REPORT OF THE SUPERINTENDENT

OF THE

UNITED STATES COAST SURVEY,

SHOWING THE

PROGRESS OF THE SURVEY

DURING

THE YEAR 1867.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1869.

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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IN THE SENATE, *May* 18, 1868.

Resolved, That there be printed two thousand extra copies of the Report of the Superintendent of the United States Coast Survey for 1867, of which one thousand copies shall be for the use of the Senate, and one thousand copies shall be for distribution by the Superintendent of the Coast Survey.

IN THE HOUSE OF REPRESENTATIVES, *June* 5, 1868.

Resolved, That there be printed twenty-five hundred extra copies of the Report of the Superintendent of the United States Coast Survey—one thousand for the Superintendent and fifteen hundred for the use of the House.

LETTER

FROM THE

SECRETARY OF THE TREASURY,

TRANSMITTING

THE COAST SURVEY REPORT FOR THE YEAR 1867.

MAY 6, 1868.—Laid on the table and ordered to be printed.

TREASURY DEPARTMENT, *May* 1, 1868.

SIR: I have the honor to transmit for the information of the House of Representatives, a report made to this department by Professor Benjamin Peirce, Superintendent of the Coast Survey, stating the operations and progress in the survey of the coast during the year ending November 1, 1867.

I have the honor to be, very respectfully,

H. McCULLOCH,
Secretary of the Treasury.

Hon. SCHUYLER COLFAX,
Speaker of the House of Representatives.

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REPORT.

CAMBRIDGE, MASS., *December* 28, 1867.

SIR: As required by law, and the regulations of the Treasury Department, I have the honor to submit my report on the progress of the coast survey of the United States during the surveying year, from November 1, 1866, to November 1, 1867.

PART I.

On the 26th of February, 1867, I received the commission of Superintendent of the Coast Survey. This important service originated with Hassler; but it received its efficient organization from Bache. The deep reverence of the latter Superintendent for his predecessor was the natural result of his noble and magnanimous character. Reciprocally to preserve his memory fresh and influential as long as the survey may continue is an act of justice which will be gladly rendered. It is only necessary conscientiously and faithfully to follow in his footsteps, imitate his example, and develop his plans in the administration of the survey. To describe what the Superintendent should do is simply to tell what Bache actually performed. The duties of the Superintendent are thus defined:

1. "The primary triangulation designated in the directions* on that subject, and the astronomical and other observations connected therewith, will be conducted by the principal of the survey, who, as such, will superintend the work in general, and be responsible for its correctness and fidelity."

Impressed with the importance of this leading portion of the field-work, I was anxious to take the field in accordance with the directions, but the melancholy illness of my predecessor had interfered with the proper provisions for its execution. While, on the one hand, there was no recognition of it in the detailed estimates, and there had not been the sufficient preliminary reconnaissance, there was, on the other hand, the necessity for quite a new outfit for the party, because the material had been otherwise usefully employed. The smallness of the appropriation would not bear this additional expense, and the work was reluctantly postponed to another year, when these obstacles may be removed.

2. "He will inspect from time to time, personally, the operations of all parties and persons employed on the survey, and will report to the department any neglect or irregular performance of duty that may fall under his observation."

The work must not be suffered to degenerate from its high standard, nor from its present economy. By personal inspection, by unceasing criticism, by temperate and seasonable censure, by judicious and generous praise, and by cautious promotion for merit, the presence of the head must be everywhere recognized as a dread to the faithless, and as an inspiration to the faithful performance of duty. Accordingly, I took the first opportunity to visit the parties in the field, as will later be stated in regard to Section I. I was well satisfied with the results of the examination, and shall strive to extend the inspection to the parties working in the winter season at the southern sections.

3. "He will furnish the necessary formulæ and methods to the assistants having calculations to make, and will give all instructions relating to the scientific parts of the work."

The ease with which the survey has kept pace with the progress of art and science, contributing more than its full share, so that its many processes are regarded as the unsurpassed models of their kind, has mostly arisen from the sympathy of my predecessor for all that was new, and his acute

* Adopted April 15, 1844.

discrimination, which retained the improvement and rejected the fallacy. The loss of his strong and comprehensive judgment must henceforth be supplied by concentrating upon the survey the wisdom of the best science of the country. The country is alive with keen, original thought, which is reaping harvests, building machines, sailing ships, exploring the earth, and observing the stars; which suffers the fetters of no prejudice, nor the darkness of any mystery; which is opening to the people the doors of the university and of the academy. Whenever inquiry may approach the survey it should always be welcome, from whatever direction it may come, whether in the form of new suggestion, or of sincere and rigid criticism.

Some of the most abstruse problems of the survey, as the figure of the earth, the theory of the tides, the difference of longitude between Europe and America, and the physical changes in the bottoms of the harbors and along the coast, must be prepared for immediate discussion and final solution. Steps have already been taken in this direction, of which the detailed account will be given in the proper place and time. It is moreover desirable that the subject of the probable error of observations be reconsidered, and that new terms be introduced which shall be more appropriate and less likely to mislead.

It may be well in this place to refer to new forms of observation which it is proposed to adopt. The telegraphic determinations will simply involve the comparison of clocks, without insisting upon the system of star signals.

Assistant Davidson has devised a new form of the portable astronomical transit instrument, equally adapted to observations of time in the usual way, and to those of latitude by the method of equal altitudes of stars north and south of the zenith, which highly commends itself for determinations of geographical positions.

The assistant in charge of the office has developed a system for the measurement of the railroads in connection with the survey, by which its distant determinations will be firmly bound together. As soon as possible the execution of this work will be commenced under his immediate supervision.

4. "He will prepare the assignment of duties of the persons and parties employed, and submit the same to the Secretary of the Treasury for his approbation."

This portion of the work is especially onerous, because every six months all the field-parties must pass from the north to the south, and the reverse. It requires for its judicious execution full consultation with the assistant in charge, the hydrographic inspector, the disbursing agent, and all the officers employed in the field. Plans for future topographical operations, to be prepared by the principal assistant in topography from personal reconnaissance, will greatly facilitate this assignment of duties.

5. "He will supervise the publication of the results of the work, and have the general superintendence of the office in Washington."

The Superintendent is greatly relieved of the care of the office by the assistant in charge, to whom its immediate custody is assigned; and the ability and fidelity with which this duty is performed by Assistant Hilgard cannot be too highly commended. To enable the officers of the survey to communicate with equal ease with the office or with the Superintendent, wherever he may be, the franking privilege is extended to both these officers, for "all letters and documents in relation to their public duties."

6. "As soon as may be, he will make known any results of the survey which may be useful to the public, such as reefs, rocks, or other dangers on the coast, new channels leading into harbors, &c."

The notices given under this direction will be referred to in their proper sections.

7. "He will report the progress and state of the work to the Treasury Department in the month of November of each year, with the view of the same being laid before the President and Congress."

By the act of March 3, 1853, it is directed that "the annual Coast Survey Report shall be submitted to Congress during the month of December in each year," but by the adjournment of Congress in that month its reception is necessarily postponed.

8. "To enable him to make such report, and at all times when he thinks proper, he will call upon any of the assistants for such information as he may desire."

The reports of each campaign are regularly submitted by the various assistants, and their punctuality during the present year deserves commendation. Many of the reports are highly interesting for the statistical information which they contain. Several of them, special in character, are given in the appendix to this report.

9. "The primary, main, and secondary triangulations, and the topography and hydrography, will be extended north and south by the Superintendent and assistants, according to directions to be given from time to time on the subject."

This immediate reference of all the work in the field to the Superintendent is essential to the preservation of its unity. The directions to the assistants are given at the beginning of each campaign, upon consultation with the chiefs of parties, the assistant in charge, and the hydrographic inspector.

10. "Requisitions for the necessary instruments, equipages, and all other outfits, will be made by the chiefs of parties upon the Superintendent for his approbation."

The rigid economy for which the survey has been distinguished depends upon the careful observance of this direction. It requires constant reference to the disbursing agent. For many years this duty has been performed by Mr. Samuel Hein, who knows how to combine the strictest regard for the interests of the government with a kindness which all members of the survey appreciate.

I do not fear that I shall be accused of timidity if I confess that I shrink before this variety of difficult duty, especially when I consider the magnitude of the commercial and scientific interests intrusted to me, and perceive that my mistakes may seriously injure so many able, accomplished, and intellectual officers. But I have before me the inspiration and example of my friend Bache. It is his organization. I have only to administer as he showed the way. If I can succeed in preserving his administration, and science do not suffer in my hands, I shall have accomplished my task.

PROGRESS OF THE SURVEY.

The progress during the year is stated in detail in Part II of this report, and in Appendix No. 1 the parties are named in the geographical order of their distribution.

Sketch No. 24 shows in a general way the aggregate advance which has been made in the several branches of field-work.

In accordance with custom, I here recite merely the localities in which progress has been made in the course of the past year, either in triangulation, topography, or hydrography, making special mention only of the less usual operations. These are on the coast of Maine, the St. Croix River, Winter Harbor, Penobscot Bay and Penobscot River near Hampden, Medomak River, the navigable passages between the Sheepscot and Kennebec rivers, (the last-named river in the vicinity of Hallowell,) the shores of Quohog Bay, Portland Harbor, and the approaches to Casco Bay and Saco River; on the coast of New Hampshire, above Portsmouth; on the coast of Massachusetts, the Merrimac River, Boston Harbor; longitude determinations between Cambridge, Albany, and the Naval Observatory at Washington City; latitude determinations at Manomet and Nantucket; magnetic observations at these stations and at Hartford, Connecticut; general progress at Duxbury Harbor and near West Sandwich, and a special survey at Provincetown Harbor; on the coast of Rhode Island, surveys in the vicinity of Providence and Fall River, and in the western part of Narraganset Bay; in New York Harbor, a special survey of the battery; on the coast of New Jersey, general progress at Sandy Hook, near Long Branch, near Shark River, at Barnegat Entrance, and at Little Egg Harbor; in Delaware Bay at two localities; in the Chesapeake Bay, at the mouth of the Susquehanna, and at Patapsco Entrance; in the Potomac River at two localities; on the coast of Virginia below Cape Henry; in North Carolina, on Neuse River; in Pamlico Sound and on the shores of Bogue Sound; in South Carolina, on the islands and estuaries adjacent to St. Helena Sound; on the coast of Georgia, the water communication between Wassaw Sound and Savannah River, and St. Catharine's Sound, including its approaches; on the coast of Florida, below St. Augustine, at the north end of Key Biscayne Bay, across the channel between Key West and Havana, in Charlotte Harbor in the vicinity of Cape St. Blas and east and west of Perdido Entrance; in the several passes of the Mississippi Delta; and on the coast of Texas, at Galveston Entrance, in West Bay, on the shores of Corpus Christi Bay and on the shores of the Laguna Madre.

On the Pacific coast of the United States the operations of the survey have been in progress near Santa Barbara; at Point Sal; and at three localities near San Francisco Bay, in California; at Tillamook Entrance, in Oregon; and at Puget Sound, in Washington Territory.

A party, fully equipped for reconnaissance surveys, has been engaged on the shores of Alaska Territory, and the results of their observations in regard to the maritime and other resources of the newly ceded territory may be expected in the course of the present month.

In twelve of the localities recited, the work done, though directly available for the main ends of the survey of the coast, was undertaken at the request of the Engineer Department, the results, at the time, being specially needed in the operations of that branch of the public service.

Progress in the office in the several divisions of computing, drawing, engraving, and other adjunct branches of the service has kept up with the field-work.

ESTIMATES FOR THE FISCAL YEAR 1868–'69.

Early in November the following estimates for the work of the survey during the next fiscal year were transmitted to the department:

The increase in the sums estimated for continuing the survey in the several sections does not arise from any augmentation of the scale of the work. No new center of operations is proposed, nor an increase in the number and outfit of the parties. It is proposed merely to keep the parties in the field during the entire working season, as had always been done by the former Superintendent, and thus to preserve the economy which has marked the previous direction of the Coast Survey. During the war many of the parties were with the armies and squadrons. At that period, therefore, the effect of the increased cost of labor and supplies was but partially felt. Now, even with larger appropriations, it operates as an embarrassment in every quarter of the coast to which the parties may be assigned. It is well known that the energy of our people is constantly seeking for every point and all the channels along the coast susceptible of development. Thus has arisen the present scale of the work, in strict obedience to public demand. The number of parties has been adjusted with reference to steady progress from the several working centers, and the estimates are intended merely to conform to the circumstances now incident to the continuance of the various branches of the service. When work has been commenced in any quarter it cannot be abandoned without heavy loss until the topography and hydrography are completed. The withdrawal of a party from the field before its season's work is finished is an unfortunate sacrifice of means and a waste of outfit which should not be incurred. Hence, it is respectfully submitted, as the wise and economical policy, to increase the appropriation to that least amount which will enable the parties to keep the field as long as the season favors the progress of their operations. This is no more than has hitherto been asked and provided for, and is the least appropriation which will enable the survey to preserve its justly acquired reputation for the strictest economy in its administration.

ESTIMATES IN DETAIL.

For general expenses of all the sections, namely: rent, fuel, materials for drawing, engraving, and printing, and for transportation of instruments, maps, and charts; for miscellaneous office expenses, and for the purchase of new instruments, books, maps, and charts $20,000

SECTION I. *Coast of Maine, New Hampshire, Massachusetts, and Rhode Island.*—FIELD-WORK: To continue the triangulation and topography of *Passamaquoddy Bay* and its estuaries, and to extend the work so as to include the northeastern boundary along the *St. Croix River;* to continue the topography of *Frenchman's Bay;* that of the islands and shores of *Penobscot Bay,* and that of *Saco Bay;* to complete that of the ocean shore of *Cape Cod,* and to continue the detailed survey of the shores and islands of *Narraganset Bay;* to continue off-shore soundings along the coast of Maine, and the hydrography of *Frenchman's Bay, Goldsborough Bay, Penobscot Bay,* and *Isle au Haut Bay;* to continue tidal and magnetic observations. OFFICE-WORK: To make the computations required for and computations from the field observations; to commence the engraving of *general chart of the coast, No. 1, from Seal Island to Cape Cod,* and continue that of No. 2, *from Cape Cod to Gay Head;* to commence the drawing and engraving of coast chart No. 4, *(Naskeag Point to White Head Light, including Penobscot Bay;)* to continue that of coast charts No. 5 and No. 6, *(White Head Light to Wood Island Light;)* that of No. 7 and No. 8, *(Seguin Light to Cape Porpoise Light;)* and to complete that of No. 9 and No. 10, which include *Massachusetts Bay* and *Cape Cod Bay;* and to continue the drawing and engraving of the harbor and river charts of the coast of Maine, and of Narraganset Bay, will require $65,000

SECTION II. *Coast of Connecticut, New York, New Jersey, Pennsylvania, and part of Delaware.*—FIELD-WORK: To make supplementary astronomical observations; to continue verification work on the *coast of New Jersey;* to continue the topography of the shores of the *Hudson River;* to execute such supplementary hydrography as may be required in *New York Bay* and *Delaware Bay;* to continue the tidal observations. OFFICE-WORK: To make the computations and reductions; to continue the drawing and engraving of a chart of *New York harbor* on a large scale, and of coast chart No. 21, *(from Sandy Hook to Barnegat,)* and to commence No. 22, *from Barnegat Bay to Absecom Inlet,* will require 14,000

SECTION III. *Coast of part of Delaware and that of Maryland and part of Virginia.*—FIELD-WORK: To continue astronomical and magnetic observations in this section; to continue the primary triangulation parallel to the coast from *Washington City* southward along the *Blue Ridge;* to complete the topography of the eastern shore of *Virginia,* and of the shores of the *Potomac* and *James Rivers,* and the triangulation requisite therefor; to make the hydrographic survey of estuaries and inlets remaining unsurveyed in this section; to continue tidal observations, and to make the observations for determining the longitude of the *Pacific coast.* OFFICE-WORK: To make the computations from field-work; to continue the drawing and engraving of coast charts No. 29 and No. 30, *(from Chincoteague Inlet to Cape Henry,)* and of general coast chart No. 4, *(approaches to Delaware and Chesapeake Bays,)* and to make supplementary work on the charts heretofore published, will require 40,000

SECTION IV. *Coast of part of Virginia, and part of North Carolina.*—FIELD-WORK: To complete, if practicable, the primary triangulation of *Pamlico Sound,* and to make the requisite astronomical and magnetic observations; to continue the triangulation and topography of the western shores and estuaries of *Pamlico Sound;* to complete the topography of the outer coast of North Carolina between *Bogue Sound* and *New River Inlet;* to continue the in-shore and off-shore hydrography between *Cape Henry* and *Cape Hatteras;* to continue soundings in *Currituck* and *Pamlico Sounds* and their estuaries, and to make observations on the tides and currents. OFFICE-WORK: To make the computations and reductions; to continue the drawing and engraving of general coast chart No. V, *(from Cape Henry to Cape Lookout;)* of coast charts No. 38 and 39, (coast from *Currituck Banks to Cape Hatteras;)* of No. 42, No. 43, and No. 44, *(Pamlico Sound and estuaries;)* of No. 45 and No. 46, (coast from *Cape Hatteras to Cape Lookout;)* and of charts of *Neuse River* and *Pamlico River,* will require 41,000

SECTION V. *Coast of South Carolina and Georgia.*—FIELD-WORK: To make the requisite astronomical and magnetic observations on the coast of Georgia; to extend the topography from *Winyah Bay to Cape Romain;* to continue the topography from St. Simon's Sound southward to the *St. Mary's River,* and to sound the interior water passages among the sea islands from *Sapelo Sound* southward, and continue the off-shore hydrography and the tidal observations. OFFICE-WORK: To make the computations; to continue the drawing and engraving of the general chart of the coast, No. VII, *(from Cape Romain to St. Mary's River;)* of coast charts No. 56 and No. 57, *(from Savannah River to St. Mary's River;)* and of charts of *St. Catharine's Sound, Doboy Sound,* and the inland tide-water communication on the coast of *Georgia,* will require.. 43,000

SECTION VI. *Coast, keys, and reefs of Florida.*—(See estimates of appropriation for those special objects.)

SECTION VII. *Western coast of Florida Peninsula, north of Tampa Bay, and coast of West*

Florida.—FIELD-WORK: To continue the triangulation from *Cedar Keys* to the *Suwanee River;* from *St. Andrew's Bay* towards *Chattahoochee Bay;* and to make such astronomical and magnetic observations as may be required; to continue the topography to the northward of *Cape San Blas*, and to the westward of *St. Andrew's Bay*, and that of the *Gulf coast* adjacent to *Santa Rosa Sound;* to survey and sound the entrance to the *Suwanee River;* to complete the hydrography of *St. George's Sound*, and to make soundings off *Cape San Blas*, and continue the tidal observations. OFFICE-WORK: To make the computation from field-work; to continue the drawing and engraving of coast charts No. 82 and No. 83, *(from Ocilla River to Cape San Blas;)* and of No. 89, *(from Pensacola to Mobile Point;)* and to prepare a chart of the approaches and entrance to the *Suwanee River*, will require $36,000

SECTION VIII. *Coast of Alabama, Mississippi, and part of Louisiana.*—FIELD-WORK: To continue the triangulation from the *Mississippi Delta* westward, and to make the astronomical and magnetic observations required in this section; to extend westward from former limits and complete the survey of the shores of *Isle au Breton Sound*, including the adjacent banks of the *Mississippi River;* to continue the hydrography within the same limits, and complete that of *Lakes Borgne* and *Pontchartrain*, and to make tidal observations. OFFICE-WORK: To make the computations pertaining to field-work; to continue the drawing and engraving of the general chart No. 14, *(Gulf Coast between Mobile Point and Vermillion Bay;)* of coast charts No. 91, *(Lake Borgne and Lake Pontchartrain;)* No. 92 and No. 93, *(Chandeleur Islands to Southwest Pass;)* and No. 94, *(Mississippi Delta,)* will require 33,000

SECTION IX. *Coast part of Louisiana and coast of Texas.*—FIELD-WORK: To measure a primary base line; to continue the triangulation and topography of *Madre Lagoon* from *Brazos Santiago* northward; to complete the hydrography of *Aransas, Copano* and *Espiritu Santo Bays;* to continue the off-shore hydrography, and to make the requisite tidal observations. OFFICE-WORK: To make the office computations; to complete the engraving of coast chart No. 107, *(Matagorda and Lavacca Bays;)* to continue the drawing and engraving of No. 108 and No. 109, *(Gulf coast from Matagorda to Corpus Christi Bay;)* to engrave the re-survey of *Galveston Entrance*, and to continue the drawing and commence the engraving of general chart No. 16, *(Gulf coast from Galveston to the Rio Grande,)* will require 38,000

Total for the Atlantic coast and Gulf of Mexico 330,000

The estimates for the Florida coast, keys and reefs, and for the western coast of the United States, are intended to provide for the following progress in the survey:

SECTION VI. *Coast, keys, and reefs of Florida.*—FIELD-WORK: To determine the longitude of several points on the west coast of Florida; to continue the triangulation and topography from *Cape Florida* northward towards *Jupiter Inlet;* and from *Cape Sable* northward to *Shark River;* and to commence the survey of *Tampa Bay;* to continue the hydrography of the *Florida Reefs* between the *Marquesas* and the *Tortugas* and that of the *Strait of Florida;* to complete the hydrography of the *Bay of Florida*, and to make tidal and magnetic observations. OFFICE-WORK: For computing the observations made in the field; to continue the drawing and engraving of the off-shore chart No. XI, *(Western part of Florida Reefs, including the Tortugas;)* and of coast charts No. 75 and No. 76, *(from Caloosa Entrance to Tampa Entrance;)* and to commence coast charts No. 70 and No. 71, (Key West to Tortugas,) will require $40,000

SECTION X. *Coast of California.*—FIELD-WORK: To make the required observations for latitude, longitude, and azimuth at stations of the primary triangulation, and to make magnetic observations; to connect the islands of *Santa Cruz, Santa Rosa*, and *San Miguel* with the coast triangulation, and to execute the topography of the same, and continue the topography of the coast from *Buenaventura* to *Santa Barbara;* to continue the off-shore hydrography of the coast of *California* and the tidal observations.

OFFICE-WORK: To continue the drawing and engraving of a chart of *San Francisco* and *San Pablo Bays* in one sheet; to complete that of *Suisun Bay;* to continue that of a general chart of the coast from *San Diego* to *Point Concepcion;* and to make additions of the recent surveys on the charts heretofore published; also for the operations in—

SECTION XI. *Coast of Oregon and of Washington Territory.*—FIELD-WORK: To continue the astronomical and magnetic observations in this section, and the triangulation, topography, and hydrography in *Washington Sound* and in *Puget Sound;* to continue the survey of the mouth of the *Columbia River;* and to make such special surveys as may be called for by public interests on the coast of *Oregon* and of *Washington Territory*, including those of *Yaquinna River*, *Port Discovery*, and *Possession Sound;* and to continue the drawing and engraving required by the field and hydrographic work, will require $175, 000

For publishing the observations made in the progress of the survey of the coast of the United States, per act of March 3, 1843 .... 10, 000

For repairs and maintenance of the complement of vessels used in the survey of the coast, including the purchase of two vessels to replace the schooners *Petrel* and *Twilight*, lost during the war, per act of March 2, 1853 .... 60, 000

For pay and rations of engineers for the steamers used in the hydrography of the coast survey, no longer supplied by the Navy Department, per act of June 12, 1858 .... 10, 000

The item for publishing the observations made in the progress of the survey of the coast has been for several years placed at the small sum of $5,000, which provided chiefly for the preparation of the manuscript matter and of the plates required for illustration. In order to proceed with the printing of a volume the estimate is now increased.

The hydrography has been much cramped during the past two years by the want of a sufficient number of vessels suitable for the service. Many of the vessels belonging to the survey have been in service so long as to require either very expensive repairs or to be regarded as unsafe for the voyages requisite in their transfer from the northern sections to the Gulf coast, while still quite serviceable if allowed to remain in the bays and sounds of one part of the coast. It is evident that they must gradually be replaced, and more especially is it necessary to replace the schooners Petrel and Twilight, which at the beginning of the war were seized by the rebels and have since disappeared. To provide for two vessels in their place the sum of $30,000 is included in the estimate for "repairs and maintenance of the complement of vessels used in the survey of the coast."

The annexed table exhibits, in parallel columns, the appropriations made for the fiscal year 1867–'68, and the estimates now submitted for the fiscal year 1868–'69:

Object.	Estimated for 1868–'69.	Appropriation for 1867–'68.
For survey of the Atlantic and Gulf coasts of the United States, including compensation of civilians engaged in the work, per act of March 3, 1843	$330, 000	$250, 000
For continuing the survey of the western coast of the United States, including compensation of civilians engaged in the work, per act of September 30, 1850	175, 000	130, 000
For continuing the survey of the reefs, shoals, keys, and coast of South Florida, including compensation of civilians engaged in the work, per act of March 3, 1849	40, 000	25, 000
For publishing the observations made in the progress of the survey of the coast of the United States, including compensation of civilians engaged in the work, per act of March 3, 1843	10, 000	5, 000
For the repairs and maintenance of the complement of vessels used in the survey of the coast, per act of March 2, 1853	60, 000	30, 000
For pay and rations of engineers for the steamers used in the hydrography of the coast survey, no longer supplied by the Navy Department, per act of June 12, 1858	10, 000	10, 000
Total	625, 000	450, 000

MAPS AND CHARTS.

The following charts and sketches accompany this report:

Progress sketch, Section I.
Merrimack River.
Coast chart No. 8, from Wells, Maine, to Cape Ann.
Boston Harbor, from recent surveys.
Provincetown Harbor.
Greenwich Bay, Rhode Island.
New York Entrance, from recent surveys.
Progress sketch, Section IV.
Neuse River, North Carolina.
St. Catharine's Sound, Georgia.
Strait of Florida.
Passes of the Mississippi.
Galveston Entrance, Texas.
Coast of Texas, from Galveston to Corpus Christi.
Point Sal Anchorage, California.
Tillamook Bay, Oregon.
Puget Sound, Washington Territory.
Shilshole Bay, Washington Territory.
Northwestern coast of America, No. 1.
Sitka Harbor, Alaska.
St. Paul Harbor, Kadiak Island, Alaska.
Illiouliouk and Captain's Harbors, Unalaska Island.
General progress sketch.
Gulf Stream section, (Key West to Havana.)
Pantagraph.
Meridian and equal altitude instrument.

SPECIAL SURVEYS.

The surveys made during the year for the immediate uses of the Engineer Department, will be mentioned under the several heads or sections of the report corresponding to the coast divisions in which the work was done. In Section I, surveys for the special uses of that branch of the public service were made on the St. Croix River; on the Penobscot; on the Kennebec; on the Saco; and in Portland Harbor. In Section II, minute surveys were made at Reedy Island and Liston's Point, in Delaware River. In Section III, a survey was made of the water approaches to Havre de Grace and of the Patapsco River. In Section VIII, the present condition of the Mississippi Passes was developed. In Section IX, Galveston Entrance was surveyed. In Section X, the marginal survey of the peninsula, near San Francisco, was extended to include all the ground involved in the study of a system of defenses for that important city. The department is now awaiting results which may be expected early in the season from one of the parties at present engaged in the survey of the mouth of the Columbia River, in Section XI.

In respect of the precision required, the work here alluded to has taxed all the resources of the assistants to whom the details were committed. In past years the same relation has subsisted between the two branches of the service. Hence, it is well understood that the purposes of the Engineer Department, whether surmised in advance as being relative to defenses, or subsequent to the survey, as in cases of obstructed channels, are best met by the utmost exactness attainable by the methods used in the coast survey.

Another class of surveys, special in their character, has claimed attention this season, as in previous years. As an indispensable requisite for the improvement of the navigation of the Merrimac River, under the auspices of the State of Massachusetts, a close development has been made of the obstructions in that river at Mitchell's Falls. This survey, like all others, in which the prospective outlay for the improvement is large, was made to include the tidal conditions and all the features usually considered in civil engineering. (See Assistant Mitchell's report, Appendix No. 14.)

Services of like character have been rendered in reference to Boston Harbor.

An elaborate survey has been made of Provincetown Harbor, with direct reference to the improvement of its present condition, under the advice of a commission of the State of Massachusetts The importance of this harbor to the coastwise trade of the United States is evidenced by the fact that, as a place of refuge, it has frequently contained as many as five hundred vessels during stormy weather. The report of Assistant Whiting, in relation to the survey of that harbor, (Appendix, No. 12,) is at once an example of the intricate nature of the questions involved in such cases, and of the care required in the survey and in collateral observations.

In Providence River and in Seekonk River, the character of existing obstructions has been developed, and charts have been furnished to the corporate bodies having in view the improvements in navigation.

A chart has been made from soundings taken last summer at the request of the pilot commissioners of New York City, to show the present condition of the water front at the Battery, in New York Harbor.

At the instance of the governor of Washington Territory, a special survey was made to determine the practicability of connecting Union Lake with the waters of Admiralty Inlet, in the neighborhood of Seattle. The object sought in this case is set forth in extracts, given under the head of Section XI, from a letter addressed to one of the assistants by Governor Pickering.

The vicinity of Point Sal, on the coast of California, has been carefully developed to determine the feasibility of increasing the safety of the anchorage by a breakwater.

These surveys and others made at the immediate request of the Light-house Board all fall within the proper working limits of the Coast Survey, and the results form part of its archives. Hence, so long as the general geodetic survey of the coast is incomplete, important objects of the classes here referred to may be undertaken with manifest advantage to the public service as to means and time. By reason of the transfers of parties from north to south, and the reverse, with changes of the season, it must happen that the assistant, assigned for any special survey, has useful knowledge respecting the peculiarities which he is to develop, in advance of actually beginning with the details, a restricted organization could not so meet the public requirements of the present time. The calls in any one season are simultaneous; in some years, few; in others, comparatively many. The execution of the work, so far as the special object is concerned, is incidental, the results making part of the records of the Coast Survey. Yet, the trained assistants, beginning each in his place, with a habit of ready and close observation gained in the performance of general duty on the Coast Survey, pass on without delay and return, as of routine, the materials that may be of vast importance; that must be so, if the results prove the feasibility of the desired improvement.

The reconnaissance of the coast of Alaska was made by one of the assistants, (George Davidson, esq.,) and the results which accompany this report, as Appendix No. 18, were gathered by him and compiled in the course of a few weeks passed on the shores of the newly acquired Territory. It is safe to say that, apart from his aptitude for such service, the comprehensiveness of that report is in a degree due to the extensive experience of Assistant Davidson, gained in observing the essential features and resources of the Pacific coast of the United States, while he was engaged in its general reconnaissance and in its local surveys.

GEODESY.

In the Coast Survey Report for 1866 mention was made of the operations for ascertaining the longitude between Europe and America by means of the Atlantic cable. The work in the field had just been completed at the date of that report. The computations have since been made under the direction of Dr. B. A. Gould, whose report will be found in Appendix No. 6, describing the operations in detail, and giving for the longitude of Harvard Observatory from Greenwich $4^h\ 44^m\ 30.85^s$.

The value of this result, in comparison with other determinations, can only be decided by future investigations. It will be important to repeat the operations by telegraph in a sufficient variety of forms to estimate, as far as possible, the sources of constant error, and a more exact and complete discussion of the occultations, with the greatly improved data of the recent theories and observations of the moon, is necessary to bring this method of longitude to its due standard of precision.

Advantage was taken of the sojourn in Paris, as a United States commissioner for the Exposition of 1867, of President Barnard, of Columbia College, to obtain a direct comparison of the original iron meter, used as the unit of length in the coast survey, with the platinum standard of France. President Barnard, whose known devotion to science justified his being called on for such a service, met with great readiness the request addressed to him, and joined Mr. Tresca, the engineer superintendent of the Conservatory of Arts and Trades, in making the comparisons. Their report is given in Appendix No. 7, from which it appears that there is no appreciable difference between the two standards compared. This highly satisfactory result confirms the confidence which has always been felt in the authenticity and correctness of the *committee meter* used in the Coast Survey, and at the same time affords a certain basis for the construction of the metric standards for the several States of the Union, recently authorized by law.

In Appendix No. 8 is given a description of a new form of portable astronomical transit instrument, adapted for determinations of latitude by the method of equal north and south zenith distances, without sacrificing any of its qualities as a perfect transit instrument. This valuable design, due to Assistant Davidson, is of special importance for determinations of geographical positions under circumstances where the transportation of instruments is difficult and expensive.

A plan for making use of our extended system of railways for accurate surveys, by taking advantage of the ready means of lineal measurement which they afford, has been developed by Assistant Hilgard, in Appendix No. 9 to this report. It appears probable that the proposed method will find a productive application in those parts of the United States where the absence of natural elevations and the prevalence of forest render the system of triangulation less available. Direct lineal measurement by means of rods has already been resorted to with advantage on some of the narrow sea beaches, bordered on the landward side by dense woods or swamps, where a triangulation would have required the cutting of lines through the forest or the traversing of impracticable ground.

In Appendix No. 10 a signal for triangulation is described, devised by Assistant Hilgard, intended to take the place of heliotropes at points difficult of approach, where the maintenance of a person to manipulate the ordinary heliotrope would be very expensive. It consists of an arrangement of silvered glass reflectors, most ingeniously so disposed as to reflect the sun all around the horizon, or in the required directions at those times of day when the measurement of horizontal angles is generally practicable.

TIDES AND CURRENTS.

The general report in regard to operations connected with the Tidal Division is given in Appendix No. 11.

Assistant Mitchell's report, (Appendix No. 13,) upon the tides and tidal currents of Hell Gate, is instructive and suggestive. The phenomena of the difference of level of the surface of the water at the extremities of the Gate, which exceeds four feet for more than two hours in each tide; of the continuance of the flow of the water in each direction for nearly an hour after the level has been reached; and that it is upwards against the pressure as well as against the regular resistance to velocity, deserve the attention which this accurate observer has given them, and will give material for profound mathematical discussion. It is clear that Mr. Mitchell is judicious in considering the progress of the tide wave, as such through the Gate, as of inferior importance, and that this channel is rather to be studied as a canal connecting two basins, each of which has its own law and times of rise and fall of tides, and it is well to observe that in this view the phenomena of the interference and meeting of the tides have an inferior significance. To complete this subject some additional observations will be required, and will be made as soon as circumstances may permit. Mr. Mitchell's general remarks at the introduction of his report are worthy of careful study.

In Appendix No. 15 an interesting paper will be found giving the results developed by soundings across the Florida Strait, and general inferences from the observations made in connection with the soundings.

A report on the examination of specimens taken from the bottom of the Florida Strait is given in Appendix No. 16.

GEOLOGICAL CHANGES OF THE COAST AND HARBORS.

In a communication from Professor Agassiz, of the 11th of September, he has discussed the importance of zoological and geological researches to the solution of some problems of deep interest, in reference to coast lines. The letter, given in the Appendix, (No. 17,) indicates, also, the true process for ascertaining the source of the various deposits in a harbor, and shows that this question is intimately dependent upon knowledge of the surrounding geological strata, as well as upon the various sources and consequences of animal life. The conditions are pointed out under which some of our capes and headlands are wearing away, and a mode is indicated for determining when they will cease to protect, the process of degradation having converted them into dangerous shoals. Attention is especially called to the interest that attaches to a careful zoological study of the reefs of Florida, and to a thorough examination of the relations of the plants and animals which live in and upon them, "in order to determine with certainty the share they have in the formation of these immense submarine walls, so dangerous to navigation." His suggestion for the organization of a party to continue the observations which he commenced under the auspices of my distinguished predecessor, will receive early attention. The letter concludes with reference to "some points which seem legitimately to belong to the Coast Survey:

"1. The salt marshes of our shores, their formation and uses, as well as their gradual disappearance under the advancing progress of the sea.

"2. The extended low islands in the form of reefs stretching along the coast of the southern States, the basis of which may be old coral reefs.

"3. The form of all our estuaries which has resulted from the conflict of the sea with the drift formation, and is therefore, in a measure, a geological problem.

"4. The extensive deposits of foraminifera along the coast, which ought to be compared with the deposits of tripoli found in many tertiary formations.

"5. The general form and outline of our continent with all its indentations which are due to their geological structure. Indeed, the character of every harbor is the result of the conflict of the ocean with the rock formations of the land, and, therefore, as much a question for geology as for geodesy to solve."

The generous offer of Professor Agassiz to contribute his services to the investigation of these great questions, will be received as freely as it is made.

In a previous communication (Appendix No. 17) he made important suggestions with regard to the proper observation of the growth of coral, which received immediate attention. The great value of such scientific researches in all parts of the world, where settlements are making in the vicinity of coral reefs, is a supplementary argument to which he has wisely referred. Careful consideration will be given to the collection of such specimens as our limited means will permit.

OBITUARY.

The record of the survey has been saddened by a loss of life, unnatural to the ordinary course of this peaceful service. A fatal accident has deprived it of a most efficient assistant in the immediate performance of his duty.

Sub-Assistant Julius Kincheloe was drowned, together with five of a crew of six hands, by the breaking of the sea, which capsized his boat outside of Tillamook Bar, on the coast of Oregon, on the 20th of May. With his energy and perseverance, he had completed the survey of the lower part of Tillamook River and of its approaches, and had patiently watched for an opportunity to verify the soundings by a concluding line across the bar. Smooth water offering, he succeeded after two vain attempts, passed out in his boat and sounded to the desired distance. His work was done, when, by an unexpected breaker, the boat was swamped, and, by a second breaker, it was capsized at a distance of about a mile and a half from land, and within the very sight of his wife.

Thus perished a faithful officer. Mr. Kincheloe entered the service in 1854. His steady application to duty, and his amiable nature, secured for him at once the confidence and favor of the older officers. He acquired experience in all branches of the field-work; he was accurate in his observations, and judiciously economical in the expenditure of the funds intrusted to him. His sacrifice of life was eminently characteristic. It was due to his reluctance to leave any uncertainty in his results, and for this he risked the dangers of the surf in which he perished.

Having worked in most of the sections on the Atlantic coast and on the Pacific, Mr. Kincheloe was generally known in the survey. No one surpassed him in the esteem in which he was held by his associates: he was beloved and respected for his courtesy and uprightness. He was strictly devoted to the interests of the work confided to his charge, and will long be remembered in the survey.

PART II.

In the following pages, condensed notices will be given of the work done in each of the places to which surveying parties have been sent in the course of the year. The positions will be mentioned as usual in geographical order, beginning with the northeastern boundary of the United States, and closing, on the Atlantic side, at the Rio Grande. The reverse order will be observed on the Pacific side, the notices of work done on that coast properly closing with the mention of the reconnaissance made along the coast of Alaska.

Appendix No. 1 is a comprehensive index relating to the persons and places mentioned in the body of the report. In that table the order is the same as that observed in regard to the condensed statements of work in the field, which will be arranged as usual under separate heads or sections.

The work done in the office in Washington will be described in the concluding chapter of the report.

SECTION I.

ATLANTIC COAST, OF MAINE, NEW HAMPSHIRE AND MASSACHUSETTS, AND OF RHODE ISLAND, AS FAR SOUTH AS POINT JUDITH.

Triangulation of St. Croix River, Maine.—The triangulation of Passamaquoddy Bay having been extended in previous seasons, by Sub-Assistant C. H. Boyd, to the mouth of the St. Croix River, and thence up the river to Calais, was, in the month of September, connected with the primary triangulation at the line which joins Chancook and Cooper Stations, the positions of which are marked on the progress sketch, No. 1. In immediate geodetic connection with those positions five other stations were occupied, four of which form a quadrilateral and connect with the station used for astronomical observations at Calais.

After completing the operations in that vicinity, Mr. Boyd made a reconnaissance along the river above Calais, and, in the course of the month of October, selected twenty stations for extending the triangulation. His inspection was continued to the Boundary Monument, which was found in a dense cedar swamp. It stands upon marshy ground, which must be seriously affected by the changes of weather. It is no longer erect, and its evident instability justifies the suspicion that it has sensibly removed from its original position, which is an important point for future determination. In the scheme of triangulation furnished as the result of this reconnaissance, the stations were selected with reference to the limited resources for transportation along the St. Croix.

Sub-Assistant Boyd was occupied within the present surveying year at another locality in this section, and for a continuous period on the coast of Texas. He is now preparing to resume hydrographic duty in Section IX.

Topography of the St. Croix River, Maine.—Assistant W. H. Dennis resumed the plane-table survey about the middle of July, tracing the shore-line from the limit reached last season, and terminating at a station about a mile above the first bridge at Calais. The detailed survey has been taken up, and both sides of the river were mapped to a point three miles below the city. The plane-table sheet, containing this work, includes the city of Calais, and the town of St. Stephen's on the New Brunswick side of the river, and the topographical features found within the limits usual in river surveys. The relative amount of detail is considerable, the banks of the river being hilly and thickly settled. Stated in the usual way, the statistics are as follows:

Shore-line surveyed	17 miles.
Wharf-line traced	4½ "
Creeks	4¼ "
Roads	29 "
Area of topography, (square miles)	7

Until October the working season as a whole, in this section, was very unfavorable. Assistant Dennis continued in the field until the middle of November. He had been previously engaged in topographical duty on the coast of South Carolina, as will be stated under the head of Section V.

St. Croix River obstructions.—At the request of the Engineer Department, Assistant F. P. Webber was sent, in February last, to examine the channel of the St. Croix where it was obstructed by materials coming from the saw mills above. The bad weather of that month prevented the thorough examination desirable as a basis for engineering operations. It was nevertheless ascertained that, beginning a quarter of a mile below the bridge at Calais, a space fourteen hundred feet long by two hundred in width of the channel of the St. Croix has been seriously injured by the deposits, and that the depth of water had been reduced as much as ten feet. The deposit has in some places reached the surface.

In the course of the present working season, Mr. Webber was engaged in two other places in this section, and at two places in Section III.

Hydrography of Winter Harbor, Maine.—The soundings made in the vicinity of Schoodic Point include Winter Harbor and all its approaches from the southward and westward, and the upper limit of the chart is the north end of Iron-bound Island. This work was executed by Sub-Assistant Horace Anderson between the 8th of August and the 23d of October. The position is plainly marked on Sketch No. 1. Winter Harbor offers a safe refuge for vessels even of large tonnage, and from the sheet turned in by Mr. Anderson appears to be free from ledges or shoals of any kind. The soundings made in the approaches to the harbor developed an average depth of about thirty fathoms. Tidal observations were made as usual while the hydrography was in progress.

Messrs. C. P. Dillaway and R. B. Palfrey were attached to the party as aids. The following are statistics of the work:

Miles run in sounding	158
Angles measured	1,449
Number of soundings	6,205

Early in the season, Sub-Assistant Anderson was employed in Section VIII, and subsequent to the period passed at Winter Harbor, in a place on the coast of Massachusetts. He is now preparing to resume hydrographic duty in Section VIII.

Topography of Penobscot Bay, Maine.—The plane-table work done this year by Assistant F. W. Dorr comprises the survey of that part of the Fox Island group (Sketch No. 1) which lies north of the Thoroughfare Passage between Rockland Harbor and Isle au Haut Bay. His party took the field at the end of July; but, as in other parts of this section, bad weather so prevailed during the greater part of August that steady progress could not be made until about the 1st of September. The topographical sheet represents the island of North Haven, with its outlying smaller islands and the ledges which show at ordinary low water. These are numerous, and many of them are important by their position, the Thoroughfare being, in fact, a continuous harbor, open to the east and west. Two indentations of the island also rank as harbors, of which the principal one is on the north side and known in the vicinity as North Harbor. That on the west side, called Bartlett's Harbor, is unprotected from northwest winds. The whole outline of the island is very irregular, and tide falls, ledges, and rocks show in every direction. All of these, of which the most dangerous are the two called the "Drunkard" and the "Fiddler," are laid down on the topographical sheet. The general statistics are as follows:

Shore-line of island and ledges	69 miles.
Roads	78 "
Water courses	32 "
Area of topography, (square miles)	18

Assistant Dorr had been previously engaged in topographical duty in Section IV. He was efficiently aided in the survey in Penobscot Bay by Mr. H. G. Ogden, whose aptitude with the plane table is commended in the report of the season. The field-work on the Fox Islands was continued until the 21st of October.

Mr. Dorr is now preparing to resume the topography of the coast of North Carolina.

Hydrography of Penobscot Bay, Maine.—The hydrography of the coast of Maine was resumed at Penobscot Entrance on the 19th of July by Sub-Assistant Charles Junken, with a party in the small steamer Endeavor. Soundings were extended eastward of former limits, and have advanced the work, as shown on Sketch No. 1, to Seal Rock and Saddleback light-house. The hydrography of the entrance was continued northward to a line joining Hurricane and Fisherman's Islands. In addition to the general work, careful developments were made, by boat soundings, in the immediate vicinity of Seal Rock, Wooden Ball, and Metinicus Island, Green Island, Metinic, and Monhegan Island.

Sub-Assistant Junken, aided by Messrs. J. B. Adamson and E. Ellicott, continued hydrographic service until the 1st of November.

In the neighborhood of the Muscle Ridge Islands, the hydrography outstanding at the beginning of the season was completed by Sub-Assistant R. E. Halter. The addition thus made in the soundings is marked on the Progress Sketch. The other work performed by this party will be mentioned under the next head. The following abstract of statistics refers to the hydrography of Penobscot Entrance:

Miles run in sounding	705
Angles measured	6,259
Number of soundings	11,973

Sub-Assistant Junken had been previously employed in the coast hydrography of Section V, and is now preparing to resume hydrographic work for the coming winter.

As the result of observations while prosecuting the hydrography of the Muscle Ridge Channel, Sub-Assistant Halter recommended the placing of buoys on the Upper Gangway and Grindstone Ledge, and on the rock in False Whitehead Harbor. His suggestions, with sketches of the hydrography adjacent to the dangers, were transmitted for the information of the Light-house Board in August.

Survey of the Penobscot River, Maine.—An official request from the Engineer Department for a minute survey of the Penobscot between Hampden and Bangor, led to the assignment to that place of Sub-Assistant J. A. Sullivan. His party took the field on the 10th of July, and concluded active operations on the 2d of September.

The object of this work may be readily inferred from the following extract, taken from the report of Mr. Sullivan: "The survey made develops the fact that from above the entrance to Crosby's Narrows, about four miles below Bangor, to the city, the navigation of the river is obstructed by immense bars composed of 'edgings,' sawdust, and alluvium, with occasional bowlders. So serious are these obstructions, that the channel, formerly in the middle of the river and open to large vessels, now meanders from shore to shore through the bars of edgings, &c., and is so narrow that, although carrying a depth of water of at least seventeen feet at low tide, it cannot now be safely used by a vessel drawing ten feet until the tide is at half flood." * * * * "Hardly a day has passed that I have not seen aground and detained for a tide vessels that should readily pass up to Bangor at extreme low water."

Proceeding in the usual mode of the regular work, in which this part of the Penobscot would have been ultimately included, the high and low water line of the shores of the river, and its immediate topography, were mapped from a point about a mile and a half below Hampden Landing upward to the bridge at Bangor. Including wharves, the plane-table sheet represents twenty-four miles of shore-line and a margin of details equal to three square miles.

