1841	52	54
" 1842	28	29
" 1843	20	14
" 1844	6	9
" 1845	13	13

According to the formula, the minimum occurs in January, 1844.

We have next to consider the eleven year inequality in the magnitude of the disturbances of the horizontal force. Table X. contains the aggregate amount of the disturbances expressed in scale divisions, and also their mean amount obtained by application of the number of disturbances already given in Table VI.

For reasons already explained, the amount of disturbances in July, 1840, equal to 10761 scale divisions, has been diminished in the ratio of 165 : 63. The ratio of each monthly mean to the mean amount of the year is also given, together with a column of corresponding ratios derived from the disturbances of the declination, as made out in Part I. of the discussion.

TABLE X.—AGGREGATE AND MEAN AMOUNT OF THE DISTURBANCES OF THE HORIZONTAL FORCE. EXPRESSED IN SCALE DIVISIONS.

MONTH.	1840-41.	1841-42.	1842-43.	1843-44.	1844-45.	Mean Amount.	Hor. force. Ratio.	Declination. Ratio.
July	(4089)	1157	1295	669	0	56	1.10	0.87
August	4084	755	131	471	142	52	1.03	1.61
September	3092	3075	2099	660	1228	56	1.11*	1.56
October	3720	1284	2399	169	1412	49	0.97	2.06*
November	2390	1991	915	34	2173	54	1.06	1.06
December	6515	1225	239	0	2283	52	1.03	1.00
January	1186	601	0	111	1402	49	0.97	0.72
February	2664	1822	44	200	806	50	0.99	0.54
March	3112	1176	39	1412	127	49	0.97	0.66
April	2138	2075	676	861	1604	49	0.97	0.94
May	2456	1211	1187	131	789	47	0.93	0.56
June	560	794	164	0	2390	44	0.87*	0.42*
Mean amount	53.9	52.0	48.6	46.3	46.8	50.6	1.00	1.00

Maxima and minima in the columns of ratios are marked with an asterisk.

The inequality in the mean amount of the horizontal force disturbances in each year, indicates the year 1843–44 as the minimum year.

From the preceding results, we may assume the month of November, 1843, as the epoch for the minimum of the eleven (ten?) year inequality, as far as indicated by the differential observations of the horizontal force.

Further Analysis of the Disturbances of the Horizontal Force.—The distribution of the disturbances in number and mean amount over the several months of the year has been given in Tables IX. and X. From Table IX. we learn that the disturbances are greatest in number in September and March or April, or about the time of the equinoxes, and least in number about January and June, or about the time of the solstices. At the autumnal equinox the numbers exceed those of the vernal equinox; the same law was found at Toronto; also the numbers are smaller at the summer solstice than at the winter solstice, in perfect accordance with the result found at Toronto. These results are shown graphically on the annexed diagram, which contains also the ratio of the disturbances for the declination in which the same law is apparent.

(B).—DISTRIBUTION OF THE NUMBER OF DISTURBANCES IN THE SEVERAL MONTHS OF THE YEAR.

Full line for horizontal force. Dotted line for declination.

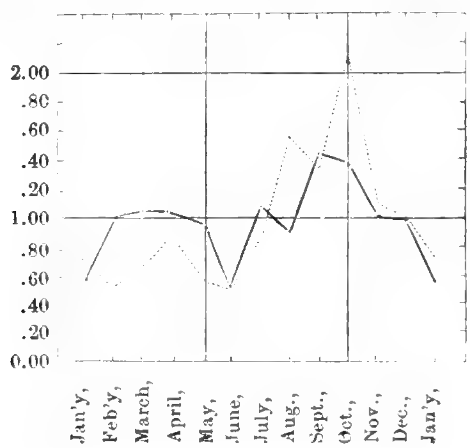


Table X. shows that, in reference to the average magnitude of the disturbances, the same law holds good, viz: the greatest relative magnitude occurring about the time of the equinoxes; the greatest amount corresponding to the autumnal equinox, and the least to about the time of the solstices, the smaller amount occurring near the summer solstice. The average magnitude of the disturbances of the declination was found subject to the same law.

If we separate the disturbances which increase the force from those which decrease it, we may form the two following tables of the distribution of the disturbances in number and average amount over the several months of the years.

TABLE XI.—ANNUAL INEQUALITY IN THE NUMBER OF DISTURBANCES, INCREASING AND DECREASING THE HORIZONTAL FORCE.

	1840–41.		1841–42.		1842–43.		1843–44.		1844–45.		Sum.		Ratios.	
	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.
July	(38)	(25)	6	20	5	19	1	14	0	0	50	78	1.2	1.0
August	18	55	6	11	1	2	2	9	0	2	27	79	0.7	1.0
September	25	29	5	36	38	6	11	5	9	4	88	80	2.1*	1.1
October	18	50	11	17	37	16	1	1	8	8	75	92	1.8	1.2
November	13	36	1	31	4	11	0	0	0	21	18	99	0.4	1.3*
December	(25)	(38)	8	18	0	5	0	0	15	8	48	69	1.1	0.9
January	19	16	6	8	3	5	0	1	3	10	31	40	0.8	0.6
February	15	35	4	33	2	18	0	3	0	9	21	98	0.5	1.2
March	17	44	10	16	3	17	0	14	1	1	31	92	0.8	1.2
April	18	30	14	24	1	13	1	7	0	16	34	90	0.8	1.2
May	24	22	16	13	10	15	1	1	5	5	56	56	1.3	0.7
June	9	9	6	10	1	3	0	0	7	21	23	43	0.5*	0.6*
Sum	239	389	93	237	105	130	17	55	48	105	502	916	12.0	12.0

In each year the number of disturbances increasing the force is less than the number which decreases it; the numbers of increase are to the numbers of decrease as 1 : 1.8. The numbers of the monthly ratio for the increasing disturbances exhibit the same law as found in Table IX.: with respect to the numbers for the decreasing force the law is apparently less distinctly marked; the maximum seems to occur about two months later (before the winter solstice), at a time when the number for increasing force is apparently at its minimum. This indistinctness in the law may possibly be due to an irregular distribution in reference to the hours of the day, and could only disappear through a longer series of observations.

Table XII.—Annual Inequality in the Mean Amount of the Disturbances of the Horizontal Force. Aggregate Amount for Increasing and Decreasing Disturbances, expressed in Scale Divisions.

Month.	1840–41.		1841–42.		1842–43.		1843–44.		1844–45.		1840–45.		Aver. am't.		Ratios.	
	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec
July	(2202)	(1887)	214	943	292	1003	41	628	0	0	2749	4461	55[d]	57[d]	1.2	1.1
August	794	3290	261	494	51	80	69	402	0	142	1175	4408	44	54	1.0	1.0
Sept.	1082	2010	186	2889	1857	242	452	208	873	355	4450	5704	45	56	1.0	1.1
October	726	2994	421	863	1685	714	128	41	691	721	3651	5333	44	53	1.0	1.0
Nov.	520	1870	35	1956	185	730	0	34	0	2173	740	6763	41	56	0.9	1.1
Dec.	2204	4311	289	936	0	239	0	0	1483	800	3976	6286	47	56	1.0	1.1
January	723	463	231	370	0	0	0	111	302	1100	1256	2044	48	50	1.1	0.8
Feb.	649	2015	140	1682	0	44	0	200	0	806	789	4747	42	52	1.0	1.0
March	643	2469	415	761	0	39	0	412	37	90	1095	4771	39	52	0.9	1.0
April	732	1406	550	1525	54	622	75	786	41	1563	1452	5902	40	52	0.9	1.0
May	1000	1456	696	515	412	775	83	48	398	391	2589	3185	42	52	1.0	1.0
June	307	253	284	510	50	114	0	0	604	1786	1245	2663	44	44	1.0	0.8
Sum	11582	24424	3722	13444	4586	4602	848	3870	4429	9927	25167	56267			12.0	12.0
Number	254	414	93	237	97	92	20	82	96	211	560	1036				
Mean	46	59	40	57	47	50	42	47	46	47	45	54				

The average amount of a disturbance increasing the horizontal force is 45 scale divisions, or 0.0069 in absolute measure; the average amount of a disturbance decreasing the same is 54 scale divisions, or 0.0082 in absolute value. The ratio of these numbers is as 1 : 1.2, whereas at Toronto the ratio is 1 : 6.4.

The law of the monthly inequality for amount of increasing or decreasing disturbances is, as in the preceding case, very indistinct and further obscured by the small absolute amount of variation.

In the following Table, XIII., the larger disturbances have been distributed over the different hours of their occurrence; in this combination the bi-hourly series (of the even hours) of observation has been used throughout.

Hour.	Aggregate amount in sc. div.	Number of occurrence.	Average amount.	Ratio of numbers.
0 (Midnight)	8116	142	57	1.12
2	5967	109	55	0.86
4	4961	93	53	0.73*
6	4751*	94	51	0.74
8	5562	104	53	0.83
10	7721*	146	53	1.15
12 (Noon)	6825	161	42	1.27*
14	6636	127	52	1.00
16	6634	135	49	1.07
18	6894	132	52	1.05
20	7574	139	55	1.09
22	7358	139	53	1.09

Directing our attention to the columns of aggregate amount and of ratios of number of occurrence, we find a principal maximum about 11 A. M., which seems to correspond to the *secondary* maximum of corresponding ratios at Toronto occurring about three hours earlier; the principal minimum occurs about 5 A. M., which corresponds to the *secondary* minimum at Toronto occurring between 5 and 6 A. M.; again, at Philadelphia, the secondary maximum at midnight is about two hours earlier than the *principal* maximum at Toronto, and the secondary minimum about

4 P. M. corresponds in time to the *principal* minimum at Toronto occurring between 2 and 6 P. M. Thus, the curves at the two stations, representing the diurnal variation of the disturbances (irrespective of increase or decrease) of the horizontal force, is double crested with an exchange of the principal and secondary maximum and also of the principal and secondary minimum.

In the next Table, XIV., the diurnal variation of the disturbances is exhibited separately for disturbances increasing and disturbances decreasing the horizontal force.

Hour.	Disturbances Increasing Horizontal Force.			Disturbances Decreasing Horizontal Force.			Excess of aggregate decrease over aggregate increase.
	Number of occurrences.	Aggregate amount.	Ratio.	Number of occurrences.	Aggregate amount.	Ratio.	
0 (Midn't)	57	2878	1.28	85	5238	1.21	2360
2	44	2173	0.97	65	3794	0.87	1621
4	42	1998	0.89	51	2963*	0.68	965
6	28	1213*	0.54	66	3538	0.81	2325
8	48	2345	1.04	56	3217	0.74	872
10	61	2732	1.22	85	4989	1.15	2257
12 (Noon)	74	3134*	1.39	87	3691	0.85	557
14	48	2239	1.00	79	4397	1.01	2158
16	49	2200	0.98	86	4434	1.03	2234
18	45	2005	0.89	87	4889	1.13	2884
20	39	1758	0.78	100	5816*	1.34	4058
22	50	2296	1.02	89	5062	1.18	2766
Sums.	585	26971	12.00	936	52028	12.00	25057

The disturbances increasing and those decreasing the horizontal force evidently follow different laws; at Toronto they were found completely opposed; they are less so at Philadelphia. The principal maximum of increasing disturbances (at noon) seem to be contemporaneous with a secondary minimum of the decreasing disturbances; again the principal maximum of the decreasing disturbances (at 8 P. M.) corresponds to a secondary minimum of the increasing disturbances. In reference to the main feature, the maximum disturbance of those increasing the force and of those decreasing the force, the Philadelphia ratios show even a greater resemblance to the results at St. Helena and the Cape of Good Hope than to those at Toronto. At the two southern stations the maximum in the disturbances which increase occurs at 11 A. M. and the maximum in the disturbances which decrease occurs about 6 or 7 P. M. (See Vol. II. of the St. Helena Observations.)

Table XIV. contains also the hourly excess of the aggregate amount of the disturbances which decrease the horizontal force over those which increase the same. If we divide the numbers by the whole number of days of observation (nearly 1500) we obtain the diurnal disturbance variation expressed in scale divisions.

Table XV.—Diurnal Disturbance Variation.

Hour.	S. D.	In absolute measure.	Hour.	S. D.	In absolute measure.
0 (Midn't)	1.6	0.00024	12 (Noon)	0.4	0.00006
2	1.1	17	14	1.4	21
4	0.7	11	16	1.5	23
6	1.6	24	18	2.0	30
8	0.6	09	20	2.8	43
10	1.5	23	22	1.9	29

The average amount by which the disturbances tend to decrease the diurnal variation of the horizontal force is 1.4 scale divisions or 0.00021 in the absolute scale. The maximum effect takes place at 8 P. M., at exactly the same hour when the declination disturbances reach their greatest effect.

In the preceding Tables, XIII., XIV., and XV., to the hours indicated 21½ minutes should be added, the observations being made so much later than the even hours.

The preceding discussion shows that for two stations, even at a comparatively short distance, as for Philadelphia and Toronto, there are, generally speaking, some close coincidences in the laws derived from independent observations; but there are also certain differences in other results; yet it must not be forgotten that for a strict comparability we require, if not simultaneous observations, at least observations extending over similar parts or the whole of an eleven year period. The Philadelphia series includes a minimum year of that inequality, with the greater extent of observations before that epoch, whereas at Toronto the series begins after the minimum epoch and barely extends to a maximum year.

For the purpose of obtaining a better view of the absolute amount of the disturbances and their frequency of occurrence,[1] they were classified in nine groups of equal differences of 20 scale divisions; the number of disturbances in each was found as follows:—

Limits Adopted.			Number of disturbances.
In scale divisions.	In parts of horizontal force.	In the absolute scale.	
33 to 53	0.0012 to 0.0019	0.005 to 0.008	1159
53 " 73	19 " 27	08 " 11	348
73 " 93	27 " 34	11 " 14	93
93 " 113	34 " 41	14 " 17	45
113 " 133	41 " 48	17 " 20	27
133 " 153	48 " 55	20 " 23	14
153 " 173	55 " 62	23 " 26	4
173 " 193	62 " 70	26 " 29	6
193 " 213	0.0070 " 0.0077	0.029 " 0.032	2
Beyond.	....	....	0

The numbers in the last column cannot be considered as entirely independent of the eleven year period, and in attempting to apply the theory of probabilities in

[1] A table analogous to that given above, showing the distribution of the disturbances in *declination*, is here added for comparison:—

Limits Adopted.		Number of disturbances.
In scale divisions.	In minutes of arc.	
8 to 16	3'.6 to 7'.2	1856
16 " 24	7.2 " 10.8	333
24 " 32	10.8 " 14.4	105
32 " 40	14.4 " 18.1	42
40 " 48	18.1 " 21.7	16
48 " 56	21.7 " 25.3	2
56 " 64	25.3 " 29.0	2
64 " 72	29.0 " 32.6	1
Beyond	....	0

reference to the number of disturbances which ought to occur between the assigned limits, it became apparent that the larger disturbances greatly preponderate, a fact no doubt intimately connected with the difficulty in correctly allowing for the progressive change during the first year of observation.

PART V.

INVESTIGATION

OF THE

SOLAR-DIURNAL VARIATION AND OF THE ANNUAL INEQUALITY OF THE HORIZONTAL COMPONENT OF THE MAGNETIC FORCE.

INVESTIGATION

OF THE

SOLAR-DIURNAL VARIATION, AND OF THE ANNUAL INEQUALITY OF THE HORIZONTAL COMPONENT OF THE MAGNETIC FORCE.

THE discussion of the diurnal and annual variations of the horizontal force is based on the resulting monthly normal values for each observation hour as given in the preceding part (IV.), in which the horizontal force has been discussed in relation to the ten or eleven year period, and which also contains the investigation of the disturbances; in the same part all necessary statements are given relating to the instrumental data and the absolute values of the horizontal force.

The normals, as has been shown, are referred to a uniform standard temperature; they are corrected for irregularity in the progressive change, and are necessarily freed from all the larger disturbances. The use of the normals instead of the simple means of the readings (corrected for difference of temperature) will insure greater regularity in the variations of the horizontal force, now under consideration.

The diurnal variation requires an arrangement of the five year series of monthly normals according to the months of the year and hours of the day; in general, the method of interpolation for an occasional omission in either a month or hour, is the same as that used in Part II. of the discussion of the Girard College observations; there is, however, this difference in the tabulation of the monthly values, that in the present case the results are consolidated in a five years' arrangement, and in consequence the year commences with the month of July. This arrangement was preferred, particularly since it was found desirable to make no use of the observations in the first month of the series.

Tabulation of monthly normals for each observing hour and each observing year, beginning and ending with July. The individual values are taken from Table VII. of the preceding Part IV.

After applying the corrections of — 19 scale divisions to the normals for January, 1841, and of +8 scale divisions to those of June, 1841, to allow for defective number of observations in these months, a further correction of + 68 scale divisions was applied to all values between July, 1840, and May, 1841, inclusive, and of + 60 to all values between July, 1840, and December, 1840, inclusive, to allow for defects in the regularity of the progressive change, thus making the total correction for the latter months = 128 scale divisions. The above corrections, when divided by 5, in order to give the correction to the means derived from five years, become, therefore: for months between July and December inclusive, + 26; for January + 10; for February, March, April, and May + 14; for June + 2. These corrections are constant for each hour of the day in any one month, and consequently do not affect the diurnal variation; but they have nevertheless been applied at once to facilitate subsequent deductions. Their origin has also been explained in the remarks accompanying Table V. of the preceding part.

The following example of the process of interpolation for the odd hour values will suffice for all similar cases: Required the mean normal from the 5 year series for $5^h\ 21\frac{1}{2}^m$ A. M. in June (see tabular values and results below). The mean normals for the two last years at $4^h\ 21\frac{1}{2}^m$, $5^h\ 21\frac{1}{2}^m$, and $6^h\ 21\frac{1}{2}^m$, are 1176, 1173, and 1169 respectively; the mean at $5^h\ 21\frac{1}{2}^m$ is therefore 3 divisions less than the mean at $4^h\ 21\frac{1}{2}^m$, and since the mean of the 5 year series at $4^h\ 21\frac{1}{2}^m$ is 853, the result for $5^h\ 21\frac{1}{2}^m$ becomes 849; again, adding 4 divisions to 847, the mean at $6^h\ 21\frac{1}{2}^m$, we find 851; the mean of the two values, or 850, is that given in the table, to which + 2 has been added, making the final result 852. The means of the odd hours, thus found from the adjacent even hours, in general, do not differ by as much as a scale division.

The time given in the tables of the normals is mean local time, counting from midnight to midnight to twenty-four hours. The observations were taken (on the average) $21\frac{1}{2}$ minutes after the full hours, as indicated in the tables. Increase of scale readings indicates decrease of horizontal force; the value of a scale division equals 0.0000365 parts of the horizontal force, or 0.0001523 in absolute measure, the mean horizontal force being 4.173 (in absolute measure). Proper weights have been given to the normals of the even and odd hours, in proportion to the number of observations, as will be seen hereafter. Other special remarks will be found at the end of the month to which they refer.

Tabulation of the hourly normals for each month and the mean of the five year series, expressed in scale division readings and reduced to the standard temperature of 63° (Fahrenheit's scale), also corrected for all irregularities in the progressive change. The regular progressive and secular change, therefore, remains in the tabular quantities.

Normals of the Horizontal Force for July.

Year.	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	+ 21½m
1840	113		97		89		50		112		116		
1841	442		442		435		435		447		458		
1842	692		686		682		678		695		708		
1843	927		924		924		923		935		941		
1844	1102	1103	1105	1106	1106	1105	1104	1104	1109	1116	1118	1114	
Mean	605		651		647		638		660		668		
Referred mean		653		649		642		647		666		664	
Constant correction + 26													
Normals	681	679	677	675	673	668	664	673	686	692	694	690	

Year.	12h Noon.	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	+ 21½m
1840	94		59		52		92		93		108		
1841	449		428		430		444		448		439		
1842	700		680		677		690		694		700		
1843	934		923		916		921		928		931		
1844	1106	1100	1096	1093	1092	1093	1096	1099	1101	1102	1103	1104	
Mean	657		637		633		649		653		656		
Referred mean		646		634		640		651		655		657	
Constant correction + 26													
Normals	683	672	663	660	659	666	675	677	679	681	682	683	

Monthly mean normal from the even hours (+ 21½m) 676.3, weight 5.
" " " odd " " 676.3, " 1.

Normals of the Horizontal Force for August.

Year.	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	+ 21½m
1840	108		112		117		106		138		153		
1841	490		494		487		482		501		518		
1842	699		694		695		692		711		721		
1843	931		930		931		927		947		954		
1844	1133	1134	1134	1133	1133	1131	1130	1135	1143	1152	1153	1147	
Mean	672		673		673		667		688		700		
Referred mean		673		672		669		676		698		692	
Constant correction + 26													
Normals	698	699	699	698	699	695	693	702	714	724	726	718	

Year.	12h Noon.	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	+ 21½m
1840	134		103		111		114		121		126		
1841	502		483		483		497		500		495		
1842	700		688		689		701		703		702		
1843	938		921		924		929		932		933		
1844	1138	1129	1121	1119	1121	1127	1134	1135	1135	1134	1135	1135	
Mean	682		663		666		675		678		678		
Referred mean		672		662		670		677		677		676	
Constant correction + 26													
Normals	708	698	689	688	692	696	701	703	704	703	704	702	

Monthly mean normal from the even hours (+ 21½m) 702.2, weight 5.
" " " odd " " 702.2, " 1.

Normals of the Horizontal Force for September.

Year.	0^h	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	$+21\frac{1}{2}^m$
1840	155		147		139		141		180		202		
1841	510		514		515		508		531		542		
1842	726		733		722		717		739		750		
1843	974		967		965		960		980		992		
1844	1106	1104	1107	1105	1101	1101	1100	1107	1117	1125	1128	1125	
Mean	694		694		688		685		709		723		
Referred mean		692		692		687		695		718		720	
Constant correction + 26 Normals	720	718	720	718	714	713	711	721	735	744	749	746	

Year.	12^h Noon.	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	$+21\frac{1}{2}^m$
1840	177		155		153		158		157		150		
1841	537		516		519		520		515		515		
1842	737		730		727		737		737		734		
1843	985		972		972		975		974		973		
1844	1115	1104	1097	1095	1095	1100	1102	1104	1104	1108	1107	1108	
Mean	710		694		693		698		697		696		
Referred mean		700		692		697		699		699		696	
Constant correction + 26 Normals	736	726	720	718	719	723	724	725	723	725	722	722	

Monthly mean normal from the even hours (+ $21\frac{1}{2}^m$) 724.4, weight 5.
" " " odd " " 724.9, " 1.

Normals of the Horizontal Force for October.

Year.	0^h	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	$+21\frac{1}{2}^m$
1840	142		137		122		138		153		166		
1841	521		517		518		514		526		537		
1842	764		759		757		757		764		781		
1843	983	978	983	978	976	978	977	980	983	787	991	992	
1844	1133	1132	1131	1127	1124	1125	1129	1134	1141	1149	1152	1145	
Mean	709		705		699		703		713		725		
Referred mean		705		701		702		708		720		724	
Constant correction + 26 Normals	735	731	731	727	725	728	729	734	739	746	751	750	

Year.	12^h Noon.	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	$+21\frac{1}{2}^m$
1840	159		158		148		146		148		151		
1841	547		530		525		527		529		528		
1842	783		776		776		768		769		764		
1843	991	989	985	983	983	983	985	985	985	986	983	984	
1844	1145	1137	1134	1130	1132	1134	1135	1137	1138	1134	1137	1135	
Mean	725		717		713		712		714		713		
Referred mean		721		714		713		713		713		712	
Constant correction + 26 Normals	751	747	743	740	739	739	738	739	740	739	739	738	

Monthly mean normal from the even hours (+ $21\frac{1}{2}^m$) 738.3, weight 5.
" " " odd " " 738.2, " 2.

Normals of the Horizontal Force for November.

Year.	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	$+ 21\frac{1}{2}^m$
1840	155		150		141		133		144		154		
1841	519		517		515		509		518		529		
1842	774		770		771		768		777		789		
1843	987	986	985	983	982	980	980	983	987	991	992	993	
1844	1131	1130	1127	1126	1125	1123	1122	1125	1130	1135	1138	1142	
Mean	713		710		707		702		711		720		
Referred mean		712		708		704		706		717		725	
Constant correction + 26 Normals	739	738	736	734	733	730	728	732	737	743	746	751	

Year.	12h Noon.	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	$+ 21\frac{1}{2}^m$
1840	175		157		151		148		144		160		
1841	531		514		518		513		516		518		
1842	787		781		778		775		776		776		
1843	991	989	987	986	984	985	986	986	987	987	988	988	
1844	1136	1133	1129	1127	1124	1131	1128	1129	1130	1130	1131	1131	
Mean	724		714		711		710		711		715		
Referred mean		720		712		713		710		713		714	
Constant correction + 26 Normals	750	746	740	738	737	739	736	736	737	739	741	740	

Monthly mean normal from the even hours (+ $21\frac{1}{2}^m$) 738.3, weight 5.
" " " odd " " 738.8 " 2.

Normals of the Horizontal Force for December.

Year.	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	$+ 21\frac{1}{2}^m$
1840	196		188		176		166		178		208		
1841	546		541		538		535		537		548		
1842	780		777		775		773		776		790		
1843	995	993	992	991	989	987	987	987	991	991	992	997	
1844	1213	1202	1200	1198	1196	1194	1190	1193	1194	1197	1209	1217	
Mean	746		740		735		730		735		749		
Referred mean		741		738		733		732		740		757	
Constant correction + 26 Normals	772	767	766	764	761	759	756	758	761	766	775	783	

Year.	12h Noon.	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	$+ 21\frac{1}{2}^m$
1840	217		193		182		185		200		194		
1841	562		549		545		547		550		552		
1842	795		786		773		776		781		782		
1843	999	998	996	993	991	990	992	995	995	995	997	998	
1844	1220	1212	1209	1202	1201	1201	1203	1198	1200	1204	1206	1206	
Mean	759		747		738		741		745		746		
Referred mean		752		742		739		742		746		745	
Constant correction + 26 Normals	785	778	773	768	764	765	767	768	771	772	772	771	

Monthly mean normal from the even hours (+ $21\frac{1}{2}^m$) 768.6, weight 5.
" " " odd " " 768.2, " 2.

NORMALS OF THE HORIZONTAL FORCE FOR JANUARY.

Year.	0^h	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	$+ 21\frac{1}{2}^m$
1841	298		300		294		284		281		302		
1842	561		556		555		558		553		573		
1843	(820)		(817)		(814)		(815)		(814)		(827)		
1844	1006	1005	1004	1002	1000	1000	999	999	1002	1005	1008	1011	
1845	1233	1228	1231	1230	1228	1226	1225	1226	1231	1241	1248	1252	
Mean	784		782		778		776		776		792		
Referred mean		782		780		777		774		785		798	
Constant correction + 16 Normals	794	792	792	790	788	787	786	784	786	795	802	808	

Year.	12^h Noon.	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	$+ 21\frac{1}{2}^m$
1841	326		311		289		296		301		302		
1842	577		559		554		564		563		564		
1843	(830)		818		(813)		(820)		(820)		(821)		
1844	1009	1006	1003	999	998	1000	1002	1003	1003	1004	1004	1005	
1845	1249	1242	1239	1233	1229	1230	1233	1231	1230	1230	1229	1229	
Mean	798		786		777		783		783		784		
Referred mean		791		780		780		784		784		786	
Constant correction + 10 Normals	808	801	796	790	787	790	793	794	793	794	794	796	

Monthly mean normal from the even hours 793.3, weight 4.
" " " odd " 793.4, " 2.

The values for 1843 within brackets are interpolated by means of the continued readings at $14^h\ 21\frac{1}{2}^m$; at this hour the difference of reading from the preceding year is 259, which added to the values of 1842 gave resulting normals for 1843; in the same manner the reading in 1843 at $14^h\ 21\frac{1}{2}^m$ when compared with the reading in the following year (1844) leaves the difference 185, which quantity when subtracted from each hourly value in 1844 gives a second determination for the year 1843; the mean of the two determinations for each hour has been inserted above.

NORMALS OF THE HORIZONTAL FORCE FOR FEBRUARY.

Year.	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	+ 21½m
1841	269		261		264		257		265		288		
1842	580		573		572		567		568		582		
1843	(820)		(816)		(813)		(810)		(812)		(822)		
1844	1031	1031	1031	1029	1026	1026	1026	1028	1029	1030	1034	1034	
1845	1230	1230	1231	1229	1229	1226	1223	1227	1231	1236	1243	1244	
Mean	786		782		781		777		781		794		
Referred mean		784		782		779		779		786		796	
Constant correction + 14 Normals	800	798	796	796	795	793	791	793	795	800	808	810	

Year.	12h Noon.	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	+ 21½m
1841	297		289		275		274		275		272		
1842	589		578		578		580		590		578		
1843	(826)		817		(818)		(820)		(826)		(819)		
1844	1035	1032	1028	1028	1030	1031	1032	1033	1034	1033	1032	1030	
1845	1250	1242	1238	1231	1233	1229	1231	1233	1235	1231	1231	1232	
Mean	799		790		787		787		792		786		
Referred mean		794		786		786		790		788		786	
Constant correction + 14 Normals	813	808	804	800	801	800	801	804	806	802	800	800	

Monthly mean normal from even hours (+ 21½m) 800.8, weight 4.
" " " " odd " " 800.4, " 2.

The values of 1843 inclosed in brackets are derived from the reading at 14h 21½m in the same manner as explained in the preceding month.

NORMALS OF THE HORIZONTAL FORCE FOR MARCH.

Year.	0^h	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	$+ 21\frac{1}{2}^m$
1841	268		272		267		257		271		294		
1842	565		559		557		554		563		574		
1843	(827)		(823)		(822)		(819)		(827)		(836)		
1844	1048	1047	1046	1046	1046	1043	1043	1047	1050	1054	1057	1063	
1845	1236	1236	1234	1235	1234	1234	1231	1233	1241	1249	1255	1261	
Mean	789		787		785		781		790		803		
Referred mean		788		786		783		785		798		808	
Constant correction + 14													
Normals	803	802	801	800	799	797	795	799	804	812	817	822	

Year.	12^h Noon.	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	$+ 21\frac{1}{2}^m$
1841	286		267		266		282		264		272		
1842	575		561		565		571		567		566		
1843	(839)		829		(828)		(831)		(828)		(828)		
1844	1063	1061	1057	1050	1051	1050	1050	1052	1050	1048	1050	1048	
1845	1260	1253	1245	1239	1240	1242	1244	1240	1239	1237	1240	1239	
Mean	805		792		790		796		790		791		
Referred mean		800		787		793		794		789		790	
Constant correction + 14													
Normals	819	814	806	801	804	807	810	808	804	803	805	804	

Monthly mean normal from the even hours ($+ 21\frac{1}{2}^m$) 805.6, weight 4.
" " " " " odd " " 805.8, " 2.

The values for 1843 are interpolated as in the preceding two months

NORMALS OF THE HORIZONTAL FORCE FOR APRIL.

Year.	0^h	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	$+ 21\frac{1}{2}^m$
1841	273		271		262		262		283		317		
1842	595		598		597		594		604		620		
1843	861		861		854		854		868		883		
1844	1070	1069	1068	1065	1063	1062	1064	1061	1067	1074	1078	1078	
1845	1252	1250	1249	1247	1245	1243	1241	1244	1253	1268	1278	1281	
Mean	810		809		804		803		815		835		
Referred mean		809		806		803		806		827		837	
Constant correction + 14													
Normals	824	823	823	820	818	817	817	820	829	841	849	851	

Year.	12^h Noon.	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	$+ 21\frac{1}{2}^m$
1841	315		279		268		271		283		280		
1842	618		603		598		607		608		611		
1843	878		863		860		861		865		859		
1844	1077	1071	1066	1062	1064	1062	1068	1068	1071	1071	1068	1069	
1845	1268	1267	1255	1252	1248	1253	1256	1254	1254	1253	1250	1254	
Mean	831		813		808		813		816		814		
Referred mean		825		810		808		813		816		813	
Constant correction + 14													
Normals	845	839	827	824	822	822	827	827	830	830	828	827	

Monthly mean normal from the even hours ($+ 21\frac{1}{2}^m$) 828.2, weight 5.
" " " " " odd " " 828.4, " 2.

Normals of the Horizontal Force for May.

Year.	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	+ 21½m
1841	311		305		306		297		306		323		
1842	614		610		611		605		621		630		
1843	864		862		858		857		875		872		
1844	1065	1065	1063	1062	1062	1061	1061	1064	1068	1076	1077	1070	
1845	1244	1243	1241	1239	1236	1233	1229	1236	1251	1261	1262	1258	
Mean	820		816		815		810		824		833		
Referred mean		819		815		812		815		832		829	
Constant correction + 14													
Normals	834	833	830	829	829	826	824	829	838	846	847	843	

Year	12h Noon.	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	+ 21½m
1841	313		301		294		306		309		313		
1842	622		606		607		615		618		619		
1843	864		855		856		862		867		863		
1844	1064	1057	1053	1053	1051	1054	1059	1063	1064	1064	1065	1063	
1845	1253	1244	1238	1236	1237	1239	1245	1246	1246	1248	1247	1242	
Mean	823		811		809		817		821		821		
Referred mean		816		810		811		818		822		818	
Constant correction + 14													
Normals	837	830	825	824	823	825	831	832	835	836	835	832	

Monthly mean normal from the even hours (+ 21½m) 832.3, weight 5.
" " " " " odd " " 832.1, " 2.

Normals of the Horizontal Force for June.

Year.	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	+ 21½m
1841	392		390		392		386		400		401		
1842	649		652		646		638		649		659		
1843	881		879		876		873		883		894		
1844	1078	1077	1076	1077	1077	1075	1073	1077	1080	1082	1084	1081	
1845	1280	1281	1281	1281	1275	1271	1266	1273	1282	1293	1295	1292	
Mean	856		856		853		847		859		867		
Referred mean		856		856		850		853		865		864	
Constant correction + 2													
Normals	858	858	858	858	855	852	849	855	861	867	869	866	

Year.	12h Noon.	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	+ 21½m
1841	395		382		385		392		402		392		
1842	650		639		638		649		648		650		
1843	884		870		870		881		881		885		
1844	1077	1072	1067	1065	1065	1067	1071	1073	1075	1077	1077	1078	
1845	1286	1280	1272	1269	1269	1273	1278	1281	1280	1277	1279	1280	
Mean	858		846		845		854		857		857		
Referred mean		853		845		849		856		856		857	
Constant correction + 2													
Normals	860	855	848	847	847	851	856	858	859	858	859	859	

Monthly mean normal from the even hours (+ 21½m) 856.6, weight 5.
" " " odd " " 857.0, " 2.

TABLE I.—RECAPITULATION OF THE HOURLY NORMALS OF THE HORIZONTAL FORCE (EXPRESSED IN SCALE DIVISIONS) FOR EACH MONTH OF THE YEAR.

Increase of scale readings denotes decrease of force.

1840–1845.	0^h	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	$+ 21\frac{1}{2}^m$
July . . .	681	679	677	675	673	668	664	673	686	692	694	690	
August . . .	698	699	699	698	699	695	693	702	714	724	726	718	
September . .	720	718	720	718	714	713	711	721	735	744	749	746	
October . .	735	731	731	727	725	728	729	734	739	746	751	750	
November . .	739	738	736	734	733	730	728	732	737	743	746	751	
December . .	772	767	766	764	761	759	756	758	761	766	775	783	
January . .	794	792	792	790	788	787	786	784	786	795	802	808	
February . .	800	798	796	796	795	793	791	793	795	800	808	810	
March . . .	803	802	801	800	799	797	795	799	804	812	817	822	
April . . .	824	823	823	820	818	817	817	820	829	841	849	851	
May	834	833	830	829	829	826	824	829	838	846	847	843	
June . . .	858	858	858	858	855	852	849	855	861	867	869	866	
Year . . .	771.5	769.8	769.1	767.4	765.7	763.7	761.9	766.7	773.7	781.3	786.1	786.5	
Summer . .	769.2	768.3	767.8	766.3	764.7	761.8	759.7	766.7	777.2	785.7	789.0	785.7	
Winter . . .	773.8	771.3	770.3	768.5	766.8	765.7	764.2	766.7	770.3	777.0	783.2	787.3	

1840–1845.	12^h Noon.	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	$+ 21\frac{1}{2}^m$
July . . .	683	672	663	660	659	666	675	677	679	681	682	683	
August . . .	708	698	689	688	692	696	701	703	704	703	704	702	
September .	736	726	720	718	719	723	724	725	723	725	722	722	
October . .	751	747	743	740	739	739	738	739	740	739	739	738	
November . .	750	746	740	738	737	739	736	736	737	739	741	740	
December . .	785	778	773	768	764	765	767	768	771	772	772	771	
January . .	808	801	796	790	787	790	793	794	793	794	794	796	
February . .	813	808	804	800	801	800	801	804	806	802	800	800	
March . . .	819	814	806	801	804	807	810	808	804	803	805	804	
April . . .	845	839	827	824	822	822	827	827	830	830	828	827	
May	837	830	825	824	823	825	831	832	835	836	835	832	
June . . .	860	855	848	847	847	851	856	858	859	858	859	859	
Year . . .	782.9	776.2	769.5	766.5	766.2	768.6	771.6	772.6	773.4	773.5	773.4	772.8	
Summer . .	778.2	770.0	762.0	760.2	760.3	763.8	769.0	770.3	771.7	772.2	771.7	770.8	
Winter . . .	787.7	782.3	777.0	772.8	772.0	773.3	774.2	774.8	775.2	774.8	775.2	774.8	

In the preceding table the normals for the summer half year comprise the months between April and September inclusive; those for the winter half year comprise the months between October and March inclusive.

The following table contains the mean values of the normals for each month and season.

TABLE II.

1840–1844.	Normal.	1841–1845.	Normal.	1840–1845.	Normal.
July	676.3	January . . .	793.3	Year	772.1
August . . .	702.2	February . . .	800.6	Summer	770.1
September . .	724.6	March	805.7	Winter	774.1
October . . .	738.2	April	828.3		
November . .	738.5	May	832 2		
December . . .	768.4	June	856.8		

Regular Solar-Diurnal Variation of the Horizontal Force.—If we subtract the hourly normals of Table I. from their respective monthly mean value as given in Table II., the difference (in scale divisions) will represent the regular solar-diurnal variation for each month in the year. In like manner we obtain the diurnal variation of the horizontal force—free of the larger disturbances—for the summer and winter half, and for the whole year. Table III. will exhibit these differences after their conversion from scale divisions into parts of the horizontal force (one scale division equalling 0.0000365 parts of the horizontal force). The tabular numbers are expressed in units of the sixth place of decimals. A plus sign indicates a greater force, a minus sign a less force than the mean value. Casting the eye over the vertical columns, we obtain also a view of the annual inequality of the diurnal variation, which will be examined further on.

TABLE III.—REGULAR SOLAR-DIURNAL VARIATION OF THE HORIZONTAL COMPONENT OF THE MAGNETIC FORCE EXPRESSED IN PARTS OF THE HORIZONTAL FORCE.

A plus sign indicates greater force than the mean. For convenience sake, the first three decimals (0.000) have been placed on the side of the table.

	1840–1845.	0ʰ	1ʰ	2ʰ	3ʰ	4ʰ	5ʰ	6ʰ	7ʰ	8ʰ	9ʰ	10ʰ	11ʰ	+ 21½ᵐ
0.000	July	−171	−098	−025	+047	+120	+303	+449	+120	−353	−572	−646	−499	
	August	+153	+116	+116	+153	+116	+262	+335	+007	−430	−795	−868	−576	
	September	+168	+241	+168	+241	+387	+423	+481	+131	−380	−708	−891	−781	
	October	+116	+262	+262	+408	+481	+372	+335	+153	−029	−284	−467	−330	
	November	−018	+018	+091	+164	+200	+310	+383	+237	+054	−164	−273	−456	
	December	−131	+051	+088	+161	+270	+343	+453	+380	+270	+088	−241	−533	
	January	−025	+047	+047	+120	+193	+230	+266	+339	+266	−061	−318	−536	
	February	+022	+095	+146	+168	+204	+277	+350	+277	+204	+022	−270	−343	
	March	+098	+134	+171	+207	+244	+317	+390	+244	+061	−230	−412	−595	
	April	+157	+193	+193	+303	+376	+412	+412	+303	−025	−433	−755	−828	
	May	−065	−029	+080	+116	+116	+226	+299	+116	−211	−503	−540	−394	
	June	−043	−043	−043	−043	+065	+175	+284	+065	−153	−372	−445	−335	
	Year	+022	+082	+108	+170	+231	+304	+370	+198	−060	−337	−511	−526	
	Summer	+033	+063	+082	+136	+197	+300	+377	+127	−259	−570	−691	−569	
	Winter	+010	+101	+134	+205	+265	+308	+363	+272	+138	−105	−330	−482	

	1840–1845.	12ʰ Noon.	13ʰ	14ʰ	15ʰ	16ʰ	17ʰ	18ʰ	19ʰ	20ʰ	21ʰ	22ʰ	23ʰ	+ 21½ᵐ
0.000	July	−244	+157	+485	+595	+631	+376	+047	−025	−098	−171	−244	−244	
	August	−211	+153	+481	+518	+372	+226	+043	−029	−065	−029	−065	+007	
	September	−416	−051	+168	+241	+204	+058	+022	−015	+058	−015	+095	+095	
	October	−467	−321	−175	−065	−029	−029	+007	−029	−065	−029	−029	+007	
	November	−419	−273	−054	+018	+054	−018	+091	+091	+054	−018	−091	−054	
	December	−606	−350	−168	+015	+161	+124	+051	+015	−095	−131	−131	−095	
	January	−536	−317	−098	+120	+230	+120	+011	−025	+011	−025	−025	−098	
	February	−453	−270	−124	+022	−015	+022	−015	−124	−197	−051	+022	+022	
	March	−485	−303	−011	+171	+061	−047	−157	−088	+061	+098	+025	+061	
	April	−609	−390	+047	+157	+230	+230	+047	+047	−061	−061	+011	+047	
	May	−175	+080	+262	+299	+335	+262	+043	+007	−102	−138	−102	+007	
	June	−116	+065	+321	+357	+357	+211	+029	−043	−080	−043	−080	−080	
	Year	−395	−152	+095	+204	+216	+128	+018	−019	−049	−051	−051	−027	
	Summer	−295	+002	+294	+361	+355	+227	+037	−009	−058	−076	−064	−028	
	Winter	−494	−306	−105	+047	+077	+029	−002	−027	−039	−026	−038	−026	

Table IV.

Table IV. is derived from Table III. by multiplication with the absolute value of the horizontal force (4.173); it contains, therefore, the regular solar-diurnal variation of the horizontal force in absolute measure. A plus sign indicates greater force than the mean. Two places of decimals have been placed on the side of the table.

0.00

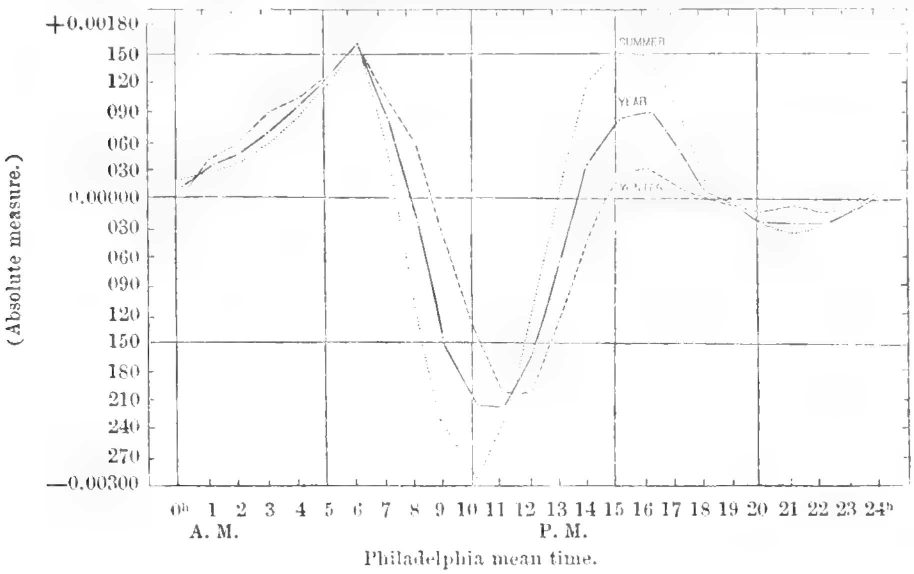
1840–1845.	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	+ 21½m
July	—071	—041	—010	+020	+050	+127	+188	+050	—147	—239	—270	—208	
August	+064	+048	+048	+064	+048	+109	+140	+003	—180	—332	—362	—241	
September	+070	+101	+070	+101	+162	+177	+201	+055	—159	—296	—372	—326	
October	+048	+109	+109	+170	+201	+155	+140	+064	—012	—119	—195	—180	
November	—008	+008	+038	+068	+083	+129	+160	+099	+022	—068	—114	—190	
December	—055	+021	+037	+067	+113	+143	+189	+159	+113	+037	—101	—223	
January	—010	+020	+020	+050	+081	+096	+111	+141	+111	—025	—132	—224	
February	+009	+040	+061	+070	+085	+116	+146	+116	+085	+009	—113	—143	
March	+041	+056	+071	+086	+102	+132	+163	+102	+025	—096	—172	—248	
April	+066	+081	+081	+127	+157	+172	+172	+127	—010	—193	—315	—346	
May	—027	—012	+033	+048	+048	+094	+125	+048	—088	—210	—226	—165	
June	—018	—018	—018	—018	+027	+073	+119	+027	—064	—155	—186	—140	
Year	+009	+034	+045	+071	+096	+127	+155	+083	—025	—141	—213	—220	
Summer	+014	+026	+034	+057	+082	+125	+157	+053	—108	—238	—289	—238	
Winter	+004	+042	+056	+086	+111	+129	+152	+114	+058	—044	—138	—201	

0.00

1840–1845.	12h Noon.	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	+ 21½m
July	—102	+065	+203	+248	+263	+157	+020	—010	—041	—071	—102	—102	
August	—088	+064	+201	+216	+155	+094	+018	—012	—027	—012	—027	+003	
September	—174	—021	+070	+101	+085	+024	+009	—006	+024	—006	+040	+040	
October	—195	—134	—073	—027	—012	—012	+003	—012	—027	—012	—012	+003	
November	—175	—114	—022	+008	+022	—008	+038	+038	+022	—008	—038	—022	
December	—253	—146	—070	+006	+067	+052	+021	+006	—040	—055	—055	—040	
January	—224	—132	—041	+050	+096	+050	+005	—010	+005	—010	—010	—041	
February	—189	—113	—052	+009	—006	+009	—006	—052	—082	—021	+009	+009	
March	—203	—127	—005	+071	+025	—020	—065	—037	+025	+041	+010	+025	
April	—254	—163	+020	+065	+096	+096	+020	+020	—025	—025	+005	+020	
May	—073	+033	+109	+125	+140	+109	+018	+003	—043	—058	—043	+003	
June	—048	+027	+134	+149	+149	+088	+012	—018	—033	—018	—033	—033	
Year	—165	—063	+040	+085	+090	+053	+008	—008	—020	—021	—021	—011	
Summer	—123	+001	+123	+151	+148	+095	+015	—004	—024	—032	—027	—012	
Winter	—206	—128	—044	+020	+032	+012	—000	—011	—016	—011	—016	—010	

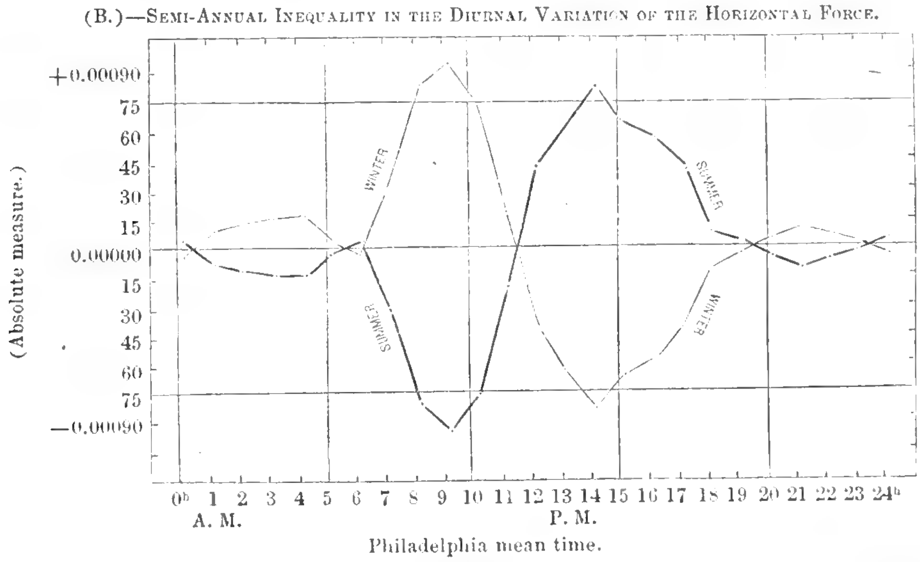
Annual Inequality in the Diurnal Variation of the Horizontal Force.—The distinctive feature of the diurnal variation is shown in the annexed diagram (A), constructed from the mean annual and half-yearly values given in the preceding table, IV. It exhibits in the annual mean, as its characteristic type, a maximum value about 6 A. M., a minimum value about 11 A. M., a secondary maximum value about 3½ P. M., and a secondary minimum about 9 P. M. For the half year when the sun has north declination, the morning minimum becomes smaller and the afternoon maximum larger, thus increasing the diurnal range; the converse takes place in the other half of the year, when the sun has south declination. The 6 A. M. maximum remains nearly unchanged throughout the year. The average summer range (April to September inclusive) is 0.0046, and the average winter range (October to March inclusive) is 0.0025, both expressed in absolute measure. The range between the morning maximum and the morning minimum is 0.0045 in summer and 0.0036 in winter, as will be explained further on.

(A.)—DIURNAL VARIATION OF THE HORIZONTAL FORCE IN SUMMER, WINTER, AND FOR THE WHOLE YEAR.



This semi-annual change in the diurnal amplitude is more conspicuously represented in the annexed diagram (B), derived from diagram (A) by straightening out the annual curve and using it as an axis of abscissæ for laying off the differences between the annual values and the summer and winter values at the same respective hours of the day.

(B.)—SEMI-ANNUAL INEQUALITY IN THE DIURNAL VARIATION OF THE HORIZONTAL FORCE.



This diagram (B) may, with advantage, be compared with the analogous one representing the annual change of the diurnal variation of the declination as given in Part II. of this discussion. The construction is the same in either case.