The present condition of the bed of the Penobscot within these limits was determined by the means applicable to the closest surveys in hydrography, as may be inferred from the statistics:

Miles run in sounding	209
Points fixed by sextant angles	132
Number of soundings	3,409

Spar buoys were placed at eight points in the river requiring special soundings.

The submarine divers employed by Brevet Brigadier General Thom, the officer of engineers in charge of the improvement of the river, were directed in their movements by the data obtained by Mr. Sullivan.

At the close of the work a complete report on the present state of the river in particular places, and illustrative maps and sketches, were furnished to General Thom. Sub-Assistant Sullivan completed and sent to the Coast Survey Office the original plane-table and hydrographic sheets, after having also furnished the engineer officer with a copy of each.

The system of the results, as devised by Mr. Sullivan, is such that by means of the completed map an improved channel can be readily traced, which, when excavated, will give a required width and depth with the least possible movement of materials.

The efficiency of Mr. Paul Mayor, the aid in the party, is highly commended in the field report, as also the services of Mr. R. H. Richards, who was temporarily employed in the work.

Inspection of topography.—Several plane-table sheets requiring to be made conformable to the standard of topographical representation, were referred to Assistant H. L. Whiting in June. As soon as practicable he took the field, first on the Medomak river, and subsequently on the shores of the St. George. After revising the sheets of that vicinity, a party was organized and placed in charge of Sub-Assistant Charles Hosmer for completing the work under the general supervision of Mr. Whiting, whose services were specially requested in August for the examination of Provincetown Harbor.

Before leaving this part of the section, Mr. Whiting resurveyed the vicinity of Thomaston. Mr. Hosmer, after adding the supplementary details required on the sheets of previous seasons, took up and completed the topography outstanding in the upper part of Muscongus Bay. By reference to the progress sketch (No. 1) it will be seen that the work here alluded to makes the plane-table survey of the coast continuous from Portland to Camden and Penobscot Bay. A few of the numerous islands in the vicinity yet remain to be surveyed. The statistics for the present season are as follows:

Shore-line surveyed	104 miles.
Roads	28 "
Area of topography, (square miles)	10

Assistant Whiting had passed the early part of the season in Section V. Before taking up work on the coast of Maine, Sub-Assistant Hosmer had been employed in service which will be mentioned under the head of Section IX.

In the latter part of September I personally visited the parties then in the field on the coast of Maine, westward of and at Penobscot Entrance. The result of close inquiry and inspection then made, in conjunction with Assistant Whiting, was highly satisfactory in regard to the methods in use for the proper representation of ground, and for securing accuracy in the soundings. I cannot forbear expressing my gratification at the integrity and economy manifested in the administration of the parties, and at the tact and judgment with which the assistant officers have gained the good will and respect of the inhabitants with whom they were quartered.

Hydrography of Friendship River, Medomak River, and John's Bay, Maine.—For the supplementary soundings needed to complete the in-shore hydrography westward of Penobscot Entrance, Sub-Assistant Halter was placed in charge of a party with the schooner Bailey and the steam launch Sagadahoc. The soundings were commenced on the 12th of July, and continued until the 4th of November. In addition to the hydrography performed and referred to under a previous head, Mr. Halter sounded the Friendship River, and, in connection with that work, extended the hydrography of Medomak River southward to Cranberry Island. He also sounded John's Bay, connecting at Pemaquid light with the hydrography of Muscongus Bay. Owing to the unfavorable weather which prevailed during a considerable part of the season, a part of the approach to Medomak River yet remains to be sounded.

Messrs. W. I. Vinal and G. T. Bigelow, jr., aided in the hydrographic work of this party.

Sub-Assistant Halter thus reports the statistics of his work in this section:

Miles run in sounding	751
Angles measured	6,600
Casts of the lead	53,000

Mr. Halter is now preparing for hydrographic duty in Section IX.

Hydrography of Sasanoa River, between the Kennebec and Sheepscot, Maine.—Sub-Assistant J. S. Bradford was assigned to this section for the completion of soundings in the water passages between the Sheepscot and Kennebec Rivers, and commenced work with a party in the schooner Caswell on the 18th of July. The hydrography accomplished includes, besides the Sasanoa River, that of Great Hell Gate and Little Hell Gate; also Knubble Bay, the Goose Rock Passage, Fire Island Harbor, and several coves ranking as harbors, the vicinity of the dangerous Cat Ledges, Birch Point Ledge, and the sounding of Back River.

Nearly all the work of this party was done at slack water, the current of from seven to ten knots rendering it impossible to sound at any other stage of the tide.

Besides the general work, Mr. Bradford determined in position the dangerous rock in Upper Hell Gate known as the "Boiler," and recommended that it should be marked by a buoy. He surveyed also four other rocks in that passage and three in Great Hell Gate, five dangerous rocks in Knubble Bay, and eight in Sheepscot River. The survey of Birch Point Ledge gave great satisfaction at Wiscasset, that danger being directly in the track of vessels beating up from Back River. The rock has nine feet at mean low water, and is so sharp that only one shoal sounding was found on it. Mr. Bradford recommends that a buoy should be placed on the ledge.

The results of the survey in the lower part of the Sheepscot River were, mainly, the development of fine anchorages at Fire Island Harbor and at Hermann's Harbor. This last, though difficult of entrance, is perhaps the best harbor on the river. Cape Harbor was sounded, and also a passage inside of Lower Mark Island. The passage inside of the Cat Ledges was traced out, the ledges being hitherto supposed to restrict the in-shore deep soundings in that vicinity.

The party in the schooner Caswell continued at work until the 7th of November. Sub-Assistant Bradford was efficiently aided by Messrs. A. F. Pearl and Lucien B. Wright, and by Amos M. Jewett, acting ensign United States Navy, commanding the Caswell.

In the various places in which the party worked in this section (see Sketch No. 1) an aggregate of about twenty thousand soundings was recorded. The resulting hydrographic sheet shows that thirty-one rocks, most of them dangerous, have been detected by the soundings.

Early in the season, Sub-Assistant Bradford was engaged in Section IV.

Survey on Kennebec River near Hallowell, Maine.—In November, 1866, at the request of Brevet Brigadier General B. S. Alexander, United States engineers, a survey was made by Sub-Assistant C. H. Boyd of the shoals which occur in the Kennebec in the vicinity of Hallowell. For the use of the engineers, the topography was mapped on a large scale. A tide gauge was kept in operation, and ten thousand soundings were recorded. Mr. Boyd also recorded observations on the currents of the river, made borings on the shoals, and furnished for the use of the engineers the data specified in the request of General Alexander.

More recently the survey of the Kennebec was extended from Shepard's Point to Gardiner, a distance of about three miles, at the request of General Thom, of the corps of engineers. Under the direction of Sub-Assistant Sullivan, the shore-line was traced by Mr. R. H. Richards. The soundings were made by Mr. Paul Mayor, who aided Mr. Sullivan in another part of this section.

Sub-Assistant Boyd is now preparing to resume field-duty in Section IX, and Sub-Assistant Sullivan to take up work in Section VIII.

Topography of Harpswell Sound, Maine.—Further progress has been made in the plane-table survey in the immediate vicinity of New Meadows River, by the party of Assistant A. W. Longfellow, who took the field on the 10th of July in this section, having been previously engaged in Section IV. By the middle of October, the shore-line survey of the estuaries of Harpswell Sound was completed, and the detailed survey of Long Reach and of the neck adjoining, as shown on the progress sketch No. 1.

Sub-Assistant H. W. Bache was attached to this party. The schooner Meredith was used for quarters and for transportation. Bad weather greatly hindered the progress of the field-work. The following is a summary of the topographical statistics:

Shore-line traced	54 miles.
Roads	6 "
Area of detailed survey, (square miles)	5

The party of Assistant Longfellow was transferred to Portland in the middle of October, for service which will be mentioned under a subsequent head.

Hydrography of Portland entrance, Maine.—The off-shore soundings needed in the approaches to Casco Bay were completed in September and October, by the party of Acting Master Robert

Platt, United States Navy, with the steamer Corwin. Progress Sketch No. 1, shows the addition thus made to the hydrography of the section. One of the results of the work is the development of a rock with five and three-quarters fathoms of water, between what is known as Bulwark Ledge and outer Green Island, near the entrance to Portland Harbor.

In a special communication, Acting Master Platt strongly urges the expediency of a light on Half-way Rock, at the entrance of Casco Bay. Having personally examined the vicinity in October, the recommendation was approved and referred for the consideration of the Light-house Board.

Tidal observations were kept up at Fort Popham, near the mouth of Kennebec River, while the hydrography was in progress. The soundings made extend in lines between Cape Elizabeth and Seguin Island.

The steamer Corwin had been previously in service in the vicinity of the Florida Reef, of which mention will be made under the head of Gulf Stream in this report.

Re-survey of Portland Harbor.—At the request of the Engineer Department, which was also warmly seconded by the Portland Board of Trade, an examination was made in November of the shore-line and soundings of the inner harbor of Portland. Assistant Longfellow revised the topographical outline so as to present its present features. The soundings needed were made by Acting Master Platt with the party in the steamer Corwin. The results obtained by both parties have been mapped on the scale desired and furnished to General Thom, of the corps of United States engineers.

Survey of Saco River, Maine.—This work was done at the request of General Thom, of the corps of United States engineers. Sub-Assistant F. F. Nes commenced a topographical survey at the mouth of the river on the 25th of September. The limits of the plane-table include the breakwater which is now under construction. From the entrance, both shores of the river were surveyed upward as far as Saco, the head of navigation. The hydrography was then taken up and completed by the 13th of November. Mr. Nes has, since that date, been employed in running levels between the three tide gauges established by General Thom—one of them being at the mouth of the river, another at Ferry House wharf, and the third at Saco. Sketches were furnished to the engineer officer showing the position and extent of the rocks which obstruct the navigation of the Saco.

Sub-Assistant Nes was engaged, during a long period of the present year, in Section IX, in work which will be referred to under that head.

The survey of the Saco River embraces the following statistics:

Shore-line	18 miles.
Marsh-line	13 "
Miles run in sounding	46
Angles measured	493
Casts of the lead	8,775

Topography near Wells, Maine.—The detailed survey of this vicinity, which has been hitherto represented only in shore-line, was taken up in the course of the season by Assistant Hull Adams, at Ogunquit Station. The coast adjacent to Wells was surveyed for three miles, and from the beach back to the road which leads from Kennebunkport.

In the neighborhood of York, Assistant Adams filled with topography a space left between the general survey of the coast and the survey of Portsmouth Harbor. This included the area between Godfrey's Cove and Brave Boat Harbor. The work was bounded by the road leading from Kittery to York. In the localities referred to, the party of Mr. Adams was occupied until the close of the season, in the middle of November. Early in the summer, the details needed to complete the survey of the coast of New Hampshire, between Rye and Portsmouth Harbor, were filled in. The new work was joined with the survey of Captain Stansbury, at a point about three miles below Portsmouth.

Assistant Adams was aided during the season by Mr. J. G. Spaulding. The following are statistics of the topography, exclusive of a revision of the former survey, of the city of Portsmouth:

Shore-line surveyed	32 miles.
Marsh-line	26 "
Roads	29 "
Area of topography, (square miles)	12

Survey on Merrimack River, Massachusetts.—Early in the summer, a request from Hon. B. F. Butler and others was met by the assignment of the party of Assistant Henry Mitchell for a survey in the lower part of the Merrimack, the improvement of its navigation by a company incorporated by the Massachusetts legislature being then under consideration.

This survey covers a reach of the river known as Mitchell's Falls, two miles in length, in which there are three rapids that offered considerable difficulty to the party in sounding, especially in the selection of proper planes of reference for indicating the depths. Many variations in the height of the river occurred at different hours of the day, under the action of the tides combining with the different discharges from the mills of Lawrence and Lowell above. The work was consequently difficult, but was executed with accuracy, and a sufficient number of bench-marks were left to aid the engineer in using all the results of the survey. The shore-lines, ledges, and bars, together with profiles of the river bed, surface slopes, hourly changes of elevation, &c., were combined into a physical map, (Sketch No. 2,) which ingeniously exhibits at once, to those who may undertake the improvement, all the elements for specifications and estimates.

Under the general direction of Assistant Mitchell, the topography, soundings, and most of the observations required in this department, were made by Mr. H. L. Marindin, who had passed the early part of the surveying year in Section VIII. Mr. J. N. McClintock served as aid in the party of Mr. Mitchell.

The expenses incurred in the survey on the Merrimack were defrayed by the Pentucket Navigation Company.

Boston Harbor.—The general duties of Assistant Mitchell permitting his continuance as a member of the United States advisory council, his regular work has been carried on within call of the harbor commission of Massachusetts, from which questions specially intricate in character are referred to the council. An extract is appended from the first annual report of the board of harbor commissioners to show the relation sustained towards that body: "The members of the board were appointed on the 29th of June, 1866, and organized on the 9th of July. The board were fortunate enough to secure as an advisory council, Rear-Admiral Charles H. Davis, Superintendent of the United States Naval Observatory, Major General Richard Delafield, of the United States corps of engineers, Major General A. A. Humphreys, Chief of Engineers of the United States, and Henry Mitchell, esq., assistant in the United States Coast Survey. The advice of the council in regard to the protection and improvement of our harbor, especially Boston Harbor, rendered as it is, gratuitously, has been, and will be, of the highest value and importance. Mr. Mitchell, as the representative of the council, has been able to attend most of the meetings of the board, and we are deeply indebted to him for his aid.

"We have engaged as engineer of the board, Albert Boschke, esq., whose services on the coast survey and in the survey of the harbor of Boston, as well as his other qualifications, specially adapt him for the situation."

An invitation to fill a vacancy which occurred within the present season in the advisory council has been accepted by the Superintendent of the Coast Survey.

Astronomical observations at Cambridge, Massachusetts.—The transatlantic telegraph operations undertaken last year by the Coast Survey, for the purpose of obtaining, if possible, a more accurate determination of the differences of longitude between the principal observatories in Europe and the United States, made it desirable that a re-determination by the telegraphic method of the difference of longitude between Cambridge and Washington should be completed this season.

Early in May, Assistant George W. Dean was directed to organize a party and to arrange the details requisite for the astronomical work.

Rear-Admiral Charles H. Davis, United States Navy, at that time Superintendent of the Naval Observatory, at Washington, and Professor Joseph Winlock, director of Harvard Observatory, at Cambridge, were invited to co-operate with the Coast Survey in making the proposed longitude experiments, and promptly made arrangements for that object. The opportunity was also notified to the directors of the several astronomical observatories convenient to the telegraph line. The director at Dudley Observatory, Professor G. W. Hough, having the requisite telegraphic apparatus, took part in the operations.*

The plan adopted was, to determine with great precision the corrections and rates of the clock, each night at the several stations, and as soon as the telegraph line was available for the use of the observers, which was generally at 9 p. m., the clock at Harvard Observatory was connected in the main telegraph circuit, and clock signals were sent to the Observatories at Albany and Washington for five minutes. Meanwhile the clocks at those places were adjusted in their respective local telegraph circuits, for the purpose of recording their clock signals upon the chronograph while receiving clock signals from Harvard Observatory.

At the expiration of five minutes, the Harvard clock was disconnected from the main telegraph circuit, and adjusted in its local circuit; the Dudley Observatory clock being meanwhile placed in the main circuit, and its signals recorded at Cambridge and Washington for five minutes. In a similar manner the clocks at coast survey station Seaton, and at the Naval Observatory at Washington, were compared by telegraph with the clocks at Cambridge and Albany.

Immediately after the first set of clock comparisons were completed between the several observatories, each night, a second series of observations were made for determining the clock corrections. This usually required about an hour and a half, after which a second set of clock comparisons followed, thus furnishing the data for ascertaining the rate of each clock from the observatories, and also from the clock comparisons.

The requisite observations at Harvard Observatory were made by Professor Winlock and his assistant, Mr. George M. Searle. The instrument used for determining the clock corrections was a forty-eight-inch Troughton & Simms transit, (Coast Survey, No. 8,) having an aperture of two and three-quarter inches.

While the longitude experiments were in progress, Mr. Searle visited Washington and made several series of observations for determining the personal equation between himself and Assistants Dean and Goodfellow, and Professor Newcomb of the Naval Observatory. On his return northward, Mr. Searle passed several days at Albany, but the weather proving unfavorable only a few observations were made for personal equation between himself and Professor Hough.

Near the close of August, Assistant Dean, with Professors Hough and Newcomb, joined Professor Winlock, at Cambridge, and made the final observations for personal equation.

The operations here noticed will be again alluded to under the heads of Section II and Section III.

Latitude observations at Manomet, near Plymouth, Massachusetts.—These observations were commenced by Assistant C. O. Boutelle, on the 27th of June, his party having been previously employed at another station in this section. Sixty-seven pairs of stars were observed for latitude, on thirty nights, with an average of six observations to each pair. In connection with these, observations were made on twenty-seven nights in July and August, for local time. The value of the scale divisions of the level of transit No. 10 was carefully determined, and observations were made to find the correction for irregularity in the form of the pivots. To find the value of the micrometer of zenith telescope No. V, five western elongations of Polaris were observed by one hundred and sixty-three readings, and the value of level A was determined in terms of the micrometer by two hundred and forty observations on six days. Assistant Boutelle was aided in the latitude and other geodetic observations at Manomet by Messrs. F. H. Agnew and C. S. Peirce. Sub-Assistant J. W. Donn also joined the party in July, and rendered good service by making the first reduction of apparent places for all the stars used for latitude. My first visit of inspection was made to this party, and I was highly gratified at the vigor and ability manifest in its conduct.

Magnetic observations at Manomet and at Nantucket, Massachusetts.—At Manomet station ten determinations of magnetic dip were made by the party of Assistant Boutelle, on four days in August, by two hundred and eight observations. Half-hourly readings of maxima and minima were taken on six days, for variation of the needle, and observations of deflection and vibration were made on three days, to determine the horizontal intensity.

The magnetic elements were determined by Mr. Boutelle also at Nantucket, in June, using, as in the observations just alluded to, declinometer No. 3, and dip circle No. 8. At Nantucket, (Cliff station,) ninety half-hourly readings were taken on four days, for variation. Six determinations of the magnetic dip were made, on two days, by ninety-six observations, and two days were employed in determining the horizontal intensity.

Assistant Boutelle was very efficiently aided in these and in the other operations here reported by Mr. F. H. Agnew. The observations for magnetic dip at Manomet, were made by Mr. C. S. Peirce, as well as the larger part of the other magnetic observations at that station.

Hydrography of Duxbury Harbor, Massachusetts.—The soundings made near Duxbury define the two channels, one of which passes up the east side of the bay to the vicinity of Powder Point, the other branching from the main channel off Clark's Island, and running towards the west shore of the bay. The work was done at low water. Tidal observations were made during twenty-six days of the month of November.

This survey was made by Sub-Assistant Horace Anderson, aided by Messrs. C. P. Dillaway and R. B. Palfrey. The following is a summary of the hydrographic statistics:

Miles run in sounding	75
Angles	455
Number of soundings	7, 453

Mr. Anderson had been previously engaged in the northern part of this section, and also in Section VIII.

The work done near Duxbury connects with the hydrography of Plymouth Harbor, which was surveyed in 1857.

Latitude observations at Nantucket, Massachusetts.—After closing at Farmington, Maine, the series of observations for latitude, mentioned in the last annual report, Assistant Boutelle transferred his party to Nantucket, the southern end of the arc of about 3°.3 of the meridian, the length of which was to result from close determinations of the latitude of the two places named. A proper site for the temporary observatory was found in the garden of Peter Folger, esq., at a point about midway between Nantucket Cliff and South Towered Church, two of the stations of the triangulation. Stone blocks not being procurable in the vicinity, Mr. Boutelle mounted the transit instrument upon a short section of a ship's mast, imbedded three feet in the sandy soil, and placed the zenith telescope upon a portable wooden stand, contrived by him for this purpose. He reports that the changes in azimuth and level resulting from that arrangement are not greater than those incident to the use of stone blocks. Seventy-one pairs of stars were selected for observation at Nantucket. One set of thirty-nine pairs were observed from the 26th of November until the 5th of December, the remaining thirty-two pairs from the 7th until the 26th of December, 1866. In all, four hundred and eleven observations were recorded for the latitude, and in connection with them observations were made on seventeen nights of the same period, for local time. After the 8th of December the latitude observations at Nantucket were continued by Mr. F. H. Agnew, the attention of Assistant Boutelle being requisite at Calais, Maine, in connection with the determination of difference of longitude by means of the Atlantic cable, reference to which was made in the last annual report. Observations for time during the same period were continued by Mr. C. B. Boutelle.

The computed latitude of the station near Nantucket, resulting from these observations, is 41° 17′ 14″.17, of which Assistant Boutelle reports the probable error to be only 0″.10.

During the winter and early spring the records of observations which had accumulated in this party were duplicated, and the field computations were made.

The geodetic observations at Nantucket requisite for connecting the latitude station with the chain of primary triangles were taken up in May of the present year. Mr. Boutelle erected at Nantucket Cliff an observing tripod and scaffold twenty-two feet high, and posted heliotropers at Indian Hill and Shootflying Hill. Primary and secondary angles were here measured, and the stations South Towered Church, Folger, and Sankaty Head Light were also occupied. Twenty angles were measured at these stations upon nineteen objects, by seven hundred and twenty observations. The height of the primary station and of the astronomical observatory were determined by leveling. Twenty consecutive tides were observed for determining the plane of mean level of the sea, to which the heights were referred.

A comparison of the effects of lateral refraction, with reference to the differing character of the lines observed, is thus concluded in the report of Assistant Boutelle: "Generally it has been my experience, that when a geodetic line passes near the surface over varying depths and *temperatures*, clear vision throughout its length will rarely be obtained, and lateral refraction will surely be encountered." One of the lines here alluded to passed within twenty feet of the water on Tuckernuck Shoal, though the ends of the line were respectively eighty-one and a half and two hundred and sixty-five feet above the sea level.

Survey of Provincetown Harbor, Massachusetts.—A call from the board of State commissioners for a comparative survey of Cape Cod Harbor, was responded to by the assignment at their request, in August, of Assistant H. L. Whiting to execute the work desired.

The local importance of the harbor at Provincetown, and the attention which its condition has attracted, make the questions depending on the present survey by Mr. Whiting of special interest. Various boards and engineers have given theoretical opinions concerning it, but for many years no investigation of physical facts and tendencies has been made. Assistant Whiting is now preparing an elaborate map comprising the topography and hydrography. This he will closely compare with the features found by the Coast Survey in 1848 and 1857; and with the survey of Major J. D. Graham, topographical engineer, in 1833, 1834, and 1835.

The present survey will investigate the changes which are taking place in the harbor, and their physical causes, and will include the study of the tidal currents and the various deposits. It will especially consider the feasibility of closing the entrance into the east harbor lagoon. Examination will also be made of the drainage and deposit of sand from the Long Point flats into the adjacent deep water of the harbor.

The investigation conducted by Mr. Whiting will not only determine the expediency of expenditures for the improvement of this harbor, but the principles thus developed will be universally applicable, and may serve as a basis for the decision of other difficult questions concerning appropriations for harbor improvement by the States or by the general government.

Assistant Whiting was engaged in the spring in Section V, and during part of the summer on the coast of Maine. In prosecuting the soundings near Provincetown he was aided by Mr. G. Bradford.

Topography of Narraganset Bay, Rhode Island.—After a close examination of the detailed survey, made under his direction, of the lower part of Providence River, Assistant A. M. Harrison resumed topographical work at the city of Providence in the latter part of June. He had previously detached a party to work at Fall River, in charge of Sub-Assistant H. M. De Wees. Mr. Harrison completed, on a large scale, a sheet containing the wharf lines at Providence, verified and inked a sheet containing Prudence Island, of which he had traced the shore-line. The details were filled in by Sub-Assistant Hosmer during the illness of the chief of the party in 1866. Both of these sheets are now in the office. The two parties, under the direction of Assistant Harrison, continued in the field until the middle of October, and completed the detailed survey of the cities of Providence and Fall River. This work is intricate in character, and was much impeded by unfavorable weather. The following is a synopsis of the statistics:

Shore-line surveyed	13 miles.
Roads	150 "
Area of topography, (square miles)	6

Providence and Seekonk Rivers, Rhode Island.—Under an application made in December, 1866, by public authorities interested in improvements of the channel of the river near the city of Providence, and in that of the Seekonk below Pawtucket, Assistant F. P. Webber was assigned to make the requisite examination. His survey revealed the precise character of the obstructions in both rivers, which were in the one case a wreck, and in the other several small bars. All the obstacles were determined by soundings and mapped. Copies of the resulting chart and of the detailed report of Assistant Webber were furnished without delay to the city authorities of Providence and Pawtucket.

Mr. Webber was subsequently employed in other parts of this section, and also in Section III.

Hydrography of Narraganset Bay, Rhode Island.—In the western part of Narraganset Bay, and in connection with the work previously done in Providence River, the hydrography has been extended by Assistant Webber with a party in the schooner Joseph Henry. The space between Rocky Point and Warwick light-house was completed by the end of August. Greenwich Bay was sounded between that date and the 2d of October. The hydrography was then resumed in Narraganset Bay, and extended to Hope Island by the 2d of November, at which time operations were closed for the season.

In prosecuting the hydrography Mr. Webber occupied forty-eight stations with the theodolite, and determined in position one hundred and twenty-one points for reference in sounding. The hydrographic statistics are as follows:

Miles run in sounding	514
Angles measured	4,497
Number of soundings	38,118

In the course of the season the tides were observed at Rocky Point and at East Greenwich.

Messrs. F. D. Granger and G. C. Schaeffer, jr., served as aids in the hydrographic party. The former had charge of the in-shore soundings, which were taken in a boat, and his good judgment in the performance of that duty is commended in the report on the season's work. Special mention is also made of the effective co-operation of Acting Ensign E. Studley, jr., United States Navy, who was in charge of the vessel during the working season.

Mention will be made under Section III, of the hydrographic service conducted by Assistant Webber in the early part of the year. His preparations are now in progress for taking up work in Section VIII.

Views for charts.—Within the present season the views from sea needful for the completion of charts of certain of the harbors between Penobscot Entrance and Sandy Hook were drawn by Mr. W. B. McMurtrie. The drawings represent twenty places on the coast of Maine, two on the coast of New Hampshire, one on that of Massachusetts, and four of the vicinity of New York Harbor. As usual, the light-houses and islands having some elevation are presented as the leading features in the several views. The proper stations at sea were obtained by the incidental use of the steamers Corwin and Endeavor, while these vessels were in hydrographic service.

Charge of vessels.—The vessels used in this section, and destined for service there in the ensuing season or for duty on the southern coast during the winter, were refitted under the care of Mr. A. C. Mitchell. Such as were not needed for work at the south, were securely laid up. The care and attention shown in these details are warmly commended by the hydrographic inspector.

Tidal observations.—The extension of the hydrography eastward, on the coast of Maine, having rendered it expedient to occupy a new station for tidal determinations, Owl's Head in Penobscot Bay was selected. A self-registering tide-gauge was set up there and started by Captain Mitchell, on the 17th of July. The observations have been regulated since that time by the light-keeper, Mr. G. D. Wooster.

Mr. Mitchell put up another self-registering gauge at the Charlestown navy yard, the records of which between the middle of August and the 1st of October were kept and forwarded by Mr. Charles Levin. Since the last mentioned date the station has been in charge of Mr. H. Howland.

The records from these gauges are designed to furnish data for the close prediction of tides, and for general investigations relating to the laws of the tides. They also afford the means of connecting and systematizing results obtained from the numerous short series recorded at intermediate stations by the hydrographic parties.

Bench-marks were established anew in resetting the gauge at the Charlestown navy yard.

SECTION II.

ATLANTIC COAST OF CONNECTICUT, NEW YORK, AND NEW JERSEY, INCLUDING PENNSYLVANIA AND DELAWARE, AS FAR SOUTH AS CAPE HENLOPEN.

Magnetic observations.—Assistant Charles A. Schott determined the magnetic declination, dip, and intensity at Hartford, Connecticut, by careful observations on the 15th and 17th of August. The station selected was near that occupied for the same purpose in 1859. In allusion to the unusual local disturbance developed by the observations, Mr. Schott remarks: "The declination in the vicinity of Hartford is undoubtedly less than might be expected from the general distribution of magnetism. As compared with results from the general formula for declination on the coast of New England, the deviation is about 54′ easterly, and is probably due to the influence of trap dikes. There is reason to think that the secular change over disturbed regions is normal, or, in other words, that the local deflection of isogonic curves is there a permanent feature."

The instrumental constants were determined by Assistant Schott immediately after his return to Washington.

Astronomical observations at Albany, New York.—In the notice given of the telegraph operations under the head of Section I in this report, it was stated that Professor G. W. Hough, director of the Dudley Observatory, availed himself of the facilities offered for obtaining a series of clock comparisons between Albany, Cambridge, and Washington. The necessary observations for determining the clock corrections at Dudley Observatory were made by Professor Hough and his assistant, Mr. Thomas E. McClure, and between the 6th and 29th of June clock signals were successfully exchanged on five nights.

Duplicates of the records of observations made by the Coast Survey party at Seaton station in Washington, have been furnished to the several observatories in exchange for transcripts of the observations made for longitude purposes at Cambridge and Albany.

The telegraphic operations of the Coast Survey party at Washington will be referred to under the head of Section III.

Soundings at the Battery, New York Harbor.—At the request of the pilot commissioners of New York city, the water-front abreast of the battery was closely sounded in September, by Assistant W. S. Edwards. The space represented by the hydrographic sheet is about twelve hundred yards long, by five hundred in breadth.

Assistant Edwards was employed in another locality in this section, and during the early part of the season in Section VI.

Topography of the coast of New Jersey.—The plane-table survey of the coast was resumed by Assistant C. M. Bache, at Deal, in July. From this point, which is about three miles south of Long Branch, the topography was extended continuously to Squan, taking in the village and the lower part of Squan Inlet. Including the beach the fringe of plane-table work is about a mile in width, and the distance surveyed ten miles. The inland bounding of the sheet is the telegraph road which runs parallel with the coast at the distance of about a mile from it. Assistant Bache continued in the field until the 4th of November, and after turning in at the office the results of his work in this section made arrangements for plane-table duty in Section V. The statistics of his work on the coast of New Jersey are as follows:

Shore-line surveyed	42 miles.
Roads	50 "
Area of topography, (square miles)	10

Triangulation of the coast of New Jersey.—This work was resumed on the 1st of July by Assistant John Farley. After completing the measurement of horizontal angles at stations laid out between Red Bog and North Cook, in the neighborhood of Squan, the series of triangles connecting the light-houses at Barnegat and Little Egg Harbor was perfected. Mr. Farley then proceeded to Atlantic City and took measures for connecting Absecom light-house as a station with the triangulation which has been passed southward from Sandy Hook along the coast of New Jersey. In the operations of this season eighteen stations were occupied with the theodolite, and two thousand and eighty-seven measurements made for horizontal angles. Mr. Farley remained in the field until the middle of November.

In the vicinity of Sandy Hook the triangulation above mentioned was connected by Assistant Edwards with the primary work which crosses New York Bay. This service engaged Mr. Edwards from the 1st until the 19th of July, and from the middle of September until the middle of November. He occupied six stations and determined the positions of twenty-five points.

In the latter part of July and early part of August Assistant Edwards was occupied near Deal, New Jersey, in furnishing points for the plane-table party of Assistant C. M. Bache. For this work seven signals were erected.

The occupation of the party of Assistant Edwards during the former part of the surveying year will be referred to under the head of Section VI.

Hydrography of Barnegat Entrance, New Jersey.—Outside of the bar at Barnegat Entrance a few lines of soundings, needed for the publication of a chart, were run by Sub-Assistant R. E. Halter in May. The chart thus perfected has been engraved and issued from the office.

In the summer and autumn Mr. Halter was occupied with hydrographic work which has been described under the head of Section I. He is now preparing for duty in Section IX.

Examination of Little Egg Harbor, New Jersey.—Some natural changes at Tucker's Island and elsewhere in Little Egg Harbor having given rise to a question regarding the expediency of a light or buoys, the locality was examined in February last by Assistant R. M. Bache. The channel, which has formed by the wearing through of a narrow beach near the south end of Tucker's Island, now has six to seven feet at low water, and for vessels of light draught offers a course into the harbor more direct than the south channel.

"The southern end of Long Beach has overlapped Tucker's Island so that its point bears southeast from the light-house.

"There is a bar between Long Beach and Tucker's Island with only three feet at low water. Old Inlet is consequently useless. The northern end of Tucker's Island has washed away. South channel is further to the west. Range Channel is not the main channel into the upper bay. The main channel is the narrow marsh passage over a mile to the northwest of Range Channel, as marked on the chart of 1846."

A full report on the changes was sent to the office by Assistant Bache. Two maps upon which the changes had been carefully indicated were turned in at the same time. A copy of the report, accompanied by copies of the maps, was furnished to General Hartman Bache, the officer of the Light-house Board having in charge the questions occasioned by the changes of shore-line and other features of the harbor.

Assistant Bache was employed during the summer at other places in this section.

Survey at Reedy Island, (Delaware River,) Delaware.—This work, and that which will be mentioned in the notice following, was undertaken for the use of the Engineer Department, the details desirable being indicated on the ground by Lieutenant Colonel C. Seaforth Stewart, of the corps of United States engineers. Early in May Assistant R. M. Bache erected signals for a close survey of the vicinity of Port Penn, including Reedy Island. The plane-table sheet shows on a large scale all the topographical details of the island, and of two miles and a half of the west bank of the Delaware, comprising an aggregate of four square miles.

The ice harbor at Reedy Island was surveyed on a larger scale. Assistant Bache followed the plane-table work by a careful hydrographic survey of the vicinity of Reedy Island, carrying the sounding three-quarters of a mile eastward, and extending the work north and south a mile beyond the extremities of the island. The passage between Reedy Island and Port Penn was also carefully sounded as well as the ice harbor. About two thousand casts of the lead were recorded. The survey was completed on the 10th of July.

Before leaving this vicinity Mr. Bache ran a line of levels from the tide-gauge which was used at the Reedy Island light-house, and established a bench-mark near the ice harbor.

The principal points used in this special survey were carefully marked for future reference. Complete copies of the two sheets, one showing the topographical features, and the other the hydrography, have been furnished to Lieutenant Colonel Stewart.

Survey at Liston's Point, (Delaware River,) Delaware.—As stated in the previous notice, this survey was made for the use of the Engineer Department; the service, depending upon the resulting map, being in charge of Lieutenant Colonel Stewart.

In the latter part of July Assistant R. M. Bache established a tide-gauge at a station a few miles above Liston's Point for the adjustment of the soundings intended to be made. Signals were then erected to give points suitable for a survey on a large scale.

The map made by Assistant Bache includes Liston's Point, and above it a mile and a half of the west bank of the Delaware river, with half a mile of the bank below the point. The topographical features were mapped so as to meet any possible requirements in engineering.

The hydrography of the vicinity of Liston's Point was extended north and south as far as the plane-table limits, and to a distance throughout of half a mile from the shore. Immediately above the point, where the water is deeper, the soundings were increased in number. About sixteen hundred casts of the lead were recorded.

This survey was concluded on the 24th of September.

The two maps resulting from this survey have been completed by Assistant Bache since the last-mentioned date, and copies of them have been furnished for the use of the Engineer Department.

Tidal observations.—At Governor's Island (New York Harbor) a self-registering tide-gauge has been kept in operation by Mr. R. T. Bassett, who has also continued to made observations for comparison with it on a box-gauge at the dock of the Hamilton Avenue ferry in Brooklyn. These observations have been continued some years, and have furnished data for many important and expensive improvements, both public and private, in and around the harbor and along the waters connected with it. Their scientific value will be made more manifest when the series becomes sufficiently extended.

Bench-marks.—At Barnegat, Absecom, Cape May, and Egg Island, on the coast of New Jersey, and at Cape Henlopen, bench-marks have been established as means of reference to the ordinary level of the sea. This duty was performed in September and October by Mr. A. C. Mitchell. Where no permanent base gave opportunity for indicating suitable mark, screw piles were set and marked in the usual way.

SECTION III.

COAST OF DELAWARE AND MARYLAND, AND OF VIRGINIA, AS FAR SOUTH AS CAPE HENRY.

Soundings in Susquehanna River, Maryland.—For the uses of the Engineer Department a hydrographic survey of the vicinity of Havre de Grace was requested in December, 1866, by Major Craighill. Sub-Assistant F. F. Nes was promptly assigned and continued work for ten days, but under many disadvantages. Severe cold having closed the river with ice, the party employed several days in observing from shore stations. Several attempts were made to continue soundings as the ice gave way, but drift ice, intense cold, and heavy gales made it impracticable to complete the work as intended. The results as far as obtained were communicated to Major Craighill. Mr. F. Blake, jr., served as aid in the hydrographic party. He had been previously engaged in similar service in Section VI.

Sub-Assistant Nes was employed during the first six months of the present year in Section IX, and in the autumn in Section I.

In March the hydrography near Havre de Grace was resumed by Assistant F. P. Webber, and in the course of the month following was extended to Spesutie Island. Current observations were made and recorded, as well as an aggregate of about seventeen thousand soundings. Complete tracings of the hydrographic survey were furnished for the use of the Engineer Department. Having completed some work in an adjacent locality, Mr. Webber was requested in July to make additional soundings near Havre de Grace. These defined the depth of water between the light-house and the new bridge, and were recorded in connection with observations on the currents of the same part of the Susquehanna.

Current observations in Chesapeake Bay.—Other duty having devolved upon Assistant Webber after he completed soundings in the Patapsco and its approaches for the Engineer Department, the intended observations on the currents in the vicinity of that entrance were deferred until near the end of May. Three stations were then occupied, at each of which a day was spent in observing the currents at the mouth of the Patapsco. A similar series was recorded at three stations across the bay, and fourteen consecutive days were passed in making half-hourly observations at a permanent station in Chesapeake Bay near the entrance of the Patapsco. The results, plotted in the usual manner, were furnished to Lieutenant Colonel Craighill, of the corps of engineers, at the end of June.

Mr. F. D. Granger efficiently aided Mr. Webber in the operations in this section, and accompanied him for duty in Section I.

Astronomical observations at Washington, D. C.—Before the arrangements mentioned under the head of Section I, for exchanging longitude signals between Cambridge and Washington were entirely completed, Rear-Admiral Davis was assigned to the command of the South Atlantic Squadron, and Commodore B. F. Sands, United States navy, was appointed as Superintendent of the Naval Observatory.

Commodore Sands, who, like his predecessor in the charge of the Naval Observatory, had in former years rendered most excellent service in the survey, at once carried into effect the arrangements which were nearly concluded between Admiral Davis and Assistant George W. Dean.

The general charge of the longitude experiments at the Naval Observatory was assigned to Professor Simon Newcomb, who was to be assisted by Professors Hall and Harkness of the navy.

The *clock corrections* were determined by observations with the large transit circle of the Observatory, having twelve feet focal length and an aperture of eight and a half inches.

Between the 4th and 29th of June clock signals were successfully exchanged for longitude determinations on five nights. The process used in the exchanges has been described under the head of Section I in a notice of the observations made at Cambridge. Seaton Station, one of the geodetic points of the Coast Survey, is near the junction of East Fifth street with North A street, on Capitol Hill in Washington City. It was first occupied for a series of telegraphic longitude experiments in the year 1847, and in subsequent years it was reoccupied for extending the telegraphic longitude operations to the southward from Washington. In May last a temporary observatory was again put up at the station, and on the 22d of that month Assistant Dean and Assistant Edward Goodfellow commenced a series of astronomical observations, which were continued until the 1st of July. During that period two hundred and nineteen standard stars were observed in determining the clock corrections, and thirty-eight stars were observed to determine personal equation between the assistants just named and Mr. Searle of Harvard Observatory. Clock signals were successfully exchanged with the observatory at Cambridge on seven nights, and with the Naval Observatory and Dudley Observatory on five nights, as previously stated.

The forty-eight-inch transit No. 4 was used at Seaton Station.

As on former occasions the Western Union Telegraph Company placed one of their lines between Cambridge and Washington at the service of the Coast Survey without charge after 9 p. m., when longitude observations were practicable. Assistant Dean acknowledges his obligations to General Thomas T. Eckert, general superintendent of the telegraph lines, and to his assistants, Messrs. Charles F. Wood and G. F. Miliken, of Boston, and Messrs. D. H. Bates and M. Marean, of Washington, for facilities extended to the party of the Coast Survey while the operations for determining longitude were in progress.

The records of this work have been duplicated, and the reductions and computations are nearly completed.

Mr. F. Blake, jr., served as aid in the party of Assistant Dean.

Hydrography of the Potomac River, District of Columbia.—Soundings have been made in the Potomac during the present season, under the immediate direction of the hydrographic inspector. Sub-Assistant Fendall made and recorded about ten thousand casts of the lead between Mason's Island and the Long bridge. His party was thus occupied between the 18th of August and the 1st of October.

Triangulation of the Potomac River, Maryland and Virginia.—In order to provide for the topographical survey of the lower part of the Potomac, and also to include on the map its principal navigable branches, Sub-Assistant Charles Ferguson was sent there early in the spring with a party in the schooner Bowditch. He commenced the triangulation on the 12th of March, and remained in the field until the end of October, at which date forty miles along the river had been included between Pope's Creek and Hull's Neck, the latter station being nearly opposite to Point Lookout at the entrance of the Potomac. Of the navigable branches an aggregate length of twenty-eight miles was embraced in triangulation, the station points of which connect with the work done on the main river. These branches are designated on the map as St. Clement's Bay, Wicomico river, Currioman Bay, Machodoc River, Yeocomico River, and Coan River. Much labor and care were employed in making the signals sufficiently stable to serve for the topographical survey; and with the same end in view, Mr. Ferguson determined and recorded the positions of a number of permanent objects along the line of the river and its branches. Fifty stations were occupied with the theodolite, at which, in the aggregate, seven thousand measures of horizontal angles were made. The journals of the work have been duplicated as usual and deposited in the office.

Sub-Assistant Ferguson is now preparing for duty in Section V.

Tidal observations.—The self-registering tide-gauge at Old Point Comfort, Virginia, has remained in charge of Mr. E. F. Krebs, who has very successfully continued the series of tidal records at this station. The series is one of the largest we have, and will soon be finally discussed for the general purposes for which it was established.

SECTION IV.

COAST OF NORTH CAROLINA, AS FAR SOUTH AS CAPE FEAR.

Triangulation near Cape Henry, Virginia.—In order to meet the difficulty presented near Cape Henry to the continuance towards the Edisto base of the main triangulation which comes down Chesapeake Bay, it has been deemed expedient to determine a line of adequate length by actual measurement along the beach southward of Cape Henry. This service has been performed within the season by Assistant Richard D. Cutts. His party took the field early in the summer and remained until the prevailing sickness of autumn made it quite impracticable to continue the work further until another season.

The line measured by Mr. Cutts is about nine miles in length and extends as far as five of the small triangles formerly used for the topography. The north end of the line is at one of three stations previously occupied with the theodolite by Assistant Cutts, on the south side of Chesapeake Entrance. He occupied also two stations on the north side of the entrance and perfected in the usual way the geodetic connection of the main triangulation with the line which had been marked out on the beach. These arrangements being complete, the line was measured by means of the apparatus described in Appendix No. 45 of the Coast Survey Report for 1857, the rods used being, however, six meters in length. In practice, one aid with a transit sector perfected the alignment of the bar and another recorded its number, the temperature of the rod and the reading of the sector, while the chief of the party made the contact with a line on a small bench where the bar had previously terminated, and gave the order for another movement of the bar. "The greatest distance measured in one day was twelve hundred meters. This, however, was an exception to the general rule, as the operation was delayed almost daily either by the sickness of one or more of the party or by the necessity of draining off the sea-water left in shallow pools in the line of the measurement after even a moderate breeze."

Before closing work for the season Assistant Cutts determined the azimuth of the line which had been measured along the beach. He was aided in the operations of the season by Mr. F. W. Perkins.

Triangulation of Neuse River, North Carolina.—This work was completed at the end of May, by the party of Assistant G. A. Fairfield, the operations of the present season having been resumed on the 10th of November, 1866. In addition to the determination of points between stations occupied last year, Mr. Fairfield set up signals beyond the entrance of the river for extending the triangulation into Pamlico Sound, and completed the measurement of horizontal angles at Brant Island. In the course of the working season a series of angles for transferring the azimuth was measured at four stations of the river triangulation; see Sketch No. 8.

Mr. J. G. Spaulding was attached to this party as aid until the 1st of January. Early in March Mr. George T. Bigelow, jr. was assigned as aid.

At the outset of the season the schooner Joseph Henry was used by the party of Assistant Fairfield, but subsequently by Sub-Assistant Bradford. The schooner Dana, employed mainly in the triangulation, was laid up at Newbern in charge of Acting Master Porter, at the end of May.

The following statistics show the concluding work in the triangulation of the Neuse River:

Signals erected	7
Stations occupied	15
Angles measured	118
Number of observations	3, 868

The descriptions of stations and records of angles have been deposited in the office, together with the observers' computations.

On the 2d of December, Mr. Fairfield took off the crew of a small vessel which was sinking in consequence of having struck one of the stakes placed in the Neuse River during the recent war. The surveying schooner Arago having met with a similar accident, the schooner Dana and party of Mr. Fairfield assisted in the raising and restoration of that vessel. He will shortly resume the triangulation in Pamlico Sound.

Topography of Neuse River, North Carolina.—The party of Assistant F. W. Dorr joined the steamer Hetzel on the 17th of January and was occupied for a few days following in adding some topographical details to the survey of the vicinity of Newbern. The vessel was available only for floating quarters, and some delay occurred in getting her towed to the intended working ground below the city, four of the steamers destined for Newbern having grounded at Hatteras Swash. The Hetzel, however, was in position off the mouth of Beard's Creek, in the middle of February. This point is thirteen miles below Newbern. On two topographical sheets the survey of the river was extended downwards on both banks, to include Whittaker's Creek on the north and Cedar Point on the south side. The intermediate creeks were surveyed to their sources, in some cases to a distance of six miles from their entrance into the Neuse. One of these, Clubfoot Creek, is connected with Newport River by a narrow canal which enters it near Beaufort.

The efficient aid of this party, Mr. L. A. Sengteller, was badly scalded in the face and hands by an explosion on the steamer Thomas Kelso, on which he had taken passage to reorganize the plane-table party at Newbern in December, 1866. Upon his recovery in a few weeks he joined Assistant Dorr, and effectively aided until the close of the season, when he was transferred for service to Section X.

The plane-table work of this season on the Neuse River (Sketch No. 8) is comprised in the following statistics:

Shore-line traced	153 miles.
Shore-line of creeks and streams	108 "
Roads	81 "
Area, (square miles)	111

The survey of the interior was carried back from the shores of the river and main creeks so as to include a belt varying in width from half a mile to a mile.

Assistant Dorr was occupied during the summer and autumn in topographical duty in Section I. He is now making arrangements to resume duty in Section IV.

Hydrography of Pamlico Sound and Neuse River, North Carolina.—After completing the reconnaissance of the vicinity of Long Shoal, of which mention is made in the report of last year, Sub-Assistant J. S. Bradford proceeded with the hydrography of Pamlico sound between Brant Island Shoal and the mouth of the Neuse River. This was continued for a short period, but a constant succession of heavy gales so retarded the work in December, 1866, that it was deemed best to resume soundings in Neuse River. The river hydrography was taken up at the limit of the preceding summer and was extended downwards to Wilkinson's Point—(Sketch No. 8.)

The schooner Arago while in this service was seriously damaged by an accident, but by the good judgment and exertions of Acting Master James H. Porter, the vessel was repaired in the course of ten days and was again employed in the survey. Aid was rendered in this emergency by Assistant Fairfield with the schooner Dana, and by Captain J. M. Rosse with the revenue cutter Stevens.

With various interruptions from bad weather the hydrography of the Neuse River was prosecuted until the 1st of June. Acting Master Porter then took charge of the Arago at Newbern. Sub-Assistant Bradford returned to the office and soon after took up hydrographic work in Section I. He was aided in the waters of North Carolina by Messrs. Stehman Forney, Arthur F. Pearl, and Lucien B. Wright. The last named aid, however, was transferred to another party in November and reassigned for service in Section I. Mr. Forney was detailed in June for service connected with the reconnaissance of Alaska Territory.

The statistics of work in Pamlico Sound and Neuse River are as follows:

Miles run in soundings	465
Angles measured	1,759
Number of soundings	59,781

The hydrography of this section will be resumed in the course of a few weeks. A chart of the dort of Newbern, with its approaches, accompanies this report as Sketch No. 9.

Topography of Bogue Sound, North Carolina.—From January to May last the party of Assistant A. W. Longfellow was employed in the detailed survey of Bogue Sound. Beginning at Whitehall signal, near the site of Carolina City, the topography was extended to the western limit of the plane-table sheet, and includes Broad Creek. Notwithstanding the inclemency of the weather, which seems not to have been equalled in the last ten years on the southern coast, the sheet projected for Mr. Longfellow was completed. Its statistics are as follows:

Shore-line of Bogue Sound	32 miles.
Ocean shore-line	10 "
Roads	35 "
Area of topography, (square miles)	20

Although the marks set by the triangulation party for the uses of the topographer were placed several years previous to the breaking out of the recent war, Mr. Longfellow in almost every instance found them where they had been buried in the earth. His party was employed in Section I during the summer and autumn.

SECTION V.

COAST OF SOUTH CAROLINA AND GEORGIA, AS FAR SOUTH AS ST. MARY'S RIVER.

Topography of the Sea Islands, South Carolina.—The work executed by Assistant W. H. Dennis in this section was the completion or filling in of three plane-table sheets, the main shore-line of which had been traced in previous years. Field operations were commenced in the middle of January. The party lived in camp until the 6th of March, when the schooner Caswell was assigned for its quarters.

Of the sea islands, one of the sheets includes Phillips' Caper's, Pritchard's, and Fripp's, which lie immediately on the coast. The topographical features represented are alternate strips or ridges of fast land covered with a pine growth, and salt marsh, the ridges running nearly parallel with the ocean outline, and the salt marsh traversed in every direction by creeks and runs. The southeastern side of St. Helena Island also falls on this sheet, the survey being carried inland far enough to include the "Seaside road." Another sheet continues the survey of St. Helena, and includes the whole of Hunting Island. The third sheet, filled with details, presents the whole of Morgan Island and part of the northwest side of St. Helena. The following aggregates were mapped:

Courses of creeks	208 miles.
Outline of marsh	121 "
Roads	33 "
Area of topography (square miles)	79

Assistant Dennis continued work in the sea islands until the 15th of June, and then dispatched the vessel for Portland. During summer and autumn he was occupied in work which has been described under the head of Section I. He is now making arrangements to take the field on the coast of Georgia.

Topographical reconnaissance.—In April and May, Assistant H. L. Whiting made a general examination of the coast of South Carolina and Georgia, to define the limits proper for the topographical survey of this section. Besides the prominent system of "inside passages" along the coast, the general and relative importance of the estuaries further inland were discussed with a view to confining the detailed survey within the bounds requisite for the public service. In his reconnaissance, Mr. Whiting carefully examined the distinction between main and secondary features in this topography and noted the relative importance of their general or detailed representation on the plane-table sheets. All the topographical parties in the section were visited for conference concerning the principles deduced from this personal examination. Besides a report of great interest on the questions referred to him, Mr. Whiting returned to the office two sketches marked with a boundary suitable for the plane-table survey between Charleston and the St. John's River, Florida. He passed the summer and autumn in field duty in Section I.

Topography of Wassaw Sound, Georgia.—The remaining plane-table work of this vicinity was assigned to Sub-Assistant Clarence Fendall, and was taken up at the end of January. All the water-courses and other details needed for completing the chart of Wassaw Sound were included on the topographical sheet projected at the office. These embrace the creeks between Wilmington Island and Tybee, and those in the vicinity of Cabbage Island. The right bank of the Savannah River was also surveyed from Lazaretto Creek to St. Augustine Creek, and the interior of Wilmington Island. Early in March the party was transferred to Savannah, and employed until the end of the working season in a topographical survey of the ground between the city and Thunderbolt. The schooner Caswell was used by this party until March, when the vessel passed into the service of Assistant Dennis.

Sub-Assistant Fendall was during the summer and autumn employed in Section III.

Topography of St. Catharine's Sound, Georgia.—This survey was commenced on the 6th of March by Sub-Assistant Cleveland Rockwell, and was prosecuted by his party with the schooner Bailey until the end of that month. Good progress had been made in the topography of St. Catharine's Island; the shores of Walburg Creek had been traced, and part of North Newport River.

Sub-Assistant J. A. Sullivan relieved Mr. Rockwell, on the 6th of April, and continued field-work until the 22d of May. All the details were completed on the side of the plane-table sheet which joins the survey of Sapelo Sound. After making the connection on that side, Mr. Sullivan extended the survey northward to include the North Newport River, and then dispatched the vessel for Portland for service in Section I, where he was occupied during the summer and autumn.

The following summary of the work at St. Catharine's Sound is taken from the report of Assistant Sullivan:

Shore-line on sheet	20	miles.
Creeks and river shore-line	100	"
Marsh-line	10	"
Roads	3	"
Area (square miles)	22	

In May Mr. Rockwell was assigned to plane-table duty in Section X.

Hydrography of St. Catharine's Sound, Georgia.—For this service Sub-Assistant Charles Junken, with a party in the steamer Endeavor, left Baltimore late in December and reached the working ground on the 19th of January of the present year. The soundings were concluded on the 25th of May. Messrs. J. B. Adamson and E. Ellicott were attached as aids under the direction of Mr. Junken.

This survey includes St. Catharine's Sound and its seaward approaches to a distance of nine miles from the coast, or within a depth of seven fathoms. The hydrography was defined by close soundings, and is connected with the previous surveys of Sapelo and Ossabaw Sounds, at the approaches as well as by the inland passages. The passages represented on the sheet are known as Bear River, Johnson's Creek, Medway River, North Newport and South Newport Rivers. The aggregate statistics of the work are as follows:

Miles run in sounding	1,185
Angles observed	13,143
Number of soundings	58,691
Area of hydrography, (square miles)	118

The resulting chart of St. Catharine's Sound accompanies this report as Sketch No. 10.

During the summer and autumn Sub-Assistant Junken was employed in Section I.

SECTION VI.

ATLANTIC COAST, OF FLORIDA; THE REEFS AND KEYS; AND THE GULF COAST OF FLORIDA AS FAR NORTH AS ST. JOSEPH'S BAY, NEAR TAMPA.

Reconnaissance between Fernandina and Cedar Keys, Florida.—With a view to preserve as far as possible the results of the triangulation going southwest from Fernandina towards Cedar Keys, Sub-Assistant J. A. Sullivan proceeded to this section in January. Every facility was afforded by the president of the Florida railroad, and by the officers of the company on the line. The examination by Sub-Assistant Sullivan, who had coöperated in the triangulation, was extended to

Gainesville, where the work stopped in June, 1860, it being then under the direction of Captain M. L. Smith, (since deceased,) as stated in the Coast Survey Report for that year. The records of the work done in the season before the breaking out of the rebellion were in his hands. It was ascertained that he forwarded in the spring of 1861, from Fernandina, the instruments belonging to the Coast Survey, under the wish and expectation that they would reach the office in Washington, and it is presumed that the records were inclosed in the same packages. Unfortunately the property did not come to hand, and has not yet been recovered, although the inquiries of Mr. Sullivan were met by earnest indications of a wish to further the objects of the survey in their recovery.

Topography of Matanzas Inlet, Florida.—The plane-table survey of the eastern coast of Florida was resumed by Assistant C. M. Bache, on the 1st of February, at a point about five miles below St. Augustine, where the work of Assistant Dorr terminated in February, 1861.

Much difficulty was experienced at St. Augustine in the attempt to engage hands suitable for the ordinary service of a plane-table party. Notwithstanding the difficulties thus arising, Assistant Bache pushed the survey of the coast southward, and included on his working sheet the lower part of the Matanzas River, with a margin of fast land which borders its western bank. The field-work was continued until the 1st of May, and resulted as follows:

Coast-line surveyed	10 miles.
River shore-line	28 "
Creeks	24 "
Area, (square miles)	20

After his return from this section, Assistant Bache took up plane-table duty in Section II.

Topography of Key Biscayne Bay, Florida.—The plane-table work outstanding for several years at the north end of Key Biscayne Bay was completed in March and April of the present year by the party of Sub-Assistant C. T. Iardella. Fifteen signals were set up and determined in position, after which the details were filled in from Morris Cut and Miami River quite to the head of the bay. This survey embraces the following in statistics:

Shore line surveyed	56 miles.
Area of topography, (square miles)	15

Topography of Charlotte Harbor, Florida.—Resuming field-work on the 14th of January, Sub-Assistant Iardella completed the plane-table survey of Charlotte Harbor with a party in the schooner Agassiz. The concluding work embraced the shore-line, lagoons, and small islands adjacent to the eastern side of Pine Island and the coast of the main land opposite, which is similarly broken into patches and lagoons. To the north this work was joined with the details mapped in 1860. The statistics are thus given in the concluding report:

Shore-line traced	99 miles.
Area of topography, (square miles)	16

Mr. Iardella was under the necessity of resetting ten signals, which had been blown down during the absence of his party from this section. The work at Charlotte Harbor was completed in the middle of March.

The party in the schooner Agassiz is about to be reorganized for service in the vicinity of Cape Sable.

Hydrography of Charlotte Harbor, Florida.—At two points the survey of Charlotte Harbor has been further extended by the party of Assistant W. S. Edwards, with the schooner G. M. Bache. Soundings were completed at the southern entrance, and inside, to a junction with the work done at the mouth of the Caloosahatchee River, including the entire breadth of the bay at the lower end of Pine Island. At the north end of Pine Island the inside of the bay was sounded, and connected properly with the hydrography of the Boca Grande Entrance.

This work involved considerable labor in the erection of signals, and in the restoration of some that had been previously set up. Among these was a large tripod at the Boca Grande, which had come into use as a day beacon. This at the request of the Light-house Board was strongly reset to resist all ordinary hurricanes, and marked so as to show plainly to vessels twelve miles distant in the Gulf of Mexico. The hydrographic work was closed on the 27th of May.

Assistant Edwards was aided in this section by Messrs. W. I. Vinal and F. Blake, jr. The tides were observed, as usual, at two stations in the course of the season. A summary of the hydrographic statistics is thus given in the report of Mr. Edwards:

Signals erected	25
Miles run in sounding	245
Angles determined	1,838
Number of soundings	20,050
Area of hydrography, (square miles)	23

After the return of the party in June, Assistant Edwards was employed in Section II. Mr. Vinal was assigned to service in Section I, and Mr. Blake to duty in Section III.

In April and May Mr. Edwards furnished such facilities as his party and the means at hand would afford to the International Ocean Telegraph Company, whose working force had landed at Punta Rasa to build the land route of the telegraph line from Cuba. In the same interest he employed the steamer Corwin, under command of Acting Master Platt, for a short period in February, to examine the coast westward of Havana for the most eligible terminus of the cable intended to pass from Key West to the coast of Cuba.

Tidal observations.—Observations were resumed at Fort Jefferson, Dry Tortugas, Florida, with a self-registering gauge, in charge of Mr. H. Benners, on the 8th of January, 1867. This station is useful as a general point of reference with which to compare the observations made at other places on the Florida Keys and the Gulf Coast of the United States.

GULF STREAM.

Explorations in the Gulf Stream during the past year were mainly for the purpose of affording information required by the International Oceanic Telegraph Company in order to lay a cable from Key West to Havana.

A party was fitted out in the spring and sent under the direction of Assistant Henry Mitchell to the Strait of Florida in the surveying steamer Corwin, Acting Master Robert Platt, commanding. Assistant L. F. Pourtales was associated with Mr. Mitchell and accompanied the party to aid in the investigations and study the organisms brought up in the specimens from the bottom of the strait.

The work commenced off the coast of Cuba, under favorable prospects, about the middle of May, and good progress was made until the 3d of June. At that date yellow fever suddenly broke out on board the Corwin. In the course of the next four days three of her crew died and others on the sick-list were in a critical condition. Under this necessity further operations in sounding were abandoned. The ship on her way northward was fortunately met by a gale from the north when nearing Port Royal, South Carolina, and there the fever cases on board took a favorable turn so that no other deaths occurred.

The work executed during the few days in which operations were continued by Assistant Mitchell was of considerable interest.

Through the intervention of our vice-consul at Havana, Mr. Savage, the steamer Corwin was allowed to rendezvous at Chorrera, the present landing point of the telegraph cable. This little port lies a few miles to the westward of Havana, and is contiguous to the narrow part of the Gulf Stream, which there passes quite near to the coast of Cuba. The season being too far advanced for continuous good weather, this port often afforded shelter from the strong trade winds of mid-day and from the violent squalls of the evening.

The soundings extended about twenty-two miles from the shore beyond the more rapid portion of the stream, and into depths exceeding one thousand fathoms. They develop the profiles of two grand terraces of the coral reef, corresponding (although at different elevations) with the two terraces on the opposite side of the strait discovered by the same party last year. Upon the upper terrace a successful dredging was made at a depth of two hundred and seventy-two fathoms, and in the living organisms examined by Mr. Pourtales, and subsequently verified by Professor Agassiz, representatives of the entire animal kingdom below fishes were found, and nearly all the specimens were new. Other dredgings were made at four hundred and fifty fathoms, and the report confidently mentions the possibility of carrying such researches to any depth yet reached by the lead and line.

Most important questions as to the limits of organized life are thus opened for solution, and would have been solved if the party had been allowed to continue their work a few days more. Accurate current observations were made, not only at the surface of the Strait of Florida, but at depths of three hundred, four hundred, and six hundred fathoms, and the temperatures at these depths were determined. It is a curious result of these observations that no change in the velocity and direction of the stream could be found to account for the thirty-eight degrees of difference of temperature, or indicate a probable cause for the existence of the terraces. The three great features seem to be independent. In the Appendices Nos. 14 and 15 the detailed reports are given as presented by Assistant Mitchell and Assistant Pourtales.

All the purposes of the party were cordially and ably seconded by Acting Master Platt. Under the judicious management of that officer, the Corwin, notwithstanding the untoward circumstances attending her stay in the Strait of Florida, was in a few weeks again fit for service, and was employed during the summer and autumn in the hydrography of Section I.

In running a line of soundings in April from the Tortugas toward the Rebecca Shoals, Acting Master Platt noticed and determined in position the mast of a sunken wreck regarded as dangerous to vessels bound through the channel either to northward or southward. The obstacle, if yet standing, bears from Garden Key light-house, E. by N. ½ N. by compass; distant nine and a half miles.

SECTION VII.

GULF COAST OF WESTERN FLORIDA AND OF ALABAMA, EAST OF MOBILE BAY.

Triangulation near Cape San Blas, Florida.—By reference to the Coast Survey Report for 1861, it will be seen that the triangulation of the vicinity of Cape San Blas was discontinued in the beginning of March of that year. In the year following our parties served either in co-operating with naval or land forces, or in active surveying duty in all the sections of the coast, with the single exception of Section VII, this part of the coast of Florida not having become at any period of the war the site of military or naval operations.

Provision was made for resuming the triangulation near Cape San Blas, by instructions issued to Assistant S. C. McCorkle, on the 1st November, 1866. The schooner Torrey, with the party and requisite instruments, was dispatched from New York on the 21st of the following month, but owing to heavy gales did not reach Apalachicola until the 24th of January. Field-work was at once commenced with reference to an improvement in the previous scheme for turning the sharp point of the coast at the cape. A line across St. Vincent's Island, after being opened with much labor, brought into view from St. George's light-house a station on the main for extending the triangulation into St. Joseph's Bay, (north,) by a line of about ten miles across the peninsula above the cape. Cutting will be required on this line, notwithstanding the platforms for the theodolite at the terminal stations are thirty-five feet high. The broken lines in the sketch are traced between stations intended to be occupied in the early part of the ensuing season. Assistant McCorkle kept the field until the 1st of June, and then laid up the schooner Torrey near Apalachicola. His report includes the following synopsis:

Signals erected	8
Stations occupied	9
Angles measured	40
Numer of observations	2,064

Angular measurements were made with the Gambey theodolites, ten-inch, No. 82, and six-inch, No. 29.

After completing his computation and turning it in, Mr. McCorkle reported in person at the office and assisted in special duty connected with the comparison of base measurements.

Survey of Perdido River entrance, Florida.—The triangulation, begun last year by Assistant J. G. Oltmanns and intended to define the lagoons along the Gulf coast westward from Pensacola Entrance, has been extended so as to connect with a station used in the survey of Mobile Bay. The lower part of Perdido River was included. Its shores were surveyed with the plane-table, and the bar, as well as several miles of the course of the river, were carefully sounded.

Although much enfeebled by ill health, Mr. Oltmanns has prosecuted his work with his accustomed zeal and industry, and did not remit his labors during the summer. Along the beach, lines conformable to the Gulf coast, and making in the aggregate twenty-five miles, were measured with the subsidiary base apparatus. Wherever practicable these lines were connected with the triangulation of the lagoons, and frequent determinations were made of azimuth. With the plane table, the immediate shores of the lagoons were then surveyed and mapped in detail. As the results of his labors Assistant Oltmanns has turned into the office three topographical sheets. One of these sheets represents the Perdido Entrance, another connects with the completed survey of Pensacola Bay, and the third with the completed work of Mobile Bay. The aggregate statistics of this survey are as follows:

Shore-line traced	82 miles.
Area of topography (square miles)	27

A sketch showing the character of the entrance to the Perdido has been issued from the office.

Mr. Oltmanns experienced a severe attack of yellow fever while that malady was prevalent on the Gulf coast, and since his recovery has steadily prosecuted the detailed survey.

SECTION VIII.

GULF COAST OF ALABAMA AND MISSISSIPPI, AND OF LOUISIANA AS FAR WEST AS VERMILION BAY.

Topography of the Mississippi Delta, Louisiana.—The plane-table survey of the delta was resumed in January by the party of Sub-Assistant J. W. Donn. All the passes and intervening bays westward of Pass à Loutre were mapped on two topographical sheets, notwithstanding the difficulty of working with the plane table. One of the expedients employed was a portable tripod for elevating the instrument above the reeds, and by that means the shore-line was traced accurately in places that would not naturally admit of the use of the plane table. Heavy fogs prevailed on the delta, in February and March, but as a rule one or more of the panes was clear while others were enveloped in fog. Advantage was skillfully taken of this circumstance, by Mr. Donn, to push the field-work, and, by additional labor, to improve opportunities for working in adjacent places when it was not practicable to continue operations in any one locality.

The survey of the Southwest Pass was completed early in March, and furnished to Assistant Gerdes, as a basis for the hydrography. The Southeast Pass, and the bayous and islands in its vicinity, were then mapped and traced for the use of the hydrographic party, as was also a sheet containing the resurvey of Pass à Loutre. In connection with the plane-table work, Mr. Donn ran and plotted a line of in-shore soundings from the bar of the Southwest Pass to the bar at the Southeast Pass. The plane-table statistics are as follows:

Shore-line of passes, bayous, &c	440 miles.
Area of topography, (square miles)	90

Among the details presented by the sheets are two hundred and seventeen of the islands and patches that form part of the area of the delta.

During the summer, Sub-Assistant Donn was attached to the party of Assistant Boutelle, in Section I.

Mr. C. P. Dillaway served as aid in the topographical party until the close of March, and was then transferred to the party of Assistant Gerdes, as was also the vessel which had been used for transportation.

Hydrography of the Mississippi Passes, Louisiana.—The important question of selecting the most favorable pass of the Mississippi Delta for improvement, being under consideration in the Engineer Department, soon after the party of Assistant F. H. Gerdes resumed work in this section, the members of the party were placed in communication with Brevet Lieutenant Colonel McAlester, the officer of the corps of engineers who was in charge of the proposed improvement. Mr. Gerdes arrived at the delta early in January, and by the end of March had made such progress as the general prevalence of fogs and strong winds would allow. After the middle of March the survey was conducted with reference to the hydrographic conditions sought by the engineer officers. The schooner Varina and the steam-launch Barataria were steadily employed in the work until the close of operations, early in July, and also the schooner James Hall, after the middle of April.

Sub-Assistant Horace Anderson and Mr. H. L. Marindin, with detached parties, assisted in the hydrography. Messrs. C. P. Dillaway and L. B. Wright were also attached as aids to the party of Assistant Gerdes.

The results of this survey in seven separate sheets have been deposited in the Coast Survey office, with the journals of tidal observations, records of angles, and registers of the soundings. Besides the hydrography of each of the passes, and the bar of each in its relation to the pass, the sheets turned in show also the soundings of the shoal bays between the passes.

For the use of the Engineer Department complete charts of the bars of the Southwest Pass and of Pass à Loutre were delivered to Lieutenant Colonel McAlester, with notes in regard to obstructions, character of bottom, and in general, such particulars as had been specified as desirable in addition to the usual hydrographic details. Tidal observations were made and recorded at four stations. The aggregate statistics of the seven hydrographic sheets are as follows:

Miles run in soundings	506
Theodolite and sextant angles	5, 251
Stations determined	93
Casts of the lead	31, 415

A chart of the passes of the Mississippi River accompanies this report, marked No. 12.

After the close of operations at the delta, Sub-Assistant Anderson and Mr. Marindin were assigned to the charge of work in Section I. Later in the season Assistant Gerdes reported for special duty to the Commissioner of Internal Revenue, in accordance with a request made by the Secretary of the Treasury.

SECTION IX.

GULF COAST OF LOUISIANA, WEST OF VERMILION BAY; AND COAST OF TEXAS.

Resurvey of Galveston Bar and Harbor, Texas.—Sub-Assistant C. H. Boyd was detailed for this and for other service on the coast of Texas, in December, 1866. After setting up a tide-gauge at one of the wharves ot Galveston a party was organized, and Mr. Boyd commenced the resurvey on the 7th of January. The city front and adjacent shore-line, making in the aggregate about twelve miles, were traced from points determined by a triangulation, of which two stations were on the islands of the harbor and two others on Bolivar Point. The hydrography within the limits of the plane-table sheet was developed by about eight thousand five hundred casts of the lead.

Early in February Sub-Assistant Boyd sent to the office the results of his work at Galveston Harbor. He was aided in this locality and elsewhere in the section by Mr. H. G. Ogden, and in the resurvey also by Messrs. G. C. Schæffer, jr., and A. L. Ross.

Having in charge also a survey which will be presently mentioned, Mr. Boyd detached two of the aids for the continuance of work at Galveston Entrance, under the direction of Sub-Assistant F. F. Nes, who had arrived in the section on the 27th of January. With the schooner M. L. Stevens the hydrography was extended so as to include close soundings on the outer bar and the entire entrance to Galveston Bay. Later in the season the work was resumed, and a minute survey of the bay was continued nearly to Edwards' Point, including Half-moon Shoal. The shore-lines of Pelican Island and Bolivar Point were traced by means of the plane table, and observations on the currents of the bay were recorded at eleven stations. These details were completed by the 10th of July. Mr. Nes had erected signals on Red Fish Bar with a view of including that part of the bay in the hydrography, but the prevalence of yellow fever made it inexpedient to retain the party longer in the section. The vessel was accordingly laid up in San Jacinto River.

Mr. Ross remained as aid in the hydrographic party during the entire season. Mr. Schæffer was detached on the 23d of April. Twenty-seven large signals were erected by the party, and fifteen stations were occupied with the theodolite. Sixteen miles of shore-line were traced and soundings made, amounting in the aggregate to fifteen thousand casts of the lead.

An interval of about seven weeks between the two periods at which the work was done in Galveston Bay was occupied in sounding West Bay. Mention of this work will be made under a separate head.

On the 28th of February the party of Sub-Assistant Nes relieved Captain Rae, of the bark Heiress, and part of his crew, whose boat had capsized near the outer bar, and who were at the time making signals of distress. The boat was righted, and having lost her oars in the breakers was towed to the Heiress. A sad counterpart to this pleasing incident will be referred to in connection with notice of the work done at San Luis Pass.

Hydrography of West Bay, Texas.—This work was taken up by Sub-Assistant Nes on the 6th of April. The weather being favorable, rapid progress was made, resulting in an aggregate of over twenty-nine thousand soundings, nearly completing the hydrography of the entire bay before the close of the following month. Twenty-nine signals were erected and twenty-six stations occupied with the theodolite. Supplementary work being then needed for the operations going on at Galveston in charge of the United States corps of engineers, the party was recalled from West Bay.

A fatal accident occurred in the transfer. On the 28th of May Mr. Nes got the vessel under way and ran a line of soundings through the channel of San Luis Pass. In going out soundings were continued across the bar, it having been alleged that the range marks on San Luis Island did not carry through the best water. The report of Mr. Nes thus continues: "In running out there was quite a heavy sea on the bar. The cutter, however, did not ship a bucket of water, and no danger was apprehended in coming in; but when returning, and just on the bar, a succession of heavy seas broke in mid-channel, swamping the cutter almost instantly. She soon drifted into the breakers on the edge of the channel, and while in them it is my painful duty to report that James Goffin and John Rigin, seamen, were lost. The officers and remainder of the crew barely saved their own lives.

"Although a terrific gale sprung up suddenly after the calamity, as thorough a search as possible was made along the beaches in the vicinity of the pass, but I am sorry to say that no traces of the bodies of the unfortunate seamen could be discovered."

Topography of Corpus Christi Bay, Texas.—This work was resumed on the 21st of January by Sub-Assistant Charles Hosmer, with a party in the surveying schooner Peirce. Working southward from the lower end of Harbor Island (Sketch No. 14) the detailed topography was extended until the 2d of May, when the survey was discontinued. The two sheets returned to the office comprise the northern and western shores of Corpus Christi Bay and fifteen miles of the length of Mustang Island, which separates the bay from the Gulf of Mexico. Stated in the usual form the details are as follows:

Shore line surveyed	102 miles.
Roads	49 "
Area of topography, (square miles)	46

The loss of several of the triangulation marks in the lower part of Corpus Christi Bay it is feared will delay the progress of the topography.

Assistant Gilbert while in this section examined the mode of working, and commends the character of the plane-table sheets.

Sub-Assistant Hosmer was employed during the summer and autumn in topographical duty in Section I, as was stated under that head.

Reconnaissance.—At the end of the year 1860 the triangulation of the coast of Texas had been extended southward and westward, and had included Corpus Christi Bay. Reference to the annual report of my predecessor for the year 1861 shows that the triangulation of the Laguna Madre was intended in the scheme of operations for that season. The stations occupied in previous years by Assistant S. A. Gilbert had been carefully marked, but it is incident to the locality that marks are not easily set so as to remain, even if not intentionally displaced. The health of Assistant Gilbert, impaired by constant military duty during a period of about four years, did not admit of his assignment to this section in the season of 1866. He was able, but with difficulty, to visit the parties detailed to work at Galveston Bar and in Corpus Christi Bay in April last; and with the energy which had marked his previous course in the triangulation, his stay in the section was employed in reconnaissance with reference to the further progress of the survey. Of one of the stations under which he had set deep the usual mark in 1860, he says: "The hill upon which it was located has blown away, leaving a large hole in its place." It is probable, however, that the earth marks remain at the terminal stations of his work of 1860, and that the triangulation of the Laguna Madre, which is now in progress, may be closed on them. This is confidently hoped, notwithstanding the fact reported of one of the stations thus relied on, that "Corpus Christi signal is down, and the materials that composed it, as well as the iron station marks, have been used in the construction of a small house close by." The earth marks are probably yet in their places.

As results of the reconnaissance, Mr. Gilbert indicates practicable sites for a base of verification in the vicinity of Corpus Christi Bay, and his report points out the feasible connection of the base with the triangulation.

After passing over the ground of his labors, Assistant Gilbert returned to Zanesville, Ohio, and reported in detail in regard to his observations. Fever and debility, by which he had been several times prostrated before the close of the war, confined him to his home during the summer.

Survey of Laguna della Madre, Texas.—The triangulation, topography, and hydrography of the lower part of the Laguna della Madre, including Brazos Santiago Entrance, were taken up by Sub-Assistant Boyd on the 7th of February. Field-work in the several branches of the survey was prosecuted steadily during the four succeeding months, and closed for the season on the 8th of June. Several of the party were then affected by the prevailing sickness, and Mr. Boyd was dangerously ill.

The progress of this survey was much advanced by the consideration of the late Major General Griffin, who furnished transportation for the party of Sub-Assistant Boyd from Galveston on the steamer Blackbird. One of the stations of the triangulation of this year is on the north side of the mouth of the Rio Grande, and from thence the triangulation was extended to points in the Laguna about twenty miles distant from the Texas boundary. The statistics are as follows:

Signals erected	15
Stations occupied	10
Angles measured	70
Number of observations	1,644

The plane-table survey, when the season closed, included the shore-line of Brazos Santiago Entrance and of Clark's Island and Long Island; also Padre Island, within the limits of the sheet on which it falls; Point Isabel, and the adjacent shores of the main land. These comprise the following aggregates:

Shore-line traced	63 miles.
Roads	11 "
Area of topography, (square miles)	20

During March, April, and May, tidal observations were made half-hourly between 6 a. m. and 6 p. m., and recorded at a station just outside of Brazos Entrance.

The hydrographic sheet sent to the office by Mr. Boyd is nearly conformable to the limits of the plane-table survey. A synopsis on the sheet gives as statistics:

Miles run in sounding	223
Sextant angles	1,262
Number of casts of the lead	14,452

All the field records of the work have been deposited in the office, and the resulting chart of Brazos Santiago has been issued.

Brazos Island not affording suitable ground for a camp, a barrack at the military post was assigned by Major General Reynolds for the use of the party. Sub-Assistant Boyd expresses in his report the many obligations due to that officer for official assistance and personal courtesy.

Mr. Ogden is commended in the field-report for the acceptable and efficient service rendered during the entire season.

Under the head of Section I, mention has been made of the previous and subsequent operations of the party of Sub-Assistant Boyd.

SECTION X.

PACIFIC COAST OF CALIFORNIA.

Triangulation of the Santa Barbara Channel, California.—The work of determining points for connecting the several topographical sheets that embrace the coast of California, in the vicinity of Santa Barbara, was prosecuted during the spring and summer of the present year by Assistant W. E. Greenwell, with a party in the schooner Humboldt. The early part of the season proved more than usually unfavorable for field operations. In April Mr. Greenwell had advanced the coast triangulation to Carpenteria, a distance of twenty miles from San Buenaventura, which station his party occupied near the end of February. Field-work was continued in this vicinity until the close of June, when the operations of the party were suspended for the purpose of making a local survey at a point higher up the coast. In October the triangulation was resumed in the vicinity of Carpenteria, and the party of Mr. Greenwell is yet in the field. The following is an abstract of the statistics of work taken from the last report from the field:

Signals erected	31
Stations occupied	23
Number of observations	4,868

Survey of the vicinity of Point Sal, California.—The feasibility of adding to the safety of the anchorage near Point Sal by the construction of a breakwater having been locally discussed on the supposition that a sunken reef ran in the direction of the intended structure, the wishes of the public respecting it have been met by a development of the locality. Assistant Greenwell reached the vicinity early in August. The point is a bold, rugged headland, and the adjacent country mountainous, with alternate valleys and ridges opposing many obstacles to the ordinary processes for mapping the coast. After selecting and measuring a base line four hundred meters in length, Mr. Greenwell included the vicinity of Point Sal in triangulation, and followed with a plane-table survey of the coast adjacent to the anchorage. A tracing from the map was furnished to Assistant Cordell for the use of the hydrographic party.

Assistant Greenwell had suspended work in the vicinity of Santa Barbara, but resumed it immediately after the completion of the survey at Point Sal, in which his party was engaged until the close of September.

Hydrography near Point Sal.—The roadstead or anchorage near Point Sal was sounded in August and September by Assistant Edward Cordell with a party in the schooner Marcy. The roadstead is about thirty miles northwest of Point Concepcion. Its character as an anchorage is thus alluded to by Mr. Cordell: "The roadstead is open from the southeast to west-northwest, and affords tolerably good shelter against the northwest trade-winds, but is exposed to the heavy swell that sets in from the westward during the summer, and from the southward after the southeast gales of the winter months.

"The best and safest anchorage was found in seven fathoms about five hundred yards to the southward and eastward of Seal Rock, the extreme end of Point Sal being just open."

Sounding was both difficult and dangerous in the vicinity of the outlying rocks and ledges, yet particular attention was given to their development. The result as represented by the chart does not favor the purpose of making a harbor of refuge which can be available at all seasons of the year. A tracing from the chart was furnished to Major R. S. Williamson, of the corps of United States engineers.

The following are statistics of the hydrography:

Miles run in sounding	78
Angles measured	851
Number of soundings	3,687

The chart of Point Sal roadstead is given as Sketch No. 15, accompanying this report.

Topography of the peninsula near San Francisco, California.—In order to meet the purposes of the Engineer Department, having in view the military defenses of the city of San Francisco, the interior of the peninsula has been surveyed by the plane-table party of Assistant A. F. Rodgers. For this work sheets were projected similar to those which contain the marginal topography, so that the work done within the present season connects accurately with the previous surveys. In the hands of Assistant Rodgers, a map is now in progress for the use of the engineers, on which will be combined all the details and features of the peninsula from the ocean back to the shore of San Francisco Bay. As usual in such cases, the field expenses incurred in the extension of the topography have been borne by the Engineer Department.

The working party of Mr. Rodgers was joined about the middle of June by Assistant Cleveland Rockwell, with an additional plane table. Mr. Alexander Chase, the efficient aid of Assistant Rodgers, also worked with a detached party, and thus, although the area of the topography is very large, this important survey has been essentially completed within the limits of a single season. The work includes two new plane-table sheets, and the revision of five sheets of previous work, to represent details as they now exist. The survey of the year embraced one hundred square miles, within which one hundred and twenty-five miles of shore-line were traced.

Owing to the steady connection of Assistant Rodgers with the survey of San Francisco Bay and of the coast adjacent to it, applications, yearly increasing in number, are made to him by persons in search of local or maritime information concerning the Pacific coast.

Hydrography of the Sacramento and San Joaquin rivers, California.—In the latter part of March Assistant Cordell resurveyed the confluence of these two rivers between the towns of Newport and New York, California, the heavy flood of last winter having occasioned considerable changes. During April the soundings were continued in both rivers, extending the hydrographic work about five miles above their confluence near Collinsville.

In connection with the hydrographic party, Sub-Assistant G. Farquhar extended the triangulation of the bay, and determined the position of signals used in sounding. He also traced the shore-line of the rivers to include the additional hydrography. This work was terminated on the 6th of May. The following are statistics of the supplementary hydrography:

Signals determined	58
Miles run in sounding	278
Angles of position	3,285
Number of soundings	18,900

Hydrography of Montezuma and Suisun Creeks, California.—These two important tributaries of Suisun Bay were traced in shore-line, and sounded from their entrances to the head of navigation in July and August by Assistant Cordell with the schooner Marcy. In the last-named channel the work was extended to Suisun City, which is in weekly communication with San Francisco by a line of steamers, as well as by other vessels engaged in carrying agricultural products from the adjacent country

The statistics of this work are as follows:

Miles run in sounding	95
Angles measured	1,868
Casts of the lead	5,844

Assistant Cordell, with the vessel and party, is now engaged in a hydrographic survey of the mouth of the Columbia River in Oregon.

Tidal observations.—The self-registering tide-gauge at San Diego has been continued in operation by Mr. A. Cassidy, and that at San Francisco by Mr. H. E. Uhrlandt. The last-named observer has tabulated as heretofore the readings of the sheets from the self-registering tide-gauges used on the Pacific coast.

The operations at both tidal stations in the section, and at the station in Section XI, have continued under the general supervision of Major G. H. Elliot, of the corps of United States engineers.

SECTION XI.

COAST OF OREGON, AND OF WASHINGTON TERRITORY.

Survey of Tillamook Entrance, Oregon.—This survey has been completed, and the chart accompanies this report as No. 16, although the preparation of the results for publication have devolved upon hands that were not directly concerned in the work.

Sub-Assistant Julius Kincheloe had essentially completed the hydrography of the bar on the 20th of May. The water being smooth at 2 p. m., that opportunity was taken to run a concluding line for the general verification of his previous soundings. In doing this, and while in seven fathoms water, the boat was suddenly swamped by a breaker, and in the next instant capsized. Five of the crew were washed from the bottom of the capsized boat by succeeding breakers, and ultimately Mr. Kincheloe from the mast. The only survivor, James Steel, clung to the mast of the boat until rescued by a lad named George W. Clark, who bravely risked his own life in a very small canoe to save those whom he saw to be in more imminent peril.

On the 1st of July the bodies of Sub-Assistant Kincheloe and Elias N. Steelcup, one of the crew, were found at a point on the coast about fourteen miles distant from Tillamook Bar. The other hands of the party drowned at the time of the disaster were Charles West, Samuel Lanagan, Henry Ballou, and Beveriah Steelcup. All of the crew were residents of Tillamook.

Triangulation of Admiralty Inlet and Puget Sound, Washington Territory.—This work was prosecuted with but little interruption throughout the entire season by the party of Assistant J. S. Lawson, with the brig Fauntleroy. The triangulation was taken up at Point Pully, and was passed southward quite through Admiralty Inlet, including in its course Quartermaster's Harbor and Commencement Bay, and also Colvos Passage along the west side of Vashon Island. In connection with these the work was continued through the Narrows, and pushed into Puget Sound as far as Anderson Island.

From stations at the north end of Admiralty Inlet, Assistant Lawson started a reconnaissance, and in its course prepared the lines necessary for triangulation across the Strait of Fuca to rest on Vancouver Island, near Victoria, and to extend as far westward as the Race-Rock light-house and Point Angeles.

The aggregate length of triangulation extended through Admiralty Inlet and the waters connecting with it is about fifty miles. The general statistics are as follows:

Signals erected	116
Stations occupied	59
Angles measured	400
Number of observations	14, 724

Mr. Lawson was efficiently aided during the season by Mr. J. J. Gilbert.

Survey of Salmon or Shilshole Bay, Washington Territory.—At the request of Governor Pickering, this bay, which is an indentation on the east side of Admiralty Inlet, a few miles north of Seattle, was sounded, and the shores were surveyed by the party of Assistant Lawson. The object of the development is thus stated in the letter of request from the governor of Washington Territory: "The surplus water of Lake Union runs into the eastern point of Salmon Bay, and many persons have thought a navigable channel might be made to connect Lake Union with Salmon Bay. But, before beginning the expenditure of large sums of money necessary for completing such a praiseworthy public inland navigation, it appears very important to understand thoroughly in regard to the depth of water at lowest tide mark in every part of the bay, and up to the eastern point where the creek enters from Lake Union."

A copy of the sheet representing the topography and soundings of the bay was prepared by Mr. Lawson and forwarded to Governor Pickering, at Olympia. The map appears as No. 18 of this report.

The sad event which has been already described made it necessary to send Assistant Lawson to Tillamook Bay in order to collect and forward to San Francisco the property and instruments which had been used by Sub-Assistant Kincheloe. Immediately upon the receipt of the telegraphic dispatch, Mr. Lawson left Olympia, where he had arrived in anticipation of the call, and after much hardship, making part of the journey on foot, reached Tillamook Bay. He found Mrs. Kincheloe prostrated by the disaster which had so suddenly taken away her husband.

After a short delay, to enable her to recover her composure, she was brought to Astoria in the vessel hired for the transfer of the property and effects of the party.

Tidal observations.—The self-registering gauge at Astoria, Oregon, has remained in charge of Mr. L. Wilson, under the general supervision of Major G. H. Elliot, of the United States engineers.

The very careful meteorological record which Mr. Wilson has continued deserves special commendation.

RECONNAISSANCE OF ALASKA.

The opportunity which was presented last June by the action of the department, in sending an agent of the treasury with the revenue cutter Lincoln to Alaska, was improved to organize and forward with that vessel a party qualified for rapid and comprehensive observation of the maritime and other resources of the coast and territory recently ceded to our government by the Emperor of Russia.

Assistant George Davidson, whose name is connected almost exclusively with the work of the Coast Survey done in Washington Territory and whose large experience of the Pacific coast is evinced in his Sailing Directory, was selected to conduct the reconnaissance of the coast of Alaska. The party was fully organized and equipped at San Francisco, and left Victoria in the cutter Lincoln on the 29th of July. Provision was made for the determination of important geographical points, the character of the tides, the magnetic declination, and generally, for the discovery of well situated harbors, of the existence of coal, and of the various resources useful in navigation.

In August and September the prevailing fogs restricted Mr. Davidson mainly to the collateral service which was devolved upon him, of collecting and arranging all previous trustworthy data relative to the resources of the newly acquired territory. At the first opportunity, however, which occurred in October, at Saint Paul, Kadiak, the party was employed in triangulation, and in the determination of latitude, longitude, and the magnetic elements. Later in the month observations of similar kind were made at Unalaska, at Chilkaht, and at Sitka, the operations being closed at the last named port by the departure of the Lincoln, on the 27th of October, for Victoria and San Francisco.

The tides were observed steadily for two months at Sitka, and Mr. Davidson made complete arrangements for the record of tides during winter at that station and at Unalaska. By the unusually severe gale which occurred on the night after the departure of the revenue cutter, and in which the United States steamer Ossipee nearly foundered, the tidal stations at Sitka were swept away. These, it is hoped, are already restored by the observer left in charge by Assistant Davidson.

Sub-Assistants A. T. Mosman and G. Farquhar, and Mr. Stehman Forney, of the Coast Survey, aided Mr. Davidson as members of his party. For the developments in regard to resources, other than those to which the attention of our surveying parties has been commonly directed, he engaged at San Francisco the temporary services of gentlemen qualified in geological and in kindred researches. The results of their observations, in connection with his own relation to the maritime and other resources of Alaska, are fully stated in the report of Assistant Davidson, which accompanies this publication as Appendix No. 18. Charts of the harbors of Sitka, St. Paul, and Iliouliouk, Unalaska, accompany this report as Nos. 21, 22, and 23.

COAST SURVEY OFFICE.

The materials for charts obtained by the field-parties in all branches of the work, astronomical, trigonometrical, topographical, hydrographical, tidal, and magnetical, are brought together at the office in Washington, where the results of observations are computed, and the maps drawn, engraved, electrotyped, and printed for publication. These various operations have been carried on during the past year, as for several preceding years, under the direction of Assistant J. E. Hilgard. The clerical duties arising from the correspondence, general management, and accounts of the office, have been performed by Mr. V. E. King, aided by Mr. W. A. Herbert, during the first part of the year, and subsequently by Mr. William H. Davis.

Hydrographic Division.—Captain C. P. Patterson, hydrographic inspector, as heretofore, remains in charge of this division. The close scrutiny and verification of all hydrographic matter previous to publication, as also the examination and discussion of sheets received from the field, and direction of details in field-work, have been under his immediate supervision; also the necessary repairs and outfit of all vessels required by field-parties.

The duties of draughtsman to this division have been very satisfactorily performed by Mr. Eugene Willenbucher, assisted by Mr. Julius Sprandel.

During the year twenty-seven original hydrographic sheets have been plotted from field-notes, and thirty-four have been verified; five reduced and five enlarged drawings have been made; eleven reduced maps have been verified, and twelve tracings and twenty-nine projections for field-work have been made; in addition to which Mr. Willenbucher has performed a large amount of miscellaneous work, such as the preparation of notes relating to navigation, for the engraved charts, and other details.

Tidal Division.—The duties of this division for the past year have been directed by Mr. R. S. Avery; and, when not engaged in field-duty, Assistant L. F. Pourtales has given the benefit of his experience and knowledge to this division, at times taking the general charge of the observers. Almost daily, information has been furnished for use in the office and field, and in reply to applications for information relating to tides. The tables predicting the time and height of all high waters, for every day in the year 1867, for the principal ports in the United States, were finished and published. Similar tables, but much more complete and accurate, were prepared for 1868 and published.

There have been permanently employed in this division, Mr. John Downes, Mr. A. Gottheil, and Miss M. Thomas, and up to May, Miss F. R. Pendleton, who resigned at that time. Mr. Julius Sprandel also aided until January, 1867, when he was transferred to the Hydrographic Division. In Appendix No. 11 are mentioned the regular stations where tidal observations were recorded.

Computing Division.—Assistant C. A. Schott has, as heretofore, had charge of the work in this division, which has fully kept pace with the current field-work, besides making marked progress in the final reductions and adjustments of the astronomical and trigonometrical work of former years. To the latter computations he has given much of his own labor, in addition to directing in detail the work of the other computers. He has, besides, compiled for the use of the survey three papers on the methods of making and computing astronomical observations for azimuth, latitude, and time; and has conducted since January last a series of observations of the magnetic elements, near the Coast Survey office, on three days near the middle of each month. In January, February, and March he was aided in these observations by Assistant E. Goodfellow. Mr. Schott also made magnetical observations at Hartford, Connecticut, in the month of August.

The work of the computers has been generally distributed as follows: Assistant T. W. Werner made the computation of triangulation; Mr. E. Nulty those of azimuths and latitudes; Mr. J. Main the revisions of azimuth and latitude computations, and the reduction of Pleiades occultations for longitude; Dr. G. Rumpf the computations of verification and adjustment, in which he was assisted by Mr. E. Courtenay.

Drawing Division.—The operations of this division have been performed under the immediate direction of the assistant in charge, who has been efficiently aided in the planning and execution of details by Mr. W. T. Bright.

Appendix No. 3 shows the lists of charts completed or in progress during the year, and also detailed statement of work of each draughtsman during the year.

The information furnished from the Coast Survey Office, by tracings of original sheets, &c., in reply to special calls, is shown in tabular form by Appendix No. 2.

Engraving Division.—The supervision of this division has been continued by Mr. E. Wharton, under the immediate direction of the assistant in charge, until September, when Mr. E. Hergesheimer was placed in charge. The operations of the division for the year, and names of engravers employed, with plates they have worked upon, is given in Appendix No. 4.

The use of the pantograph, as successfully employed in engraving, is described in Appendix No. 5.

Mr. T. H. Rich performed the clerical duties until March, when he resigned, having received an appointment in the army, and was succeeded by Mr. W. N. Meeks.