At 6 A. M. there is hardly any change throughout the year. The maximum variation, in the course of a year, takes place at 9 A. M. (range 0.00194 in absolute measure); about $11\frac{1}{2}$ A. M. there is an epoch of no variation; at 2 P. M. a second maximum is reached (range 0.00167); again at $7\frac{1}{2}$ and 11 P. M. points of no variation are reached. Owing to the prominent annual variation near 2 P. M., the range of the diurnal variation between the morning minimum at 11 A. M. and the afternoon maximum at $3\frac{1}{2}$ P. M. is of more interest in the discussion of the diurnal fluctuation of the horizontal force than the 6 A. M. and 11 A. M. range, which latter range, as we have seen, is slightly greater than the first one.

To find the turning epochs of the annual variation, the monthly values for the hours 9 A. M. and 2 P. M., when it is best developed, were taken from Table IV., and each value was again compared with its annual mean.

TABLE V.—ANNUAL VARIATION AT THE HOURS 9 A. M. AND 2 P. M.

MONTH.	9 A. M. 0.00	Differences. 0.00	2 P. M. 0.00	Differences. 0.00	Mean difference. 0.00
January	—025	+116	—041	—081	+099
February	+009	+150	—052	—092	+121
March	—096	+045	—005	—045	+045
April	—193	—052	+020	—020	—016
May	—210	—069	+109	+069	—069
June	—155	—014	+134	+094	—054
July	—239	—098	+203	+163	—130
August	—332	—191	+201	+161	—176
September	—296	—155	+070	+030	—092
October	—119	+022	—073	—113	+046
November	—068	+073	—022	—062	+068
December	+037	+178	—070	—110	+144
Mean	—141		+040		

Casting the eye over the columns headed "differences," we see by the change of sign and the magnitude of the values that the transition from a positive to a negative value occurs some time after the equinoxes, and that the maximum variation is reached about the time of the solstices—a result in close correspondence with the conclusions reached in the discussion of the annual inequality in the diurnal variation of the declination (Part II. of the discussion). For convenience in the analytical treatment, a column headed "mean difference" has been added to Table V., obtained by changing the signs of the 2 P. M. differences (the annual variation being then opposite to the morning values), and taking the mean of the 9 A. M. and 2 P. M. differences. The values in this column are tolerably well represented by the following formula:—

$$\Delta_a = +0.00129 \; sin \; (\theta + 79^\circ) + 0.00018 \; sin \; (2\theta + 191^\circ).$$

the angle θ counting from January 1. at the rate of 30° a month. Accordingly, we find the transition to take place shortly before the middle of April and October, or about twenty-two days after the equinoxes. This is about twelve days later than the epoch found in Part II. for the declination.

Analysis of the Solar-Diurnal Variation of the Horizontal Force.—For convenience of investigation and proper comparison with similar results at other localities, the values given in Table I. have been put in an analytical form, and are represented by the following expressions. It will be seen that the difference between any monthly normal mean and the corresponding mean in Table V. of Part IV., which latter mean is affected with the disturbances, does not exceed $2\frac{1}{2}$ scale divisions. This small difference includes also a small effect due to the necessity of different methods of interpolation in the construction of the two tables. In the determination of the numerical quantities (by application of the method of least squares) in the monthly equations, due attention was paid to the relative weights of the values for the even and odd hours. The coefficients are expressed in scale divisions (increasing numbers denoting decrease of force), and the angle θ counts from midnight at the rate of 15° an hour.

For January, $\Delta_h = +793^d.3 + 3^d.77 \sin(\theta + 236° 52') + 6^d.56 \sin(2\theta + 96° 52') + 3^d.99 \sin(3\theta + 282° 13') + 2^d.00 \sin(4\theta + 97°)$

For February, $\Delta_h = +800^d.6 + 5^d.50 \sin(\theta + 218° 26') + 4^d.57 \sin(2\theta + 102° 29') + 3^d.27 \sin(3\theta + 282° 40') + 1^d.66 \sin(4\theta + 121°)$

For March, $\Delta_h = +805^d.7 + 6^d.56 \sin(\theta + 243° 31') + 5^d.35 \sin(2\theta + 114° 14') + 4^d.23 \sin(3\theta + 316° 04') + 1^d.91 \sin(4\theta + 113°)$

For April, $\Delta_h = +828^d.3 + 7^d.65 \sin(\theta + 257° 37') + 9^d.55 \sin(2\theta + 123° 06') + 5^d.15 \sin(3\theta + 306° 44') + 1^d.18 \sin(4\theta + 163°)$

For May, $\Delta_h = +832^d.2 + 2^d.24 \sin(\theta + 314° 31') + 7^d.81 \sin(2\theta + 140° 53') + 4^d.40 \sin(3\theta + 330° 05') + 1^d.34 \sin(4\theta + 214°)$

For June, $\Delta_h = +856^d.8 + 2^d.12 \sin(\theta + 356° 03') + 6^d.40 \sin(2\theta + 140° 32') + 4^d.48 \sin(3\theta + 327° 14') + 0^d.92 \sin(4\theta + 216°)$

For July, $\Delta_h = +676^d.3 + 3^d.42 \sin(\theta + 4° 11') + 11^d.50 \sin(2\theta + 139° 14') + 6^d.14 \sin(3\theta + 330° 15') + 0^d.78 \sin(4\theta + 210°)$

For August, $\Delta_h = +702^d.2 + 5^d.32 \sin(\theta + 310° 58') + 10^d.37 \sin(2\theta + 153° 46') + 6^d.79 \sin(3\theta + 335° 55') + 2^d.88 \sin(4\theta + 203°)$

For September, $\Delta_h = +724^d.6 + 8^d.02 \sin(\theta + 271° 57') + 9^d.59 \sin(2\theta + 137° 25') + 7^d.08 \sin(3\theta + 345° 17') + 1^d.99 \sin(4\theta + 215°)$

For October, $\Delta_h = +738^d.2 + 8^d.06 \sin(\theta + 237° 57') + 6^d.40 \sin(2\theta + 123° 37') + 1^d.34 \sin(3\theta + 325° 20') + 0^d.29 \sin(4\theta + 174°)$

For November, $\Delta_h = +738^d.5 + 4^d.13 \sin(\theta + 237° 36') + 6^d.08 \sin(2\theta + 100° 01') + 1^d.93 \sin(3\theta + 310° 45') + 0^d.46 \sin(4\theta + 211°)$

For December, $\Delta_h = +768^d.4 + 5^d.03 \sin(\theta + 212° 48') + 8^d.07 \sin(2\theta + 94° 14') + 3^d.98 \sin(3\theta + 269° 17') + 1^d.31 \sin(4\theta + 88°)$

We have also: For summer half year (April to September inclusive), for winter half year (October to March inclusive), and for the whole year, the following expressions for the regular solar diurnal variations:—

For summer, $\Delta_h = +770^d.1 + 3^d.79 \sin(\theta + 293° 49') + 9^d.11 \sin(2\theta + 139° 10') + 5^d.36 \sin(3\theta + 329° 17') + 1^d.42 \sin(4\theta + 202°)$

For winter, $\Delta_h = +774^d.1 + 5^d.36 \sin(\theta + 231° 36') + 6^d.04 \sin(2\theta + 104° 46') + 2^d.88 \sin(3\theta + 293° 54') + 1^d.11 \sin(4\theta + 108°)$

For year, $\Delta_h = +772^d.1 + 3^d.95 \sin(\theta + 256° 19') + 7^d.25 \sin(2\theta + 125° 05') + 3^d.96 \sin(3\theta + 317° 31') + 0^d.86 \sin(4\theta + 165°)$

The following expressions for January may serve as specimens of the agreement of the result derived from the even and odd hours independently:—

From even hours, $\Delta_h = 793^d.3 + 3^d.81 \sin(\theta + 238° 01') + 6^d.56 \sin(2\theta + 94° 32') + 4^d.10 \sin(3\theta + 280° 19') + 2^d.08 \sin(4\theta + 86°)$

From odd hours, $\Delta_h = 793^d.4 + 3^d.71 \sin(\theta + 234° 35') + 6^d.56 \sin(2\theta + 101° 32') + 3^d.76 \sin(3\theta + 286° 00') + 1^d.85 \sin(4\theta + 119°)$

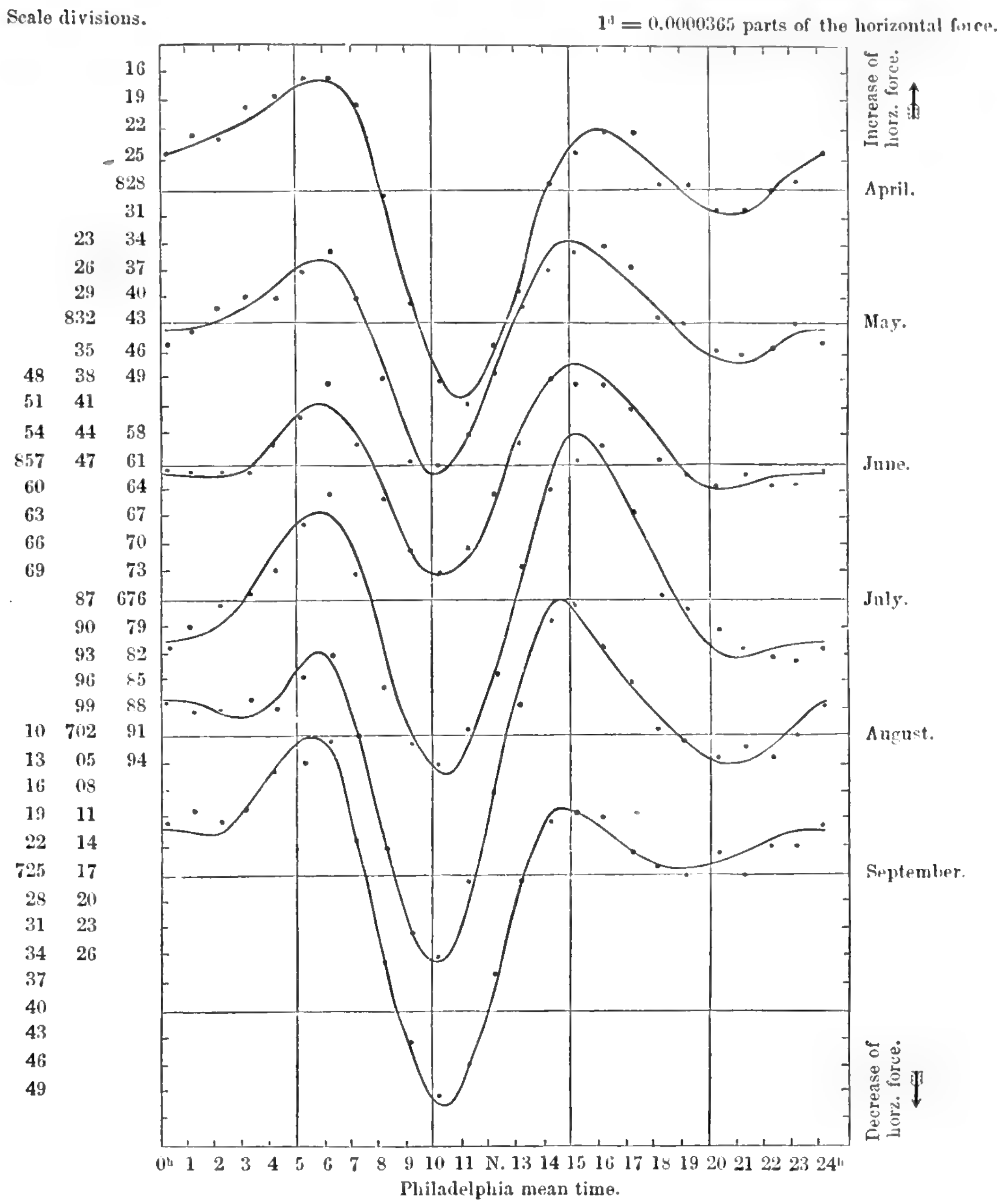
giving to the first equation the weight 2 and to the second the weight 1, we obtain the equation as given above.

The following comparison will show the agreement of the observed and computed values we have for August:—

(A. M.)	Computed.	Observed.	Δ	(P. M.)	Computed.	Observed.	Δ
$0^h\ 21\frac{1}{2}^m$	698.3	698	0	$12^h\ 21\frac{1}{2}^m$	707.7	708	0
1 "	698.3	699	—1	13 "	695.1	698	—3
2 "	699.6	699	+1	14 "	688.4	689	—1
3 "	699.7	698	+2	15 "	888.7	688	+1
4 "	697.6	699	—1	16 "	692.5	692	0
5 "	694.3	695	—1	17 "	697.1	696	+1
6 "	694.5	693	+1	18 "	700.3	701	—1
7 "	701.2	702	—1	19 "	702.6	703	0
8 "	712.7	714	—1	20 "	704.5	704	0
9 "	723.6	724	0	21 "	704.8	703	+2
10 "	727 1	726	+1	22 "	703.3	704	—1
11 "	720.4	718	+2	23 "	700.6	702	—1

Diagrams C and D exhibit the regular solar-diurnal variation of the horizontal force; the dots represent the observations directly taken from Table 1; the curves give the computed values from the preceding equations. These diagrams also exhibit the general agreement between the observed and computed values. The summer months are represented on diagram C, the winter months on diagram D; their comparison shows plainly the much greater range of the diurnal variation when the sun is north of the equator than when south of it, as was also the case with the magnetic declination.

(C.)—Solar-diurnal Variation of the Horizontal Force; April to September, 1840 to 1845.



(D.)—Solar-diurnal Variation of the Horizontal Force; October to March, 1840 to 1845.

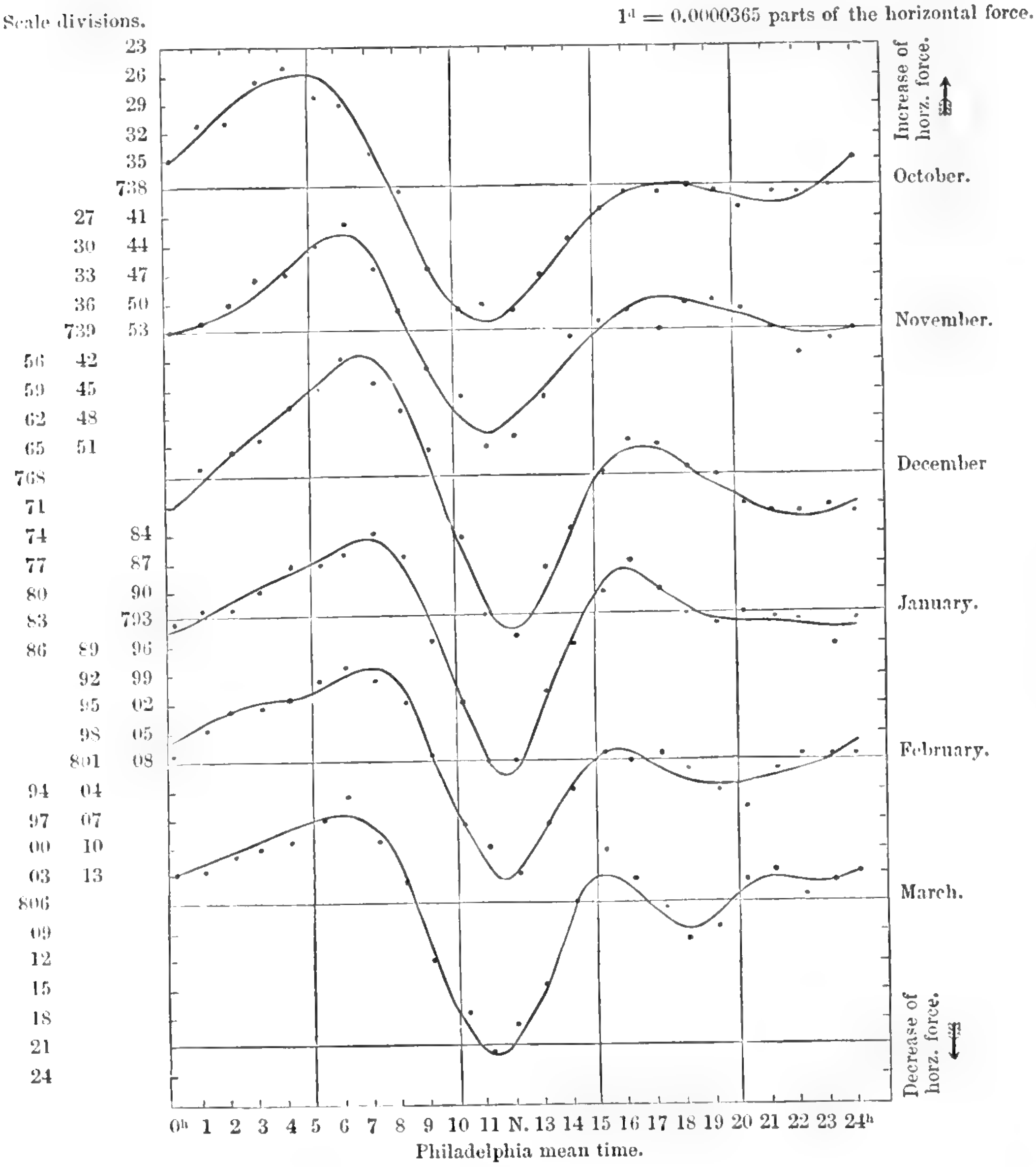


Table VI. contains the coefficients B_1 B_2 B_3 B_4 of the general equation:—

$$\Delta_h = A + B_1 \sin(\theta + C_1) + B_2 \sin(2\theta + C_2) + B_3 \sin(3\theta + C_3) + B_4 \sin(4\theta + C_4)$$

expressed in parts of the horizontal force, by multiplying the corresponding quantities in the preceding equations with the value of a scale division. The angles C_1 C_2 C_3 C_4 will be found in Table VII.; they are the same as given before, increased by 180°, so as to make a corresponding change in the direction of the scale readings; increasing numbers will now indicate increasing force.

The first three decimals (0.000) have been placed in front of the table.

TABLE VI.

MONTH.		B_1	B_2	B_3	B_4
January	0.000	138	239	146	073
February		202	167	119	060
March		239	195	154	070
April		279	349	188	043
May		082	285	161	049
June		077	234	164	034
July		125	420	224	029
August		194	379	248	105
September		295	350	258	073
October		294	234	048	011
November		151	222	071	017
December		184	295	145	048
Summer		138	333	196	052
Winter		196	220	105	040
Year		144	265	145	031

In Table VII. the same quantities are given in absolute measure; the first two places of decimals (0.00) are placed at the head of the columns. (Increasing numbers denote increase of force.) The numerical values of *A* will be found in connection with the discussion of the annual variation of the horizontal force.

TABLE VII.

MONTH.	B_1 0.00	C_1	B_2 0.00	C_2	B_3 0.00	C_3	B_4 0.00	C_4
January	057	56° 52′	100	276° 52′	061	102° 13′	030	277°
February	084	38 26	070	282 29	050	102 40	025	301
March	100	63 31	082	294 14	064	136 04	029	293
April	117	77 37	146	303 06	079	126 44	018	343
May	034	134 31	119	320 53	057	150 05	020	34
June	032	176 03	098	320 32	068	147 14	014	36
July	052	184 11	175	319 14	094	150 15	012	30
August	081	130 58	158	333 46	104	155 55	044	23
September . . .	122	91 57	146	317 25	108	165 17	030	35
October	123	57 57	098	303 37	020	145 20	005	354
November . . .	063	57 36	093	280 01	029	130 45	007	31
December . . .	077	32 48	123	274 14	061	89 17	020	268
Summer	058	113 49	139	319 10	082	149 17	022	22
Winter	082	51 36	092	284 46	044	113 54	017	288
Year	060	76 19	111	305 05	060	137 31	013	345

On diagram E the average value of the diurnal variation throughout the year, together with the summer and winter value, has been represented as resulting from the numerical quantities in the above table. It exhibits the noticeable feature in the annual curve of a greater morning maximum (about 6 A. M.) than afternoon maximum (about $3\frac{1}{2}$ P. M.), whereas in the summer curve it is the afternoon maximum which is the greater of the two.[1] In the winter season the contrast is more

[1] The same is the case at Prague; in May, June, and July, the afternoon maximum was the greater of the two. Karl Kreil, in vol. VIII. Proceedings of the Academy of Sciences of Vienna, 1855: "Resultate aus den magnetischen Beobachtungen zu Prag."

marked, the morning maximum being considerably greater. These curves also show the gradual shifting of the maxima and minimum to a later hour in winter than in summer, a phenomenon also well exhibited in the preceding diagrams C and D. The numerical values of this change of hours will be given in tabular form further on. The small afternoon minimum about 9 P. M. is less distinctly marked than any other feature of the diurnal curve.

(E.) Regular Solar Diurnal Variation of the Horizontal Force for Summer, Winter, and whole Year. (In absolute measure.)

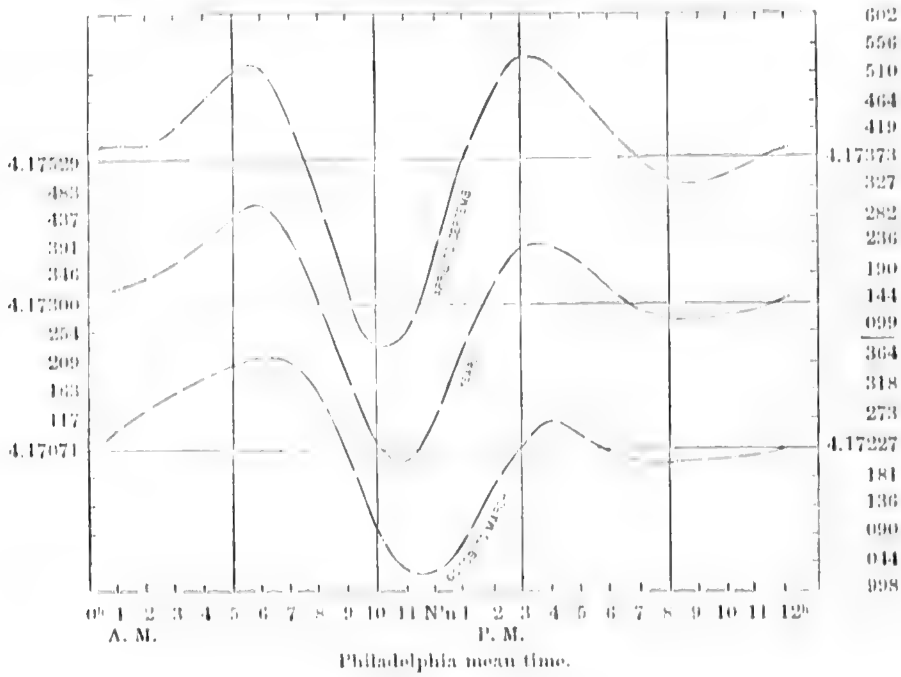


Table VIII. contains the computed values of the time and amount of the morning maximum and minimum, and of the afternoon maximum. The values for the secondary afternoon minimum are taken from the diagrams. The time of the A. M. maximum and minimum is within the nearest eighth minute; that of the P. M. maximum within the nearest tenth minute. The time for the P. M. secondary minimum is within the nearest hour. The amount of change of horizontal force is expressed in scale divisions.

TABLE VIII.

MONTH.	Morning maximum.		Morning minimum.		Afternoon maximum.		Secondary afternoon minimum.		Interval A. M min to P. M. max.
January . . .	$7^h 10^m$	$-9^d.2$	$11^h 50^m$	$+15^d.7$	$4^h 10^m$	$-5^d.3$	11^h	$+2^d$	$4^h 20^m$
February . . .	7 15	−9.6	11 40	+12.7	4 00	−0.9	7	+2	4 20
March	6 15	−9.2	11 30	+16.4	3 20	−2.3	6	+3	3 50
April	6 00	−12.3	11 20	+22.5	3 55	−6.6	9	+3	4 35
May	5 50	−7.9	10 25	+15.5	3 10	−9.8	9	+4	4 45
June	5 50	−6.3	10 30	+12.5	3 20	−10.4	8	+3	4 50
July	5 35	−9.9	10 30	+19.3	3 25	−17.5	9	+6	4 55
August	5 55	−8.5	10 10	+24.8	2 45	−14.2	9	+3	4 35
September . . .	5 35	−14.9	10 20	+25.9	3 05	−6.7	7	−1	4 45
October . . .	5 00	−12.6	11 15	+13.7	5 10	−0.1	9	+2	5 55
November . . .	6 00	−9.8	11 25	+11.0	5 15	−3.0	11	+0	5 50
December . . .	7 05	−12.1	12 05	+16.1	4 35	−5.1	10	+4	4 30
Summer . . .	5 50	−9.8	10 30	+19.6	3 25	−10.5	$20\frac{1}{2}$	+3	4 55
Winter	6 15	−9.4	11 45	+13.9	4 10	−2.2	21	+2	4 25
Year	5 55	−9.6	11 00	+15.6	3 35	−6.0	$20\frac{3}{4}$	+2.5	4 35

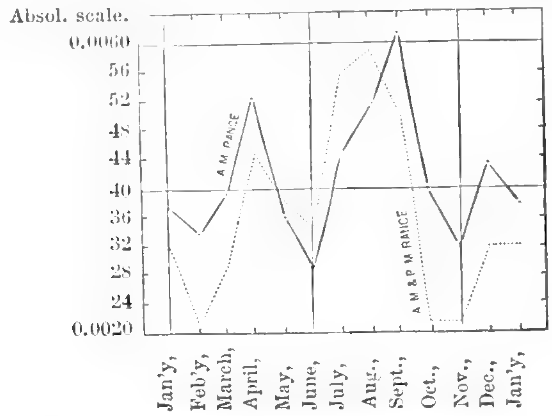
The extreme variation in the epoch of the A. M. maximum is therefore $2^h\ 15^m$; the variation for the A. M. minimum is $1^h\ 55^m$; for the P. M. maximum it is $2^h\ 30^m$, and for the secondary afternoon minimum between 3 and 4 hours. In all cases, the earlier hours occur in the summer season.

Table IX. shows the diurnal range, expressed in scale divisions, parts of the horizontal force and in absolute measure. In the second column the range between the A. M. maximum and minimum is given; in the third column that between the A. M. minimum and the P. M. maximum. These two amplitudes for A. M., and for A. M. and P. M., are further illustrated in diagram F, which shows the curve to be double crested, with maxima near the time of the equinoxes, and the greater of these near the autumnal equinox.

TABLE IX.—AMPLITUDE OF THE DIURNAL VARIATION OF THE HORIZONTAL FORCE.

MONTH.	For A. M.	For A. M. and P. M.	For A. M.	For A. M. and P. M.	For A. M.	For A. M. and P. M.
January	$24^d.9$	$21^d.0$	0.00091	0.00077	0.0038	0.0032
February	22.3	13.6	081	050	34	21
March	25.6	18.7	093	068	39	29
April	34.8	29.1	127	106	53	45
May	23.4	25.3	085	092	36	38
June	18.8	22.9	069	084	29	35
July	29.2	36.8	106	134	45	56
August	33.3	39.0	122	142	51	59
September	40.8	32.6	149	119	62	50
October	26.3	13.6	096	050	40	21
November	20.8	14.0	076	051	32	21
December	28.2	21.2	0.00103	077	0.0043	0.0032
Summer	29.4	30.1	0.00107	0.00110	0.0045	0.0046
Winter	23.3	16.1	0.00085	0.00059	0.0036	0.0025
Year	25.2	21.6	0.00092	0.00079	0.0038	0.0033
	In scale divisions.		In parts of the horizontal force.		In absolute measure.	

(F.)—Solar-Diurnal Range of the Horizontal Force for each Month of the Year.



The next table contains the epochs when the mean horizontal force is reached in each day, as computed by the preceding formulæ. The diurnal curves intersect the axis of abscissæ four times, of which the table contains only the A. M. and first P. M. intersection: those later in the afternoon and near midnight occur in summer, winter, and whole year at 7 P. M., 5¾ P. M., and 6½ P. M. respectively, and at 11¼ P. M., 12 P. M., and 11¾ P. M. respectively.

Table X.—Principal Epochs of Mean Horizontal Force.

Month.	A. M.	P. M.
January	$9^h 20^m$	$2^h 36^m$
February	9 23	2 58
March	8 42	2 28
April	8 14	2 19
May	7 44	0 59
June	7 47	0 48
July	7 57	0 53
August	7 28	0 44
September	7 42	1 29
October	8 08	5 00
November	8 40	3 28
December	9 34	3 03
Summer	$7^h 45^m$	$1^h 12^m$
Winter	9 00	3 07
Year	8 14	1 54

The above times are generally correct within two minutes (according to the formulæ). The morning hour of average daily horizontal force is less variable in the course of a year than the afternoon hour.

The following table contains the computed diurnal variation of the horizontal force. The values have been expressed in absolute measure. It compares directly with Table IV., which contains the observed values. It will be useful for the interpolation of observations, or for their reduction to the mean value of the day from observations taken at irregular hours. The table also forms the basis for the construction of diagram G.

TABLE XI.—COMPUTED SOLAR-DIURNAL VARIATION OF THE HORIZONTAL FORCE IN ABSOLUTE MEASURE.

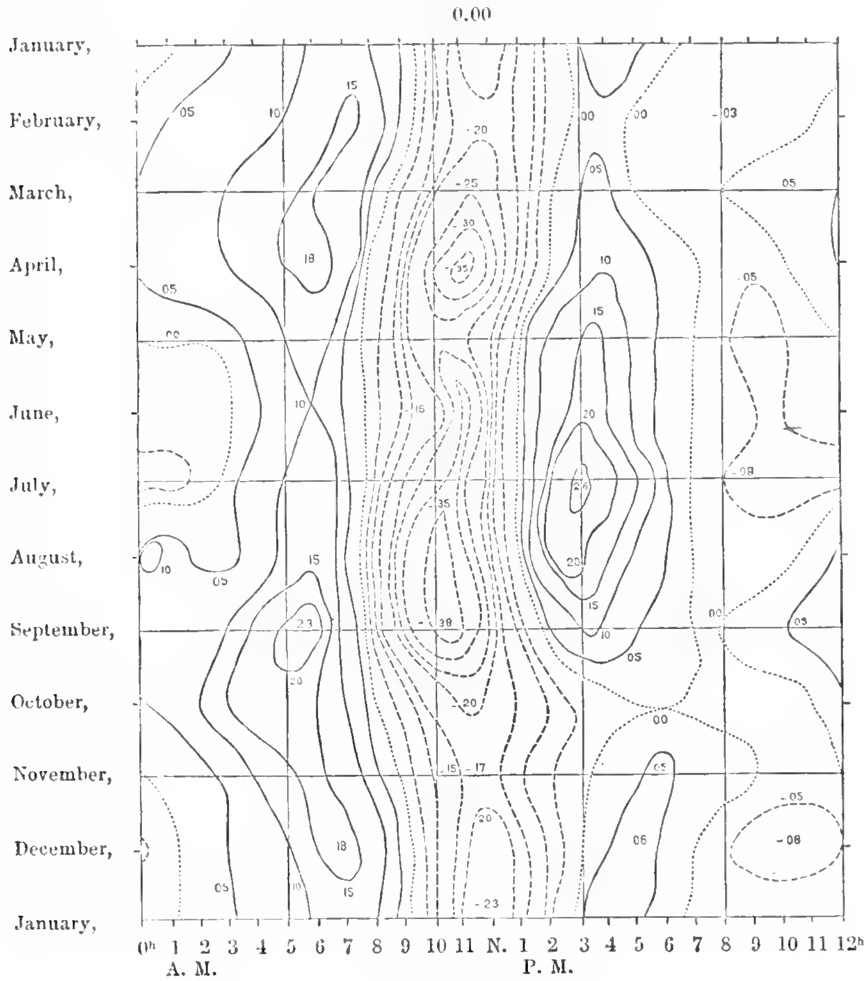
The first two places of decimals (0.00) are placed in front of the table.

	1840–1845.	0^h	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	$+21\frac{1}{2}^m$
	July	—061	—061	—030	+015	+091	+137	+137	+046	—107	—244	—290	—244	
	August	+122	+061	+030	+030	+061	+122	+122	+015	—167	—335	—381	—274	
	September	+061	+061	+061	+107	+182	+229	+198	+061	—152	—320	—381	—320	
	October	+046	+091	+122	+167	+182	+182	+137	+076	—030	—122	—182	—213	
	November	000	+015	+030	+061	+107	+152	+152	+122	+030	—061	—137	—167	
0.00	December	—046	000	+030	+061	+091	+137	+167	+182	+122	+015	—122	—229	
	January	—030	000	+030	+046	+061	+091	+107	+122	+091	—015	—137	—229	
	February	+030	+061	+076	+076	+091	+107	+137	+152	+137	+015	—107	—182	
	March	+046	+061	+076	+107	+107	+137	+137	+122	+030	—076	—198	—244	
	April	+061	+076	+091	+107	+137	+167	+182	+122	—015	—198	—320	—351	
	May	000	000	000	+030	+061	+107	+107	+046	—076	—198	—244	—182	
	June	—015	—030	—030	000	+046	+091	+091	+046	—061	—152	—182	—305	

	1840–1845.	12^h Noon.	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	$+21\frac{1}{2}^m$
	July	—091	+076	+213	+259	+229	+152	+046	—015	—061	—091	—076	—076	
	August	—091	+107	+213	+198	+152	+076	+030	—015	—030	—046	—015	+015	
	September	—152	—015	+091	+107	+076	+046	+015	000	+030	+030	+046	+076	
	October	—182	—137	—076	—030	—015	000	000	—015	—015	—030	—015	+015	
	November	—137	—091	—046	000	+030	+046	+046	+030	+015	000	—015	—015	
0.00	December	—244	—182	—076	+015	+061	+061	+015	—015	—046	—061	—076	—061	
	January	—229	—137	—030	+061	+076	+046	+015	—015	—030	—015	—015	—030	
	February	—182	—107	—030	+015	+015	—015	—030	—030	—030	—015	—015	000	
	March	—198	—107	000	+046	+015	—015	—046	—030	+015	+046	+046	+046	
	April	—274	—137	000	+076	+091	+061	+030	000	—030	—030	000	+030	
	May	—076	+046	+122	+152	+122	+076	+030	—015	—046	—061	—046	—015	
	June	—046	+061	+137	+167	+137	+076	+030	—015	—030	—046	—030	—015	

Diagram G exhibits the changes in the horizontal force (in absolute measure) from the monthly normal value for each hour of the day and for each month of the year. The three variables are: the hour of the day, the month of the year, and the difference of the horizontal force from the normal. The contour lines of the magnetic surface differ 0.0005 of horizontal force in absolute measure. Full lines indicate greater value, lines of dashes less value than the mean; dotted lines represent the normal value.

(G.)—Changes of the Horizontal Force from its Normal Value, for each Hour of the Day and Month of the Year. Expressed in absolute measure.



Philadelphia mean time.

Annual Variation of the Horizontal Force.—For the discussion of the annual variation we make use of the monthly normal readings of the horizontal force as given in Table II. If m equals the monthly effect of the total progressive change, we obtain from the twelve equations by the usual method the value $m = + 15.49$, and the correction for progressive change for July and June, for instance, becomes $+ 5.5\ m$ and $- 5.5\ m$ respectively. The following table contains the monthly normals uncorrected and corrected for progressive change; also the differences from the mean for each month, constituting the annual variation.

TABLE XII.

MONTH.	Normals.	Corrected for progressive change.	Corrected normals.	Differences, or annual variation.		
					0.000	0.00
July	676.3	+85.2	761.5	+10.6	+39	+16
August	702.2	+69.7	771.9	+ 0.2	+01	+00
September . . .	724 6	+54.2	778.8	— 6.7	—24	—10
October . . .	738.2	+38.7	776.9	— 4.8	—17	—07
November . . .	738.5	+23.2	761.7	(+10.4)	(+38)	(+16)
December . . .	768.4	+ 7.7	776.1	— 4.0	—15	—06
January . . .	793.3	— 7.7	785.6	—13.5	—49	—20
February . . .	800.6	—23.2	777.4	— 5.3	—19	—08
March	805.7	—38.7	767.0	+ 5.1	+19	+08
April	828.3	—54.2	774.1	— 2.0	— 7	—03
May	832.2	—69.7	762.5	+ 9.6	+35	+15
June	856.8	—85.2	771.6	+ 0.5	+02	+01
Mean	772.1	0.0	772.1	In scale divisions.	In parts of the horizontal force	In absolute measure.

With the exception of the month of November, the values given above for the annual variation are tolerably regular in their progression, and considering the delicacy of the test applied to the observations in deducing the annual variation, this exceptional irregularity in the November value will not affect the general conclusion. We have as the general result: a greater horizontal force in summer (from April to August), and a smaller horizontal force in winter (from September to March) than the average annual value. The maximum occurs in July (at Toronto in June), and the minimum in January (at Toronto in December).

For Toronto we have the expression for the annual variation:—

$$3.531 + 0.002 \, sin \, (\theta + 312^\circ).$$

For Philadelphia (omitting the November value):

$$4.176 + 0.001 \, sin \, (\theta + 306^\circ);$$

the angle θ in both equations counting from January 15th.

The annual range is 0.0021 (in absolute measure). The transition appears to take place about the time of the equinoxes or a short time before.

Table XIII. contains the monthly normal values of the horizontal force in absolute measure, obtained by adding (algebraically) 4.1730 to the values in the last column of Table XII. These numbers, it will be observed, are corrected for secular change; if we apply the same we obtain the resulting monthly mean values of the horizontal force answering to the epoch January, 1843. The quantity A, mentioned in the explanatory remarks to Table VII., is given in the last column of Table XIII.

TABLE XIII.

Month.	Normals corrected for secular change.	Monthly means (affected with secular change).
July	4.1746	4.1759
August	4.1730	4.1740
September	4.1720	4.1727
October	4.1723	4.1728
November	4.1746	4.1749
December	4.1724	4.1725
January	4.1710	4.1709
February	4.1722	4.1719
March	4.1738	4.1733
April	4.1727	4.1720
May	4.1745	4.1735
June	4.1731	4.1718
Mean	4.1730	4.1730

PART VI.

INVESTIGATION

OF THE

LUNAR INFLUENCE ON THE MAGNETIC HORIZONTAL FORCE.

INVESTIGATION

OF THE

INFLUENCE OF THE MOON ON THE MAGNETIC HORIZONTAL FORCE.

THE method pursued in the investigation of the lunar effect on the horizontal force is, in general, the same as that explained in Part III. of the discussions of the Girard College observations. The process may be briefly recapitulated as follows: Each horizontal force observation, after it had been corrected for the effect of difference from the standard temperature and for progressive change, the disturbed readings being omitted (as fully explained in Part IV.), was marked with its corresponding lunar hour; the observation nearest to the time of the moon's upper transit over the true meridian of the observatory was marked 0^h, that nearest to the lower transit was marked 12^h, and the observations between, for western and eastern hour angles of the moon, were marked with the proper lunar hour by interpolation. In the hourly series where thirteen observations are recorded in twelve lunar hours, that observation which is nearest midway between any two consecutive lunar hours was omitted. Each observation and reduced reading thus marked with its corresponding lunar hour was subtracted from the monthly normal belonging to its respective hour, and these differences were set down in tabular form, arranged according to lunar hours and keeping each monthly result separate for future combination. Let n = any normal belonging to any reduced reading r, the following tables contain the mean monthly values of the differences $n - r$; a positive sign, therefore, indicates greater force, a negative sign less force than the normal. It need hardly be repeated that in the original record of the horizontal force increasing numbers denote a decrease of the force. The greatest possible difference is 33, the number of scale divisions, which, according to the criterion, separates a disturbed from an undisturbed observation. For the formation of these differences which amount to more than 22,000, the manuscript tables of the reduced record were used: these tables have already been referred to in the preceding Part IV.

The units in which the differences $n - r$ are expressed are scale divisions, one division being equal 0.0000365 parts of the horizontal force, or equal to 0.000152 in absolute measure, the mean X being = 4.173 (in units of grains and feet).

The lunar effect on terrestrial magnetism being exceedingly minute, the process required for its elucidation is proportionally delicate; all the regular and irregular deviations arising from other sources must first be eliminated. In the method, as indicated above, the magnetic disturbances (as far as they could be recognized as such), the diurnal and annual solar variation, as well as the eleven (or ten) year inequality and secular change, are all eliminated, leaving numbers fitted for the lunar research.

The readings taken in the month of June, 1840, have not been used in this discussion (these had likewise been rejected in the two preceding parts), on account of the imperfect manner in which the allowance for the progressive change could only be made at that time. For the lunar hour 21 in July, 1840, the number of differences is so small that the mean had necessarily to be reduced; one-fourth of its amount was set down in the table. In January, February, and March, 1843, the observations were discontinued, excepting a single daily reading. These months, therefore, do not occur in the lunar discussion.

The number of observations used are distributed over the several months and years, as shown in the following table.

TABLE I.—NUMBER OF OBSERVATIONS FOR LUNAR DISCUSSION.

MONTH.	1840–1841.	1841–1842.	1842–1843.	1843–1844.	1844–1845.	Sum.
July	157	297	284	294	627	1659
August	235	295	318	313	622	1783
September	258	269	265	296	556	1644
October	255	281	257	*602	597	1992
November	245	279	297	603	564	1988
December	199	297	318	603	559	1976
January	179	298	- - - -	621	601	1699
February	238	250	- - - -	575	541	1604
March	260	297	- - - -	576	601	1734
April	262	271	286	586	575	1980
May	264	271	299	623	612	2069
June	212	295	309	579	522	1917
Sum	2764	3400	2633	6271	6977	22045

TABLE II.—DISTRIBUTION OF THE NUMBER OF OBSERVATIONS ACCORDING TO WESTERN AND EASTERN HOUR ANGLES OF THE MOON.

YEAR.	Western hour angles.	Eastern hour angles
1840–41	1371	1393
1841–42	1688	1712
1842–43	1320	1313
1843–44	3138	3133
1844–45	3499	3478
Sum	11016	11029

Tables III., IV., V., VI. and VII. contain the monthly and annual means of the lunar diurnal variation for the years 1840 to 1845. The numbers are expressed in scale divisions.

* Commencement of the hourly series.

TABLE III.—DIFFERENCES FROM THE MONTHLY NORMALS, 1840–41, WESTERN HOUR ANGLES OF THE MOON.

1840–41.	0h Up. cul.	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h
July	+2	+1	+3	—9	+3	+7	—1	—17	+12	—4	—3	— 8
August	0	—4	+3	—5	+6	+2	—4	— 4	— 2	+2	+5	— 1
September	—2	0	+8	+1	0	—4	—5	+ 2	— 4	—7	+8	+ 4
October	—3	—1	—1	+[illegible]	0	—4	—4	+ 1	— 7	+7	+4	+10
November	—6	+3	0	—4	+1	—5	+4	— 4	— 4	+1	+6	— 1
December	—4	—3	+3	+4	+2	—7	—5	— 3	0	+3	—8	+ 9
January	+1	+3	—1	+8	—7	+3	—8	+ 1	— 9	—4	0	+ 2
February	+7	+5	0	+6	—3	+4	—2	0	— 4	0	—2	0
March	—4	+4	+1	0	+3	+3	—7	— 1	+ 8	+1	+3	— 2
April	0	+6	+1	—2	—2	—1	—1	+ 3	— 1	—2	+1	— 1
May	+3	—3	+1	—1	—8	+2	—1	— 1	— 6	0	+2	— 5
June	—1	—5	0	—3	+4	+4	+5	+ 8	— 1	+1	—1	— 8
Mean	—0.4	+0.5	+1.5	—0.3	—0.1	+0.3	—2.4	— 1.3	— 1.5	—0.2	+1.3	— 0.1

1840–41.	12h Low. cul.	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
July	+11	— 9	—5	+ 2	+6	0	— 2	— 5	+6	— 5	—4	— 2
August	+ 7	+ 6	+9	+ 1	+5	+2	+ 5	— 3	+5	—11	0	— 2
September	— 2	— 1	+2	+ 6	+5	+4	— 4	+ 1	—2	— 3	—1	— 2
October	—16	+14	—9	+ 4	—7	+3	—10	— 2	—1	+ 6	—3	+ 5
November	— 2	+ 1	—1	+ 4	—6	0	+ 1	— 1	+4	+ 6	+1	+ 5
December	+ 6	+ 9	+2	+10	—3	+2	— 6	—12	—3	— 6	+3	+ 5
January	— 2	— 4	+3	— 1	+1	—1	+ 4	— 2	—2	+ 1	+3	+ 7
February	— 5	+ 4	—4	— 7	—6	+5	+ 1	+ 2	+1	— 5	+3	+ 4
March	— 4	0	—5	+ 2	—1	+4	—10	+ 2	—2	— 2	+2	+ 2
April	— 1	— 3	+3	— 8	—3	—4	0	+ 3	—2	+ 2	+4	+ 2
May	+ 8	— 3	0	— 3	0	0	— 2	+ 8	+3	— 2	—2	+ 2
June	+ 8	— 4	+6	— 5	+7	—8	— 5	— 7	0	— 7	+1	—11
Mean	+ 1.0	+0.8	+0.1	+ 0.4	—0.2	+0.6	— 2.3	— 1.3	+0.6	— 2.1	+0.6	+ 1.2

TABLE IV.—DIFFERENCES FROM THE MONTHLY NORMALS, 1841–42, WESTERN HOUR ANGLES OF THE MOON.

1841–42.	0^h Up. cul.	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h
July	+4	+5	0	+8	—4	0	0	—2	0	—8	+2	0
August	—1	0	— 2	+2	+2	+3	+3	0	—5	0	+1	+ 5
September	—3	+8	+ 2	—1	0	—1	—5	—3	+1	0	—3	+10
October	+7	—1	+ 4	+4	0	+1	—1	+4	+1	—2	0	+ 1
November	0	+6	— 3	+1	—7	0	—3	—1	+6	+3	+1	+ 3
December	+8	—4	+12	—2	—1	—3	+2	—3	—2	—1	—3	0
January	—2	+8	+ 2	+2	—1	+7	0	+3	—2	+1	+5	0
February	—5	+1	— 1	—3	+4	+2	+4	—7	—5	+5	0	+ 2
March	+4	+3	+ 2	—1	+2	—1	+2	0	—1	—1	—2	— 3
April	0	0	+ 1	0	0	+4	+1	+3	+2	—1	0	+ 1
May	0	—2	+10	+1	+5	+4	+6	—4	+5	—7	—3	— 4
June	+1	0	+ 3	0	+4	—3	—1	—3	—5	—5	0	— 3
Mean	+1.1	+2.0	+ 2.5	+0.9	+0.3	+1.1	+0.7	—1.1	—0.4	—1.3	—0.2	+ 1.0

1841–42.	12^h Low. cul.	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h
July	+3	—5	+3	+5	+1	—1	—8	—4	+1	—1	—1	+3
August	+1	+3	0	+2	+1	—5	—1	+3	—4	—3	—5	—1
September	+3	+2	+2	—6	+5	—1	—5	—2	+1	+4	—5	+6
October	+3	—1	—3	—5	—4	—3	+7	—3	—1	—3	—1	+1
November	—1	+4	+3	—6	—1	—5	+1	—2	0	—3	—4	—3
December	—1	0	—1	+2	—4	—3	—1	+1	+1	+1	+6	+1
January	+4	—2	—2	—4	—1	—5	—3	—3	+5	0	—3	+2
February	+7	+1	+1	—2	—3	0	—8	+6	—7	+1	+3	+2
March	—2	+3	—2	0	—6	—1	0	—2	—1	+2	—6	—1
April	+1	+1	+3	—3	+1	—1	—3	+2	—5	—3	—2	+1
May	0	—5	—3	—3	+4	—6	+6	—4	0	+3	+4	+2
June	—4	—2	—4	+2	0	+2	+2	+6	+6	—2	+2	+4
Mean	+1.2	—0.1	—0.2	—1.5	—0.6	—2.4	—1.1	—0.2	—0.3	—0.3	—1.0	+1.4

TABLE V.—DIFFERENCES FROM THE MONTHLY NORMALS, 1842–43, WESTERN HOUR ANGLES OF THE MOON.

1842–43.	0^h Up. cul.	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h
July	+3	—3	+2	— 1	+1	0	+7	+2	0	—4	+1	—8
August	+3	+1	—3	0	—1	—4	—3	+4	+2	+1	+1	+3
September	+3	—6	—1	+ 9	+4	—1	+7	+1	0	+2	—3	0
October	+2	—7	0	+ 1	—6	+3	—1	+3	—3	+5	—3	+2
November	+1	+3	—1	+ 2	+1	+1	0	—2	—2	—1	—4	+1
December	—2	—3	—6	+ 1	—5	0	—2	0	+1	—1	+5	0
January	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
February	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
March	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
April	—1	+2	0	+10	+4	+9	—1	+1	—3	—1	+1	—4
May	+3	—2	+2	+ 5	+3	+4	—1	+9	—1	+1	—6	+3
June	—6	+7	—4	— 1	0	+2	0	—1	—5	+4	—1	+3
Mean	+0.7	—0.9	—1.0	+ 2.9	+0.1	+1.6	+0.7	+1.9	—1.2	+0.7	—1.0	0.0

1842–43.	12^h Low. cul.	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h
July	+1	+1	+4	—2	+4	—3	—4	—1	0	—2	+ 3	—1
August	—2	+1	+1	+2	+2	—4	+3	—5	—1	+2	+ 2	—2
September	+6	—1	—1	—8	—3	—1	—4	—1	—2	—7	+ 1	—6
October	—7	—3	+2	—1	+1	0	—1	+4	+4	—3	+11	+3
November	—2	—2	—1	—3	+1	+4	—1	+6	0	+1	+ 1	+2
December	+3	+3	+2	+1	+3	0	+1	+2	—2	+4	— 3	+3
January	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
February	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
March	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
April	+2	—2	+3	+2	0	—2	—5	0	—3	—2	+1	—1
May	0	+1	+4	0	+1	—4	—3	—1	—1	—1	—1	—2
June	0	+3	—1	+4	—2	+2	—3	—3	+2	+1	—7	+4
Mean	+0.1	+0.1	+1.4	—0.6	+0.8	—0.9	—1.9	+0.1	—0.3	—0.8	+0.9	0.0

TABLE VI.—DIFFERENCES FROM THE MONTHLY NORMALS, 1843–44, WESTERN HOUR ANGLES OF THE MOON.