Electrotype and Photograph Division.—Under the direction of Mr. George Mathiot, thirty-four engraved plates have been duplicated by the electrotype process. The reduction of original field-sheets by the photograph has been successfully continued. Seven positives, twelve negatives, and twenty-six paper prints, (forty-five in all,) have been made, supplying the engravers as wanted.

Division of Charts and Instruments.—The work in this division, which includes besides the safe-keeping of archives, the map-printing, distribution of charts and reports, lithographing and the mechanicians's and carpenter shops, has been directed during the year by Mr. J. T. Hoover. Within the year Mr. G. C. Krebs has engraved on stone Half-moon Bay; plane-table diagrams, (illustrating Appendix No. 22, 1865 Report;) Theodolite Magnetometer, (Sketch No. 29, 1865 Report;) Destruction Island, Washington Territory; City of San Francisco, California; Northwestern America, (in colors,) showing the Territory ceded by Russia to the United States; also miscellaneous notes, circulars, &c.

The duty of registering and filing for convenient reference the original maps and charts of the survey, and the records of observations made in the field, and of keeping an account of the same as they are used in the office, has been performed by Mr. A. Zumbrock.

The work of backing with muslin the sheets required by field and hydrographic parties, and the miscellaneous duties pertaining to the folding-room, were performed during the year by Mr. H. Nissen.

By the press used for copper-plate printing, ten thousand nine hundred and sixty-five copies of charts and sketches have been printed within the year; with the lithographic press nine thousand five hundred and ten copies were printed. The copper-plate press has been worked as heretofore by Mr. T. V. Durham; the lithographic press by Mr. A. Brown.

Distribution of Maps and Annual Reports.—An aggregate of 9,703 copies of charts has been issued within the year, and 5,314 copies of Annual Reports, of various years, have been distributed.

The map-room was, as heretofore, in the care of Mr. T. McDonnell.

Mr. T. J. Hunt was continued as foreman of the instrument shop until January; since then the work has been done, under the efficient supervision of Mr. William Wurdemann, by J. Foller, C. W. Black, and William Jacobi. The woodwork of instruments, their packing for transportation, the construction of cases for maps and copper-plates, and all work of carpentry required in the office, has been performed by Mr. A. Yeatman, assisted by Mr. H. Trine during a part of the year, afterwards by Mr. G. Plimley.

I must repeat the expression of my obligations to the assistant in charge for his able and faithful co-operation in the administration of the office, and for his judicious advice in the conduct of the survey.

My thanks are especially due to the hydrographic inspector, Captain Patterson, for his faithful and comprehensive suggestions in regard to the stimulating and developing of individual thought, and for his wise recommendations concerning commercial and maritime interests, derived from his extensive experience.

It is a pleasure to add to the often recorded testimony of my predecessor that the integrity, care, and forethought of the disbursing agent, Samuel Hein, esq., have been important adjuncts in the direction and superintendence of the work.

The clerical duties of the Superintendent's office have been performed by W. W. Cooper, esq., whose fidelity, zeal, and practical skill deserve this special acknowledgment.

Respectfully submitted:

BENJAMIN PEIRCE,
Superintendent United States Coast Survey.

Hon. HUGH MCCULLOCH,
Secretary of the Treasury.

APPENDIX.

APPENDIX No. 1.

Distribution of the parties of the Coast Survey upon the coasts of the United States during the surveying season of 1866–'67.

Limits of Sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I.				
Atlantic coast of Maine, New Hampshire, and Massachusetts, and of Rhode Island, as far south as Point Judith.	No. 1	Triangulation	C. H. Boyd, sub-assistant	Triangulation of the St. Croix River, Me., connected with primary work at Chamcook station, and reconnaissance for continuing the triangulation to the Boundary Monument. (See also Section IX.)
	2	Topography	W. H. Dennis, assistant	Shore-line survey of the St. Croix River, Me., extended to a point above Calais, and detailed survey continued within the same limits. (See also Section V.)
	3	Special examination	F. P. Webber, assistant	Obstructions in the channel of the St. Croix, near Calais, examined and reported to the Engineer Department. (See also Section III.)
	4	Hydrography	Horace Anderson, sub-assistant; C. P. Dillaway and R. B. Palfrey, aids.	Complete hydrographic survey of Winter Harbor, Me., including its approaches. (See also Section VIII.)
	5	Topography	F. W. Dorr, assistant; H. G. Ogden, aid.	Plane-table survey of the Fox Islands, which lie north of the Thoroughfare, in Penobscot Bay. (See also Section IV.)
	6	Hydrography	Chas. Junken, sub-assistant; J. B. Adamson and Eugene Ellicott, aids.	Hydrography of Penobscot entrance continued eastward to Seal Rock and Saddleback lighthouse, and close soundings made in the vicinity of the islands off the entrance. (See also Section V.)
	7	Hydrography	R. E. Halter, sub-assistant; W. I. Vinal and G. T. Bigelow, jr., aids.	Soundings completed in the vicinity of the Muscle Ridge Islands, Penobscot Bay. (See also Section II.)
	8	Topography and hydrography.	J. A. Sullivan, sub-assistant; Paul Mayor, aid.	Minute survey of Penobscot River, between Hampden and Bangor, and special development of obstructions in the channel, for the use of the Engineer Department. (See also Sections V and VI.)
	9	Inspection and topography.	H. L. Whitney, assistant; Charles Hosmer, sub-assistant.	Plane-table survey of the shores of the Medomak River, and revision of topography in the vicinity of St. George's River, Me. (See also Sections V and IX.)
	10	Hydrography	R. E. Halter, sub-assistant; W. I. Vinal and G. T. Bigelow, jr., aids.	Hydrography completed in Friendship River, and in John's Bay, Me., and nearly completed in the approaches of Medomak River. (See also Section II.)
	11	Hydrography	J. S. Bradford, sub-assistant; A. F. Pearl and Lucien B. Wright, aids.	Hydrography of Sasanoa River, and completion of soundings in the passages between the Sheepscot and Kennebec River. (See also Section IV.)
	12	Shore-line survey and soundings.	C. H. Boyd, assistant	Development of shoals in the Kennebec River, near Hallowell, Me., and shore-line traced for the Engineer Department.
	13		J. A. Sullivan, sub-assistant; Paul Mayor, aid.	Extension of similar work for the use of the Engineer Department, between Shepherd's Point and Gardiner, on the Kennebec. (See also Sections V, VI, and IX.)
	14	Topography	A. W. Longfellow, assistant; H. W. Bache, sub-assistant.	Shore-lines traced and detailed survey continued in Harpswell Sound, Me. Revision of shore-line survey to develop changes in the inner harbor of Portland. (See also Section IV.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I—Continued.	No. 15	Hydrography	Acting Master Robert Platt, U. S. N., *assistant*; Gershom Bradford and G. W. Bissell, aids.	Off-shore hydrography beyond Casco Entrance, and soundings to determine the character of changes in Portland Harbor. (See also Gulf Stream.)
	16	Topography and soundings.	F. F. Nes, sub-assistant	Saco River, Me., developed between its entrance and Saco, for the use of the Engineer Department. (See also Section IX.)
	17	Topography	Hull Adams, assistant; J. G. Spaulding, aid.	Plane-table survey completed on the north side of Portsmouth Harbor, N. H., and topography continued to the vicinity of Wells, Me.
	18	Special survey	Henry Mitchell, assistant; H. L. Marindin and J. N. McClintock, aids.	Merrimack River, Mass., at Mitchell's Falls, completely surveyed and mapped for the uses of a navigation company. (See also Gulf Stream and Section VIII.)
	19	Special investigations.	Henry Mitchell, assistant	Services continued in the advisory council of the Boston Harbor commission.
			L. F. Pourtales, assistant	Examination of specimens from the harbor deposits, to determine their source. (See also Gulf Stream.)
	20	Astronomical observations.	Prof. Joseph Winlock, director of Cambridge Observatory; G. M. Searle, observer.	Exchange of clock signals with Albany and Washington, and observations for local time, to determine difference of longitudes. (See also Sections II and III.)
	21	Hydrography	Horace Anderson, sub-assistant; C. P. Dillaway and R. B. Palfrey, aids.	Soundings near Duxbury, to extend hydrography on the engraved chart of Plymouth Harbor. (See also Section VIII.)
	22	Astronomical observations.	C. O. Boutelle, assistant; J. W. Donn, sub-assistant; C. S. Peirce and F. H. Agnew, aids.	Determination of latitude and the magnetic elements at Manomet, near Plymouth, and at Cliff Station, near Nantucket.
	23	Special survey	H. L. Whiting, assistant; Gershom Bradford, aid.	Comparative survey, showing the present and previous conditions in topography and hydrography of Provincetown Harbor, Mass.
	24	Topography	P. C. F. West, assistant	Plane-table survey of the shore of Cape Cod Bay, continued in the vicinity of West Sandwich, Mass.
	25	Topography	A. M. Harrison, assistant; H. M. De Wees, sub-assistant.	Detailed plane-table surveys, including the vicinities of Providence, R. I., and Fall River, Mass.
	26	Hydrography	F. P. Webber, assistant; F. D. Granger and G. C. Schaeffer, jr., aids.	Soundings in Providence and Seekonk rivers, R. I., to determine the character of obstructions hindering their navigation. General hydrography continued in the western part of Narragansett Bay. (See also Section III.)
		Tidal observations	A. C. Mitchell, G. D. Wooster, H. Howland.	Series of observations commenced at Owl's Head, in Penobscot Bay; observations continued at the Charlestown navy-yard.
SECTION II. Atlantic coast of Connecticut, New York and New Jersey, including Pennsylvania and Delaware, as far south as Cape Henlopen.	No. 1	Magnetic observations.	Charles A. Schott, assistant	Determination of the magnetic elements at a station in Hartford, Conn.
	2	Astronomical observations.	Prof. G. W. Hough, director of Dudley Observatory; Thomas E. McClure, observer.	Exchange of clock signals with Cambridge and Washington, and observations for local time, to determine difference of longitudes. (See also Sections I and III.)
	3	Hydrography	W. S. Edwards, assistant	Water-front of the Battery, in New York Harbor, sounded for the pilot commissioners of New York City. (See also Section VI.) Triangulation of the coast of New Jersey, connected with primary work by lines crossing New York Harbor.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION II—Continued.	No. 4	Topography	C. M. Bache, assistant	Topography of the coast of New Jersey continued from Deal southward to Squan Inlet. (See also Section VI.)
	5	Triangulation	John Farley, assistant	Triangulation of the coast of New Jersey completed between Barnegat light-house and Dry Inlet, south of Absecom.
	6	Hydrography	R. E. Halter, sub-assistant	Soundings across the bar, outside of Barnegat Inlet, N. J. (See also Section I.)
	7	Special examination	R. M. Bache, assistant	Little Egg Harbor, N. J., examined and changes reported to the Light-house Board.
	8	Topography and hydrography.	R. M. Bache, assistant	Minute local surveys made in Delaware River, including the vicinities of Reedy Island and Liston's Point, for the use of the Engineer Department.
		Tidal observations	R. T. Bassett	Series of observations continued with a self-registering tide-gauge, in New York Harbor, at Governor's Island, and with a box-gauge in Brooklyn.
		Bench-marks	A. C. Mitchell	Bench-marks for the reference of tidal observations, made at Barnegat, Absecom, Cape May, Egg Island, and Cape Henlopen. (See also Section I.)
SECTION III. Coast of Delaware and Maryland, and of Virginia as far south as Cape Henry.	No. 1	Hydrography	F. F. Nes, sub-assistant, (part of season;) F. Blake, jr., aid; F. P. Blake, assistant, (part of season.)	Soundings made at the mouth of the Susquehanna River, in the vicinity of Havre de Grace, Md., for the use of the Engineer Department. (See also Sections I and IX.)
	2	Current observations	F. P. Webber, assistant; F. D. Granger, aid.	The currents of Chesapeake Bay, observed in the vicinity of Patapsco Entrance, for the Engineer Department. (See also Section I.)
	3	Astronomical observations.	Geo. W. Dean, assistant; Edward Goodfellow, assistant; F. Blake, jr., aid; in co-operation with Naval Professors Newcomb, Hall, and Harkness.	Exchange of clock signals between Seaton (Coast Survey station,) in Washington City, and the National Observatory, with observations for local time; to determine difference of longitudes; and similar exchanges made with Albany and Cambridge. (See also Sections I and II.)
	4	Hydrography	Clarence Fendall, sub-assistant	Soundings in the Potomac River, between Mason's Island and the Long bridge, at Washington City, and at Georgetown. (See also Section V.)
	5	Triangulation	Charles Ferguson, sub-assistant	Determination of points for the topographical survey of the Potomac River, and of its navigable branches, from Matten Creek to Point Lookout.
		Tidal observations	E. F. Krebs	Observations continued with the self-registering tide-gauge, at Old Point Comfort, Va.
SECTION IV. Coast of North Carolina, as far south as Cape Fear.	No. 1	Triangulation	Richard D. Cutts, assistant; F. W. Perkins, aid.	Primary work perfected at Chesapeake Entrance, and continued south of Cape Henry, Va., by determination with the base-measuring apparatus.
	2	Triangulation	G. A. Fairfield, assistant; J. G. Spaulding and G. T. Bigelow, jr., aids.	Triangulation of the Neuse River, N. C., completed, and connected with primary work in progress in Pamlico Sound.
	3	Topography	F. W. Dorr, assistant; L. A. Sengteller, aid.	Detailed plane-table survey of the shores of Neuse River, extended downward from Beard's Creek to Cedar Point. (See also Sections I and X.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION IV.—Continued.	4	Hydrography	J. S. Bradford, sub-assistant; Stehman Forney, A. F. Pearl, and Lucien B. Wright, aids.	Hydrography of Pamlico Sound, N. C., extended, in the vicinity of the entrance to Neuse River. (See also Sections I and XI.)
	5	Topography	A. W. Longfellow, assistant	Plane-table survey of the shore of Bogue Island, N. C., extended from the site of Carolina City westward to Broad Creek. (See also Section I.)
SECTION V.				
Coast of South Carolina and Georgia, as far south as St. Mary's River.	No. 1	Topography	W. H. Dennis, assistant	Detailed survey of the Sea Islands, completed in the vicinity of St. Helena Sound, S. C. (See also Section I.)
	2	Topographical reconnaissance.	H. L. Whiting, assistant	Field inspection of parties, and examination in regard to proper limits for plane-table work in this section. (See also Section I.)
	3	Topography	Clarence Fendall, sub-assistant	Topography of Wassaw Sound, Ga., completed in connection with survey of the adjacent shore of Savannah River, and of the water passages connecting the sound with that river. (See also Section III.)
	4	Topography	Cleveland Rockwell, sub-assistant, (part of season;) J. A. Sullivan, sub-assistant, (part of season.)	Plane-table survey of St. Catharine's Sound, Ga., continued. (See also Sections I, VI, and X.)
	5	Hydrography	Charles Junken, sub-assistant; J. B. Adamson and Eugene Ellicott, aids.	Hydrography completed in St. Catharine's Sound, including also the seaward approaches and the bar. (See also Section I.)
SECTION VI.				
Atlantic coast of Florida, the reefs and keys, and the gulf coast of Florida, as far south as St. Joseph's Bay, near Tampa.	No 1	Reconnaissance	J. A. Sullivan, sub-assistant	Examination and report upon the condition of the triangulation done between Fernandina and Cedar Keys. (See also Sections I and V.)
	2	Topography	C. M. Bache, assistant	Plane-table survey of the coast of Florida, advanced south of St. Augustine, including Matanzas Inlet. (See also Section II.)
	3	Topography	C. T. Iardella, sub-assistant	Topography completed by plane-table survey of the upper part of Key Biscayne Bay. Detailed survey of the vicinity of Pine Island, completing the topography of Charlotte Harbor, Fla.
	4	Hydrography	W. S. Edwards, assistant; W. I. Vinal and F. Blake, jr., aids.	Hydrography completed in the southern approaches and soundings, continued in the upper part of Charlotte Harbor, Fla. (See also Section II.)
		Tidal observations	H. Benners	Observations with self-registering tide-gauge, at Fort Jefferson, Dry Tortugas.
GULF STREAM.		Deep-sea soundings	Henry Mitchell, assistant; L. F. Pourtales, assistant; Acting Master Robert Platt, U. S. N., ass't.	Special soundings between Key West and the coast of Cuba; and examination of specimens from the bottom of the Gulf Stream. (See also Section I.)
SECTION VII.				
Gulf coast of Western Florida, and of Alabama, east of Mobile.	No. 1	Triangulation	S. C. McCorkle, assistant	Triangulation extended westward from St. Vincent's Sound, and continued around Cape San Blas, Fla.
	2	Triangulation, topography, and hydrography.	J. G. Oltmanns, assistant	Determination of points, and plane-table survey of the Gulf coast, between Pensacola entrance and Mobile Point, including survey and soundings at Perdido Entrance, Fla.
SECTION VIII.				
Gulf coast of Alabama and Mississippi, and of Louisiana, as far west as Vermilion Bay.	No. 1	Topography	J. W. Donn, sub-assistant; C. P. Dillaway, aid.	Plane-table survey of the southeast and southwest passes of the Mississippi River, including the adjacent bayous and islands. (See also Section I.)
	2	Hydrography	F. H. Gerdes, assistant; H. Anderson, sub-assistant; H. L. Marindin and L. B. Wright, aids; C. P. Dillaway, aid, (part of season.)	Hydrography of the Mississippi passes completed. Special developments made in sounding for the Engineer Department. (See also Section I.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION IX.				
Gulf coast of Louisiana, west of Vermilion Bay, and coast of Texas.	No. 1	Hydrography......	C. H. Boyd, sub-assistant, (part of season;) F. F. Nes sub-assistant, (part of season;) H. G. Ogden, G. C. Schaeffer, jr., and A. L. Ross, aids.	Hydrography of Galveston Bar and Entrance, for the use of the Engineer Department. Soundings continued inside of the bay, and hydrography of West Bay, nearly completed. (See also Section I.)
	2	Topography	Chas. Hosmer, sub-assistant........	Plane-table survey, nearly completing the topography of Corpus Christi Bay, Texas. (See also Section I.)
	3	Reconnaissance....	Samuel A. Gilbert, assistant........	Examination of stations and reconnaissance for continuing the triangulation of the coast of Texas, south of Corpus Christi.
	4	Triangulation, topography, and hydrography.	C. H. Boyd, sub-assistant; H. G. Ogden, aid.	Determination of points, shore-line survey, and soundings in the lower part of the Laguna della Madre, including Brazos Santiago. (See also Section I.)
SECTION X.				
Pacific coast of California.	No. 1	Triangulation and topography.	W. E. Greenwell, assistant.........	Triangulation of the coast of Santa Barbara Channel, continued in the vicinity of Carpenteria, Cal. Triangulation and topography of the vicinity of Point Sal.
	2	Hydrography......	Edward Cordell, assistant	Soundings to develop the character of the anchorage near Point Sal, coast of California.
	3	Topography	Aug. F. Rodgers, assistant; Cleveland Rockwell, assistant; Alex. Chase and L. A. Sengteller, aids.	Minute topographical survey of the peninsula near San Francisco, for the uses of the Engineer Department. (See also Sections IV and V.)
	4	Hydrography......	Edward Cordell, assistant	Hydrography revised at the confluence of the Sacramento and San Joaquin Rivers, and soundings extended in both streams above Collinsville, California. Montezuma and Suisun Creeks sounded and connected with the hydrography of Suisun Bay.
		Tidal observations.	Major G. H. Elliot, U. S. engineers; A. Cassidy and H. E. Uhrlandt.	Series of observations continued with self-registering tide-gauges, at San Diego and San Francisco. (See also Section XI.)
SECTION XI.				
Coast of Oregon and of Washington Territory.	No. 1	Shore-line and hydrography.	Julius Kincheloe, sub-assistant......	Survey of the bar and entrance of Tillamook River, Oregon.
	2	Triangulation, topography, and hydrography.	James S. Lawson, assistant; J. J. Gilbert, aid.	Triangulation completed in Admiralty Inlet, and extended into Puget Sound, including also Colvos Passage, Commencement Bay, and Quartermaster's Harbor. Salmon Bay surveyed in shore-line and sounded.
		Tidal observations.	Major G. H. Elliot, U. S. engineers; L. Wilson.	Observations continued at Astoria, with self-registering tide-gauge. (See also Section X.)
ALASKA.		Reconnaissance....	George Davidson, assistant; A. T. Mosman, sub-assistant; G. Farquhar, sub-assistant; Stehman Forney, aid.	Examination of the coast and detailed report on maritime resources. Triangulation and magnetic elements determined; also latitude and longitude at Saint Paul, Kadiak, Unalaska, Chilkaht and Sitka, tidal observations, &c.

APPENDIX No. 2.

Information furnished from the Coast Survey office, by tracings from original sheets, &c., in reply to special calls, during the year 1867.

Date.		Names.	Data furnished.
1867. January	25	Tipton Walker, esq	Topography of Galveston Island, Texas.
	31	Light-house Board	Hydrography of north shore of Long Island Sound, from Stratford Point to Pine Creek Point, including the harbors of Bridgeport and Black Rock, Conn.
February	1	Professor Geo. H. Cook, State geologist of New Jersey	Comparative map of coast of New Jersey, south of highlands of Navesink.
	1	Engineer Bureau	Drawings of topography of entrance to Pensacola and Mobile Bays.
	1	Light-house Board	Hydrographic survey of Horse-shoe Shoal, Cape Fear River, (surveys of 1851 and 1866.)
	12	C. B. Thompson, esq	Topography of Far Rockaway, Long Island, N. Y.
	13	Light-house Board	Hydrographic surveys of York Spit, Rappahannock Spit, Wolf Trap Spit, and shoals off Smith's Point, Chesapeake Bay.
	16	F. L. Olmsted, esq	Topographical survey coast of New Jersey, vicinity of Long Branch.
March	11	Light-house Board	Hydrographic and topographical survey of Point Año Nuevo, Cal.
	11	A. Boschke, esq., Boston harbor commission	Hydrographic survey of Provincetown Harbor and shore-line of Cape Cod.
	11	J. G. Thornton & Co., Pawtucket, R. I	Hydrographic survey of the Seekonk River, R. I.
	11	City of Providence, R. I	Hydrographic survey of Providence River and head of Narraganset Bay.
	16	Engineer Bureau	Hydrographic surveys of Providence Port and Narraganset Bay.
April	3	H. A. Chambers, esq., New York	Survey of Absecom Inlet in 1841.
	11	Engineer Bureau	Hydrographic survey of Hell Gate, Back River, Maine.
	29	Central Railroad of New Jersey	Hydrographic survey of part of Newark Bay, N. J.
June	8	City of Galveston, Texas	Hydrographic surveys of Red Fish and other bars, Galveston Bay.
	15	John Hoey, esq	Topographical survey coast of New Jersey, from Sandy Hook to Thompson's Pond.
	26	Winchester and Prince	Topographical survey of St. Catharine's Island and vicinity, Ga.
	29	City of Richmond, Va	Hydrographic survey of city front.
July	13	Board of pilot commissioners, Savannah	Hydrographic resurvey of Savannah River, from entrance to beyond the city.
	13	City of Savannah, Ga	Survey of city of Savannah, Ga.
	16	Engineer Bureau	Hydrographic survey mouth of Connecticut River.
August	16	Post Office Department	Coast-line measurements.
November	5	Brevet Brig. Gen. M. D. McAlester, corps of engineers	Hydrographic survey of Galveston Bay and entrance in 1850 and 1851.
	5	do do	Hydrographic survey of Galveston Bay and entrance in 1850 and 1867.
	5	do do	Comparative chart of Galveston Bay and entrance, from surveys made in 1851 and 1867.
	5	do do	Comparative chart of entrance to Galveston Harbor and city front, scale 1-10,000, from surveys made in 1851 and 1867.
	9	E. B. Colt, esq	Topographical survey coast of New Jersey, from highlands of Navesink southward.
	29	George W. Blunt, esq	Hydrographic survey of East River, from Governor's Island to Blackwell's Island.

APPENDIX No. 3.

DRAWING DIVISION.

Charts completed or in progress during the year.

1. Hydrography. 2. Topography. 3. Drawing for photographic reduction. 4. Drawing for pantographic reduction. 5. Pantographic engraving. 6. Verification. 7. Lettering.

Title of charts.	Scale.	Draughtsmen.	Remarks.
Eastport Harbor, Maine	1-40,000	1. A. Lindenkohl.	
St. George's River and Muscle Ridge Channel, Maine	1-40,000	1. A. Lindenkohl. 6. E. Hergesheimer. 7. E. Hergesheimer.	
Muscongus Bay and Damariscotta River, Maine	1-40,000	4. E. Hergesheimer. 4. E. Molkow. 4. J. Hergesheimer. 5. E. Molkow. 6. E. Hergesheimer.	Finished chart.
Damariscotta River, Maine	1-40,000	1. L. Karcher. 4. E. Molkow. 5. E. Molkow	Preliminary edition; completed.
White Head light to Seguin Island light, Maine, (coast chart No. 5.)	1-80,000	2. E. Hergersheimer. 2. H. Lindenkohl. 3. E. Hergesheimer. 6, 7. E. Hergesheimer.	
Seguin Island light to Cape Porpoise light, Maine, (coast chart No. 7.)	1-80,000	1. A. Lindenkohl.	
Kennebec and Sheepscot Rivers, Maine	1-40,000	1. A. and H. Lindenkohl. 2. E. Hergesheimer. 6. E. Hergesheimer.	Additions; completed.
Casco Bay, Maine	1-40,000	1. A. Lindenkohl. 4. E. Molkow. 5. E. Molkow.	
Boon Island light to Gloucester Harbor, Mass., (coast chart No. 8.)	1-80,000	2. E. Molkow. 3, 6, 7. E. Hergesheimer.	
Cape Small Point to Cape Cod, Mass., (sea-coast chart No. 3.)	1-200,000	2. A. Lindenkohl	Additions; completed.
Boston Harbor and approaches, Mass	1-40,000	1. A. Lindenkohl. 1. A. Balbach	Additions; completed.
Boston Bay and approaches, Mass., (coast chart No. 9)	1-80,000	1. A. Lindenkohl. 2. E. Hergesheimer	Completed.
Narraganset Bay, R. I., (coast chart No. 13)	1-80,000	2. E. Hergesheimer. 3. E. Hergesheimer.	
Providence Port, R. I	1-10,000	7. E. Hergesheimer	Additions; completed.
Warren River, R. I	1-10,000	1. F. Fairfax. 2. F. Fairfax	Prelim'ry; completed.
New York Bay and Harbor, (coast chart No. 20)	1-80,000	2. E. Hergesheimer. 6. E. Hergesheimer	Additions; completed.
New York Bay and Harbor, (lower part)	1-40,000	1. A. Lindenkohl. 4, 5. E. Molkow. 7. E. Hergesheimer.	
New York Bay and Harbor, (upper part)	1-40,000	4. E. Molkow. 5. E. Molkow.	
Barnegat Inlet, N. J	1-20,000	1. F. Fairfax. 1. L. Karcher. 2. F. Fairfax	Completed.
Chincoteague Inlet to Hog Island light, Va., (coast chart No. 29.)	1-80,000	1. F. Fairfax.	
Cape Henry and southern approaches to Chesapeake Bay, (coast chart No. 37.)	1-80,000	6. E. Hergesheimer. 7. E. Hergesheimer	Completed.
General coast chart No. V, Cape Henry to Cape Lookout	1-400,000	1, 2. A. and H. Lindenkohl. 6, 7. E. Hergesheimer.	
Core Sound, N. C	1-40,000	1, 2. A. Lindenkohl. 1. A. Balbach. 6. F. Fairfax.	Completed.
Lookout Shoals, N. C	1-80,000	2. A. Lindenkohl	Additions; completed.
Cape Fear River, N. C., (entrance sheet)	1-30,000	2. F. Fairfax	Additions; completed.
Charleston Harbor, S. C	1-30,000	1. A. Lindenkohl. 7. E. Hergesheimer	Completed.
Savannah River and Wassaw Sound, Ga	1-40,000	1. L. Karcher.	
Savannah River to Sapelo light, Ga., (coast chart No. 56.)	1-80,000	6. E. Hergesheimer.	
Charlotte Harbor and approaches, Fla., (coast chart No. 75.)	1-80,000	1. H. Lindenkohl. 2. H. Lindenkohl.	
Caloosa Entrance, Fla	1-40,000	1. F. Fairfax. 2. F. Fairfax	Completed.
Charlotte Harbor, Fla., (main entrance)	1-40,000	1. A. Balbach	Additions; completed.
Perdido Entrance, Fla	1-2,500	1. H. Lindenkohl. 2. H. Lindenkohl	Completed.
Gulf of Mexico, (sailing charts)	1-1,200,000	1. A. Lindenkohl	Additions; completed.
General coast chart No. XIII, Cape San Blas to Mississippi Delta.	1-400,000	1. A. Lindenkohl. 2. A. Lindenkohl.	
Lavacca and San Antonio Bays, Texas, (coast chart No. 108.)	1-80,000	2. A. Lindenkohl.	
Aransas and Copano Bays, Texas, (coast chart No. 109)	1-80,000	2. H. Lindenkohl.	
San Francisco Bay, Cal., (upper part)	1-50,000	6. H. Lindenkohl	Additions; completed.
Half-moon Bay, Cal	1-20,000	2. F. Fairfax	Additions; completed.
Point Pinos to Bodega Head, Cal	1-200,000	1. A. Lindenkohl. 2. A. Lindenkohl	Additions; completed.
Koos Bay, Oregon	1-30,000	1. L. Karcher. 7. E. Hergesheimer	Completed.
Destruction Island, W. T	1-40,000	1. F. Fairfax. 2. F. Fairfax	Completed.
Washington Sound, W. T	1-200,000	1. A. Lindenkohl. 2. A. Lindenkohl. 7. E. Hergesheimer.	Completed.

APPENDIX No. 4.

ENGRAVING DIVISION.

Plates completed, continued, or commenced during the year.

1. Outlines. 2. Topography. 3. Sanding. 4. Lettering.

Titles of plates.	Scale.	Engravers.	Remarks.
COMPLETED.			
Pacific coast, Point Pinos to Bodega Head	1-200, 000	4. Knight and Petersen.	
Coast chart No. 21, New York Bay and Harbor	1-80, 000	2. Evans.	
Coast chart No. 36, Chesapeake Bay, York River, to the capes.	1-80, 000	4. Knight. 3. Benner.	
Damariscotta River	1-40, 000	1. W. A. Thompson. 4. J. G. Thompson. 1. Sipe.	Outlines pantographed; soundings punched.
Cape Lookout Shoals	1-80, 000	3. Benner. 4. Davis	New edition.
Cape Fear River Entrance	1-30, 000	1, 2. A. Maedel. 3, 4. Petersen. 3. Benner	New edition.
CONTINUED.			
General coast chart No. IV, Cape May to Cape Henry	1-400, 000	2. A. Maedel.	
Coast chart No. 6, Muscongus to Portland	1-80, 000	2. Evans.	
Coast chart No. 7, Seguin Island to Kennebunkport	1-80, 000	4. Knight. 3. Barnard.	
Coast chart No. 8, Cape Neddick to Cape Ann	1-80, 000	1, 2. Sengteller. 4. E. A. Maedel.	
Coast chart No. 9, Boston Bay and approaches	1-80, 000	2. Enthoffer.	
Coast chart No. 13, Buzzard Bay to Block Island	1-80, 000	4. E. A. Maedel.	
Coast chart No. 27, Cape May to Fenwick's Island light	1-80, 000	1, 2. Rollé.	
Coast chart No. 29, Chincoteague to Hog Island light	1-80, 000	2. Rollé. 4. E. A. Maedel.	
Coast chart No. 37, Cape Henry to Currituck	1-80, 000	4. Knight. 2. Sengteller.	
Coast chart No. 54, Charleston to St. Helena	1-80, 000	4. Knight. 3. Barnard.	
Coast chart No. 67, Florida Reefs, Elbow to Matecumbe	1-80, 000	3. Barnard.	
Coast chart No. 90, west part Mississippi Sound	1-80, 000	4. Knight.	
Coast chart No. 105, Galveston to Oyster Bay	1-80, 000	2. Bartle.	
Camden and Rockport Harbors	1-20, 000	2. Bartle.	
St. George's River and Muscle Ridge Channel	1-40, 000	4. E. A. Maedel. 3. Benner	Preliminary edition.
Kennebec and Sheepscot Rivers	1-40, 000	2. Evans. 3. Barnard and Bartle. 4. Petersen.	
Portsmouth Harbor	1-30, 000	2. Kondrup.	
Nantucket Harbor	1-20, 000	3. Benner. 4. Davis	New edition.
Port of Providence	1-10, 000	4. J. G. Thompson. 3. Benner.	
New York Bay and Harbor, (lower)	1-40, 000	4. E. A. Maedel. 1. Bartle, W. A. Thompson, and Molkow.	Pantographed outlines.
Hampton Roads and Elizabeth River	1-40, 000	3. Benner.	
Core Sound	1-40, 000	1, 4. Sipe.	
Charlotte Harbor	1-40, 000	2. J. G. Thompson.	
San Francisco Bay, (upper)	1-50, 000	2. Kondrup. 3. A. Maedel, Barnard, and W. A. Thompson. 4. Petersen.	
Koos Bay, Oregon	1-30, 000	3. Bartle. 2. W. A. Thompson. 4. J. G. Thompson. 3. Benner. 4. Sipe.	
Diagrams, tides west coast	....	4. Sipe.	
COMMENCED.			
General coast chart No. V, Cape Charles to Cape Fear	1-400, 000	1, 2. A. Maedel. 4. Petersen.	
General coast chart No. XIII, Cape San Blas to Mississippi Delta.	1-400, 000	1, 2, 3. A. Maedel.	
Coast chart No. 5, Whitehead to Seguin Island	1-80, 000	4. Knight. 2. Evans.	
Coast chart No. 30, Hog Island light to Cape Henry	1-80, 000	4. Knight. 1, 2. Rollé.	
Coast chart No. 56, Savannah to Sapelo Sound	1-80, 000	1. Sengteller.	
Coast chart No. 79, Cedar Keys, &c	1-80, 000	1. Sengteller.	
Damariscotta River, &c	1-40, 000	1. W. A. Thompson and Molkow	Pantographed outlines.
Casco Bay	1-40, 000	1. Bartle, W. A. Thompson, and Molkow	Pantographed outlines.
Boston Harbor	1-40, 000	1. Rollé. 3, 4. Petersen	New edition.
New York Bay and Harbor, (upper)	1-40, 000	1. Molkow	Pantographed outlines.
Charleston Harbor	1-30, 000	1, 3. Barnard. 4. Petersen. 3. Benner	New edition.
Caloosa Entrance	1-40, 000	1. Bartle.	
Washington Sound	1-200, 000	4. E. A. Maedel, Davis, and Buckle. 1. Sipe	New edition.
Progress sketches for annual report	....	4. Sipe and Davis.	

APPENDIX No. 5.

THE PANTOGRAPH—ITS USE IN ENGRAVING.

ENGRAVING DIVISION, COAST SURVEY OFFICE,
Washington, December 1, 1867.

DEAR SIR: The want of success attending the early experiments of applying the pantograph to engraving on copper in this division, arose chiefly from the faulty construction of the machines used; faulty in failing to combine sufficient strength with freedom of motion. The experience gained in the topographical bureau of Denmark, enabled Mr. R. Sorensen, of Copenhagen, to make for the Coast Survey two pantographs which have been used during the last two years with results so satisfactory, that I take pleasure in laying before you a short description of the machines and the process of applying them economically as auxiliaries in copper-engraving. (See sketch No. 27.)

A great objection to the pantographs used previous to those made by Mr. Sorensen, arose from the weakness of the joints of the arms, vertically. Mr. Sorensen overcame this difficulty by terminating one end of each arm in a vertical fork, the extremities of which are separated about two inches for the reception of the end of the adjacent arm consisting of a brass bar. The joint is formed by steel screw points through the extremities of the fork, which are received into corresponding sockets in the ends of the bar. This gives a good bracing, vertically, and forms a joint with very little friction. A great advantage of this strength is that it permits the application of adjustable force by means of springs on the engraving point. The weakness of the other machines in the particular noted, required weights to be directly applied on the point, the momentum of which interfered with a free and ready change of direction of motion. The arms themselves of Mr. Sorensen's machines are made very strong, consisting of brass tubes, one inch in diameter, braced longitudinally by a brass rod. Much mechanical skill is shown in the construction of the traverse wheels, which move and change direction very freely. A ground diamond point is used for engraving on the plate and a steel point for tracing the work to be engraved.

The pantograph being only a repeating and not an inverting machine with the points in the same plane, experiments have been made by facing the plate downward in a plane parallel to that in which the tracing point moves. In this manner the drawing may be inverted on the plate, but the difficulty of preserving correct position is so great as to make the mode now employed of obtaining an inverted drawing preferable.

It is seldom possible to use a plane-table sheet for direct reduction by mechanical means on account of the sensitiveness of the paper to the humidity of the atmosphere, which does not act equally in all its parts, resulting generally in a permanent contraction, after the usual exposure in the field. Recourse is therefore had to tracing vellum, a less sensitive material and consequently more permanent in its dimensions, on which a correct projection is constructed, and the original sheet traced minute by minute with great care. The reversal of the tracing gives the reverse image ready for duplicating or reducing.

The table used is made carefully horizontal, the portion receiving the plate being cut out to the depth of its thickness, so that its upper surface comes in the plane of the table. The portion of the table on which the tracing is used is covered with white paper, pasted firmly to it, so that the work on the tracing will show distinctly. The pantograph being set to the proportion the map to be engraved bears to the original, a projection is carefully made on the plate, and the pantograph made fast in the most desirable position for free motion within the best range for accuracy. The diamond or engraving point is then set on each point of intersection of the parallels and meridians of the projection on the plate, the position of the tracing point at the opposite end of the pantograph being marked in each case, so that a projection of the scale of the original is thus constructed on the table, to which the tracing is carefully set, minute by minute.

As there is a limit to the strength of the line a diamond point will cut without danger or injury, those lines that are required of a strength greater than this limit, such as roads, fences, &c., are only drawn in with a light line as a guide for the engraver; other portions, such as contours of hills, are cut finally, the strength of line being regulated by springs acting on the diamond point and adjustable for different forces.

The advantage gained by dispensing with the old methods of reduction, which required an experienced draughtsman at an expense quite equal to the present cost of the completed outlines in the plate, together with the greater accuracy resulting from but one operation mechanically in reducing from the original to the plate, is apparent, when we consider the usual process of drawing, tracing, transferring, and entering by hand, involving four distinct operations, each liable to more probable error than the one operation performed with the pantograph.

The usual operation requires skilled labor, that by the pantograph requires only patience, judgment, and application, and such skill as can easily be acquired by those of average intelligence.

This process, too, works to the advantage of the engraver in dispensing with the least agreeable operation of his art and giving him cleanly entered work ready for the point and graver.

The work, with the present pantographs, has been done under my direction, by Mr. E. Molkow, to whose patience and cheerful application through details so trying, much of the success so far achieved is due.

Respectfully, &c.,

E. HERGESHEIMER,
Assistant Coast Survey, in charge of Engraving Division.

J. E. HILGARD, Esq.,
Assistant Coast Survey, in charge of Office.

APPENDIX No. 6.

ON THE LONGITUDE BETWEEN AMERICA AND EUROPE FROM SIGNALS THROUGH THE ATLANTIC CABLE.

I.—ORIGIN OF THE COAST SURVEY EXPEDITION.

The determination of longitudes by means of the electro-magnetic telegraph was, as is well known, first practiced by the United States Coast Survey; and the methods by which it attained its full development were here in use several years before they began to be employed elsewhere. From the year 1849 until the beginning of the late war, early in 1861, they were unremittingly prosecuted. At that time twenty-four independent determinations had been made, no pains being spared for the attainment of all possible precision, and the series of telegraphic longitudes extended from the northeastern boundary to New Orleans, covering two and a half hours of longitude, and fifteen degrees of latitude, within our own territory, as well as some portions of the British provinces. Upon the completion of the Pacific telegraph, arrangements were made* for extending the connection to San Francisco, but these were reluctantly deferred in consequence of the condition of the country.

For longitudes reckoned from any transatlantic zero, much coarser results only have hitherto been attained; and the uncertainty of the determinations has been twenty or thirty times greater than that between any of the points which form the series of American determinations, and very much larger than that between any points referred to these fundamental ones by the geodetic operations of the survey.

The Atlantic cable promised, at last, to afford an opportunity of connecting the American with the European longitudes, and thus of practically reducing the two independent series of determinations into what should practically be but one. The large views of the late honored head of the Coast Survey, Professor Bache, led him to take immediate steps for the attainment of this end; and upon the first organization of the Atlantic Telegraph Company, to the assistance of which he gave his hearty and effective support, he obtained† from the officers of this and of the Newfoundland companies their ready promise of all needful facilities for determining the relative longitude of their terminal stations.

Immediately upon the landing of the cable at Trinity Bay, Mr. Hilgard was dispatched to this remote spot, in order to decide, from personal inspection, whether the communication was sufficiently good to permit of satisfactory longitude signals without delay; but his report was necessarily adverse.

Upon the organization of the telegraphic cable expedition of 1865, Mr. Hilgard, who, during Professor Bache's illness, was acting in his behalf, obtained anew from the respective companies permission for our use of the cable, if successfully laid, and the honorable Secretary of the Treasury authorized the necessary outlays. Mr. L. F. Pourtales repaired to Heart's Content, and there awaited the arrival of the Great Eastern, in order to notify me, without delay, of the character and availability of the signals, should the cable be successfully laid; but the rupture of the cable, in mid-ocean, made his expedition unavailing.

The same preliminary steps were again taken in 1866, Mr. G. W. Dean awaiting the arrival of the Great Eastern at Heart's Content. The expedition of this year was happily successful, and Mr. Dean reported, by telegraph, that the sharpness of the signals was all that could be desired. Measures were at once taken for organizing the parties. Mr. Dean returned only a few hours too late to present his report while we were attending the session of the National Academy of Sciences, at Northampton, but he found Mr. Hilgard and myself at the meeting of the American Association, in Buffalo, where all the details for the expedition were arranged without delay, and the needful directions for preparation of instruments and observers given by Mr. Hilgard.

The large interval between the meridians of the two extremities of the cable precluded the

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* Coast Survey Report, 1861, p. 2.

† Coast Survey Report, 1858, pp. 33, 34, 43; 1859 p. 6.

employment of the method of star-signals, for many reasons. This method requires a more protracted occupation of the cable than it seemed right or reasonable to solicit. The climate of Newfoundland, according to the best information received, is too variable and uncertain to warrant reliance upon the continuance of a clear sky for three hours, while, unless they should promise favorably, it would be unwise to employ the cable for transmitting observations from Valencia, which would be useless, unless combined with subsequent observations of the same stars from Heart's Content. Moreover, for a longitude so great as that to be measured, the special advantages of the method of star-signals chiefly disappear, the clock-rates becoming matters of serious importance, and entailing errors of the same order of magnitude as those of the absolute time-determinations, while the wide separation of the observers precludes that thorough elimination and control of personal equation which is feasible when the longitude observations are restricted to zenithal stars, and the observers can easily exchange positions and frequently meet at one or the other station.

There was also ground for confidence that the catalogue of standard stars to be employed for determining time was so well freed from systematic errors that the difference of half a quadrant in the meridians would introduce no error, depending on the right ascensions, no matter at what hour the comparisons might be made—a confidence which the event has fully justified.

II.—Previous Determinations of the Transatlantic Longitude.

The several determinations of longitude between European and American stations, which have hitherto served as the basis for astronomical and nautical computations, may be classified under three heads—*from moon culminations; from eclipses and occultations;* and *from chronometers.* Most of them have been referred to one or the other of two American points—the College Observatory, at Cambridge, and the Naval Observatory, at Washington. The former has presented especial conveniences for the chronometric expeditions, both from its close vicinity to the point of landing and shipment in Boston, and from the charge of these expeditions being confided to the director of the observatory, who was specially versed in chronometric matters, and whose office in Boston was connected with the Cambridge clock by a telegraph wire, so that not even the transportation to the observatory was requisite. The latter, as situated at the national capital, and administered by one of the departments of government, has been naturally selected, in most cases during recent years, as the fundamental point for other determinations. As the European point of reference, Greenwich has been employed in all cases.

The telegraphic longitudes of the Coast Survey have, since the first year, been uniformly referred to a third American point, the Seaton station of the Coast Survey, in the City of Washington; but the longitudes of New York and Philadelphia, upon which that of Cambridge depends, were referred to the Washington Observatory, which is situated* $12^s.44$ westward from the Seaton station, by geodetic measurement. The longitude between Cambridge and Washington, as determined by my predecessor, Mr. Walker, in 1848 and 1849,† is as follows:

	h.	m.	s.
Cambridge, east from Mr. Rutherford's Observatory, New York	0	11	26.07
Mr. Rutherford's, east from Jersey City station, (geodetic)			11.93
Jersey City station, east from Washington	0	12	3.54
Cambridge, (dome,) east from Washington	0	23	41.54

And this value has, since that time, been adopted in all computations and in the standard books of reference. It must be very near the truth, yet it depends in part upon a geodetic measurement across the Hudson River, where no telegraph wire then existed, and was the earliest determination by the new method, before the employment of many refinements and precautions since introduced. Moreover, the portion between Jersey City and Washington was deduced from the simple telegraphic comparison of clocks, a method which repeated experience, as well as theory, shows to

* Value determined since that given in the C. S. Report, 1851, p. 322.
† Coast Survey Report, 1848, p. 22; 1849, pp. 19, 20, 31.

be entirely inferior in precision to the Coast Survey method of star-signals. For this reason, I have more than once urged a redetermination of the only weak link in our chain of telegraphic longitudes, by connecting Mr. Rutherford's Observatory at New York with the Seaton station, as well as the Washington Observatory, by the same methods which have been employed for all the other measurements from our boundary to New Orleans.

Using the value above cited, the following are the determinations of the longitude of Washington from Greenwich which have appeared best entitled to confidence in recent years:

I. *From eclipses and occultations.*—These furnished the values generally adopted prior to the year 1848; namely, not less than $5^h\ 8^m\ 14^s$. Thus, Gilliss, in 1846, used[1] $5^h\ 8^m\ 4^s.6$ for the provisional observatory on Capitol Hill, which was,[2] geodetically, $10^s.05$ east of the present observatory. And in the volume of observations made in 1845, the first issued by the Washington Observatory, the adopted longitude is given[3] as $5^h\ 8^m\ 14^s.64$.

Peirce's reductions, in 1845, of occultations observed by Bond at Dorchester, from 1839 to 1841, gave[4] $5^h\ 8^m\ 13^s.9$; Walker, from an elaborate discussion of all available observations between 1769 and 1842, inclusive, obtained[5] $5^h\ 8^m\ 14^s.16$, a value subsequently[6] reduced to $13^s.81$ by change in the adopted longitude of Philadelphia, Cambridge, and Washington. In 1839 Walker had deduced a new value for the moon's horizontal parallax from a discussion[7] of the eclipse of 1836, May 14, according to which the mean value used by Burckhardt in the lunar tables, employed in the computation of the longitude, required an increase of $1''.52$; and he discovered[8] that, although the probable accidental error of his former result for the longitude of Philadelphia was but $\pm 0^s.35$, (subject, however, to the influence of any error in the adopted parallax and semi-diameter of the moon,) yet the employment of his new value of the horizontal parallax would diminish the longitudes assigned to all the stations of the Coast Survey by about two seconds of time. Prof. Airy, at Greenwich, had already adopted,[9] in reducing the Greenwich observations of 1840, Henderson's determination,[10] according to which Burckhardt's constant required to be increased by its twenty-six-hundredth part. So, too, Olufsen, from discussion,[11] in 1837, of Lacaille's meridian altitudes at the Cape of Good Hope, had inferred the need of an increase of this constant by $2''.24$, and Henderson in the same year, from his own observations with the mural circle at Cape Town, deduced[12] $1''.3$ as the requisite increase. All these investigations, though greatly varying among themselves, agreed in the result that Burckhardt's value was decidedly too small, and corroborated thus the change which Walker's computation of the eclipse of 1836 showed to be necessary. Relying on these confirmations Walker adopted[13] the correction $+1''.5$ to Burckhardt's constant, and found that the transatlantic longitude deduced from eclipses was thus diminished by $2^s.67$ for the whole coast of the United States. The report of the astronomer royal concerning the reductions of the Greenwich lunar observations appeared soon after, and indicated[14] that Burckhardt's coefficient required an increase by its twelve-hundredth part, or $2''.85$, thus dissipating any yet remaining doubts as to the necessity of a large diminution of all American longitudes counted from a European meridian.

We thus have at present, from observations of eclipses and occultations,

	h. m. s.
Walker[15], corrected value from observations before 1843	5 8 11.14
Peirce[16], from eclipse of 1851, July 28	11.57
Peirce[17], from emersions of Pleiades, 1839, September 26	11.45 ± 0.3
Peirce[18], from emersions of Pleiades, 1856–1861	13.13

but neither of the last three determinations is considered by Professor Peirce as final.

[1] Gilliss Astr. Obs., p. x.
[2] By Ellicott's original survey of Washington City, see Report, 1846, p. 72.
[3] Wash. Obs., 1845, p. 87.
[4] Coast Survey Report, 1846, p. 71.
[5] Coast Survey Report, 1848, p. 113.
[6] Coast Survey Report, 1851, p. 480.
[7] Trans. Amer. Phil. Soc., VI, p. 383.
[8] Coast Survey Report, 1848, p. 115.
[9] Greenwich Obs'ns, 1840, p. xlviii.
[10] Mem. R. Astr. Soc., X, p. 283.
[11] Astr. Nachr., XIV, p. 226.
[12] Mem. R. Astr. Soc., X, p. 294.
[13] Coast Survey Report, 1851, p. 480.
[14] Monthly Notices R. Astr. Soc., VIII, p. 186; Mem. R. Astr. Soc., XVII, p. 52.
[15] Coast Survey Report, 1851, p. 480.
[16] Coast Survey Report, 1861, p. 195.
[17] Coast Survey Report, 1861, p. 220.
[18] MS. report in Coast Survey Office.

II. *From moon culminations:*

	h. m. s.
Walker[1], from Cambridge observations, 1843–45	5 8 10.01
Loomis[2], from Hudson observations, 1838–44	9.3
Gilliss[3], from Capitol Hill observations, 1838–42	10.04
Walker[1], from Washington observations, 1845	9.60
Newcomb[4], from Washington observations, 1846–60	11.6 ±0.4
Newcomb[5], from Washington observations, 1862–63	9.8

Walker considered $9^s.96$ as the most probable value from moon culminations, and Newcomb assigned $11^s.1$ as that indicated by those observed at the Naval Observatory, from 1846 to 1863, inclusive.

III. *From chronometers transported between Boston and Liverpool:*

	h. m. s.
Indiscriminate mean[6] from 373 chronometers previous to 1849	5 8 12.46
Bond's[7] discussion of 175 chronometers, expedition of 1849	11.14
Walker's[1] discussion of 175 chronometers, expedition of 1849	12.00
Bond's[8] discussion of 175 chronometers, expedition of 1849	12.20±0.20
Bond's[9] discussion of 52 chronometers, six trips, expedition of 1855	13.43±0.19

All of these values require to be increased by $0^s.06$ to conform to the new telegraphic determination[10] by the astronomer royal of the longitude between Liverpool and Greenwich.

The discordance of results, which individually would have appeared entitled to full reliance, is thus seen to exceed four seconds; the most recent determinations, and those which would be most relied upon, being among the most discordant. No amount of labor, effort, or expense had been spared by the Coast Survey for its chronometric expeditions, inasmuch as the most accurate possible determination of the transatlantic longitude was specially required[11] by law; and the thorough accuracy of Professor Newcomb's investigations is well known to astronomers. Yet the result of the latest chronometric expedition differs from that deduced by Newcomb, from moon culminations observed at the Washington Observatory since its regeneration, compared with those observed at Greenwich,—by more than three and a half seconds of time.

The value employed by the Coast Survey, from 1852 to 1859, was $5^h\ 8^m\ 11^s.2$; since 1859 it has been $5^h\ 8^m\ 11^s.8$.

III.—History of the Expedition.

The building erected in Calais, Maine, and occupied as a longitude station in 1857, was still in existence, though much dilapidated, the stone piers being undisturbed. Mr. George Davidson, assistant in the Coast Survey, was to take charge of this station, with Mr. S. C. Chandler, jr., as aid. Mr. Dean was assigned to the station at Heart's Content, with the assistance of Mr. Edward Goodfellow, while I was to occupy the Valencia station, Mr. A. T. Mosman accompanying. Each station required a small transit instrument, a chronograph, and an astronomical clock.

The most questionable feature of the arrangement was the use of the land line of wire, about 1,100 miles long, between Heart's Content and Calais. Hitherto all our telegraphic longitudes have been determined without any use of "repeaters," or double relay magnets, which have been most carefully avoided as inevitably introducing an additional element of error, or at least of uncertainty into the result. The armature times of different electro-magnets, acted on by galvanic currents of different intensities, enter into the result, and only their mean amount is eliminated, while one-half their difference is inseparably merged with the resultant longitude. Between Calais and Heart's Content there were known to be not only several of these repeaters, but also one or two stations,

[1] Coast Survey Report, 1851, p. 480.
[2] Astr. Journal, I, p. 67, using telegraphic longitude of Huson, from Washington, as given by Walker, C. S. Rep. 1851, p. 481. See also Trans. Amer. Phil. Soc., X, p. 10.
[3] Trans. Amer. Phil. Soc., X, p. 223. Wash. Obs., 1862, p. vii.
[4] Wash. Obs., 1862, p. lii.
[5] Wash. Obs., 1864, p. 46.
[6] Coast Survey Report, 1851, p. 480.
[7] Coast Survey Report, 1850, pp. 17, 19.
[8] Coast Survey Report, 1854, pp. 120, 138, 141.
[9] Coast Survey Report, 1856, p. 182.
[10]
[11] Coast Survey Report, 1858, p. 32.

at least where the messages were received and resent by hand, without the intervention even of an automatic repeater. Yet not only our financial resources, but also our available time and our supply of instruments, precluded the occupation of more than three stations at once, and it was reluctantly decided to make use of so many repeaters in this interval as careful investigation should show to be absolutely necessary.

Messrs. Davidson and Dean left Boston for Halifax, in the steamer of September 5, to make an examination of the condition of the telegraph line, and a week later Messrs. Goodfellow, Mosman, and myself sailed in the Cunard steamship Asia, bound for Liverpool via Halifax and Queenstown, taking the instruments for Newfoundland and Ireland. But a short time before our departure, the welcome tidings had arrived of the recovery in mid-ocean of the lost cable of 1865, and of the successful continuation of this second line to Newfoundland.

To the courtesy and interest of the officers of the Cunard Company we were indebted, from the beginning to the end of our expedition, for many favors and much assistance. The cordial sympathy of Captain J. P. Anderson, of her Britannic Majesty's mail steamer Africa, then temporarily in command of the Asia, was of peculiar value, and calls for the sincerest acknowledgments. I may also mention here our obligations to Mr. Grierson, agent of the Cunard steamship at Queenstown, who, both at the debarkation and reshipment of the instruments, assisted in the most effective manner.

At Halifax the accounts given by Messrs. Davidson and Dean were far from encouraging. Between the terminus of the Atlantic cable and the American frontier there proved to be four repeaters, and two stations at which messages were re-written. Repeaters and batteries were at once provided by us for use at these last-named stations, and it was decided that Mr. Davidson should charter a schooner in which to visit the various points along the coast of Nova Scotia, Cape Breton Island, and Newfoundland, carrying with him the necessary outfit and giving the requisite instructions to the operators.

This Mr. Davidson successfully accomplished by dint of great energy and personal exertion, while Mr. Chandler, at his direction, refitted the Calais station and mounted the instruments, the first observations made there being on the 25th of October.

Messrs. Dean and Goodfellow reached Heart's Content on the 20th September, and proceeded to the immediate preparation of an astronomical station; but were not favored with the sight of any celestial luminary until the 16th October, on which day they brought the transit and clock into tolerable adjustment, and on the 18th their regular observations commenced.

On the morning of Saturday, September 22, the Asia arrived off Queenstown, where Mr. Mosman landed with the instruments, while I kept on the voyage to Liverpool, and thence to London to confer with the officers of the company.

The management and control of the cables being with the Anglo-American Telegraph Company, which had conducted the expedition of 1866, and not with the Atlantic Telegraph Company, on whose friendly promises of assistance we had depended, it became necessary to apply anew for permission to use the lines, and for the needful facilities at Valencia. To the cordial friendliness of George Saward, esq., secretary of the Atlantic Company, we had already been indebted for many acts of courtesy, and he aided me without delay in the most effective manner.

The use of the cables was at once granted by John C. Deane, esq., secretary of the Anglo-American Company, subject, of course, to the condition that the observations and experiments should not interfere with the regular business of the company; and I was furnished by him with letters to the telegraphic staff at Valencia. From the eminent electrician to the company, Latimer Clark, esq., I received much valuable information and important practical suggestions, as well as full authority for the trial of electro-magnets in connection with the cables, beside the needle-galvanometers in use by the company.

The astronomer royal also gave his ready sympathy to the undertaking. His own plans had been formed, authority obtained, and some of the preparations already commenced for making a telegraphic longitude determination between Valencia and Newfoundland in June next; but with extreme kindness he placed me in possession of all his special information pertaining to the subject, and aided our operations with word and deed. Subsequently, when, to my own great regret as well as to his, it proved necessary to establish our station at the cable terminus, near the western en of the Island of Valencia, rather than at either of the two points for which he had already determined the longitude from Greenwich, he carried out a third determination of longitude for Valencia, by a telegraphic interchange of signals between Greenwich and our station at Foilhommerum Bay.

On the 1st October I met Mr. Mosman at Killarney. According to previous arrangement he had already brought the instruments to that point by rail, and had visited Valencia to examine the ground and learn what provision would be required for the stone piers of our transit instrument and clock, and for the materials of our astronomical station. From his report it was manifest that the requisite supplies could be obtained upon the island, or in its immediate vicinity, and early on the morning of October 2 we started westward. The six large boxes of instruments were piled and carefully made fast upon a large "Irish car," the only vehicle upon springs to be found in the town, and the transportation of this huge tower on wheels forty-two miles to the ferry, across the Straits of Valencia, and deposit of the instruments in a place of shelter, were accomplished without accident before daylight had wholly disappeared.

The longitude stations occupied by Mr. Airy in the great chronometer expedition of 1844, (Greenwich observations, 1845,) was at Feagh Main, an elevated position previously used as a station by the British Trigonometrical Survey; his transit instrument being placed upon the station-point. For the telegraphic determination of 1862, the instrument used for determining time was mounted in the village of Knightstown, at the eastern extremity of the island. The employment of the same station-point, the position of which was well marked, was of course highly desirable. Moreover, it was situated at that point of the island which afforded by far the greatest conveniences, and it was close to the hotel. But the electricians of the company have always been extremely averse to any connection, however brief, between the cable and any land lines, on account of the possibility of injury to the cable by lightning. This fact, to say nothing of others connected with prompt exchange of messages with Newfoundland, and a readiness to avail ourselves of any sudden change of weather at either place, rendered it imperative that our station should be established very near the building of the telegraph company at Foilhommerum Bay, five and one-half miles west of Knightstown, and remote from any other dwelling-house except the unattractive cabins of the peasantry.

Here, as close to the telegraph-house as was consistent with an unobstructed meridian, the astronomical station was established, and a building constructed eleven feet wide and twenty-three feet in length. This was divided by a transverse partition into two apartments; the larger of these serving as an observatory, while the eastern end was used as a dwelling place. This building was bolted to six heavy stones buried in the earth, and was protected from the southwest gales by the telegraph-house, the corner of which was within a very few yards at the nearest point; while rising ground to the northwest guarded us against the winds from that quarter.

In the observing-room were mounted the transit instrument, clock, and chronograph. It also contained a table for a relay magnet and Morse register, and a recording table.

For the kind reception which we met at Valencia, I know not how to give an adequate expression of my thanks. A more hearty welcome, a more thorough and delightful hospitality, or more friendly aid, could have been found at no time or place. The inevitable hardships and exposure of our life, at a distance from any permanent habitation other than the over-tenanted house of the telegraph company, and under circumstances apparently incompatible with comfort, were thus mitigated and compensated to an incredible degree.

To the Knight of Kerry we were indebted, not only for a hospitality worthy the traditional reputation of the land, and for which we shall always remain personally grateful, but also for the most practical and efficient aid in furtherance of our operations. All his agents received instructions to assist us by every means in their power; his buildings afforded storage for our instruments at Knightstown; his quarries and stone-cutters furnished piers; his factor enabled us to obtain lumber; and his carpenter was detailed for expediting the work upon our building.

The gentlemen of the telegraphic staff received us with a kindliness to which there was no exception; welcoming us to their quarters, and sharing with us their comforts.

Of the sixteen electricians and operators in the service of four different companies, there is no one to whom we are not indebted for essential aid in our work, as well as under personal obligations for many acts of kindness. To James Graves, esq., superintendent of the station, and Edgar George, esq., second in charge, we owe especial acknowledgments.

The peculiarly unastronomical sky of Valencia delayed adjustments for a while, but one or two glimpses of the sun at noon enabled us to establish our meridian, and on the 14th October, at 3^h a. m., we obtained transits of a few stars. At that time the observers in Newfoundland had seen neither sun, moon, nor stars, and I am inclined to believe that, excepting the short periods when sharp frosts prevail there, the climate of Newfoundland is nearly as unfavorable for astronomical purposes as that of Valencia itself. As regards the Valencia climate, I was informed on our arrival that it had rained every day, without exception, for eight weeks. During the seven weeks of our sojourn there were but four days on which no rain fell, and there was but one really clear night during the period while the instruments were in position. The observations were, in general, made during the intervals of showers; and it was an event of frequent occurrence for the observer to be disturbed by a copious fall of rain while actually engaged in noting the transit of a star.

The method of telegraphing through the Atlantic cable is based upon the ingenious device of Professor Thomson, in applying to a delicate galvanometer the principle of reflection used by Gauss for heavy magnets. A small mirror, to the back of which is attached a permanent magnet, the joint weight of the two being from five to six centigrams, is held by means of a single fiber above and below, in the center of a coil of fine wire which forms part of the galvanic circuit, and its position and sensitiveness are regulated by movable bar-magnets placed in the immediate vicinity. Upon the mirror is thrown a beam of light through a slit in front of a bright kerosene lamp, and the deflections of the needle are noted by the movements of the reflected beam, which is received upon a strip of white paper. The exquisite delicacy of this galvanometer, as well as the electrical excellence of the telegraph cables, may readily be appreciated after the beautiful experiment in which the electricians at Valencia and Newfoundland conversed with each other on a circuit not far from 700 myriameters (4,320 statute miles) in length, formed of the two cables joined at the ends, using a battery composed of a percussion gun-cap, a morsel of zinc, and a drop of acidulated water.

The absence of any means for the automatic registration of signals received presented, of course, a very serious obstacle in the way of an accurate longitude determination, inasmuch as the loss of time in noting the signals was not only very considerable, but quite uncertain; but the programme of operations which I had prepared before leaving home was based upon the assumption that the use of self-registering electro-magnetic signals would not be acceptable to the telegraph company. All objections to these were, however, waived in our favor by Mr. Latimer Clark in the most cordial manner, and considerable time was expended on two evenings in endeavoring to obtain satisfactory signals which should be self-registering. Unfortunately, these efforts were unsuccessful. The cable could not be discharged with sufficient rapidity for the purpose when the charge was sufficiently strong to actuate our most sensitive electro-magnet. A permanent deflection, only, was observed at Newfoundland, while the Valencia clock was breaking the circuit during an eighth part of every second; nor did any modification in the character of the battery render these interruptions of continuity perceptible at the other extremity of the cable.

I had previously designed availing myself of an elegant suggestion of Dr. Gibbs, by which the heat from the lamp should be concentrated and reflected, together with the light, by the mirror-galvanometer; being then received on a very delicate thermo-electric pile, which should thus record upon the chronograph the time of the signals. But too little time was available for the purpose, and although Mr. Farmer, whom I had requested to prepare some apparatus based on this principle, made sufficient progress with his experiments to show the practicability of the suggestion, he was obliged to abandon all hopes of constructing any satisfactory instrument in season to be available for our purposes.

Thus it became necessary to fall back upon the original programme, which had been prepared before leaving Boston, and furnished to Messrs. Dean and Davidson. This was as follows:

PROGRAMME FOR TRANS-ATLANTIC LONGITUDE CAMPAIGN.

This campaign will consist of two parts, "Heart's Content—Calais" and "Valencia—Heart's Content."

Star signals being impracticable in each case, the only determinations of longitude will be by comparisons of clocks between the stations. Consequently, no precautions should be omitted which can in any way increase the precision of the clock-corrections and rates. Only stars of the American Ephemeris should be employed; levels should be continually read during the observations; all circumpolars should be reversed upon; and stars as far north as 80° should be observed by the old method of eye and ear, instead of the chronograph.

Whenever possible, sets of observations should be made at least twice during the night—each set consisting of not less than three circumpolars, (not all at the same culmination,) and three time-stars north of the Equator, together with any southern time-star which may be convenient. A set of observations should always precede, and another set follow the exchange of signals when the weather permits.

One or more of these sets should be computed promptly, that observers may constantly be acquainted with the condition of their instruments. The azimuth error should never remain for more than a day larger than $0^s.2$, nor the collimation error larger than $0^s.1$. For the field computations it will suffice to read off a single tally for each star.

The amount of battery power and condition of the wire is always to be noted when telegraphic signals are exchanged; also any indications of aurora.

HEART'S CONTENT—CALAIS.

So soon as the instruments are in adjustment, the exchange of clock-signals should commence, and it should be continued nightly, whatever the weather, until the operations for transatlantic longitude are completed at Heart's Content. At the time of the exchange, Calais should notify Heart's Content whether it can determine the clock-correction on the same night, and should transmit the correction deduced for the time of the signals sent on the preceding night.

To exchange clock-signals, put the Calais clock into circuit two or three times, for not more than half a minute at each time, and at intervals of at least a minute, while the Heart's Content clock is graduating the chronograph. Arrange the time of putting on the Calais clock, so that the record of 0^s shall be included in the series of its signals. It is very desirable that both chronographs should record this comparison; but, if this should be found impossible, the Heart's Content chronograph is the proper one to keep the record. If any confusion is likely to arise as to the precise seconds recorded by the Calais clock, this can be readily obviated by making a couple of quick taps immediately after 15^s, 30^s, or 45^s of the clock time—entering this fact upon the day-book and communicating it to Heart's Content.

VALENCIA—HEART'S CONTENT.

First. For this determination three nights exchanges through each cable will suffice, provided the clock-corrections are well determined at each station before and after the exchange. Should circumstances be especially favorable on any occasion, there is no reason why work should not be done with both cables on the same night, thus reducing the requisite number of nights to five.

Second. The times at which exchanges will be made must necessarily depend upon the convenience of the telegraph company; but the hours between 10 p. m. and 6 a. m. are preferable. (All civil times in this programme are understood to be Greenwich mean times.) Whenever exchanges are to be undertaken, Valencia will notify Heart's Content as early as 6 p. m., if practicable, naming the hour when this can be done. Should no such notice be received by midnight, Heart's Content need not feel obliged to attend further.

Third. At the appointed hour Valencia will telegraph the word *Gould* as a notice that all is ready; and upon the reception of the word *Dean* in reply will begin the signals.

Fourth. The exchange of signals will be effected as follows:

a. Beginning with a positive current, sets of alternate positive and negative signals will be made, each signal consisting of a single tap, half a second in length. The first group will consist of four taps, at intervals of five seconds. Then, after a pause of ten seconds, will follow a group of three taps, five seconds apart; and, after a second pause of ten seconds, yet another group of three taps, at five seconds intervals; these ten taps, in three groups, constituting a "set." The arrangement of the set will then be thus:

$$P_{5^s}\ N_{5^s}\ P_{5^s}\ N_{10^s}\ P_{5^s}\ N_{5^s}\ P_{10^s}\ N_{5^s}\ P_{5^s}\ N,$$

and each set will occupy one minute.

b. Two such sets following one another, at an interval of ten seconds, will be sent first from Valencia, then two sets returned from Heart's Content; and this exchange will be made three times, which will suffice for the telegraphic work of the night. The time requisite will therefore be $2^m\ 10^s$ for each series of two sets. Three such series being sent from each station, the time actually consumed for the signals will be but 13^m; so that 20^m will probably suffice for the whole operation.

c. Before sending each series of taps, the sender will call attention by a few rapid alternations of positive and negative signals, to be answered in the same way before he begins the series. Consequently, the order of proceedings will be as follows:

First exchange.
- Valencia gives rapid signals, and Heart's Content responds.
- Valencia sends two series of taps, occupying $2^m\ 10^s$.
- Heart's Content gives rapid signals, and Valencia responds.
- Heart's Content sends two series of taps, occupying $2^m\ 10^s$.

Valencia then proceeds to give the preliminary signals for a second exchange, and in this way the three exchanges are made. If possible, each observer should then state whether the signals have been successfully received.

Fifth. The length of the taps and of the intervals between them is a matter of some importance. Hence a mean-time watch or clock should be used, and the same care taken in giving signals as in making observations, especially should all the taps be of equal length.

The observer of signals should have the break-circuit key of the chronograph in his hand and record the earliest indication of deflection. Should the deflection ever be in the reverse direction of that indicated by the programme, this fact should be noted.

Sixth. It may conduce to a better determination of the time of transmission if exchanges are made at different hours of the day. One set of ten taps, as already described, exchanged at the beginning of each third hour would probably suffice for this purpose, although each alternate hour would be preferable. These experiments should be made on both cables separately, and, if possible, on the circuit formed by connecting the two cables, without any earth connection to either. The times for these experiments must be left to subsequent arrangement.

If possible, the following experiments for velocity should be made by use of both cables; they are more important than the system of observations at different hours of the day:

I. The two cables being connected at Heart's Content, but without battery there, Valencia first, and then Heart's Content, will send two sets—

1. With the two ends to earth at Valencia through battery.
2. With the two ends to earth at Valencia, one through battery and the other direct.
3. With the two ends at Valencia to the two poles of battery, without earth connection.

II. The same, with the Heart's Content battery included in the circuit.

III. (Like I, *vice versa.*) The cables being connected at Valencia without battery, Valencia first, and then Heart's Content, will send two sets—

1. With both ends to earth at Heart's Content, through battery.
2. With both ends to earth at Heart's Content, one through battery, the other direct.

IV. The same with the Valencia battery included in the circuit.

Seventh. At the earliest convenient opportunity after an exchange of signals, each observer will communicate to the other his corrected sidereal time, corresponding to the mean of the last set of ten taps received and the last set of ten taps sent.

On the 24th October, 1866, longitude-signals were exchanged with Newfoundland for the first time. Between that date and November 20 four more opportunities had been found, and the entire series of experiments for determining the velocity of signals under different circumstances had been satisfactorily tried, as well as some others which I found practicable at Valencia, although not provided for in the programme.

Meanwhile, the astronomer royal, who had with his usual kindness acceded to my request for a telegraphic connection between our station point and Greenwich, and assumed all the labor and embarrassment of the necessary arrangements, had carried out the series of exchanges with Foilhommerum, an undertaking attended with no little inconvenience and vexation from the various difficulties attending land lines, especially when a submarine cable of the length of that across the Irish Channel formed a part of the circuit. After many fruitless attempts, clock signals were exchanged on three nights, upon two of which the time was well determined at both places.

Upon the 20th November the weather at Heart's Content as well as at Valencia was extremely unpromising; no communication had yet been obtained between that station and Calais, and it seemed best on all accounts to bring our cable signals to an end also. After visiting Greenwich to offer such aid in the reduction of the longitude exchanges with that observatory as might be acceptable to the astronomer royal, Mr. Mosman reached home on the 22d December, and I followed four weeks later.

The personal error, and other loss of time in observing signals, has happily proved more constant and more measurable than I had ventured to anticipate. No matter how great the interval, the resultant longitude will only be affected by one-half the difference of the values for the two observers; while the average value for the two observers would be merged with the time of transmission for the signals. It is not the least satisfactory of our results that this interval proved capable of measurement with an accuracy which leaves no ground for apprehension that it has appreciably affected our value for the longitude, and which enables us to infer the velocity of transmission within restricted limits of probable error.

The exchanges between Heart's Content and Calais were far less satisfactory. Notwithstanding the laborious precautions taken by Mr. Davidson, all efforts at direct communication proved unavailing, day after day, and week after week. Mr. Davidson's health became seriously impaired, and Mr. F. W. Perkins was added to the Calais party, joining it on the 12th November. Finally, Mr. Davidson being called to important duties at the Isthmus of Darien, was compelled to leave Calais, and Mr. Charles O. Boutelle, one of the most experienced officers of the survey, was assigned to the charge of the station. Still, the necessity of an intermediate astronomical station at Port Hood or Aspy Bay seemed inevitable, when suddenly on the 11th December, only a couple of hours before Mr. Boutelle's arrival, the long-desired communication was found to be established. A sharp frost had thrown the otherwise defective line into a condition of admirable insulation, so that an interchange of clock signals was effected without difficulty. Comparisons of clock time at the two stations were also made on the 12th, 14th, and 16th December, though not in a manner wholly satisfactory, since clouds interfered with the attainment of sufficient observations for time. At this juncture Mr. Dean, at Heart's Content, decided to discontinue observations and dismount his instruments, so that the work was brought to a close, the Newfoundland observers reaching Boston again in the last week of December.

In reducing the observations I have been aided in some degree by Mr. Mosman, but chiefly by Mr. Chandler, who has for several years rendered efficient and skillful services in computations of this kind, as well as in numerous other astronomical observations and reductions. To both these gentlemen I desire to make acknowledgment for their valuable services in the office as well as in the field.

The nature of the undertaking had, of course, thus far precluded any determination of personal equation between the observers. This was provided for with as little delay as possible. My plan had contemplated the entire elimination of this disturbing element at Heart's Content, since it would affect the longitudes of Valencia and Calais equally, but with opposite signs. It proved that this precaution had been overlooked, and that the time had been determined by Mr. Dean during the exchanges of signals with Europe, and by Mr. Goodfellow during those with the United States; but as will be seen this proved of no practical importance. During a long series of years, the personal equation between these two gentlemen, as determined several times annually, was inappreciable, and so too it proved in the comparisons made after their return from the present expedition.

At the earliest practicable date extensive observations were made for the determination of personal equation between each pair of observers. The result of these will be given in its place.

It may perhaps be well to add a few words concerning the instruments used, which were the ordinary apparatus of the telegraph party of the Coast Survey, consisting at each station of a transit instrument, a chronograph, and a circuit-breaking clock.

The transit instruments have an aperture of about seven centimeters and a focal length of about one hundred and sixteen centimeters. Each is provided with a reversing apparatus, attached to the iron stand, and capable of reversing the instrument with ease in about twenty seconds; so that it is not difficult to observe a star, in one position of the axis, within 30^s or 35^s after observing it in the other. The illuminating lamps are placed on brackets, unconnected with the instrument and placed as far from it as may well be. The reticule carries five "tallies," or sets, of five spider-lines each, at intervals of about two and a half equatorial seconds of time, the several tallies being separated from one another by twice this distance. The tallies are denoted by the letters of the alphabet from B to F, inclusive, and the individual threads by subjacent numbers; the numeration commencing at the lamp end, or end at which the illumination is admitted to the field, so that when the lamp end is west the star at its upper culmination traverses the threads in the direct order of their numeration from B_1 to F_5. The instruments are provided with diagonal eye-pieces of magnifying powers not far from one hundred, and signal keys are permanently fixed on each side in convenient positions. The chronographs at Valencia and Heart's Content were "spring governors," by Messrs. William Bond & Son; that at Calais was a "Kerrison's regulator," with modifications by Mr. Saxton. Upon all of them one pen, which is constantly tracing a line upon the revolving cylinder, records the signals both from the clock and the observer by offsets from this normal line. The experience of eighteen years has shown that the greater simplicity of the apparatus, when provided with but a single electro-magnet and recording pen, far overbalances, at least in the longitude work of the survey, any inconveniences arising from a possible confusion of the clock signals with those given by the observer. The offsets produced by the former are of practically equal length, this length depending on the adjustment of the armature and strength of the battery; while those produced by the observation signals are for a practiced observer quite near enough to equality to preclude any difficulty in reading off the records, except in very rare cases. For portable instruments there seems to be no room for reasonable doubt as to the superiority of instruments with a single pen, and for the fixed instruments of an observatory I should, personally, also give this construction a decided preference. All signals are given by the interruption of a closed circuit, so that when the observing key is properly adjusted no interval elapses between the first pressure and the transmission of the telegraphic signal, while the moment of release of the armature from the electro-magnet is distinctly recorded.

The clocks are all provided, according to Saxton's plan, with delicate platinum tilt-hammers, resting on platinum disks, and so adjusted that a small pin fixed in the pendulum rod at its center of percussion shall strike the tilt-hammer when the rod is vertical, and thus lift the hammer from the disk for a very brief period, generally about the one-hundredth part of a second. The galvanic circuit to the chronograph being conducted through the tilt-hammer and disk, the circuit becomes interrupted for a moment at each oscillation of the pendulum.

The advantages of this mode of recording the clock-signals over any in which the galvanic current traverses any portion of the clock itself, or in which the signals are produced, according to Saxton's original plan, by contact with a globule of mercury, have been sufficiently set forth in previous reports, and require no repetition here.

IV.—Observations at Valencia.

Here the Krille clock and transit No. 4 were employed. I had supposed all precautions taken to insure that the instruments should be in good order; but, owing probably in part to the haste with which the expedition was organized in view of the approach of winter, this was not the case; and the want of proper condition of both these instruments, as well as of the minor telegraphic apparatus, much augmented the unavoidably serious difficulties of the enterprise.

Observations were obtained on fifteen nights during our sojourn at Valencia, on no one of which the sky was unclouded. On only two of the five nights on which longitude signals were exchanged with Newfoundland was it possible to obtain observations after the exchange; and the same was possible on only one of the three nights when signals were successfully exchanged with Greenwich.

Observations of circumpolar stars for the special purpose of determining the intervals of the transit-threads were out of the question. Indeed, there was but one instance when the transit of any star north of 60° declination was observed over all twenty-five threads. In those rare instances when this would have been possible, the stars were needed for determining the error of collimation.

At the close of the series of observations, it was found that fifty-three complete transits had been observed over all the threads; and, since the equatorial intervals for the same reticule had been very thoroughly and satisfactorily deduced from an ample series of observations, in 1860–'61, at Pensacola, it appeared that little would probably be gained by an attempt to obtain additional data at Valencia. Indeed, after assorting the thread-intervals deduced from the Valencia observations into three classes, the accordance of the mean values for these classes showed a probable error amounting to $0^s.02$ of a great circle for but few of the threads.

The Pensacola values had been deduced from one hundred and twenty-one observations of twenty-one stars, the average declination of nine of them being 75½°. The probable error of but few of the intervals was as large as $0^s.005$, and the combination of these values with those derived from the Valencia observations gives all needful accuracy.

The Pensacola values were, therefore, reduced to the focal adjustment of the instrument at Valencia, by diminishing each interval by its three-thousandths part, and a triple weight assigned to the resultant values.

We thus have for the equatorial intervals of the several threads from the mean of all, the following determination:

Equatorial intervals of transit No. 4.

	Pensacola, 1860–'61.	Values reduced to Valencia focus.	Valencia, 1866.	Adopted value.
	s.	s.	s.	s.
B 1	34.156	34.145	34.117	34.138
2	31.784	31.774	31.834	31.789
3	29.255	29.245	29.311	29.261
4	26.850	26.841	26.829	26.838
5	24.317	24.309	24.289	24.304
C 1	19.450	19.444	19.424	19.439
2	17.136	17.130	17.134	17.131
3	14.574	14.569	14.570	14.569
4	12.204	12.200	12.187	12.197
5	9.799	9.796	9.755	9.786
D 1	4.909	4.908	4.904	4.907
2	+ 2.456	+ 2.455	+ 2.462	+ 2.457
3	— 0.034	— 0.034	— 0.038	— 0.035
4	2.372	2.371	2.366	2.370
5	4.717	4.716	4.750	4.724
E 1	9.677	9.674	9.693	9.679
2	12.220	12.216	12.175	12.206
3	14.634	14.629	14.647	14.634
4	17.154	17.148	17.166	17.152
5	19.467	19.461	19.442	19.456
F 1	24.438	24.430	24.433	24.431
2	26.858	26.849	26.837	26.846
3	29.382	29.372	29.361	29.369
4	31.770	31.760	31.789	31.767
5	—34.168	—34.157	—34.119	—34.147

Levelings of the axis were, of course, made as frequently as possible, and the correction for inequality of the pivots thence deduced is $-0^s.013$, the perforated end of the axis being the larger. The value resulting from Pensacola levelings having been $-0^s.015$, the mean of these, or $-0^s.014$, is applied to all level readings as a correction for inequality of pivots.

On October 27, and after November 5, the transit observations upon which the longitudes depend were made by Mr. Mosman alone. On the 25th and 28th October they were made by myself, and on the 30th, the only other date which enters in any way, however implicitly, into the longitude determinations, the transits were observed by both of us. This circumstance, undesirable in itself, was from the necessities of the case not to be avoided.

With these few explanations, and the added remark that the observations for time were, almost without exception, obtained with extreme difficulty in the intervals of clouds and rain, in one of the most unfavorable climates of the globe for an astronomer, I give the crude observations, as well as their reduction, for the groups immediately preceding and following each series of longitude signals, omitting the others, generally, as needless. The notation and methods of observation and reduction are as prepared by me for the longitude-work of the Coast Survey some fifteen years ago, and are described in detail, by Mr. Dean, in the appendix (p. 167) to the Coast Survey Report for 1856. The conditional equations for clock-correction and azimuth are solved by least squares, after correcting for level-error and clock-rate, the normal equations and resultant values being appended to each group.

1866, *October* 25. *G. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
γ Aquilæ	E.	B_1–F_5	19 40 3.67	+0.128	0 0.000	+0.087
α Aquilæ	"	B_1–F_5 exc. F_4	44 26.42	+0.132	—0 1.338	+0.087
(a) ε Draconis, U. C	"	D_4–$E_{1\,3\,5}$	48 11.45	+0.136	+0 33.603	+0.337
ε Draconis, U. C	W.	E_5–$F_{1\,4\,5}$	50 5.12	+0.138	—1 19.972	+0.342
τ Aquilæ	"	C_1–E_5	19 57 45.94	+0.143	+0 0.015	+0.092

T = 19h.8 θ = —8s.3 ρ = 0s.00 c = —0s.019

Star.	t	α	Cc	ω'_0	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
γ Aquilæ	19 40 3.76	39 55.43	—0.020	—0.04	+0.17	—8.51
α Aquilæ	44 25.17	44 16.86	—0.020	—0.03	+0.17	8.50
ε Draconis, U. C	48 45.44	48 36.77	....	—0.37	—0.22	8.45
τ Aquilæ	19 57 46.05	57 37.85	—0.020	+0.12	+0.18	—8.36

(*a*) Illumination very bad.

$$4\ \triangle\theta + 1.159a = -0.316$$
$$+1.159\ \triangle\theta + 2.259a = +0.375$$
$$a = +0^s.243 \qquad \triangle\theta - 0^s.147 \quad \triangle t - 8.447$$

1866, *October* 27. *M. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
θ' Ceti	E.	B_1–F_5	1 17 31.77	—0.160	0 0.000	—0.089
η Piscium	"	B_1–F_5 exc. $E_{1\,2\,4}$	24 33.53	—0.132	—0 1.945	—0.119
ο Piscium	"	B_1–F_5	38 31.67	—0.104	0 0.000	—0.086
β Arietis	"	B_1–F_5	47 27.40	—0.098	0 0.000	—0.106
50 Cassiopeæ, U. C	"	E_1–F_5 exc. $F_{2\,3}$	51 16.84	—0.091	+1 5.330	—0.314
50 Cassiopeæ, U. C	W.	D_5–F_2 exc. E_2	1 53 14.49	—0.069	—0 53.402	—0.308

T = 1h.7 θ = —8s.5 ρ = —0s.010 c = +0s.170

Star.	t	α	Cc	ω'_0	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
θ' Ceti	1 17 31.68	17 23.11	+0.172	+0.10	+0.08	—8.48
η Piscium	24 31.47	24 22.92	0.175	0.13	+0.06	8.43
ο Piscium	38 31.58	38 23.15	0.172	0.24	+0.06	8.32
β Arietis	47 27.29	47 18.73	+0.181	+0.12	+0.05	8.43
50 Cassiopeæ, U. C	1 52 21.31	52 12.78	....	—0.03	—0.10	—8.43

$$5\ \triangle\theta + 1.675a = +0.551$$
$$+1.675\ \triangle\theta + 3.156a = +0.420$$
$$a = +0^s.091 \qquad \triangle\theta = +0^s.080 \quad \triangle t = -8.420$$

1866, *October* 28. *G. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
α Cygni	E.	B_1–F_5	20 37 2.92	−0.059	0 0.000	−0.102
μ Aquarii	"	B_1–F_5	45 37.04	−0.063	0 0.000	−0.041
12 Y. Cat., 1879, U. C	"	D_4–F_5	51 55.63	−0.069	+1 49.390	−0.422
12 Y. Cat., 1879, U. C	W.	E_1–F_4 exc. F_2	56 5.04	−0.076	−2 21.419	−0.458
σ^2 Urs. Majoris, L. C	"	B_1–E_3 exc. E_1	20 59 15.35	−0.079	−0 29.862	+0.132
ξ Cygni	"	B_1–F_5	21 7 25.42	−0.085	0 0.000	−0.101

$T = 21^h \quad \theta = -8^s.7 \quad \rho = -0^s.025 \quad c = +0^s.124$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
α Cygni	20 37 2.82	36 53.91	+0.177	−0.04	0.00	−8.74
μ Aquarii	45 37.00	45 28.03	+0.125	−0.15	−0.01	8.84
12 Y. Cat., 1879, U. C	53 43.88	53 35.11	....	−0.07	+0.04	8.81
σ^2 Urs. Majoris, L. C	20 59 45.62	58 36.48	+0.329	−0.11	−0.03	8.78
ξ Cygni	21 7 25.32	7 16.56	−0.144	−0.20	−0.01	−8.89

$$5\,\triangle\theta + 1.058a = -0.347$$
$$+1.058\,\triangle\theta + 13.708a = +0.101$$
$$a = -0^s.013 \qquad \triangle\theta = -0^s.112$$
$$\triangle t = -8.812$$

1866, *October* 30.

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m s.	*s.*	*m. s.*	*s.*
ν Cygni	E.	B_1–F_5	20 52 22.13	−0.067	0 0.000	−0.107
σ^2 Urs. Majoris, L. C	"	B_1–C_5 exc. C_3	57 45.98	−0.067	+0 59.920	+0.117
σ^2 Urs. Majoris, L. C	W.	B_1–C_5 exc. C_3	20 59 45.12	−0.067	−0 59.920	+0.117
ξ Cygni	"	B_1–F_5 exc. C_4	21 7 26.54	−0.063	−0 0.577	−0.077
226 Cephei, U. C	"	C_4–D_2	22 29 40.24	−0.041	+0 29.371	−0.200
226 Cephei, U. C	E.	B_1–C_5	31 37.52	−0.090	−1 27.850	−0.378
ι Cephei, U. C	"	E_1–F_5	44 16.12	−0.097	+0 52.953	−0.257
ι Cephei, U. C	W.	E_1–F_5	46 2.28	−0.099	−0 52.953	−0.262
α Pegasi	"	B_1–F_5	22 58 17.89	−0.102	0 0.000	−0.093
ι Piscium	"	B_1–F_5	23 33 16.48	−0.104	0 0.000	−0.081
a) Groombr., 4163, U. C.	"	B_1–C_5 exc. B_5	47 21.36	−0.107	+1 17.140	−0.403
Groombr., 4163, U. C.	E.	B_1–C_5 exc. B_4	49 53.75	−0.108	−1 16.140	−0.397
ω Piscium	"	B_1–F_5	23 52 38.63	−0.108	0 0.000	−0.086

(*a*) Star very faint. Observation difficult.

$T = 22^h \quad \theta = -9^s.3 \quad \rho = -0^s.030 \quad c = -0^s.080$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
ν Cygni	20 52 22.02	52 12.94	−0.106	+0.08	+0.02	−9.24
σ^2 Urs. Majoris, L. C	20 58 45.67	58 36.70	....	+0.30	+0.13	9.13
ξ Cygni	21 7 25.89	7 16.52	+0.092	0.00	+0.03	9.32
226 Cephei, U. C	22 30 9.35	30 0.06	....	+0.02	−0.09	9.18
ι Cephei, U. C	45 8.94	44 59.55	....	−0.07	−0.03	9.33
α Pegasi	22 58 17.80	58 8.57	+0.083	+0.19	+0.04	9.15
ι Piscium	23 33 16.40	33 7.01	+0.080	+0.12	+0.04	9.23
Grombr,. 4163, U.C.	48 37.65	48 28 45	....	+0.16	−0.08	9.07
ω Piscium	23 52 38.54	52 29.42	−0.080	+0.15	+0.04	−9.19

$$9\,\triangle\theta + 1.571a = +0.954$$
$$+1.571\,\triangle\theta + 11.581a = +0.818$$
$$a = +0^s.058 \qquad \triangle\theta = +0^s.096$$
$$\triangle t = -9.204$$

1866, *November* 3.

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
μ Aquarii	E.	B_1-_5	20 46 10.28	—0.055	—0 29.673	—0.037
ν Cygni	"	B_1-F_5	52 25.44	—0.053	0 0.000	—0.089
σ^2 Urs. Majoris, L. C.	"	E_2-F_5	20 59 51.41	—0.046	—1 1.386	+0.090

T=21^h θ=—12^s.4 ρ=—0^s.015 c=+0^s.009

Star.	t	α	Cc	ω'$_0$	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
μ Aquarii	20 45 40.57	45 27.94	+0.009	—0.22	—0.32	—12.30
ν Cygni	52 25.43	52 12.84	+0.012	—0.26	—0.09	12.41
σ^2 Urs. Majoris, L. C.	20 58 50.19	58 36.93	—0.023	—0.89	—0.82	—12.38

$$3\ \triangle\theta+3.437a=-1.132$$
$$+3.437\ \triangle\theta+6.102a=-2.074$$
$$a=-0^s.360 \quad \triangle\theta=-\ 0^s.009 \quad \triangle t=-12.365$$

1866, *November* 5. *M. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
11 Cephei, U. C	W.	E_1-F_5	21 41 19.10	—0.037	—1 6.419	—0.146
μ Capricorni	"	B_1-F_5	46 15.33	—0.021	0 0.000	—0.019
79 Draconis, U. C	"	C_1-E_5	51 28.05	—0.016	+0 0.052	—0.091
α Aquarii	"	B_1-F_5	21 59 10.13	—0.007	0 0.000	—0.014
32 Urs. Majoris, L. C	"	E_1-F_5	22 7 37.29	—0.019	+0 53.504	+0.042

T=23^h θ=—13^s.1 ρ=—0^s.015 c=+0^s.009

Star.	t	α	Cc	ω'$_0$	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
11 Cephei, U. C	21 40 12.54	39 59.74	—0.027	+0.26	+0.14	—12.98
μ Capricorni	46 15.31	46 2.08	—0.009	—0.16	—0.13	13.13
79 Draconis, U. C	51 28.01	51 15.22	—0.031	+0.26	+0.17	13.01
α Aquarii	21 59 10.12	58 56.86	—0.009	—0.18	—0.11	13.17
32 Urs. Majoris, L. C	22 8 30.84	8 17.64	+0.022	—0.09	—0.30	—12.89

$$5\ \triangle\theta+1.683a=+\ 0.093$$
$$+1.683\ \triangle\theta+8.679a=-\ 1.068$$
$$a=-\ 0^s.140 \quad \triangle\theta=+\ 0^s.066 \quad \triangle t=-13.034$$

1866, *November* 5. *M. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
ξ Pegasi	E.	B_1-F_5	22 35 3.28	—0.027	0 0.000	—0.030
ι Cephei, U. C	"	E_1-F_5	44 19.29	—0.033	+0 52.952	—0.107
ι Cephei, U. C	W.	E_1-F_5	46 5.35	—0.036	—0 52.952	—0.114
α Pegasi	"	B_1-F_5	22 58 21.88	—0.048	0 0.000	—0.049
ο Cephei, U. C	"	B_1-C_5	23 12 28.87	—0.050	+0 57.061	—0.155
ο Cephei, U. C	E.	B_1-D_1	14 19.32	—0.083	—0 53.034	—0.238
θ Piscium	"	B_1-F_5	23 21 27.13	—0.096	0 0.000	—0.077

$T = 23^h \quad \theta = -13^s.1 \quad \rho = -0^s.015 \quad c = +0^s.009$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
ξ Pegasi	22 35 3.25	34 49.79	+0.009	−0.36	−0.39	−13.07
ι Cephei, U. C	45 12.21	44 59.32	......	+0.21	+0.32	13.21
α Pegasi	22 58 21.83	58 8.49	−0.009	−0.28	−0.36	13.02
ο Cephei, U. C	23 13 25.91	13 13.39	......	+0.58	+0.40	12.92
θ Piscium	23 21 27.05	21 13.56	+0.009	−0.38	−0.41	−13.06

$$5 \triangle\theta + 0.767a = -0.225$$
$$+0.767 \triangle\theta + 2.184a = -1.215$$
$$a = -0^s.571 \qquad \triangle\theta = +0^s.042$$
$$\triangle t = -13.058$$

1866, *November* 6. *M. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
σ² Urs. Majoris, L. C	E.	E_1–F_1	20 59 32.45	−0.020	−0 42.798	+0.056
a) β Cephei, U. C	"	D_1–F_5 exc. F_4	21 26 32.07	−0.053	+0 39.124	−0.187
b) θ Aquarii	"	B_{12}–C_{345}	22 10 22.46	−0.053	−0 20.719	−0.036
π Aquarii	"	B_1–F_5	18 42.11	−0.061	0 0.000	−0.048
c) 9 Draconis, L. C	"	$C_{1-5}E_{12}$	23 17.83	−0.062	+0 31.132	+0.229
ξ Pegasi	"	B_1–D_5	35 17.91	−0.083	−0 14.873	−0.073
α Pegasi	"	B_1–F_5	22 58 21.79	−0.072	0 0.000	−0.069
d) ο Cephei, U. C	"	E_1–F_5	23 12 29.70	−0.060	+0 57.094	−0.180
ο Cephei, U. C	W.	F_{1-5}	14 42.73	−0.058	−1 16.158	−0.176
λ Draconis, L. C	"	B_1–D_5 exc. B_5	24 18.09	−0.052	−0 40.896	+0.071
ι Piscium	"	B_1–F_5	33 20.20	−0.051	0 0.000	−0.045
e) ω Piscium	"	B_1–E_5 exc. E_{13}	23 52 33.14	−0.038	+0 9.548	−0.037

(*a*) Very faint through clouds.
(*b*) Very faint through clouds.
(*c*) Observation doubtful.
(*d*) Very bad observation; doubtful.
(*e*) Faint; observation uncertain.