1843–44.	0^h Up. cul.	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h
July	+6	+4	+2	+4	+5	—4	+3	+1	+1	—2	—5	—2
August	+2	+2	0	—1	+2	+1	—3	+4	0	—1	—2	—2
September	+1	—1	—3	+6	0	—2	—1	—4	—1	0	—2	0
October	—1	+4	+3	+5	+2	+3	+2	+1	0	—2	—1	—3
November	+1	+1	0	0	0	0	0	—2	0	0	+1	+1
December	+2	+1	+2	0	0	—2	—1	—1	—1	—2	+1	—1
January	+1	0	0	0	—1	—1	+1	+1	+1	0	—1	0
February	—1	—1	+1	+2	+1	—1	0	0	+3	0	—1	+2
March	—1	—3	+1	+1	+1	+1	+2	+2	0	+2	+1	+1
April	+2	+2	+3	+2	0	0	+1	+1	—1	—2	—3	—2
May	—2	—2	0	—1	—2	0	—1	—1	—2	—1	0	—1
June	0	—2	0	0	+2	+2	+2	+2	+1	—1	—2	0
Mean	+0.9	+0.4	+0.8	+1.5	+0.9	—0.3	+0.4	+0.3	+0.1	—0.8	—1.2	—0.6

1843–44.	12^h Low. cul.	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h
July	—2	—7	—2	—3	+3	—1	+4	—2	+1	—1	+2	+2
August	+4	0	+2	—1	—2	0	+2	+1	+1	—2	+4	0
September	+3	0	+3	+3	+8	+2	—6	—1	—6	—3	—2	0
October	—3	—4	—2	—1	—2	0	0	—1	—1	+1	—2	—1
November	+1	+2	+2	+2	+2	0	—1	—2	—1	—1	0	—1
December	0	+1	+1	0	+1	—1	—3	—4	—4	—3	—2	0
January	+1	+2	—1	—1	—1	—2	0	—1	+1	+2	+1	+2
February	+2	+1	+1	+2	+2	—3	—2	+1	—2	—1	—1	—2
March	+1	0	—1	0	0	0	—1	—1	—1	—1	+1	—3
April	—4	0	0	0	+2	0	0	+1	0	0	—1	0
May	0	0	—2	0	0	—2	—3	+1	+1	+1	+2	+1
June	0	+2	+1	+3	+2	0	—1	0	0	—1	—2	0
Mean	+0.3	—0.2	+0.2	+0.3	+1.3	—0.6	—0.9	—0.7	—0.9	—0.8	0.0	—0.2

Equal weight has been given to each monthly result in the formation of the annual mean.

TABLE VII.—DIFFERENCES FROM THE MONTHLY NORMALS, 1844–45, WESTERN HOUR ANGLES OF THE MOON.

1844–45.	0h Up. cul.	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h
July	0	+1	+1	+1	0	+1	+2	+2	0	+1	0	−2
August	−3	+1	−1	0	+2	0	+1	+3	+1	−3	−2	+1
September	−2	0	−1	0	−2	+2	0	+3	+2	+2	+2	+4
October	0	+4	+5	+2	+3	+4	+2	0	0	+1	−3	0
November	−1	+3	+1	+2	+1	+3	+3	+3	+3	+3	+2	−1
December	−1	0	−1	0	−2	−3	−3	−2	−1	−1	+1	−1
January	+1	+2	+4	−2	−3	−4	−1	−3	0	−1	+4	+2
February	+1	+1	0	0	+1	+1	+1	+2	−1	−2	0	+4
March	+1	−3	−3	−3	0	0	+1	+1	0	+1	+1	0
April	−4	+2	+2	+2	0	+2	0	+2	−2	−2	−1	−1
May	+2	0	+2	+2	0	−2	0	−1	−2	−2	+1	0
June	−5	−4	−3	−1	0	+3	+1	+1	+1	0	−5	−4
Mean	−0.9	+0.6	+0.5	+0.3	0.0	+0.6	+0.6	+0.9	+0.1	−0.3	0.0	+0.2

1844–45.	12h Low. cul.	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
July	0	0	+1	0	−1	0	0	0	−2	−2	−2	−3
August	+3	+2	+3	−1	0	−2	0	0	−3	−3	0	−2
September	+2	+3	+1	+1	−1	−2	−3	−3	−4	−3	−4	−4
October	+1	+2	+1	+2	0	−2	−2	−4	−4	−5	0	−2
November	−1	−4	0	−2	0	0	−3	−2	−1	+1	−4	−3
December	+1	0	−1	+2	0	+2	+2	+1	0	+3	+2	0
January	+4	0	+2	−1	−5	−4	−4	−4	0	+2	+1	+2
February	+1	+2	+1	−1	−3	−1	−2	−1	−5	−1	−1	−1
March	+1	+2	−1	0	+4	+3	+2	+1	−3	−2	−1	−3
April	−2	+1	0	0	+1	+1	+3	−1	−3	−4	−3	−4
May	+1	−2	−2	−2	−2	0	−1	0	+1	−3	0	+2
June	+1	−1	+1	+2	−1	+4	+4	+3	+2	+2	0	−1
Mean	+1.0	+0.4	+0.5	0.0	−0.7	−0.1	−0.3	−0.8	−1.8	−1.2	−1.0	−1.6

TABLE VIII.—RECAPITULATION OF THE ANNUAL MEANS EXHIBITING THE LUNAR-DIURNAL VARIATION, FROM 22,045 OBSERVATIONS BETWEEN 1840 AND 1845, EXPRESSED IN SCALE DIVISIONS.

July to July.	0h Up. cul.	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h
1840–41	−0.4	+0.5	+1.5	−0.3	−0.1	+0.3	−2.4	−1.3	−1.5	−0.2	+1.3	−0.1
1841–42	+1.1	+2.0	+2.5	+0.9	+0.3	+1.1	+0.7	−1.1	−0.4	−1.3	−0.2	+1.0
1842–43	+0.7	−0.9	−1.0	+2.9	+0.1	+1.6	+0.7	+1.9	−1.2	+0.7	−1.0	0.0
1843–44	+0.9	+0.4	+0.8	+1.5	+0.9	−0.3	+0.4	+0.3	+0.1	−0.8	−1.2	−0.6
1844–45	−0.9	+0.6	+0.5	+0.3	0.0	+0.6	+0.6	+0.9	+0.1	−0.3	0.0	+0.2
Mean	+0.3	+0.5	+0.9	+1.1	+0.2	+0.7	0.0	+0.1	−0.6	−0.4	−0.2	+0.1

July to July.	12h Low. cul.	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
1840–41	+1.0	+0.8	+0.1	+0.4	−0.2	+0.6	−2.3	−1.3	+0.6	−2.1	+0.6	+1.2
1841–42	+1.2	−0.1	−0.2	−1.5	−0.6	−2.4	−1.1	−0.2	−0.3	−0.3	−1.0	+1.4
1842–43	+0.1	+0.1	+1.4	−0.6	+0.8	−0.9	−1.9	+0.1	−0.3	−0.8	+0.9	0.0
1843–44	+0.3	−0.2	+0.2	+0.3	+1.3	−0.6	−0.9	−0.7	−0.9	−0.8	0.0	−0.2
1844–45	+1.0	+0.4	+0.5	0.0	−0.7	−0.1	−0.3	−0.8	−1.8	−1.2	−1.0	−1.6
Mean	+0.7	+0.2	+0.4	−0.3	+0.1	−0.7	−1.3	−0.6	−0.5	−1.0	−0.1	+0.2

If we give weight to the annual means according to the number of observations, they would be; one for the first and second year, three-fourths for the third year, one and three-fourths for the next year, and two for the last year: a general examination, however, shows that, owing to the disturbing effect of the progressive change, the monthly means are very nearly of equal value, derived either from the bi-hourly or the hourly series. It will also be shown in the sequel that the lunar diurnal variation is nearly the same in the summer and winter seasons; the means of Table V. and the final means of Table VIII. have therefore been adopted without reference to combinations or weights.

A comparison of the values of Table VIII. among themselves shows them to be very irregular, although derived from many thousand observations; a five year series of observations seems barely sufficient to exhibit a tolerably regular progression. In the following table two groups have been formed, one of results from three years, 1840 to 1843, comprising 8,797 observations, the other from the remaining two years comprising 13,248 observations. From these it appears that the lunar diurnal variation during these two periods exhibits the same general character.

LUNAR-DIURNAL VARIATION DURING THE PERIODS 1840–43 AND 1843–45.

Groups.	0^h	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h
1840–43	+0.5	+0.5	+1.0	+1.2	+0.1	+1.0	—0.3	—0.2	—1.0	—0.3	0.0	+0.3
1843–45	0.0	+0.5	+0.7	+0.9	+0.4	+0.3	+0.5	+0.6	+0.1	—0.6	—0.6	—0.2

Groups.	12^h	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h
1840–43	+0.8	+0.3	+0.4	—0.6	0.0	—0.9	—1.8	—0.5	0.0	—1.2	+0.2	+0.9
1843–45	+0.7	+0.1	+0.4	+0.2	+0.3	—0.4	—0.6	—0.7	—1.3	—1.0	—0.5	—0.9

Before proceeding to the analysis of the final result of Table VIII. the separate results have been combined into summer and winter groups; the first group comprising the months from April to September, the second group the months from October to March.

Table IX. exhibits the lunar diurnal variation of the horizontal force during the summer and winter seasons.

Table IX.—Lunar-Diurnal Variation in Summer.

(In scale divisions.)

Apr. to Sept.	0^h Up. cul.	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h
1840–41	+0.7	−0.9	+2.7	−3.2	+0.5	+1.7	−1.1	−1.5	−0.3	−1.7	+2.0	−3.2
1841–42	+0.2	+1.8	+2.3	+1.7	+1.2	+1.2	+0.7	−1.5	−0.3	−3.5	−0.5	+1.5
1842–43	+0.8	−0.2	−0.7	+3.6	+1.8	+1.7	+1.5	+2.7	−1.2	+0.5	−1.2	−0.5
1843–44	+1.5	+0.5	+0.3	+1.7	+1.2	−0.5	+0.2	+0.5	−0.3	−1.2	−2.3	−1.2
1844–45	−2.0	0.0	0.0	+0.7	0.0	+1.0	+0.7	+1.7	0.0	−0.7	−0.8	−0.3
Mean	+0.2	+0.2	+0.9	+0.9	+0.9	+1.0	+0.4	+0.4	−0.4	−1.3	−0.6	−0.7

	12^h	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h
1840–41	+5.8	−2.3	+2.5	−1.2	+3.2	−1.0	−1.3	−0.5	+1.7	−4.3	−0.3	−2.2
1841–42	+0.7	−1.0	+0.2	−0.5	+2.0	−2.0	−1.5	+0.2	−0.2	−0.3	−1.2	+2.5
1842–43	+1.2	+0.5	+1.7	−0.3	+0.3	−2.0	−2.7	−1.8	−0.8	−1.5	−0.2	−1.3
1843–44	+0.2	−0.8	+0.3	+0.3	+2.2	−0.2	−0.7	0.0	−0.5	−1.0	+0.5	+0.5
1844–45	+0.8	+0.5	+0.7	0.0	−0.7	+0.2	+0.5	−0.2	−1.5	−2.2	−1.5	−2.0
Mean	+1.7	−0.6	+1.1	−0.3	+1.4	−1.0	−1.1	−0.5	−0.3	−1.9	−0.5	−0.5

Lunar-Diurnal Variation in Winter.

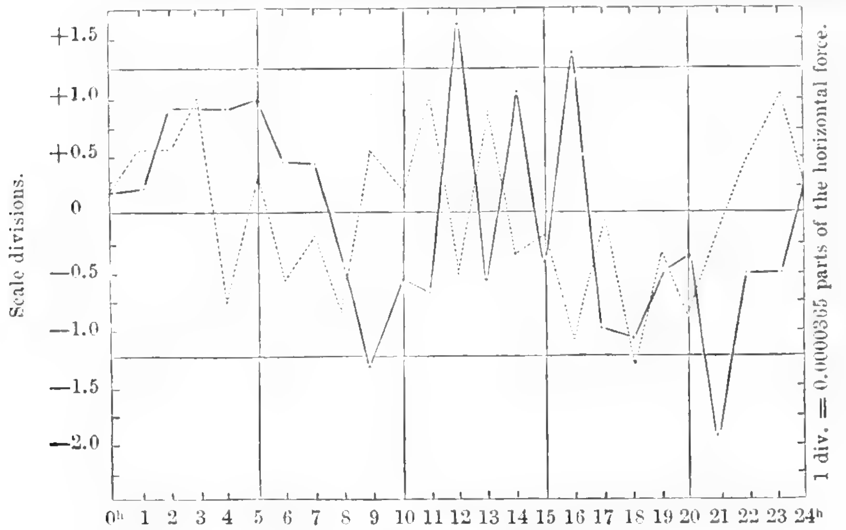
(In scale divisions.)

Oct. to Mar.	0^h Up. cul.	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h
1840–41	−1.5	+1.8	+0.3	+2.5	−0.7	−1.0	−3.7	−1.0	−2.7	+1.3	+0.5	+3.0
1841–42	+2.0	+2.2	+2.7	+0.2	−0.5	+1.0	+0.7	−0.7	−0.5	+0.8	+0.2	+0.5
1842–43	+0.3	−2.3	−2.3	+1.3	−3.3	1.3	−1.0	+0.3	−1.3	+1.0	−0.7	+1.0
1843–44	+0.2	+0.3	+1.2	+1.3	+0.5	+0.0	+0.7	+0.2	+0.5	−0.3	0.0	0.0
1844–45	+0.2	+1.2	+1.0	−0.2	0.0	+0.2	+0.5	+0.2	+0.2	+0.2	+0.8	+0.7
Mean	+0.2	+0.6	+0.6	+1.0	−0.8	+0.3	−0.6	−0.2	−0.8	+0.6	+0.2	+1.0

	12^h	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h
1840–41	−3.8	+4.0	−2.3	+2.0	−3.7	+2.2	−3.3	−2.2	−0.5	0.0	+1.5	+4.7
1841–42	+1.7	+0.8	−0.7	−2.5	−3.2	−2.8	−0.7	−0.5	−0.5	−0.3	−0.8	+0.3
1842–43	−2.0	−0.7	+1.0	−1.0	+1.7	+1.3	−0.3	+4.0	+0.7	+0.7	+3.0	+2.3
1843–44	+0.3	+0.3	0.0	+0.3	+0.3	−1.0	−1.2	−1.3	−1.3	−0.5	−0.5	−0.8
1844–45	+1.2	+0.3	+0.3	0.0	−0.7	−0.3	−1.2	−1.5	−2.2	−0.3	−0.7	−1.2
Mean	−0.5	+0.9	−0.3	−0.2	−1.1	−0.1	−1.3	−0.3	−0.8	−0.1	+0.5	+1.1

The results are exhibited in the annexed diagram. The number of observations (about 11,000 for each group) is evidently too small to eliminate the greater irregularities.

(A.)—LUNAR-DIURNAL VARIATION OF THE HORIZONTAL FORCE IN SUMMER AND WINTER.



U. C. (Western hour angles of the moon.) L. C. (Eastern hour angles of the moon.) U. C.

——— summer deflection.
- - - - - - - winter deflection.

If there is any marked difference in the lunar diurnal variation in the summer and winter season, the summer range is slightly greater than the winter range; as to the epoch, there is no doubt that in winter the lunar maxima and minima are earlier than in summer. It is a remarkable fact that we have found the same features in the lunar effect on the declination, viz., a greater amplitude in summer and an earlier occurrence of the maxima and minima in winter; the amount of the shifting of the two curves appears to be nearly the same. From the ten year series of observations at Prague (1840–49) Mr. Karl Kreil found a larger lunar effect in the summer months than in the winter months.

Recurring to the final values of the lunar-diurnal variation of the horizontal force, as given in Table VIII., they can be represented by the usual Besselian form of periodic functions.

The angle θ counts from the moon's upper culmination westward at the rate of 15° to an hour; a + sign indicated greater, a — sign, less force than the average normal. The observed values are represented by the following expression:—

$$H_{☾} = -0.01 + 0.40 \sin(\theta + 13^\circ 29') + 0.60 \sin(2\theta + 38^\circ 43') + 0.155 \sin(3\theta + 244^\circ 31').$$

The three coefficients are expressed in scale divisions; if expressed in parts of the horizontal force the equation may be written as follows: (M signifies millionth parts of the force.)

$$H_{☾} = -\overset{M}{0.36} + \overset{M}{14.60} \sin(\theta + 13^\circ.5) + \overset{M}{21.90} \sin(2\theta + 38^\circ.7) + \overset{M}{5.64} \sin(3\theta + 244^\circ.5.)$$

If expressed in absolute measure and if n = number of hours after the upper culmination, it may be written

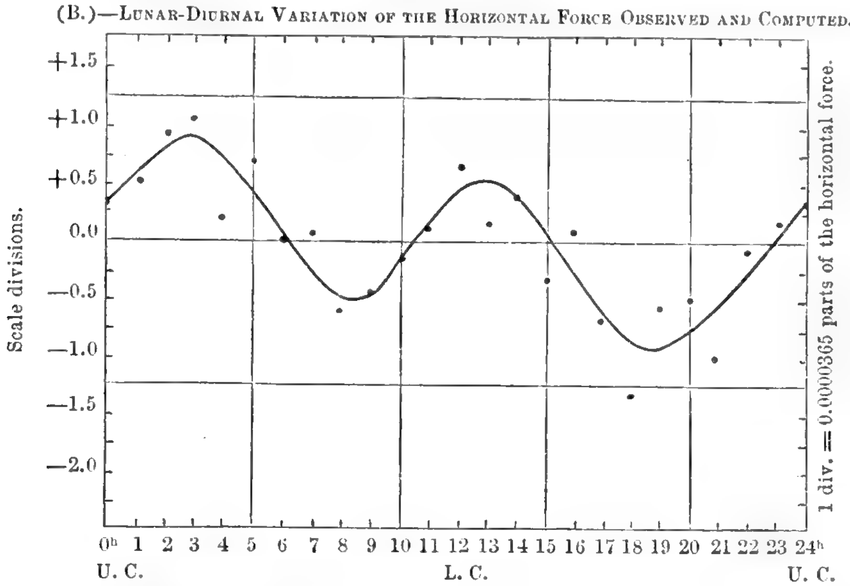
$$H_{☾} = -\overset{M}{1.5} + \overset{M}{61.0} \sin(15n + 13^\circ.5) + \overset{M}{91.5} \sin(30n + 39^\circ) + \overset{M}{23.6} \sin(45n + 244^\circ.5.)$$

The curve is double-crested and is exhibited, together with the observed values, in the annexed diagram. It presents two maxima and two minima, which are found from the equation

$$\frac{d\,H}{d\,\theta} = 0 = +\,0.40\,cos\,(\theta + 13^\circ) + 1.20\,cos\,(2\,\theta + 39^\circ) + 0.45\,cos\,(3\,\theta + 245^\circ).$$

The lunar effect on the declination we have found likewise to present two maxima and two minima. (See Part III. of the discussion.)

(B.)—Lunar-Diurnal Variation of the Horizontal Force Observed and Computed.



We find:	Principal maximum	$2^h\ 52^m$ after	Upper Culmination;	+ 0.87	scale divisions.
	Secondary "	1 7 "	Lower "	+ 0.51	" "
	Principal minimum	6 41 "	" "	— 0.87	" "
	Secondary "	8 19 "	Upper "	— 0.45	" "

The epoch of the horizontal force tide for the high values is nearly 2 hours after the culminations, and for the low values it is $7\frac{1}{2}$ hours after the same phases.

For Makerstoun, in Scotland, at General Sir Thomas M. Brisbane's observatory, in 1843–46, Mr. J. A. Broun found (Trans. Royal Society of Edinburgh, Vol. XIX. p. 11, 1849) the smaller maximum of the horizontal force 2 hours after upper culmination, the greater maximum $1\frac{1}{4}$ hours after the lower culmination, the smaller minimum 8 hours after the upper culmination, and the greater minimum 9 hours after the lower culmination.

At Prague all extremes appear from 2 to 3 hours later. Mr. Karl Kreil (Denkschriften of the Imperial Academy of Sciences, at Vienna, Vol. V. 1853), found from the ten year series at Prague (1840—49) maxima of horizontal force between four and five hours after the upper and lower culminations, the latter being the greater of the two; and minima between ten and eleven hours after the same epoch, that after the upper culmination being the greater of the two.

From the Toronto observations, continued for five years, Major-General Sabine deduced the formula (see Vol. III. of the Toronto Magnetical and Meteorological Observations, London, 1857).

$$\Delta_x = +\,0.05 + 0.215\,sin\,(\alpha + 353^\circ.6) + 0.3324\,sin\,(2\,\alpha + 13^\circ.5).$$

The coefficients are in decimals of scale divisions (1 div. = 0.000087) parts of the horizontal force); the angle a counts from the superior culmination, giving a curve of which the general features are in exact accordance with those deduced from the Philadelphia observations, viz: a principal maximum after Upper Culmination, followed by the secondary minimum; the secondary maximum after the Lower Culmination, followed by a principal minimum. The times and amount of these values are compared in the following Table X.

TABLE X.—COMPARISON OF THE LUNAR-DIURNAL VARIATION OF THE HORIZONTAL COMPONENT OF THE MAGNETIC FORCE AS DEDUCED FROM 22,045 OBSERVATIONS BETWEEN 1840 AND 1845 AT PHILADELPHIA, AND AS DEDUCED FROM 34,303 OBSERVATIONS BETWEEN 1844 AND 1848 (A FIVE YEAR SERIES) AT TORONTO, CANADA.

	Philadelphia.	Toronto.
Time of principal maximum	$2^h.9$ after up. cul.	3^h after up. cul.
" " secondary minimum	8.3 " "	9 " "
" " secondary maximum	1.1 " low. cul.	2 " low. cul.
" " principal minimum	6.7 " "	8 " "
	In parts of horizontal force.	
Amount of principal maximum	+0.000032	+0.000046
" " secondary minimum	—0.000016	—0.000010
" " secondary maximum	+0.000019	+0.000024
" " principal minimum	—0.000032	—0.000041
	In absolute measure.	
Amount of principal maximum	+0.000133	
" " secondary minimum	—0.000068	
" " secondary maximum	+0.000078	
" " principal minimum	—0.000133	

Probable error of any single representation of the Philadelphia values = $\pm$ $0^d.25$ = $\pm$ 0.000009 parts of the horizontal force = $\pm$ 0.000038 in absolute measure.

Investigation of the Horizontal Force in Reference to the Lunar Phases.—The following process of reduction has been adopted: After marking the days of the full and new moon, and also the days preceding and following, the daily means of the horizontal force readings were taken (already corrected for difference of temperature and progressive change.) In the place of any disturbed observation, the monthly normal, belonging to the respective hour, was substituted before taking the daily mean. All accidental omissions in the record of the hourly or bi-hourly series were supplied by the hourly normal of the month. The means thus obtained are independent of the solar diurnal variation. The monthly normal was next compared with each daily mean and the differences (normal minus mean) were tabulated.

A positive sign signifies a greater; a negative sign, a less force than the normal value. As the results deduced from a single year are yet too much affected by the incidental irregularities of the observations, the collective results from the five year series (1840–45) are herewith presented.

TABLE XI.—INFLUENCE OF THE LUNAR PHASES ON THE HORIZONTAL FORCE.

	Scale divisions.	Parts of the hor. force	In absolute measure.
One day before full moon	—1.0	—0.000036	—0.00015
On the day of full moon	—1.5	—0.000055	—0.00023
One day after full moon	—0.2	—0.000007	—0.00003
One day before new moon	+0.0	+0.000000	+0.00000
On the day of new moon	+2.4	+0.000091	+0.00038
One day after new moon	+0.9	+0.000033	+0.00014
Difference for new-full moon	3.9	0.000146	0.00061

The average number of observations from which any one of the above six means were deduced, is over 800, and the probable error, in scale divisions, of any one of the results is $\pm$ 0.7 (nearly).

From the Makerstoun observations, Broun found for the years 1843–46, a minimum at the time of the full moon, and a maximum at the time of the new moon; Kreil, from the Prague observations, between 1843–46, found the same result, all in accordance with the Philadelphia results, as given above. It must be remarked, however, that after the year 1848, Kreil found that the signs were reversed and consequently it appears that the lunar influence on the horizontal force is subject to a cycle of short period. This last remark does not apply to the effect of the moon's declination and variations in distance.

Influence of the Moon's Changes of Declination on the Horizontal Force.—The method of investigation is precisely the same as that adopted for the phases. We find:—

TABLE XII.

	Scale divisions.	
One day before the greatest north declination	+0.8	Mean +1.1.
On the day of " " " "	+0.6	
One day after " " " "	+2.2	
Two days after " " " "	+0.9	
On the day of the moon's crossing the equator	—1.2	Probable error of any one result $\pm$0.9.
One day before the greatest south declination	—3.4	Mean —0.6.
On the day of " " " "	—0.9	
One day after " " " "	+0.9	
Two days after " " " "	+1.0	

It seems probable that the greatest effect takes place rather a day after than on the day of the moon's greatest declination. Taking means, as indicated in the above table, we find about the time of the maximum north declination an increase of horizontal force of 1.1 scale divisions (or 0.000040 parts of the horizontal force); at the time of the moon's crossing the equator the force is decreased 1.2 scale divisions (or 0.000044 parts of the horizontal force); the horizontal force also appears decreased about the time of the moon's greatest south declination; the amount is about half that of the other two cases, and is somewhat doubtful, from an apparently excessive value on the preceding day.

According to Broun, there is at Makerstoun a maximum horizontal force at the time of the moon's greatest north and south declination, with a minimum force at the time of her crossing the equator; in two cases, therefore, viz: for north declination and no declination, the Makerstoun and Philadelphia results agree; while in the third case they disagree or remain doubtful. Kreil's results, from the Prague observations, do not appear to me sufficiently decisive and regular to admit of comparison.

Influence of the Moon's Variation in Distance on the Horizontal Force.—By a process of reduction similar to that followed in the preceding investigation we find:—

TABLE XIII.

	Scale divisions.	s. d.
One day before perigee	—1.5	Mean —1.8.
On the day of "	—1.9	
One day after "	—2.0	
One day before apogee	+2.3	Mean —2.4.
On the day of "	+2.3	
One day after "	+2.7	

The probable error of any one result is about the same as in the preceding results (Tables XI. and XII.). The results for variation in the moon's distance are more consistent and satisfactory than those depending on the phases and declination changes. The lunar effect is to diminish the horizontal force by its 0.000066 part in perigee, and to increase it by its 0.000088 part when she is in apogee.

The Prague results are the same, viz: a greater horizontal force at and after the moon's apogee than at and after her perigee; a three years' series of observations at Milan, however, do not agree therewith.

In no branch of magnetic research would additional results from independent observations, particularly at stations widely apart, be more acceptable and valuable than in the study of the lunar effect in its various manifestations.

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RECORDS AND RESULTS

OF A

MAGNETIC SURVEY OF PENNSYLVANIA

AND PARTS OF ADJACENT STATES,

IN

1840 AND 1841, WITH SOME ADDITIONAL RECORDS AND RESULTS OF 1834–35, 1843 AND 1862, AND A MAP.

BY

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CONTENTS.

INTRODUCTION.

In the years 1840 and 1841, I made a detailed magnetic survey of Pennsylvania, and adjacent parts of New York, Ohio, and Maryland, determining at a number of stations, suitably selected with regard to the course of the iso-magnetic lines, the magnetic declination, dip, and intensity; to these I added some dip and intensity observations in 1843, while on a tour through Western New York and Canada.

The total number of declination stations is 16, and of dip and intensity stations 48. On assuming the duties of Superintendent of the U. S. Coast Survey, in 1843, I could not find the necessary leisure to work up these observations, although Mr. J. Ruth and Mr. G. Davidson had commenced preparing, under my direction, a partial abstract confined to dip and intensity observations, and to relative results. In the spring of 1862, I availed myself of the services of Charles A. Schott, assistant in the U. S. Coast Survey, who reduced, under my direction, the observations, discussed the distribution of the three magnetic elements, presenting the latter results also graphically, and prepared this report for the press.

In the summer of 1862, Mr. Schott visited six of the stations previously occupied by me, and redetermined the magnetic elements. Three of these stations falling within the scope of the operations of the U. S. Coast Survey were at the expense of the Coast Survey, the observations at the three Western stations were secured by the liberality of the Secretary of the Smithsonian Institution who, at the same time, offered to publish the observations and results in the Smithsonian Contributions to Knowledge.

The observations of 1862 greatly enhance the value of my older operations, and furnish the means of presenting results for two epochs about 20 years apart, thus not only giving the most modern values, but also determining, by the known secular change of the three elements, any intermediate results.

The fruit of these labors, undertaken for this continent, at a comparatively early period, and comprising the three elements, and the whole conducted systematically, with instruments well constructed for the time, will no doubt afford adequate means of watching, hereafter, the secular changes of terrestrial magnetism within the geographical extent of this survey.

The declinations were determined with a new Gambey declinometer belonging to the Girard College, the astronomical observations were made with a sextant and vertical circle and chronometer (Grant, No. 3861). The dip was determined with a portable circle by Robinson, the total intensity with Lloyd needles by Robinson, and the horizontal intensity by a magnetic bar and cylinder according to the method described by me in the American Phil. Trans., Vol. V, 1837, in which the vibrations are made in a rarified medium.

MAGNETIC SURVEY OF PENNSYLVANIA.

(INCLUDING PART OF OHIO AND MARYLAND.)

FIRST MAGNETIC TOUR OF 1840.

Abstract of Results for Relative Intensity and Dip at 16 Stations.

Philadelphia.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity.
July 16	$9^h\ 30^m$	Cylinder	76°.5	2	360	$34^s.51$	$34^s.480$	1.0000
" "	10 30	Bar	77.5	2	450	36.85	36.775	1.0000

Date.	Time.	Needle.	Dip.
July 21		No. 1	71° 51′.7
" "		No. 2	71 51.7
	Mean . . .		71 51.7

Cumulus, wind N. W.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 21		No. 1	71° 55′.8	76°.5	—1°09′.9	71° 51′.4	1.0453
" "		No. 3	71 50.1	77.0	+1 09.1	57.4	1.0586
				Mean . . .		71 54.4	1.0520

Lloyd Needle No. 1, weight in third hole of S. pole, or end B.
No. 3, Weight in last hole.
(Old weights.)

$$\text{Relative total intensity} = \frac{\cos.\ \theta}{\sin.\ (\delta - \theta)}$$

Reading, Pa.—(In middle of graveyard of Universalist Church.) Cloudy, wind E. of S.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 23		No. 1	72° 29′.7	86°.7	—2° 19′.4	72° 25′.3	1.0356
" "		No. 3	72 31.9	84.0	+0 36.6	72 39.2	1.0512
				Mean . . .		72 32.2	1.0434

Harrisburg, Pa.—Opposite avenue, between Capitol and State-house to E., near centre of grass plot, say 100 feet from building. Clear, wind N. W.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000
July 25		Cylinder	75°	2	300	34ˢ.860	34ˢ.833	0.9805
" "		Bar	76		250	37.220	37.150	0.9802
				Mean				0.9803

Date.	Time.	Needle.	Dip.
July 25		No. 1	72° 14′.4
" "		No. 2	72 23.3
		Mean . . .	72 18.8

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 25		No. 1	72° 27′.3	78°	—2° 32′.0	72° 22′.9	1.0347
" "		No. 3	72 17.3	78	—0 13.9	72 24.6	1.0477
					Mean . . .	72 23.8	1.0412

Duncan's Island, Pa.—About 15 miles north of Harrisburg. In field E. of barn, under large walnut tree, 400 feet from N. E. end of barn.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 27		No. 1	72° 36′.2	85°.5	—3° 47′.0	72° 31′.8	1.0270
" "		No. 3	72 30.9		—0° 23.2	72 38.2	1.0455
					Mean . . .	72 35.0	1.0362

Lewistown, Pa.—Across creek to south of town, about 100 yards to west of road, and along a street or road.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 29	5ʰ 30ᵐ A.M.	No. 1	72° 34′.4	74°	—3° 16′.4	72° 30′.0	1.0300
" "		No. 3		73	—0 47.6		1.0440[1]
					Mean . . .	72 30.0	1.0370

Clear, wind N., slight aurora last night.

[1] Using dip 72° 30′.0

Huntingdon, Pa.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
July 30		Cylinder	79°.0	2	400	34ˢ.716	34ˢ.682	0.9896
" "		Bar	77.7	2	350	37.119	37.042	0.9861
						Mean	. . .	0.9878

Hazy and cloudy, wind W.

Date.	Time.	Needle.	Dip.
July 30		No. 1	72° 19′.6
" "		No. 2	72 14.2
	Mean	. . .	72 16.9

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 30		No. 1	72° 22′.1	81°.7	old weight —3° 21′.3	72° 17′.7	1.0305
					new weight 15 56.9		1.1551
" "		No. 3	72 14.2	81.0	old weight +0 14.3	72 21.5	1.0507
					new weight 17 11.7		1.1639
					Mean . .	72 19.6	1.0406
							1.1595

N. B. The angle θ produced by the new or pin weights is always +.

Armagh, Pa.—Field in rear of Inn.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 2	9ʰ A. M.	No. 1	72° 19′.9	67°.5	15° 45′.9[1]	72° 15′.5	1.1542
" "	"	No. 3	72 14.6	68.5	16 42.9	72 21.9	1.1600
					Mean . .	72 18.7	1.1571

Clear, cumulus, fog in morning.

[1] New or pin weight.

Economy, Pa.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 8		No. 1					
" "		No. 3	72° 27′.7	86°	17° 54′.5[1]	72° 35′.0	1.1662
					Mean . .	72 35.0	1.1662

Cloudy, wind S. W.

Homewood, near Pittsburg, Pa.—Six miles S. E. from Pittsburg, under trees near gully in front of house, nearly N. of it.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
Aug. 13	6h P. M.	Cylinder	72°.7	2	310	35s.017	34s.994	0.9732
" "	"	Bar	66.5	2	360	37.320	37.292	0.9733
						Mean		0.9732

Date.	Time.	Needle.	Dip.
Aug. 10	Noon	No. 1	72° 32′.8
" "	"	No. 1	72 32.4
	Mean . . .		72 32.6

Cloudy, cumulus, and cir-cumulus.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 10	Noon	No. 1	72° 34′.3	78°	old weight +3° 34′.7	72° 29′.9	1.0696
					new weight 16 17.1		1.1550
" "	"	No. 3	72 24.9	77	old weight +0 45.9	72 32.2	1.0529
					new weight 18 25.8		1.1711
					Mean . .	72 31.0	1.0612 1 1630

Steubenville, Ohio.—Across river from city, in a glen near city ferry, about 100 feet E. of road; schoolhouse bears W. 4° S.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 15.	10h 15m A.M	No. 1	72° 35′.8	72°	14° 07′.3	72° 31′.4	1.1386
" "	"	No. 3	72 27.0	72	16 13.0	72 34.3	1.1534
					Mean . .	72 32.8	1.1460

Clear, cirrus and cumulus, wind N.

[1] New or pin weight.

Wheeling, Va.—Zane's Island, opposite Wheeling, to north of hotel, near east bank of river branch.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity
Aug. 16	9h A. M.	No. 1	72° 13′.6	75°	14° 02′.6	72° 09′.2	1.1425
" "	"	No. 3	72 01.4	78	16 09.2	72 08.7	1.1587
					Mean . .	72 08.9	1.1506

Johnson's Tavern, near Brownsville, Pa.—In cornfield in rear of inn, house bears W. of S., N. E. corner distant 350 yards.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000
Aug. 18		Cylinder	80°.0	2	310	34s.368	34s.332	1.0114
" "		Bar	80.7	2	300	36.685	36.596	1.0109
						Mean		1.0112

Date.	Time.	Needle.	Dip.
Aug. 18		No. 1	71° 54′.7
" "		No. 2	71 54.6
	Mean		71 54.7

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 18		No. 1	71° 57′.0	77°.0	15° 36′.7	71° 52′.6	1.1581
" "		No. 3	71 42.5	74.5	18 02.5	71 49.8	1.1784
				Mean		71 51.2	1.1682

Frostburgh, Md.—On national road, east of mountain.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 20	0h 10m P.M.	No. 1	71° 39′.6	79°	16° 52′.3	71° 35′.2	1.1723
" "	"	No. 3	71 20.0	78	18 43.1	71 27.3	1.1900
					Mean . .	71 31.3	1.1811

Cumuli, wind S. by E.

Irwin's Mill, near Mercersburg, Pa.—Ten miles from Clear Spring, Md., and six miles from Mercersburg. Field (limestone) to N. W.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity. Phil. 1.0000
Aug. 24	Noon	Cylinder	78°.5	2	160	34ˢ.45	34ˢ.419	1.0068
" "		"	76.0	2	160	34.45	34.419	1.0068
" "	2ʰ P. M.	Bar	92.0	1		36.62	36.482	Rejected temp. doubtful
					Mean			1.0068

Cumuli, wind brisk.

Date.	Time.	Needle.	Dip.
Aug. 24		No. 1	71° 51′.0
" "		No. 2	71 47.3
	Mean . . .		71 49.1

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 24		No. 1	71° 50′.5	81°.0	17° 27′.3	71° 46′.1	1.1745
" "		No. 3	71 34.2	81.5	19 41.5	71 41.5	1.1948
					Mean . .	71 43.8	1.1847

Baltimore.—Second square N. E. from Washington Monument.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
Aug. 27		Bar	71°.5	2	150	36ˢ.39	36ˢ.342	1.0252
" "		Bar	71.0	2	150	36.39	36.342	1.0252
					Mean			1.0252

Hazy, wind brisk.

Date.	Time.	Needle.	Dip.
Aug. 27		No. 1	71° 31′.7
" "		No. 2	71 39.1
	Mean . . .		71 35.4

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 27		No. 1	71° 37′.1		16° 56′.3	71° 32′.7	1.1736
" "		No. 3	71 22.0		19 08.5	71 29.3	1.1933
					Mean . .	71 31.0	1.1834

Frenchtown, Md.—Frenchtown Landing. Under oak tree, about 200 yards S. E. from brick tavern.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
?[1]		No. 1	71° 44′.8	83°	18° 33′.3	71° 40′.4	1.1852
?		No. 3	71 32.8	83	20 37.6	71 40.1	1.2035
					Mean . .	71 40.2	1.1943

Cumulus and cirro-cumulus, wind S. E.

Girard College, Philadelphia.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Oct. 28	Noon	No. 1	72° 01′.8	52°	old weight +1° 28′.9	71° 57′.4	1.0606
					new weight 17 15.3		1.1701
" "	"	No. 3	71 47.4	50	old weight +2 37.2	71 54.7	1.0680
					new weight 19 23.0		1.1886
					Mean . .	71 56.0	1.0643 1.1793

N. B. Old weights in third hole; new or pin weights in third hole.

Date.	Time.	Needle.	Dip.
Oct. 28	Noon	No. 1	71° 52′ 2
Nov. 3		No. 2	71 51.0
	Mean . . .		71 51.6

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity.
Nov. 3	2h P. M.	Cylinder	54°	2	350	34s.630	34s.641	1.0000
" "	" "	Bar	54	2	340	36.815	36.841	1.0000

[1] Probably end of August.

MAGNETIC SURVEY OF PENNSYLVANIA.

(INCLUDING PART OF OHIO AND NEW YORK.)

SECOND MAGNETIC TOUR OF 1841.

Abstract of Relative Intensity and Dip at 20 Stations.

Girard College, Philadelphia.

Date.	Time.	Needle.	Dip.
April 26	4h P. M.	No. 1	71° 59′.2
" "	" "	No. 2	71 57.1
	Mean . . .		71 58.1

Sky covered, light fleecy, cirro-stratus, and cirrus.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
April 26	4h P. M.	No. 1	72° 00′.4	68°	18° 06′.7	72° 01′.1	1.1778
" "	" "	No. 3	72 00.4	68	13 55.9[1]	72 10.1	1.1415 rejected
					Mean .	71 01.1	1.1778

N. B. Needle No. 1, new or pin weight in last hole of end B.
" No. 3, " " hole nearest to end B.

Philadelphia.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity.
July 20		Cylinder	75°.8	2	500	34s.770	34s.741	1.0000
" "		Bar	79.1	2	500	36.918	36.836	1.0000

Date.	Time.	Needle.	Dip.
July 20		No. 1	71° 56′.0
" "		No. 2	71 59.6
	Mean . . .		71 57.8

Clear.

[1] This observation is defective, should be about 20°. The record says L. Needle, No. 2, but no such Lloyd needle is used elsewhere.

Philadelphia.—Continued.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 20	2h 10m P.M.	No. 1	71° 53′.4	92°.5	17° 54′.5	71° 54′.1	1.1762
" "	"	No. 3	71 46.8	87.6	19 31.4	71 56.5	1.1893
					Mean . .	71 55.3	1.1827

N. B. Needle No. 1. Weight in last hole of end B.
No. 3. " hole nearest to end B.

Doylestown, Pa.—Twenty-four miles N. of Philadelphia, by turnpike. 150 feet N. 50° W. of middle of back of Methodist Epis. Church, on west side of a crooked apple tree.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 22	10h 30m A.M.	No. 1	72° 24′.7	81°.0	16° 50′.1	72° 25′.4	1.1602
" "	"	No. 3	72 11.1	81.8	19 20.7	72 20.8	1.1814
					Mean . . .	72 23.1	1.1708

Clear, cirro-cumulus, wind fresh from S. W.

Easton, Pa.—Yard S. of Lafayette College.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 22	4h 40m P.M.	No. 1	72° 43′.3	87°5.	17° 02′.2	72° 44′.0	1.1572
" "	"	No. 3	72 24.3	85.5	19 35.2	72 34.0	1.1800
					Mean . . .	72 39.0	1.1686

Wilkesbarre, Pa.—On a small knoll to N. E. of town. Under a chestnut tree near river bank, same side as town.

After completing observations with needle No. 1, wind too high, moved into valley to N. E. New station bears from steeple of Presbyterian Church N. 54° E., and the old station from the new bears N. 55° W., about 120 feet.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 26		No. 1	73° 08′.8	66°	16° 35′.4	73° 09′.5	1.1483
" "		No. 3	73 00.7	68	18 57.3	73 10.4	1.1658
					Mean . . .	73 10.0	1.1570

Clear, cumulus, wind fresh from W. of N.

Williamsport, Pa.—From the academy S. W. by S. 350 feet, in the angle of a road.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
July 28		Cylinder	70°.7	2	400	35s.560	35s.540	0.9560
" "		Bar	73.2	2	392	37.740	37.682	0.9559
					Mean	. . . . .		0.9560

Date.	Time.	Needle.	Dip.
July 28	3h 40m P.M.	No. 1	72° 52′.2
" "	4 45 "	No. 2	72 58.8
	Mean . . .		72 55.5

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 28	10h 30m A.M	No. 1	72° 52′.5	74°.8	15° 57′.2	72° 53′.2	1.1473
" "	3 10 P.M.	No. 3	72 41.6	77.6	18 41.2	72 51.3	1.1684
				Mean	. . .	72 52.3	1.1578

Bellefonte, Pa.—Graveyard near S. E. corner. Steeple of Presbyterian Church bears W. 8° S.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 30	11h 15m A.M.	No. 1	72° 41′.9	75°	15° 53′.8	72° 42′.6	1.1492
" "	"	No. 3	72 32.2	75	18 09.2	72 41.9	1.1665
				Mean	. . .	72 42.3	1.1578

Clear, a few cirro-cumuli. Wind, a gale from W. N. W.

Curwinsville, Pa.—West branch of Susquehanna, in a meadow above dam, which is less than $\frac{1}{8}$th of a mile from Ross's Tavern, under tree by river side.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
Aug. 1		Cylinder	71°.5	2	400	35s.501	35s.479	0.9595
" "		Bar	73.5	2	400	37.655	37.595	0.9604
						Mean	. . . .	0.9600

Date.	Time.	Needle.	Dip.
Aug. 1	11h 15m A.M.	No. 1	72° 49′.9
" "	0 5 P.M.	No. 2	72 44.7
	Mean . . .		72 47.3

Curwinsville, Pa.—Continued.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 1	$9^h 45^m$ A.M.	No. 1	72° 52′.3		15° 27′.3	72° 53′.0	1.1436
" "	"	No. 3	72 40.1		17 48.5	72 49.8	1.1620
				Mean . . .		72 51.4	1.1528

Wind S. E., cloudy, drizzle.

Berlin Tavern, Pa.—Near road from Clarion to Franklin; 19 miles from Franklin by account.

Place of observation in woods to E. of N. of house, about 150 yards from turnpike, under dwarf oaks.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 3		No. 1	72° 51′.3	78°.9	15° 56′.4	72° 52′.0	1.1475
" "		No. 3	72 43.9	80.0	18 30.7	72 53.6	1.1665
				Mean . . .		72 52.8	1.1570

Calm, clear, very warm.

Mercer, Pa.—Forrest Inn, $\frac{3}{16}$ of a mile from Mercer court-house, in centre of field.

Farthest cupola to W. reads . . .	238° 38′	
Next of brick (more ornamented) . .	229 48	
N. E. corner of tavern	241 25	
" " barn	279 12	76 paces.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
Aug. 5		Cylinder	79°.5	2	350	$35^s.535$	$35^s.499$	0.9586
" "		Bar	79.5	2	370	37.657	37.571	0.9618
					Mean			0.9602

Date.	Time.	Needle.	Dip.
Aug. 5	$10\frac{1}{4}^h$ A. M.	No. 1	72° 54′.4
" "	$0\frac{1}{4}$ P. M.	No. 2	72 59.3
	Mean . . .		72 56.8

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 5	9^h A. M.	No. 1	72° 54′.6		15° 11′.3	72° 55′.3	1.1413
" "	$9\frac{1}{2}$ "	No. 3	72 50.9		17 33.8	73 00.6	1.1576
				Mean . . .		72 58.0	1.1494

Cloudy, showery, wind S. E., light.

Warren, Ohio.—In a field N. of town, under walnut tree, about $\frac{1}{8}$ of a mile from American Hotel, and $\frac{1}{6}$ of a mile from brick house (white). Centre bears S. $15\frac{1}{2}°$ E.

N. W. end of American Hotel bears S. $17\frac{1}{4}°$ E.

Wooden church (4 points), N. W. corner of steeple bears S. $15\frac{1}{3}°$ W.

512 paces from walnut tree to back of American Hotel.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 6.	11h 50m A.M.	No. 1	73° 01′.0	73°.5	15° 20′.2	73° 01′.7	1.1410
" "	0 05 P.M.	No. 3	72 48.3	73.5	17 55.0	72 58.0	1.1609
				Mean . . .		72 59.9	1.1510

Ashtabula Landing, Ohio.—Near the shore of the lake, $2\frac{1}{4}$ miles north from Ashtabula, under an oak in a glen.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 7	$0\frac{1}{4}$h P. M.	No. 1	73° 23′.7	73°.5	13° 47′.9	73° 24′.4	1.1258
" "	"	No. 3	73 12.9	73.5	16 40.9	73 22.6	1.1461
				Mean . . .		73 23.5	1.1359

Clear and warm, wind W.

Erie, Pa.—Residence of Rev. Mr. Reid, in field about 40 feet to the S. E., near the road, under elder bushes.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
Aug. 9		Cylinder	72°.0	2	450	36s.457	36s.437	0.9102
" "		Bar	69.2	2	430	41.079	41.035	0.8067 rejected
								0.9102

Date.	Time.	Needle.	Dip.
Aug. 8		No. 1	73° 44′.0
" "		No. 2	

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 8	3h 07m P.M.	No. 1	73° 47′.3	72°.0	14° 20′.9	73° 48′.0	1.1250
" "	"	No. 3	73 40.7	69.5	17 11.1	73 50.4	1.1436
				Mean . . .		73 49.2	1.1343

Clear, cumulus, wind S. of W., brisk.

Dunkirk, N. Y.—In front of house of Major T. S. Brown.

S. edge of beacon-light from station reads . .	90° 27′ 50″
S. E. corner of Brown's house	144 05 30
S. E. corner of hotel	158 37 30
Middle and upper bar of middle and upper window of large brick house (McDonald's)	180 41 47

Station in woods S. of Brown's house, marked with cedar post.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 13	$4\frac{1}{2}^h$ P. M.	No. 1	74° 17′.6	73°.2	14° 56′.9	74° 18′.3	1.1230
" "	"	No. 3	74 06.4	72.5	17 25.9	74 16.1	1.1397
					Mean . . .	74 17.2	1.1313

Clear, gentle breeze from N. W.

Ellicottville, N. Y.—Near Valley Creek, 100 yards S. E. from Episcopal Church. Station 113 chains nearly E. from transit meridian line, Aug. 15. Aug. 16, station S. of former under an elm tree near the creek (Gr. Valley).

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
Aug. 16	$1\frac{1}{2}^h$ P. M.	Cylinder	77°.5	2	420	36ˢ.819	36ˢ.787	0.8933
" "	"	Bar	80.7	2	360	39.034	38.939	0.8958
					Mean			0.8945

Date.	Time.	Needle.	Dip.
Aug. 16	$10^h 10^m$ A. M.	No. 1	74° 20′.2
" "	"	No. 2	74 20.2
	Mean . . .		74 20.2

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 16	8^h A. M.	No. 1	74° 12′.5	67°	13° 10′.7	74° 13′.2	1.1128
" "	$8\frac{1}{2}$ "	No. 3	74 02.9	77	16 00.6	74 12.6	1.1310
					Mean . . .	74 12.9	1.1219

Belvidere, N. Y.—Residence of Judge Church. In orchard S. of the house.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 17		No. 1	74° 10′.2	86°	15° 30′.6	74° 10′.9	1.1281
" "		No. 3	73 58.4	86	18 00.3	74 08.1	1.1454
					Mean . . .	74 09.5	1.1367

Bath, N. Y.—Observations for latitude in field S. W. from court-house. Aug. 19, place to W. of former, and about 130 feet from it.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
Aug. 19		Cylinder	80°.5	2	380	36ˢ.969	36ˢ.931	0.8865
" "		Bar	80.5	2	350	39.410	39.315	0.8788
					Mean			0.8826

Date.	Time.	Needle.	Dip.
Aug. 19		No. 1	74° 23′ 9
" "		No. 2	74 33.2
	Mean . . .		74 28.5

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 19	10ʰ A. M.	No. 1	74° 24′.9	79°.0	13° 10′.1	74° 25′.6	1.1105
" "	"	No. 3	74 15.6	79.5	15 34.7	74 25.3	1.1256
				Mean . . .		74 25.5	1.1181

Cloudy and clear by turns.