$T = 23^h \quad \theta = -13^s.2 \quad \rho = -0^s.039 \quad c = +0^s.050$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
σ² Urs. Majoris, L. C	20 58 49.71	58 37.13	−0.132	......	......	......
β Cephei, U. C	21 27 11.01	26 57.47	+0.146	−0.24	−0.04	−13.40
θ Aquarii	22 10 1.71	9 48.54	+0.051	+0.05	+0.04	13.19
π Aquarii	18 42.06	18 28.92	+0.050	+0.08	+0.04	13.16
9 Draconis, L. C	23 49.19	23 37.43	−0.213	......	......	......
ξ Pegasi	35 2.96	34 49.78	+0.051	+0.05	+0.03	13.18
α Pegasi	22 58 21.72	58 8.48	+0.051	+0.01	+0.03	13.22
ο Cephei, U. C	23 13 26.50	13 13.36	......	+0.06	−0.03	13.10
λ Draconis, L. C	23 37.27	23 23.95	+0.147	+0.05	+0.12	13.27
ι Piscium	33 20.16	33 6.94	−0.050	−0.05	+0.04	13.28
ω Piscium	23 52 42.65	52 29.37	−0.050	−0.10	+0.04	−13.33

$$9 \triangle\theta + 5.303a = -0.073$$
$$+5.303 \triangle\theta + 10.765a = +0.325$$
$$a = +0^s.048 \qquad \triangle\theta = -0^s.036$$
$$\triangle t = -13.236$$

1866, *November* 6. *M. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0 + \kappa$
			h. m. s.	s.	m. s.	s.
ζ Arietis	W.	B_1–F_5 exc. $F_{4\,5}$	3 7 26.87	— 0.015	+ 0 3.061	— 0.024
α Persei	"	B_1–F_5 exc. C_5 D_1 E_5 F_3	3 15 2.96	— 0.015	+ 0 2.495	— 0.043

$T = 3^h \quad \theta = \ldots\ldots \quad \rho = \ldots\ldots \quad c = + 0^s.050$

Star.	t	α	Cc	ω'_0	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
ζ Arietis	3 7 29.91	7 16.61	— 0.053	....	+ 0.03	— 13.38
α Persei	3 15 5.41	14 52.14	— 0.076	....	0.00	13.35

(*a*) Very faint through clouds.
(*b*) Observation doubtful.
(*c*) Observation very bad.
(*d*) Faint; observation uncertain.

Assumed $a = + 0^s.048$. $\triangle t = — 13^s.364$.

1866, *November* 9. *M. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0 + \kappa$
			h. m. s.	s.	m. s.	s.
γ Aquilæ	W.	B_2–F_5	19 40 12.43	— 0.015	— 0 1.445	— 0.021
α Aquilæ	"	B_1–F_5	44 32.40	— 0.015	0 0.000	— 0.021
β Aquilæ	"	B_1–F_5	49 1.61	— 0.013	0 0.000	— 0.020
τ Aquilæ	"	B_1–F_5	19 57 53.42	— 0.010	0 0.000	— 0.017
α^2 Capricorni	"	B_1–F_5	20 10 55.13	+ 0.004	0 0.000	— 0.012
κ Cephei, U. C	"	D_1–F_5	14 41.58	+ 0.012	— 1 6.549	— 0.011
π Capricorni	"	C_2–F_5	20 6.34	+ 0.021	— 0 9.201	— 0.003
ε Delphini	"	B_1–F_5	27 6.62	+ 0.021	0 0.000	+ 0.006
Groombr., 3241, U.C	"	B_3–C_5	29 47.39	+ 0.017	+ 1 2.357	+ 0.011
Groombr., 3241, U.C	E.	B_1–D_3	31 47.02	+ 0.015	— 0 56.685	+ 0.006
α Cygni	"	B_1–F_5	37 9.75	— 0.008	0 0.000	— 0.031
μ Aquarii	"	B_1–F_5	20 45 43.72	— 0.011	0 0.000	— 0.015

$T = 20^h \quad \theta = — 15^s.9 \quad \rho = — 0^s.090 \quad c = + 0^s.050$

Star.	t		Cc	ω'_0	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
γ Aquilæ	19 40 10.96	39 55.19	— 0.051	+ 0.05	+ 0.11	— 15.97
α Aquilæ	44 32.38	44 16.62	— 0.051	+ 0.07	+ 0.12	15.95
β Aquilæ	49 1.59	48 45.81	— 0.050	+ 0.05	+ 0.12	15.97
τ Aquilæ	19 57 53.40	57 37.62	— 0.050	+ 0.06	+ 0.12	15.96
α^2 Capricorni	20 10 55.12	10 39.34	— 0.051	+ 0.09	+ 0.16	15.97
κ Cephei, U. C	13 35.02	13 18.93	— 0.237	— 0.41	— 0.33	15.97
π Capricorni	19 57.14	19 41.27	— 0.052	+ 0.01	+ 0.17	16.06
ε Delphini	27 6.63	26 50.78	— 0.051	+ 0.04	+ 0.11	15.97
Groombr., 3241, U. C	30 50.05	30 33.85	....	— 0.26	— 0.19	15.96
α Cygni	37 9.72	36 53.58	+ 0.070	— 0.12	+ 0.02	16.04
Aquarii	20 45 43.70	45.27.85	+ 0.051	+ 0.16	+ 0.15	15.89

$$11 \triangle \theta + 3.361\, a = \cdot\ 0.252$$
$$+ 3.361 \triangle \theta + 10.096\, a = + 1.488$$
$$a = + 0^s.171 \qquad \triangle \theta = — 0^s.077$$
$$\triangle t = — 15\ 977$$

1866, *November* 9. *M. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
σ^2 Urs. Majoris, L. C...	E.	B_1–C_5	20 57 54.82	— 0.008	+ 0 57.754	+ 0.040
σ^2 Urs. Majoris, L. C...	W.	B_1–D_2	20 59 42.25	— 0.006	— 0 49.772	+ 0.038
ζ Persei	"	B_1 C_1–F_5	3 46 10.41	— 0.006	— 0 6.259	— 0.017
γ Tauri	"	C_1–D_5	4 12 23.26	— 0.019	+ 0 7.606	— 0.026
ϵ Tauri	"	B_1–F_5	21 8.42	— 0.021	0 0.000	— 0.028
α Tauri	"	B_1–F_5	28 34.62	— 0.016	0 0.000	— 0.022
α Camelop., U. C	"	B_1–F_5	4 41 10.10	— 0.015	0 0.000	— 0.066

$T = 4^h$ $\theta = -16^s.7$ $\rho = -0^s.090$ $c = +0^s.050.$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
σ^2 Urs. Majoris, L. C.......	20 58 52.57	58 37.35	....	+ 0.84	+ 0.77	— 16.63
ζ Persei	3 46 4.13	45 47.72	— 0.058	+ 0.21	+ 0.14	16.63
γ Tauri	4 12 30.84	12 14.45	— 0.052	+ 0.28	+ 0.21	16.63
ϵ Tauri	21 8.39	20 52.01	— 0.053	+ 0.30	+ 0.20	16.60
α Tauri	28 34.60	28 18.30	— 0.052	+ 0.39	+ 0.21	16.51
α Camelop., U. C	4 41 10.03	40 53.25	— 0.123	— 0.14	+ 0.21	— 16.64

$$6\,\triangle\theta + 3.893\,a = +1.870$$
$$+3.893\,\triangle\theta + 6.863\,a = +2.680$$
$$a = +0^s.338 \quad \triangle\theta = +\ 0^s.092$$
$$\triangle t = -16.608$$

1866, *November* 13. *M. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
ι Cephei, U. C........	E.	B_1–D_5	22 45 52.21	— 0.073	— 0 35.320	— 0.201
α Pegasi	"	$E_{2\,3}$ F_1	22 58 8.53	— 0.073	+ 0 17.650	— 0.069
θ Piscium	"	B_1–F_5 exc. D_3....	23 21 31.31	— 0.073	0 0.000	— 0.060
ω Piscium	"	B_1–F_5	23 52 47.23	— 0.073	0 0.000	— 0.061

$T = 23^h$ $\theta = -17^s.8$ $\rho = -0^s.015$ $c = +0^s.050$

Star.	t		Cc	ω'_0	Aa	t
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
ι Cephei, U. C	22 45 16.69	44 58.97	+ 0.121	+ 0.20	+ 0.07	— 17.67
α Pegasi	22 58 26.11	58 8.39	+ 0.051	+ 0.13	— 0.07	17.60
θ Piscium	23 21 31.25	21 13.46	+ 0.050	+ 0.07	— 0.08	17.65
ω Piscium	23 52 47.17	52 29.29	+ 0.050	— 0.02	— 0.08	— 17.73

$$4\,\triangle\theta + 1.506\,a = +0.377$$
$$+1.506\,\triangle\theta + 1.736\,a = +0.006$$
$$a = -0^s.115 \quad \triangle\theta = +\ 0^s.137$$
$$\triangle t = -17.663$$

1866, *November* 13. *M. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
α Ceti	E.	B_1–F_2 exc. $C_{1\,4\,5}$ D_1	2 55 41. 23	— 0. 064	— 0 2. 731	— 0. 053
α Persei	"	B_1–F_5 exc. B_5 $C_{1\,2}$ $D_{1\,3}$	3 15 5. 07	— 0. 064	— 0 5. 047	— 0. 118
γ^2 Urs. Minoris, L. C.	"	$D_{3\,4\,5}$ F_4–F_5	3 22 12. 26	— 0. 064	— 1 2. 569	+ 0. 158
Groombr., 2320, L. C.	"	B_1–C_3	4 5 5. 21	+ 0. 003	+ 1 6. 312	+ 0. 296
γ Tauri	W.	B_1–F_5	12 32. 30	+ 0. 014	0 0. 000	+ 0. 002
ε Tauri	"	B_1–F_5	21 9. 85	+ 0. 010	0 0. 000	— 0. 001
α Tauri	"	B_{1-4} D_{1-5} $F_{2\,3}$	28 29. 90	— 0. 007	+ 0 6. 254	— 0. 016
α Camelop., U. C.	"	B_1–C_5 exc. C_4	40 14. 35	— 0. 007	+ 0 56. 866	— 0. 047
α Camelop., U. C.	E.	B_1–C_5	42 5. 63	— 0. 005	— 0 54. 192	— 0. 042
ι Aurigæ	"	B_1–F_5	48 39. 08	— 0. 015	0 0. 000	— 0. 026
11 Orionis	"	B_1–C_5	4 57 16. 94	— 0. 057	0 0. 000	— 0. 057

$T = 4^h \quad \theta = -17^s.8 \quad \rho = -0^s.015 \quad c = +0^s.050$

Star.	t	α	Cc	ω'_0	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
α Ceti	2 55 38. 45	55 20. 58	+ 0. 050	— 0. 03	— 0. 02	— 17. 82
α Persei	3 15 10. 00	14 52. 24	+ 0. 076	+ 0. 11	0. 00	17. 70
γ^2 Urs. Minoris, L. C.	3 21 9. 85	20 52. 11	— 0. 165	— 0. 11	— 0. 05	17. 86
Groombr., 2320, L. C.	4 6 11. 55	5 53. 80	— 0. 134	— 0. 08	— 0. 04	17. 84
γ Tauri	12 32. 30	12 14. 51	— 0. 052	— 0. 04	— 0. 01	17. 83
ε Tauri	21 9. 85	20 52. 07	— 0. 053	— 0. 03	— 0. 01	17. 82
α Tauri	28 36. 13	28 18. 35	— 0. 052	— 0. 03	— 0. 01	17. 82
α Camelop., U. C.	45 11. 28	40 53. 39	....	— 0. 08	+ 0. 01	17. 89
ι Aurigæ	48 39. 05	48 21. 13	+ 0. 060	— 0. 05	— 0. 01	17. 84
11 Orionis	4 57 16. 88	56 59. 09	+ 0. 052	+ 0. 07	— 0. 01	— 17. 71

$$10\,\triangle\theta + 8.063\,a = -0.279$$
$$+8.063\,\triangle\theta + 15.376\,a = -0.159$$
$$a = -0^s.019 \qquad \triangle\theta = -0^s.013$$
$$\triangle t = -17^s.813$$

1866, *November* 16. *M. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
η Aquarii	E.	B_1–F_5	22 28 49. 85	— 0. 003	0 0. 000	— 0. 039
ι Cephei, U. C.	"	B_1–F_1	45 31. 69	— 0. 003	— 0 14. 021	— 0. 037
α Pegasi	"	B_1–F_5	22 58 27. 12	+ 0. 001	0 0. 000	— 0. 009
o Cephei, U. C.	"	E_1–F_5	23 12 34. 54	+ 0. 008	+ 0 57. 094	— 0. 010
o Cephei, U. C.	W.	E_1–F_5	14 28. 88	+ 0. 019	— 0 57. 094	— 0. 007
θ Piscium	"	B_1–F_5	21 32. 18	— 0. 004	0 0. 000	— 0. 013
λ Draconis, L. C.	"	B_1–C_5	24 47. 81	— 0. 020	— 1 4. 370	+ 0. 043
ι Piscium	"	B_1–F_5	23 33 25. 52	— 0. 050	0 0. 000	— 0. 013

$T = 23^h \quad \theta = -18^s.8 \quad \rho = -0^s.013 \quad c = 0^s.000$

Star.	t	α	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
η Aquarii	22 28 49.81	28 31.04	0.000	+ 0.02	— 0.03	— 18.75
ι Cephei, U. C	45 17.63	44 58.85	0.000	+ 0.01	+ 0.02	18.77
a Pegasi	22 58 27.11	58 8.35	0.000	+ 0.04	— 0.02	18.78
o Cephei, U. C	23 13 31.70	13 12.94	....	+ 0.04	+ 0.03	18.78
θ Piscium	21 32.17	21 13.43	0.000	+ 0.07	— 0.03	18.71
λ Draconis, L. C	23 43.48	23 24.57	0.000	— 0.11	— 0.10	18.81
ι Piscium	23 33 25.51	33 6.84	0.000	+ 0.14	— 0.03	— 18.63

$$7 \,\triangle\, \theta + 4.107a = +0.215$$
$$+4.107 \,\triangle\, \theta + 9.097a = -0.112$$
$$a = -0^s.036 \qquad \triangle\, \theta = +0^s.052$$
$$\triangle\, t = -18^s.748$$

V.—OBSERVATIONS AT NEWFOUNDLAND.

At the Heart's Content station, as elsewhere, our party was received with friendly kindness and aided in every way by the gentlemen of the telegraphic staff. Messrs. Dean and Goodfellow express their especial obligations to Mr. C. W. Lundy, whom they found in charge of the cable office on their arrival, and who gave them every facility; and, also, in an equal degree, to Mr. Henry Weedon, his successor, who specially exerted himself in overcoming various obstacles which were encountered in carrying out the plan of operations.

Cordial thanks are likewise due to Mr. A. M. Mackay, superintendent of the Newfoundland land line, who gave all the aid in his power for effecting the exchanges with Calais, and to Mr. Waddell, chief operator, for unwearying kindness and patience.

A station was erected upon land belonging to the telegraph company, in close proximity to their office, the center of the transit instrument being found by measurement to be two hundred and forty-three feet west and eighty-three feet south of the cross upon the tower of the Episcopal church, which was placed upon the British Admiralty Chart No. 619, from survey of the harbor by Captain Orlebar, royal navy, in latitude 47° 52′ 35″, longitude 53° 22′ 14″ west from Greenwich—a longitude which is remarkably corroborated by our telegraphic results.

The Kessels clock was here used, and the Coast Survey transit instrument No. 6.

For determining the intervals of the threads, one hundred complete transits of forty-three stars are available, which were assorted into seven classes, and the several results then combined according to weights. Happily the reticule of this instrument had remained unchanged and unharmed during no less than ten previous longitude expeditions, for each of which the equatorial intervals had been carefully determined. The subjoined values are already reduced to the focal adjustment used at Heart's Content, those in the first column being deduced from eight, and those in the second from two, independent expeditions. In forming the column of adopted values these received the respective weights of 4 and 1, the weight 1 being also assigned to the Heart's Content results.

Equatorial thread intervals of transit No. 6, reduced to Heart's Content, 1866.

	From 8 campaigns before 1859.	Macon, 1859, and Appalachicola, 1860.	Heart's Content, 1866.	Adopted.
B 1	+35. 650	+35. 687	+35. 604	+35. 648
2	33. 120	33. 111	33. 117	33. 118
3	30. 623	30. 614	30. 616	30. 620
4	28. 054	28. 062	28. 052	28. 054
5	25. 437	25. 426	25. 425	25. 433
C 1	20. 565	20. 552	20. 610	20. 570
2	17. 950	17. 937	17. 954	17. 952
3	15. .07	15. 406	15. 403	15. 406
4	12. 703	12. 696	12. 686	12. 699
5	10. 249	10. 240	10. 228	10. 244
D 1	5. 100	5. 106	5. 116	5. 104
2	2. 585	2. 590	2. 600	2. 588
3	+ 0. 052	+ 0. 068	+ 0. 084	+ 0. 060
4	— 2. 461	— 2. 469	— 2. 474	— 2. 464
5	5. 066	5. 085	5. 078	5. 071
E 1	10. 112	10. 096	10. 092	10. 106
2	12. 828	12. 838	12. 813	12. 827
3	15. 341	15. 344	15. 343	15. 342
4	17. 969	17. 968	17. 964	17. 968
5	20. 447	20. 460	20. 441	20. 448
F 1	25. 543	25. 532	25. 535	25. 540
2	28. 120	28. 116	28. 103	28. 116
3	30. 692	30. 692	30. 684	30. 691
4	33. 147	33. 152	33. 134	33. 146
5	—35. 770	—35. 746	—35. 834	—35. 777

The correction for inequality of pivots, as indicated by the Newfoundland observations, is —$0^s.019$; and since the average value deduced from the five previous expeditions was —$0^s.017$, the mean of these, or —$0^s.018$, has been employed, the perforated pivot being the larger.

Although the climate of Newfoundland proved by no means a favorable one for astronomical observations, the observers had the satisfaction of obtaining excellent series of transits for time-determinations, both before and after exchanges on every night in which longitude signals were exchanged, whether with Valencia or with Calais. Here as in the Valencia series those observations are given, together with their reductions, upon which the longitudes depend. All transit observations upon which the longitude from Valencia depends were made by Mr. Dean, and all for the Calais longitude for Mr. Goodfellow.

1866, *October* 25. *D. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
κ Cephei, U. C........	W.	B_1–C_5	20 11 31. 94	—0. 124	+1 44. 553	—0. 555
κ Cephei, U. C........	E.	B_1–C_5	15 0. 30	—0. 148	—1 44. 553	—0. 650
α Cygni	“	B_1–F_5	36 49. 22	—0. 154	0 0. 000	—0. 236
μ Aquarii	“	C_1–E_5	45 23. 66	—0. 153	—0 0. 028	—0. 098
ν Cygni	“	B_1–C_5	20 52 38. 64	—0. 132	—0 30. 280	—0. 191
ξ Cygni	W.	B_{1-4} D_3–F_5 exc. E_2.	21 7 19. 11	—0. 101	—0 6. 990	—0. 126
α Cephei	“	B_1–C_5	14 32. 13	—0. 124	+0 48. 960	—0. 286
1 Pegasi..............	“	C_1–F_5	15 59. 75	—0. 127	—0 8. 095	—0. 132
24 Urs. Majoris, L. C...	“	E_1–F_5	21 23. 62	—0. 138	+1 8. 610	+0. 236
24 Urs. Majoris, L. C...	E.	E_1–F_5	23 41. 48	—0. 138	—1 8. 610	+0. 236
ζ Aquarii.............	“	C_1–E_5	30 35. 41	—0. 142	—0 0. 028	—0. 094
11 Cephei, U. C	“	E_1–F_5	38 45. 96	—0. 146	+1 9. 560	—0. 451
11 Cephei, U. C	W.	E_1–F_5	21 41 5. 67	—0. 146	—1 9. 560	—0. 451

$T = 21^h \quad \theta = +4^s.7 \quad \rho = 0^s.000 \quad c = -0^s.110$

Star.	t	a	Cc	ω'₀	Aa	△t
	h. m. s.	m. s.	s.	s.	s.	s.
κ Cephei, U. C	20 13 15.52	13 20.51	....	+0.29	+0.60	+4.39
α Cygni	36 46.98	36 53.99	—0.155	+0.15	—0.02	4.87
μ Aquarii	45 23.54	45 28.08	—0.111	—0.27	—0.23	4.66
ν Cygni	20 52 8.17	52 13.06	—0.145	+0.05	—0.04	4.79
ξ Cygni	21 7 11.99	7 16.62	+0.127	+0.05	—0.10	4.85
α Cephei	15 20.80	15 25.44	+0.234	+0.17	+0.14	4.73
1 Pegasi	15 51.52	15 56.15	+0.116	+0.04	—0.14	4.88
24 Urs. Majoris, L. C	22 32.79	22 36.65	....	—0.84	—0.71	4.57
ζ Aquarii	30 35.29	30 39.85	—0.111	—0.25	—0.23	4.68
11 Cephei, U. C	21 39 55.36	40 0.40	....	+0.34	+0.32	+4.72

$$10 \triangle \theta + 1.499\, a = -0.260$$
$$+1.499 \triangle \theta + 15.420\, a = -3.910$$
$$a = -0^s.268 \quad \triangle \theta = +0^s.014 \quad \triangle t = +4^s.714$$

1866, *October* 25. *D. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
γ Cephei, U. C	W.	B_3–C_5	23 32 27.93	—0.168	+1 28.678	—0.723
γ Cephei, U. C	E.	B_1–C_5	35 37.32	—0.138	—1 41.250	—0.601
ω Piscium	"	B_1–F_5	23 52 24.79	—0.147	0 0.000	—0.124
α Andromedæ	"	B_1–F_5	0 1 27.22	—0.154	0 0.000	—0.181
γ Pegasi	"	B_1–F_5	6 19.40	—0.138	0 0.000	—0.133
κ Draconis, L. C	"	B_1–C_5	26 29.25	—0.150	+1 8.916	+0.255
κ Draconis, L. C	W.	B_1–C_5	29 46.16	—0.152	—1 8.916	+0.255
α Cassiopeæ	"	B_1–E_5	32 42.79	—0.155	+0 13.637	—0.297
β Ceti	"	C_1–E_5	36 50.93	—0.151	+0 0.030	—0.078
32 Camel., (foll.) L. C	"	E_1–F_3	44 31.74	—0.133	+3 17.218	+1.007
32 Camel., (foll.) L. C	E.	D_1–E_3	0 48 37.30	—0.164	—0 46.605	+1.211

$T = 0^h \quad = +4^s.7 \quad \rho = 0^s.000 \quad c = -0^s.110$

Star.	t		Cc	ω'₀	Aa	△t
	h. m. s.	m. s.	s.	s.	s.	s.
γ Cephei, U. C	23 33 56.34	34 0.93	....	+0.55	+0.64	+4.62
ω Piscium	23 52 24.79	52 29.45	—0.111	—0.03	—0.20	4.87
α Andromedæ	0 1 27.22	1 31.93	—0.125	—0.03	—0.11	4.78
γ Pegasi	6 19.40	6 24.01	—0.114	—0.07	—0.17	4.80
κ Draconis, L. C	27 37.70	27 41.86	....	—0.80	—0.78	4.68
α Cassiopeæ	32 56.43	33 0.83	+0.196	+0.20	+0.07	4.82
β Ceti	36 50.96	36 55.11	+0.116	—0.36	—0.29	4.63
32 Camel., (foll.) L. C	0 47 49.83	47 53.52	....	—2.11	—2.16	+4.75

$$8 \triangle \theta + 10.124\, a = -2.651$$
$$10.214 \triangle \theta + 66.556\, a = -19.293$$
$$a = -0^s.297 \quad \triangle \theta = +0^s.045 \quad \triangle t = +4^s.745$$

1866, *October* 28. *D. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0 + \kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
ξ Aquarii	W.	B_1–F_5	21 30 34 77	+0.011	0 0.000	—0.020
11 Cephei, U. C	"	B_1–C_5	38 46.28	+0.009	+1 9.493	—0.019
11 Cephei, U. C	E.	B_1–C_5	41 2.59	+0.007	—1 9.493	—0.024
μ Capricorni	"	B_1–F_5	45 56.13	+0.005	0 0.000	—0.012
α Aquarii	"	B_1–F_5	21 58 50.94	—0.019	0 0.000	—0.027
π Aquarii	"	B_1–F_5	22 18 22.95	—0.019	0 0.000	—0.027
9 Draconis, L. C	"	B_{45} C_{45} D_{123}	22 41.66	—0.009	+0 51.148	+0.081
9 Draconis, L. C	W.	B_1–C_5	25 7.02	—0.005	—1 37.712	+0.071
η Aquarii	"	B_1–F_5	28 26.32	+0.003	0 0.000	—0.012
ζ Pegasi	"	B_1–F_5	34 44.83	+0.004	0 0.000	—0.011
ι Cephei, U. C	"	B_1–C_5	43 59.64	—0.016	+0 55.394	—0.069
ι Cephei, U. C	E.	B_1–C_5	22 45 48.35	—0.031	—0 55.394	—0.103

$$T = 22^h \quad \theta = +5^s.7 \quad \rho = +0^s.040 \quad c = -0^s.416$$

Star.	t.	α	Cc.	o'	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
ξ Aquarii	21 30 34.75	30 39.80	+0.421	—0.21	—0.04	+5.54
11 Cephei, U. C	39 54.41	40 0.20	....	+0.11	+0.06	5.75
μ Capricorni	45 56.12	46 2.20	—0.429	—0.04	—0.05	5.71
α Aquarii	21 58 50.91	58 56.96	—0.313	+0.03	—0.04	5.77
π Aquarii	22 18 22.92	18 29.02	—0.416	—0.03	—0.04	5.71
9 Draconis, L. C	23 31.14	23 36.64	....	—0.22	—0.19	5.67
η Aquarii	28 26.31	28 31.31	+0.416	—0.30	—0.04	5.44
ζ Pegasi	34 44.82	34 49.92	+0.423	—0.19	—0.03	5.54
ι Cephei, U. C	22 44 53.90	44 59.62	....	—0.02	+0.04	+5.64

$$9 \,\triangle\theta + 6.222\, a = -0.872$$
$$+6.222 \,\triangle\theta + 17.817\, a = -1.425$$
$$\triangle\theta = -0^s.060$$
$$a = -0^s.053 \qquad \triangle t = +5^s.640$$

1866, *October* 28. *D. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0 + \kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
α Cassiopeæ	E.	B_1–F_5	0 32 54.28	—0.071	0 0.000	—0.149
21 Cassiopeæ, U. C	"	B_5–C_3	38 6.40	—0.071	—1 13.113	—0.285
ε Piscium	"	B_1–F_5	0 55 57.15	—0.071	0 0.000	—0.068
Polaris, U. C	"	D_3–E_4	1 4 48.10	—0.071	+6 11.875	—2.759
Polaris, U. C	W.	D_4–E_3	17 46.90	—0.004	—6 13.717	—0.687
η Piscium	"	B_1–F_5	24 17.86	—0.032	0 0.000	—0.041
o Piscium	"	B_1–F_5	38 18.00	—0.076	0 0.000	—0.073
β Arietis	"	B_1–F_5	47 13.61	—0.095	0 0.000	—0.105
50 Cassiopeæ, U. C	"	B_1–C_5	50 55.18	—0.111	+1 13.440	—0.368
50 Cassiopeæ, U. C	E.	B_1–C_5	53 19.08	—0.127	—1 13.440	—0.415
α Arietis	"	B_1–F_5	1 59 35.66	—0.138	0 0.000	—0.151

$T = 1^h \quad \theta = +5^s.8 \quad \rho = +0^s.040 \quad c = -0^s.416$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
α Cassiopeæ	0 32 54.13	33 0.82	—0.740	+0.17	+0.07	+5.90
21 Cassiopeæ, U. C	36 53.00	37 0.45	—1.533	+0.13	+0.44	5.49
ε Piscium	0 55 57.08	56 3.10	—0.419	—0.20	—0.18	5.78
Polaris, U. C	1 11 14.87	11 27.75	....	+7.08	+7.13	5.75
η Piscium	24 17.82	24 22.93	+0.430	—0.28	—0.15	5.67
o Piscium	38 17.93	38 23.16	+0.421	—0.18	—0.17	5.79
β Arietis	47 13.51	47 18.73	+0.442	—0.17	—0.13	5.77
50 Cassiopeæ, U. C	52 7.06	52 12.79	....	—0.11	+0.35	5.34
α Arietis	1 59 35.51	59 41.80	+0.451	0.00	—0.12	+5.92

$$9 \triangle \theta - 26.964 a = + \quad 6.439$$
$$-26.964 \triangle \theta + 713.993 a = -188.899$$
$$a = -0^s.268 \quad \begin{array}{l} \triangle \quad = -0^s.087 \\ \triangle t = +5^s.713 \end{array}$$

1866, *November* 5. *D obs.*

Star.	Lamp.	Threads.	M	b_0	R.	$Bb_0 + \kappa$
			h. m. s.	s.	m. s.	s.
9 Draconis, L. C	W.	E_1-F_5	22 22 51.74	—0.038	+1 37.810	+0.150
9 Draconis, L. C	E.	E_1-F_5 exc. F_2	24 49.73	—0.044	—1 20.762	+0.164
ζ Pegasi	"	B_1-F_5	34 41.58	—0.061	0 0.000	—0.063
ι Cephei, U. C	"	E_1-F_5	43 55.93	—0.032	+0 55.442	—0.106
ι Cephei, U. C	W.	E_1-F_5	45 46.44	—0.016	—0 55.442	—0.069
α Pegasi	"	D_2-F_5 exc. D_4	22 58 18.68	—0.036	—0 18.462	—0.046
ι Piscium	"	C_2-F_5	23 33 7.81	—0.063	—0 9.162	—0.060
γ Cephei, U. C	"	E_3-F_5	35 46.01	—0.063	—0 54.045	—0.304
ω Piscium	E.	B_1-F_5	23 52 21.10	—0.136	0 0.000	—0.116
α Andromedæ	"	B_1-F_5	0 1 23.60	—0.018	0 0.000	—0.035
γ Pegasi	W.	B_1-F_5	0 6 15.69	0.000	0 0.000	—0.014

$T = 23^h \quad \theta = +8^s.3 \quad \rho = 0^s.000 \quad c = +0^s.033$

Star.	t	a	Cc	ω'_0	Aa	
	h. m. s.	m. s.	s.	s.	s.	s.
9 Draconis, L. C	22 23 29.42	23 37.34	....	—0.43	—0.34	+8.21
ζ Pegasi	34 41.52	34 49.79	+0.034	+0.01	—0.06	8.37
ι Cephei, U. C	44 51.10	44 59.32	....	—0.08	+0.07	8.15
α Pegasi	22 58 0.17	58 8.49	—0.034	—0.02	—0.06	8.34
ι Piscium	23 32 58.59	33 6.95	—0.033	+0.03	—0.07	8.40
γ Cephei, U. C	33 51.66	34 0.30	—0.147	+0.19	+0.21	8.28
ω Piscium	23 52 20.95	52 29.38	+0.033	+0.16	—0.07	8.53
α Andromedæ	0 1 23.57	1 31.86	+0.038	+0.03	—0.04	8.37
γ Pegasi	0 6 15.68	6 23.94	—0.034	—0.07	—0.06	+8.29

$$9 \triangle \theta + \quad 4.140 a = -0.170$$
$$+4.140 \quad \triangle \theta + 19.703 a = -1.755$$
$$a = -0^s.098 \quad \begin{array}{l} \triangle \theta = +0^s.026 \\ \triangle t = +8^s.326 \end{array}$$

1866, *November* 5. *D. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
θ′ Ceti	W.	B_1–F_5	1 17 14.92	—0.101	0 0.000	—0.070
A Cassiopeæ, U. C	"	B_1–C_5	20 12.71	—0.098	+1 5.828	—0.301
A Cassiopeæ, U. C	E.	B_1–C_5	22 24.44	—0.098	—1 5.828	—0.301
η Piscium	"	B_1–E_5	24 22.66	—0.095	—0 7.922	—0.096
ο Piscium	"	B_1–F_5	38 14.92	—0.104	0 0.000	—0.095
β Arietis	"	B_1–F_5	47 10.56	—0.107	0 0.000	—0.116
50 Cassiopeæ, U. C	"	E_1–F_5	50 51.22	—0.106	+1 13.510	—0.354
50 Cassiopeæ, U. C	W.	E_1–F_5	53 18.13	—0.103	—1 13.510	—0.345
α Arietis	"	B_1–F_5	1 59 33.58	—0.099	0 0.000	—0.112
65 ξ′ Ceti	"	B_1–F_5	2 5 49.83	—0.087	0 0.000	—0.082
ι Cassiopeæ, U. C	"	B_1–C_5	17 5.84	—0.103	+0 58.037	—0.282
ι Cassiopeæ, U. C	E.	B_1–C_5	19 2.63	—0.123	—0 58.037	—0.331
5 Urs. Minoris, L. C	"	B_1–C_5	25 58.14	—0.126	+1 36.946	+0.357
5 Urs. Minoris, L. C	W.	B_1–D_3	2 28 52.39	—0.114	—1 17.092	+0.327

$T = 2^h \quad \theta = +8^s.3 \quad \rho = 0^s.000 \quad c = +0^s.033$

Star.	t	α	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
θ′ Ceti	1 17 14.85	17 23.11	—0.034	—0.07	—0.16	+8.38
A Cassiopeæ, U. C	21 18.27	21 26.77	....	+0.20	+0.20	8.30
η Piscium	24 14.64	24 22.93	+0.034	+0.02	—0.11	8.43
ο Piscium	38 14.82	38 23.18	+0.034	+0.09	—0.12	8.51
β Arietis	47 10.44	47 18.76	+0.036	+0.05	—0.09	8.44
50 Cassiopeæ, U. C	52 4.33	52 12.81	....	+0.18	+0.24	8.24
α Arietis	1 59 33.47	59 41.84	—0.036	+0.04	—0.09	8.42
65 ξ′ Ceti	2 5 49.75	5 57.95	—0.034	—0.13	—0.12	8.29
ι Cassiopeæ, U. C	18 3.93	18 12.24	....	+0.01	+0.15	8.16
5 Urs. Minoris, L. C	2 27 35.53	27 43.04	....	—0.79	—0.66	+8.16

$$10\,\triangle\theta + 3.969a = -0.427$$
$$+3.969\,\triangle\theta + 17.993a = -3.258$$
$$a = -0^s.188 \qquad \triangle\theta = +0^s.032$$
$$\triangle t = +8.332$$

1866, *November* 6. *D. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
α² Capricorni	W.	B_1–C_5	20 10 7.83	+0.087	+0 23.574	—0.030
κ Cephei, U. C	"	B_4–D_3	12 8.24	+0.061	+1 2.852	+0.179
κ Cephei, U. C	E.	B_1–C_5	14 55.99	+0.037	—1 44.555	+0.084
π Capricorni	"	$B_{1\,2\,3}$ E_1–E_5	19 36.36	+0.006	—0 2.994	—0.012
ε Delphini	"	B_1–F_5	26 42.81	—0.032	0 0.000	—0.040
Groombr., 3241, U. C.	"	C_5–F_5	29 41.77	—0.038	+0 44.580	—0.174
α Cygni	"	B_1–F_5	36 45.74	—0.059	0 0.000	—0.102
μ Aquarii	"	B_1–F_5	45 20.03	—0.079	0 0.000	—0.057
12 Y. Cat. 1879, U. C	"	D_3–F_2	52 6.36	—0.059	+1 19.774	—0.369
12 Y. Cat. 1879, U. C	W.	E_1–F_5	20 55 39.03	—0.040	—2 13.109	—0.376
ξ Cygni	"	B_1–F_5	21 7 8.38	—0.002	0 0.000	—0.018
α Cephei	"	B_1–C_5	14 28.01	—0.026	+0 48.960	—0.082
1 Pegasi	"	C_3–E_5	15 50.96	—0.038	—0 3.106	—0.049
24 Urs. Majoris, L. C.	"	E_1–F_5	21 21.51	—0.074	+1 8.610	+0.146
24 Urs. Majoris, L. C.	E.	E_1–F_5	21 23 38.33	—0.088	—1 8.610	+0.165

$T = 21^h \quad \theta = +7^s.9 \quad \rho = +0^s.030 \quad c = +0^s.033$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
a^2 Capricorni	20 10 31.43	10 39.38	—0.034	+0.04	—0.06	+8.00
κ Cephei, U. C	13 11.39	13 19.24	....	—0.03	+0.16	7.71
π Capricorni	19 33.35	19 41.32	+0.035	+0.12	—0.07	8.09
ε Delphini	26 42.77	36 50.83	+0.034	+0.21	—0.04	8.15
Groombr., 3241, U. C	30 26.18	30 34.07	+0.108	+0.12	+0.09	7.92
α Cygni	36 45.64	36 53.67	+0.037	+0.18	—0.01	8.09
μ Aquarii	45 19.97	45 27.89	+0.034	+0.06	—0.06	8.02
12 Y. Cat. 1879, U. C	20 53 25.70	53 33.91	....	+0.31	+0.22	7.99
ζ Cygni	21 7 8.36	7 16.39	—0.038	+0.09	—0.03	8.01
α Cephei, U. C	15 16.89	15 24.93	—0.071	+0.06	+0.04	7.93
1 Pegasi	15 47.80	15 55.95	—0.035	+0.20	—0.04	8.14
24 Urs. Majoris, L. C	21 22 30.07	22 37.52	....	—0.47	—0.18	+7.62

$$12\,\triangle\theta - 0.272\,a = +0.889$$
$$-0.272\,\triangle\theta + 26.685\,a = -1.844$$
$$a = -0^s.070 \quad \triangle\theta = +0^s.073$$
$$\triangle t = +7^s.973$$

1866, *November* 6. *D. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
ι Cephei, U. C	E.	E_1–F_5	22 43 56.08	—0.003	+0 55.448	—0.039
ι Cephei, U. C	W.	E_1–F_5	45 46.76	0.000	—0 55.448	—0.032
α Pegasi	"	B_1–F_5	22 58 0.52	—0.056	0 0.000	—0.062
ο Cephei, U. C	"	B_1–C_5	23 12 5.69	—0.069	+0 59.729	—0.205
ο Cephei, U. C	E.	B_1–C_3	14 12.84	—0.057	—1 7.205	—0.176
θ Piscium	"	C_1–F_5	20 58.08	—0.072	+0 7.681	—0.068
λ Draconis, L. C	"	C_1–F_5	23 38.76	—0.092	—0 22.424	+0.168
ι Piscium	"	B_1–F_5	32 59.08	—0.126	0 0.000	—0.107
ω Piscium	"	B_1–F_5	23 52 21.48	—0.162	0 0.000	—0.026
α Andromedæ	W.	B_1–F_5	0 1 23.93	—0.128	0 0.000	—0.153
γ Pegasi	"	B_1–F_5	0 6 16.04	—0.097	0 0.000	—0.098

$T = 23^h \quad \theta = +8^s.0 \quad \rho = +0^s.030 \quad c = +0^s.033$

Star.	t		Cc	ω'_0	Aa	t
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
ι Cephei, U. C	22 44 51.38	44 59.28	....	—0.10	+0.12	+7.79
α Pegasi	22 58 0.46	58 8.48	—0.034	—0.01	—0.09	8.08
ο Cephei, U. C	23 13 5.34	13 13.36	....	+0.02	+0.14	7.88
θ Piscium	21 5.69	21 13.55	+0.033	—0.12	—0.11	7.99
λ Draconis, L. C	23 16.50	23 23.96	+0.098	—0.66	—0.42	7.76
ι Piscium	32 58.97	33 6.94	+0.033	—0.02	—0.11	8.10
ω Piscium	23 52 21.45	52 29.37	+0.033	—0.08	—0.11	8.03
α Andromedæ	0 1 23.78	1 31.85	—0.038	0.00	—0.06	8.07
γ Pegasi	0 6 15.94	6 23.93	—0.035	—0.08	—0.08	+8.00

$$9\,\triangle\theta + 4.540\,a = -1.034$$
$$+4.540\,\triangle\theta + 10.441\,a = -1.845$$
$$a = -0^s.162 \quad \triangle\theta = -0^s.033$$
$$\triangle t = +7^s.967$$

1866, *November* 9. *D. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
Groombr., 3241, U.C.	W.	B_1–E_4 exc. $D_{4\,5}$ ..	20 30 18.36	—0.055	+0 7.685	—0.298
α Cygni	"	B_4–D_4 exc. D_1 ...	36 27.42	—0.055	+0 18.397	—0.096
μ Aquarii	"	B_1–F_5 exc. $D_{1\,2}$ ..	45 20.75	—0.055	—0 0.339	—0.044
ν Cygni	"	B_1–F_5	52 4.93	—0.071	0 0.000	—0.111
σ^2 Urs. Majoris, L. C	"	D_3–E_5	20 58 1.96	—0.095	+0 27.697	+0.144
ξ Cygni	E.	B_1–F_5	21 5 8.63	—0.121	0 0.000	—0.148
α Cephei	"	D_1–F_5	14 44.56	—0.175	+0 32.640	—0.302
24 Urs. Majoris, L. C	"	B_1–C_5	21 21.51	—0.143	+1 8.544	+0.244
24 Urs. Majoris, L. C	W.	B_1–D_2	23 29.05	—0.107	—0 59.024	—0.193
β Cephei, U. C	"	E_1–F_5	27 56.94	—0.165	—1 7.150	—0.324
ζ Aquarii	"	B_1–F_5	36 32.07	—0.113	0 0.000	—0.077
11 Cephei, U. C.	"	B_1–C_5	38 42.40	—0.141	+1 9.493	—0.437
11 Cephei, U. C	E.	B_1–C_5	41 1.54	—0.153	—1 9.493	—0.471
μ Capricorni	"	B_1–F_5	45 54.36	—0.163	0 0.000	—0.093
79 Draconis, U. C	"	E_1–F_5	49 48.56	—0.170	+1 8.962	—0.575
79 Draconis, U. C	W.	D_3–F_5	21 52 10.23	—0.170	—1 2.713	—0.575

$T = 21^h \quad \theta = +7^s.8 \quad \rho = 0^s.000 \quad c = +0^s.033$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s*	*s.*
Groom., 3241, U. C.	20 30 25.84	30 33.85	—0.108	+0.11	+0.12	+7.78
α Cygni	36 45.72	36 53.58	—0.047	+0.01	—0.01	7.82
μ Aquarii	45 20.37	45 27.94	—0.034	—0.26	—0.08	7.62
ν Cygni	52 4.82	52 12.70	—0.044	+0.04	—0.01	7.85
σ^2 Urs. Majoris, L. C	20 58 29.80	58 37.35	+0.088	—0.16	—0.22	7.86
ξ Cygni	21 5 8.48	5 16.33	+0.038	+0.09	—0.03	7.92
α Cephei	15 16.81	15 24.80	+0.071	+0.26	+0.05	8.02
24 Urs. Majoris, L. C	22 30.26	22 37.75	....	—0.31	—0.24	7.73
β Cephei, U. C	26 49.47	26 57.28	—0.097	—0.09	+0.10	7.61
ζ Aquarii	30 31.99	30 39.63	—0.034	—0.20	—0.08	7.68
11 Cephei, U. C	39 51.52	39 59.49	....	+0.17	+0.11	7.87
μ Capricorni	45 54.27	46 2.02	+0.035	—0.01	—0.08	7.87
79 Draconis, U. C	21 51 6.94	51 14.98	....	+0.23	+0.13	+7.90

$$13\,\triangle\theta + 2.620\,a = -0.115$$
$$+2.620\,\triangle\theta + 21.728\,a = -2.008$$
$$a = -0^s.093 \qquad \triangle\theta = +0^s.010$$
$$\triangle\theta = +7^s.810$$

1866, *November* 9. *D. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
β Ceti	W.	B_1–F_5	0 36 47.47	—0.138	0 0.000	—0.073
32 Camel., (foll.) L. C.	"	D_3–F_2	45 33.60	—0.156	+2 15.030	+1.158
32 Camel., (foll.) L. C.	E.	E_1–F_5	51 32.00	—0.173	—3 45.318	+1.270
ε Piscium	"	B_1–F_5	0 55 55.58	—0.185	0 0.000	—0.155
ο Piscium	"	B_1–F_5	1 38 15.55	—0.233	0 0.000	—0.196
β Arietis	"	B_1–F_5	47 11.24	—0.206	0 0.000	—0.209
50 Cassiopeæ, U. C	"	E_1–F_5	50 52.01	—0.188	+1 13.510	—0.594
50 Cassiopeæ, U. C	W.	E_1–F_5	53 18.82	—0.180	—1 13.510	—0.570
α Arietis	"	B_1–F_5	1 59 34.22	—0.186	0 0.000	—0.198
65 ξ^1 Ceti	"	B_1–F_5 exc. $B_{4\,5}C_5F_1$	2 5 52.21	—0.221	—0 1.838	—0.186
ι Cassiopeæ, U. C	"	B_1–C_5 exc. B_3	17 8.71	—0.203	—0 0.203	—0.522
ι Cassiopeæ, U. C	E.	B_1–C_5 exc. C_1	2 18 4.13	—0.195	—0 0.195	—0.503