Owego, N. Y.—Near Owego Hotel, on bank of river.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 21	10ʰ A. M.	No. 1	74° 11′.0	76°.0	13° 33′.9	74° 11′.7	1.1155
" "	"	No. 3	74 06.3	78.0	16 48.5	74 16.0	1.1355
				Mean . . .		74 13.9	1.1255

Silver Lake, Pa.—Near east end of residence of Dr. Rose.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
Aug. 23		Cylinder	67°.7	2	402	36ˢ.545	36ˢ.530	0.9064
" "		Bar	62.2	2	460	38.664	38.654	0.9092
					Mean			0.9078

Date.	Time.	Needle.	Dip.
Aug. 23	3ʰ 35ᵐ P. M.	No. 1	73° 41′.4
" "	" "	No. 2	73 38.8
	Mean . . .		73 40.1

Silver Lake, Pa.—Continued.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 23	$10^h 50^m$ A.M.	No. 1	73° 45′.2	66°.0	15° 43′.5	73° 45′.9	1.1346
" "	"	No. 3	73 33.1	69.0	18 23.6	73 42.8	1.1539
				Mean . . .		73 44.4	1.1442

Milford, Pa.—Field on west side of creek from town.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal Intensity Phil. 1.0000
Aug. 26	5^h P. M.	Cylinder	62°.7	2	380	36^s.587	36^s.582	0.9039
" "	6 "	Bar	62.2	2	500	38.738	38.738	0.9054
					Mean			0.9046

Date.	Time.	Needle.	Dip.
Aug. 26	$2\frac{3}{4}^h$ P. M.	No. 1	73° 44′.0
" "	$4\frac{3}{4}$ "	No. 2	73 51.4
	Mean . . .		73 47.7

Cumulus and cirro-cumulus, Wind S.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 26	$10\frac{1}{4}^h$ A.M.	No. 1	73° 45′.4	73°.0	15° 54′.9	73° 46′.1	1.1357
" "	"	No. 3	73 38.7	73.0	18 25.0	73 48.4	1.1528
				Mean . . .		73 47.3	1.1442

Bushkill, Pa.—Near the Delaware and Bushkill Creek, 21 miles by river road from Milford and 13 from Water Gap.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 27	$0^h 20^m$ P.M.	No. 1	73° 29′.1	71°.0	16° 32′.2	73° 29′.8	1.1436
" "	"	No. 3	73 23.3	69.0	19 14.3	73 33.0	1.1626
				Mean . . .		73 31.4	1.1531

Girard College, Philadelphia.—Magnetic observatory, on stand near marble pillar where dip is observed.

Date.	Time.	Needle.	Dip.
Oct. 9	— P. M.	No. 1	71° 57′.9
" "	— P. M.	No. 2	71 58.2
	Mean . . .		71 58.0

Date.	Time.	Needle.	Dip.
Oct. 9		No. 1	71° 57′.8
Nov. 1		No. 1	71 58.3
	Mean . . .		71 58.0

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity.
Nov. 1	$4^h 15^m$ P. M.	Cylinder	63°.5	2	500	$34^s.86$	$34^s.854$	1.0000
" "	"	Bar	63.0	2	400	36.92	36.907	1.0000

MAGNETIC SURVEY OF WESTERN NEW YORK.

(PART OF CANADA, ALSO NEW JERSEY AND PENNSYLVANIA.)

THIRD MAGNETIC TOUR OF 1843.

Abstract of Results for Relative Intensity and Dip at 15 Stations.

Girard College, Philadelphia.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity.
July 20	$4^h 37^m$ P. M.	Cylinder	79°.5	2	500	$35^s.080$	$35^s.045$	1.0000
" "	6 27 "	Bar	72.6	1	250	36.968	36.914	1.0000

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 20	7^h P. M.	No. 1	71° 56′.2	75°.2	+0° 42′.7	71° 57′.8	. . . . . .
				74.6	18 26.1		1.1797
" "	"	No. 3	71 45.3	75.8	+4 48.0	71 55.3	. . . . . .
				73.3	21 34.1		1.2078
				Mean . . .		71 56.5	1.1937

The smaller values of θ refer to the old London weights } in last hole.
" larger " " " new pin weights }

For these observations see Vol. II. of Girard College Magnetic and Meteorological Observations, pp. 1537–38.

Princeton, N. J.—Middle of the field S. from college.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 21		No. 1	72° 39′.2		18° 25′.2	72° 40′.8	1.1689
" "		No. 3	72 25.8		22 03.9	72 35.8	1.2005
				Mean . . .		72 38.3	1.1847

West Point, N. Y.—North of Mansfield House, 5 feet N. W. of pier marking Courtenay's Station.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity
July —	5h 55m A.M.	No. 1	73° 09′.2	71°.2	17° 30′.0	73° 10′.8	1.1548
" "	"	No. 3	73 03.5	71.5	21 08.1	73 13.5	1.1822
				Mean . . .		73 12.2	1.1685

Clear, calm.

Union College, Schenectady, N. Y.—Under large poplar tree in Dr. Potter's garden, 15 yards from S. W. end of College.

Date.	Time.	Needle.	Temp. Fahr.	No. of series	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
July 27	4h 13m P. M.	Cylinder	80°.0	2	500	38s.260	38s.220	0.8408
" "	5 01 "	Bar	78.5	1	250	40.413	40.323	0.8381
			Mean					0.8394

Date.	Time.	Needle.	Dip.
July 27		No. 1	74° 53′ 9
" "		No. 2	74 57.0
	Mean . . .		74 55.4

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 27	10h A. M.	No. 1	74° 55′.6	79°.3	17° 42′.0	74° 57′.2	1.1327
" "	"	No. 3	74 39.9	79.2	21 27.2	74 49.9	1.1597
				Mean . . .		74 53.6	1.1462

Utica, N. Y.—On the hill S. of the city; residence of Judge M. S. Miller, Esq., S. W. corner of John and Rutger Streets.

N. W. corner of house, S. 12° W.
N. E. " " S. 8° E.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
July 28	3h 30m P.M.	No. 1	74° 49′.6	83°.5	15° 48′.5	74° 51′.2	1.1220
" "	6 00 "	No. 3	74 39.4	83.5	19 31.6	74 49.4	1.1465
				Mean . . .		74 50.3	1.1342

Cloudy.

Syracuse, N. Y.—Centre of meadow owned by Aaron Burk and John Wilkinson, midst of clump of chestnut trees, south side of road.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000
July 29	0ʰ 09ᵐ P. M.	Cylinder	73°.0	2	260	38ˢ.028	38ˢ.004	0.8509
" "	0 46 "	Bar	73.0	1	100	40.020	39.959	0.8537
					Mean			0.8523

Date.	Time.	Needle.	Dip.
July 29		No. 1	74° 51′.9
" "		No. 2	74 49.9
	Mean . . .		74 50.9

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. ϑ	Relative total intensity.
July 29	9ʰ 25ᵐ A. M.	No. 1	74° 50′.6	77°.0	15° 50′.9	74° 52′.2	1.1220
" "	10 10 "	No. 3	74 41.3	77.0	19 03.0	74 51.3	1.1428
				Mean . . .		74 51.8	1.1324

Geneva, N. Y.—New cemetery west of public square. East side of path opposite, and 30 feet from monument of Gideon Lee.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
July 31	11ʰ 06ᵐ A. M.	Cylinder	72°.2	2	500	37ˢ.572	37ˢ.548	0.8718
" "	0 05 P. M.	Bar	72.0	2	500	39.624	39.568	0.8707
					Mean			0.8712

Date.	Time.	Needle.	Dip.
July 31	2ʰ 58ᵐ P. M.	No. 1	74° 31′.3
" "	3 44 "	No. 2	74 37.8
	Mean . . .		74 34.5

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. ϑ	Relative total intensity.
July 31	4ʰ 08ᵐ P. M.	No. 1	74° 28′.5	74°.0	15° 08′.4	74° 30′.5	1.1219
" "	4 30 "	No. 3	74 20.9	74.0	18 49.8	74 30.9	1.1460
				Mean . . .		74 30.7	1.1339

Rochester, N. Y.—Mount Hope Cemetery, near large oak tree, S. 25° E. of obelisk monument of Mrs. Mary Brooks.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 1	3h 14m P.M.	No. 1	74° 41′.6	69°.5	15° 13′.7	74° 43′.2	1.1199
" "	"	No. 3	74 33.7	69.5	19 02.9	74 43.7	1.1445
				Mean . . .		74 43.5	1.1322

Clear, wind N. W.

Niagara Falls, N. Y.—On Goat Island, in hollow leading to the Biddle stairs, which bear about N. 35° W., large bass-wood tree intervenes.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
Aug. 3	11h 30m A.M.	Cylinder	79°.0	2	500	37s.970	37s.933	0.8544
" "	0 38 P.M.	Bar	79.7	2				obser's imperfect.
					Mean			0.8544

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 3	3h 13m P. M.	No. 1	74° 46′.8	80°.2	14° 03′.8	74° 48′.4	1.1119
" "	3 54 "	No. 3	74 39.3		17 59.1	74 49.3	1.1369
				Mean . . .		74 48.9	1.1244

Niagara Falls.—British side, opposite centre of American Fall, near to N. of large limestone rock terminating in a bluff.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 4	4h 12m P. M.	No. 1	74° 52′.0	79°.0	14° 21′.2	74° 53′.6	1.1127
" "	"	No. 3	74 42.7		18 15.2	74 52.7	1.1373
				Mean . . .		74 53.2	1.1250

Cloudy, cumulus, wind S. W.

Magnetic Observatory, Toronto, Canada.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
Aug. 7	1h 05m P. M.	Cylinder	78°.7	2	550	38s.112	38s.075	0.8483
" "	2 16 "	Bar	79.0	2	500	40.205	40.116	0.8472
					Mean			0.8478

Cloudy, cumulus, wind S. E.

Magnetic Observatory, Toronto, Canada.—Continued.

Date.	Time.	Needle.	Dip.
Aug. 7	10h 59m A.M.	No. 1	75° 07′.5
" "	"	No. 2	75 13.1
	Mean . . .		75 10.3

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ_{θ}	Relative total intensity.
Aug. 7	10h 34m A.M.	No. 1	75° 12′.0	77°.5	12° 30′.9	75° 13′.6	1.0985
" "	"	No. 3	75 03.3	78.0	16 59.1	75 13.3	1.1249
				Mean . . .		75 13.5	1.1117

Oswego, N. Y.—On river bank, 120 yards above bridge on left bank, under three trees grown together.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 8	4h P.M.	No. 1	75° 05′.9	75°.7	15° 20′.2	75° 07′.5	1.1159
" "	"	No. 3	74 56.7	75.7	19 57.4	75 06.7	1.1453
				Mean . . .		75 07.1	1.1306

Cloudy, cumulus.

Ogdensburgh, N. Y.—At Mile Point, under small pine tree, on river bank.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000
Aug. 9	5h 27m P.M.	Cylinder	77°.5	2	500	39s.550	39s.514	0.7877
" "	6 17 "	Bar	76.4	2	400	41.585	41.505	0.7915
					Mean			0.7896

Date.	Time.	Needle.	Dip.
Aug. 9		No. 1	75° 59′.5
" "		No. 2	76 15.3
	Mean . . .		76 07.4

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 9		No. 1	76° 05′.0	77°.5	13° 57′.0	76° 06′.6	1.0976
" "		No. 3	75 58.5	77.0	18 23.7	76 08.5	1.1221
				Mean . . .		76 07.6	1.1098

Quebec, Canada.—In the Governor's garden, side of alley from gate to Wolfe's battery, 20 military paces from entrance gate.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 14.	10h 00m A.M.	No. 1	77° 08′.5	77°.0	16° 54′.3	77° 10′.1	1.1019
" "	10 22 "	No. 3	77 07.6	77.2	21 24.5	77 17.6	1.1245
				Mean . . .		77 13.9	1.1132

Date.	Time.	Needle.	Dip.
Aug. 14	10h 43m A.M.	No. 1	77° 09′.8
" "	"	No. 2	77 14.2
	Mean . . .		77 12.0

Out of the city of Quebec, on the St. Louis Avenue; second house on avenue near road on city side from Wolfe's Monument. In garden of Mr. Sampson, S. W. of house, under small apple tree.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 14	0h 55m P.M.	No. 1	77° 13′.9	86°.4	16° 52′.3	77° 15′.5	1.1007
" "	"	No. 3	77 07.3	86.2	21 25.9	77 17.3	1.1247
				Mean . . .		77 16.4	1.1127

Montreal, Canada, St. Helen's Island. South shore of island, at foot of hill, just below two large elms growing close together, one rod below elms.

Date.	Time.	Needle.	Temp. Fahr.	No. of series.	No. of vibrations.	Time of 10 vibrations.	Corr'd.	Horizontal intensity Phil. 1.0000.
Aug. 15	4h 12m P. M.	Cylinder	72°.2	2	500	40s.700	40s.674	0.7437
" "	5 03 "	Bar	72.0	2	500	42.800	42.740	0.7466
					Mean			0.7451

Date.	Time.	Needle.	Dip.
Aug. 15	2h 47m P.M.	No. 1	76° 41′.9
" "	3 11 "	No. 2	76 55.0
	Mean . . .		76 48.4

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Aug. 15	2h 05m P. M.	No. 1	76° 44′.8	73°.0	16° 21′.5	76° 46′.4	1.1034
" "	2 25 "	No. 3	76 37.7	72.0	21 09.7	76 47.7	1.1298
				Mean . .		76 47.1	1.1166

Troy, N. Y.—In orchard of Mr. Albert P. Heart, under apple tree, third from yard fence, 65 paces S. W. from house; above river 230 feet.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. ϑ	Dip reduced. δ	Relative total intensity.
Aug. 18	10h 30m A. M.	No. 1	74° 44′.6	81°.5	16° 39′.1	74° 46′.2	1.1283
" "	10 48 "	No. 3	74 39.6	81.0	20 54.2	74 49.6	1.1558
					Mean . . .	74 47.9	1.1421

Girard College, Philadelphia.

Date.	Time.	Needle	Dip.	Temp. Fahr.	Dip when loaded. ϑ	Dip reduced. δ	Relative total intensity.
Aug. 26	6h P. M.	No. 1	71° 54′.0			71° 55′.6	
" "	"	No. 3	71 51.2	82°.4	21° 42′.9	72 01.2	1.2074
						Corr'n.	—0.0141
			Mean of both needles		. . .	71 58.4	1.1933

Difference No. 1 and No. 3, July 20, 1843	+0.0281
" " " Sept. 5, 1843	+0.0284
Mean difference	+0.0282
Corr'n = half difference	±0.0141

For these observations, see Vol. II. of Girard College Magnetic and Meteorological Observations, p. 1540.

Date.	Time.	Needle.	Dip.
Sept. 5	10h A. M.	No. 1	71° 59′.6
" "	"	No. 2	

See Vol. II. of Girard College Magnetic and Meteorological Observations, p. 1542.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. ϑ	Dip reduced. δ	Relative total intensity.
Sept. 5	11h A. M.	No. 1	71° 58′.9	82°.8	18° 36′.0	72° 00′.5	1.1804
" "	"	No. 3	71 49.3	82.9	21 48.7	71 59.3	1.2088
					Mean . . .	71 59.9	1.1946

See Vol. II. of Girard College Magnetic and Meteorological Observations, pp. 1542–43.

Date.	Time.	Needle.	Dip.
Sept. 12	10 A. M.	No. 1	71° 58′.2
" "	11 "	No. 2	71 55.9
		Mean . . .	71 57.1

See Vol. II. of Girard College Magnetic and Meteorological Observations, pp. 1543–44.

Girard College, Philadelphia.—Continued.

Date.	Time.	Needle.	Dip.	Temp. Fahr.	Dip when loaded. θ	Dip reduced. δ	Relative total intensity.
Sept. 12	1ʰ P. M.	No. 1	71° 57′.1	62°7.		71° 58′.7	
" "	2 "	No. 3	71 48.4	62.6	21° 34′.0	71 58.4	1.2069
						Corr'n.	—0.0141
Mean of both needles . . .						71 58.6	1.1928

See Vol. II. of Girard College Magnetic and Meteorological Observations, pp. 1544–45.

ABSTRACT AND REDUCTION OF OBSERVATIONS FOR DECLINATION.

OBSERVED IN PENNSYLVANIA AND ADJACENT STATES IN 1840 AND 1841.

THESE observations were made with a Gambey Declinometer belonging to the Girard College.

One division (small) of the scale was found equal to 14''.54, as determined in 1844, at Sandy Hook, by Lieut. G. M. Bache (See Coast Survey records). 1 large division = 60 small divisions.

The observations were made with telescope *direct*, with slit to the right hand or *E.*, and with telescope *inverted*, with slit to the left or *W.*; also with needle *direct* or hairs *up*, and with needle *inverted* or hairs *down*. With needle north, W. readings are +, E. readings —; with needle south, west readings are —, east readings +.

Throughout the record the *apparent* direction (E. or W.) is given, the same is to be understood in this reduction; apparent E. is real W., and when the angle is west of true north, apparent east is + for the north end of the needle, but as the azimuth circle reads from north to east this sign is to be reversed if we apply the correction directly to the circle reading.

The accompanying papers contain also the reduction of the observations for time, for azimuth, and for latitude.

DECLINATION STATIONS OF 1840.

1. Harrisburg.
2. Huntingdon.
3. Homewood, near Pittsburg.
4. Johnson's Tavern, near Brownsville.
5. Irwin's Mill, near Mercersburg.
6. Baltimore.

Chronometer, Grant No. 3861, *London* (*Pocket Chr.*).

For chronometer error and rate.

Chron. fast, Philadelphia time, July 21	$5^h\ 01^m\ 25^s.0$
" Pittsburg " Aug. 5	5 21 23.9
Diff. long., $5^h\ 20^m\ 08^s$—$5^h\ 00^m\ 40^s$	0 19 28
Chron. fast, Philadelphia time, Aug. 5	5 01 55.9
Gain in 15 days	30.9

Daily rate = $2^s.06$ (travelling rate).

Between July 15 and July 21, the daily rate was $3^s.3$ (stationary rate).

No. 1. **Harrisburg.**—Lat. 40° 16′; long. 76° 53′. July 25, 1840.

Declination Observations.

NEEDLE DIRECT. — Tel. direct.

N. end.		S. end.	
0 56 W	0 58 E.	3 02 W	1 32 E.
0 52	0 56	3 02	1 35
0 50	0 52	2 58	1 38
		2 56	1 42
0 52.7	0 55.3	2 54	1 44
1.3 E.		2 58.4	1 38.2
		40.1 W.	

NEEDLE INVERTED. — Tel. reversed.

N. end.		S. end.	
0 35 W.	2 05 E.	3 55 W.	0 25 E.
0 35	2 05	3 50	0 35
0 35	2 05	3 45	0 40
0 35	2 05	3 50	0 38.3
0 45 E.		1 38.3 W.	

NEEDLE DIRECT. — Tel. reversed.

N. end.		S. end.	
0 41 W.	0 51 E.	2 52 W.	1 38 E.
0 40	0 52	2 48	1 38
0 38	0 50	2 48	1 38
0 36	0 50	2 49.3	1 38
0 34	0 50	35.6 W.	
0 37.8	0 50.6		
6.4 E.			

Vernier, 296° 32′ 20″

NEEDLE INVERTED. — Tel. direct.

N. end.		S. end.	
0 35 W.	1 55 E.	4 15 W.	0 10 E.
0 30	1 55	4 20	0 10
0 15	1 50	4 25	0 00
		4 15	0 12
0 26	1 53.3	4 05	0 18
43.6 E.		4 16	0 10
		2 03 W.	

Vernier, 296 32 15

N. end.	S. end.
0 01.3 E.	0 40.1 W.
0 06.4 E.	0 35.6 W.
0 45.0 E.	1 38.3 W.
0 43.6 E.	2 03.0 W.
—0 24.1	—1 14.2

	—0 49.1	= -0° 11′ 54″
Mean of verniers,		296 32 18
Magnetic meridian reads,		296 20 24

Observations for azimuth of Polaris.

Tel. direct. Chron. time.	Tel. direct. Circle reads.	Tel. reverse. Chron. time.	Tel. reverse. Circle reads.
1h 48m 46s.0	301° 15′ 15″	2h 04m 06s.4	301° 19′ 00″
51 53.8	16 15	08 13.6	20 10
54 52.0	17 10		
1 51 50.6	301 16 13	2 06 10.0	301 19 35

Mean of times, 1h 59m 00s.3

Mean circle reading, 301° 17′ 54″

July 21, chron. fast, Philadelphia time	5h 01m 25s.0
Rate for 4 days (daily rate 2s.1)	+8.4
July 25, chron. fast, Philadelphia time	5 01 33.4
Diff. long.	6 52.0
Chron. fast, Harrisburg time	5 08 25.4
Chron. time of observation	1 59 00.3
Mean time of "	8 50 34.9
Corresponding sidereal time	17 05 54.8
R. A. of Polaris	1 02 18.6
Hour angle	16 03 36.2
[1]Azimuth of Polaris (E. of N.)	1° 45′.0
Reading of "	301 17.9
" astron. meridian	299 32.9
" magnetic meridian	296 20.4
Magnetic declination W.	3 12.5

No. 2. **Huntingdon.**—Lat. 40° 30′.5; long. 78° 02′. July 30, 1840.

Abstract of Declination Observations.

N. end.	S. end.
0 30 E.	
0 25	0
—0 27.5	0

—0 13.2 = -0 03′.2

Azimuth circle reads, 74 54.2

Magnetic meridian reads, 74 51.0

Abstract of Observations for Azimuth of Polaris.

Tel. direct, set 1. Chron. time.	Circle reads.	Set 2. Chron. time.	Circle reads.
1h 57m 06s.1	78° 34′ 23″	2h 07m 49s.6	78° 32′ 00″

	1st set.	2d set.
July 30, chron. fast	5h 13m 11s.9	
Chron. time of observation	1 57 06.1	2h 07m 49s.6
Mean " "	8 43 54.2	8 54 37.7
Corresponding sid. time	17 18 56.6	17 19 41.9
R. A. of Polaris	1 02 22.4	
Hour angle	16 16 34.2	16 27 19.5
Azimuth of Polaris	1° 48′.7	1° 51′.0
Reading of Polaris	78 34.4	78 32.0
" ast. meridian	76 45.7	76 41.0
" magnetic meridian	74 51.0	76 51.0
Magnetic declination W.	1 54.7	1 50.0
Mean	1° 52′3	

[1] The azimuth of Polaris is computed by Struve's method. (See Sawitsch's Astronomy, vol. 3.)

No. 3. **Homewood, near Pittsburg.**—Lat. 40° 28′; long. 79° 59′.5. Aug. 10, 1840.

Abstract of Declination Observations.

Set I. N. end.	Set I. S. end.	Set II. N. end.	Set II. S. end.
2 55.3 E.	5 23.5 E.	3 27.9 E.	4 33.5 E.
3 17.5 E.	5 28.8 E.	4 34.7 E.	3 38.2 E.
2 17.0 E.	5 51.0 E.		
2 20.1 E.	5 48.3 E.		
—2 42.5	+5 37.9	—4 01.3	+4 05.8

Set I: +1 27.7 = +0° 21′.3
Circle reads, 284 31.9
Magnetic meridian reads, 284 53.2

Set II: +0 02.2 = +0° 00′.5
284 49.8
284 50.3

Giving double weight to set I.

Magnetic meridian reads, 284° 52′.2.

Abstract of Observations for Azimuth of Polaris.

Mean of times	$6^h\ 32^m\ 25^s.8$
Mean circle reading	286° 16′ 32″
Aug. 10, chron. fast	$5^h\ 21^m\ 22^s.4$
Chron. time of observation	6 32 25.8
Mean " "	13 11 03.4
Corresponding sid. time	22 30 13.0
R. A. of Polaris	1 02 30.2
Hour angle	21 27 42.8
Azimuth of Polaris	1° 16′.3
Reading of Polaris	286 16.5
" astron. meridian	285 00.2
" magnetic meridian	284 52.2
Magnetic declination W.	0 08.0

No. 4. **Johnson's Tavern, near Brownsville.**—Aug. 17, 1840. Lat. 39° 59′.5; long. 79° 47′8.

Abstract of Declination Observations.

N. end.	S. end.
0 0.2 W.	2 12.5 E.
0 1.5 E.	2 6.0 E.
0 5.0 W.	2 43.3 E.
0 46.0 W.	2 17.5 E.
+0 12.4	+2 19.8

+1 16.1 = +0 18′.5
Azimuth circle reads, 138 41.8
Magnetic meridian reads, 139 00.3

Abstract of Observations for Azimuth of Polaris.

	Set I.	Set II.
Mean of times	1h 14m 10s.6	4h 35m 48s.0
Mean circle reading	141° 17′ 03″	141° 12′ 14″
Aug. 17, chron. fast	5h 20m 52s.3	5h 20m 52s.3
Chron. time of observation	1 14 10.6	4 35 48.0
Mean " "	7 53 18.3	11 14 55.7
Corresponding sid. time	17 39 11.5	21 01 22.0
R. A. of Polaris	1 02 34.8	1 02 34.9
Hour angle	16 36 36.7	19 58 47.1
Azimuth of Polaris	1° 52′.1	1° 46′.1
Reading of Polaris	141 17.0	141 12.2
" ast. meridian	139 24.9	139 26.1
" magnetic meridian	139 00.3	139 00.3
Magnetic declination W.	0 24.6	0 25.8

Mean . . . . 0° 25′.2

No. 5. **Irwin's Mill, near Mercersburg.**—Aug. 24, 1840. Lat. 39° 47′; long. 77° 56′.

Abstract of Declination Observations.

N. end.	S. end.
0 17.1 W.	0 21.5 E.
0 21.1 W.	0 12.4 E.
0 38.9 E.	0 34.2 E.
0 31.1 E.	0 31.2 E.
—0 8.0	+0 24.8

+0 8.4 = +0° 02′.0

Azimuth circle reads, 323 19.9

Magnetic meridian reads, 323 21.9

Abstract of Observations for Azimuth of Polaris.

Mean of times	1h 13m 35s.0
Mean circle reading	326° 13′ 22″
Aug. 24, chron. fast	5h 13m 39s.8
Chron. time of observation	1 13 35.0
Mean " "	7 59 55.2
Corresponding sid. time	18 13 24.3
R. A. of Polaris	1 02 38.9
Hour angle	17 10 45.4
Azimuth of Polaris	1° 57′.1
Reading of Polaris	326 13.4
" ast. meridian	324 16.3
" magnetic meridian	323 21.9
Magnetic declination W.	0 54.4

No. 6. **Baltimore.**—Aug. 27, 1840. Lat. 39° 17′.8; long. 76° 36′.6.

Abstract of Declination Observations.

N. end.	S. end.
0 47.6 E.	0 18.0 E.
0 32.0 E.	0 7.6 E.
1 25.7 E.	2 22.0 E.
1 01.2 E.	2 20.5 E.
—0 56.6	+1 17.0

+0 10.2	=0° 02′.5
Azimuth circle reads,	210 57.1
Magnetic meridian reads,	210 59.6

Abstract of Observations for Azimuth of Polaris.

Mean of times	$12^h\ 59^m\ 04^s.9$
Mean circle reading	215° 12′ 44″
Aug. 27, chron. fast	$5^h\ 08^m\ 28^s.5$
Chron. time of observation	12 59 04.9
Mean " "	7 50 36.4
Corresponding sid. time	18 15 52.7
R. A. of Polaris	1 02 40.6
Hour angle	17 13 12.1
Azimuth of Polaris	1° 56′.6
Reading of Polaris	215 12.7
" astrom. meridian	213 16.1
" magnetic meridian	210 59.6
Magnetic declination W.	2 16.5

RECAPITULATION OF RESULTS FOR MAGNETIC DECLINATION, 1840.

1. Harrisburg	July 25,	3° 12′.5 W.
2. Huntingdon	July 30,	1 52.3
3. Homewood, near Pittsburg . .	Aug. 10,	0 08.0
4. Johnson's Tavern, near Brownsville .	Aug. 17,	0 25.2
5. Irwin's Mill, near Mercersburg . .	Aug. 24,	0 54.4
6. Baltimore	Aug. 27,	2 16.5

DECLINATION STATIONS OF 1841.

1. Philadelphia.
2. Easton.
3. Williamsport.
4. Curwinsville.
5. Mercer.
6. Erie.
7. Dunkirk.
8. Ellicottville.
9. Bath.
10. Silver Lake.

Chronometer Grant No. 3861, *London.*

For chronometer error and rate.

	Chron. fast.	Daily rate gaining.
July 19, Philadelphia time	$0^h\ 00^m\ 06^s.0$	$2^s.03$
Aug. 30, " "	01 31.4	2.11
Sept. 14, " "	02 01.0	

(Previous to July 19, the chron. was gaining $2^s.0$ per day.)

The longitude of the State house, to which the above refers, is 75° 08′ 41″.9, or in time $5^h\ 00^m\ 34.^s8$.

Philadelphia.—July 20, 1841. Lat. 39° 58′.4; long. 75° 10′ 0.

Abstract of Declination Observations.

N. end.	S. end.
1 40.9 E.	1 48.2 E.
2 03.2 E.	1 49.4 E.
0 31.8 E.	3 10.1 E.
0 13.1 E.	3 13.5 E.
—1 07.3	+2 30.3

+0 41.5	= +0° 10′.1	
Azimuth circle reads,	218	52.9
Magnetic meridian reads,	219	03.0

Abstract of Observations for Azimuth of Polaris.

Mean of times	$8^h\ 34^m\ 52^s.7$
Mean circle reading	224° 33′ 25″
July 20, chron. fast	$0^h\ 00^m\ 13^s.2$
Chron. time of observation	8 34 52.7
Mean " "	8 34 39.5
Corresponding sid. time	16 29 16.8
R. A. of Polaris	1 02 37.2
Hour angle	15 26 39.6
Azimuth of Polaris	1° 33′.3
Reading of Polaris	224 33.4
" ast. meridian	223 00.1
" magnetic meridian	219 03.0
Magnetic Declination W.	3 57.1

Easton.—July 23, 1841. Lat. 40° 42′; long. 75° 15′.

Abstract of Declination Observations.

N. end.	S. end.
0 30.0 W.	1 15.7 W.
0 22.1 W.	1 14.8 W.
0 28.4 W.	1 22.7 W.
0 02.4 W.	1 36.4 W.
+0 20.7	—1 22.4

—0 30.8	= —0° 07′.5	
Azimuth circle reads,	332	51.9
Magnetic meridian reads,	332	44.4

Abstract of Observations for Azimuth of Polaris.

Mean of times	$8^h\ 53^m\ 05^s.0$
Mean circle reading	338° 05′ 41″
July 23, chron. fast	$0^h\ 00^m\ 34^s.8$
Chron. time of observation	8 53 05.0
Mean " "	8 52 30.2
Corresponding sid. time	16 58 59.3
R. A. of Polaris	1 02 39.5
Hour angle	15 56 19.8

Azimuth of Polaris	1° 43′.3
Reading of Polaris	338 05.7
" ast. meridian	336 22.4
" magnetic meridian	332 44.4
Magnetic declination W.	3 38.0

Williamsport.—July 28, 1841. Lat. 41° 14′.0; long. 77° 03′.5.

Abstract of Declination Observations.

N. end.	S. end.
0 54.6 W.	0 21.9 W.
1 01.8 W.	1 02.6 W.
1 31.6 W.	0 15.0 W.
1 36.7 W.	0 18.7 W.
+1 16.2	—0 29.6

+0 23.3	= +0° 05′.6
Azimuth circle reads,	241 22.2
Magnetic meridian reads,	241 27.8

Abstract of Observations on the Sun for time.

Set.	Chron. time.	Obs'd double alt. of sun's centre.	True altitude.	Computed mean time.	Chron. fast.
1	2h 38m 11s.4	104° 12′ 28″	52° 05′ 31″	2h 30m 16s.6	7m 45s.8
2	2 50 27.5	99 58 15	49 58 20	2 42 34.4	7 53.1
3	3 03 59.2	95 13 13	47 35 46	2 56 02.4	7 56.8
				Mean . . .	7 54.5

The weight 2 is given to the 1st and 2d sets.

Abstract of Observations on Polaris for Latitude.

	Set I.	Set II.
Chron. time	9h 41m 17s.5	9h 59m 34s.7
Observed double alt. . . .	81° 39′ 06″	81° 51′ 50″
True altitude	40 48 23	40 54 45
Mean time	9h 33m 23s.0	9h 51m 40s.2
Corresponding sid. time . . .	17 59 42.8	18 18 03.0
R. A. of Polaris	1 02 42.9	1 02 42.9
Hour angle	16 56 59.9	17 15 20.1
Latitude	41° 14′ 26″	41° 13′ 40″
Mean,	41° 14′ 03″	

Abstract of Observations for Azimuth of Polaris.

Mean of times	8h 51m 11s.8
Mean circle reading	246° 46′ 00″
July 28, mean time of observation	8h 43m 17s.3
Corresponding sid. time	17 09 28.8
R. A. of Polaris	1 02 42.9
Hour angle	16 06 45.9
Azimuth of Polaris	1° 47′.0
Reading of Polaris	246 46.0
" astron. meridian	244 59.0
" magnetic meridian	241 27.8
" Magnetic Declination W.	3 31.2

Curwinsville.—Aug. 1, 1841. Lat. 40° 57′.7; long. 78° 35′.

Abstract of Declination Observations.

N. end.	S. end.
0 59.2 W.	0 51.2 W.
1 04.6 W.	0 54.0 W.
0 56.2 W.	0 46.5 W.
0 57.5 W.	0 47.1 W.
+0 59.4	—0 49.7

+0 04.8	= +0° 01′.2
Azimuth circle reads,	207 56.0
Magnetic meridian reads,	207 57.2

Abstract of Observations on Arcturus for time.

Chron. time	9^h 34^m 20^s
Observed double alt.	73° 14′ 22″
True alt.	36 35 50
Computed mean time	9^h 19^m 56^s
Chron. fast	0 14 24

Abstract of Observations for Latitude.

	Jupiter.	Polaris.
Chron. time	8^h 35^m 39^s	9^h 57^m 39^s 0
Observed double alt.	54° 25′ 25″	81° 26′ 31″
True altitude	27 10 46	40 42 04
Mean time	8^h 21^m 15^s	9^h 43^m $30^s.1$
Corresponding sid. time	17 03 10	18 25 39.0
R. A. of star	16 33 58	1 02 46.4
Hour angle	0 29 12	17 22 52.6
Latitude	40° 57′ 26″	40° 58′ 00″
Mean	40° 57′ 43″	

Abstract of Observations for Azimuth of Polaris.

Mean of times	8^h 43^m $19^s.5$
Mean circle reading	211° 29′ 05″
Aug. 1, mean time of observation	8^h 28^m $55^s.5$
Corresponding sid. time	17 10 52
R. A. of Polaris	1 02 46
Hour angle	16 08 06
Azimuth of Polaris	1° 46.8
Reading of Polaris	211 29.1
" ast. meridian	209 42.3
" magnetic meridian	207 57.2
Magnetic Declination W.	1 45.1

Mercer.—Aug. 4, 1841. Lat. 41° 13′.8; long. 80° 16′.

Abstract of Declination Observations.

N. end.		S. end.	
0 40.1 W.		0 56.0 W.	
0 38.6 W.		0 53.0 W.	
1 01.4 W.		0 42.7 W.	
1 05.2 W.		0 43.0 W.	
+0 51.3		—0 48.7	
	+0 01.3		=+0° 00′.3
	Azimuth circle reads,		220 31.3
	Magnetic meridian reads,		220 31.6

Abstract of Observations on Jupiter for Latitude.

Chron. time	8^h 50^m $48^s.7$
Observed double alt.	52° 30′ 48″
True altitude	26 13 23
Mean time	8^h 29^m 35^s
Corresponding sid. time	17 23 22
R. A. of Jupiter	16 33 50
Hour angle	0 49 32
Latitude	41° 13′ 45″

Abstract of Observations for Azimuth of the Sun, Aug. 5.

	Set I.	Set II.
Mean of times	11^h 57^m $01^s.0$	1^h 05^m $23^s.0$
Sun's centre reads	202° 39′ 30″	241° 14′ 40″
Mean time of observation	11^h 35^m $45^s.0$	0^h 44^m $07^s.0$
App. time	11 30 05.6	0 38 28.0
Azimuth of Sun (from S.)	17° 02′.2	21° 37′.7
Reading of Sun	202 39.5	241 14.7
" ast. meridian	219 41.7	219 37.0

Mean	219° 39′.3
Corr'n for adjustment, Aug. 5	+1.1
Reading of ast. meridian, Aug. 4	219 40.4
" magnetic meridian, Aug. 4	220 31.6
Magnetic declination E.	0 51.2

Erie.—Aug. 9, 1841. Lat. 42° 07′.5; long. 80° 06′.

Abstract of Declination Observations.

N. end		S. end.	
0 44.1 W.		0 50.8 W.	
0 40.3 W.		0 59.5 W.	
1 01.2 W.		0 59.1 W.	
1 03.6 W.		0 48.8 W.	
+0 52.3		—0 54.5	
	—0 01.1		=—0° 00′.3
	Azimuth circle reads,		192 02.0
	Magnetic meridian reads,		192 01.7

Abstract of Observations for time, equal double Altitudes of Sun.

Set.	A. M.	P. M.	Elapsed time.
1	9h 22m 42s.3	3h 29m 19s.7	6h 06m 37s.4
2	10 18 23.2	2 33 53.4	4 15 30.2
3	10 38 39.8	2 13 39.7	3 34 59.9
Mean	10 06 35.1	2 45 37.6	4 39 02.5
Middle chron. time			0h 26m 06s.3
Equation of equal alts.			+8.0
Equation of time			—5 10.3
Chron. fast			0 21 04.0

Abstract of Observations for Latitude.

	Jupiter.	Saturn I.	Saturn II.	Saturn III.	Polaris.
Chron. time	8h 19m 33s.0	8h 32m 39s.2	9h 02m 02s.8	9h 08m 08s.0	10h 11m 57s.2
Observed double alt.	51° 32′ 26″	50° 28′ 13″	50° 51′ 20″	50° 43′ 57″	84° 14′ 23″
True altitude	25 44 08	25 11 58	25 23 33	25 19 51	42 06 01
Mean time	7h 58m 29s.0	8h 11m 35s.2	8h 40m 58s.8	8h 47m 04s.0	9h 50m 53s
Correspond'g sid. time	17 11 54.6	17 25 03.0	17 54 31.5	18 00 37.1	19 04 37
R. A. of star	16 33 52.0	17 46 19.3	17 46 19.3	17 46 19.3	1 02 52
Hour angle	0 38 02.6	23 38 43.7	0 08 12.2	0 14 17.8	18 01 45
Latitude	42° 08′ 28″	42° 08′ 45″	42° 06′ 43″	42° 07′ 00″	42° 06′ 26″
Mean					42° 07′ 28″

Abstract of Observations for Azimuth of Polaris.

	Set I.	Set II.
Aug. 9, mean of times	8h 53m 52s	9h 17m 47s
Mean circle reading	14° 38′ 22″	14° 42′ 20″
Mean time of observation	8h 32m 48s	8h 56m 43s
Corresponding sid. time	17 46 19	18 10 18
R. A. of Polaris	1 02 52	1 02 52
Hour angle	16 43 27	17 07 26
Azimuth of Polaris	1° 56′.7	2° 00′.5
Reading of Polaris	14 38.4	14 42.3
" ast. meridian	12 41.7	12 41.8
" magnetic meridian	12 11.7	12 11.7
Magnetic declination W.	0 30.0	0 30.1
Mean	0° 30′.0	

Dunkirk.—1841. Lat. 42° 29′.3; long. 79° 22′.

Abstract of Observations for time, equal double Altitudes of Sun.

	Set.	A. M.	P. M.	Elapsed time.
Aug. 11	1	9h 49m 53s.8	2h 55m 45s.6	5h 05m 51s.8
	2	10 11 42.1	2 34 04.0	4 22 21.9
	3	10 28 09.3	2 17 33.9	3 49 24.6
	Mean,	10 09 55.1	2 35 47.8	4 25 52.8
Middle chron. time				0h 22m 51s.4
Equation of equal alts.				+08.4
Equation of time				—4 52.6
Chron. fast				0 18 07.2

	A. M.	P. M.	Elapsed time.
Aug. 12	9h 21m 04s.7	3h 24m 17s.7	6h 03m 13s.0
Middle chron. time			0h 22m 41s.2
Equation of equal alts.			+09.4
Equation of time			—4 42.8
Chron. fast			0 18 07.8

	A. M.	P. M.	Elapsed time.
Aug. 13	9h 16m 25s.9	3h 28m 36s.9	6h 12m 11s.0
Middle chron. time			0h 22m 31s.4
Equation of equal alts.			+09.7
Equation of time			—4 32.6
Chron. fast			0 18 08.5

Abstract of Observations for Latitude.

Polaris, Aug. 11.

	Set I.	Set II.
Chron. time	10h 10m 53s.8	10h 22m 24s.2
Observed double alt.	85° 06′ 09′′	85° 16′ 48′′
True altitude	42 32 10	42 37 30
Mean time	9h 52m 46s.6	10h 04m 17s.0
Corresponding sid. time	19 14 22.9	19 25 55.2
R. A. of Polaris	1 02 53.4	1 02 53.4
Hour angle	18 11 29.5	18 23 01.8
Latitude	42° 28′ 41′′	42° 29′ 19′′
Mean	42° 29′ 00′′	

Polaris, Aug. 13.

	Set I.	Set II.	Set III.
Chron. time	8h 57m 35s.2	9h 14m 31s.5	9h 31m 21s.3
Obs'd double alt.	84° 13′ 52′′	84° 30′ 18′′	84° 42′ 27′′
True altitude	42 05 20	42 13 33	42 19 38
Mean time	8h 39m 26s.7	8h 56m 23s.0	9h 13m 12s.8
Correspond. sid. time	18 08 44.1	18 25 43.2	18 42 35.6
R. A. of Polaris	1 02 54.5	1 02 54.5	1 02 54.5
Hour angle	17 05 49.6	17 22 48.7	17 39 41.1
Latitude	42° 25′ 53′′	42° 27′ 22′′	42° 26′ 41′′
Mean		42° 26′ 39′′	

Aquilæ, Aug. 13.

	Set I.	Set II.
Chron. time	9h 51m 31s.6	10h 17m 13s.3
Observed double altitude	109° 40′ 42′′	111° 32′ 17′′
True altitude	54 49 08	55 44 56
Mean time	9h 33m 23s.1	9h 59m 04s.8
Corresponding sid. time	19 02 49.2	19 28 35.2
R. A. of Aquilæ	19 43 05.3	19 43 05.3
Hour angle	23 19 43.9	23 45 29.9
Latitude	42° 30′ 27′′	42° 33′ 43′′
Mean	42° 32′ 05′′	

	Latitude.
Aug. 11, Polaris	42° 29′ 00″
" 13, Polaris	26 39
" 13, α Aquilæ	32 05
Mean	42 29 15

Aug. 12, 1841. Abstract of Declination Observations.

N. end.	S. end.
1 20.4 E.	0 48.6 E.
1 10.2 E.	0 46.7 E.
1 01.7 E.	0 58.4 E.
1 01.2 E.	0 47.3 E.
—1 08.4 E.	+0 50.2

—0 09.1 = —0° 02′.2

Azimuth circle reads,	101 01.5
Magnetic meridian reads,	100 59.3

Abstract of Observations for Azimuth of Polaris.

Mean of times	9h 15m 13s.5
Mean circle reading	283° 54′ 24″
Mean time of observation	8h 57m 05s.7
Corresponding sid. time	18 22 29.5
R. A. of Polaris	1 02 53.9
Hour angle	17 19 35.6
Azimuth of Polaris	2° 02′.6
Reading of Polaris	283 54.4
" ast. meridian	281 51.8
" magnetic meridian	280 59.3
Magnetic declination W.	0 52.5

Ellicottville.—Aug. 14, 1841. Lat. 42° 18′.1; long. 78° 42′.

Abstract of Declination Observations.

N. end.	S. end.
0 47.2 W.	0 55.2 W.
0 45.7 W.	0 57.2 W.
1 19.2 W.	0 46.7 W.
1 18.7 W.	0 46.1 W.
+ 1 02.7	—0 51.3

+0 05.7 = +0° 01′.4

Azimuth circle reads,	233 39.9
Magnetic meridian reads,	233 41.3

Abstract of Observations for Azimuth of Polaris.

Mean of times	10h 36m 59s.6
Mean circle reading	238° 19′ 13″
Mean time of observation	10h 21m 29s.0
Corresponding sid. time	19 54 59.1
R. A. of Polaris	1 02 56.2
Hour angle	18 52 02.9

Azimuth of Polaris	2° 02′.2
Reading of Polaris	238 19.2
" ast. meridian	236 17.0
" magnetic meridian	233 41.3
Magnetic declination W.	2 35.7

Abstract of Observations for time. Aug. 15.

	Arcturus.	α Androm.
Mean of chron. times	9ʰ 23ᵐ 01ˢ.5	9ʰ 51ᵐ 32ˢ.3
" observed double alt.	57° 13′ 51″	63° 02′ 16″
True altitude	28° 34′ 39″	31° 29′ 03″
Hour angle	4ʰ 36ᵐ 21ˢ.3	—4ʰ 47ᵐ 00ˢ.4
R. A. of star	14 08 26.9	0 00 14.4
Sid. time	18 44 48.2	19 13 14.0
Corresponding mean time	9 07 33.7	9 35 54.8
Chron. fast	0 15 27.8	0 15 37.5
Mean	0ʰ 15ᵐ 32ˢ.6	

Abstract of Observations for Latitude. Aug. 15.

	Jupiter.	Saturn.	α Aquilæ.
Chron. time	8ʰ 02ᵐ 00ˢ.7	8ʰ 23ᵐ 52ˢ.7	10ʰ 11ᵐ 55ˢ.9
Observed double alt.	50° 24′ 09″	50° 31′ 24″	112° 10′ 36″
True altitude	25 09 31	25 13 08	56 04 08
Mean time	7ʰ 46ᵐ 30ˢ.2	8ʰ 08ᵐ 22ˢ.2	9ʰ 56ᵐ 25ˢ.4
Correspond. sid. time	17 23 31.4	17 45 27.0	19 33 47.8
R. A. of star	16 34 19.8	17 45 34.6	19 43 05.3
Hour angle	0 49 11.6	23 59 52.4	23 50 42.5
Latitude	42° 16′ 57″	42° 18′ 07″	42° 19′ 15″
Mean		42° 18′ 06″	

Bath.—Aug. 19, 1841. Lat. 42° 20′.8; long. 77° 21′.

Abstract of Declination Observations.

N. end.	S. end.
0 47.9 E.	1 23.7 E.
0 43.2 E.	1 21.9 E.
0 26.6 E.	1 25.4 E.
0 26.6 E.	1 27.5 E.
—0 36.1	+1 24.6

+0 24.2 = +0° 05′.8

Azimuth circle reads,	312 47.2
Magnetic meridian reads,	312 53.0

Abstract of Observations for Azimuth of Polaris.

Mean of times	9ʰ 26ᵐ 37ˢ.4
Mean circle reading	318° 29′ 10″
Chron. fast	0ʰ 10ᵐ 16ˢ.6
Mean time of Observation	9 16 20.8
Corresponding sid. time	19 09 22.1
R. A. of Polaris	1 02 58.6
Hour angle	18 06 23.5

Azimuth of Polaris	2° 04′.8
Reading of Polaris	318 29.2
" ast. meridian	316 24.4
" magnetic meridian	312 53.0
Magnetic declination W.	3 31.4

Abstract of Observations for Latitude. Aug. 18, 1841.

	Jupiter
Chron time	7h 55m 06s.3
Observed double alt.	49° 22′ 00″
True altitude	24 38 23
Chron. fast	0h 10m 14s.6
Mean time	7 44 51.7
Corresponding sid. time	17 33 41.5
R. A. of star	16 34 44.5
Hour angle	0 58 57.0
Latitude	42° 20′ 46″

Silver Lake.—Aug. 23, 1841. Lat. 41° 56′.6; long. 76° 05′.

Abstract of Observations for time, equal double Altitudes of Sun.

Set.	A. M.	P. M.	Elapsed time.
1	8h 59m 50s.8	3h 13m 50s.9	6h 14m 00s.1
2	9 04 43.1	3 08 56.9	6 04 13.8
3	9 09 10.1	3 04 31.3	5 55 21.2
Mean	9 04 34.7	3 09 06.4	6 04 31.7

Middle chron. time	0h 06m 50s.5
Equation of equal alts.	+ 11.0
Equation of time	—2 21.9
Chron. fast	0 04 39.6

Abstract of Observations for Latitude.

	Saturn.	Polaris.
Chron. time	8h 36m 11s.2	8h 52m 25s.9
Observed double alt.	48° 41′ 30″	83° 48′ 15″
True altitude	24 18 03	41 52 32
Mean time	8h 31m 31s.6	8h 47m 46s.3
Corresponding sid. time	18 40 10.3	18 56 27.7
R. A. of star	17 44 57.0	1 03 00.7
Hour angle	0 55 13.3	17 53 27.0
Latitude	41° 56′ 55″	41° 56′ 17″
Mean	41° 56′ 36″	

Abstract of Observations for Declination.

N. end.	S. end.
0 46.3 W.	1 09.7 W.
0 44.6 W.	1 11.9 W.
0 01.2 E.	1 35.0 W.
0 01.7 W.	1 35.7 W.
+0 22.8	—1 23.1

—0 30.1	= —0° 07′.3
Azimuth circle reads,	299 31.5
Magnetic meridian reads,	299 24.2

Abstract of Observations for Azimuth of Polaris.

Mean of times	9h 33m 59s.4
Mean circle reading	305° 57′ 32″
Mean time of observation	9h 29m 19s.8
Corresponding sid. time	19 38 08.8
R. A. of Polaris	1 03 00.8
Hour angle	18 35 08.0
Azimuth of Polaris	2° 03′.1
Reading of Polaris	305 57.5
" ast. meridian	303 54.4
" magnetic meridian	299 24.2
Magnetic declination W.	4 30.2

Girard College, Philadelphia.—Nov. 1, 1841. Lat. 39° 58′.4; long. 75° 10′.0.

Abstract of Observations for Declination.

N. end.	S. end.
0 10.7 E.	2 24.5 W.
0 02.9 E.	2 07.5 W.
0 38.2 W.	2 18.4 W.
0 38.8 W.	2 03.8 W.
+0 15.8	—2 13.5

—0 58.8 = —0° 14′.3

Azimuth circle reads, 130 35.5

Magnetic meridian reads, 130 21.2

Abstract of Observations for Azimuth of Polaris.

Mean of times	8h 08m 50s.6
Mean circle reading	135° 17′ 41″
Chron. fast	0h 01m 34s.0
Mean time of observation	8 07 16.6
Corresponding sid. time	22 51 50.2
R. A. of Polaris	1 03 15.7
Hour angle	21 48 34.5
Azimuth of Polaris	1° 06′.2
Reading of Polaris	135 17.7
" ast. meridian	134 11.5
" magnetic meridian	130 21.2
Magnetic declination W.	3 50.3

RECAPITULATION OF RESULTS FOR MAGNETIC DECLINATION, 1841.

1	Philadelphia	July 20, and Nov. 1,	3° 53′.7 W.
2	Easton	July 23,	3 38.0 W.
3	Williamsport	July 28,	3 31.2 W.
4	Curwinsville	Aug. 1,	1 45.1 W.
5	Mercer	Aug. 4,	0 51.2 E.
6	Erie	Aug. 9,	0 30.0 W.
7	Dunkirk	Aug. 12,	0 52.5 W.
8	Ellicottville	Aug. 14,	2 35.7 W.
9	Bath	Aug. 19,	3 31.4 W.
10	Silver Lake	Aug. 23,	4 30.2 W.

RECAPITULATION OF OBSERVED LATITUDES, 1841.

Williamsport	41° 14′.0
Curwinsville	40 57.7
Mercer	41 13.8
Erie	42 07.5
Dunkirk	42 29.3
Ellicottville	42 18.1
Bath	42 20.8
Silver Lake	41 56.6

Comparison of Declination for Secular Change. Results of 1840–41, *and of* 1862.

				1862 (Schott).	Annual increase.
Philadelphia, Girard College,	July and Nov.,	1841,	3° 53′.7 W.	5° 00′.0 W.	3′.2
Harrisburg,	July,	1840,	3 12.5 "	3 44.5 "	1.5
Williamsport,	July,	1841,	3 31.2 "	4 25.7 "	2.6
Johnson's Tav., near Brownsville,	Aug.,	1840,	0 25.2 "	1 13.6 "	2.2
Erie	Aug.,	1841,	0 30.0 "	1 33.0 "	3.0
Bath	Aug.,	1841,	3 31.4 "	4 47.9 "	3.6
		Mean			2′.7

Harrisburg was occupied in July, 1862, and all the other stations of 1862 in August.

Chronometric Results for Longitude.

In the tour of 1840, the error and rate of chronometer determined at Philadelphia was depended upon for time. The longitudes of the stations were taken from the best authorities.

In the tour of 1841, observations for time were made at stations, and the error of the chronometer was determined at Philadelphia, before setting out, and after return.

		Daily rate.
July 19. Corr'n to chron.	—0h 00m 06s.0	—2s.03
Aug. 30. " "	—0 01 31.4	

WILLIAMSPORT.—July 28, obs'd corr'n to chron.	—0h 07m 54s.5
Corr'n to chron., by rate Philadelphia	—0 00 24.3
Diff. of long.	0 07 30.2
Long. of Williamsport by chron.	77° 01′.3
CURWINSVILLE.—Aug. 1, obs'd corr'n to chron.	—0h 14m 24s.0
Corr'n to chron., by rate, Philadelphia	—0 00 32.4
Diff. of long.	0 13 51.6
Long. of Curwinsville by chron.	78° 36′.6
ERIE.—Aug. 9, obs'd corr'n to chron.	—0h 21m 04s.0
Corr'n to chron., by rate, Philadelphia	—0 00 48.6
Diff. of long.	0 20 15.4
Long. of Erie by chron.	80° 12′.5

	Aug. 11.	Aug. 12.	Aug. 13.
DUNKIRK.—Obs'd corr'n to chron.	—0h 18m 07s.2	—0h 18m 07s.8	—0h 18m 08s.5
Corr'n to chron. by rate, Phila.	—0 00 52.7	—0 00 54.7	—0 00 56.7
Diff. of long.	0 17 14.5	0 17 13.1	0 17 11.8
Long. of Dunkirk by chron. (mean)		79° 27′.0	

ELLICOTTVILLE.—Aug. 15, obs'd corr'n to chron.	.	—0h 15m 32s.6
Corr'n to chron. by rate, Philadelphia	.	—0 01 00.8
Diff. of long.	.	0 14 31.8
Long. of Ellicottville by chron.	.	78° 46′.6
SILVER LAKE.—Aug. 23, obs'd corr'n to chron.	.	—0h 04m 39s.6
Corr'n to chron. by rate, Philadelphia	.	—0 01 17.1
Diff. of long.	.	0 03 22.5
Long. of Silver Lake by chron.	.	75° 59′.3

Milford.—Aug. 26, 1841. Lat. 41° 19′.0.

Abstract of Observations on the Sun for time.

Set.	Chron. time.	Obs'd double alt. of sun's centre.	True altitude.	Computed mean time.	Chron. fast.
I.	9h 51m 05s.3	95° 35′ 28″	47° 46′ 20″	9h 50m 45s.7	0h 00m 19s.6
II.	10 18 20.3	103 09 30	51 33 28	10 17 54.6	0 00 25.7
III.	10 31 00.9	106 20 45	53 09 07	10 30 43.7	0 00 17.2
				Mean	0 00 20.8

MILFORD.—Obs'd corr'n to chron.	.	—0h 00m 20s.8
Corr'n to chron. by rate, Philadelphia	.	—0 01 23.2
Diff. of long.	.	0 01 02.4
Long. of Milford by chron.	.	74° 53′.1

	Longitude.			
	By chron.	From lake survey.	Previously adopted.	Final adopted.
Williamsport	77° 01′.3		77° 03′.5	77° 02′
Curwinsville	78 36.6		78 35	78 36
Erie[1]	80 12.5	80° 05′	80 06	80 06
Dunkirk[2]	79 27.0	79 22	79 22	79 23
Ellicottville	78 46.6		78 42	78 44
Silver Lake	75 59.3		76 05	76 02
Milford	74 53.1		74 50	74 51.5

[1] Colton's Map, 80° 10′.

[2] Colton's Map, 79° 22′.5.

GEOGRAPHICAL POSITIONS OF THE MAGNETIC STATIONS.

Table of Geographical Positions

TAKEN from special observations; H. F. Walling's large map of Pennsylvania; J. H. French's large map of New York; the U. S. Coast Survey; and from Railroad and Canal map of Pennsylvania, Tanner, 1834, and other sources.

Tour of 1840, through Southern Pennsylvania, and part of Ohio, Virginia, and Maryland.

		Latitude.	Longitude.
Philadelphia, Girard College,	Pa.	39° 58′.4	75° 10′.0
Reading,	"	40 19	75 55
Harrisburg,	"	40 16	76 53
Duncan's Island,	"	40 25	77 01
Lewistown,	"	40 35	77 36
Huntingdon,	"	40 30.5	78 02
Armagh,	"	40 29	79 04
Economy	"	40 37	80 16
Homewood, near Pittsburg,	"	40 28	79 59.5
Steubenville,	Ohio	40 25	80 39
Wheeling,	Va.	40 08	80 42
Johnson's Tavern, near Brownsville,	Pa.	39 59.5	79 47.8
Frostburgh,	Md.	39 41	78 56
Irwin's Mill, near Mercersburg,	Pa.	39 47	77 56
Baltimore,	Md.	39 17.8	76 36.6
Frenchtown,	"	39 35	75 51

Tour of 1841, through Northern Pennsylvania, and part of Ohio and New York.

		Latitude.	Longitude.
Doylestown,	Pa.	40° 18′	75° 10′
Easton,	"	40 42	75 15
Wilkesbarre,	"	41 14	75 58
Williamsport,	"	*41 14.0	†77 02
Bellefonte,	"	40 55	77 49
Curwinsville,	"	*40 57.7	†78 36
Berlin's Tavern,	"	41 16	79 36
Mercer,	"	41 13.8	80 16
Warren,	Ohio	41 17	80 50
Ashtabula Landing,	"	41 54	80 47
Erie,	Pa.	*42 07.5	†80 06
Dunkirk,	N. Y.	*42 29.3	†79 23
Ellicottville,	"	*42 18.1	†78 44

		Latitude.	Longitude.
Belvidere,	N. Y.	42 13	78 06
Bath,	"	*42 20.8	77 21
Owego,	"	42 08	76 17
Silver Lake,	"	*41 56.6	†76 02
Milford,	Pa.	41 19	†74 51.5
Bushkill,	"	41 07	75 02

Tour of 1843, through New York, and part of Canada and New Jersey.

		Latitude.	Longitude.
Princeton,	N. J.	40° 20′.7	74° 39′.6
Schenectady, Union College,	N. Y.	42 48	73 57
Utica,	"	43 05	75 14
Syracuse,	"	43 03	76 09.3[1]
Geneva,	"	42 53	77 02
West Point,	"	41 23.4	73 57.0
Rochester,	"	43 07	77 39
Niagara Falls,	"	43 04	79 05
Toronto,	Canada W.	43 39.5	79 21.5
Oswego,	N. Y.	43 26	76 35
Ogdensburgh,	"	44 42	75 31
Quebec,	Canada E.	46 48	71 14
Montreal,	"	45 30	73 35
Troy,	N. Y.	·42 43.7	73 40.7

Latitudes determined astronomically are marked with an asterisk (*); longitudes determined astronomically, combined with other determinations, are marked with a cross (†).

[1] From telegraphic determination; see report of the Regents of the University of the State of New York, 1862.

DISTRIBUTION OF THE MAGNETIC DECLINATION.

Distribution of the Magnetic Declination for the Epoch, 1842.0.

FROM the comparison of Observations for secular change, we have :—

Harrisburg,	annual increase	1′.5
Johnson's Tavern,	"	2.2
Philadelphia,	"	3.2
Williamsport,	"	2.6
Erie,	"	3.0
Bath,	"	3.6
	Mean	2.7
Toronto, between 1845 and 1855 (see Vol. III. of the Obs'ns)		2.3

General Table of results referred to the common epoch 1842.0.

No.	Station.	Date.	Obs'd decl. W.	Red. to epoch.	Declination 1842.0.
1	Harrisburg	1840, July 25	3° 12′.5	+4′.0	3° 16′.5
2	Huntingdon	" July 30	1 52.3	"	1 56.3
3	Near Pittsburg	" Aug. 10	0 08.0	"	0 12.0
4	" Brownsville	" Aug. 17	0 25.2	"	0 29.2
5	" Mercersburg	" Aug. 24	0 54.4	"	0 58.4
6	Baltimore	" Aug. 27	2 16.5	"	2 20.5
7	Philadelphia	1841, July 20, Nov. 1	3 53.7	+0.7	3 54.4
8	Easton	" July 23	3 38.0	+1.3	3 39.3
9	Williamsport	" July 28	3 31.2	"	3 32.5
10	Curwinsville	" Aug. 1	1 45.1	"	1 46.4
11	Mercer	" Aug. 4	—0 51.2	"	—0 49.9
12	Erie	" Aug. 9	0 30.0	"	0 31.3
13	Dunkirk	" Aug. 12	0 52.5	"	0 53.8
14	Ellicottville	" Aug. 14	2 35.7	"	2 37.0
15	Bath	" Aug. 19	3 31.4	"	3 32.7
16	Silver Lake	" Aug. 23	4 30.2	"	4 31.5

No.	Station.	Latitude.	Longitude.	Decl. W. 1842.0.
1	Harrisburg	40°.27	76°.88	3°.27
2	Huntingdon	40.51	78.03	1.94
3	Near Pittsburg	40.47	79.99	0.20
4	" Brownsville	39.99	79.80	0.49
5	" Mercersburg	39.78	77.93	0.97
6	Baltimore	39.30	76.61	2.34
7	Philadelphia	39.97	75.17	3.89
8	Easton	40.70	75.25	3.65
9	Williamsport	41.23	77 03	3.54
10	Curwinsville	40.96	78.60	1.77
11	Mercer	41.23	80.27	—0.83
12	Erie	42.13	80.10	0.52
13	Dunkirk	42.49	79.38	0.90
14	Ellicottville	42.30	78.73	2.62
15	Bath	42.35	77.35	3.55
16	Silver Lake	41.94	76.03	4.52
	Mean	40.98	77.95	2.08

The small extent of the survey, as well as the comparatively small number of observations, will not permit the introduction of curvature in the isogonic lines; they are therefore treated as straight lines. This assumption also serves for the recognition of any local disturbances as indicated by the differences of observed and computed values.

Let $D = +2^\circ.08 + x\,dL + y\,dM \cos L$

Where $dL = Lat. - 40^\circ.98$

$dM = Long. - 77.95$

The 16 conditional equations have been formed, and the values of x y & D found from the normal equations, are as follows:—

$$x = +0.5102$$

$$y = -1.206$$

$$D = +2^\circ.08 + 0.5102\,dL - 1.206\,dM \cos L.$$

A comparison of the observed and computed declinations shows the necessity of introducing a term involving $dL\,dM \cos L$; this has been done and the solution of the normal equations gives us the following expression:—

$$D = +2^\circ.14 + 0.513\,dL - 1.231\,dM \cos L - 0.203\,dL\,dM \cos L.$$

Comparison of Observed and Computed Values.

Station.	Observed declination.	Computed declination.	Observed — computed.
Harrisburg	3°.27	+2°.67	+36′
Huntingdon	1.94	1.82	+ 7
Near Pittsburg	0.20	0.13	+ 4
" Brownsville	0.49	0.16	+20
" Mercersburg	0.97	1.54	—34
Baltimore	2.34	2.21	+ 8
Philadelphia	3.89	3.81	+ 5
Easton	3.65	4.41	—46
Williamsport	3.54	3.16	+23
Curwinsville	1.77	1.51	+16
Mercer	—0.83	0.04	—52
Erie	0.52	0.44	+ 5
Dunkirk	0.90	1.29	—23
Ellicottville	2.62	1.96	+40
Bath	3.55	3.50	+ 3
Silver Lake	4.52	4.66	— 8

The probable error of any single representation is ± 19′.4

The curves of 0° 2° 4° pass through the following positions :—

0°	lat. 41° 00′ long. 80 15	lat. 42° 30′ long. 80 33	lat. 39° 30′ long. 79 54
2°	lat. 41° 00′ long. 78 07	lat. 42° 30′ long. 78 46	lat. 39° 30′ long. 77 05
4°	lat. 41° 00′ long. 75 56	lat. 42° 30′ long. 76 59	lat. 39° 30′ long. 74 17

These curves have been finally adopted.

DETERMINATION OF THE MAGNETIC INTENSITY AND DIP,

1834–5, 1840, 1841, AND 1843.

Determination of the Magnetic Intensity.

A. RELATIVE horizontal intensity by vibrations of a bar (needle A), and of a cylinder (needle C).

B. Relative total intensity by deflections of Lloyd needles with weights.

C. Magnetic inclination.

Correction for Temperature to the observed Time of Vibration.

The coefficient of temperature m has been determined by special experiments which, together with the result, are published in the Trans. of the Amer. Phil. Society, Philadelphia, Vol. V. new series, Part III. 1837, Art. XXVIII. "On the relative horizontal intensities of terrestrial magnetism at several places, by A. D. Bache and E. H. Courtenay."

The bar is called in that paper needle A, and the cylinder needle C; on page 443 the value of the temperature coefficient is stated as follows:—

For the bar, $m = 0.000117$
For the cylinder, $m = 0.000052$

Let T = time of oscillation at temp. t
T' = " " " t'

$$\text{then } T = T' \left\{ 1 - m\,(t' - t) \right\}$$

The above numerical values were used in reducing the time of 10 vibrations to the adopted standard temperature 60° Fahr.

log m for the bar, 6.068186
log m for the cylinder, 5.716003

Magnetic Survey of 1840–41.

Recapitulation of Magnetic Results at Girard College, Philadelphia.

Time of 10 vibrations, reduced to temp. 60°, and *correction* for *loss of magnetism.*

Date.	Duration.		Daily change.	
	Cylinder.	Bar.	Cylinder.	Bar.
July 16, 1840	34ˢ.480	36ˢ.775		
Nov. 3, 1840	34.641	36.841	+0.001464	+0.00060
July 20, 1841	34.741	36.836		
Nov. 1, 1841	34.854	36.907	+0.001086	+0.00068

The daily change being known, we can compute the time of 10 vibrations at Philadelphia corresponding in time to the observations made at any of the other stations in 1840 and 1841, and thus obtain, by comparison, the relative horizontal intensity at each station, Philadelphia being 1.000; and introducing the horizontal intensity in absolute measure for Girard College, Philadelphia, we can express the magnetic intensity, at all the stations visited, in the same measure.

The secular change in the horizontal intensity has been shown by Assistant Schott (U. S. Coast Survey Report, 1861, Appendix, No. 22) to be small. He found, for a number of stations near the Atlantic coast, the annual secular change to be on the average —0.001 (in parts of the horizontal force, the negative sign indicating a diminution). The effect of the secular change may, therefore, be safely considered as imperceptible during the interval of the magnetic survey in 1840 and in 1841, each trip extending over a period of but little more than a month.

The following table contains the duration of 10 vibrations reduced to 60° Fahr. observed at stations in 1840 and in 1841, together with the corresponding duration as it would have been observed at Girard College and the deduced horizontal intensity, Philadelphia being 1.000.

Relative horizontal intensity $H = \frac{T^2}{T_1^2}$

where T = time of 10 vibrations (at 60°) at Philadelphia,

and T_1 = " " " at any other station.

Station.	Date.	Cylinder or bar.	Observed time of 10 vibrations reduced to temp. 60°.	Corresponding time of 10 vib'ns (at 60°) at Philadelphia.	Relative horizontal intensity, Philadelphia = 1.0000.
Harrisburg	July 25, 1840	C	34ˢ.833	34ˢ.492	0.9805
		B	37.150	36.780	0.9802
				Mean	0.9803
Huntingdon	July 30, 1840	C	34.682	34.500	0.9896
		B	37.042	36.783	0.9861
				Mean	0.9878
Homewood	Aug. 13, 1840	C	34.994	34.521	0.9732
		B	37.292	36.792	0.9733
				Mean	0.9732
Johnson's Tavern	Aug. 18, 1840	C	34.332	34.528	1.0114
		B	36.596	36.795	1.0109
				Mean	1.0112
Irwin's Mill	Aug. 24, 1840	C	34.419	34.537	1.0068
		B	36.482	36.798	(1.117) Rejected, temp. doubtful.
Baltimore	Aug. 27, 1840	C	. . . .	. . . .	. . . .
		B	36.342	36.801	1.0252
Williamsport	July 28, 1841	C	35.540	34.750	0.9560
		B	37.682	36.841	0.9559
				Mean	0.9560
Curwinsville	Aug. 1, 1841	C	35.479	34.753	0.9595
		B	37.595	36.843	0.9604
				Mean	0.9600
Mercer	Aug. 5, 1841	C	35.499	34.757	0.9586
		B	37.571	36.846	0.9618
				Mean	0.9602
Erie	Aug. 9, 1841	C	36.437	34.762	0.9102
		B	41.035	36.850	(0.8064) Rejected, some error in the observations.
Ellicottville	Aug. 16, 1841	C	36.787	34.769	0.8933
		B	38.939	36.854	0.8958
				Mean	0.8945
Bath	Aug. 19, 1841	C	36.931	34.772	0.8865
		B	39.315	36.856	0.8788
				Mean	0.8826
Silver Lake	Aug. 23, 1841	C	36.530	34.778	0.9064
		B	38.654	36.858	0.9092
				Mean	0.9078
Milford	Aug. 26, 1841	C	36.582	34.781	0.9039
		B	38.738	36.860	0.9054
				Mean	0.9046

Magnetic Survey of 1843.

The trip in 1843 occupied less than one month, and since the needles were not again vibrated after returning to Philadelphia, we adopt the same rate of change as found in 1840 and 1841, viz.: for the cylinder + 0.00127, and for the bar + 0.00064.

We have at Philadelphia—

Time of 10 vibrations, reduced to 60°, cylinder 35ˢ.045, July 20, 1843.
bar 36.914.

Station.	Date.	Cylinder or bar.	Observed time of 10 vibrations reduced to temp. 60°.	Corresponding time of 10 vib'ns (at 60°) at Philadelphia.	Relative horizontal intensity, Philadelphia = 1.0000
Union College, Schen. .	July 21, 1843	C	38ˢ.220	35ˢ.046	0.8408
		B	40.323	36.915	0.8381
				Mean	0.8394
Syracuse	July 29, 1843	C	38.004	35.056	0.8509
		B	39.959	36.919	0.8537
				Mean	0.8523
Geneva	July 31, 1843	C	37.548	35.059	0.8718
		B	39.568	36.921	0.8707
				Mean	0.8712
Niagara Falls	Aug. 3, 1843	C	37.933	35.063	0.8544
		B[1]	. . .	. . . .	. . . .
Toronto	Aug. 7, 1843	C	38.075	35.068	0.8483
		B	40.116	36.925	0.8472
				Mean	0.8478
Ogdensburgh	Aug. 9, 1843	C	39.514	35.070	0.7877
		B	41.505	36.926	0.7915
				Mean	0.7896
Montreal	Aug. 15, 1843	C	40.674	35.078	0.7437
		B	42.740	36.930	0.7466
				Mean	0.7451

[1] Observations imperfect.

In 1843, at Toronto, the horizontal intensity in absolute measure was determined by Lieuts. Lefroy and Younghusband at the magnetic observatory (see Mr. Schott's report of Jan. 19, 1861, U. S. Coast Survey Report, 1861), and found to be 3.537, hence by the above proportion Philadelphia becomes 4.172, a value in excellent agreement with the other determinations at this place.

If we compare with Montreal, we have Lieut. Lefroy's determination at St. Helen's in 1843, 3.083, hence Philadelphia becomes 4.138, a value not quite so accordant as that found from the comparison with Toronto.

For the introduction of the absolute value for the stations visited in 1840, we have, from Dr. Locke's observations at Baltimore in 1841, at St. Mary's, 4.261; at the city, 4.238; mean, 4.250; which gives for Philadelphia 4.146. At Philadelphia we have Prof. Loomis' determination in 1839, 4.149 (Chestnut Street), and Dr. Locke's, 4.172, at the Girard College, the mean of which will be 4.160. This value may be adopted for the 1840 series.

For the stations occupied in 1841, the mean of the absolute values used in 1840 and 1843 for Philadelphia, viz., 4.166, has been used as the base number.

Accordingly, we obtain the following magnetic horizontal intensities, expressed in terms of the absolute scale (British units):—

		X.
	1840.	
Harrisburg	July 25,	4.078
Huntingdon	July 30,	4.109
Homewood	Aug. 13,	4.049
Johnson's Tavern	Aug. 18,	4.207
Irwin's Mill	Aug. 24,	4.188
Baltimore	Aug. 27,	4.265
Philadelphia (base)	July 16 and Nov. 3,	4.160
	1841.	
Williamsport	July 28,	3.983
Curwinsville	Aug. 1,	3.999
Mercer	Aug. 5,	4.000
Erie	Aug. 9,	3.792
Ellicottville	Aug. 16,	3.726
Bath	Aug. 19,	3.677
Silver Lake	Aug. 23,	3.782
Milford	Aug. 26,	3.769
Philadelphia (base)	July 20 and Nov. 1,	4.166
	1843.	
Philadelphia	July 20,	4.172
Union College, Schenectady	July 21,	3.502
Syracuse	July 29,	3.556
Geneva	July 31,	3.635
Niagara Falls	Aug. 3,	3.565
Toronto (base)	Aug. 7,	3.537
Ogdensburgh	Aug. 9,	3.294
Montreal	Aug. 15,	3.109

Connection of the European and American Series of 1836, '37, '38, *and* 1840.[1]

The series of observations made in Europe in the years 1836, '37, and '38, when the same cylinder and bar magnets were used, previously and subsequently used at Philadelphia and other places, give us additional means of introducing the absolute measures of the horizontal force, though in a somewhat circuitous way.

According to General Sabine, the total force at Woolwich, in June, 1846, may be taken at 10.388; Dr. Lamont thinks that the total force in Europe has but a small, if any change; we may therefore take 10.388 to represent the total force in

[1] Art. IX, Transactions American Philosophical Society, Philadelphia, Vol. VII, new series, Part I, 1840. Observations of the Magnetic Intensity at twenty-one stations in Europe. By A. D. Bache, LL.D., President of the Girard College of Orphans.

1836 and '37; the dip was observed by me at London (at Westbourne Green) and found to be 69° 17'.8 in June, 1837. The adopted annual decrease of the dip being 2'.4, we have the dip at London, in Nov. 1836, 69° 19'.2, and in Feb. 1837, 69° 18'.6. The horizontal intensity at London (Woolwich) becomes therefore in Nov. 1836, 3.669, and in Feb. 1837, 3.670, and in June, 1837, 3.672. From the general table of results we have further the relative horizontal intensities at Edinburgh (Feb. 1837), at Dublin (Nov. 1836), and at London (June, 1837), 0.841, 0.879, and 0.939 respectively, whence the horizontal intensities, in absolute measure, at these localities and times, are for Dublin 3.436, and for Edinburgh 3.287. At Philadelphia, the vibrations of the bar magnet and magnet B were observed in Sept. 1836, and also afterwards at the above European stations from which, in my manuscript record, the relative intensities were deduced as follows: Philadelphia 1.0000, Dublin 0.8300, and Edinburgh 0.7957. Using the above absolute values for Dublin and Edinburgh, Philadelphia becomes, from comparison with Dublin, 4.140, and from comparison with Edinburgh 4.131, mean of the determinations 4.136. The difference in the intensity at Girard College and the house in Chestnut Street we find, by comparison of Prof. Loomis' observations in 1839 (4.149), with Dr. Locke's in 1841 (4.172), is 0.023, hence the magnetic intensity at Girard College in Sept. 1836, from comparison with the European stations, becomes 4.159; the value actually used for the survey in 1840 was 4.160, and since the effect of the secular change for this interval of four years must be small, there is no reason for changing the value adopted, it being correct within the limits of uncertainty of the several comparisons.

For comparison and the effect of secular change in X, we have the following collection (from Mr. Schott's report of Jan. 19, 1861, U. S. Coast Survey Report of 1861):—

At **Philadelphia**.

		X.
1835.0	Bache & Courtenay	4.195
1836.7	Bache	4.159
1839.5	Loomis	4.149
1841.5	Locke	4.172
1842.5	Locke	4.174
1842.8	Lefroy	4.176
1843.6	Bache	4.172
1844.5	Locke	4.162
1846.4	Locke	4.143
1855.7	Schott	4.226
1862.6	Schott	4.088

At **Baltimore**.

1840.7	Bache	4.265
1841.5	Locke	4.261
1841.5	Locke	4.238
1842.8	Lefroy	4.238
1856.7	Schott	4.203

At **Montreal**.

1842.7	Lefroy	3.064
1843.3	Lefroy	3.083
1843.6	Bache	3.109
1845.5	Younghusband	3.011
1859.6	Schott	3.111

Magnetic Tour of 1834 *and* 1835, *in the Northeastern States.*

(In connection with Prof. Courtenay.)

The results of the observations for horizontal intensity, as published in Vol. V (new series) of the Transactions of the American Philosophical Society, Part III, 1837, are expressed in relative measure, Philadelphia being taken as unit. It seems to be desirable to present these results, expressed in terms of the absolute scale, and I have, therefore, inserted them here in connection with my other determinations.

From Mr. Schott's collection of intensities we have, at New York (Columbia College), in 1822, the intensity 3.981 (Col. Sabine observer); and in 1841, in the same locality, 4.018 (Dr. Locke observer); whence the horizontal intensity in 1835 is 4.006, from which we obtain for Philadelphia, in 1835, the value

$$4.006 \times \frac{1.00000}{0.94705} = 4.23$$

In 1836, the value found was 4.16; the mean of these determinations I have adopted as the nearest value that can at present be assigned, viz., 4.195.

We have, accordingly, the following table of results:—

1834—35.		Relative hor. intensity.	Hor. intensity, absol. scale.
Philadelphia,	1834–5	1.00000	4.195
West Point,	"	0.92156	3.866
New York,	"	0.94705	3.973
Newport, R. I.,	1835	0.90086	3.779
Providence, R. I.,	"	0.89869	3.770
Springfield, Mass.,	"	0.88711	3.721
Albany, N.Y.,	"	0.85290	3.578

That the value adopted for Philadelphia is very nearly correct (and will not bear diminution), may be inferred from the following comparison and the known law of secular change of the horizontal intensity. The comparison is obtained from Mr. Schott's collection:—

At **West Point**.

		X.
1835.0	Bache & Courtenay	3.866
1842.5	Lefroy	3.881

At New York.

		X.	
1822.5	Sabine,	3.981	Columbia College.
1835.0	Bache & Courtenay,	3.973	"
1841.5	Locke,	4.018	"
1841.5	Locke,	4.015	Lunatic Asylum.
1842.7	Lefroy,	4.008	"
1844.5	Locke,	4.010	Columbia College.
1844.5	Locke,	4.007	Lunatic Asylum.
1844.5	Renwick,	4.071	Columbia College.
1846.3	Locke,	4.009	Bloom. Asylum.
1846.4	Locke,	4.053	Mt. Prospect.
1855.7	Schott,	3.920	Bedloe's Island.
1855.7	Schott,	3.926	Governor's Island.
1855.7	Schott,	3.938	Receiving Reservoir.
1860.8	Schott,	4.052	Mt. Prospect.

At Providence.

		X.
1835.0	Bache & Courtenay	3.770
1839.5	Loomis	3.726
1842.7	Lefroy	3.715
1855.6	Schott	3.590

At Springfield.

1835.0	Bache & Courtenay	3.721
1859.6	Schott	3.691

At Albany.

1835.0	Bache & Courtenay	3.578
1842.8	Lefroy	3.579
1844.5	Locke	3.582
1844.5	Locke	3.571
1855.6	Schott	3.587
1856.7	Friesach	3.575
1858.4	Dean	3.574

Reduction of the relative Total Intensity Observations by Lloyd's Needles.

Let $\delta =$ true dip,
$\zeta =$ dip by a Lloyd needle when unloaded,
$\varepsilon =$ correction to ζ,
then $\delta = \zeta + \varepsilon$, ε may be assumed as constant for each tour.

For finding the value of ε we have the following results:—

Station.	Date.	δ	ζ Lloyd 1.	ζ Lloyd 3.	ε Lloyd 1.	ε Lloyd 3.
For 1840.						
Philadelphia	July 21	71° 51′.7	71° 55′.8	71° 50′.1	— 4′.1	+ 1′.6
Harrisburg	July 25	72 18.8	72 27.3	72 17.3	— 8.5	+ 1.5
Huntingdon	July 30	72 16.9	72 22.1	72 14.2	— 5.2	+ 2.7
Homewood	Aug. 10	72 32.6	72 34.3	72 24.9	— 1.7	+ 7.7
Johnson's Tavern	Aug. 18	71 54.7	71 57.0	71 42.5	— 2.3	+12.2
Irwin's Mill	Aug. 24	71 49.1	71 50.5	71 34.2	— 1.4	+14.9
Baltimore	Aug. 27	71 35.4	71 37.1	71 22.0	— 1.7	+13.4
Philadelphia	Oct. 28	71 51.6	72 01.8	71 47.4	—10.2	+ 4.2
			Mean		—4.4	+7.3
For 1841.						
Philadelphia	April 26	71 58.1	72 00.4	72 00.4	—2.3	(—2.3) rejected.
"	July 20	71 57.8	71 53.4	71 46.8	+4.4	+11.0
Williamsport	July 28	72 55.5	72 52.5	72 41.6	+3.0	+13.9
Curwinsville	Aug. 1	72 47.3	72 52.3	72 40.1	—5.0	+ 7.2
Mercer	Aug. 5	72 56.8	72 54.6	72 50.9	+2.2	+ 5.9
Erie	Aug. 8	73 44.0	73 47.3	73 40.7	—3.3	+ 3.3
Ellicottville	Aug. 16	74 20.2	74 12.5	74 02.9	+7.7	+17.3
Bath	Aug. 19	74 28.5	74 24.9	74 15.6	+3 6	+12.9
Silver Lake	Aug. 23	73 40.1	73 45.2	73 33.1	—5.1	+ 7.0
Milford	Aug. 26	73 47.7	73 45.4	73 38.7	+2.3	+ 9.0
Philadelphia	Oct. 9 } Nov. 1 }	71 58.0	71 58.0	. . . . .	0.0	. . .
			Mean		+0.7	+9.7
For 1843.						
Schenectady	July 27	74 55.4	74 55.6	74 39.9	—0.2	+15.5
Syracuse	July 29	74 50.9	74 50.6	74 41.3	+0.3	+ 9.6
Geneva	July 31	74 34.5	74 28.5	74 20.9	+6.0	+13.6
Toronto	Aug. 7	75 10.3	75 12.0	75 03.3	—1.7	+ 7.0
Ogdensburgh	Aug. 9	76 07.4	76 05.0	75 58.5	+2.4	+ 8.9
Quebec	Aug. 14	77 12.0	77 08.5	77 07.6	+3.5	+ 4.4
Montreal	Aug. 15	76 48.4	76 44.8	76 37.7	+3.6	+10.7
Philadelphia	Sept. 5	[1]71 59.6	71 58.9	71 49.3	+0.7	+10.3
"	Sept. 12	[2]71 57.1	71 57.1	71 48.4	0.0	+ 8.7
			Mean		+1.6	+10.0

We have, therefore, the following values of ε:—

For 1840,	Lloyd Needle, No. 1,	—4′.4 + 0′.8	Lloyd, No. 3,	+ 7′.3 ± 1′.0
1841,	" "	+0.7 ± 1.3	"	+ 9.7 ± 0.7
1843,	" "	+1.6 + 0.7	"	+10.0 ± 0.8

Correction for loss of magnetism.—In my paper on the magnetic observations and results in Europe, during 1836, '37, '38, I have shown that during the short

[1] Dip by needle No. 1.

[2] Mean by two needles, viz., No. 1, 71° 58′.2, and No. 2, 71° 55′.9.

interval of a month, the loss of magnetism of the Lloyd Needles is too small to require any correction.

Table of Resulting Dips.

At those stations where the Lloyd needles were used, the dip was obtained by applying the correction ε to the results by the needle when unloaded; when the dip was also observed in the ordinary way, the result by the Lloyd needle was allowed the weight one-half, as it depends on half the number of observations.

Results for dip in 1840.				
Station.	Date.	Needle 1 and 2.	Needle Ll. 1 and Ll. 3.	Dip by combination.
Philadelphia	July 21	71° 51′.7	71° 54′.4	71° 52′.6
Reading	July 23		72 32.2	
Harrisburg	July 25	72 18.8	72 23.8	72 20.5
Duncan's Island	July 27		72 35.0	
Lewistown	July 29		[1]72 30.0	
Huntingdon	July 30	72 16.9	72 19.6	72 17.8
Armagh	Aug. 2		72 18.7	
Economy	Aug. 8		[2]72 35.0	
Homewood	Aug. 10	72 32.6	72 31.0	72 32.1
Steubenville	Aug. 15		72 32.8	
Wheeling	Aug. 16		72 08.9	
Johnson's Tavern	Aug. 18	71 54.7	71 51.2	71 53.5
Frostburgh	Aug. 20		71 31.3	
Irwin's Mill	Aug. 24	71 49.1	71 43.8	71 47.3
Baltimore	Aug. 27	71 35.4	71 31.0	71 33.9
Frenchtown			71 40.2	
Philadelphia	Aug. 28	71 51.6	71 56.0	71 53.1
Results for Dip in 1841.				
Philadelphia	April 26	71° 58′.1	72° 05′.6	72° 00′.6
"	July 20	71 57.8	71 55.3	71 57.0
Doylestown	July 22		72 23.1	
Easton	July 22		72 39.0	
Wilkesbarre	July 26		73 10.0	
Williamsport	July 28	72 55.5	72 52.3	72 54.4
Bellefonte	July 30		72 42.3	
Curwinsville	Aug. 1	72 48.8	72 51.4	72 49.7
Berlin's Tavern	Aug. 3		72 52.8	
Mercer	Aug. 5	72 56.8	72 58.0	72 57.2
Warren	Aug. 6		72 59.9	
Ashtabula Landing	Aug. 7		73 23.5	
Erie	Aug. 8	[3]73 44.0	73 49.2	73 46.6
Dunkirk	Aug. 13		74 17.2	
Ellicottville	Aug. 16	74 20.2	74 12.9	74 17.8
Belvidere	Aug. 17		74 09.5	
Bath	Aug. 19	74 28.5	74 25.5	74 27.5
Owego	Aug. 20		74 13.9	
Silver Lake	Aug. 23	73 40.1	73 44.4	73 41.5
Milford	Aug. 26	73 47.7	73 47.3	73 47.6
Bushkill	Aug. 27		73 31.4	
Philadelphia	Oct. 9	71 58.0	71 58.6	71 58.2
"	Nov. 1		71 59.1	

[1] By Lloyd 1. [2] By Lloyd 3. [3] By 1, equal weight with Ll. 1 and Ll. 3.

Results for Dip in 1843.

Station.	Date.	Needle 1 and 2.	Needle Ll. 1 and Ll. 3.	Dip by combination.
[1]Philadelphia	July 20		71° 56'.5	
Princeton	July 21		72 38.3	
West Point	July		73 12.2	
Schenectady	July 27	74° 55'.4	74 53.6	74° 54'.8
Utica	July 28		74 50.3	
Syracuse	July 29	74 50.9	74 51 8	74 51.2
Geneva	July 31	74 34.5	74 30.7	74 33.2
Rochester	Aug. 1		74 43.5	
Niagara Falls	Aug. 3		74 48.9	74 51.0
"	Aug. 4		74 53.2	
Toronto	Aug. 7	75 10.3	75 13.5	75 11.4
Oswego	Aug. 8		75 07.1	
Ogdensburgh	Aug. 9	76 07.4	76 07.6	76 07.5
Quebec	Aug. 14	77 12.0	77 13.9	77 13.8
"	Aug. 14		77 16.4	
Montreal	Aug. 15	76 48.4	76 47.1	76 48.0
Troy	Aug. 18		74 47.9	
[2]Philadelphia	Aug. 26		71 58.4	
"	Sept. 5	71 59.6	71 59.9	71 59.7
"	Sept. 12	71 57.1	71 58.6	71 57.6

Recapitulation of the observed Dip at Philadelphia.

		Means.	
July 21, 1840	71° 52'.6		
Oct. 28, 1840	71 53.1	71° 55'.4	Dec. 1840
April 26, 1841	71 60.6		
July 20, 1841	71 57.0		
Oct. 9, 1841	71 58.2	71 58.1	Oct. 1841
Nov. 1, 1841	71 59.1		
July 20, 1843	71 56.5		
Sept. 5, 1843	71 59.7	71 57.9	Aug. 1843
Sept. 12, 1843	71 57.6		

By means of the preceding results for horizontal intensity X, and dip δ, we find the total intensity ϕ, as follows:—

$$\phi = X \sec \delta.$$

	1840.	ϕ
Philadelphia,	July,	13.37
Harrisburg,	"	13.44
Huntingdon,	"	13.51
Homewood,	Aug.,	13.49
Johnson's Tav.,	"	13.54
Irwin's Mill,	"	13.40
Baltimore,	"	13.49
Philadelphia,	Oct.,	13.38

	1841.	ϕ
Philadelphia,	April,	13.49
"	July,	13.45
Williamsport,	"	13.55
Curwinsville,	Aug.,	13.55
Mercer,	"	13.64
Erie,	"	13.57
Ellicottville,	"	13.77
Bath,	"	13.72
Silver Lake,	"	13.47
Milford,	"	13.50
Philadelphia,	Oct.,	13.46
"	Nov.,	13.47

[1] From the 2d Vol. of the Girard College Magnetical and Meteorological observations, we find the dip at Philadelphia as follows:—

Ll. 1, 71° 5[illegible]'.2, and Ll. 3, 71° 45'.3;
hence resulting dip, 71° 56'.5.

[2] Dip from 2d Vol. of Girard College observations.

	1843.	φ
Philadelphia,	July,	13.46
Schenectady,	"	13.45
Syracuse,	"	13.61
Geneva,	"	13.63
Niagara Falls,	Aug.,	13.64
Toronto,	"	13.84
Ogdensburgh	"	13.74
Montreal,	"	13.62

Recapitulation of φ at Philadelphia.

			Means.
July,	1840,	13.37	
Oct.,	1840,	13.38	13.41
April,	1841,	13.49	
July,	1841,	13.45	
Oct.,	1841,	13.46	13.46
Nov.,	1841,	13.47	
July,	1843,	13.46	13.46

The above values of φ will furnish the means for the introduction of the total intensity at the remaining stations where the Lloyd needles alone have been used.

Comparison of values for φ, with determinations by other observers.

Philadelphia.

		φ	
1835.0	Bache & Courtenay	13.58	dip 72° 00′
1836.7	Bache	13.46	
1839.5	Loomis	13.41	
1840.9	Bache	13.41	
1841.5	Locke	13.51	
1841.8	Bache	13.46	
1842.5	Locke	13.52	
1842.8	Lefroy	13.50	
1843.6	Bache	13.46	
1844.5	Locke	13.47	
1846.4	Locke	13.42	
1855.7	Schott	13.89	
1862.6	Schott	13.30	

Baltimore.

1840.7	Bache	13.49
1841.5	Locke	13.47
1841.5	Locke	13.50
1842.8	Lefroy	13.49
1856.7	Schott	13.43

Montreal.

1842.7	Lefroy	13.78
1843.3	Lefroy	13.80
1843.6	Bache	13.62
1845.5	Younghusband	13.53
1859.6	Schott	13.68

Toronto.

1843.0	Lefroy & Younghusband	13.90
1843.6	Bache	13.84
1845.5	Lefroy	13.93

Relative Intensities by the Lloyd Needles.

Temperature correction.—For the old London weights.

No special observations to determine the temperature coefficient have been made, we may deduce it, however, from the following combination of observations at the Girard College Station, Philadelphia:—

For Lloyd Needle No. 1.

July 21, 1840,	$t = 76°.5$	$\theta = -1° 09'.9$	(weight in third hole).
Oct. 28, 1840,	52.0	+1 28.9	" "
	$\Delta t = 24.5$	$\Delta\theta = -2$ 38.8	

hence $\Delta\theta = -6.5\,\Delta t$

In Vol. II of the Magnetic and Meteorological Observations at Girard College (p. 1537), we find the additional observation:—

July 20, 1843, $t = 75°.2$ $\theta = +0° 42'.7$ (position of weight not stated).

For Lloyd Needle No. 3.

July 21, 1840,	$t = 77°.0$	$\theta = +1° 09'.1$	
Oct. 28, 1840,	50.0	+2 37.2	
	$\Delta t = 27.0$	$\Delta\theta = -1$ 28.1	

hence $\Delta\theta = -3.3\,\Delta t$

In Vol. II of the Magnetic and Meteorological Observations at Girard College (p. 1537), we find the additional observation:—

July 20, 1843, $t = 75°.8$ $\theta = +4° 48'.0$ (position of weight not stated).

The mean of both needles gives $\theta = \theta' \left\{1 - 4'.9\,(t - t')\right\}$

The mean temperature would have to be taken as the standard temperature to which all observations for relative horizontal intensity are to be referred.

N. B. For the old weights the sign of the angle θ has significance.

These weights were also used in Europe.

We may safely assume that within the interval of the survey the needles have not perceptibly lost in their magnetism. The total intensity is also very nearly constant for any one place.

Temperature Correction.—For the new or pin weights.

Lloyd Needle No. 1.

Oct. 28, 1840,	$t = 52°.0$	$\theta = 17° 15'.3$	(pin in third hole).
April 26, 1841,	68.0	18 06.7	" "
July 20, 1841,	92.5	17 54.5	" "

Lloyd Needle No. 3.

Oct. 28, 1840,	$t = 50°.0$	$\theta = 19° 23'.0$	(pin in third hole).
April 26, 1841,	68.0	13 55.9	" "
July 20, 1841,	87.6	19 31.4	" "

From these observations it would appear that the incidental errors of observation, or other accidental causes, exercise a greater influence on the resulting angle than the change due to changes of temperature within the above range.

I have therefore concluded to apply no temperature correction to the observations in which the old London or the pin weights were used, which in any case would necessarily be small.

In Vol. II of the Magnetic and Meteorological Observations at Girard College, we find the following additional observations[1] (see pp. 1537–8, 1540, 1842–3, 1545):—

Lloyd Needle No. 1.

July 20, 1843,	$t = 75°.2$	$\theta = 18° 26'.1$	(position of pin not stated).
Sept. 5, 1843,	82.8	18 36.0	(pin weight in third hole).

Lloyd Needle No. 3.

July 20, 1843,	$t = 73°.3$	$\theta = 21° 34'.1$	(position of pin not stated).
Aug. 26, 1843,	82.4	21 42.9	(pin weight in third hole).
Sept. 5, 1843,	82.9	21 48.7	" "
Sept. 12, 1843,	62.6	21 34.0	" "

These observations tend to the same conclusion arrived at above.

Considering the results of 1840 and 1841, and comparing them with those of 1843, it seems, upon the whole, preferable to apply no temperature correction for either needle or weight.

Computation of the Relative and Absolute Total Intensity by Dr. Lloyd's Statical Method.

(See Trans. Royal Irish Academy for 1836, also Report of the British Association for Advancement of Science for 1835.)

Let $\delta =$ magnetic dip,

$\zeta =$ the inclination of a Lloyd needle when unloaded,

$\theta =$ " " loaded,

$\rho =$ ratio of moment of needle to added weight,

$$\delta = \zeta + \varepsilon, \qquad \sin \varepsilon = \rho \frac{\cos \zeta}{\sin \theta} \sin (\zeta - \theta),$$

$\phi =$ total magnetic force,

$\beta =$ a coefficient,

$$\phi = \frac{\beta \cos \theta}{\sin (\delta - \theta)}, \text{ for any other station } \phi_1 = \frac{\beta \cos \theta_1}{\sin (\delta_1 - \theta_1)}.$$

Hence for the ratio of total force at any two stations—

$$\frac{\phi}{\phi_1} = \frac{\cos \theta}{\cos \theta_1} \cdot \frac{\sin (\delta_1 - \theta_1)}{\sin (\delta - \theta)}.$$

In what follows, the relative total force $\frac{\cos \theta}{\sin (\delta - \theta)}$ was computed for each place of observation.

The mean of these values was taken at all the stations where the total force was also determined by the vibrations of the cylinder and bar in connection with the dip.

[1] Made about 20 feet from S. E. angle of observatory.

The total force in absolute measure for each station where the Lloyd needles *alone* were used, was then obtained by comparison of its value with this mean value.

The final horizontal force was found by the formula

$$X = \phi \cos \delta.$$

1840.

No.	Station.	ϕ by vibrations and dip.	Relative ϕ by Lloyd Needles. By the old London weights.	Relative ϕ by Lloyd Needles. By the new pin weights.
1	Philadelphia	13.37	1.052	
2	Harrisburg	13.44	1.041	
3	Huntingdon	13.51	1.041	1.159
4	Homewood	13.49	1.061	1.163
5	Johnson's Tavern	13.54		1.168
6	Irwin's Mill	13.40		1.185
7	Baltimore	13.49		1.183
8	Philadelphia	13.30	1.064	1.179
	Mean of 1, 2, 3, 4, 8	13.44	1.052	
	Mean of 3, 4, 5, 6, 7, 8	13.47		1.173

Station.	Old London weights.	Absolute total intensity.	Dip from preceding pages.	Deduced X.
Reading	1.043	13.33	72° 32′.2	4.000
Duncan's Island	1.036	13.24	72 35.0	3.963
Lewistown	1.037	13.25	72 30.0	3.984
	new pin weights.			
Armagh	1.157	13.29	72 18.7	4.038
Economy	1.166	13.39	72 35.0	4.008
Steubenville	1.146	13.16	72 32.8	3.947
Wheeling	1.151	13.22	72 08.9	4.053
Frostburgh	1.181	13.56	71 31.3	4.298
Frenchtown	1.194	13.71	71 40.2	4 312

1841.

Station.	ϕ by vib'ns & dip.	Relative ϕ Pin weights.
Philadelphia	13.49	1.178
"	13.45	1.183
Williamsport	13.55	1.158
Curwinsville	13.55	1.153
Mercer	13.64	1.149
Erie	13.57	1.134
Ellicottville	13.77	1.122
Bath	13.72	1.118
Silver Lake	13.47	1.144
Milford	13.50	1.144
Philadelphia	13.46	not used
"	13.47	not used
Mean	13.57	1.148

1841.

Station.	Relative φ pin weights.	φ	Dip.	X.
Doylestown	1.171	13.84	72° 23′.1	4.189
Easton	1.169	13.82	72 39.0	4.121
Wilkesbarre	1.157	13.68	73 10.0	3.961
Bellefonte	1.158	13.69	72 42.3	4.069
Berlin's Tavern	1.157	13.68	72 52.8	4.026
Warren	1.151	13.61	72 59.9	3.978
Ashtabula Landing	1.136	13 43	73 23.5	3.838
Dunkirk	1.131	13.37	74 17.2	3.621
Belvidere	1.137	13.44	74 09.5	3.669
Owego	1.125	13.30	74 13.9	3.614
Bushkill	1.153	13.63	73 31.4	3.866

1843.

Station.	φ by vib'ns & dip.	Relative φ Pin weights.
Philadelphia	13.46	1.194
Schenectady	13.45	1.146
Syracuse	13.61	1.132
Geneva	13.63	1.134
Niagara Falls	13.64	1.125
Toronto	13.84	1.112
Ogdensburgh	13.74	1.110
Montreal	13.62	1.117
Philadelphia	13.46[1]	1.194
Mean	13.61	1.140

Station.	Relative φ Pin weights.	φ	Dip.	X.
Princeton	1.185	14.15	72° 38′.3	4.222
West Point	1.169	13.96	73 12.2	4.033
Utica	1.134	13.54	74 50.3	3.541
Rochester	1.132	13.51	74 43.5	3.560
Oswego	1.131	13.50	75 07.1	3.467
Quebec	1.113	13.29	77 13.8	2.937
Troy	1.142	13.63	74 47.9	3.575

[1] Mean of 3 determinations.

DISTRIBUTION OF THE MAGNETIC INCLINATION.

Distribution of the Magnetic Dip and Construction of the Isoclinal Lines for 1842.

For the more convenient application of the usual analytical expression for the representation of the observed dips, and for their interpolation, the stations have been divided into six groups, as follows:—

GROUP I.

	Station.	Latitude.	Longitude.	Date.	Observed dip.
1	Philadelphia[1]	39° 58′.4	75° 10′.0	Feb. 1842	71° 57′.1
2	Doylestown	40 18	75 10	July 1841	72 23.1
3	Easton	40 42	75 15	July 1841	72 39.0
4	Reading	40 19	75 55	July 1840	72 32.2
5	Frenchtown	39 35	75 51	Aug. 1840	71 40.2
6	Baltimore	39 17.8	76 36.6	Aug. 1840	71 33.9
7	Washington[2]	38 53.1	77 00.2	Sept. 1841	71 15.9
8	Harrisburg	40 16	76 53	July 1840	72 20.5
9	Duncan's Island	40 25	77 01	July 1840	72 35.0
10	Near Mercersburg	39 47	77 56	Aug. 1840	71 47.3
	Mean	39 57.1	76 16.8	1841.0	72 04.4

GROUP II.

	Station.	Latitude.	Longitude.	Date.	Observed dip.
1	Armagh	40° 29′	79° 04′	Aug. 1840	72° 18′.7
2	Frostburgh	39 41	78 56	Aug. 1840	71 31.3
3	Near Brownsville	39 59.5	79 47.8	Aug. 1840	71 53.5
4	Near Pittsburg	40 28	79 59.5	Aug. 1840	72 32.1
5	Economy	40 37	80 16	Aug. 1840	72 35.0
6	Wheeling	40 08	80 42	Aug. 1840	72 08.9
7	Steubenville	40 25	80 39	Aug. 1840	72 32.8
	Mean	40 15.4	79 54.9	1840.6	72 13.2

[1] The dip is the mean from groups of Dec. 1840, Oct. 1841, and Aug. 1843.