$T = 1^h \quad \theta = +7^s.8 \quad \rho = 0^s.000 \quad c = +0^s.033$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
β Ceti	0 36 47.40	36 55.04	—0.035	—0.19	—0.23	+7.84
32 Camel., (foll.) L. C.	47 48.87	47 54.84	....	—1.83	—1.75	7.72
ε Piscium	0 55 55.42	56 3.07	+0.033	—0.12	—0.16	7.84
o Piscium	1 38 15.35	38 32.18	+0.034	+0.06	—0.15	8.01
β Arietis	47 11.03	47 18.76	+0.035	—0.04	—0.12	7.88
50 Cassiopeæ, U. C	52 4.83	52 12.80	....	+0.17	+0.31	7.66
α Arietis	1 59 34.02	59 41.85	—0.036	—0.01	—0.07	7.86
65 Ceti	2 5 50.19	5 57.96	—0.034	—0.06	—0.16	7.90
ι Cassiopeæ, U. C	2 18 4.49	18 12.26	....	—0.03	—0.20	+7.58

$$9 \triangle \theta + 9.039a = -2.050$$
$$+9.039 \triangle \theta + 58.021a = -13.809$$
$$a = -0^s.240 \quad \triangle \theta = +0^s.013 \quad \triangle t = +7^s.813$$

1866, *December* 11.—*Gf. obs.*

Star.	Lamp.	Threads.	M	b	R	$Bb_0 + \kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
9 Draconis, L. C	E.	B_1-C_5	22 22 1.36	—0.099	+1 37.712	+0.296
9 Draconis, L. C	W.	B_1-D_5 exc. D_4	24 49.70	—0.089	—1 10.610	+0.272
ξ Pegasi	"	E_{2-5}	35 4.27	—0.054	—0 16.909	—0.057
ι Cephei, U. C	"	B_1-F_5	44 55.55	—0.068	0 0.000	—0.188
α Pegasi	"	C_1-C_4	22 57 48.82	—0.084	+0 17.202	—0.094
θ Piscium	"	B_1-F_5	23 21 11.16	—0.108	0 0.000	—0.094
γ Cephei, U. C	"	B_1-C_5	32 14.29	—0.121	+1 41.250	—0.528
γ Cephei, U. C	E.	B_1-C_5	35 37.21	—0.127	—1 41.250	—0.550
Groombr., 4163, U. C.	"	B_1-F_5	48 24.20	—0.144	0 0.000	—0.511
ω Piscium	"	B_1-E_5	23 52 34.61	—0.148	—0 7.708	—0.125
α Andromedæ	"	C_1-E_5	0 1 29.34	—0.147	—0 0.032	—0.173
4 Draconis, L. C	"	B_1-C_5	3 55.23	—0.145	+1 53.865	+0.493
4 Draconis, L. C	W.	B_1-D_5	0 7 5.11	—0.141	—1 15.985	+0.481

$T = 23^h \quad \theta = +2^s.1 \quad \rho = +0^s.02 \quad c = +0^s.033$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
9 Draconis, L. C	22 23 39.37	23 41.18	....	—0.30	—0.36	+2.17
ξ Pegasi	34 47.30	34 49.32	—0.034	—0.13	—0.66	2.04
ι Cephei, U. C	44 55.36	44 57.72	—0.080	+0.17	+0.08	2.20
α Pegasi	22 58 5.93	58 8.03	—0.034	—0.03	—0.06	2.13
θ Piscium	23 21 11.07	21 13.13	—0.033	—0.06	—0.07	2.11
γ Cephei, U. C	33 55.21	33 57.53	....	+0.22	+0.22	2.10
Groombr., 4163, U. C	48 23.69	48 26.12	+0.119	+0.47	+0.16	2.40
ω Piscium	23 52 27.03	52 29.00	+0.033	—0.08	—0.07	2.09
α Andromedæ	0 1 29.14	1 31.43	+0.038	+0.24	—0.04	2.38
4 Draconis, L. C	0 5 49.60	5 51.42	....	—0.25	—0.42	+2.26

$$10 \triangle \theta + 6.015a = +0.257$$
$$+6.015 \triangle \theta + 37.765a = -3.483$$
$$a = -0^s.104 \quad \triangle \theta = +0^s.088 \quad \triangle t = +2^s.188$$

1866, *December* 11. *Gf. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
δ Draconis, L. C	W.	E_1–F_5	7 11 26.58	—0.137	+0 59.903	+0.188
δ Draconis, L. C	E.	D_3–F_5	13 13.84	—0.151	—0 47.577	+0.204
β Geminorum	"	B_1–F_5	37 9.45	—0.223	0 0.000	—0.255
φ Geminorum	"	D_1–F_5	45 3.06	—0.208	+0 17.205	—0.235
ε Draconis, L. C.......	"	B_1–C_5	47 25.07	—0.197	+1 6.936	+0.308
ε Draconis, L. C.......	W.	B_1–D_3...........	49 25.45	—0.187	—0 53.228	+0.294
3 Ursa Majoris, U. C ..	"	B_1–D_5	7 58 49.83	—0.154	+0 42.513	—0.437
Groomb., 3241, L. C ..	"	C_1–E_5	8 30 30.04	—0.107	—0 0.091	+0.219
ε Hydræ.............	"	B_1–F_5	8 39 42.64	—0.103	0 0.000	—0.092
κ Cancri	"	B_1–F_5	9 0 31.11	—0.129	0 0.000	—0.120

$$T=8^{h} \quad \theta=+1^{s}.9 \quad \rho=-0^{s}.020 \quad c=+0^{s}.033$$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
δ Draconis, L. C	7 12 26.54	12 28.33	....	—0.12	—0.28	2.06
β Geminorum	37 9.20	37 11.34	+0.038	+0.27	—0.05	2.22
φ Geminorum	45 20.03	45 22.13	+0.038	+0.23	—0.05	2.18
ε Draconis, L. C............	48 32.41	48 34.09	....	—0.23	—0.31	1.98
3 Urs. Majoris, U. C.........	7 59 31.94	59 34.07	—0.092	+0.13	+0.12	1.91
Groombr., 3241, L. C......	8 30 30.17	30 31.77	+0.108	—0.18	—0.34	2.06
ε Hydræ	8 39 42.55	39 44.53	—0.033	+0.06	—0.08	2.04
Cancri	9 0 30.99	0 32.95	—0.034	+0.06	—0.07	+2.03

$$8\triangle\theta + 8.801a = +0.227$$
$$+8.801\triangle\theta + 22.225a = -1.252$$
$$a = -0^{s}.120 \quad \triangle\theta = +0^{s}.160$$
$$\triangle t = +2^{s}.060$$

1866, *December* 12. *Gf. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
θ′ Ceti................	W.	B_1–F_5	1 17 21.45	+0.077	0 0.000	+0.028
A Cassiopeæ, U. C.....	"	B_1–C_5	20 17.80	+0.074	—1 5.828	+0.157
η Piscium	"	C_1–F_5	24 29.23	+0.068	—0 7.901	+0.045
β Arietis	"	B_1–C_2 E_3–F_4	1 47 15.58	+0.061	+0 1.533	+0.043
ζ Urs. Minoris, L. C ..	"	E_1–F_3	3 47 5.96	+0.009	+1 38.478	+0.042
ζ Urs. Minoris, L. C ..	E.	D_1–F_5 exc. F_1....	3 49 55.34	—0.001	—1 11.358	+0.071
γ Tauri	"	B_1–F_5	4 12 13.38	—0.039	0 0.000	—0.048
ε Tauri	"	B_1–F_5	20 50.98	—0.037	0 0.000	—0.049
α Tauri	"	B_1–F_5	28 17.19	—0.030	0 0.000	—0.041
α Camelop., U. C.....	"	E_1–F_5	39 55.70	+0.002	+0 56.784	—0.029
α Camelop., U. C	W.	D_3–F_5	4 41 37.50	+0.008	—0 45.099	—0.016

$T = 3^h \quad \theta = +1^s.6 \quad \rho = +0^s.000 \quad c = +0^s.033$

Star.	t	a	Cc	ω′₀	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
θ′ Ceti	1 17 21.48	17 22.90	—0.034	—0.21	—0.22	+1.61
A Cassiopeæ, U. C.	21 23.78	21 25.82	—0.096	+0.34	+0.28	1.66
η Piscium	24 21.37	24 22.75	—0.035	—0.26	—0.15	1.49
β Arietis	1 47 17.16	47 18.66	—0.036	—0.13	—0.13	1.60
ξ Urs. Minoris, L. C.	3 48 44.07	48 44.68	....	—0.99	—1.03	1.65
γ Tauri	4 12 13.33	12 14.80	+0.035	—0.10	—0.15	1.65
ε Tauri	20 50.93	20 52.38	+0.035	—0.12	—0.13	1.62
α Tauri	28 17.15	28 18.68	+0.035	—0.03	—0.14	1.71
α Camelop., U. C.	4 40 52.42	40 54.11	....	+0.09	+0.20	+1.49

$$9\,\triangle\theta + 5.646\,a = -1.407$$
$$+5.646\,\triangle\theta + 19.478\,a = -4.845$$
$$a = -0^s.261 \quad \triangle\theta = +0.007 \quad \triangle t = +1.607$$

1866, *December* 12. *Gf. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
ε Hydræ	W.	B_1–F_5	8 39 43.37	—0.079	0 0.000	—0.074
σ² Urs. Majoris, U. C.	"	B_1–C_5	57 37.69	—0.113	+1 0.481	—0.316
σ² Urs. Majoris, U. C.	E.	B_1–D_3	8 59 26.54	—0.116	—0 48.095	—0.323
1 Draconis, U. C.	"	D_1–F_5	9 16 3.71	—0.117	+1 48.775	—0.787
α Hydræ	"	B_1–F_5	21 2.38	—0.107	0 0.000	—0.075
θ Urs. Majoris	"	E_1–F_5	23 17.91	—0.104	+0 37.589	—0.192
β Cephei, L. C.	"	B_2–C_5	25 55.51	—0.100	+0 58.759	+0.176
β Cephei, L. C.	W.	B_1–C_5	28 1.60	—0.094	—1 7.086	+0.168
ε Leonis	"	B_1–F_5	38 16.67	—0.083	0 0.000	—0.099
ω Leonis	"	B_1–E_4	9 45 0.38	—0.083	+0 10.228	—0.103

$T = 9^h \quad \theta = +1^s.6 \quad \rho = 0^s.000 \quad c = +0^s.033$

Star.	t	a	Cc	ω′₀	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
ε Hydræ	8 39 43.30	39 44.48	—0.033	—0.45	—0.18	+1.33
σ² Urs. Majoris, U. C.	8 58 37.99	58 39.72	....	+0.13	+0.24	1.49
1 Draconis, U. C.	9 17 51.70	17 53.88	+0.237	+0.82	+1.07	1.34
α Hydræ	21 2.30	21 3.70	+0.034	—0.17	—0.23	1.65
θ Urs. Majoris	23 55.31	23 56.88	+0.054	+0.03	+0.03	1.59
β Cephei, L. C.	26 54.56	26 55.31	....	—0.75	—0.70	1.54
ε Leonis	38 16.57	38 18.08	—0.036	—0.13	—0.12	1.59
μ Leonis	9 45 10.52	45 11.77	—0.037	—0.39	—0.11	+1.32

$$8\,\triangle\theta - 0.076\,a = -0.916$$
$$-0.076\,\triangle\theta + 24.801\,a = -5.712$$
$$a = -0^s.270 \quad \triangle\theta = -0^s.117 \quad \triangle t = +1^s.483$$

1866, *December* 14. *Gf. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
9 Draconis, L. C	W.	E_1–F_5	22 22 4.17	—0.029	+1 37.808	+0.128
9 Draconis, L. C	E.	D_3–F_5 exc. F_1....	24 56.68	—0.035	—1 34.548	+0.143
ι Cephei, U. C........	"	E_1–F_5 exc. E_2....	22 43 59.64	—0.059	+0 58.181	—0.168
ο Piscium	"	B_1–F_5	1 38 23.14	—0.024	0 0.000	—0.033
β Arietis	W.	B_1–F_5	47 18.78	—0.022	0 0.000	—0.035
α Arietis	"	B_1–F_5	1 59 41.81	—0.010	0 0.000	—0.025
α Persei	"	C_1–F_5	3 15 4.22	—0.074	—0 11.741	—0.135
γ^2 Urs. Minoris, L. C ...	"	E_1–F_5	19 37.46	—0.104	+1 15.680	+0.217
γ^2 Urs. Minoris, L. C ...	E.	D_2–F_5	21 48.14	—0.124	—0 55.205	+0.250
η Tauri	"	C_1–E_5	39 36.36	—0.156	—0 0.031	—0.170
ξ Persei	"	C_1–E_5	45 48.38	—0.134	—0 0.033	—0.167
ξ Urs. Minoris, L. C ...	"	C_1–C_5	47 29.83	—0.130	+1 15.212	+0.442
ξ Urs. Minoris, L. C ...	W.	B_1–D_4	3 50 7.21	—0.120	—1 22.130	+0.414
Groombr., 2320, L. C.	"	B_1–F_5 exc. D_5....	4 5 55.28	—0.127	—0 0 567	+0.187
γ Tauri	"	B_1–F_5	12 15.11	—0.145	0 0.000	—0.141
ε Tauri	"	B_1–F_5	20 52.79	—0.167	0 0.000	—0.169
α Tauri	E.	B_1–F_5	4 28 18.90	—0.183	0 0.000	—0.176

$T = 2^h \quad \theta = -0^s.05 \quad \rho = -0^s.030 \quad c = +0^s.033.$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
9 Draconis, L. C	22 23 42.09	23 41.43	....	—0.72	—0.81	+0.04
ι Cephei, U. C	22 44 57.66	44 57.59	+0.080	—0.04	+0.17	—0.25
ο Piscium	1 38 23.11	38 23.02	+0.034	—0.02	—0.15	+0.08
β Arietis	47 18.74	47 18.64	—0.036	—0.10	—0.12	—0.03
α Arietis	1 59 41.79	59 41.75	—0.036	—0.02	—0.11	+0.04
α Persei	3 14 52.34	14 52.34	—0.051	+0.03	+0.01	—0.03
γ^2 Urs. Minoris, L. C ...	20 53.27	20 52.63	....	—0.55	—0.66	+0.06
η Tauri	39 36.16	39 36.18	+0.036	+0.16	—0.10	+0.21
ξ Persei	45 48.18	45 48.02	+0.039	—0.02	—0.08	+0.01
ξ Urs. Minoris, L. C ...	3 48 45.49	48 44.72	....	—0.67	—0.91	+0.20
Groombr., 2320, L. C.	4 5 54.90	5 53.89	+0.089	—0.81	—0.56	—0.30
γ Tauri	12 14.97	12 14.80	—0.035	—0.09	—0.13	—0.01
ε Tauri	20 52.62	20 52.40	—0.035	—0.14	—0.12	—0.07
α Tauri	4 28 18.72	28 18.70	+0.038	+0.14	—0.12	+0.21

$$14 \triangle \theta + 15.950\, a = -2.826$$
$$+15.950 \triangle \theta + 44.430\, a = -8.695$$
$$a = -0^s.231 \quad \triangle \theta = +0^s.061$$
$$\triangle t = +0^s.011$$

1866, *December* 14. *Gf. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s*
γ Geminorum	E.	B_1–F_5	6 30 3.18	—0.207	0 0.000	—0.158
51 Cephei, U. C	"	D_1–E_2	36 30.90	—0.222	+1 7.471	—3.856
51 Cephei, U. C	W.	E_1–F_5	45 31.60	—0.244	—7 58.244	—4.209
ε Canis Majoris	"	C_1–E_5	6 53 25.97	—0.273	+0 0.032	—0.088
δ Canis Majoris	"	B_1–F_5	7 3 0.98	—0.307	0 0.000	—0.109
δ Geminorum	"	B_1–F_5	12 12.25	—0.318	0 0.000	—0.325
τ Draconis, L. C	"	D_1–E_5	17 36.76	—0.318	+0 26.313	+0.611
τ Draconis, L. C	E.	E_4–F_5	19 36.74	—0.319	—1 34.226	+0.613
β Geminorum	"	B_1–F_5	37 11.91	—0.427	0 0.000	—0.473
φ Geminorum	"	C_1–E_5	45 22.93	—0.399	—0 0.031	—0.435
ε Draconis, L. C	"	B_1–C_5	47 27.73	—0.395	+1 6.936	+0.577
ε Draconis, L. C	W.	B_1–D_3	7 49 27.95	—0.389	—0 53.228	+0.568

$T=7^h \quad \theta=-0^s.20 \quad \rho=-0^s.03 \quad c=+0^s.033$

Star.	t	a	Cc	ω'₀	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
γ Geminorum	6 30 30.22	30 2.84	+0.035	+0.04	—0.14	—0.02
51 Cephei, U. C	37 31.83	37 35.04	....	+3.39	+3.51	—0.32
ε Canis Majoris	6 53 25.91	53 25.41	—0.038	—0.34	—0.30	—0.25
δ Canis Majoris	7 3 0.87	3 0.42	—0.037	—0.29	—0.29	—0.20
δ Geminorum	12 11.92	12 11.75	—0.036	+0.01	—0.12	—0.07
τ Draconis, L. C	18 3.41	18 2.16	....	—1.04	—0.79	—0.45
β Geminorum	37 11.44	37 11.41	+0.038	+0.23	—0.10	+0.13
φ Geminorum	45 22.49	45 22.21	—0.037	—0.02	—0.11	—0.12
ε Draconis, L. C	7 48 35.26	48 34.00	....	—1.04	—0.69	—0.55

$$9\triangle\theta - 3.692a = +0.923$$
$$-3.692\triangle\theta + 192.501a = -51.059$$
$$a=-0^s.266 \quad \triangle\theta=-0^s.006 \quad \triangle t=-0^s.206$$

1866, *December* 16. *Gf. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
ο Piscium	W.	B_1–F_5	1 38 24.26	+0.144	0 0.000	+0.098
β Arietis	"	B_1–F_5	47 19.80	+0.118	0 0.000	+0.096
50 Cassiopeæ, U. C	"	B_1–C_5	50 58.54	—0.097	+1 13.440	+0.240
50 Cassiopeæ, U. C	E.	B_1–D_4	53 6.10	+0.087	—0 53.665	+0.210
α Arietis	"	B_1–F_5	1 59 42.86	+0.073	0 0.000	+0.057
65 ξ' Ceti	"	B_1–F_5	2 5 59.16	+0.069	0 0.000	+0.040
ι Cassiopeæ, U. C	"	E_1–F_5	17 14.38	+0.093	+0 58.363	+0.188
ι Cassiopeæ, U. C	W.	D_3–F_5	2 18 58.85	+0.114	—0 46.353	+0.239

$T=2^h \quad \theta=-1^s.10 \quad \rho=0^s.000 \quad c=+0.033$

Star.	t	a	Cc	ω'₀	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	s.
ο Piscium	1 38 24.36	38 23.01	—0.034	—0.28	—0.22	—1.17
β Arietis	47 19.90	47 18.62	—0.036	—0.21	—0.17	1.15
50 Cassiopeæ, U. C	52 12.43	52 11.89	....	+0.56	+0.43	0.98
α Arietis	1 59 42.92	59 41.74	—0.036	—0.04	—0.15	0.99
65 ξ' Ceti	2 5 59.20	5 57.87	—0.034	—0.20	—0.22	1.08
ι Cassiopeæ, U. C	2 18 12.83	18 11.83	....	+0.10	+0.28	—1.28

$$6\triangle\theta + 0.124a = -0.079$$
$$+0.124\triangle\theta + 3.652a = -1.230$$
$$a=-0^s.336 \quad \triangle\theta=-0^s.006 \quad \triangle t=-1^s.106$$

1866, *December* 16. *Gf. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
η Tauri	W.	B_1–F_5 exc. Γ_{15}	3 39 34.05	+0.077	+0 3.273	+0.062
ζ Persei	"	B_1–D_5	45 31.15	+0.062	–0 17.979	+0.054
ζ Urs. Minoris, L. C	"	D_1–E_5	48 10.05	+0.053	+0 37.410	–0.085
ζ Urs. Minoris, L. C	E.	E_1–F_5	3 51 1.17	+0.044	–2 13.966	–0.059
γ Tauri	"	B_1–F_5	4 12 16.04	+0.026	0 0.000	+0.009
ε Tauri	"	B_1–F_5	20 53.65	+0.040	0 0.000	+0.022
15 Draconis, L. C	"	B_1–C_5	27 8.58	+0.063	+1 4.277	–0.041
15 Draconis, L. C	W.	B_1–D_4	4 28 59.92	+0.066	–0 46.970	–0.045

$$T=4^h \quad \theta=-1^s.10 \quad \rho=0^s.000 \quad c=+0^s.033$$

Star.	t	α	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*s.*
η Tauri	3 39 37.39	39 36.18	–0.036	–0.14	–0.15	–1.09
ζ Persei	45 49.18	45 48.02	–0.039	–0.10	–0.11	1.09
ζ Urs. Minoris, L. C	3 48 47.20	48 44.78	....	–1.38	–1.34	1.14
γ Tauri	4 12 16.05	12 14.81	+0.034	–0.10	–0.19	1.02
ε Tauri	20 53.67	20 52.41	+0.035	–0.13	–0.17	1.05
15 Draconis, L. C	4 48 12.86	28 11.12	....	–0.63	–0.85	–0.88

$$6\,\triangle\theta + 8.296\,a = -2.485$$
$$+8.296\,\triangle\theta + 22.690\,a = -7.249$$
$$a = -0^s.340 \qquad \triangle\theta = +0^s.056$$
$$\triangle t = -1.044$$

VI.—Observations at Calais.

The Hardy clock was used at this station, and the transit instrument No. 8, which had been employed with the same reticule at Mobile in 1858 and Eufaula in 1860, and the gentlemen of our party desire to express their warm acknowledgments of the ready courtesy and most efficient aid of Mr. Samuel Black, chief operator, to whom they are much indebted for what success they attained.

The cumbrous structure of the clock gave much trouble to the observers, which was increased by a couple of accidents. Some of the teeth of the escapement wheel were bent, in the transportation or otherwise, and the performance of the clock was unsatisfactory, the compensation of the pendulum rod having apparently been inadequate. Still the most of these difficulties were obviated by the care and zeal of all the members of the party, and although the time determinations could not always be all that they desired, and those of December 12 especially seem affected by some unexplained source of error, there is small doubt that had the observations continued a week longer these irregularities would have been eliminated or removed. The determinations on different dates are much more accordant than might have been expected under the circumstances, and the probable error of the final result is small.

The thread-intervals are derived from twenty-two complete transits, and the values deduced from these observations have been combined with those found for the same instrument and reticule at Mobile and Eufaula. The several determinations are given in the annexed table, where the intervals previously found are reduced to the scale corresponding to the Calais focus by increasing them by three ten-thousandths.

Equatorial thread intervals of Transit No. 8.

	Mobile, 1858.	Eufaula, 1860.	Calais, 1866.	Adopted.
B 1	+37. 925	+37. 926	37. 976	+37. 942
2	35. 194	35. 205	35. 214	35. 204
3	32. 664	32. 665	32. 611	32. 647
4	29. 959	29. 963	29. 986	29. 969
5	27. 214	27. 215	27. 183	27. 204
C 1	21. 728	21. 742	21. 810	21. 760
2	19. 069	19. 056	19. 047	19. 057
3	16. 286	16. 284	16. 271	16. 280
4	13. 644	13. 619	13. 583	13. 615
5	10. 950	10. 930	10. 948	10. 943
D 1	5. 546	5. 562	5. 528	5. 545
2	+ 2. 737	+ 2. 747	+ 2. 706	+ 2. 730
3	— 0. 065	— 0. 060	— 0. 060	— 0. 062
4	2. 794	2. 796	2. 641	2. 740
5	5. 527	5. 532	5. 555	5. 538
E 1	10. 922	10. 909	10. 936	10. 922
2	13. 600	13. 594	13. 663	13. 619
3	16. 371	16. 378	16. 376	16. 375
4	19. 032	19. 035	19. 013	19. 027
5	21. 700	21. 686	21. 679	21. 688
F 1	27. 137	27. 113	27. 115	27. 122
2	29. 871	29. 870	29. 850	29. 864
3	32. 591	32. 612	32. 626	32. 610
4	35. 305	35. 315	35. 321	35. 314
5	—37. 999	—38. 014	—38. 038	—38. 017

The correction for inequality of pivots, as deduced from the Calais observations, is $+0^s.022$, the pivot at the lamp end of the axis being smaller. The results from five previous campaigns having in no instance varied by more than $0^s.001$ from their mean value, $+0^s.027$, the quantity $+0^s.025$ has been used for the correction in the reductions.

The observations here given were made by Mr. Boutelle on the dates December 12, 13, 14, 15, and by Mr. Chandler December 11, 16, and 18. The time on those days when it was determined by the latter has been reduced to Mr. Boutelle's scale by applying $-0^s.04$ as the correction for personal equation.

It will be seen that on the 16th December, the last date of longitude exchanges, only the transit of a single star could be obtained before or after the longitude signals, one of these stars, too, being a circumpolar, and that the obstacles to good determinations of time were quite serious on other nights when exchanges were made with Newfoundland. On those nights when the Calais sky was clear the weather at Heart's Content appears to have been unfavorable. It is greatly to be regretted that exchanges were not continued on at least two more good nights, as desired by Mr. Boutelle; and it is due to him to state that he acceded most unwillingly to the discontinuance of operations.

The accordance of the values of the longitude, resulting from observations made under such unfavorable circumstances, is in the highest degree creditable to the gentlemen concerned.

1866, *December* 11. *C. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
α Pegasi	E.	B_1–F_5 exc. C_3 D_4	23 0 56. 69	—0. 18	+0 0. 61	—0. 18
σ Cephei, U. C	"	E_1–F_5 exc. F_4	15 0. 19	—0. 19	+1 0. 47	—0. 50
σ Cephei, U. C	W.	E_3–F_5	17 12. 56	—0. 23	—1 11. 53	—0. 59
θ Piscium	"	B_1–F_5	24 2. 57	—0. 25	0 0. 00	—0. 21
γ Cephei, U. C	"	B_1–C_5	34 59. 88	—0. 25	+1 47. 89	—1. 01
γ Cephei, U. C	E.	B_1–C_5	38 33. 75	—0. 21	—1 47. 89	—0. 86
Groombr., 4163, U. C ..	"	E_{1-4}	50 21. 95	—0. 20	+0 53. 32	—0. 67
Groombr., 4163, U. C ..	W.	E_1–F_5	23 52 42. 72	—0. 24	—1 27. 00	—0. 80

$T = 0^h \quad \theta = -2^m\,49^s.00 \quad \rho = -0^s.080 \quad c = -0^s.090.$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*m. s.*
α Pegasi	23 0 57.12	58 8.02	—0.09	+0.53	—0.15	—2 49.12
o Cephei, U. C	16 0.30	13 11.77	....	—0.98	+0.28	48.87
θ Piscium	24 2.36	21 13.13	+0.09	+0.64	—0.18	49.01
γ Cephei, U. C	36 45.88	33 57.53	....	—2.32	+0.67	49.04
Groombr., 4163, U. C	23 51 14.76	48 26.11	....	—1.70	+0.49	—2 49.15

$$5 \triangle \theta - 3.831a = +0.920$$
$$-3.831 \triangle \theta + 9.906a = -2.704$$
$$a = -0^s.289 \quad \triangle \theta = -0^s.037$$
$$\triangle t = -2^m\,49^s.037$$

1866, *December* 11. *C. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0 - \kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
ε Bootis	W.	$\{B_{135}\ C_{135}\ D_{135}\ E_{135}\ F_{35}\}$	14 41 57.21	—0.14	+0 2.19	—0.17
β Urs. Minoris, U. C	"	B_1–C_5	52 19.36	—0.14	+1 32.70	—0.53
β Urs. Minoris, U. C	E.	B_1–C_5	14 55 23.67	—0.10	—1 32.70	—0.39
γ² Urs. Minoris, U. C	"	E_1–F_5	15 22 22.11	—0.10	+1 20.47	—0.34
γ² Urs. Minoris, U. C	W.	F_2–F_5	25 34.77	—0.14	—1 51.71	—0.46
α Coronæ	"	$B_1\ C_{13}\ D_5$	31 32.30	—0.13	+0 19.80	—0.16
α Serpentis	"	E_1–F_5	15 40 57.10	—0.12	—0 24.63	—0.12

$T = 15^h \quad \theta = -2^m\,50^s.00 \quad \rho = -0^s.062 \quad c = -0^s.090$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*m. s.*
ε Bootis	14 41 59.23	39 9.12	+0.10	—0.03	—0.10	—2 49.93
β Urs. Minoris, U. C	14 53 51.06	51 1.57	....	+0.51	+0.54	50.03
γ² Urs. Minoris, U. C	15 23 42.45	20 52.50	....	—0.08	+0.43	50.35
α Coronæ	31 51.94	29 1.70	+0.10	—0.11	—0.10	50.01
α Serpentis	15 40 32.35	37 41.60	+0.09	—0.62	—0.18	—2 50.44

$$5 \triangle \theta - 2.054a = -0.170$$
$$-2.054 \triangle \theta + 6.363a = -1.511$$
$$a = -0^s.287 \quad \triangle \theta = -0^s.151$$
$$\triangle t = -2^m\,50^s.151$$

1866, *December* 12. *B. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0 +$
			h. m. s.	*s.*	*m. s.*	*s.*
β Arietis	W.	B_1–F_5	1 50 10.06	—0.18	0 0.00	—0.19
α Arietis	"	B_1–F_5	2 2 33.07	—0.19	0 0.00	—0.21
β Urs. Minoris, L. C	E.	C_1–E_5	2 53 52.03	—0.20	+0 0.01	+0.43
ξ Arietis	"	B_1–F_2	3 10 12.67	—0.19	—0 5.14	—0.21
α Persei	"	B_1–F_5	3 17 42.95	—0.19	0 0.00	—0.31
α Camelop., U. C	"	B_1–F_5 exc. E_5 F_1	4 43 50.03	—0.21	—0 5.24	—0.52
ι Aurigæ	"	D_1–D_5	4 51 11.76	—0.21	—0 0.02	—0.26

T = 3h $\theta = -2^m\ 50^s.50$ $\rho = -0^s.065$ $c = -0^s.080$

Star.	t	α	Cc	ω'₀	Aα	Δt
	h. m. s.	m. s.	s.	s.	s.	m. s.
β Arietis	1 50 9.87	47 18.66	+0.08	−0.71	−0.02	−2 51.19
α Arietis	2 2 32.86	59 41.77	+0.08	−0.57	−0.02	51.05
β Urs. Minoris, L. C	2 53 52.47	51 1.64	+0.30	−0.04	−0.14	50.40
ζ Arietis	3 10 7.32	7 16.77	−0.08	−0.12	−0.02	50.60
α Persei	3 17 42.64	14 52.37	−0.12	+0.13	+0.01	50.38
α Camelop., U. C	4 43 44.27	40 54.09	−0.20	+0.17	+0.04	50.37
ι Aurigæ	4 51 11.48	48 21.59	−0.09	+0.58	−0.01	−2 49.91

$$7 \triangle \theta + 3.853a = -0.560$$
$$+3.853 \triangle \theta + 12.217a = -0.757$$
$$a = -0^s.044 \quad \triangle \theta = -0^s.056$$
$$\triangle t = -2^m\ 50^s.556$$

1866, *December* 12. *B. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
α Canis Minoris	W.	B_1–F_5	7 35 12 03	−0.34	0 0.00	−0.28
β Geminorum	E.	B_1–F_5 exc. F_2	40 4.24	−0.28	−0 1.41	−0.32
ε Draconis, L. C	"	B_1–F_5	7 51 24.32	−0.28	0 0.00	+0.39

T = 7h $\theta = -2^m\ 51^s.00$ $\rho = -0^s.065$ $c = -0^s.080$

Star.	t	α	Cc	ω'₀	Aα	Δt
	h. m. s.	m. s.	s.	s.	s.	m. s.
α Canis Minoris	7 35 11.75	32 21.32	+0.08	+0.68	−0.06	−2 50.26
β Geminorum	40 2.51	37 11.35	−0.09	−0.21	−0.03	51.18
Draconis, L. C	7 51 24.71	48 34.05	+0.23	+0.62	−0.26	−2 50.12

$$3 \triangle \theta + 3.608a = +1.090$$
$$+3.608 \triangle \theta + 7.484a = +1.002$$
$$a = -0^s.097 \quad \triangle \theta = +0^s.480$$
$$\triangle t = -2^m\ 50^s.520$$

1866, *December* 13. *B. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
65 ξ' Ceti	W.	B_1–F_5	2 8 50.32	−0.02	0 0.00	−0.04
ι Cassiopiæ, U. C	"	B_1–F_5	21 5.36	−0.02	0 0.00	−0.09
5 Urs. Minoris, L. C	"	E_1–F_5	28 51.50	−0.01	+1 43.15	+0.08
5 Urs. Minoris, L. C	E.	E_1–F_5	33 18.41	+0.03	−1 43.15	−0.01
γ Ceti	"	B_1–F_5	39 17.87	+0.03	0 0.00	0.00
α Ceti	"	B_1–E_5	2 58 21.10	+0.06	−0 8.16	+0.02

$T = 3^h \quad \theta = -2^m\ 52^s.80 \quad \rho = -0^s.074 \quad c = -0^s.060$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*m. s.*
65 ξ' Ceti	2 8 50.28	5 57.89	+0.06	+0.40	+0.35	—2 52.75
ι Cassiopeæ, U. C	21 5.27	18 11.91	+0.15	—0.47	—0.54	52.73
5 Urs. Minoris, U. C	30 34.99	27 44.36	....	+2.13	+2.08	52.75
γ Ceti	39 17.87	36 25.48	—0.06	+0.33	+0.39	52.86
α Ceti	2 58 12.96	55 20.63	—0.06	+0.41	+0.39	—2 52.78

$$5 \triangle \theta + 4.612a = +2.800$$
$$+4.612 \triangle \theta + 15.082a = +8.840$$
$$a = +0^s.578 \quad \triangle \theta = +0^s.027$$
$$\triangle t = -2^m\ 52^s.773$$

1866, *December* 14. *B. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0 + \kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
β Arietis	W.	B_1–F_5	1 50 12.44	+0.13	0 0.00	+0.11
α Arietis	"	B_1–F_5 exc. C_4	2 2 36.31	+0.14	—0 0.62	—0.12
65 ' Ceti	"	B_1–D_3	8 32.39	+0.14	+0 19.65	+0.09
ι Cassiopeæ, U. C	"	B_1–F_5	21 5.66	+0.15	0 0.00	+0.31
γ Ceti	E.	{ B_1–C_3 E_4–F_5 exc. F_2 }	39 22.72	+0.21	—0 3.31	+0.13
α Ceti	"	B_1–F_5	2 58 14.52	+0.17	0 0.00	+0.11
α Persei	"	B_1–F_5	3 17 46.04	+0 14	0 0.00	+0.19

$T = 3^h \quad \theta = -2^m\ 54^s.00 \quad \rho = -0^s.081 \quad c = -0^s.060$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*m. s.*
β Arietis	1 50 12.55	47 18.64	+0.06	+0.05	—0.04	—2 53.91
α Arietis	2 2 35.81	59 41.76	+0.06	—0.07	—0.04	54.03
65 ξ' Ceti	8 52.04	5 57.88	+0.06	—0.17	—0.06	54.11
ι Cassiopeæ, U. C	21 5.97	18 11.89	+0.15	—0.02	+0.09	54.07
γ Ceti	39 19.54	36 25.47	—0.06	—0.16	—0.06	54.10
α Ceti	2 58 14.63	55 20.63	—0.06	—0.06	—0.06	54.09
α Persei	3 17 46.23	14 52.36	—0.09	+0.06	+0.01	—2 53.95

$$7 \triangle \theta + 1.767a = -0.330$$
$$+1.767 \triangle \theta + 2.531a = -0.282$$
$$a = -0^s.095 \quad \triangle \theta = -0^s.023$$
$$\triangle t = -2^m\ 54^s.023$$

1866 *December* 14. *B. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0 + \kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
μ Geminorum	E.	B_1–B_5 F_2–F_5	6 17 54.26	+0.10	—0 3.27	+0.08
γ Geminorum	W.	B_1–F_5 exc. B_5 C_2	32 52.26	+0.04	+0 4.92	+0.02
ε Canis Majoris	"	D_3–E_5	6 56 32.48	+0.04	—0 12.83	—0.01
δ Canis Majoris	"	B_5–E_4	7 5 51.31	+0.04	+0 3.63	—0.01
δ Geminorum	"	{ B_1–D_5 C_{145} D_{14} F_1–F_5 }	7 15 2.51	+0.04	+0 3.61	+0.02

$T = 7^h \quad \theta = -2^m\, 54^s.30 \quad \rho = -0^s.081 \quad c = -0^s.060$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	m. s.
μ Geminorum	6 17 51.07	14 56.07	—0.06	Reject.	....	....
γ Geminorum	32 57.20	30 2.84	—0.06	—0.04	+0.03	—2 54.37
ε Canis Majoris	6 56 19.64	53 25.41	+0.07	+0.14	+0.07	54.23
δ Canis Majoris	7 5 54.93	3 0.42	+0.07	—0.13	+0.07	54.50
δ Geminorum	7 15 6.14	12 11.75	+0.06	—0.01	+0.03	—2 54.34

$$4\,\triangle\,\theta + 3.075\,a = -0.040$$
$$+3.075\,\triangle\,\theta + 2.747\,a = -0.007$$
$$a = +0^s.063 \quad \triangle\,\theta = -0^s.058 \quad \triangle\,t = -2^m\,54^s.358$$

1866, *December* 15. *B. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	s.	m. s.	s.
α Arietis	W.	$B_3\,C_3\,D_3\,E_3\,F_3$	2 2 37.56	+0.26	—0 0.03	+0.24
ι Cassiopeæ, U. C	"	B_1–F_5	21 7.40	+0.19	0 0.60	+0.40
5 Urs. Minoris, L. C	E.	C_3–F_5	31 29.68	+0.23	—0 47.75	—0.45
γ Ceti	"	B_1–F_5	39 21.63	+0.24	0 0.00	+0.16
α Ceti	"	{ B_1–F_5 exc. C_{123} $D_1\,E_1$ }	2 58 14.22	+0.25	+0 2.59	+0.17
48 Cephei, U. C	"	B_1–F_5 exc. D_3	3 6 34.46	+0.27	—0 0.01	+0.96
α Persei	W.	B_1–F_5	17 48.93	+0.25	0 0.00	+0.36
γ^2 Urs. Minoris, L. C	"	$B_{12}\,C_1$–F_1	23 57.72	+0.26	—0 8.41	+0.34
δ Persei	"	B_1–F_5	36 25.82	+0.26	0 0.00	+0.36
η Tauri	E.	B_1–F_5	3 42 32.30	+0.30	0 0.00	+0.28

$T = 3^h \quad \theta = -2^m\, 56^s.20 \quad \rho = -0^s.087 \quad c = -0^s.060$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	m. s.	s.	s.	s.	m. s.
α Arietis	2 2 37.77	59 41.75	+0.06	+0.15	—0.06	—2 56.00
ι Cassiopeæ, U. C	21 7.80	18 11.86	+0.15	+0.35	+0.12	55.98
5 Urs. Minoris, L. C	30 41.48	27 44.46	+0.25	—0.61	—0.48	56.33
γ Ceti	39 21.79	36 25.47	—0.06	—0.24	—0.09	56.35
α Ceti	2 58 16.98	55 20.63	—0.06	—0.21	—0.09	56.32
48 Cephei, U. C	3 6 35.41	3 39.64	—0.27	+0.17	+0.32	56.35
α Persei	17 49.29	14 52.36	+0.09	Reject.	....	....
γ^2 Urs. Minoris, L. C	23 48.97	20 52.65	—0.20	—0.29	—0.39	56.10
δ Persei	36 26.18	33 29.75	+0.09	—0.11	+0.01	56.32
η Tauri	3 42 32.58	39 36.18	—0.06	—0.20	—0.05	—2 56.35

$$9\,\triangle\,\theta + 5.275a = -0.990$$
$$+5.275\,\triangle\,\theta + 29.338a = -4.092$$
$$a = -0^s.134 \quad \triangle\,\theta = -0^s.032 \quad \triangle\,t = -2^m\,56^s.232$$

1866, *December* 16. *C. obs.*

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+
			h. m. s.	*s.*	*m. s.*	*s.*
o Cephei, U. C	E.	B_5–C_2 D_2–E_1	23 16 26.26	+0.15	—0 16.74	+0.32
ι Aurigæ	"	B_1–F_5	4 51 19.92	+0.11	0 0.00	+0.10

$T=3^h \quad \theta=-2^m\,58^s.40 \quad \rho=-0^s.087 \quad c=-0^s0.60$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*m. s.*
o Cephei, U. C	23 16 9.84	13 11.53	—0.16	—0.39	—0.39	—2 58.40
ι Aurigæ	4 51 20.02	48 21.63	—0.07	+0.10	+0.10	—2 58.40

$$2\,\triangle\theta-0.730a=-0.290$$
$$-0.730\,\triangle\theta+1.031a=+0.408$$
$$a=+0^s.395 \quad \triangle\theta=-0^s.001$$
$$\triangle t=-2^m\,58^s.401$$

1866, *December* 18. *C. obs.*

Star.	Lamp.	Threads.	M	b_0	R	$Bb_0+\kappa$
			h. m. s.	*s.*	*m. s.*	*s.*
α Camelop., U. C	E.	B_1–F_5 exc. C_{345} D_2	4 43 51.78	+0.04	+0 5.12	+0.05
ι Aurigæ	"	B_1–F_5	51 21.16	+0.06	0 0.00	+0.05
ε Urs. Minoris, L. C...	"	B_1–C_5	4 59 28.97	+0.07	+3 1.47	—0.21
ε Urs. Minoris, L. C...	W.	B_1–C_5	5 5 30.99	+0.04	—3 1.47	—0.03
α Aurigæ	"	D_1–F_5	10 19.96	+0.05	—0 23.42	+0.05
β Tauri	"	B_1–C_5 exc. C_1	20 39.22	+0.05	+0 18.11	+0.03
δ Orionis	"	B_1–F_5	28 16.37	+0.05	0 0.00	+0.02
ε Orionis	"	B_1–F_5 exc. E_5....	32 30.73	+0.05	+0 0.90	+0.01
ψ' Draconis, L. C......	"	E_1–F_5	45 54.84	+0.05	+1 20.07	—0.03
ψ' Draconis, L. C......	E.	E_2–F_5	48 40.23	+0.09	—1 24.99	—0.09
α Orionis	"	B_1–F_5	5 51 1.82	+0.09	0 0.00	+0.05

$T=5^h \quad \theta=-3^m\,3^s.00 \quad \rho=-0^s.088 \quad c=-0^s.050$

Star.	t	a	Cc	ω'_0	Aa	Δt
	h. m. s.	*m. s.*	*s.*	*s.*	*s.*	*m. s.*
α Camelop., U. C.........	4 43 56.95	40 54.12	—0.12	+0.03	—0.52	—3 2.45
ι Aurigæ	4 51 24.21	48 21.64	—0.06	+0.36	+0.15	2.79
ε Urs. Minoris, L. C.......	5 2 29.86	59 31.22	....	+4.36	+3.50	2.14
α Aurigæ	9 56.59	6 53.93	+0.07	+0.42	—0.01	2.57
β Tauri	20 57.36	17 54.56	+0.06	+0.19	+0.19	3.00
δ Orionis	28 16.39	25 13.98	+0.05	+0.68	+0.42	2.74
ε Orionis	32 31.64	29 29.13	+0.05	+0.58	+0.43	2.85
ψ' Draconis	47 15.01	44 14.01	....	+2.07	+1.73	2.66
α Orionis	5 51 1.87	47 59.54	—0.05	+0.70	+0.37	—3 2.67

$$9\,\triangle\theta+10.537a=+9.390$$
$$+10.537\,\triangle\theta+49.521a=+33.065$$
$$a=+0^s.594 \quad \triangle\theta=+0^s.348$$
$$\triangle t=-3^m\,2^s.652$$

VII.—LONGITUDE SIGNALS BETWEEN FOILHOMMERUM AND HEART'S CONTENT.

The method of giving and receiving the signals for longitude between Foilhommerum and Heart's Content was that prescribed in the programme which I had prepared before leaving home. Three series, of two sets each, were exchanged on each occasion; each set consisting of ten signals, alternately positive and negative, and at intervals of about five seconds, except that the fifth and eight were preceded by a pause of ten seconds, which was also the interval between the two sets. The purpose of this arrangement was to discover whether the velocity of transmission was perceptibly affected by a longer time being allowed for the cable to recover its electrical equilibrium, and also to facilitate the identification of the individual signals. Some slight convenience in the practical detail also arose from the circumstance that each set occupied one minute, and that each series consisted of ten positive and ten negative signals. Those signals were considered positive by which the platinode was put in connection with the cable and the zincode with the ground. In receiving the signals the observer, (Mr. Dean at Newfoundland, and myself at Valencia,) watched the deflections of the light-spot, while his thumb rested on the button of a delicately adjusted break-circuit key, which was pressed at the instant in which the deflection was perceived. This instant was thus recorded upon the chronograph after a certain amount of delay which we will call the *personal error of noting*, and which depends upon a considerable number of influences to be discussed hereafter. The keys by which the signals were transmitted were made by the American Telegraph Company, under the supervision of Mr. Dean, and are constructed according to the arrangement devised by Professor Thomson for the Atlantic telegraph, in such a manner that pressure upon one button produced a positive, and upon the other a negative signal, while no current flows at other times. To this arrangement an additional contrivance was applied by which the local circuit to the chronograph passed through the same key and was interrupted by pressure upon either button, so that the moment of every signal was recorded upon the chronograph of the station whence it was sent.

It is thus manifest that the times of sending the signals were accurately recorded, while the times of receiving signals were recorded after an interval of time dependent on the personal error of noting, and inseparable from the time of transmission through the cable, unless by some independent means of measurement. If this interval were the same for both observers, it would be eliminated entirely from the longitude and merged with the time of transmission; otherwise it would affect the resultant longitude by one-half the difference between the personal errors of noting for the two observers. Happily it proved to be very nearly the same for Mr. Dean and myself, and also measurable, so that it has been possible to eliminate its influence from the measure of velocity as well as from the longitude.

If now we denote the clock times at Valencia and Newfoundland by T and T′ respectively, the connections for reducing these to the true sidereal time by $\triangle t$ and $\triangle t'$, the time of transmission for the galvanic signals by x, and the longitude by λ; and if furthermore we distinguish those quantities which pertain to Valencia signals by a subjacent 1, and similarly those belonging to Newfoundland signal by the subjacent figure 2, it is manifest that if we include in x the personal error of noting signals, then the signals given and recorded at Valencia at the time T_1 will be registered upon the Newfoundland record at $T'_1 = T_1 + \triangle t_1 - \triangle t'_1 - \lambda + x_1$, and the signals given and recorded at Newfoundland at T'_2 will be registered upon the Valencia record at $T_2 = T'_2 + \triangle t'_2 - \triangle t_2 + \lambda + x_2$, so that the comparison of the records of Valencia signals at the two stations gives

$$T_1 - T'_1 = \triangle t'_1 - \triangle t_1 + \lambda + x_1,$$

while the comparison of the records of Newfoundland signals gives—

$$T_2 - T'_2 = \triangle t_2 - \triangle t_2 + \lambda + x_2,$$

so that

$$2\lambda = (T_2 - T'_2) + (T_1 - T'_1) + (\triangle t_2 - \triangle t'_2) + (\triangle t_1 - \triangle t'_1) + (x_1 - x_2)$$
$$x_1 + x_2 = (T_2 - T'_2) - (T_1 - T'_1) + (\triangle t_2 - \triangle t'_2) - (\triangle t_1 - \triangle t'_1).$$

If we assume the personal error of noting to be the same for the two observers, and the signals to travel with equal velocity in the two directions, the term $x_1 - x_2$ will disappear from the first equation, while the second will give the measure of the sum of the transmission-times and the personal errors of noting.