[2] This station has been added to the discussion as we have observations in 1840 and 1841; see Appendix, No. 26, Coast Survey Report of 1858. Mean dip from several observers in 1841.0, 71° 18′.3, and in 1842.5, 71° 13′.5: mean 71° 15′.9, in 1841.8.

Group III.

	Station.	Latitude.	Longitude.	Date.	Observed dip.
1	Warren	41° 17′	80° 50′	Aug. 1841	72° 59′.9
2	Mercer	41 13.8	80 16	Aug. 1841	72 57.2
3	Ashtabula Landing	41 54	80 47	Aug. 1841	72 23.5
4	Erie	42 07.5	80 06	Aug. 1841	73 46.6
5	Dunkirk	42 29.3	79 23	Aug. 1841	74 17.2
6	Ellicottville	42 18.1	78 44	Aug. 1841	74 17.8
7	Berlin's Tavern	41 16	79 36	Aug. 1841	72 52.8
	Mean	41 48.0	79 57.4	1841.6	73 30.7

Group IV.

	Station.	Latitude.	Longitude.	Date.	Observed dip.
1	Curwinsville	40° 57′.7	78° 36′	Aug. 1841	72° 49′.7
2	Belvidere	42 13	78 06	Aug. 1841	74 09.5
3	Bath	42 20.8	77 21	Aug. 1841	74 27.5
4	Owego	42 08	76 17	Aug. 1841	74 13.9
5	Silver Lake	41 56.6	76 02	Aug. 1841	73 41.5
6	Wilkesbarre	41 14	75 58	July 1841	73 10.0
7	Williamsport	41 14.0	77 02	July 1841	72 54.4
8	Bellefonte	40 55	77 49	July 1841	72 42.3
9	Lewistown	40 35	77 36	July 1840	72 30.0
10	Huntingdon	40 30.5	78 02	July 1840	72 17.8
	Mean	41 24.5	77 16.9	1841.4	73 17.7

Group V.

	Station.	Latitude.	Longitude.	Date.	Observed dip.
1	Niagara Falls	43° 04′	79° 05′	Aug. 1843	74° 51′.0
2	Toronto Observatory	43 39.5	79 21.5	Aug. 1843	75 11.4
3	Rochester	43 07	77 39	Aug. 1843	74 43.5
4	Geneva	42 53	77 02	July 1843	74 33.2
5	Syracuse	43 03	76 09.3	July 1843	74 51.2
6	Oswego	43 26	76 35	Aug. 1843	75 07.1
	Mean	43 12.1	77 38.6	1843.6	74 52.9

Group VI.

	Station.	Latitude.	Longitude.	Date.	Observed dip.
1	Utica	43° 05′	75° 14′	July 1843	74° 50′.3
2	Schenectady	42 48	73 57	July 1843	74 54.8
3	Troy	42 43.7	73 40.7	Aug. 1843	74 47.9
4	West Point	41 23.4	73 57.0	July 1843	73 12.2
5	New York[1]	40 46.1	73 56.3	Dec. 1841	72 39.6
6	Milford	41 19	74 51.5	Aug. 1841	73 47.6
7	Bushkill	41 07	75 02	Aug. 1841	73 31.4
8	Princeton	40 20.7	74 39.6	July 1843	72 38.3
	Mean	41 41.6	74 24.8	1842.9	73 47.8

[1] See Appendix, No. 32, C. S. Report of 1856. This station was added owing to the numerous observations taken in this locality. (At Lunatic Asylum, dip 1841.3, 72° 41′.0, in 1842.5, 72° 38.′3.)

RECAPITULATION.—Number of observations 48.

Station.	Latitude.	Longitude.	Date.	Observed dip.
Group I, No. 10	39° 57′.1	76° 16′.8	1841.0	72° 04′.4
" II, " 7	40 15.4	79 54.9	1840.6	72 13.2
" III, " 7	41 48.0	79 57.4	1841.6	73 30.7
" IV, " 10	41 24.5	77 16.9	1841.4	73 17.7
" V, " 6	43 12.1	77 38.6	1843.6	74 52.9
" VI, " 8	41 41.6	74 24.8	1842.9	73 47.8
Mean	41 23.1	77 34.9	1841.85	73 17.8

By comparing the differences in latitude and the corresponding differences in dip for each place with the mean values of the group, their general accordance was ascertained. None of the differences were large enough to require an exclusion from the series. It need hardly be remarked that a slight consideration shows that the dip depends almost exclusively upon the latitude; the longitude factors will, therefore, necessarily be very small.

Method of Discussion.—The interpolation formula, proposed by the Rev. H. Lloyd in 1838 (see the eighth report of the British Association, Vol. VII, p. 91), will be used here in a slightly altered form, to allow for the convergence of the meridians.

Let I = resulting dip or inclination.

I_0 = assumed mean dip for the epoch adopted (1842.0), and the mean latitude and longitude, i its correction.

dL = difference of latitude, dM = difference of longitude, x, y, z, p, q, as well as i are to be determined by application of the method of least squares, from the observations themselves.

$$I = I_0 + i + xdL + ydM \cos L + zdL\, dM \cos L + pdL^2 + qdM^2 \cos^2 L.$$

Correction to epoch.—The mean epoch of the six groups is November, 1841, for which we can substitute without material loss of accuracy January, 1842 (or 1842.0). Comparing the observations made by Mr. Schott, in July and August, 1862, with the corresponding observations about the epoch 1842, we have the following table of differences of results for an interval of nearly 20 years:—

	Date.	Dip.	Date.	Dip.	Average annual increase.
Washington	Sept. 1841	71° 15′.9	Aug. 1862	71° 19′.0	+0′.15
Harrisburg	July 1840	72 20.5	July 1862	72 31.6	+0.50
Near Brownsville	Aug. 1840	71 53.5	July 1862	71 56.9	+0.15
Erie	Aug. 1841	73 46.6	Aug. 1862	73 52.2	+0.27
Bath	Aug. 1841	74 27.5	Aug. 1862	74 26.2	—0.06
Williamsport	July 1841	72 54.4	Aug. 1862	72 51.0	—0.16
Philadelphia	Feb. 1842	71 57.1	Aug. 1862	72 05.8	+0.43
			Mean		+0.18

Mean total change in 21 years = 3′.8.

The increase in the dip is therefore very slight, and if we consider that, according to Mr. Schott's investigation (Appendix, No. 32, Coast Survey Report for 1856) the dip near the Atlantic coast, about the years 1841—1844, was at its minimum value, and hence could not have changed sensibly for several years, we can without any sacrifice of accuracy in our reduction, use our results as if all belonging to the mean epoch 1842.0. No reduction to epoch has therefore been applied. It is probable that the present annual increase amounts to about 1′. At Toronto, between 1844 and 1855 (see Vol. III), the annual increase was 0′.8.

In the formula of interpolation, I retain the factor cos L, thus making it comparable with similar expressions, for other localities, where the introduction of $\cos L$ may be more important.

The value of the magnetic survey of Pennsylvania is increased from the fact that the isoclinal lines are presented for an epoch at which the dip was probably near its minimum value.

The conditional equations are of the form—

$$0 = I_0 - I + i + x dL + y dM \cos L + z dL\, dM \cos L + p dL^2 + q dM^2 \cos^2 L.$$

We find from the solution of the normal equations, the expression,

$$I = 73°.26 + 0.876\, dL - 0.076\, dM \cos L - 0.023\, dL\, dM \cos L + 0.007\, dL^2 + 0.013\, dM^2 \cos^2 L$$

where dL = lat. —41°.38
dM = long.— 77.58.

This equation represents the mean values as follows:—

	Latitude.	Longitude.	Observed dip.	Computed dip.	Observed — computed.
Group I	39°.95	76°.28	72°.07	72°.06	+0°.01
" II	40.26	79.92	72.22	72.22	0.00
" III	41.80	79.96	73.51	73.52	—0.01
" IV	41.41	77.28	73.30	73.30	0.00
" V	43.20	77.64	74.88	74.87	+0.01
" VI	41.69	74.41	73.80	73.80	0.00

The preceding investigation was made for the purpose of ascertaining what terms should be finally admitted in the discussion.

Next, nine groups of five or six observations in each, arranged, in regard to their geographical position and area, with as much regularity as the nature of the case admits of, give,

Group I.

	Station.	Latitude.	Longitude.	Dip.
1	New York	40°.77	73°.94	72°.66
2	Easton	40.70	75.25	72.65
3	Princeton	40.35	74.66	72.64
4	Doylestown	40.30	75.17	72.39
5	Reading	40.32	75.92	72.54
6	Philadelphia	39.97	75.17	71.95
	Mean	40.40	75.02	72.47

Group II.

	Station.	Latitude.	Longitude.	Dip.
1	Frenchtown	39°.58	75°.85	71°.67
2	Baltimore	39.30	76.61	71.57
3	Washington	38.89	77.00	71.26
4	Harrisburg	40.27	76.88	72.34
5	Near Mercersburg	39.78	77.93	71.79
	Mean	39.56	76.85	71.73

Group III.

	Station.	Latitude.	Longitude.	Dip.
1	Frostburgh	39°.68	78°.93	71°.52
2	Near Brownsville	39.99	79.80	71.89
3	Wheeling	40.13	80.70	72.15
4	Steubenville	40.42	80.65	72.56
5	Near Pittsburg	40.47	79 99	72.53
6	Economy	40.62	80.27	72.58
	Mean	40.22	80.06	72.20

Group IV.

	Station.	Latitude.	Longitude.	Dip.
1	Berlin's Tavern	41°.27	79°.60	72°.88
2	Mercer	41.23	80.27	72.95
3	Warren	41.28	80.83	73.00
4	Ashtabula	41.90	80.78	73.39
5	Erie	42.13	80.10	73.78
	Mean	41.56	80.32	73.20

Group V.

	Station.	Latitude.	Longitude.	Dip.
1	Duncan's Island	40°.42	77°.02	72°.58
2	Lewistown	40.58	77.60	72.50
3	Huntingdon	40.51	78.03	72.30
4	Armagh	40.48	79.07	72.31
5	Bellefonte	40.92	77.82	72.70
6	Curwinsville	40.96	78.60	72.83
	Mean	40.65	78.02	72.54

Group VI.

	Station.	Latitude.	Longitude.	Dip.
1	Belvidere	42°.22	78°.10	74°.16
2	Ellicottville	42.30	78.73	74.30
3	Dunkirk	42.49	79.38	74.29
4	Niagara Falls	43.07	79.08	74.85
5	Toronto	43.66	79.36	75.19
	Mean	42.75	78.93	74.56

Group VII.

	Station.	Latitude.	Longitude.	Dip.
1	Bushkill	41°.12	75°.03	73°.52
2	Williamsport	41.23	77.03	72.91
3	Wilkesbarre	41.23	75.97	73.17
4	Silver Lake	41.94	76.03	73.69
5	Owego	42.13	76.28	74.23
	Mean	41.53	76.07	73.50

Group VIII.

	Station.	Latitude.	Longitude.	Dip.
1	Bath	42°.35	77°.35	74°.46
2	Rochester	43.12	77.65	74.72
3	Geneva	42.88	77.03	74.55
4	Syracuse	43.05	76.16	74.85
5	Oswego	43.43	76.58	75.12
	Mean	42.96	76.95	74.74

Group IX.

	Station.	Latitude.	Longitude.	Dip.
1	Westpoint	41°.39	73°.95	73°.20
2	Milford	41.32	74.86	73.79
3	Utica	43.08	75.23	74.84
4	Schenectady	42.80	73.95	74.91
5	Troy	42.73	73.68	74.80
	Mean	42.26	74.33	74.31

Recapitulation of Mean Values of Groups.

Group.	Latitude.	Longitude.	Dip.
I	40°.40	75°.02	72°.47
II	39.56	76.85	71.73
III	40.22	80.06	72.20
IV	41.56	80.32	73.20
V	40.65	78.02	72.54
VI	42.75	78.93	74.56
VII	41.53	76.07	73.50
VIII	42.96	76.95	74.74
IX	42.26	74.33	74.31
Mean	41.32	77.39	73.25

The trial of an equation of the form,

$$I = I_0 + i + xdL + ydM \cos L + zdL\, dM \cos L;$$

and of the form,

$$I = I_0 + i + xdL + ydM \cos L + qdM^2 \cos^2 L$$

showed that the extent of the survey is not sufficiently great to admit of the determination of curvature of the isoclinal lines; and, finally, the following expression was adopted:—

$$I = 73°.25 + 0.912\ dL - 0.069\ dM \cos L.$$

This equation represents the observations as follows:—

Group.	Observed dip.	Computed dip.	Diff. observed — computed.
I	72°.47	72°.54	—0°.07
II	71.73	71.68	+0.05
III	72.20	72.11	+0.09
IV	73.20	73.31	—0.11
V	72.54	72.61	—0.07
VI	74.56	74.47	+0.09
VII	73.50	73.51	—0.01
VIII	74.74	74.76	—0.02
IX	74.31	74.26	+0.05

The isoclinal lines of 71°, 72°, 73°, 74°, and 75°, pass through the following positions:—

71°	Long.	77° 00′		
	Lat.	38 49		
72°	Long.	75° 00′	78° 00′	81° 00′
	Lat.	39 49	39 59	40 10
73°	Long.	74° 00′	78° 00′	81° 00′
	Lat.	40 50	41 05	41 15
74°	Long.	74° 00′	78° 00′	81° 00′
	Lat.	41 57	42 11	42 22
75°	Long.	75° 00′	77° 00′	79° 00′
	Lat.	43 07	43 13	43 20

These lines have been finally adopted.

Comparison of the Observed and Computed Dip.

(All stations where the dip has been found indirectly only, by means of the Lloyd needles, are marked with an asterisk; 27 in number. Total number of stations, 48.)

Station.	Observed dip.	Computed dip.	Diff. observed. — computed.
Group I.			
New York	72°.66	72°.93	—0°.27
*Easton	72.65	72.80	—0.15
*Princeton	72.64	72.51	+0.13
*Doylestown	72.39	72.44	—0.05
*Reading	72.54	72.42	+0.12
Philadelphia	71.95	72.14	—0.19
Group II.			
*Frenchtown	71.67	71.75	—0.08
Baltimore	71.57	71.45	+0.12
Washington	71.26	71.06	+0.20
Harrisburg	72.34	72.32	+0.02
Near Mercersburg	71.79	71.88	—0.09

Station.	Observed dip.	Computed dip.	Diff. observed — computed.
Group III.			
*Frostburgh	71°.52	71°.67	—0°.15
Near Brownsville	71.89	71.91	—0.02
*Wheeling	72.15	71.99	+0.16
*Steubenville	72.56	72.26	+0.30
Near Pittsburg	72.53	72.24	+0.29
*Economy	72.58	72.46	+0.12
Group IV.			
*Berlin's Tavern	72.88	73.09	—0.21
Mercer	72.95	73.02	—0.07
*Warren	73.00	73.03	—0.03
*Ashtabula	73.39	73.60	—0.21
Erie	73.78	73.85	—0.07
Group V.			
*Duncan's Island	72.58	72.45	+0.13
*Lewistown	72.50	72.57	—0.07
Huntingdon	72.30	72.48	—0.18
*Armagh	72.31	72.40	—0.09
*Bellefonte	72.70	72.86	—0.16
Curwinsville	72.83	72.86	—0.03
Group VI.			
*Belvidere	74.16	74.03	+0.13
Ellicottville	74.30	74.05	+0.25
*Dunkirk	74.29	74.21	+0.08
*Niagara Falls	74.85	74.76	+0.09
Toronto	75.19	75.28	—0.09
Group VII.			
*Bushkill	73.52	73.19	+0.33
Williamsport	72.91	73.19	—0.28
*Wilkesbarre	73.17	73.24	—0.07
Silver Lake	73.69	73.88	—0.19
*Owego	74.23	74.05	+0.18
Group VIII.			
Bath	74.46	74.19	+0.27
*Rochester	74.72	74.87	—0.15
Geneva	74.55	74.69	—0.14
Syracuse	74.85	74.89	—0.04
*Oswego	75.12	75.21	—0.09
Group IX.			
*Westpoint	73.20	73.49	—0.29
Milford	73.79	73.38	+0.41 maximum difference = 25'.
*Utica	74.84	74.96	—0.12
Schenectady	74.91	74.77	+0.14
*Troy	74.80	74.72	+0.08

The probable error of any single observation is $\pm$ 0°.12 = $\pm$ 7′.2; the probable error of any observation with the regular dip needles, and the Lloyd needles combined, is $\pm$ 0°.13: with the latter needles alone, $\pm$ 0°.11. This shows that the irregularities in the observed dip are due to local attractions rather than to imperfections in the needles employed. It is proper, therefore, to assign equal weights to results by the direct and indirect method of observing.

If we apply Peirce's criterion for the rejection of observations differing too much from the regular value indicated by all other observations, we find the limit of rejection to be $\pm$ 0°.46, or $\pm$ 28′; the maximum difference in the preceding table is 25′; hence no observation is excluded.

General Sabine's resulting isoclinal lines, in his seventh contribution to terrestrial magnetism (*Phil. Trans. Roy. Soc.*, Part III, 1846, p. 237), refer to an average period between 1840 and 1842, and correspond in their position very closely to those now presented; they are deduced from independent data.

DISTRIBUTION OF THE MAGNETIC HORIZONTAL FORCE AND TOTAL FORCE.

Distribution of the Magnetic Horizontal Intensity and Construction of Isodynamic Lines for 1842.

If we group the observed intensities in the same manner as the dip, the mean epoch 1842.0 may likewise be assumed, and all observed intensities be reduced to that date.

Correction to Epoch.—We have the following direct comparisons:—

	Date.	X.	Date.	X_1.	$X-X_1$.	Annual decrease.
Washington[1] . .	Jan. 1843	4.320	Aug. 1862	4.255	0.065	0.0033
Harrisburg . .	July 1840	4.078	July "	4.012	0.066	0.0030
Near Brownsville .	Aug. 1840	4.207	July "	4.138	0.069	0.0031
Erie	Aug. 1841	3.792	Aug. "	3.728	0.064	0.0030
Bath	Aug. 1841	3.677	Aug. "	3.639	0.038	0.0018
Williamsport . .	July 1841	3.983	Aug. "	3.924	0.059	0.0028
Philadelphia[2] . . .	Jan. 1842	4.166	Aug. "	4.088	0.078	0.0039
				Mean . . .		0.0030

The average annual decrease in the value of X between 1840 and 1862, is, therefore, 0.0030, or, when expressed in parts of X, equal to 0.00076. This result agrees tolerably well with that deduced by Assistant Chas. A. Schott in the Coast Survey Report of 1861, where 0.00110 was found.

Supposing the dip to increase at the rate of 1′ a year, and the total intensity to remain constant, the corresponding decrease of the horizontal intensity would amount to nearly the quantity found above; we cannot, therefore, as yet decide whether the total intensity remains stationary, or is slightly changing.

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[1] From Coast Survey Report of 1861 (yet in manuscript).
1842.5, X = 4.347, Captain Lefroy.
1843.5, = 4.292, Dr. Locke.
Mean, 1843.0, = 4.320

[2] In July and Nov. 1840, X = 4.160 }
In July and Nov. 1841, = 4.166 } Mean, 4.166 for 1842.0.
In July, 1843, = 4.172 }

At Toronto (See Vol. III) the annual decrease of X between 1845 and 1852 inclusive, was 0.0037 (in absolute measure), or when expressed in parts of X, 0.00105.

Formation of groups for the analytical expression of the distribution of the magnetic horizontal force, referred to the epoch 1842.0.

At stations marked with an asterisk, the horizontal force was determined by vibrations; at those not so marked, the horizontal force was determined by Lloyd's statical method.

Group I.				
	Date.	X.	Correction to epoch.	X. 1842.0.
*Philadelphia	1842.0	4.166	0.000	4.166
Doylestown	1841.6	4.189	—0.001	4.188
Easton	1841.6	4.121	—0.001	4.120
Reading	1840.6	4.000	—0.004	3.996
Frenchtown	1840.6	4.312	—0.004	4.308
*Baltimore	1840.6	4.265	—0.004	4.261
Washington	1843.0	4.320	+0.003	4.323
*Harrisburg	1840.6	4.078	—0.004	4.074
Duncan's Island	1840.6	3.963	—0.004	3.959
*Near Mercersburg	1840.6	4.188	—0.004	4.184
		Mean		4.158

Group II.				
Armagh	1840.6	4.038	—0.004	4.034
Frostburgh	1840.6	4.298	—0.004	4.294
*Near Brownsville	1840.6	4.207	—0.004	4.203
*Near Pittsburg	1840.6	4.049	—0.004	4.045
Economy	1840.6	4.008	—0.004	4.004
Wheeling	1840.6	4.053	—0.004	4.049
Steubenville	1840.6	3.947	—0.004	3.943
		Mean		4.082

Group III.				
Warren	1841.6	3.978	—0.001	3.977
*Mercer	1841.6	4.000	—0.001	3.999
Ashtabula Landing	1841.6	3.838	—0.001	3.837
*Erie	1841.6	3.792	—0.001	3.791
Dunkirk	1841.6	3.621	—0.001	3.620
*Ellicottville	1841.6	3.726	—0.001	3.725
Berlin's Tavern	1841.6	4.026	—0.001	4.025
		Mean		3.853

GROUP IV.

	Date.	X.	Correction to epoch.	X. 1842.0.
*Curwinsville	1841.6	3.999	—0.001	3.998
Belvidere	1841.6	3.669	—0.001	3.668
*Bath	1841.6	3.677	—0.001	3.676
Owego	1841.6	3.614	—0.001	3.613
*Silver Lake	1841.7	3.782	—0.001	3.781
Wilkesbarre	1841.6	3.961	—0.001	3.960
*Williamsport	1841.6	3.983	—0.001	3.982
Bellefonte	1841.6	4.069	—0.001	4.068
Lewistown	1840.6	3.984	—0.004	3.980
*Huntingdon	1840.6	4.109	—0.004	4.105
		Mean . . .		3.883

GROUP V.

*Niagara Falls	1843.6	3.565	+0.005	3.570
*Toronto Observatory . .	1843.6	3.537	+0.005	3.542
Rochester	1843.6	3.560	+0.005	3.565
*Geneva	1843.7	3.635	+0.005	3.640
*Syracuse	1843.6	3.556	+0.005	3.561
Oswego	1843.6	3.467	+0.005	3.472
		Mean . . .		3.558

GROUP VI.

Utica	1843.6	3.541	+0.005	3.546
*Schenectady	1843.6	3.502	+0.005	3.507
Troy	1843.6	3.575	+0.005	3.580
West Point	1843.6	4.033	+0.005	4.038
New York[1]	1841.9	4.014	0.000	4.014
*Milford	1841.7	3.769	—0.001	3.768
Bushkill	1841.7	3.866	—0.001	3.865
Princeton	1843.5	4.222	+0.005	4.227
		Mean . . .		3.818

RECAPITULATION.

Group.	No.	Latitude.	Longitude.	X. 1842.0.
I	10	39° 57′.1	76° 16′.8	4.158
II	7	40 15.4	79 54.9	4.082
III	7	41 48.0	79 57.4	3.853
IV	10	41 24.5	77 16.9	3.883
V	6	43 12.1	77 38.6	3.558
VI	8	41 41.6	74 24.8	3.818
Mean		41 23.1	77 34.9	3.892

[1] At New York we have: 1841.5 Dr. Locke, 4.015. 1842.7 Dr. Locke, 4.008; 1842.7 Capt. Lefroy, 4.010. Mean 4.014 for 1841.9.

Let X = resulting horizontal force,

X_0 = assumed mean horizontal force for 1842.0 at the mean latitude and mean longitude, x its correction.

dL = difference of latitude, dM = difference of longitude,

x, y, z, p, q, and χ to be determined from the observations

$$X = X_0 + \chi + xdL + ydM \cos L + zdL\, dM \cos L + pdL^2 + qdM^2 \cos^2 L.$$

Forming the conditional and normal equations we find the expression

$$X = 3.890 - 0.1787\, dL + 0.0085\, dM \cos L + 0.0161\, dL\, dM \cos L - 0.0017\, dL^2 + 0.0027\, dM^2 \cos^2 L.$$

where dL = Lat.—41°.38

dM = Long.—77.58.

This formula is applied for determining the relative weights of the observations from vibrations and by deflections of the dipping needle; for this purpose the horizontal force was computed by the formula, and the results compared with observation. From the differences we find the probable error of an observation (and local irregularity) = $\pm$ 0.036 for the bar and cylinder vibrations, and $\pm$ 0.062 for the Lloyd needle deflections and dip; the relative weights, therefore, become 754 for the former, and 257 for the latter, or nearly as 3 to 1. These weights have been adopted.

Formation of nine groups of five or six observations in each, with weights. The arrangement is the same as in the case of the dip. The sum of the weights for each group is, as near as may be equal.

Group I.	Latitude.	Longitude.	X.	Weight.
New York	40°.77	73°.94	4.014	3
Easton	40.70	75.25	4.120	1
Princeton	40.35	74.66	4.227	1
Doylestown	40.30	75.17	4.188	1
Reading	40.32	75.92	3.996	1
Philadelphia	39.97	75.17	4.166	3
Mean by weights	40.39	74.83	4.107	$\Sigma w = 10$

Group II.	Latitude.	Longitude.	X.	Weight.
Frenchtown	39°.58	75°.85	4.308	1
Baltimore	39.30	76.61	4.261	3
Washington	38.89	77.00	4.323	1
Harrisburg	40.27	76.88	4.074	3
Near Mercersburg	39.78	77.93	4.184	3
Mean by weights	39.68	77.01	4.199	$\Sigma w = 11$

	Latitude.	Longitude.	X.	Weight.
Group III.				
Frostburg	39°.68	78°.93	4.294	1
Near Brownsville	39.99	79.80	4.203	3
Wheeling	40.13	80.70	4.049	1
Steubenville	40.42	80.65	3.943	1
Near Pittsburg	40.47	79.99	4.045	3
Economy	40.62	80.27	4.004	1
Mean by weights	40.22	79.99	4.103	Σw = 10
Group IV.				
Berlin's Tavern	41°.27	79°.60	4.025	1
Mercer	41.23	80.27	3.999	3
Warren	41.28	80.83	3.977	1
Ashtabula	41.90	80.78	3.837	1
Erie	42.13	80.10	3.791	3
Mean by weights	41.61	80.26	3.912	Σw = 9
Group V.				
Duncan's Island	40°.42	77°.02	3.959	1
Lewistown	40.58	77.60	3.980	1
Huntingdon	40.51	78.03	4.105	3
Armagh	40.48	79.07	4.034	1
Bellefonte	40.92	77.82	4.068	1
Curwinsville	40.96	78.60	3.998	3
Mean by weights	40.68	78.14	4.035	Σw = 10
Group VI.				
Belvidere	42°.22	78° 10	3.668	1
Ellicottville	42.30	78.73	3.725	3
Dunkirk	42.49	79.38	3.620	1
Niagara Falls	43.07	79.08	3.570	3
Toronto	43.66	79.36	3.542	3
Mean by weights	42.89	79.00	3.618	Σw = 11
Group VII.				
Bushkill	41°.12	75°.03	3.865	1
Williamsport	41.23	77.03	3.982	3
Wilkesbarre	41.23	75.97	3.960	1
Silver Lake	41.94	76.03	3.781	3
Owego	42.13	76.28	3.613	1
Mean by weights	41.56	76.27	3.858	Σw = 9

GROUP VIII.

	Latitude.	Longitude.	X.	Weight.
Bath	42°.35	77°.35	3.676	3
Rochester	43.12	77.65	3.565	1
Geneva	42.88	77.03	3.640	3
Syracuse	43.05	76.16	3.561	3
Oswego	43.43	76.58	3.472	1
Mean by weights	42.85	77.17	3.606	$\Sigma w = 11$

GROUP IX.

	Latitude.	Longitude.	X.	Weight.
West Point	41°.39	73°.95	4.038	1
Milford	41.32	74.86	3.768	3
Utica	43.08	75.23	3.546	1
Schenectady	42.80	73.95	3.507	3
Troy	42.73	73.68	3.580	1
Mean by weights	42.17	74.37	3.665	$\Sigma w = 9$

RECAPITULATION OF MEAN (WEIGHTED) VALUES OF GROUPS.

Group.	Latitude.	Longitude.	X.
I	40°.39	74°.83	4.107
II	39.68	77.01	4.199
III	40.22	79.99	4.103
IV	41.61	80.26	3.912
V	40.68	78.14	4.035
VI	42.89	79.00	3.618
VII	41.56	76.27	3.858
VIII	42.85	77.17	3.606
IX	42.17	74.37	3.665
Mean	41.34	77.45	3.900

$$X = X_0 + \chi + xdL + ydM \cos L + zdL\, dM \cos L + pdL^2 + qdM^2 \cos^2 L$$

$$dL = \text{Lat.} - 41°.34$$

$$dM = \text{Long.} - 77.45.$$

Forming the conditional and normal equations, we deduce:—

$$X = 3.920 - 0.1936\, dL + 0.0146\, dM \cos L + 0.0203\, dL\, dM \cos L - 0.01587\, dL^2 - 0.0005\, dM^2 \cos^2 L.$$

It is, however, preferable to shorten the formula, and use instead, the following:—

$$X = 3.900 - 0.1934\, dL + 0.0134\, dM \cos L + 0.02\, dL\, dM \cos L.$$

Comparison of Observed and Computed Values.			
Group.	X Observed.	X computed.	Observed — computed.
I	4.107	4.095	+0.012
II	4.199	4.227	—0.028
III	4.103	4.100	+0.003
IV	3.912	3.887	+0.025
V	4.035	4.028	+0.007
VI	3.618	3.651	—0.033
VII	3.858	3.842	+0.016
VIII	3.606	3.599	+0.007
IX	3.665	3.670	—0.005

The next and last hypothesis,

$$X = 3.900 - 0.1934\ dL + 0.0134\ dM \cos L,$$

in which the isodynamic lines are treated as straight lines presents, perhaps, the best and most simple expression of the *irregular* distribution of the horizontal force. These lines run nearly parallel with the dip lines.

Comparison of Observed and Computed Values on this hypothesis.			
Group.	X observed.	X computed.	Observed — computed.
I	4.107	4.057	+0.050
II	4.199	4.216	—0.017
III	4.103	4.143	—0.040
IV	3.912	3.876	+0.036
V	4.035	4.035	0.000
VI	3.618	3.616	+0.002
VII	3.858	3.846	+0.012
VIII	3.606	3.605	+0.001
IX	3.665	3.708	—0.043

The difference between the lines of this and the previous hypothesis shows the large amount of local irregularity.

The lines of this hypothesis pass through the following positions:—

4.2	Long. 81°.0 Lat. 39° 58′	Long. 77°.5 Lat. 39° 47′	Long. 74°.0 Lat. 39° 36′
4.0	Long. 81°.0 Lat. 41° 01′	Long. 77°.5 Lat. 40° 49′	Long. 74°.0 Lat. 40° 39′
3.8	Long. 81°.0 Lat. 42° 02′	Long. 77°.5 Lat. 41° 51′	Long. 74°.0 Lat. 41° 41′
3.6	Long. 81°.0 Lat. 43° 04′	Long. 77°.5 Lat. 42° 53′	Long. 74°.0 Lat. 42° 43′

The observed and computed values of X by the previous and last hypotheses, compare as follows:—

Station.	X observed.	X by previous hypothesis.	Δ	X by last hypothesis.	Δ
*Philadelphia	4.17	4.19	—0.02	4.14	+0.03
Doylestown	4.19	4.11	+0.08	4.08	+0.11
Easton	4.12	4.02	+0.10	4.00	+0.12
Reading	4.00	4.10	—0.10	4.08	—0.08
Frenchtown	4.31	4.27	+0.04	4.22	+0.09
*Baltimore	4.26	4.32	—0.06	4.29	—0.03
Washington	4.32	4.38	—0.06	4.37	—0.05
*Harrisburg	4.07	4.11	—0 04	4.10	—0.03
Duncan's Island	3.96	4.08	—0.12	4.07	—0.11
*Near Mercersburg	4.18	4.21	—0.03	4.20	—0.02
Armagh	4.03	4.06	—0.03	4.08	—0.05
Frostburg	4.29	4.20	+0.09	4.24	+0.05
*Near Brownsville	4.20	4.14	+0.06	4.19	+0.01
*Near Pittsburg	4.05	4.06	—0.01	4.09	—0.04
Economy	4.00	4.04	—0.04	4.07	—0.07
Wheeling	4.05	4.11	—0.06	4.17	—0.12
Steubenville	3.94	4.07	—0.13	4.11	—0.17
Warren	3.98	3.94	+0.04	3.95	+0.03
*Mercer	4.00	3.94	+0.06	3.95	+0.05
Ashtabula	3.84	3.80	+0.04	3.83	+0.01
*Erie	3.79	3.81	—0.02	3.77	+0.02
Dunkirk	3.62	3.70	—0.08	3.70	—0.08
*Ellicottville	3.72	3.75	—0.03	3.73	—0.01
Berlin's Tavern	4.02	3.93	+0.09	3.94	+0.08
*Curwinsville	4.00	3.98	+0.02	3.99	+0.01
Belvidere	3.67	3.75	—0.08	3.74	—0.07
*Bath	3.68	3.70	—0.02	3.70	—0.02
Owego	3.61	3.73	—0.12	3.74	—0.13
*Silver Lake	3.78	3.76	+0.02	3.77	+0.01
Wilkesbarre	3.96	3.93	+0.03	3.91	+0.05
*Williamsport	3.98	3.92	+0.06	3.92	+0.06
Bellefonte	4.07	3.99	+0.08	3.99	+0.08
Lewistown	3.98	4.05	—0.07	4.05	—0.07
*Huntingdon	4.10	4.06	+0.04	4.07	+0.03
*Niagara Falls	3.57	3.62	—0.05	3.58	—0.01
*Toronto	3.54	3.53	+0.01	3.47	+0.07
Rochester	3.56	3.57	—0.01	3.56	0.00
*Geneva	3.64	3.59	+0.05	3.60	+0.04
*Syracuse	3.56	3.53	+0.03	3.56	0.00
Oswego	3.47	3.46	+0.01	3.49	—0.02
Utica	3.55	3.49	+0.06	3.54	+0.01
*Schenectady	3.51	3.51	0.00	3.58	—0.07
Troy	3.58	3.52	+0.06	3.59	—0.01
West Point	4.04	3.85	+0.19	3.86	+0.18
*New York	4.01	4.01	0.00	3.97	+0.04
*Milford	3.77	3.88	—0.11	3.88	—0.11
Bushkill	3.86	3.92	—0.06	3.92	—0.06
Princeton	4.23	4.07	+0.16	4.06	+0.17

For the last hypothesis (straight lines) we find the probable error of an observation and local irregularity from the bar and cylinder vibrations, ±0.029; and from the Lloyd needle deflections and dip, ±0.062. For the previous hypothesis, these quantities are respectively, ±0.030 and ±0.059, showing but little gain in the representation of the observations by the additional term *dL dM cos L*.

For the general representation, the probable errors are ±0.050 and ±0.051.

Representation of the Total Force.

From the expressions

$$X = 3.900 - 0.1934\ dL + 0.0134\ dM \cos L,$$
$$I = 73^{\circ}.25 + 0.912\ \ dL - 0.0690\ dM \cos L,$$

we have to deduce the total force $\phi = X \sec I$.

In the expression for X, dL = lat. — 41°.34 and dM = long. — 77°.45.

In the expression for I, dL = lat. — 41°.32 and dM = long. — 77°.39.

We have in

Long. 81°.00 Lat. 39.97	$X = 4.200$ $I = 71^{\circ}.828$	$\phi = 13.47$
Long. 77°.50 Lat. 42.89	$X = 3.600$ $I = 74^{\circ}.676$	$\phi = 13.62$
Long. 74°.00 Lat. 39.60	$X = 4.200$ $I = 71^{\circ}.861$	$\phi = 13.49$

Assuming in the expression for the total force,

$$\phi = \phi_0 + f + x dL + y dM \cos L,$$

dL and dM as in the expression for X we find:—

$$\phi = 13.55 + 0.0451\ dL - 0.00682\ dM \cos L.$$

The lines of equal total force of 13.45, 13.5, 13.55, and 13.6 pass through the following positions:—

13.45 . . .	Long. 81° Lat. 39° 31′	Long. 77°.5 Lat. 39° 07′	
13.50 . . .	Long. 81° Lat. 40° 37′	Long. 77°.5 Lat. 40° 13′	Long. 74° Lat. 39° 49′
13.55 . . .	Long. 81° Lat. 41° 43′	Long. 77°.5 Lat. 41° 19′	Long. 74° Lat. 40° 55′
13.60 . . .	Long. 81° Lat. 42° 49′	Long. 77°.5 Lat. 42° 25′	Long. 74° Lat. 42° 01′

The observed and computed values of ϕ at the stations where the bar and cylinder were employed, compare as follows:—

Station.	φ observed.	φ computed.	Observed — Computed.
Philadelphia	13.45	13.50	—0.05
Harrisburg	13.44	13.50	—0.06
Huntingdon	13.51	13.51	0.00
Homewood	13.49	13.50	—0.01
Johnson's Tavern	13.54	13.48	+0.06
Irwin's Mill	13.40	13.48	—0.08
Baltimore	13.49	13.46	+0.03
Williamsport	13.55	13.55	0.00
Curwinsville	13.55	13.53	+0.02
Mercer	13.64	13.53	+0.11
Erie	13.57	13.57	0.00
Ellicottville	13.77	13.59	+0.18
Bath	13.72	13.60	+0.12
Silver Lake	13.47	13.58	—0.11
Milford	13.50	13.56	—0.06
Schenectady	13.45	13.63	—0.18
Syracuse	13.61	13.63	—0.02
Geneva	13.63	13.62	+0.01
Niagara Falls	13.64	13.62	+0.02
Toronto	13.84	13.65	+0.19

The probable error of any representation is ± 0.066.

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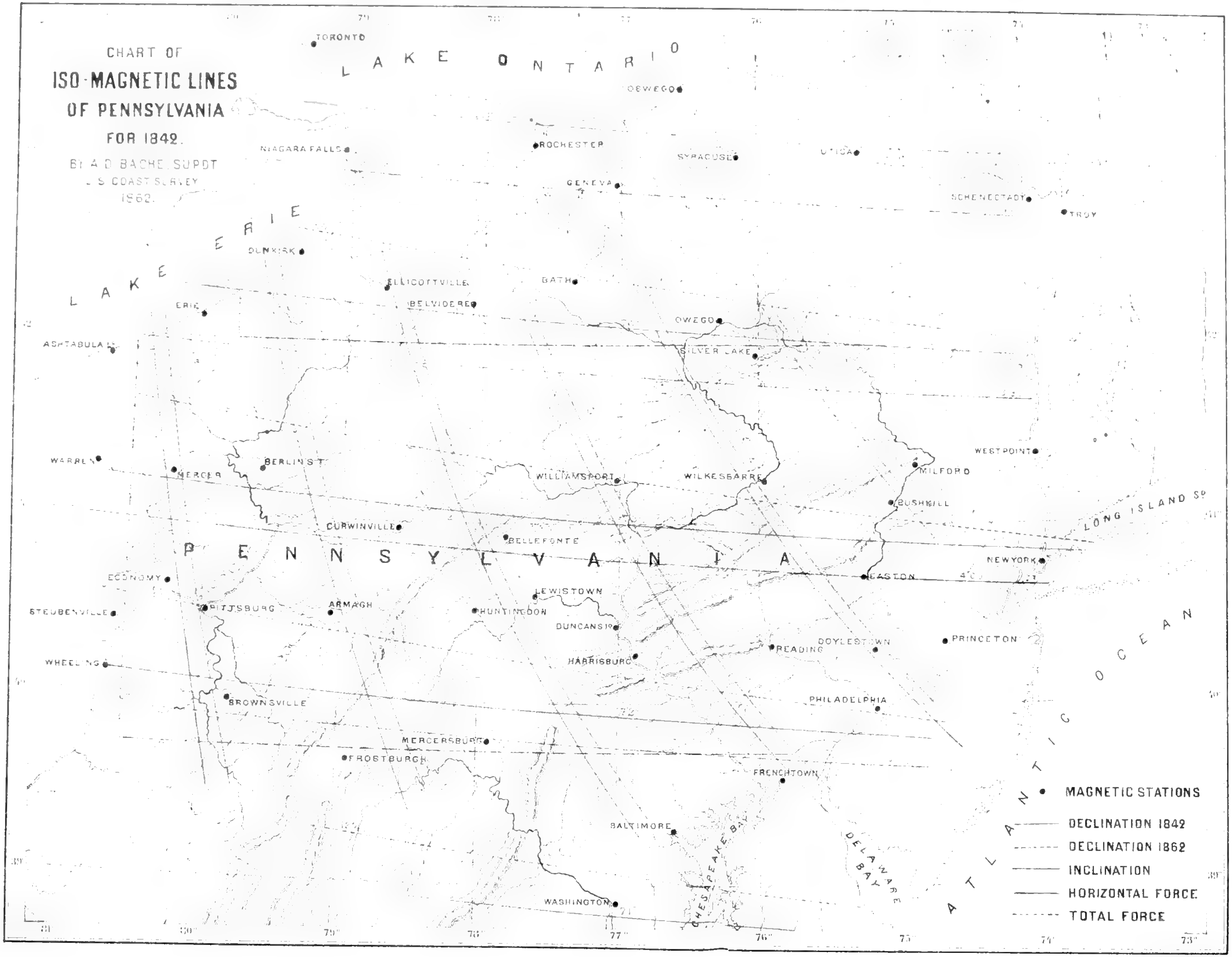
CHART OF
ISO-MAGNETIC LINES
OF PENNSYLVANIA
FOR 1842.
BY A. D. BACHE, SUPDT
U. S. COAST SURVEY
1862.
LAKE ONTARIO
LAKE ERIE
PENNSYLVANIA
ATLANTIC OCEAN
LONG ISLAND SD
DELAWARE BAY
CHESAPEAKE BAY
TORONTO
OSWEGO
NIAGARA FALLS
ROCHESTER
SYRACUSE
UTICA
GENEVA
SCHENECTADY
TROY
DUNKIRK
ELLICOTTVILLE
BATH
BELVIDERE
ERIE
OWEGO
ASHTABULA
SILVER LAKE
WESTPOINT
WARREN
MERCER
BERLIN
WILLIAMSPORT
WILKESBARRE
MILFORD
BUSHKILL
CURWINVILLE
BELLEFONTE
NEWYORK
EASTON
ECONOMY
LEWISTOWN
PITTSBURG
ARMAGH
HUNTINGDON
STEUBENVILLE
DUNCANS ID
PRINCETON
DOYLESTOWN
READING
WHEELING
HARRISBURG
BROWNSVILLE
PHILADELPHIA
MERCERSBURG
FROSTBURGH
FRENCHTOWN
BALTIMORE
WASHINGTON
MAGNETIC STATIONS
DECLINATION 1842
DECLINATION 1862
INCLINATION
HORIZONTAL FORCE
TOTAL FORCE
80°
79°
78°
77°
76°
75°
74°
73°
39°
Chas G. Krebs, Lith.

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

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RESEARCHES

UPON THE

ANATOMY AND PHYSIOLOGY OF RESPIRATION

IN THE

CHELONIA.

BY

S. WEIR MITCHELL, M. D. AND GEORGE R. MOREHOUSE, M. D.

[ACCEPTED FOR PUBLICATION, MARCH, 1863.]

COMMISSION

TO WHICH THIS PAPER HAS BEEN REFERRED.

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Secretary S. I.

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PREFACE.

With certain slight exceptions, which we have pointed out in the text, the following essay is in the strictest possible sense the joint production of its two authors, who are equally responsible for all of its statements.

The woodcuts owe much of their accuracy to the skill of the engraver, Mr. Wilhelm, to whose experience as an anatomical draughtsman the authors are under obligation.

They entertain the wish that the novel views of the present paper may induce comparative anatomists and physiologists to examine afresh the respiratory mechanism of other reptiles, and also of birds—a labor in which they indulge the hope of sharing.

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RESEARCHES

UPON THE

ANATOMY AND PHYSIOLOGY OF RESPIRATION IN THE CHELONIA.

CHAPTER I.

In the whole animal series there is scarcely a creature that would be less likely to suggest itself as a field for discovery than the Turtle. Its temptingly curious form, its world-wide distribution, its limited means of escape and of defence, would seem to combine to render it an easy and early object of investigation to the naturalist. And yet the history of Chelonians is full of discordant observations; functions have been misinterpreted, and even important parts of structure have been asserted to exist by some, and again denied by others, until at the present day the uncertain record has forced opinion into error, and permitted the conduct of one of the most important processes of life, that of respiration, to remain misunderstood, and the means of its accomplishment neglected and in part unknown. The view now entertained by the leading authorities upon the subject, that Turtles inspire by an act of deglutition, as do the frogs, has prevailed from the first, and doubtless arose from the panting movements of the under part of the throat, common to both orders, and among turtles, especially observable in marine species. It will be the object of this paper to show that this view is incorrect, that turtles do not swallow the air in breathing, but that their respiratory act is effected by inspiratory and expiratory muscles situated within the trunk.

The solid thorax clearly indicates that Chelonians do not enjoy the perfect respiratory mechanism of the highest vertebrates. The ordinary tranquil respiration of mammals, when the ribs are at rest and the cavity of the thorax is enlarged by the descent of the diaphragm alone, is, however, very strikingly analogous to that of turtles, in which the cavity of the shield is enlarged by the contraction of the muscles of the flanks.

In tracing the anatomical history of the organs of respiration in Chelonians, the earliest work to which we have had access is a "Dissertation on the Respiration of the Tortoise," by Robert Townson, LL. D., written at Göttingen, May, 1795; and as we find in it a brief review of all that was known previously upon the subject, we have taken the privilege of embodying this rare and interesting paper in the present sketch. This we do more cheerfully as an act of justice to the author; for, having conducted our inquiry with a full knowledge of the opinions of modern authorities, we were surprised, on afterwards learning the singularly truthful views of Townson, to find they had fallen unappreciated, and that, in many instances, they had not even been honored by a notice, or, when so noticed, had been mentioned only to be condemned.

Physiological Observations on the Amphibia. *Dissertation the Third, on the Respiration of the Tortoise.* Robert Townson.

The first inspection of the structure of the animals I have lately treated of, the Ranæ and Salamandræ of Linnæus, will show that respiration cannot be performed in them as it is in man and animals similar to him; the absence of the osseous parts and diaphragm is sufficient to demonstrate this; and though, on the records of physiology, there are instances of the continuation of respiration after the mobility of the osseous parts had ceased, yet, as these were only instances of suffering nature, where the accompanying assistant, the diaphragm, still continued in full energy, physiologists ought, likewise, in examining the structure of the animals I am now to treat of, the Tortoise-tribe, to have suspected that this function was not performed in them as it is in us. Yet these hints given by this anomalous structure have either been neglected or made an improper use of, and the manner of their respiring remains in the greatest obscurity to the present hour. Before I proceed to show the present state of our knowledge on this subject, by giving the opinions of the celebrated anatomists and physiologists who have written upon it, I will just observe that, as the impossibility of respiration being performed in the frog-tribe, in the usual manner, consists in the absence of the ribs and diaphragm, so here the immobility of the whole bones of the trunk, and absence of the diaphragm, form the insuperable hindrance, and not a deficiency of solid parts as in the preceding; for a modification of the ribs and sternum here envelops the whole animal. The diaphragm, though said by some to exist, is really wanting. Blasius, however, asserts its existence, and describes it thus: "Diaphragma insigne admodum, oblique a pectoris anteriore inferioresque parte sursum adscendet, lateribus primo, hinc dorso firmiter adhærens; altiorem adeoque situm in posticis obtinet, quam in anticis, contra ac in homine, canibus bobus aliisque animalibus observamus, ubi anteriora sublimem majis locum habent posterioribus. Membranosum hoc totum notatur, similiter ac in avibus variis deprehendimus, nullis fibris carneis manifeste gaudens. Distinguit equidem thoracem a ventre inferiore, ast non sit in animalibus aliis: Pulmones enim cum hic sese in hoc magis, quam illo ventre exhibeant magne parte, diaphragmate haud includuntur, imo vix aliqua parte. Extendit se supra hepar partesque alias ipsi adsitas, usque ad vesicam urinariam cui valide adeo unitur tota superficie superiore ut non nisi magno artificio separari queat. Superius pericardio jungitur." But I am convinced he has taken the peritonæum for it. I have sought for it in vain, as well as other zootomists; neither Gotwald nor Wallbaum has observed it, and the French academicians, who dissected one near five feet long, say, that "la tortue a non seulement son écaille, qui lui sont lieu de thorax, absolument immobile, mais nous ne lui avons trouvé n'y de diaphragme, n'y d'autres parties qui puissent supplier à ce mouvement." This deficiency of the requisite mechanism for respiration has led some physiologists to explain this important function upon principles inconsistent with sound physiology, analogy, or experience. Perault attributes the expansion of the lungs, and consequent inspiration, to the elasticity of the membranes forming their cells; and the expiration to the compression of muscles, of which, he says, these animals have plenty. "Apparement," he says, "il est necessaire de supposer que l'inspiration se fait par le ressort des ligamens durs et fermes qui composent les mailles qui ont été décrites: en sorte que lorsque les muscles qui peuvent comprimer le poumon viennent à se relacher, les ligamens s'étendent et élargissant les ouvertes de toutes les vessies augment la capacité de tout le poumon." Varnier boldly asserted that the whole process of respiration, both expiration as well as inspiration, was effected by the lungs themselves alone, by the means of their muscular texture, as a muscular network surrounded them, by which means they could respire by the alternate dilatation and contraction of the vesicules without the aid of the other instruments of respiration. He says, "Je parvins à me démontrer à moimême que le poumon de la tortue etoit entouré d'un réseau musculaire que par ce moyen ils étoit parfaitement irritable, qu'ils avoit une action propre, indépendente des autres agens de la respiration et qu'ils pouvoit inspirer par lui même;" and soon after adds, "le muscle du poumon de la tortue qui produit un mouvement convulsive," and then says that, "dans le tortue le poumon est cellulaire; les cellules se correspondent comme dans la grenouille; le muscle enveloppe toute la masse, et en se contractant la remue toute entière;" and concludes his memoire by saying, "le poumon est un organ actif; qu'il est le premier et le principal agent de la respiration, et que cette fonction dépend, comme dans les amphibies, de la dilatation et contraction alternative des vésicules qui determinent alternativement la contraction des muscles inspirateurs et expirateurs, et cela indépendamment de la volonté." Admitting the lungs to possess this muscular texture, which could not be perceived by Haller and the best anatomists, they would still be ill adapted to inflate by their own power. We learn, through the Transactions of the Royal Academy of Paris, that it was the opinion of Monsieur Tauvry that they breathed only in walking. "La tortue est enfirmée entre deux écailles immobiles, et elles n'a d'ailleurs aucun diaphragme qui puisse servir à une compression alternative des poumons. Dans cette difficulté d'expliquer sa respiration, Monsieur Tauvry s'est avisé d'en rapporter la cause au mouvement du marcher; quand la tortue est en repos, sa tête et ses pies sont retirés sous l'écaille supérieure, et la peau qui l'enveloppe entièrement est plissé, mais quand l'animal marche, il pousse au dehors sa tête et ses pies; sa peau s'étend, puisqu'elle est tirée par ces parties, et par conséquent elle forme intérieurement un plus grand espace, et c'est dans cet espace vuide que l'air extérieur est obligé d'entrer." This explanation, which is very anomalous with everything we know of this function in other animals, I put to the test of the following experiments, which proved it erroneous. I took the Testudo orbicularis in its contracted state, and wrapt it up in paper, binding it all round with bandages so fast, that the testa and sternum were brought so near before as not to admit the exit of the head. I then made an aperture in the paper opposite to its nose, and thus deprived of every motion, I placed it before the flame of a candle, yet I found not only that it blew the flame, but sometimes so strongly as nearly to extinguish it.

This experiment, though conclusive against the opinion of Tauvry, I strengthen by another; in this I kept the legs out, binding them very firmly under the sternum, the head being contracted as before, yet I still observed that it breathed, and as in the former experiment, sometimes with great force. The respiration, therefore, of the tortoise has no more connection with its other motions than that of other animals. But Morgagni, who was, as I have mentioned in the second dissertation, acquainted with the manner of respiring in frogs, which I have given in detail, supposes that the tortoise respires in the same manner; for, speaking of the frog, he says: "Inspiratio autem iis instrumentis per quæ inferior buccæ pars amplificata animal contracta ærem in pulmones compellit;" and then adds, "quin imo id ipsum, dum fluvialem quandam testudinem vivam inciderem, observavi invenique, totam eam partem quæ intra cavitatem mandibulæ inferioris est, multum posse extrorsum curvari ut hinc ær immitti posset, pulmones vero fibrarum rite firmari, ut hinc ær vicissim posset remitti." Notwithstanding the high reputation of Morgagni, I must dissent from the opinion of the tortoise respiring like the frog. I will not say that none of the genus do respire in this manner, as I have had no opportunity of examining any of the turtles. I wish to be understood as speaking of the Testudo orbicularis, my observations having chiefly been confined to this species, though I think I may say the same of the græca and palustris. Yet the opinion of this celebrated man is supported by Coiter and Varnier saying that, after the sternum is taken off, and the lungs are laid bare, the animal can still inflate them. But if, after the sternum was taken off, the peritoneum cut through, and the lungs laid bare, these appeared to Coiter and Varnier to inflate, this might not have proceeded from any power residing in the lungs themselves, nor from any air being impelled into them by the muscles of the throat, but by the parts in contact with them, as the neck before, and the muscles behind (which I shall soon describe), shortening them, in which case they would appear more distended, though the quantity of air within was not increased. The tortoises which I opened I never observed to inflate their lungs as the frogs do; nor did the anatomists mentioned by Valentini observe it, for they say, "Pulmones enim depressi remanebent, nec inflabuntur ab illa aeris attractione quod fieri potuisset tamen ab animali adhuc vivente licet capite truncato, quod ego subito, antequam aperiri, curarem, abscindi jusseram." Yet adds, "Vitalis autem haec testudo actiones habuit horæ spatio absque corde sed et absque capite; nam pedas movit ad tactum nostrum et sine eodem quoque retraxit." These are the opinions of the older anatomists; and amongst the moderns I know of none who have said anything on this subject. Being dissatisfied with them, I entered into the investigation by actual observation, and opened one for this purpose. The sternum being taken off with great care, the periosteum presents itself as a strong white membrane like parchment; when I had cut through this, I found many muscles inserted into it, particularly over the scapulæ and os pubis, which, in the contracted state of the animal, are not far asunder. Just above the os pubis it is connected to the peritonæum; by this means these bones, with their muscles, are enclosed as in a bag, having the peritonæum beneath, and the periosteum above; the scapulæ, and their connected bones and muscles, are enclosed in the same manner. The peritonæum being cut through, and the intestinal canal, liver, &c., removed, the lungs, consisting of two lobes, are seen covering nearly the whole of the testæ; they are cellular, as in the frog, and consist of two lobes, one on each side of the spina dorsi, each of which is subdivided into four or five indistinct lobules. The cellular texture of these is not uniform; the cells of the middle lobules being the smallest, and those of the last lobule the greatest; this lobule is likewise loose, not being tied down on the sides nor beneath, the rest are tied down to the spine. My attention was soon called to observe the structure and office of some muscles in the region of the flanks, which I observed often to be in motion, contracting and extending alternately, and though placed by the side of the hind legs, these were not moved by them. Further, they were placed at the end of the last lobule of the lungs, and they appeared to retain their irritability the longest. This was sufficient to lead me to conjecture that these might be the parts by which respiration in these animals was performed; and to see them act in their natural position I sawed off, in another tortoise, that part of the shell which covers them, and I then saw them constantly working. One was now placed nearly in a perpendicular direction, and another, or part of the same, was placed nearer the sternum, lying almost in a horizontal direction. The first in its contraction receded from the testa inwards, whilst the latter, in its contraction, observed a contrary direction. When I attributed to them the office of expirator and inspirator muscles, which I supposed them to perform, I was embarrassed, because I could not conceive how a muscle could be a constrictor with its convex side; yet when the expirator, by contracting, had receded from the shell inwards, it appeared, when viewed from without, to be concave. But this difficulty ceased as soon as I had opened the animal and dissected the parts, for I then found the following admirable contrivance of nature. This part is composed of two distinct muscles, with their risings and insertions quite different, yet firmly connected in the middle by cellular membrane. The first rises from the testa near the spina dorsi, and is inserted into the peritonæum; this is the constrictor of the lungs, or the muscle of expiration. The other is nearly spread over the whole cavity between the upper and under shell, where the hind legs are drawn in during the contracted state of the animal, being inserted into the margin of the testa above, and the margin of the sternum below. The places of insertion of these muscles, and their connection in the middle being known, there is then no difficulty in explaining why the muscle, while acting as a constrictor, appeared concave, as it was only the inspirator brought into that position by its antagonist; nor any difficulty in conceiving how they carry on the function of respiration; for the expirator being connected, as I have already said, to the testa below and to the peritonæum above, envelops in a manner the last movable lobule of the lungs; when, therefore, it contracts, it compresses this part of the lungs, and by that means expels the air; then ceasing to act, the other contracts, and draws the former with it, thus a vacuum is formed, into which the air rushes, as in the respiration of those animals which have a thorax.

To prove that this explanation was well-founded, and that the motions of these muscles were really those of respiration, I made the following experiment. I fastened on the nose of a tortoise a little valve made of white paper, which covered the nostrils, and with the assistance of a friend, I watched the motions of the soft parts lying within the hollow where the hind legs came out, and I found that these motions perfectly corresponded with the motions of the valve, which was put into motion by the expirations and inspirations of the animal. In this manner I conceive respiration to be carried on in the tortoise, without, however, meaning to extend this explanation to the whole of the genus Testudo, some families of which I have never yet had an opportunity to examine. These animals will therefore materially differ from those of the two preceding families in the mode of respiring; the air in them being driven into the lungs by the muscles of the throat, which act like a pair of bellows, whilst in these it is performed by the lungs following the motions of their containing parts, and they will therefore differ from the animals having a thorax chiefly in the form and situation of the parts. Respiration is not, I think, the only office of the muscles which I have just described; they are closely connected to the bladder, and to them, I think, this animal is indebted for the power it possesses of sucking in water by the anus, as I mentioned in my last dissertation; but this investigation I must leave to another time.

It will thus be seen, while this close observer fully realized that respiration in the turtle was not effected by deglutition, but by muscles of expiration and inspiration situated in the flank spaces, yet, failing to recognize the true office of the anterior muscles, his conception of the respiratory process was necessarily imperfect and insufficient, and to this, no doubt, must be ascribed the neglect into which his views have fallen.

In 1819 appeared the most important contribution to the literature of the subject, the monograph of Ludovicus Henricus Bojanus, on the Anatomy of the Testudo Europææ. This work being purely anatomical, we have no means of judging as to the author's knowledge of the muscular apparatus concerned in respiration, except by the nomenclature he adopts, and some details of description. The inspiratory muscle and the posterior belly of the expiratory muscle are grouped as abdominal muscles, and described as the obliquus and transversus-abdominis, while the anterior belly of the expiratory muscles, under the name of diaphragmaticus, is thus referred to: "A corpore vertebræ dorsi quartæ et tertiæ et a costa tertia oriundus, triplici fasciculo complanato, divergentibus eundo; quorum bini ad marginem internum pulmonis, sui lateris, descendunt eique agglutinantur; tertius vero supra pulmonis anterius extremum revolutes ad peritoneum (a pulmonum facie inferiore versus cardiam et hepar deflecteus) desinit." It is, no doubt, probable that these names have been determined by supposed homologies of the muscles, and yet we may reasonably conclude that Bojanus had not perceived any relationship between the diaphragmaticus and the transversus abdominis, and did not realize that the broad fibrous membrane extending between them was their common tendon. This conception is essential to the full realization of the respiratory process.

G. De Cuvier, bearing in mind the type of batrachian respiration, regards the alternate contraction and dilatation of the throat as movements of deglutition of air, and thinks them a sufficient and the only means by which inspiration is effected. The expulsion of the air from the lungs he refers to the agency of two muscles in the flank, the obliquus and transversus of Bojanus, at the same time calling attention to the fact that Townson has erroneously attributed to one of these (the obliquus) the function of an inspirator. He thinks also that the analogues of the quadratus lumborum and the rectus abdominis, by compressing the viscera, may assist in expiration. In his Leçons d'Anatomie Comparée, vol. vii. p. 216, Duvernoy's edition, 1840, we find his opinion in detail.

"Le même mécanisme est mis en jeu dans les chéloniens. La déglutition de l'air est le seul moyen dont ils puissent se servir pour faire entrer ce fluide dans leurs poumons. Ils dilatent et contractent leur gorge alternativement, ayant la bouche fermée, absolument comme les batraciens et par les mêmes puissances. Il est expulsée par deux pairs de muscles analogues à ceux du bas-ventre des animaux précedents. Ces muscles remplissent l'intervalle postérieur du sternum et de la carapace, dans lequel se replient les extrémités pelviennes dans l'état de repos, et c'est à cet endroit qu'on aperçoit dans les chéloniens les mouvements de contraction et de dilatation qui, dans les mammifères, se voient dans toute l'étendue du ventre.(1) La première paire ou l'externe résemblent à l'oblique descendant, elle s'attache à tout le bord antérieur du bassin, à la carapace et au sternum, et s'étend dans tout l'intervalle postérieur de ces deux parties. L'interne ou l'analogue du transverse est composé de fibres transversales s'attachent supérieurement à la moitié postérieur de la carapace près des vertèbres, descendent en dehors des viscères, les enveloppent et viennent aboutir inférieurement à une aponevreuse moyenne. Celle-ci passe en partie sous la face inférieure de la vessie, et doit servir à la vider lorsque ces muscles se contractent. Ils ne comprennent immédiatement qu'une petite portion des poumons; mais leur action s'exercant plus fortement sur les viscères du bas-ventre, ceux-ci pressent à leur tour les premiers organes et en expulsent l'air. Les muscles analogues du quarré des lombes et du droit abdominal qui ont été décrits (t. i, pp. 488, 489) doivent aussi comprimer les viscères abdominaux, et par leur moyens les poumons. Les chéloniens qui ont leur cavité viscérale divisé par le pleuro-péritoine à la manière de celle des oiseaux, ont une de ces cloisons celle qui descend de la partie antérieure du bouclier dorsal, au devant du foie, constituée comme un diaphragme par des fibres musculaires et aponevretiques. Bojanus décrit un muscle diaphragmatique pair composé de fibres musculaires épanouies de chaque côté sur cette cloison, que nous avons fait connaitre comme une sorte de diaphragme (t. iv, 2d partie, p. 651). Son action, quoique faible, peut contribuer à l'expiration en comprenant les poumons.

"Peut être que les poumons se contractent aussi par une force propre que réside dans le réseau tendineux qui entre dans leur composition (Art. 11, de cette Leçon, p. 130).

"N. 1. Je crois l'avoir fait connaître le premier (Bull. de la Soc. Phil. an. xiii, No. 97, p. 279) en démontrant, contrairement à l'opinion de Townson, que les muscles du bas-ventre sont l'un et l'autre des muscles expirateur. Et cependant c'est à cet auteur qu'on attribue l'explication que j'ai donnée en montrant l'inexactitude de la sienne."

Dumeril et Bibron, vol. i. p. 176, 1834, described briefly the mechanism of respiration in chelonians thus: air enters the buccal cavity through the nose, then the fleshy tongue is applied to the posterior nares so as to close them, and the mylo-hyoid floor of the mouth contracts, to force the imprisoned air into the lung. A succession of such acts fills it.

Before entering upon the details of description, it may be well to premise, that this anatomical section of our paper is intended mainly as an exposition of the muscular and neural apparatus by means of which the movements of air to and from the lungs are effected in chelonians, and while, to render the subject more intelligible, we shall rehearse the general anatomy of the organs of respiration, we shall avoid all questions of structure or function irrelative to the point of inquiry, referring the reader desirous of such knowledge to the more general works on comparative anatomy.

Underlying the floor of the mouth, and embracing with its cornua the sides of the pharynx posterior to the jaw, is the hyoid apparatus, or the tongue-bone, Fig. 1,

Fig. 1.

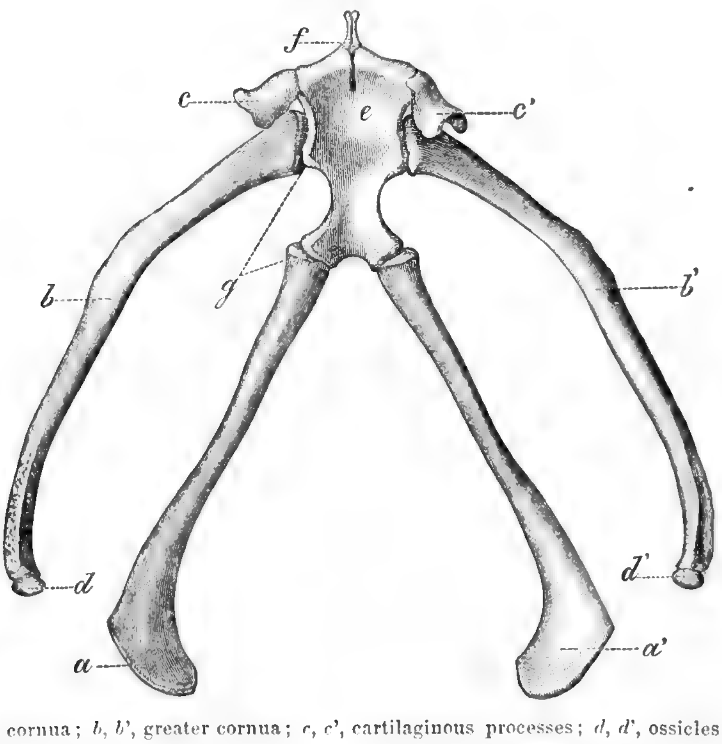
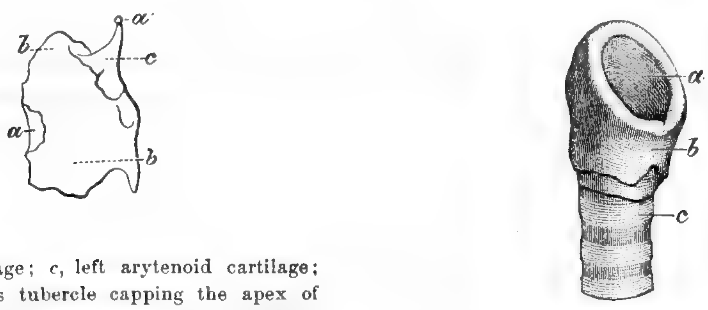


Fig. 1. *a*, *a'*, lesser cornua; *b*, *b'*, greater cornua; *c*, *c'*, cartilaginous processes; *d*, *d'*, ossicles for attachment of suspensory ligaments; *e*, body of bone; *f*, fenestrum, closed by cartilage; *g*, articulations of cornua with body.

an instrument conspicuous for the part it has evidently played in fixing upon its possessor the batrachian type of respiration. It consists of an elongated body, excavated for the lodgment of the larynx and upper rings of the trachea, and of a cartilaginous process and two bony cornua on each side, connected with it by movable articulations. To the extremity of the anterior or major cornu is attached a knob or ossicle, for the reception of the suspensory ligament. This ligament arises from the mastoid process of the temporal bone of the cranium, and forms the fulcrum on which the apparatus swings backwards and forwards, moved by alternate contractions of the genio-hyoid and omo-hyoid, and other muscles of the neck. The hyoid bone, in its movements, carries with it the glottis, and removes it from obstructions during inspiration. The larynx, Fig. 2, A and B, consists of a largely-developed cricoid cartilage and two arytenoid cartilages. The cricoid rests in the bowl of the hyoid bone, is somewhat helmet-shaped, and has on its under surface a visor-like oval fenestrum. This fenestrum is covered by membrane, and is traversed from side to side by the chiasm of the superior laryngeal nerves, of which we shall speak more fully hereafter. Superiorly the cricoid presents an oval opening, filled in by membrane, upon which rest the arytenoid cartilages, one on either side, with the glottic slit

A Fig. 2. B



b b'. Cricoid cartilage; *c*, left arytenoid cartilage; *a'*, cartilaginous tubercle capping the apex of the arytenoid cartilage; *a*, oval fenestrum of cricoid, filled in with membrane.

b. Cricoid cartilage; *a*, superior opening; *c*, trachea.

between them. The arytenoid cartilages, Fig. 2, A, *c*, are two irregularly triangular solids, opposing flat surfaces to each other, their bases incorporated with the superior cricoid membrane, and their apices extending vertically, and terminating in a small cartilaginous tubercle. They are the framework upon which the crico-hyoid and crico-arytenoid muscles act, in closing and opening the glottis. The trachea, smaller in diameter than the cricoid bulb, descends the neck, inclining to the left side, until opposite the margin of the shell it divides into two bronchi, which, curving right and left, open free into the corresponding lungs, at the under and inner edge, a little behind the anterior extremity. The lungs are two wedge-shaped sacs, the base of the wedge being anterior. They lie in contact with the vault of the dorsal shield, and are separated from each other by the large retractor muscles of the neck, the bloodvessels, and nerves. They are anterior and above the peritoneal sac, except the posterior pointed extremity, which projects into that cavity, carrying with it a covering of peritoneum. The walls of the lungs being elastic lend aid to the act of expiration, but as they give no evidence of muscular fibre to mechanical or galvanic stimuli or to the microscope, it is impossible, for this and for other reasons, to suppose with Varnier that they possess any intrinsic power to assist in the act of inspiration.

The turtle which has served us for most of our experiments, is Chelydra Serpentina, the well-known Snapping Turtle of the United States. Selected at first from the facility with which we could procure fine specimens, we soon found that its well developed muscular system and its exposed flanks admirably fitted it for the study of respiratory myology, while its middle rank among Testudinata led us to expect, in its organization, more striking ordinal characters than we would find in the extreme marine or terrestrial families. We have therefore adopted Chelydra

Serpentina as our typical turtle, and will describe in detail the apparatus of respiration as we find it in this species, noting, subsequently, the modifications of structure existing in the different genera that we have had the opportunity to examine. In all turtles we have found the general plan of the respiratory apparatus constant, an inspiratory muscle in each flank, and an expiratory muscle with four bellies, two anterior and two posterior, connected by a broad membranous tendon, inclosing the viscera and capable of compressing them against the under surface of the dorsal shield. The discrepancies characterizing different genera principally affect the origin of the anterior belly of the expiratory muscle; these may naturally be arranged in two groups, those in which the origin is anterior (about the second rib), (see Fig. 5) and extends nearly across the width of the shield, and those in which the origin is posterior (about the third or fourth rib), and in extent more limited. The specimens we have had the opportunity to examine are too few to enable us to determine whether this structural diversity can be received as an element in determining generic rank. We will content ourselves, therefore, at present, with the description of each specimen, including a brief notice of its habits and shell-measurements, which may serve as a nucleus for future and more extended observations.

Chelydra Serpentina is a carnivorous turtle living in the water, under bank-eaves, or at the bottom of streams, and yet capable of moving over the land with facility. The under surface of the body is much exposed, the plastron being small and cruciform, and connected with the carapace by a narrow bridge, which widens to join the fourth, fifth, and sixth ribs. The flank spaces are large, flat, and unprotected, and the extremities incapable of complete retraction under the shell. The height of the trunk compared with the width and length of the carapace is as one to three and three and a half.

Carefully watching the animal while breathing, we notice synchronous movements of the trunk, of the throat, and of the glottis within the mouth. With the first element of the respiratory act, expiration, the glottis opens, the hyoid apparatus descends and widens, the shoulders sink and the flanks become increasingly concave; then follows immediately the inspiratory effort, the glottis remaining open, the throat narrows, the flanks become tense, and the shoulders are pushed forwards as the act culminates; afterwards the muscles relax, the glottis closes, and the creature is at rest until again impelled to renew the air in its lungs, when the same sequence of expiration, inspiration and pause is repeated.

We shall follow the order of the elements of the respiratory act in describing the apparatus by which it is effected. And first, of the muscles of expiration. For the purpose of dissection, it is desirable to place the animal upon its back and fix it, by extending and securing its head, tail, and extremities. Separate with a saw the bony bridges connecting the plastron with the carapace, and sweeping a knife close to the inner surface of the former, divide from before, backwards, the deltoid, pectoral, pelvic and flank muscles, the acromial articulations posterior to the first pair of sternal bones, and the loose cellular bands binding the visceral sac to the middle line. This permits the removal of the plastron. Drawing the shoulders forward, cut the ligaments, holding the scapulæ to the spine anterior to the first rib, which loosens the entire muscular and bony mass, and facilitates its detachment. The section should be made with the lung partially inflated, to secure from injury the anterior belly of the expiratory muscle, which lies in contact with the posterior surface of the serratus magnus. The further removal of the tissues of the flank, and their careful separation from the posterior belly of the expiratory muscle to which they are adherent, completes the exposure.

Looking at the result of our dissection, we find a tendinous and muscular sac occupying the dorsal shield, filling its entire width in the middle and most of its length; its general form is cordate, the apex dipping into the pelvis, and its anterior notch giving place to the heart and the muscles and vessels of the neck. Much the larger portion of the sac visible is tendon (Fig. 3, *g*, *g'*), and has hitherto been regarded as peritoneum, but a closer scrutiny would have revealed its fibres gathering from all sides towards an oval centre, in which they are inseparably interwoven. The tendon in many places can be lifted from the peritoneum, by which it is lined. Curving around its anterior and posterior borders are muscular fringes (Fig. 3, *d*, *d'* and *e*), the fibres running from the carapace in lines parallel to the long axis of the trunk. These are the anterior and posterior bellies of the expiratory muscle, the diaphragmaticus and transversus abdominis of Bojanus. These muscles are inserted into the common tendon, and in contracting compress the contained viscera against the shell and expel the air from the lungs. Dividing the tendon through its middle from side to side, and removing the abdominal organs and permitting the lungs to collapse, we are enabled to obtain a satisfactory view of the origin of these muscular bellies from within.

The posterior belly arises from the pelvic fascia from a point opposite the anterior third of the ilium backwards to the spine, from the eighth vertebra, and by tendinous fibres from the carapace as far as the sixth rib, the line of origin slowly leaving the spinal column as it reaches forwards. Turning outwards at an obtuse angle, after joining the sixth rib, the muscle follows its posterior edge until near its extremity, where it inclines forwards and terminates at the fifth rib as it joins the marginal plates, a point corresponding very nearly with the pelvic end of the suture connecting the carapace and plastron.

From this sigma-shaped origin the fibres curve backwards and downwards, embracing the abdominal viscera, and unite with the tendon below, forming a regular and well-defined line, varying in position as the muscle is contracting or at rest. Fig. 3, *e*, represents the lungs distended and the muscle relaxed. This belly, considered by itself, is a strong membranous muscle, somewhat triangular in shape, the apex being at the edge of the shell, and the base at the pelvis. In a turtle weighing sixteen pounds, the fibres at the apex measured one-half inch in length, while in the middle and at the base they measured respectively five and one-half and four inches.

The anterior belly arises from the vertebral margins of the second and third intercostal spaces, from the second costal arch, from the second rib along two-thirds of its length, and across the carapace in a line curving backwards and outwards, from the third and fourth ribs, near their junction with the marginal plates. It will thus be seen that the outermost origins of the anterior and posterior bellies closely approximate above the plastron where it meets the upper shield, while at the middle line of the body the origins are separated by the distance of the eighth from the third vertebra. The fibres composing the anterior belly are close and firm for the outer

Fig. 3.

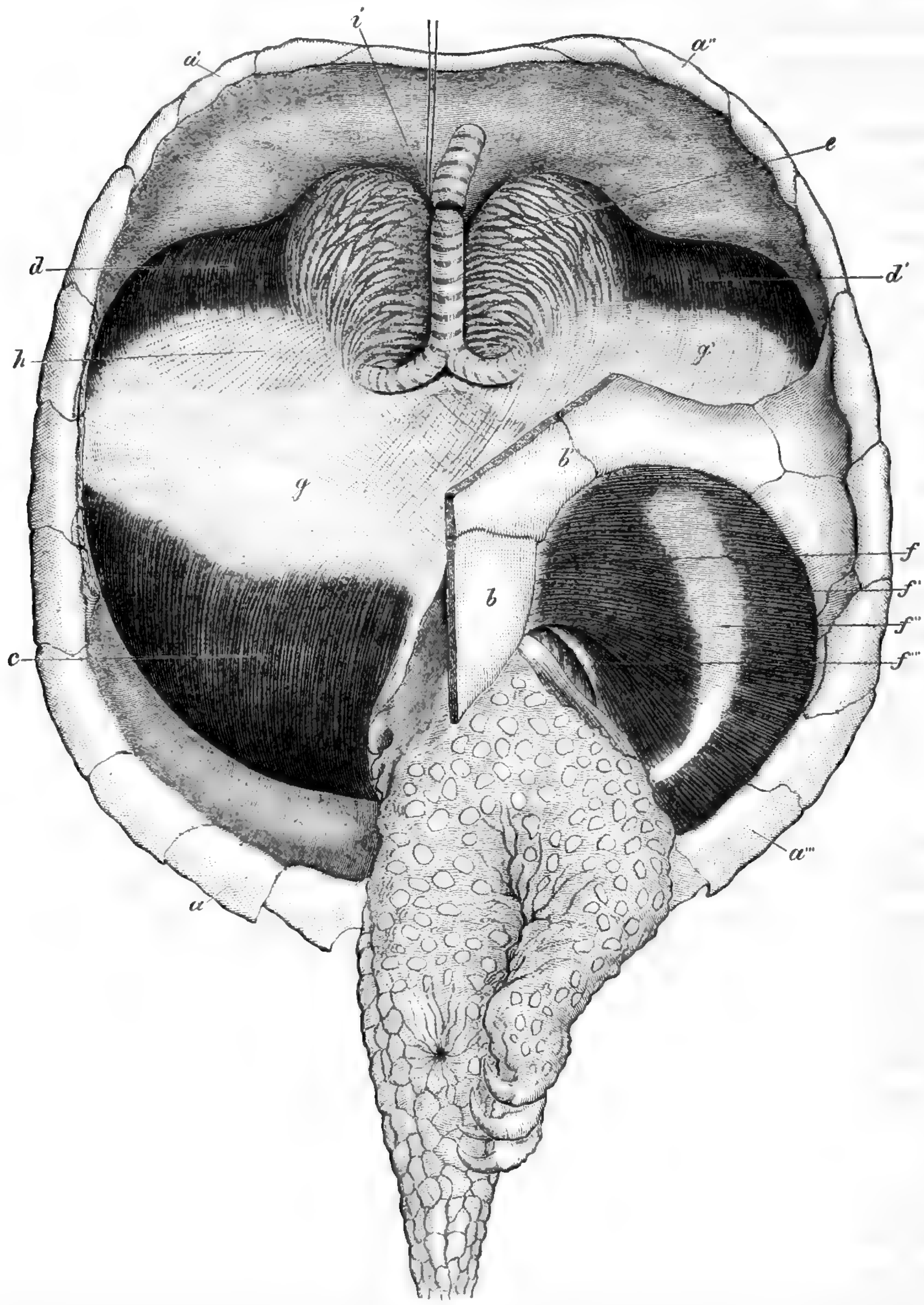


Fig. 3. Muscles of inspiration and expiration.—*a a' a'' a'''*, margin of carapace; *b b'*, portion of plastron in position; *c*, posterior belly of the expiratory muscle on the right side; *d d'*, anterior bellies of the expiratory muscle; *e*, reticulated portion showing the lung beneath; *f f'*, inspiratory muscle of the left side; *f''*, central tendon; *f'''*, tendinous ligament; *g g'*, tendon of expiratory muscle; *h*, muscular fibres beneath the tendon *g g'*, and attached to the lung.

half, while those capping the inner portion are fewer in number and reticulated, permitting the lung to be seen through their interspaces. (See Fig. 3, *e.*) The part of the muscle which arises from the vertebræ covers that triangular surface of the lung which looks towards the interpulmonary notch, while that of costal origin spreads over the anterior face of the lung, sheathing its entire thickness when the organ is fully inflated. A few of the fibres capping the anterior and superior extremity of the lung continue their course over the under surface of that organ, spreading fan-like towards its outer edge, and being inserted into its adherent peritoneal covering. They are represented by the dotted lines (Fig. 3, *h*). These fibres are much more largely developed in some other genera, and seem to have the power of drawing the lung in towards the spine, and keeping it well under the viscera when compressed during expiration.

The inspiratory muscles (Fig. 3, ff'') are to be sought for in the flank spaces at the under and posterior portion of the trunk, into which the hind limbs of the animal are drawn during repose. There is one muscle in each flank, superficial, and readily displayed, by reason of the loose cellular connection it has with the tissues concealing it. Turning aside the skin and fascia loaded with adipose matter, as it often is in this locality, we at once expose this beautiful sheet of muscular fibre, during contraction, stretching like a drum-head over the entire space, and fitting closely its irregular boundary. Through its centre, from before backwards, runs a flat tendon (Fig. 3, f''), averaging in width one-sixth of the breadth of the muscle, and receiving throughout its length, on both sides, the insertion of fibres. It is usually a single band, but in several specimens we found it irregularly double, being divided by islets or patches of muscular fibre. In some form, however, it exists in all Chelydra, and constitutes a striking feature of the muscle, its white pearly hue contrasting boldly with the crimson fringes between which it is placed. In some families it loses its significance, dwindling to a central raphé, or more rarely is absent altogether. The direction of the muscular fibres is transverse, especially in the anterior part of the space; behind and outside of the tendon they diverge to accommodate themselves to the circular sweep of the carapace. Being attached to no other mobile part than the central tendon, we may consider that as their insertion; their origin embracing the entire circumference of the space. Beginning with the posterior sternal bone, we may trace its fibres coming from the inner edge of the plastron, where it curves around the flank, from within the marginal plates of the carapace, from the fascia filling the space posterior to the sacrum, and along the pelvic muscles from a ligament, the counterpart of Poupart's ligament in man, stretching between the ilium and pubis. The fibres arising from the anterior end of this ligament underlie the lowest fibres from the plastron, and give to the latter a falciform appearance, represented in (Fig. 3, f'''). On the upper side, the inspiratory muscle is attached by cellular tissue to the posterior belly of the muscle of expiration, and by the contraction of this latter muscle during the expulsion of air from the lung, is carried downwards and forwards into a strongly concave position, most favorable for its own subsequent effort.

The capability of the turtle to hold the air in its lung at will, or when subjected to great external pressure, as must constantly occur in marine species,

Fig. 4.

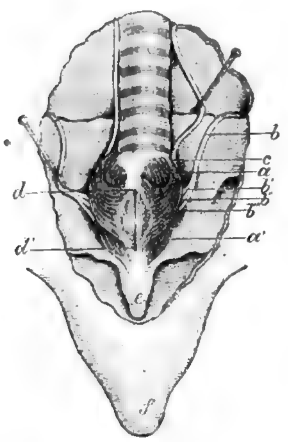


Fig. 4. Glottic muscles and nerves.—*a a'*, crico-hyoid; the muscle overlying it is the crico-arytenoid; *b*, superior laryngeal nerve; *b'*, communicating branch; *b''*, branch to crico-arytenoid; *b'''*, branch to crico-hyoid; *c*, recurrent laryngeal; *d d'*, glottic slit; *e*, point of hyoid bone; *f*, tongue.

is determined by two pairs of muscles situated about the glottis, and controlling its movements. These are the crico-arytenoid and the crico-hyoid of Bojanus; to the former is intrusted the opening of the glottic lips, while the latter, acting as a sphincter, serves to close them. The crico-arytenoid (Fig. 4) lies beneath the mucous membrane, superficial to the crico-hyoid, and crossing it nearly at right angles. It arises from the sides of the cricoid cartilage anteriorly, and is inserted into the body and vertical limb of the arytenoid as far as its extreme point.

The crico-hyoid (Fig. 4, *a a'*) arises from the body of the hyoid bone anterior to the depression for the larynx, its middle resting upon and exterior to the arytenoid cartilage. It is inserted into the cricoid cartilage at its anterior raphé. The muscles of the two sides approximate each other at their origins, and interlace at their insertions, forming an elliptical muscle surrounding the rima glottidis.

Our opportunities for studying the arrangement of the respiratory muscles in other turtles than Chelydra have been limited to the representatives of two families, Chelonioidæ and Emydoidæ.

Among the Chelonians we have examined but one species, Chelonia mydas, the Green Turtle of the Atlantic Ocean. Its habits are entirely aquatic, seeking the land only for the purpose of depositing its eggs. The body is flat, the under surface well covered by the plastron, leaving, however, naked flank spaces, as in the snapper. The union between the plastron and carapace extends from the second to the seventh rib. The inspiratory muscles occupy the flanks, arising a half inch or more within that part of their boundary which is formed by the plastron. The central tendon exists, and is wide and irregular, and extends the whole length of the muscle.

The origin of the expiratory muscles is similar to that found in Chelydra; the muscular bellies are shorter, however, and the common tendon broader and longer in accordance with the shape of the turtle.

The dimensions of the shell are—length, 38 inches; width, 28 inches; elevation, 13 inches.

Among the Emydoidæ we have examined individuals from eight genera, and find them to present considerable variations in the origin of the anterior belly of the muscle of expiration. And as these differences seem to characterize groups in harmony with the subdivisions of Agassiz, founded on minor differences of form observed in this family, we shall follow his classification in their description.

The first subdivision suggested by this distinguished observer, and styled Nectemydoidæ, is thus characterized: "The body is rather flat. The bridge connecting the plastron and carapace is wide, but flat. The hind legs are stouter than the fore legs, and provided with a broad web, extending beyond the articulation of the nail joint. The representatives of this group are the largest and most aquatic of the whole family." Of the genera included in this sub-family we have observed four: Ptychemys, Graptemys, Malacoclemmys and Chrysemys.

Fig. 5.

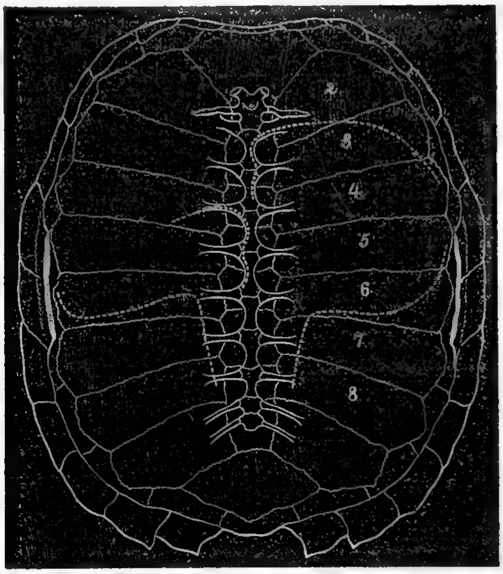


Fig. 5. Diagram of carapace of turtle, showing with the dotted lines the two principal types of origin of the expiratory muscle. The left side of the diagram shows the line of origin in the most aquatic species. The right side that of the most terrestrial. The numbers indicate the ribs.

Ptychemys rugosa, Ag.—The inspiratory muscles are found in the flanks as usual, but they have no central tendon, a simple line or raphé marking the junction of the converging fibres.

The anterior belly of the expiratory muscles arises from the vertebral margin of the fourth and fifth intercostal spaces and from the surface of the fourth rib near its posterior edge for a distance one-third its length. From this right-angular origin the fibres diverge, expanding over the upper and anterior surface of the lung, to join the common tendon at the anterior and inferior pulmonary margin. The fibres extending back on the under surface of the lung, as indicated by the dotted lines (Fig. 3, *h*), are numerous and large in this species, and seem almost to foreshadow the muscular separation between the thoracic and abdominal viscera in higher vertebrates.

The posterior belly in its origin presents no variation from that of the Snapper. Its outermost fibres, however, are much developed, forming a muscular band which reaches forwards nearly as far as the anterior junction of the carapace and plastron. The dimensions of this turtle are—length, 11 inches; width, $8\frac{1}{10}$ inches; and elevation, 5 inches.

Ptychemys mobiliensis.—Shell measurements. Length, $13\frac{12}{16}$ inches; width, $9\frac{4}{16}$ inches; elevation, $6\frac{1}{16}$ inches. The general shape and appearance of this turtle resembles P. rugosa. The anterior and posterior extremities of the bridge connecting the plastron and carapace are much more strongly involute than we have observed in any other species. When the shell is separated, they appear like four projecting keels directed towards each other, the front ones looking inwards and backwards, and the posterior ones looking inwards and slightly forwards. The concavities thus formed before and behind, external to the keels, lodge projecting portions of the lungs. The anterior and posterior keels projecting into the space usually occupied by the air sacs, deeply indent them, and cause them to present a lobulated appearance, which they retain when removed from the shell. Besides these four large indentations, there are smaller ones, in the edge of the lungs, one in front and two or more between the keels. To the inner side and behind the posterior keel lies the large posterior lobe occupying chiefly the flank space immediately above and in front of the inspiratory muscle. The reticulations of its interior structure are much larger and more coarsely marked than those of other parts of the lung.

The anterior belly of the expiratory muscle arises from the vertebral margins of the third and fourth intercostal spaces, and from the carapace in a line diverging at an angle of 30° from the spine for the space of two inches, crossing the fourth rib. From this origin the fibres cover the front of the lung, the anterior and interior ones being distributed as in P. rugosa, and owing to the intrusion of the anterior keel upon the lung, the external fibres are displaced, so to speak, with the portions of lung to which they belong, which portions lie immediately back of the ridge or keel so often referred to. The largest band of those lateral fibres finds its way between the two lobules of the lung which lie first and second in order of succession behind the ridge. The posterior belly arises from the pelvic fascia, from the eighth and seventh vertebræ, and from a curved line whose convexity looks forwards, and which terminates in front of the posterior projecting keel about two and a half inches above the posterior angle of junction of the carapace and plastron. This line is rendered more sharply convex at its external third by the projection inwards of the keel alluded to. The muscular fibres curve around the posterior part of the lung. The inner ones for half the width of the muscle are about two and a quarter inches long; and from this point they increase gradually in length to the external edge, where they are longest, extending forward in a tongue-like band about five and a half inches. In the single specimen examined we found on the left side a few additional fibres reaching forwards and inwards at least two inches beyond the main body of the muscle. The inspiratory muscle arises as in P. rugosa. It has a linear central tendon, bifid at its posterior extremity, the shorter terminating arm being external. Into the tendon and its branches the muscular fibres are inserted as in other species.

In *Graptemys geographica*, Ag., the inspiratory muscle is, in its general features, the same as described in other species, and differs only in not having even a central raphé, the convergent fibres interlacing at the middle of the muscle in an imperfect network which serves to replace the tendon usually found in this situation. The anterior belly of the expiratory muscle arises from the vertebral margin of the third and fourth intercostal spaces, and continuously from the costal margin of the third space nearly its entire circumference, and from the surface of the fourth and fifth ribs. The lines of origin diverge at an angle of 30° from the anterior margin of the third intercostal space, and in this specimen, the inner line bordering the spine measures three-fourths of an inch, and the outer one, stretching along the intercostal space and across the shield, one inch and three-eighths; from this origin the fibres spread over the anterior part of the lung and are inserted into the common tendon and into the peritoneal covering of its under surface. The posterior belly is similar to that of P. rugosa, the muscular band underlying the bridge which joins the carapace and plastron being somewhat wider. The dimensions are—length, $8\frac{1}{2}$ inches; width, 6 inches; elevation, $3\frac{1}{4}$ inches.

In *Malacoclemmys palustris*, Ag., the inspiratory muscle is the same as in Geographica. The anterior belly of the expiratory muscle arises from the third and fourth spaces at their vertebral margins, and from a line running across the shield to the fourth rib, diverging at an angle of about 70°.

The posterior belly is like that of geographica. The dimensions are—length, 7 inches; width, $4\frac{3}{8}$ inches; elevation, $3\frac{6}{8}$ inches.

Chrysemys picta, Gray.—Inspiratory muscles as in E. terrapin. The anterior belly of the expiratory muscle arises from the vertebral margins of the third and fourth intercostal spaces and a slip from the fifth, and from across the carapace to the junction of the fourth and fifth ribs, the divergence being about 30°.

The posterior belly as in geographica. Dimensions—Length, $4\frac{2}{8}$ inches; width, $3\frac{2}{8}$ inches; elevation, $1\frac{6}{8}$ inches.

Of the second and third subdivisions we have examined no specimens. The fourth, Clemmydoidæ, is characterized by "their more arched though elongated form, and the more compact structure of their feet, the front and hind pairs of which are more nearly equal, and their toes united by a smaller web; they are less aquatic and generally smaller than the preceding." Of these we have dissected representatives of three genera, Nanemys, Calemys and Glyptemys.

In *Nanemys guttata*, Ag., the inspiratory muscle presents no peculiarities. The anterior belly of the expiratory muscle arises from the vertebral margins of the second and third intercostal spaces and from part of the fourth, and from the posterior edge of the second rib as far as its extremity; from this extensive origin the fibres descend over the lungs, covering the front and anterior part of their lateral walls.

The posterior belly resembles that of the Snapper. Dimensions are—length, $4\frac{1}{16}$ inches; width, $2\frac{6}{8}$ inches; elevation, $1\frac{9}{16}$ inches.

In *Calemys Mühlenbergii*, Ag., the muscles are the same as in guttata. Dimensions—length, $3\frac{7}{8}$ inches; width, $2\frac{5}{8}$ inches; elevation, $1\frac{4}{8}$ inches.

In *Glyptemys insculpta*, Ag., the muscles are the same as in guttata. Dimensions—length, $4\frac{9}{16}$ inches; width, $3\frac{7}{16}$ inches; elevation, $1\frac{6}{8}$ inches.

In the fifth subdivision, Cistudinina, "the body is remarkably short and high, slightly oblong, and almost round. The plastron, which is movable upon itself and upon the carapace, as in the Evemydoidæ, is also connected with the carapace by a narrow bridge; but the feet are very different, the toes, as in the Testudinina, being nearly free of web. Their habits are completely terrestrial." Of this subfamily we have examined one species, Cistudo Virginea, Ag. The flank spaces in which the inspiratory muscles play are extremely deep, owing to the high carapace. The amount of muscular fibre is relatively greater than in the other turtles, and the central tendon is narrow, and irregularly triangular in shape. The anterior belly of the expiratory muscle arises from the vertebral margins of the second and third intercostal spaces and from the second rib throughout its length.

The posterior belly is like in origin to that of other Emydoidæ; the muscular fibres are longer, however, and terminate squarely in the tendon, as does also the anterior belly.

For convenience of reference, we have thrown into a tabular form the measurements and muscular origins of the above genera.

Species.	Mode of Life.	Dimensions in inches.			Origin of Respiratory Muscles.
		L.	W.	E.	
NECTEMYDOIDÆ.					
Ptychemys rugosa		11	$8\frac{1}{16}$	5	4th and 5th vertebræ.
" mobiliensis		$13\frac{12}{16}$	$9\frac{4}{16}$	$6\frac{1}{16}$	3d and 4th "
Graptemys geographica	Aquatic.	$8\frac{1}{2}$	6	$3\frac{1}{4}$	3d and 4th "
Malacoclemmys palustris		7	$4\frac{3}{8}$	$3\frac{6}{8}$	3d and 4th "
Chrysemys picta		$4\frac{1}{4}$	$3\frac{1}{4}$	$1\frac{3}{4}$	3d and 4th "
CLEMMYDOIDÆ.					
Nanemys guttata		$4\frac{1}{16}$	$2\frac{3}{4}$	$1\frac{9}{16}$	2d and 3d "
Calemys mühlenbergii	Less aquatic.	$3\frac{7}{8}$	$2\frac{5}{8}$	$1\frac{4}{8}$	2d and 3d "
Glyptemys insculpta		$4\frac{9}{16}$	$3\frac{7}{16}$	$1\frac{6}{8}$	2d and 3d "
CISTUDININÆ.					
Cistudo virginea	Terrestrial.	$4\frac{3}{8}$	$3\frac{3}{8}$	$2\frac{2}{8}$	2d and 3d "

A glance at the table will show that in the most aquatic species of Emydoidæ the origin of the anterior belly of the muscle of expiration is from nearly the middle of the shell; while in the less aquatic and terrestrial genera it is from the forward part, and much more extensive. This arrangement is too uniform to be passed by unnoticed, although our facts are so few that we cannot form any conclusions as to its generic meaning. Whether the same diversity of origin exists in the genera of other families, and bears a similar relation to their family rank, and also whether this origin is modified during the development of the turtle, we must leave for future inquiry.

The neural apparatus of respiration in Chelonians, as in the Mammalia, consists essentially of the nervus vagus supplying the larynx, of spinal nerves distributed to the respiratory muscles of the trunk, and of the medulla oblongata, the common centre through which the synchronous movements of the glottis and of the flanks are incited and controlled. Between the ganglionic enlargements supplying the upper and lower extremities, the spinal cord is attenuated, the nerves coming from this region being restricted, by the existence of a bony thorax, almost entirely to those concerned in the movements of respiration. The disposition of the trunks of these nerves closely resembles that of the intercostals in man. Escaping from the spinal canal at the intervertebral foramina they traverse the carapace in parallel lines between the ribs, giving off branches from time to time to their appropriate muscles. By dissection and by mechanical irritation of the peripheral end of the cut nerve, exciting contraction of different fibres, we have determined that the filaments finally distributed to the expiratory muscle are derived from the first, second and third dorsal nerves for the anterior belly, and from the fifth, sixth and seventh for the posterior belly. The sixth and seventh nerves are also the sources of supply to the muscles of inspiration, the seventh being distributed over the inner or pelvic side, and the sixth to those fibres connecting the central tendon and carapace. Section of the medulla spinalis in the cervical region effectually intercepts communication between these nerves and their usual source of excitation. Under these circumstances the muscles of the trunk remain at rest, although the movements of the glottis indicate that the creature feels the respiratory need. These glottic movements continue normal even after the further section of both pneumogastrics.

The respiratory nerve of the larynx, the par vagum, emanating from the medulla oblongata, passes out of the cranium at the posterior jugular foramen, and courses down the neck within the sheath of the cervical vessels. Soon after leaving the skull, it gives off the superior laryngeals, and low down in the neck, opposite the aorta, the inferior laryngeal, the two branches that interest us at present. The superior laryngeal (Fig. 4, *b*), soon after separating from the parent nerve, approaches the major cornu of the hyoid bone, and under shelter of its posterior border, follows it closely to its junction with the body, then winding spirally forwards, it crosses the articulation, and runs along the margin of the excavation in close proximity with the larynx. In this position it gives off three principal branches. 1st. A communicating branch (Fig. 4, *b'*); 2d. A branch to the crico-arytenoid, or opening muscle of the glottis (Fig. 4, *b''*); and 3d. A branch to the crico-hyoid or glottic sphincter (Fig. 4, *b'''*). The communicating branch (Fig. 6) is a relatively large nerve, but has hitherto escaped observation; it is easily brought into view by dividing the trachea and lifting it forwards. It passes beneath the larynx directly from side to side, traversing the membrane of the cricoid fenestrum, about its middle. It is composed of fibres derived in part from each of the superior laryngeal nerves, which cross each other, to be distributed to the glottic muscles of the side opposite to that from which they originate. This remarkable nerve, we believe, furnishes the only known instance in nerve anatomy of an extracranial chiasm. Some few filaments penetrate the cricoid membrane, to be distributed to the mucous membrane of the larynx, and are doubtless sensitive fibres. At page 20 of the physiological section, will be found the experiments by which we have determined the function of this intercommunicating nerve.

Fig. 6.

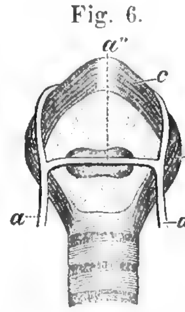


Fig. 6. The intercommunicating nerve seen from below.—*a a'*, superior laryngeal nerves; *a''*, intercommunicating nerve crossing the fenestrum of the cricoid cartilage; *b*, crico-arytenoid muscle; *c*, crico-hyoid muscle.

The second and third branches present no peculiarities; they penetrate the muscles and are lost to view. Sometimes, however, they can be seen to divide into three or more filaments before so doing.

Fig. 4, *c*.—The pneumogastric, before reaching the aorta, gives off a branch, which, winding around the arch, changes its course upwards, and soon divides into two nerves; one crossing the neck enters the œsophageal tissue—the other, the recurrent laryngeal (Fig. 4, *c*), joins the trachea, and, in close contact with its side, follows it to the larynx, and enters the crico-arytenoid muscle. There are no fibres from the recurrent distributed to the crico-hyoid directly, or indirectly through communication with the superior laryngeal.

CHAPTER II.

The preceding chapter has been altogether taken up with anatomical descriptions of the respiratory organs and their appendages. So much that was new was met with during our dissections, that it was thought better to separate the description of the anatomy from the physiological statements. We have thus the physiology of the respiratory organs still to describe, and this can now be done without repeating any more of the anatomical detail than is necessary to enable the reader to comprehend the actions of the organs concerned.

The history of the theories entertained as to the nature of the respiratory motions in turtles, appears to us one of the most extraordinary in the records of science. Totally misunderstood by the earlier naturalists and biologists, or confounded as to type with the respiration of Batrachians, this function in turtles was first rightly comprehended, at least to some extent, by R. Townson in the latter part of the last century. How far he went, and how far he was correct, we shall more fully point out in another place. The authority of more eminent naturalists, and an obstinate disposition to associate the turtle with the frog, and to insist on similarity as to the execution of their functions, gradually drew attention from Townson's statement, and more modern authors have paid it no deference whatever; yet, as we shall distinctly show, all the later writers are utterly wrong, and his opinions as to the facts in question are thus far the only ones which seem to be correct. In reading his very ingenious essay, which we have elsewhere quoted at length, p. 2, it is hard to see how the statements and evidence could have failed of more respectful and permanent attention. A complete review of the theories entertained in regard to the respiratory function in Chelonian reptiles, will more fully illustrate the above remarks.

As early as 1719, Malpighi[1] described the respiration of turtles as similar to that of frogs. Both alike were supposed to distend the lungs by swallowing air, so that, in place of air being drawn into the lung-sacs, it was forced into them by the movements of parts above the trachea; but while in the frog this was effected plainly through the aid of the bellows-like mouth, in the turtles their vast hyoid apparatus was by some supposed to constitute a forcing pump of similar purpose and nature. The authors of Malpighi's era shared these opinions, and with the one notable exception above mentioned, they have stood almost uncontradicted up to the date of a paper by one of the authors of the present essay.

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[1] Adversaria Anatomica, t. v Animadv, 29.

The latest and best work on comparative anatomy and physiology[1] thus describes its author's conclusions as to this subject: "C'est aussi par des mouvements de déglutition que la majeure partie de l'air inspiré est poussée dans les poumons chez les tortues; mais ici ce mode de respiration est nécessité par une disposition organique inverse de celle que je viens de signaler chez les Batraciens." M. Edwards then proceeds to point out the rigid form of the turtle's frame, the absence of mobile ribs, and the consequent necessity for the belief that the lungs in these animals cannot be dilated from without, as occurs in mammals. The same opinion is held by nearly all writers at the present time; but some, in place of describing the process as one of deglutition, effected alone by muscles on the floor of the mouth, regard the hyoid apparatus as the true forcing pump concerned in propelling air into the interior. Thus, T. Rymer Jones,[2] after describing the fixity of the bones of the chest in turtles, adds, that "under these circumstances, as a compensation for the want of mobility in the chest, the os hyoides and the muscles of the throat are converted into a kind of bellows, by which the air is forced mechanically into the lungs, and they are thus distended at pleasure." In fact, the submaxillary space with the hyoid arches, are in continual motion in turtles, and this movement precisely resembles the like action in frogs; but while in these latter it is really a respiratory act, in turtles, as we shall show, it has other purposes, and, while it has deceived observers, may be proved to have no influence of any moment in carrying on the breathing process. Muller[3] gives a like account, and adds, that expiration is effected by means of muscles between the lower shield or plastron, and the posterior extremities. Carpenter[4] has a brief description of the respiration in chelonia, which corresponds to the general opinion already quoted above.

Prof. Agassiz's description[5] being one of the latest, and certainly one of the most authoritative statements, we quote in full, to complete our history of the generally received ideas as to the mechanism of chelonian respiration.

"Here, again, we meet with a very striking ordinal character. The turtles swallow the air they breathe. The breast box, which includes the lungs, being immovable, a respiration like that of the other reptiles, the birds, and mammalia, performed by the expansion and compression of the breast box, and consequently of the lungs, is impossible. Owing to the peculiar structure of their trunk, breathing is therefore only possible for turtles, by a pressure of the air from the mouth down into the lungs; but though we are persuaded that this swallowing of the air constitutes the main act in the process of breathing, still we are inclined to believe, against the opinion of other anatomists, that the diaphragm, which in turtles is very much developed, and attached to the lungs, takes also its part in that act. Moreover, the muscles of the shoulder and of the pelvic region may assist in that

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[1] Milne Edwards, Leçons sur la Physiologie et l'Anatomie comparée de l'Homme et des Animaux, t. deuxième, deuxième partie, p. 387. 1858. Paris.

[2] The General Structure of the Animal Kingdom, p. 567.

[3] Physiology—London translation, p. 360, vol. ii.

[4] Gen. and Comp. Phys., p. 493.

[5] Contributions to the Natural History of the United States, vol. i. p. 281.

operation, either by immediately compressing the lungs, which generally extend in turtles from one end of the trunk to the other, or by pressing the bowels against them.

"The act of swallowing the air is chiefly performed by the apparatus of the tongue-bone, and the tongue itself, which, by its large size, facilitates the operation. Being drawn backwards and upwards, this organ shuts up the choannæ, and at the same time opens the slit of the windpipe, situated just at its base, thus giving to the air a passage into the windpipe, and at the same time preventing its entrance through the choannæ into the nose. In this way, the tongue takes the place, in a certain sense, of the velum palatinum of the higher vertebrata, which is wanting in turtles. After the air has passed into the windpipe, the tongue is drawn forwards, and thus the longitudinal glottis is again closed, while now the choannæ are again opened to a free communication with the cavity of the mouth."

Professor Agassiz adds, in a following note:—

"We find the same mode of breathing in the class of Batrachians, but for an entirely different reason, namely, on account of the absence of ribs."

Also. "The existence of a diaphragm is erroneously denied to turtles by Dumeril and Bibron, Erpétologie générale, 1, p. 175."

In the above description, Prof. Agassiz exhibits some doubt as to the correctness of received views on this subject, and speaks of the musculus diaphragmaticus (Bojanus) as having something to do with the act of respiration, which he thinks may also be aided by other muscular parts, as those concerned in locomotion, and by certain pelvic muscles which he does not specify by name.

We shall show as we proceed that, although the muscle covering the lungs may be homologous with the diaphragm of mammals, it is really a muscle of *expiration*, and therefore not analogous to the diaphragm when regarded from a physiological stand-point.

Except for the purpose of completing this brief history of opinions held now or abandoned, it is only requisite to allude to the views of Perault, who attributed the inspiratory act to the elasticity of the lungs, and the expiratory motion to muscles of which, he says naively, the turtle has an abundance. M. Tauvry, whose views Milne Edwards partially indorses, attributed the whole respiratory act to the changes in the capacity of the chest, caused during locomotion, by the advance of the head and limbs from and their retraction within the carapace. M. Haro[1] supports the same views, but, although both are successful in showing that these movements may alter the capacity of the chest-box, and thus under some circumstances modify respiration, neither has proved that respiration relies for its continued occurrence upon these motions, nor would such a supposition be entertained for a moment by any one who surveyed the mechanical conditions which are effective in carrying on respiration in other animals. That the locomotive movements may, and perhaps do at times *modify* the respiratory process, may be taken for granted. That other agents are constantly employed in this function is not less clear, nor shall we have any difficulty in disproving M. Haro's theory by unanswerable facts.

[1] Mem. sur le respiration des Grenouilles, Ann. des Sc. Nat. 2 serie, t. xviii. p. 48.

The author to whom we have alluded as the only one who has approached to a clear comprehension of the true mechanism of respiration in turtles is Robert Townson, LL. D.[1] The anatomy of the respiratory muscles of the breast-box is described by this author, as we have elsewhere shown, with much correctness. His statement as to the mechanism of the movements of the chest and belly muscles in breathing are, also, remarkably truthful, and are approached in this particular by those of no other or later authors.

He came to the conclusion, as we have seen, p. 6, that the turtle and frog do not breathe alike, but that while the latter forces air into the lungs, the former possesses a type of respiratory movement closely analogous to that of the mammal.

He described an inspiratory muscle in the posterior flanks, and an expiratory muscle covering the back of each lung, and attached to a broad tendinous expansion, running forward, to be inserted in front on the carapace, above the lung. To do full justice to this most ingenious and neglected observer, we have quoted, in connection with the anatomy of our subject, the experiments, by means of which he proved that turtles do not force air into the lungs, p. 6, and by which he also showed that they draw the air into the chest, by muscles attached to the breast-box, and expel it through the aid of the expiratory muscle covering the posterior end of the lung.

Considering the period at which he wrote, nothing could be clearer than the above statement, and we are amazed, that its obvious truth should have so long escaped recognition.

In the summer of 1861, one of us, Dr. Weir Mitchell, while engaged in studying the blood-pressure in the snapping turtle, Chelydra serpentina, became convinced that the prevailing views as to the respiratory mechanism of Chelonian reptiles were totally incorrect. Accordingly he partially studied the subject, and incidentally embodied his opinions in an essay upon the blood-pressure in the snapping turtle.[2] At the time referred to, Dr. Mitchell was unacquainted with Townson's researches. The views of Dr. Mitchell, and the experiments by which he supported them, will be found scattered through the text of the present essay, of which, indeed, they form the basis. In the summer of 1862, the present authors took up anew the study of the respiration in turtles, and have endeavored to render it as complete as possible. In so doing they have been fortunate enough to carry the subject far beyond the crude experiments of Townson, and to discover anatomical and physiological facts of the utmost interest and novelty, which have hitherto escaped attention.

To facilitate the comprehension of the subject, we shall divide the physiological part of this essay in the following manner:—

1st. The externally visible phenomena of respiration.

2d. Physiology of the muscles of respiration.

3d. Physiology of the respiratory nerves.

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[1] Tracts and Observations in Natural History in Physiology. London, 1799. Cuvier's views and his criticism of Townson may be found appended to the full quotation of Townson's dissertation, at p. 6 of this essay.

[2] American Phil. Trans., Phil. 1862.

When a turtle of any kind is observed with care, it will be seen that it breathes at very irregular intervals. These are much prolonged when it is in the water, and half an hour or more may elapse before it rises to the top, to take two or three respirations, preparatory to a second plunge. When, during summer weather, the snapping turtle was placed on a table, and observed in air, its respiration averaged one to every two minutes and a half, although certain individuals breathed more rarely, and all irregularly. The box turtle breathes still less frequently. A large snapper observed for some time, gave the following record:—Ten respirations were noted with the intervals between them, which were as follows:—1, 2, 1, $\frac{1}{2}$, 5, $\frac{1}{2}$, 1, 4, 3, 2, $\frac{1}{2}$ minutes respectively. In another the respirations during an hour were at almost perfectly regular intervals of two minutes. The size of the turtles did not seem to bear any notable relation to the number of respirations per minute.

During the respiratory act in the snapping turtle, C. serpentina, the box turtle Cistudo Virginea, the green turtle Chel. mydas, and several Emydæ, we have noticed carefully the exact details of the motions of the various parts. The head and neck, the flank spaces in front of and behind the limbs, these themselves, and the mouth, glottis, and hyoid apparatus, have been scrutinized with care in hundreds of instances, and with these results.

Turtles breathe easily with the mouth open or shut. This fact alone deprives their respiration of all resemblance to that of Batrachians.

The respiratory process is threefold, and consists of—

1. Complete expiration.
2. Complete and very full inspiration.
3. An appearance of slight, or partial expiration, followed by a pause of greater or less duration.

During the period which precedes this series of movements, the turtle being at rest, the spaces between the posterior members and the plastron and carapace are nearly level, or only a little concave. The shoulders are pushed forward somewhat, the lungs being full at this time, while the large hyoid apparatus is usually dilated or drawn backwards and downwards. Sometimes it is in continual motion, like that of the frog when breathing, but in the turtle this rise and fall of the hyoid arches has no essential connection with that function. When, during the inter-respiratory pause, we open the jaws the same movements of the hyoid apparatus may still be seen, nor is it easy at these times to assign to them any very obvious purpose. The glottis may be seen at rest, as a linear slit, Fig. 7, A, in the centre of an ovoidal slightly elevated mound, just back of the tongue, on the floor of the mouth. The first respiratory act is one of expiration. Whether the mouth be opened for observation or not, the following movements occur: The hyoid apparatus descends and broadens laterally especially at its posterior part, carrying the glottis back and a little down. The object of this action we suppose to be, the separation of the glottis from contact with the roof of the mouth, in order that the air may the more readily enter it after passing through the nares. At the moment of beginning to expire the glottis opens wide, so as to form a rhombic figure (Fig. 7, B.) It remains thus until the whole respiratory act is completed. Meanwhile, during expiration the limbs fall in towards the shell quite passively, and the flank spaces in front of the posterior limbs sink so as to present deeply concave surfaces.

A Fig. 7. B

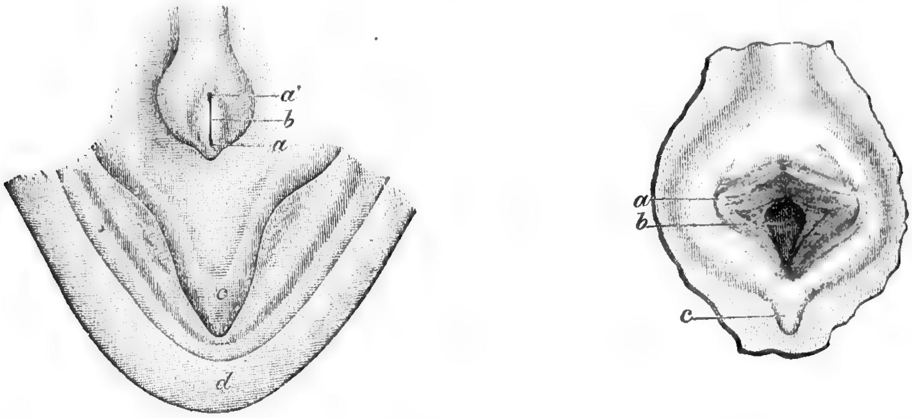

Fig. 7, A. The glottis closed.—*a a'*, the line formed by the glottic lips when the animal is not breathing; *b*, the prominent central part of the glottic lips, indicating the summit of the arytenoid cartilage; *c*, tongue; *d*, lower jaw.

Fig. 7, B. The appearance of the glottis during respiration.—*a*, right glottic lip; *b*, rima glottidis; *c*, extremity of the hyoid bone.

A full inspiration instantly follows. The flank spaces become flat and tense, rising to a level. The glottis remains open. The hyoid arches advance, and at the close of the inspiration the shoulders are pushed passively forward.

As soon as the lungs are completely filled, a very slight expiration relieves them of the surplus air, the flank spaces sinking a little, the hyoid arch at rest, the glottis closing at the end of the expiration. The final action here described appears to be due to the cessation of activity on the part of the inspiratory muscles and to the passive falling in of the limbs displaced during their contraction. The lungs are thus left full of air, and ready for the next act of respiration. Whenever a turtle in air breathes, these triple actions occur, but when under water it occasionally expires air, and does not rise to renew the supply until some time has passed by.

Type of respiration in Chelonia.—We are now prepared to examine the subject from another point of view. A superficial observer, or one who accepts the present belief, sees in the motions of the hyoid arches a movement in appearance corresponding to the respiratory play of the floor of the frog's mouth. Yet the slightest anatomical examination should have shown that, while in the frog the nostrils have valves essential to their mode of breathing, in the turtle there are none, while the form of the horny lips in the latter animal renders it impossible to make the mouth so air-tight as to act the part of a chamber in the supposed process of pumping air into the lungs. On the other hand, the laryngeal cavity is also too small to act as a chamber, nor does the hyoid arch, in its descent, enlarge the laryngeal area.

When, at the beginning of this research, one of us observed the turtle (snapper) breathing *with an open mouth*, while watching a chance to bite, he was at once convinced that the agents of respiratory movement were below the trachea, and the following very simple experiments converted this conviction into the most absolute certainty—a certainty which every future step served but to illustrate from new points of view.

On page 77 of the memoir of Dr. Weir Mitchell, previously cited, are to be found the experiments above alluded to. The trachea of a large snapping turtle was cut across, after which breathing went on at the usual rate, or more often, owing to causes presently to be mentioned. Next, a bent glass tube, two millimetres in width, was adapted to the upper or outer end of the divided trachea, and allowed to dip into water. If the breathing power resided in the hyoid arches, larynx, and mouth, the water in the tube should have been forced downwards during inspiration, but, although respiration continued, the fluid moved at this time only about one millimetre, and even this was plainly due to the motion of opening and closing the glottic lips, which occurs synchronously with the respiratory movements in the breast-box.

The same bent tube was next adapted securely to the lower end of the divided trachea, and again dipped into water as before. At each subsequent inspiration the water was forcibly and largely drawn up into the lung, and again rejected during expiration. After this no doubt could exist as to the locality in which arose the mechanical force productive of respiration. With this convincing proof the subject was laid aside for the future and more thorough investigation, of which this essay is the record.

Function of the respiratory muscles of the Turtle.—A large snapping turtle was secured on its back, and an incision made over the flank space, between the posterior limb and the plastron and carapace. The skin and superficial fascia were then carefully removed so as to expose the whole muscle which fills this space, and which has already been fully described.

When inspiration took place, the muscle contracted, and as it is possessed of a central tendon from which radiate fibres in all directions, the result of their shortening was to convert its previous deeply concave surface into one which was nearly level, while at the same time the air rushed through the open glottis into the lung. The analogy between this muscle and the diaphragm of mammals was absolutely perfect. The central tendon, the converging muscular fibres, and the form of movement resulting from this beautiful arrangement, all united to suggest the resemblance. The inspiratory function of this muscle was palpably evident, nor could any other office be possibly assigned to it, because it was attached to no movable bone or other parts susceptible of motion.

Repeated galvanization of this muscle served further to demonstrate its purpose. Finally, the muscles on both sides were removed, when all inspiratory power was lost. The turtle could empty its lungs, but possessed no power to fill them anew.

The muscles engaged in expiration were next made the subject of study. At first we were led to believe, that the elastic contractility of the lungs might alone suffice to empty them, but this was opposed to all physiological analogy, and the power with which expiration occurred was too great to allow us to suppose that no muscular force intervened for its production.

To examine this part of the subject, a turtle (snapper) was secured, as usual, and the plastron removed, with the exception of a rim at the back and on each side, to which remained attached the fibres of the inspiratory muscles. After a few minutes the turtle expired the air in the lung. During this action, the fascia covering the lungs below, and lying between the peritoneum and the plastron, was observed to become tense, owing to the contraction of the two sheets of muscle, which terminate this tendon anteriorly and posteriorly, and find origin in the carapace.

Recalling the full anatomical description already given, it will be remembered, that the lungs and abdominal viscera are covered outside of, and below the peritoneal sac, by a white membranous tendon, which extends across the middle line, and is firmly attached to the pericardium, as well as by firm areolar tissue to the central line of the plastron or lower shell. The muscular bellies arising from this covering tendon, fold over the lung in front and behind. Opposite to the inspiratory muscles are also areolar fibres, binding its tendon to the fascia of the expiratory muscle above it. When the four bellies of this muscle, or muscles contract, the lungs are acted upon directly, or by being compressed through the medium of the other viscera which are, so to speak, grasped during this powerful movement. At the same time, the passive inspiratory muscles are drawn up with the retreating lungs, owing to the pressure of the external air, and to the close union between the two sets of antagonistic muscles. Although the pericardium is also fastened to the expiratory tendon, this sac is so firmly bound to the plastron below it, that it does not appear to be disturbed during expiration, unless the connecting fibres are divided, in which case the heart sac and its contents are strongly drawn from the plastron, as the air is expired from the lung.

As in the case of the inspiratory muscle, the expiratory muscle was also tested by observing its action when exposed in the living animal, and by galvanizing its fibres. The purpose of this singular sheet of muscle and connecting tendon admits then of no doubt. Aided by the elasticity of the lung, it empties that viscus of air, and no other muscle appears to lend it any aid.

The third period of respiratory movement is marked by the closure of the glottis, and by the relaxation of the muscle of inspiration, the limbs then settling passively to their new positions. Hence the general appearance of a slight expiration at the end of the inspiratory act.

It is impossible to review this account of the respiration in chelonians, without being struck with the simplicity of the plan. A box containing all the viscera of the chest and belly has an open space on each side, filled by a muscle of peculiar form, whose contraction increases the size of the visceral cavity, and thus causes air to rush into it. Within the breast-box, the lungs and visceral mass embraced by a single muscle, obey its contraction in effecting expiration, and as the visceral cavity thus becomes smaller, the inspiratory flank muscles curve in to fill the gap.

After the most careful investigation, we can discover no other respiratory muscles within the breast-box.

The muscular apparatus of the glottis is equally simple. There is a muscle to open it, and another muscle to close it. Here, as in the rest of this portion of our essay, we shall not commit ourselves by names, which, although they may recognize homologies, confuse the reader, who has sometimes to bear in mind that their functions may be exactly the reverse of those of the human muscle whose name they carry.

The two glottic muscles have already been fully described; when both are cut away or paralyzed, by section of their nerves, the glottis still closes, owing to the elasticity of its cartilages, but it does not shut firmly, and if the lungs be previously filled with air, a large part always escapes. Under ordinary circumstances, the glottic lips are closely pressed together by the sphincter-like muscle which we have described and figured. The mass of its fibres lie below the opening muscle, and are parallel to the direction of the glottic lip, while its connections are principally at the anterior and posterior end of the glottic line. When contracted, as it always is more or less strongly during the interval between two respirations, it would tend to pucker the glottis somewhat, if it were not that the anterior and posterior insertion are firmly fixed, by the parts in front of and behind them respectively. Thus attached, the only influence it can exert, is to close the glottis whose lips stiffened by the arytenoid cartilages facilitate the process.

The opening muscle lies outside of the closing muscle, nearly at right angles to it, and immediately under the mucous membrane of the glottic mound. At the moment when expiration begins the respiratory act, this opening muscle contracts so as to draw the glottic lips wide open and permit the air to escape. Then follows a full inspiration, the glottis still open, and lastly it is closed by the constrictor muscle just after the great flank muscles of inspiration cease to act.

The downward movement of the hyoid arches is effected by the omo-hyoid and other muscles of the neck. It appears to be intended to remove the glottis from contact with the roof of the mouth during the act of respiration. The upward motion of the hyoid apparatus is produced by a thin sheet of muscular fibres spread transversely across it and over the whole upper part of the neck.

The function of all of the above muscles was determined by simple observation, by stimulating them directly, and by irritating their nerves.

The necessity for closing the glottis firmly in these animals becomes obvious, when we reflect, that not only must they be enabled to retain the air, but when under water be competent to exclude that fluid from the lungs. In fact, when we divide the trachea, or in any way paralyze the glottic muscles, the power of retaining air in the lungs is totally lost for a time. The moment the respiratory muscles cease to act, the elasticity of the lung asserts itself, and that viscus is immediately emptied. After a day or two, however, a curious change may be noticed; the turtle breathes as usual, but in place of allowing the air to escape through the open trachea, the animal holds the inspiratory muscle contracted, and thus retains the air in the lung a considerable time after each inspiration. There seems to be some urgent necessity for thus holding the air a long time in the lung, and perhaps for keeping the lung distended. The instinctive provision for these purposes when the usual means fail, is well worthy of note. As we proceed with the study of the laryngeal nerves, we shall have further occasion to observe the great importance of the glottis, and to wonder at the singular means to which creative power has resorted, in order to secure the orifice from the ordinary chances of accident and disease.

The physiology of the nerves of respiration in turtles has been the subject of our most careful and complete study. So novel and surprising were some of its results that we have felt it right to surround ourselves with more than common precautions. For this purpose we have repeated our experiments and dissections on several species of turtles, and on numerous individuals of each species, until incessant repetition left no question unanswered, and no conclusion doubtful.

We shall study,

1st. The physiology of the pneumogastric nerve and its branches, so far as they concern the respiratory function.

2d. The physiology of the nerves which supply the respiratory muscles of the breast-box. For all necessary details as to the anatomy of the vagus nerve and its branches we refer to the former part of this memoir. Here it will only be requisite to repeat that, as in most mammals, the larynx receives a superior laryngeal nerve, and an inferior or recurrent laryngeal trunk. The superior, which in man is the nerve of sensation to the larynx, is in turtles distributed to the mucous membrane of that organ, and also to *both* of the glottic muscles. The recurrent laryngeal, which in man is the principal motor nerve to the larynx and glottis, is in turtles also motor, but it sends branches only to the opening muscle. The remaining peculiarities will be better understood as we proceed to state in sequence the experiments which led to their discovery.

Experiment.—A large turtle (snapper) was secured on its back, its mouth held open. It breathed well at intervals of two minutes or more. The recurrent nerves were exposed and galvanized at the middle third of the trachea. Irritation by this agent and by mechanical means, caused the lips of the glottis to open, although not very freely. The two nerves were then divided, and the trachea cut across. The glottic movements continued perfect, and were synchronous with the respiratory motions of the breast-box. The muscles of the right side over the hyoid apparatus were then removed, the covering fascia beneath them dissected off, and the superior laryngeal nerve discovered lying under the shelter of the superior hyoid wing. Irritation of this nerve or its fellow on the opposite side caused the outer edge of the glottic lips to open, while the inner edge appeared to be forcibly closed at the same time. On cutting the nerves across, and stimulating the peripheral ends, like results were observed.

The left superior laryngeal nerve being intact, galvanization of the centric end of the divided nerve on the right side caused first, closure of the inner lips and opening of the outer lips of the glottis; and second, violent and general muscular movements and winking, apparently expressive of acute pain.

Finally the left superior laryngeal nerve was divided, when complete paralysis of the glottis ensued.

Order of section, and results:—

1. Section of both inferior laryngeal nerves, causing glottis to open; glottic movements perfect after section.

2. Cut right superior laryngeal nerve, causing glottis to open superficially and to close below; galvanization of outer end of nerve caused same result; galvanization of centric end gave signs of sensibility and reflex closure of glottis, and opening of its outer lips.

3. Section of left superior laryngeal nerve; complete paralysis of glottis.

Experiment.—A small snapper was secured as usual, and the hyoid apparatus separated from the lower jaw and turned up for convenience of observing glottis. We then cut subcutaneously the left superior laryngeal nerve, causing motion in the glottic lips. This section slightly lessened the power to move the glottic lips on the side cut. We next divided, in like manner, the right superior laryngeal nerve. The power to open the glottis remained but little impaired, but the air could no longer be retained in the lungs. Respiration went on as usual, but when inspiration was complete and the muscles relaxed, the glottic lips fell together by virtue of their own elasticity, although this seemed insufficient to balance the contractile force of the expanded lung, whose contents therefore escaped. Then followed renewed inspiratory efforts, necessitated by the loss of power to close the glottis, until the animal learned to hold the air in its lungs by keeping tense, for a time, the flank muscles of inspiration. The left and right inferior laryngeal nerves having next been divided, entire paralysis of the glottis ensued, the flaccid lips falling together valve-like when efforts were made to inhale air, while, if air was blown into the lungs, it escaped without difficulty.

Order of section, and results:—

Section of left superior laryngeal.	Glottic lips convulsed by section.
Section of right superior laryngeal.	Loss of power to close glottis firmly.
Section of both recurrent laryngeals.	Complete paralysis of glottis; loss of power to open glottis.

The above experiments, repeated upwards of twelve times on the Chrysemys picta, the Cistudo virginea, the Chelonia mydas, and the Chelydra serpentina, left no doubt in our minds as to the functions of the two laryngeal nerves in turtles. Careful dissections enabled us moreover to trace these nerves so as to show that, while the inferior laryngeal is distributed only to the opening muscle of the larynx, the superior laryngeal sends branches to both the dilating and the constricting muscles.

This anatomical arrangement explained to us some of the difficulties which we had encountered while testing the function of the muscles by means of irritants applied to the nerves. Thus, when the upper nerves were irritated, the glottis opened at the outer lip and closed within, because the irritant necessarily acted both on the nerve fibres of the closing and of the opening muscles. Again, when the lower nerve, inferior laryngeal, was galvanized, it caused the lips of the glottis to open, but not freely, because the motion of the lips seemed to act reflectively as a cause of irritation through the mucous branches of the superior laryngeal on to its nerve centres, and thence by its motor fibres upon the opponent closing muscles. When, however, the superior laryngeal nerves were cut, the closing power was abolished, and then, irritation of the inferior nerves produced more perfect dilatation of the glottic chink. We have thus determined by every necessary means that the superior laryngeal nerves in turtles are the nerves of sensibility for the mucous membrane of the larynx and glottis. That they are the motor nerves of all the true glottic muscles, and enjoy thus the ability to open and to close this orifice, and that the inferior laryngeal nerves are the motor nerves of the dilating muscles only, and have not sensibility or power to close the glottis.

What then is the reason of this double distribution of two nerves to one muscle? Upon this question we shall presently return. It seems highly probable that both nerves usually act at once to open the glottis, since galvanization of either set of nerves does not fully effect this end, while, when both sets of nerves are stimulated, the glottis opens wide.

The distribution and functions of the two laryngeal nerves in turtles are thus seen to be totally different from what we see in mammals. In them, as we need only to remind the reader, the superior laryngeal is a nerve of sensation chiefly, and although it possesses also a motor filament, this, in man at least, is distributed to a muscle, the crico-thyroid, which has neither homologue nor analogue in chelonian reptiles. In mammals the inferior laryngeal is, as in the turtle, a motor nerve, but it supplies alike the dilating and the closing muscles of the glottis.

On reference to the anatomical part of this essay, it will be seen that the hypoglossal nerve lies close to the track of the superior laryngeal nerve, and might readily be confounded with it, when the intention is to find and divide the latter alone. The nerve in question supplies muscular branches to the tongue only.

Thus far the physiology of the glottic nerves in turtles, although determined for the first time, and shown to present points of great interest and novelty, has not exhibited any peculiarity so exceptional as that to which we shall now direct attention.

This was brought to our notice while further pursuing the study of the functions of the glottic nerves. The mode in which it was first suspected, then discovered, and finally set in clear light by every available means, will be best set forth in the following record of our experiments and inferences, in the order in which they occurred.

Experiment.—A small snapper, one and a half pounds in weight, was secured as usual. Its respiratory acts observed to be perfect, and the two inferior laryngeal nerves divided one after the other, causing twitching of the glottic lips. After this the glottis still opened and shut as before, and, indeed, equally as well. It was plain, as we have already seen, that the superior laryngeal nerves could open and shut the glottis without other aid. Next, the right superior laryngeal nerve was cut at the middle of the upper hyoid cornu, and the glottis was carefully observed.

The section caused twitching of the glottic lip, and at the next respiration, to our great surprise, *both* sides of the glottis, the right as well as the left, opened equally well. In fact there was no difference. A close inspection satisfied us that the section of the nerve was complete.

If now we recall the facts, that the glottis of both sides was moving despite the section of both recurrents and one superior laryngeal nerve, it will be seen how mysterious this must have appeared to those who first observed it. We came to the conclusion either that there existed some mechanical arrangement of the glottis and its muscles, which enabled one side, while in motion, to communicate that movement to the other, or, that there was a direct nerve communication between the right and left superior nerves of the larynx. The first hypothesis was unsupported by anything that we knew of the parts. The second seemed unlikely, since on reflection we could recall no instance of a true chiasm of any nerves except those of sight. We hastened to examine the question by new experiments.

Experiment.—Snapper, weight two pounds. We exposed and galvanized the left inferior laryngeal nerve, thus causing both lips of the glottis to open. The same result was obtained with the right nerve. This fact, observed by us in other cases, was soon found to be due to the difficulty of insulating the current in one nerve. When, however, we made use of mechanical irritants, stimulation of one nerve affected only the glottic lips of the same side.

The right inferior laryngeal nerve was then cut, and immediately afterwards the right superior laryngeal nerve. The glottis still moved as well as before these sections. Next, we cut the left recurrent (inferior laryngeal nerve), thus leaving the left superior laryngeal the only nerve entire. Nevertheless, the glottic lips on both sides opened and shut, as well and as completely as ever. Lastly, we cut this remaining nerve, causing total paralysis of the glottis, and the usual results as to respiration.

Order of section, and results:—

1st. Cut right recurrent nerve (inferior laryngeal) and rig t superior laryngeal nerve; glottis continues to move perfectly on both sides.

2d. Cut left recurrent (left inferior laryngeal); glottic action perfect on both sides.

3d. Cut left superior laryngeal nerve; total paralysis of glottis.

Experiment.—Snapping turtle, weight three and a half pounds. We dissected the hyoid apparatus from its connection with the lower jaw, and held it back, thus freely exposing to view the chink of the glottis. Up to this time we had reached the conclusion, that somewhere on the fenestrum in the cricoid cartilage there might be a branch of communication between the two superior laryngeal nerves of the larynx. Therefore, on the turtle prepared as above described, we made an incision on to the fenestral membrane, between the larynx and the hyoid bone, opposite to the junction of the superior cornu with this bone. The section made a little to the left of the median line caused slight twitching in the glottic muscles, but had no influence on the respiratory motions of the glottis.

The two inferior laryngeal nerves were next divided, and still the glottis moved as perfectly as before. The left superior laryngeal nerve was divided at the middle of the upper hyoid cornu, and immediately all motion of the left side of the glottis ceased, the right side moving during respiration as usual, although somewhat feebly, owing perhaps to loss of blood during the first part of the experiment.

Section of the right superior laryngeal nerve completed the paralysis of the glottis.

Order of section, and results:—

1st. Section through supposed site of communicating nerve; no effect as to respiratory movements.

2d. Section of both inferior laryngeal nerves; no further effect of any permanent nature.

3d. Section of left superior laryngeal nerve; paralysis of left glottic lip.

4th. Section of right superior laryngeal nerve; complete paralysis of glottis

The above experiments led us, irresistibly, to the conclusion, that there must be a chiasm of the two superior laryngeal nerves, and it only remained to prove, with the scalpel, the presence of this branch. A careful series of dissections on large turtles of various species and genera, satisfactorily proved that we were not mistaken. In every case the nerve was readily found, and the physiological prediction as to its existence verified in the most absolute manner.

The discovery of a new nerve in turtles, and upon ground over which the accurate knife of Bojanus had passed, called for a still more rigorous testing of our previous results. For this purpose the following experiments were made.

The first of this second series is of unusual value, owing to circumstances which arose incidentally.

Experiment.—Snapping turtle, weight nineteen and three-quarter pounds. We cut down on the middle line of the hyoid bone and divided it throughout its length with a hair-saw and nippers. When this operation is done with care, it exposes to the operator enough of the cricoid fenestrum to enable him to cut the communicating nerve at its central part. Next, both recurrent nerves were divided at the middle of their course. The section, and after stimulation of the right nerve, had no effect on the glottis, which we thought singular. Section of the right superior laryngeal nerve was satisfactorily made as usual, the nerve being readily exposed and divided. To our surprise, the right glottic lip became paralyzed almost totally, the left side moving in respiration as usual. This result was opposed to all our former experiments. After a rigid examination of the conditions of this last experiment, and finding in them no explanation of the contradiction which it offered, we dissected, with scrupulous care, the whole track of the pneumogastric nerve and its branches to the larynx, as well as that organ itself. The following appearances were noted: On the left mucous lip of the glottis, a small white patch of diseased tissue. The inner end of the right upper hyoid cornu was enlarged to double its normal size; thus of necessity stretching the right superior laryngeal nerve where it crosses the cornu at its inner end. On the left side the superior laryngeal nerve was perfect up to the point at which it gave off the interlateral communicating branch. This latter nerve, lying on the cricoid fenestrum, was involved in a mass of diseased tissue, which extended between the trachea and the body of the hyoid bone, from its lower part to a point about one-quarter of an inch above the fenestrum. This disease, doubtless, affected the communicating branch, so as to cause partial paralysis of the right glottic lip to follow section of the corresponding superior laryngeal nerve. Had the interlateral branch been completely destroyed, section of one laryngeal nerve must have produced *entire* paralysis of the glottic lip on the side operated upon.

This observation, which at first promised to cast doubt upon those which preceded it, thus proved at last the most conclusive evidence of the correctness of the view to which we had arrived. An accident of disease or injury had so altered the communication between the two superior nerves of the larynx, as to make unnecessary the section, which would under ordinary circumstances have followed as the third step in the experiment.

Experiment.—This experiment was designed to be a repetition of the plan of the last one, but in dividing the hyoid bone to reach the nerve at the middle line, the saw, accidentally carried too deep, touched the membrane on which runs the nerve. Section of the recurrents followed with the usual negative result. Section of the right superior laryngeal nerve produced paralysis in the right glottic lip. If our former view be correct, then in the present case we must have cut the communicating branch with the saw. In the above experiments, the sections and results may be thus stated:—

1. Section of interlateral communication between the two superior laryngeal nerves; glottic respiratory motions as usual.
2. Section of both inferior laryngeal nerves; glottic respiratory motions as usual.
3. Section of right superior laryngeal nerve; paralysis of right lip of glottis.

Experiment.—Snapper, weight four pounds. We cut first the two inferior laryngeals; next we divided the right superior laryngeal. The glottic movements were still perfect. One nerve was sustaining unimpaired the whole ordinary motions of the glottis in respiration. Indeed, the closest scrutiny failed to discover in its action any departure from the condition of health. Lastly, we sawed through the hyoid bone, glottic acts still regular. Then with a hook we lifted the nerve and divided it. Instantly a respiration followed, but the right glottic lip was now motionless.

Order of section, and results:—

1. Section of both inferior laryngeal nerves.
2. Section of right superior laryngeal nerve; after which the glottis moved in respiration as usual.
3. Section of median intercommunicating nerve; paralysis of right glottic lip.

Experiment.—This turtle had been used for other purposes, and had undergone an hour before section of the middle cervical spine. The respiratory motions of the breast-box had ceased, but at intervals the glottis opened and closed with normal regularity. The trachea was divided, and with it both recurrent laryngeal nerves. Next we cut the interlateral communicating nerve. The glottic acts still remained perfect. Lastly, we exposed the left superior laryngeal nerve, and divided it, causing instant paralysis of the left glottic lip.

Order of section, and results:—

1. Section of both recurrent laryngeal nerves.
2. Section of communicating branch; glottic acts perfect.
3. Section of left superior laryngeal nerve; paralysis of left glottic lip.

As further illustration, we give in brief the order of section and results in two box-turtles.

Experiment.

1. Section of both inferior laryngeal nerves; glottic motion perfect.
2. Section of right superior laryngeal nerve; glottic motion perfect.
3. Section of communicating nerve; paralysis of right lip of glottis.
4. Section of left superior laryngeal nerve; total paralysis of glottis.

Experiment.

1. Section of communicating nerve.
2. Section of right superior laryngeal; glottic acts perfect, perhaps not closing

firmly on the right side; the right glottic lip now relied alone on the recurrent nerve for opening power.

3. Section of right recurrent (inferior laryngeal nerve); paralysis of right glottic lip.

The above stated experiments were repeated very frequently, and always with the like results. If the evidence which we have given be reliable, we have now proved that in turtles there exists a communication between the right and left superior laryngeal nerves, of the nature of a true *chiasm* precisely like that of the optic nerves, and, so far as we know, the only instance thus far discovered of this anatomical peculiarity in nerves exterior to the great centres.

Fig. 8.

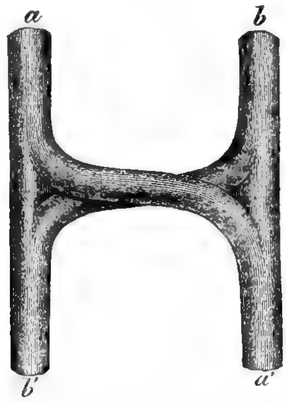

Fig. 8. Diagram of the chiasm of the superior laryngeal nerves.—*a a'*, intercommunicating fibres of the right nerve; *b b'*, similar fibres from the left nerve.

The diagram, Fig. 8, illustrates our views in regard to the track of the nerve fibres. Part of each nerve probably proceeds directly to the two glottic muscles of its own side, while another strand crosses over through the interlateral trunk to be similarly distributed to the two muscles of the opposite side.

Keeping this in view, we can now see how one single superior laryngeal nerve may move the glottis on both sides, until the chiasm is divided, when it will be left in connection only with the muscles on its own side of the glottis.

Having thus established the fact of a chiasm between the superior glottic nerves, it was requisite to ascertain whether the inferior or recurrent laryngeal nerves entered into communication with the superior nerves, or whether they possessed any similar interlateral connection of their own.

Experiment.—Snapper, weight six pounds. We divided first the right and left superior laryngeal nerves. The glottis opened as usual, but had lost its power to close firmly.

Section of the right recurrent which followed, as the next step, produced paralysis of the right glottic lip.

Galvanization of one recurrent caused opening of only the corresponding lip of the glottis. Repetitions of the above experiment led to no different result.

Order of section, and results:—

1. Section of both superior laryngeal nerves; loss of closing power.

2. Section of right inferior laryngeal nerve; loss of opening power in right lip of glottis.

We inferred from the above stated experiment and the repetitions of it, that no interlateral nerve fibres connected the two inferior laryngeal nerves. Furthermore, we failed to discover any branch to which such a function could have been assigned.

The object of the very extraordinary and really exceptional arrangements, which we have here pointed out, is not altogether clear. We arrive only at the general conclusion, that the integrity of the glottic function in turtles, appears to have been guarded with unusual care. Why this should be the case in aquatic chelonians it is easy to understand, but the necessity for it in terrestrial species seems to us less obvious, yet it is as perfect in the box turtle as in the emydæ and chelonuræ. Perhaps the need for such precautions in all may be due to the fact that all retain the inspired air during long periods, even when on land. Paralysis of the closing power of the glottis would allow the air to escape instantly, and would oblige the animal to make repeated and therefore laborious inspiratory efforts. Paralysis of the opening power would insure death from apnœa. Hence we have two sets of nerves controlling the opening muscles. One entire set may be destroyed and yet respiration continue. Even one of those remaining, if these be the upper nerves, may be lost, and still the glottis fulfil its entire duty in the train of breathing movements. Thus, also, in regard to the closing power. The elasticity of the glottic lips is one agent, although but a subsidiary one. Then we have the interlateral communication between the two superior laryngeal nerves, which alone can forcibly close the chink of the glottis. By virtue of this true chiasm one of these nerves being injured, the other is ample to effect the normal purpose of both.

Nor is it less curious to observe how artfully the whole apparatus has been guarded against accident.

The lower or recurrent laryngeal nerves lie alongside of the trachea, sheltered by its projecting form. The superior nerves are protected in their course by the superior hyoid cornu, and the larynx and its singular nervous circle are deeply buried beneath, or rather above the strong bony and cartilaginous body of the hyoid bone. Nature seems to have been lavish of expedients for securing the safety of these most important parts.

Before leaving this portion of our subject, it may not be amiss to state that we have made a number of experiments on birds and mammals, to ascertain whether any such chiasm exists in the glottic nerves of these animals. But in all cases section of one motor nerve caused loss of movement in its own side of the larynx, and we therefore conclude that this arrangement does not extend to the classes in question. Whether or not it is to be found in Batrachia and ophidian reptiles, we have not as yet ascertained.

The remaining physiology of the pneumogastric nerve in turtles is not less obscure than in other animals. As in these latter, so in turtles, it sends branches to the trachea, lungs and heart.

We have cut the nerve in a number of turtles, some of whom survived upwards of a month and then exhibited no marked evidence of diseased lungs. In others, there was occasionally found an abscess at the base of the neck. This pathological occurrence is, however, a common one in turtles caught with the hook, and cannot, with any probability, be supposed to be due to the section of the pneumogastric.

The only striking effect of this section was, the constant sensibility which the nerve then exhibited. At the moment of dividing or crushing it, the animal showed every possible evidence of acute pain. Irritation of the centric end of the cut nerve gave rise to like phenomena, while stimulation of the peripheral end caused no such results.

A number of careful experiments were made to ascertain whether these irritations of the nerve produced any instant effect, either upon the inspiratory or expiratory muscles of the breast-box. But in no case did the stimulation seem to influence them to movement.

Galvanization of the pneumogastric nerve in turtles arrests the heart's movements. Gentle irritation of the trunk causes the heart to beat more rapidly. Section of one nerve causes the heart to quicken its pulsations. Division of both nerves induces still more rapid action, but in either case the heart, after a few hours, regains its original rate of pulsation.

The nerves which supply motor endowments to the internal respiratory muscles need no special illustration here. They are fully described in the anatomical section of this essay. It only remains to add, that their office and relation to the muscles was tested by stimulating them with galvanism and by dividing them, so as to cause paralysis of the muscles in question.

The centre, to which proceed impressions, giving rise therein to respiratory impulses, appears to be, as in other animals, the medulla oblongata. The site of the respiratory ganglions would scarcely have attracted our attention, however, had it not been, that, in the following experiment, a fact was noticed which induced us to examine the question more fully.

Experiment.—In a turtle previously used to examine the offices of the laryngeal nerves, and in whom the glottis could still open on one side, we divided the cervical spine at its upper third, and continued to watch the respiratory muscles. To our surprise the flank muscles acted at intervals for thirty minutes, but the two sides no longer moved synchronously. At one moment the right muscle contracted, at another the left, and the movements of both were irregular and sometimes incomplete.

It appeared to us, that these motions after section of the spine might be merely the rhythmic repetition of habitual movements, such as, according to Brown-Séquard, appear sometimes in the diaphragms of mammals even. Long after these muscles in the turtle ceased to move, all the other reflex acts continued, and excepting these, almost every muscle below the point of section could be excited easily to reflex motion; neither was there any longer a synchronism of action between the respiratory muscles of the glottis and those of the breast-box.

Experiment.—Turtle, weight six pounds. In this case, also, the cervical spine was divided, but although the reflex activity of most of the parts below the section was remarkable, the respiratory muscles alone failed to respond to excitation of distant parts. During the spasm caused by the section of the spine, the expiratory muscles, contracting, emptied the lungs, which were not again filled with air.

Experiment.—Turtle, weight 4 pounds. The sympathetic nerves on both sides, in this turtle, had been cut several weeks, and the wounds in the neck were nearly healed. The animal seemed well and very active. The cervical spine was divided with little loss of blood. General spasm ensued, the glottis opened, expiration followed, but no after inspiration, and the glottis closed. During an hour no inspiration occurred, although the glottis opened and shut at about the usual respiratory intervals. To make more sure of this, the trachea was cut across, the lung fully inflated, and a tube secured in the lower end of the trachea. Through a short caoutchouc tube the trachea was thus connected with Poiseuille's hæmadynamometer, filled to its 0° with mercury; on turning a stopcock the column rose about two millimetres, the glottis continuing in repose. Then the glottis opened, but no synchronous contraction of the lung muscles took place; indeed, the slightest must have been indicated instantly by the mercurial column. During frequent repetitions of glottic motion, no correspondent activity was at any time exhibited by the respiratory muscles of the breast-box. It follows, therefore, that while the flank respiratory muscles may after separation from their nerve centres move for a time, as do other habitually rhythmical muscles like the heart, that these motions do not occur in all cases, and that they are plainly not dependent on a respiratory centre below the line of spinal section.

The regular movements of the glottis were, as we we have shown, uninterrupted by the section of the cervical spine. The question arose as to the exciting cause of these motions. That they were not due to impulses propagated through the main trunks of the pneumogastric nerves, was shown by their continuance after the successive division of these two nerves below the origin of the glottic nerves. It thus became plain that the medulla must receive its excitations from the head alone, perhaps through the fifth pair of nerves, which acted as afferent trunks, the motor nerves of the larynx completing the nervous circle as efferent branches. Hence the continued action of the glottis after division of the cervical spine.

The principal points in the foregoing paper to which we desire to draw attention as novelties are as follows:—

1st. In Chelonians the superior laryngeal nerve is distributed both to the opening and closing muscles of the glottis.

2d. The inferior laryngeal nerve is distributed solely to the opening muscle of the glottis.

3d. A true chiasm exists between the two superior laryngeal nerves.

4th. The expiratory muscle lies within the breast-box, and consists of anterior and posterior bellies connected by a strong tendon continuous across the middle line, and common to both sides of the animal.

5th. The inspiratory muscles occupy the flank spaces on either side.

6th. Inspiration is effected by the contraction of the flank muscles, which in appearance strongly resemble the diaphragms of superior animals.

7th. Expiration is effected by the consentaneous action of the four muscular bellies above described, which thus compress the viscera against the lungs. The act of respiration consists of an expiration and an inspiration, during which the glottis remains open.

8th. The opening of the glottis is effected through the agency of the superior and inferior laryngeal nerves, both of which are distributed to the dilating muscle of the glottis. The superior laryngeal nerve presides over the closure of the glottis, being in part distributed to its sphincter muscle. The elastic contractility of the glottic cartilages aids in closing this orifice. After section of the superior laryngeal nerves, the glottis may still be opened by the agency of the inferior laryngeal nerves, its imperfect closure being then effected by means of the elasticity of its cartilaginous lips. The chiasm of the superior laryngeal nerves enables one of these nerves to open and shut the glottis after section or disease of the opposite nerve and of both inferior laryngeals.

Physiologists have therefore been in error when describing the respiration of Chelonians as analogous to that of Batrachians, since it far more closely resembles the breathing of the higher vertebrates.

APPENDIX.

SINCE committing to the press the preceding paper, we have had the opportunity of examining the respiratory apparatus of one of the Trionychidæ.[1] The striking characters of this family and its border rank amongst fresh-water turtles, render a knowledge of its respiratory structure of peculiar interest, and constitute our apology for this appendix.

Amyda mutica, FITZ.—The general plan of arrangement of the respiratory muscles is the same as heretofore described, the inspiratory muscles occupying the flank spaces, and the expiratory muscle being attached to the dorsal shield and inclosing the viscera. The origin of each inspiratory muscle, in detail, is as follows: From the bony edge of the plastron, from the carapace at the line of termination of the ribs, from the fascia lata, where the thigh bounds the flank space, from the spinous process of the ilium and thence to the place of beginning on the plastron. The central tendon into which these fibres are inserted, is a mere raphæ posteriorly, but widens anteriorly into a lance-shaped extremity, one-fourth of an inch wide at its widest part. The whole muscle is relatively large compared with that of other species. The expiratory muscle presents greater variation in origin and form than the inspiratory muscle; the fibres are longer than in other turtles examined, and the anterior and posterior bellies broader. These bellies meet at their outer margins and leave no space under the bridge of the plastron where the muscular fringe is absent when the muscle is viewed from below, as exists in the snapper, Fig. 3. The effect of this widened muscular margin is to diminish the size of the common tendon, and reveal its true character more strikingly than in other families. On dividing the tendon and removing the viscera, the muscular fibres are observed spreading out across the dorsal shield in fan-like radii from each intercostal space, from the first to the sixth inclusive. The third intercostal space gives attachment to the strongest fibres, causing it to appear as the centre from which the whole muscle radiates, the fibres running forward and outward across the area of a quarter circle constituting the anterior belly, and those running backwards over a similar area, the posterior belly. More precisely, however, the origin of the anterior belly is from the first and second intercostal spaces and from the costal margin of the third space;

[1] For living specimens of *Amyda mutica*, we are indebted to Mr. Robert L. Walker, of Allegheny County, Pennsylvania.

from these points the fibres extend in a prevailing direction forwards, over the anterior quarter shell towards its periphery, and then, arching around the viscera, are inserted into the central tendon. At the line where the muscle leaves the shell it receives additional fibres. The posterior belly arises from the sixth, fifth, and fourth intercostal spaces, and from the vertebral margin of the third space (overlying the fibres of the anterior belly that come from this space), and stretches over the posterior quarter circle of the shell, to be inserted into the common tendon. It receives reinforcements of fibres where it leaves the shell to inclose the viscera, as does the anterior belly.

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