From the time determinations in Chapters IV and V, we may obtain the clock corrections as follows, for the periods in which longitude signals were exchanged. They are first given for those epochs for which they were determined, and the interpolated values for intervals of five minutes during the period of the exchanges follow.

On November 5, a double weight is assigned to the first time determination on account of the much smaller value of the azimuth error, this having been largely changed by an accident, (due to no carelessness of the observer,) which interrupted the first series of observations.

Clock corrections at each station.

Date.	Valencia clock corrections.		Newfoundland clock corrections.	
	Sid. Time = T.	At	Sid. Time = T′	Δt′
1866.	*h.*	*s.*	*h.*	*s.*
October 25	19.8	— 8.447	October 25 21.0	+ 4.714
27	1.7	— 8.420	0.0	+ 4.745
28	21.0	— 8.812	October 28 22.0	+ 5.640
30	22.0	— 9.266	1.0	+ 5.713
November 5	23.0	— 13.034	November 5 23.0	+ 8.326
	"	.058	2.0	+ 8.332
6	23.0	— 13.236	November 6 21.0	+ 7.973
	3.0	.364	23.0	+ 7.967
9	20.0	— 15.977	November 9 21.0	+ 7.810
	4.0	— 16.608	1.0	+ 7.813
	h. m.		*h. m.*	
October 25	1 50	— 8.442	23 0	+ 4.735
	1 55	.441	23 5	.736
	0	.441	23 10	.737
	2 5	.441	23 15	.738
October 28	2 35	— 8.864	23 40	+ 5.681
	2 40	.865	23 45	.683
	2 45	.865	23 50	.685
	2 50	.866	23 55	.687
	2 55	.867	0 0	.689
November 5	3 30	— 13.078	0 40	+ 8.329
	3 35	.079	0 45	.329
	3 40	.079	0 50	.329
	3 45	.080	0 55	.329
	3 50	.080	1 0	.329
November 6	1 10	— 13.305	22 15	+ 7.967
	15	.308	22 20	.967
	20	.311	22 25	.966
	25	.313	22 30	.966
November 9	3 0	— 16.529	0 10	+ 7.812
	5	.535	0 15	.812
	10	.542	0 20	.812
	15	.548	0 25	.813
	20	.555	0 30	.813

We are thus enabled to construct the following table, in which the times given are the means of the clock-times for each set, to the nearest minute, and the results for positive and negative signals are exhibited separately, as well as together:

13

Transatlantic longitude and transmission time.

1866—OCTOBER 25.

	Series I.		Series II.		Series III.	
VALENCIA SIGNALS.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
T_1	1 49 1	1 50 7	1 55 27	1 56 32	2 1 48	2 2 53
T'_1	22 56 52	22 57 58	23 3 18	23 4 23	23 9 40	23 10 45
Pos	2 52 9.02	2 52 8.99	2 52 9.03	2 52 9.05	2 52 9.08	2 52 9.09
Neg	8.90	9.05	8.95	9.06	9.13	9.10
All	8.96	9.02	8.99	9.05	9.11	9.10
$\Delta t_1-\Delta t'_1$	−13.176	−13.176	−13.177	−13.177	−13.178	−13.178
NEWFOUNDLAND SIG'S.						
T_2	1 52 9	1 53 15	1 58 41	1 59 6	2 5 11	2 6 17
T'_2	23 0 0	23 1 5	23 6 30	23 7 36	23 13 1	23 14 6
Pos	2 52 10.26	2 52 10.25	2 52 10.25	2 52 10.28	2 52 10.26	2 52 10.29
Neg	10.26	10.26	10.29	10.28	10.25	10.32
All	10.26	10.26	10.27	10.28	10.25	10.30
$\Delta t_2-\Delta t'_2$	−13.176	−13.176	−13.177	−13.177	−13.178	−13.178
SUM OF INTERVALS.						
Cor.	−26.352	−26.352	−26.354	−26.354	−26.356	−26.356
Pos.	5 44 19.28	5 44 19.24	5 44 19.28	5 44 19.32	5 44 19.34	5 44 19.38
Neg	19.16	19.31	19.24	19.34	19.38	19.42
All	19.22	19.28	19.26	19.33	19.36	19.40
Pos	0.62	0.63	0.61	0.61	0.59	0.60
x Neg	0.68	0.60	0.67	0.61	0.56	0.61
All	0.65	0.62	0.64	0.61	0.57	0.60
	2 51	56.449	2 51	56.470	2 51	56.512

1866—OCTOBER 28.

	Series I.		Series II.		Series III.	
VALENCIA SIGNALS.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
T^1	2 33 30	2 34 35	2 39 35	2 40 40	2 52 37	2 53 42
T'_1	23 41 20	23 42 25	23 47 35	23 48 30	0 0 27	0 1 32
Pos	2 52 10.34	2 52 10.36	2 52 10.40	2 52 10.39	2 52 10.43	2 52 10.42
Neg	10.39	10.36	10.40	10.41	10.42	10.42
All	10.37	10.36	10.40	10.40	10.42	10.42
$\Delta t-\Delta t'_1$	−14.546	−14.547	−14.549	−14.550	−14.556	−14.556
NEWFOUNDLAND SIG'S.						
T_2	2 36 37	2 37 43	2 42 38	2 43 43	2 56 40	2 56 45
T'_2	23 44 25	23 45 31	23 50 26	23 51 31	0 3 28	0 4 33
Pos	2 52 11.78	2 52 11.79	2 52 11.65	2 52 11.67	2 52 11.68	2 52 11.66
Neg	11.69	11.68	11.64	11.72	11.57	11.69
All	11.73	11.74	11.64	11.69	11.62	11.67
$\Delta t_2-\Delta t'_2$	−14.548	−14.548	−14.551	−14.551	−14.557	−14.558
SUM OF INTERVALS.						
Cor	−29.094	−29.095	−29.100	−29.101	−29.113	−29.114
Pos	5 44 22.12	5 44 22.15	5 44 22.05	5 44 22.06	5 44 22.11	5 44 22.08
Neg	22.08	22.04	22.04	22.13	21.97	22.11
All	22.10	22.10	22.04	22.09	22.04	22.09
Pos	0.72	0.72	0.62	0.64	0.62	0.62
Neg	0.65	0.66	0.62	0.66	0.58	0.64
All	0.68	0.69	0.62	0.65	0.60	0.63
λ	2 51	56.502	2 51	56.482	2 51	56.476

Transatlantic longitude and transmission time—Continued.

1866—NOVEMBER 5.

	Series I.		Series II.		Series III.	
VALENCIA SIGNALS.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
T_1	3 32 35	3 33 41	3 39 22	3 40 27	3 46 0	3 47 0
T'_1	0 40 18	0 41 23	0 47 5	0 48 10	0 53 42	0 54 42
Pos	2 52 17.25	2 52 17.30	2 52 17.32	2 52 17.31	2 52 17.25	2 52 17.27
Neg	17.25	17.29	17.30	17.31	17.26	17.25
All	17.25	17.30	17.31	17.31	17.26	17.26
$\Delta t_1-\Delta t'_1$	—21.407	—21.407	—21.408	—21.408	—21.409	—21.409
NEWFOUNDLAND SIG'S.						
T_2	3 35 45	3 36 50	3 42 46	3 43 51	3 49 19	3 50 24
T'_2	0 43 27	0 44 32	0 50 28	0 51 33	0 57 1	0 58 6
Pos	2 52 18.42	2 52 18.47	2 52 18.44	2 52 18.47	2 52 18.46	2 52 18.47
Neg	18.43	18.48	18.43	18.55	18.46	18.47
All	18.42	18.47	18.43	18.51	18.46	18.47
$\Delta t_2-\Delta t'_2$	—21.408	—21.408	—21.408	—21.408	—21.409	—21.409
SUM OF INTERVALS.						
Cor	—42.815	—42.815	—42.816	—42.816	—42.818	—42.818
Pos	5 44 35.67	5 44 35.77	5 44 35.76	5 44 35.78	5 44 35.71	5 44 35.74
Neg	35.68	35.77	35.73	35.86	35.72	35.72
All	35.67	35.77	35.74	35.82	35.72	35.73
Pos	0.57	0.58	0.56	0.58	0.60	0.60
x Neg	0.59	0.60	0.56	0.62	0.60	0.61
All	0.58	0.59	0.56	0.60	0.60	0.60
λ	2 51 56.428		2 51 56.482		2 51 56.454	

1866—NOVEMBER 6.

	Series I.		Series II.		Series III.	
VALENCIA SIGNALS.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
T_1	1 9 10	1 10 15			1 21 20	1 22 17
T'_1	22 16 53	22 17 58			22 29 3	22 30 0
Pos	2 52 17.19	2 52 17.20			2 52 17.18	2 52 17.20
Neg	17.22	17.18			17.30	17.18
All	17.20	17.19			17.24	17.19
$\Delta t-\Delta t'_1$	—21.272	—21.272			—21.277	—21.278
NEWFOUNDLAND SIG'S.						
T_2	1 12 25	1 13 30			1 24 26	1 25 32
T'_2	22 20 6	22 21 11			22 32 8	22 33 14
Pos	2 52 18.32	2 52 18.31			2 52 18.25	2 52 18.33
Neg	18.30	18.33			18.29	18.33
All	18.31	18.32			18.27	18.33
$\Delta t_2-\Delta t'_2$	—21.273	—21.274			—21.279	—21.279
SUM OF INTERVALS.						
Cor	—42.545	—42.546			—42.556	—42.557
Pos	5 44 35.51	5 44 35.51			5 44 35.43	5 44 35.53
Neg	35.52	35.51			35.59	35.51
All	35.51	35.51			35.51	35.52
Pos	0.56	0.55			0.54	0.56
Neg	0.54	0.57			0.50	0.58
All	0.55	0.56			0.52	0.57
λ	2 51 56.482				2 51 56.480	

Transatlantic longitude and transmission time—Continued.

1866—NOVEMBER 9.

	Series I.		Series II.		Series III.	
VALENCIA SIGNALS.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
T_1	3 0 0	3 1 6	3 10 12	3 11 17	3 16 23	3 17 28
T'_1	0 7 40	0 8 45	0 17 52	0 18 56	0 24 3	0 25 8
Pos	2 52 20.25	2 52 20.37	2 52 20.30	2 52 20.26	2 52 20.27	2 52 20.29
Neg	20.27	20.30	20.28	20.26	20.29	20.26
All	20.26	20.28	20.29	20.26	20.28	20.28
$\Delta t_1 - \Delta t'_1$	—24.341	—24.342	—24.354	—24.355	—24.363	—24.364
NEWFOUNDLAND SIG'S.						
T_2	3 3 6	3 4 11	3 13 13	3 14 18	3 19 44	3 20 50
T'_2	0 10 44	0 11 49	0 20 51	0 21 56	0 27 25	0 28 28
Pos	2 52 21.32	2 52 21.34	2 52 21.34	2 52 21.39	2 52 21.35	2 52 21.41
Neg	21.34	21.33	21.36	21.37	21.37	21.36
All	21.33	21.33	21.35	21.38	21.36	21.39
$\Delta t_2 - \Delta t'_2$	—24.345	—24.346	—24.358	—24.360	—24.367	—24.369
SUM OF INTERVALS.						
Cor	—48.686	—48.688	—48.712	—48.715	—48.730	—48.733
Pos	5 44 41.57	5 44 41.61	5 44 41.64	5 44 41.65	5 44 41.62	5 44 41.70
Neg	41.61	41.63	41.64	41.63	41.66	41.62
All	41.59	41.62	41.64	41.64	41.64	41.66
Pos	0.53	0.53	0.52	0.57	0.54	0.56
Neg	0.53	0.51	0.54	0.55	0.54	0.55
All	0.53	0.52	0.53	0.56	0.54	0.56
λ	2 51 56.459		2 51 56.463		2 51 56.459	

It is manifest that $\Delta t - \Delta t'$ was in no instance variable during the telegraphic exchanges, so that no correction is needed for the deduced values of x on account of difference of clock-rates; and there is every reason to believe, both from theoretical considerations and from special experiment, that the velocity is the same for eastward and for westward signals, and that the resultant λ is consequently subject to no correction depending upon the clocks.

The resultant values of the longitude are thus found to be—

1866.		h. m. s.
October	25	2 51 56.477
	28	56.487
November	5	56.455
	6	56.481
	9	56.460

subject, however, in every case, to a correction for personal equation in determining the time.

The mean interval between the moments of giving the signals, and of their record upon the chronograph sheet, is similarly found to have been—

1866.		s.	s.
October	25	0.62 ±	0.008
	28	0.64	.010
November	5	0.59	.004
	6	0.55	.007
	9	0.54	.005

in which the quantities appended are the probable errors of the respective determinations as deduced from the total results of the several sets, there being six sets for each determination except that of November 6.

On the 25th October the cable of 1865 was employed, one half the circuit being formed by the earth. A battery of ten cells was used at each station and "condensers" were interpolated between the battery and the cable. On the 28th October the connections were the same, in every respect, as on the 25th; but on three other days the two cables were joined so as to form a complete metallic circuit, the number of elements employed being—

November	5	3 at Valencia; 3 at Newfoundland.
	6	3 at Valencia: 10 at Newfoundland.
	9	4 at Valencia; 10 at Newfoundland.

VIII.—Longitude Signals Between Heart's Content and Calais.

Clock-signals were exchanged between these two stations on four nights, upon only two of which the clock-errors at Calais could be determined either immediately before or soon after the exchange, one of these two nights being the same on which the clock occasioned so much trouble. It is a source of regret, also, that the signals were not exchanged according to the rule laid down in the programme, which prescribed that the Calais clock should be put into the circuit several times, for not more than half a minute at each time, while the time-scale was graduated for both chronographs by the Heart's Content clock only. In this way it would not have been difficult to obtain both records on the sheets at both stations, with the ordinary connections and without the necessity of continual adjustments of the relay magnets, and the results would have been more satisfactory in other respects.

On the 11th and 12th December, only the first and last signals of the Heart's Content clock in each minute can be deciphered, but these are legible by reason of the omission of the second-marks corresponding to the beginning of the minute. For the other two nights this difficulty does not exist. The means of the records are appended for the two stations separately. Upon the first two dates, the individual measures from the Calais registers, although numbering but two in each minute, were derived from consecutive minutes.

Newfoundland signals.

Date.	No.	H. C. clock time.	Calais clock time.
1866.		h. m. s.	h. m. s.
December 11	10	6 46 0.0	5 53 13.912
	10	7 8 0.0	6 15 13.908
December 12	10	6 21 0.0	5 28 14.828
	16	7 29 30.0	6 36 44.813
	12	7 57 30.0	7 4 44.838
December 14	38	5 43 40.0	4 50 56.462
	40	44 20.0	51 36.461
	39	45 0.0	52 16.453
	39	45 40.0	52 56.451
	40	46 20.0	53 36.455
	39	47 0.0	54 16.450
	59	47 50.0	4 55 6.446
	56	54 17.0	5 1 33.457
	58	55 25.0	2 41.454
	54	56 23.0	3 39.451
	57	5 57 45.0	5 5 1.444
	38	6 5 4.0	5 12 20.459
	56	5 54.0	13 10.445
	55	6 54.0	14 10.440
	59	7 54.0	15 10.463
	59	8 54.0	16 10.464
	59	6 9 44.0	5 17 0.457
December 16	59	2 26 20.0	1 33 39.714
	59	27 20.0	34 39.709
	59	28 20.0	35 39.711
	52	2 29 20.0	1 36 39.734
	59	2 37 4.0	1 44 23.689
	58	38 3.0	45 22.691
	59	39 4.0	46 23.701
	47	2 40 0.0	1 47 19.700
	53	2 48 22.0	1 55 41.704
	56	49 23.0	56 42.707
	56	50 23.0	57 42.709
	57	2 51 23.0	1 58 42.719

Calais signals.

Date.	No.	Cal. clock time.	H. C. clock time.
1866.		*h. m. s.*	*h. m. s.*
December 11	59	5 43 26.0	6 36 12.598
	59	44 26.0	37 12.594
	58	45 25.0	38 11.594
	56	46 25.0	39 11.578
	59	5 47 26.0	6 40 12.562
	58	5 59 15.0	6 52 1.586
	80	6 0 26.0	6 53 12.578
	56	5 32 25.0	6 25 10.797
	50	33 23.0	26 8.793
	56	34 25.0	27 10.803
	61	5 35 30.0	6 28 15.818
	55	6 28 5.0	7 20 50.783
	56	29 5.0	21 50.786
	58	30 5.0	22 50.773
	59	31 7.0	23 52.761
	60	6 32 7.0	7 24 52.770
December 14	59	4 56 36.0	5 49 20.113
	59	57 36.0	50 20.103
	59	58 36.0	51 20.102
	58	59 36.0	52 20.102
	57	5 0 36.0	5 53 20.099
	57	5 6 50.0	5 59 34.096
	57	7 50.0	6 0 34.092
	41	8 48.0	1 32.092
	18	5 9 46.0	6 2 30.091
	36	5 18 10.0	6 10 54.086
	62	5 21 6.0	6 13 50.143
	34	5 22 31.0	6 15 15.168
December 16	56	1 38 32.0	2 31 12.901
	39	39 28.0	32 8.926
	59	40 32.0	33 12.902
	59	41 32.0	34 12.905
	59	1 42 32.0	2 35 12.897
	42	1 49 33.0	2 42 13.832
	55	50 34.0	43 14.843
	55	51 34.0	44 14.869
	59	52 34.0	45 14.877
	58	1 53 34.0	2 46 14.881
	57	2 0 39.0	2 53 19.839
	47	1 35.0	54 15.843
	56	2 39.0	55 19.830
	52	2 3 38.0	2 56 18.847

From the reductions of Chapters V and VI, we may deduce the following determinations of the clock corrections at the two stations:

Date.	Heart's Content clock corrections.		Calais clock corrections.	
	Sid. clock time = T′	Δt′	Sid. clock time = T″	Δt″
1866.	*h. m.*	*s.*	*h. m.*	*m. s.*
December 11	6 35	+2. 080	5 40	—2 49. 457
	40	. 079	45	. 463
	45	. 078	50	. 469
	50	. 077	55	. 475
	55	. 075	6 0	. 482
	7 0	. 074	5	. 488
	5	. 073	10	. 494
	7 10	+2. 072	6 15	—2 49. 501
December 12	6 20	+1. 538	5 25	—2 50. 535
	25	. 536	30	. 534
	30	. 535	5 35	. 533
	7 20	. 518	6 25	. 526
	25	. 516	30	. 525
	30	. 515	35	. 524
	7 55	. 505	7 0	. 520
	8 0	—1. 504	7 5	—2 50. 519
December 14	5 40	—0. 149	4 50	—2 54. 204
	45	. 152	55	. 197
	50	. 156	5 0	. 190
	55	. 160	5	. 183
	6 0	. 163	10	. 176
	5	. 167	15	. 169
	10	. 170	20	. 162
	6 15	—0. 174	5 25	—2 54. 155
	2 25	—1. 092	1 30	—2 58. 266
	30	. 090	35	. 274
	35	. 087	40	. 281
	40	. 085	45	. 288
	45	. 082	50	. 295
	50	. 080	1 55	. 303
	2 55	. 077	2 0	. 311
	3 0	—1. 075	2 5	—2 58. 318

We have thus from the Heart's Content signals, recorded at Calais—

Date.	T′	No. signals.	Diff. of clocks.	Δt′ − Δt″	λ − x
1866.	*h. m. s.*		*h. m. s.*	*m. s.*	*h. m. s.*
December 11	6 46 0	10	0 52 46. 09	+2 51. 55	0 55 37. 64
	7 8 0	10	46. 09	51. 57	37. 66
December 12	6 21 0	10	0 52 45. 17	+2 52. 07	0 55 37. 24
	7 29 30	16	45. 19	52. 04	37. 23
	7 57 30	12	45. 16	52. 02	37. 18
December 14	5 45 40	294	0 52 43. 56	+2 54. 04	0 55 37. 59
	5 56 0	225	43. 55	54. 02	37. 57
	6 7 30	326	43. 55	54. 00	37. 55
December 16	2 27 50	229	0 52 40. 28	+2 57. 18	0 55 37. 46
	2 38 30	223	40. 30	57. 20	37. 50
	2 50 0	222	40. 29	57. 22	37. 51

And from the Calais signals, recorded at Heart's Content—

Date.	T′	No. signals.	Diff. of clocks.	Δt′	λ+x
1866.	h. m. s.		h. m. s.	m. s.	h. m. s.
December 11	6 38 12	291	0 52 46.59	+2 51.54	0 55 38.13
	6 52 36	138	46.58	+2 51.55	38.13
December 11	6 26 40	223	0 52 45.80	+2 52.07	0 55 37.87
	7 22 50	288	45.78	+2 52.04	37.82
December 14	5 51 20	292	0 52 44.10	+2 54.03	0 55 38.13
	6 0 40	177	44.09	54.01	38.10
	6 10 54	36	44.09	53.99	38.08
	6 14 25	96	44.16	+2 53.98	38.14
December 16	2 33 12	272	0 52 40.91	+2 57.19	0 55 38.10
	2 44 15	269	40.86	57.21	38.07
	2 55 30	212	40.84	+2 57.23	38.07

From these we find the several values of the longitude and time of transmissions:

Date.	λ	x
1866.	h. m. s.	s.
December 11	0 55 37.89	0.24
December 12	37.53	0.31
December 14	37.84	0.27
December 16	37.78	0.28

the longitude results requiring, however, a correction for personal equation.

IX.—Personal Error in Noting Signals.

Since the signals sent through the telegraphic cable were recorded at the transmitting station upon the chronograph automatically, but at the receiving station through the mediation of an observer who noted the deflection of the light-spot from the galvanometer, by sending a second telegraphic signal to his own chronograph, it will be seen that the interval x, which elapses between the giving of a signal at one station and its chronographic record at the other, may be conveniently divided into four different parts, viz: the time requisite—

1. For the signal to arrive at the other station.
2. For the magnet of the galvanometer to be moved through an arc sufficient to be readily perceived.
3. For the observer to take cognizance of the deflection and give his signal upon the break-circuit key.
4. For this observation signal to be recorded upon the chronograph.

Each of these four parts comprises the time, appreciable or otherwise, consumed in more than one distinct process; yet this division suffices for all our purposes. If these several intervals be practically equal at the two stations, they become absolutely eliminated in our determination of the longitude. If they be unequal, the resultant longitude will require an increase by one-half the excess of their sum for westward signals. In either case, only their total sum at the two stations is determined by the operations for longitude.

If we assume that the time lost upon the chronograph circuit is the same at each station, the last of the above-mentioned intervals becomes eliminated by the comparison of the two records. The second and third depend upon the galvanometer and observer at the receiving station, and are not easily to be separated from each other in any determination of their amount, but if their sum can be measured, this, substracted from our quantity x, will afford a trustworthy determination of the velocity with which the signals are actually transmitted through the telegraphic circuit.

This sum of the delays, dependent on the galvanometer and the observer, I have called "the personal error of noting," and the attempts to measure its amount have been so successful and have manifested such an unexpected constancy in its value for different persons, at different times, and at both stations, that the results obtained for the velocity of transmission of our signals seem entitled to a high degree of confidence.

By observing a series of signals similar to those exchanged for longitude, and so arranged that both the original signal and the observation of the consequent deflection shall be recorded on the same chronograph, the desired measure may be obtained. Experiment showed at once that the interval thus determined was altogether too large for any inconvenience to arise from the use of a single recording pen. The obstacle first encountered arose from the circumstance that the minimum battery force requisite for the electro-magnet of the chronograph pen was about seventy-five times greater than the maximum, which could be safely employed for the galvanometer signals. To obviate this difficulty, a battery of two Minotti cells being employed, the circuit was divided at the galvanometer into two branches, one of fine German silver wire, passing to the galvanometer and thence again to the main circuit, while the other branch was made to pass through the break-circuit key, by means of which the deflections were noted. The resistances of these two branches were so adjusted that they were in the ratio of 1 to 100, by which device each signal at the Observatory was sharply indicated on the galvanometer, without too great violence, and by slight adjustment of the movable permanent magnets, it was always possible to render these deflections similar in amount to those received from Newfoundland. It was of course necessary to include the clock in the galvanic circuit, in order to obtain a time scale; but the interruption and restoration of the circuit at each oscillation of the pendulum caused a vibration in the galvanometer needle, which was not quieted for more than half a second, and then only to be renewed immediately. To render all the circumstances of the experiment as similar to those of the longitude signals as the nature of the case permitted, as well as to avoid any tendency to mechanical rhythm in the act of noting the signals, (a source of inaccuracy which every observer by the chronographic method must have recognized whenever the beats of his clock have been audible or visible during the process of observation,) it was necessary to dispense with the clock while the measures were actually in process.

The observations were therefore arranged as follows: After the clock had been included in the circuit for some minutes, recording its beats upon the chronograph in the observatory, and manifesting them likewise upon the galvanometer in the telegraph office, the assistant in the observatory excluded the clock from the circuit by means of a plug-switch, thus stopping all record of time upon the chronograph sheet, although the pen continued to trace a straight line, and stopping likewise the pulsations of the galvanometer needle, by which indication the observer was warned that the signals were about to begin. He then gave a set of ten signals on one of the observing keys, at the same intervals, roughly, as those exchanged for longitude, namely: four sharp quick taps upon the key, about five seconds apart; then after ten seconds, three more; and after another ten seconds, yet three more. At the close of this set of signals, he restored the clock to the circuit by removing the plug from the switch, and the time-scale was graduated as before, after an intermission of scarcely a minute, so that the times of each signal could be read off by means of the second marks of the preceding and following minutes with an accuracy scarcely, if at all, inferior to that attainable when the time record is simultaneously in progress. The chronographic records of the signals thus given are about $0^s.04$ long.

The observer is meanwhile at the galvanometer in the other building, out of sight and hearing of the assistant, and notes the moments of deflection of the light-spot by a tap upon the break-circuit key, which he holds in his hand, taking care to conform in all respects to his habitudes while observing longitude signals. The intervals between the chronographic records of the original signals and his observations of the same then furnish a measure of the "personal error of noting," as already defined, and show the lapse of time corresponding to all the various delays of which our x is composed, except the actual time of transmission through the cable, unless the adjustments of the two chronographic or local circuits are so diverse that the loss of time which they entail cannot be regarded as equal for the two instruments. This is not the case, since repeated examination has shown that the difference is not measurable. The exclusive employment of signals given by interrupting the galvanic circuit, and of a pen which is not removed from the paper during the whole period, renders the measurement of armature time very easy, and eliminates it from ordinary observations.

On the 2d November I made five such determinations of my personal error of noting, each one based upon one series of signals, and with the following results. The errors appended are the mean errors of the mean, not the so-called probable errors, which would be but two-thirds as large.

s.		s.
0.277	±	0.013
0.256	±	.012
0.230	±	.011
0.248	±	.014
0.262	±	0.018
Giving final value, 0.253	±	0.006

A series by Mr. Mosman gave 0.275 ± 0.014; and one by Mr. George, of the telegraphic staff, who had had no previous experience in observing, gave 0.296 ± 0.017.

On the 7th November, five determinations gave for my own error—

s.		s.
0.292	±	0.010
0.300	±	0.013
0.288	±	0.006
0.285	±	0.007
0.291	±	0.010

the mean value being 0.289 ± 0.005.

Mr. Mosman's error from four determinations being

0.322 ±
0.296 ±
0.303 ±
0.297 ±

and Mr. George's, $0^s.309$ ±.

The galvanometer was evidently somewhat less sensitively adjusted than on the previous occasion, as was indeed known independently of the signals, since it had been undergoing some repairs; yet the average excess was but three-and-one-half-hundredths of a second.

The Kessel's clock at Heart's Content was provided with two signal-giving attachments, one being the ordinary arrangement for breaking circuit at the moment when the pendulum rod is vertical, and an additional tilt-hammer being available for interrupting the circuit at the instant of extreme elongation, on alternate seconds. Mr. Dean availed himself of this means, for measuring the personal error of noting signals, by connecting each tilt-hammer with a separate circuit. One of these passed through the normal signal apparatus of the clock, the Morse register, the signal key, and the galvanometer; the other, through the subsidiary tilt-hammer, the observing-key, and the chronograph. The original signals were thus recorded on the chronograph sheets, by means of a clock-scale graduated to two seconds, while the observations of the same were registered upon the Morse fillet; and a slight change made in the connections at the close of the experiment sufficed to put the records of both tilt-hammers upon the chronograph, and thus permit an accurate measurement of the interval between the two systems of clock signals. In the first named circuit a battery of two carbon cells was employed, resistance coils being interposed to reduce the deflections of the galvanometer to the magnitude of those obtained through the cable; and the chronograph magnet proved sufficiently sensitive to record these.

On November 10 five series of measures gave for his personal error:

	s.		s.
	0.22	±	0.020
	0.28	±	.019
	0.24	±	.010
	0.24	±	.025
	0.22	±	.008
Or from all	$0^s.192$	±	$0^s.009$.

On the 12th November, again, his observations of twelve sets of signals give, after deducting $0^s.48$ from each to correct for the difference of the two time-scales—

s.	s.	s.	s.
0.224 ±	0.017	0.148 ±	0.010
.244	20	.195	09
.193	14	.208	16
.181	14	.171	12
.170	17	.239	22
0.239	16	0.209	0.013

Or from all, $0^s.192 \pm 0^s.009$.

The marked inferiority of these values to those found for three observers on two different occasions at Valencia excited my suspicions, and on inquiry of Mr. Dean it proved that his observations had been made in the same room in which Mr. Goodfellow had given the signals, so that the click of the key was distinctly audible, so that the observation was not purely dependent upon the deflection of the needle, but was possibly influenced by the sense of hearing.

Mr. Dean therefore repeated his observations under circumstances precluding the possibility of his personal error being affected by an extraneous influence of this kind. This was done on November 17, and ten series of signals (one of the original eleven being discarded for manifest irregularity) afford the following results:

s.	s.	s.	s.
0.833 ±	0.027	0.832 ±	0.020
.8	.014	.795	.018
.831	.020	.847	.026
.820	.017	.870	.027
.848 ±	.021	0.864 ±	0.026

the definite value for the ten series being $0^s.830 \pm 0^s.008$.

For the difference of the time-scales fifty-two comparisons during one minute preceding the observations, give $0^s.491$, and sixty comparisons immediately afterwards give $0^s.499$. Adopting $0^s.495$, therefore, as the most probable value, and deducting this from the final value $0^s.830$, we have $0^s.335$ as Mr. Dean's personal error in noting the signals.

The difference between this error and that found for my own observations at Valencia is small, and is probably owing to the galvanometer rather than the observer; the apparatus at Heart's Content being known to be somewhat less sensitive than that at Foilhommerum. The constancy of the error is also here strongly manifest; and the illustration of the unrecognized but marked effect of the sound of the tap in observations, supposed to be of the visible deflection only, is instructive.

It may not be inappropriate to mention in this connection that a very marked effect upon the observation of transits of stars is likely to be produced when the chronograph is in the same apartment, so that the regular beats of the magnet are audible. When the intervals between the transit threads are approximately multiples of a second, the tendency so to tap upon the observing key as to produce a rhythmical beat in the armature, is very great; and when the interval differs from the multiple of a second, the occurrence of the magnet-beat which records an even second often precipitates the tap of the observer, whose nerves are in keen tension awaiting the instant of bisection. Only a strong effort of will can obviate these perturbing influences, which are akin to those exhibited in the measurements just described.

The personal error of noting being then assumed as $0^s.271$ at Valencia, and $0^s.335$ at Newfoundland, the sum of these quantities, or $0^s.606$, is to be deducted from our value of $x_1 + x_2$ to obtain the true time of transmission; and half their difference, or $0^s.032$, is to be deducted from the longitude after all other corrections are applied. This correction will be taken into account in fixing the value to be adopted.

It may be added that the indications are strong that a considerable portion of this "personal error of noting" is not strictly a personal phenomenon, but that it is due to the consumption of a very appreciable interval of time, while the inertia of the needle is overcome and the needle moved through an arc sufficient to attract attention. Indeed, it is my conviction that not less than the tenth of a second is thus lost.

An automatic apparatus might be arranged, all other means failing for recording the signals received, by placing of delicate silver wires on each side of the galvanometer needle, in such a position, and so connected with the battery that they would be brought in contact whenever the deflection of the needle reached a certain angle, and the signal be thus recorded upon the chronograph. This would definitely decide the question; but, for obvious reasons no such experiment was undertaken at Valencia. My immediate object was thoroughly attained by the satisfactory results of these measurements of the sum of all delays not due to time consumed in the actual transit of the signals across the Atlantic.

X.—Personal Equation in Determining Time.

In the telegraphic operations of the Coast Survey, the unvarying rule has been that the personal equation be eliminated as far as possible by an interchange of position of the two observers, and also measured, at least once, during the progress of each longitude campaign, by observations specially instituted for that purpose. These determinations are made with the same instruments used for the other work, the two observers sitting side by side and observing alternate tallies of five threads each. A pair of stars thus gives a measure of personal equation unaffected by any small error in the adopted values of the thread intervals, since the same person who observes the first, third, and fifth tallies for the first star observes the second and fourth tallies for the second star. The advantages and defects of this method are evident to the astronomer at once. For the end to which it is ordinarily applied it is especially adapted. Since the longitudes depend on transit signals for zenithal stars, the observations for personal equation are made by the use of stars of the same class, and care is moreover taken that the magnitudes of stars employed for the two purposes shall not differ essentially from one another. On the other hand, it cannot be denied that a certain amount of nervous excitement is likely to accompany observations thus made, since the observer has usually but a short time available after bringing his eye to the telescope before the first transit occurs.

Furthermore, the eye-piece has to be moved to bring the new tally into the middle of the field, and the position of the body is frequently somewhat constrained in consequence of the close proximity of the two observers. The careful and long-continued study of these observations of personal differences, for a considerable number of observers, during a period of about eighteen years, has thoroughly convinced me, as often stated on other occasions, that the personal equation varies decidedly with the magnitude and very greatly with the declination of the star.

Three elements seem especially to enter into the magnitude of the personal differences in right ascension: 1, the perceptions of the observer, which are affected by the magnitude of the star, and possibly to some extent by the rapidity of its apparent motion; 2, the habitudes of the observer, as determining the moment at which he endeavors to give his signal upon the telegraphic key; and 3, the construction and adjustment of this key itself, which affect, to a certain extent, the interval between the intention to give the signal and the complete execution of this intention. The unrecognized interval which intervenes between the perception by sight and the performance of the consequent endeavor to press the button of the observing key, may be regarded as merged with the second of the influences just cited. It forms a large portion of the theoretical personal equation, but a much smaller part of its practical amount, which is very dependent upon less subtle causes of delay.

The first of these elements of personal equation explains the difference which certainly exists in its value for the same observers where different instruments are employed for its measurement, the magnifying power and the amount of light each appearing to exert a distinct effect.

The second is a subject of considerable interest, and extended series of comparisons between the observations of the same persons, using eye-pieces of different magnifying power, with the same instrument, and using instruments of different aperture, with similar reticules and eye-pieces, could not fail to afford much information. It had long been my desire to carry out this investigation, toward which, indeed, a considerable amount of materials has been collected, but, for the present, at least, no facilities are within my reach. It is certain that persons of the most delicate nervous organizations are not generally those who observe a transit earliest; nor does the reverse hold true. And it would seem that an influence is here involved which does not exist in the method of observation by eye and ear, viz: a generally unconscious effort of judgment by which many, if not most, observers give their signal-tap, not at the instant when the star is seen upon the thread, but at such a previous moment that the signal may, in their estimation, take effect at the instant which it is desired to record, after the lapse of an interval of volition and an interval of muscular contraction. It is readily seen that if an observer succeed in attaining this end for both equatorial and circumpolar stars, it can only be by a very accurate estimate of the apparent rate of motion of the star, and that a change of eye-piece for the same star will produce an effect analogous to a change of declination in the star observed. The true method to be aimed at in chronographic observation is clearly to give the signal at that instant when the star is actually seen to be bisected. Then, however large the personal difference from other observers, the personal equation becomes constant, unaffected by many extraneous influences, which cannot otherwise fail to produce a perturbing effect. Still the attainment of this end is by no means entirely within the observer's control, but must, under any ordinary circumstances, vary with their organization and training of the individual. The strictly psychophysical part of the personal equation is, as I have already remarked, merged with such other parts as depends upon the observer's habitude. Yet, it is clear that all these portions are, in general, not constant, but vary to a great extent with the position of the star, and probably with other external circumstances. It is probably in this element also that the well known variation takes place according to the condition of the observer.

The third element, the key used, is generally of more importance in those chronographs on which the signals are given by the closing or making of a circuit than on our own, all of which are arranged for break-circuit signals, inasmuch as, in the former case, it is usually needful for the contact-piece to be moved through an appreciable space before the signal is given, while in the last-named arrangement the first motion of the contact-piece breaks the galvanic circuit and records itself upon the chronograph; but if the spring, which maintains the contact when the button is not pressed, be stronger than usual, or not nicely adjusted, there is danger that an observer accustomed to the use of a more delicate key, upon which a touch suffices to produce an interruption of the circuit, may either fail to record his signals at all or, in default of this, may consume an appreciable time in exerting sufficient muscular force to produce a galvanic circuit. For the sharpest observations a delicate adjustment is requisite; yet this very delicacy of touch, which requires, ordinarily, no muscular effort, becomes a source of inaccuracy when the habitude of observation thus acquired is applied to a coarsely-adjusted key. From this extreme case downward every degree of gradation may exist, and this crude source of discordance between observers may acquire great importance, under some circumstances, when the same key is employed by different observers; for the most delicate adjustment tolerable for one person may, and often does, require too strong a pressure for another's observations to be at all satisfactory.

These various considerations are here presented in some detail, inasmuch as they have proved particularly important in this investigation, in which the question of personal equation has been the most embarrassing, and in which all the considerations here presented are to be carefully weighed.

It will readily be seen that the measurements of personal difference by the ordinary method, properly and successfully used in connection with the determinations of longitude by star-signals, are inapplicable, in great measure, to determinations like the present one, by comparison of clocks. For the clock-corrections at the two stations, upon the correctness and congruity of which the resultant longitude is dependent, are determined by the combination of transits of high and low, zenithal and equatorial stars. And the personal difference of observers for the aggregate of such observations upon stars not the same, is a quantity entirely different from that which would be deduced from and applicable to stars of any one particular class. Indeed, when transits of stars, at declinations beyond the limit proper for chronographic determinations, are combined with the time-stars in the neighborhood of the zenith or equator, the two values of the personal difference are scarcely comparable. In a word, the values applicable to the method of star-signals are inapplicable to the method of clock-comparisons, and their employment may result, not in the removal, but the introduction of error. For time-determinations in general, there are two modes in which the personal equation may be measured or eliminated: one is an interchange of stations by the observers; the other is the systematic determination of time by the two observers independently, using the same instrument and clock, and a well-determined series of stars, carefully reduced to the same equinoctial points. These methods give, not the personal difference, strictly speaking, but the mean value of the personal differences for such stars as are habitually employed for determining time, and either of them, thoroughly applied, would remove all effect of personal equation from the longitude, as measured by clock-comparisons. The last-named method is, as is well known, exclusively employed at Greenwich, and with excellent results.

Of course neither of these methods were available for the transatlantic longitude. The remoteness of the stations from each other, and their difficulty of access, precluded any undertaking of the kind, except at an inadmissible outlay of time and money. It was therefore arranged that a thorough series of comparisons between all the observers should take place at the earliest possible time after their return to the United States, and the corrections to be adopted thus determined. The misapprehension by which the intended elimination of the personal equation of the observers at Newfoundland failed of accomplishment is attended by a minimum of embarrassment, since the equation between Messrs. Dean and Goodfellow has varied between very narrow limits on the two sides of nothing for a number of years.

It was found impracticable to make the arrangements for the series of personal comparisons, without fitting up a small building specially for the purpose, which could not be accomplished till the middle of April, on account of the snow and various delays. On the 9th April the comparisons commenced, and were continued on every occasion that the extremely unfavorable weather permitted, until sixteen comparisons had been made between eight pairs of observers; four of the six observers comparing each with three others, and two of them each with two others. It was provided that a single comparison should depend upon not less than ten pairs of stars, ten transits over twenty-five threads being thus observed by each person, and that no person should take part in more than one comparison on the same night.

The results of these comparisons, together with their mean errors, stars between 25° and 50° being almost exclusively used, are as follows:

	s.	s.		
Gould—Dean . . .	= +0.427	± 0.034	April	13
	+0.330	0.026		18
Gould—Mosman . .	= +0.472	0.028	May	23
	+0.459	0.070		28
Gould—Chandler . .	= +0.190	0.037	June	1
	+0.202	0.033		19
Dean—Goodfellow . .	= −0.013	0.023	April	9
	−0.008	0.024		11
Dean—Mosman . . .	= +0.109	0.014		19
	+0.094	0.024		23
Boutelle—Goodfellow .	= −0.134	0.029		19
	−0.146	0.029		23
Boutelle—Chandler .	= −0.147	0.028		11
Goodfellow—Chandler	= −0.021	0.032		13
	−0.072	± 0.026		18

Further comparisons between Messrs. Boutelle, Mosman, and Chandler were contemplated, but were prevented by duties which called two of these gentlemen away, before further observations could be obtained. One comparison between Mr. Chandler and myself was rejected for manifest error, on a night when the stars were only visible between rapidly flying clouds.

Assigning to these several determinations their appropriate weights, and equating, we arrive at the following values:

	s.
Gould—Dean	= +0.333
Gould—Mosman	= +0.454
Gould—Chandler	= +0.216
Dean—Goodfellow	= −0.029
Dean—Mosman	= +0.121
Boutelle—Goodfellow . . .	= −0.132
Boutelle—Chandler . . .	= −0.223
Goodfellow—Chandler . .	= −0.090

or reducing to Mr. Goodfellow as the standard of comparison:

		s.
Goodfellow—Gould	. . . . . =	−0.304
Goodfellow—Mosman	. . . . =	+0.150
Goodfellow—Dean	. . . . . . =	+0.029
Goodfellow—Chandler	. . . . =	−0.090
Goodfellow—Boutelle	. . . . =	+0.132

In considering these quantities the attention is at once attracted by the unusual magnitude of some of them, by the excessive tardiness of my own signals as compared with those of the other five observers, and by the fact that the personal differences in ordinary time determinations had not been comparable with those here deduced. For example, although my own observations have usually been somewhat later than those of the many others with whom I have measured personal equations on past occasions, there is no room for the hypothesis that my difference from Mr. Mosman can have reached the enormous value of nearly half a second for chronographic observations. Indeed a very thorough study of our observations at Valencia established the fact, that it must certainly have been less than $0^s.05$ upon those occasions, when observations were made by both of us during the same night.

A similar inference is deducible from a comparison of the longitude-results themselves. Thus the time being determined by myself alone for the first series of exchanges, the resultant value for the longitude between Foilhommerum and Heart's Content is $56^s.477$; for the second series, where the clock-correction is derived from interpolation between one determination by myself alone, and one made by Mr. Mosman and myself jointly, the deduced value is $56^s.487$; while the mean of the other three series, all which depend upon time determined by Mr. Mosman alone, gives $56^s.465$, and one of these three gives $56^s.481$. Since the observer at Newfoundland was the same for all five series, it is very evident that no decided personal difference existed between Mr. Mosman and myself. That it could have amounted to one-tenth part of the value deduced on the 23d and 28th of May, at Cambridge, is totally out of the question.

So too, Mr. Chandler's comparisons, which indicate for him a habit of observing nearly a quarter of a second later than Mr. Mosman, although more than two-tenths of a second earlier than myself. Until he went to Calais he had observed exclusively with the same signal-key which I have employed at Cambridge; and at Calais his key was similarly adjusted. And during a very considerable series of observations with a large transit instrument during the last two years, in which Mr. Chandler took part, I had convinced myself that so large a difference as one-tenth of a second between our observations was out of the question. Yet in the present comparisons my observations were recorded later than his by more than two-tenths of a second.

The difference between Messrs. Chandler and Boutelle seems, from examination of the Calais records, to have been, likewise, by no means so large as these special observations would indicate. A series of similar observations with the large transit instrument of the Coast Survey, on four nights immediately after the close of the comparisons just described, using delicately adjusted keys, to which both of us were accustomed, gave as the difference between Mr. Chandler and myself—

$$\text{Gould} - \text{Chandler} = -0^s.021$$

instead of $+0^s.216$ as above, while the difference between Mr. Boutelle and myself, as measured in past years, has rarely attained the limit of $0^s.2$.

The comparisons between Messrs. Dean and Mosman seem to have been similarly, although not equally affected by the same cause; and I have thus been led to the conviction that but little, if any weight ought to be assigned to these determinations of personal equation, as regards their application to the clock-errors from which the longitude must be deduced. If further argument were needed, it would only be necessary to apply to the series of preliminary results already deduced in chapter VII and VIII, the values of personal difference here obtained. The accordance, now so satisfactory, would be entirely destroyed; and the probable error of the result increased more than tenfold, for each of the two longitudes.

The difference here found between Messrs. Dean and Goodfellow is the only satisfactory one. These gentlemen have been accustomed to observe in connection with one another for ten or twelve years, and a very extensive series of measurements, both by observations specially made for the purpose, and by the comparison of longitude—results deduced from their observations before and after exchanging stations, and their personal difference has usually been found very little, if any, to exceed the limits of probable error, while it has varied in sign as already stated.

A satisfactory explanation of the phenomena is, I think, to be found in the break-circuit keys employed, of which the springs were so strong as to occasion a memorandum on each date when I observed, to the effect, that my observations were embarrassed by the strong tension of the keys, which were those used at Newfoundland. Many of my observations were lost in this way at the commencement of the work; and my first night's comparisons proved futile for this reason; inasmuch as the greater proportion of my signal-taps were found not to have been recorded at all upon the chronograph, which was in another building, some twenty-five rods distant. My pressure upon the key had not been forcible enough to break the contact. Mr. Boutelle also complained of the stiffness of the observing key, and caused a note to this effect to be entered upon the journal of the observations for personal equation.

Under these embarrassing circumstances only two courses seem to be available. A repetition of the comparisons using more delicate signal keys, would have been highly desirable, and was earnestly hoped for; but apart from other serious obstacles, the assignment of the various observers to other duties, some of them at very remote stations, precluded all possibility of this solution of the difficulty. We may, however, totally discard all consideration of the personal equation except the value between Dean and Goodfellow, which latter may be regarded as so small and well established as to reduce nearly to a minimum the effects of the misapprehension by which the time determinations at Calais for the two steps in the longitude were made by different persons; or we may fix upon approximate values by considering the tolerably accordant determinations made at other times, and comparing the transit-observations made by different persons at the same station during the present longitude operations.

The latter course seems preferable, and all the more allowable, inasmuch as those values which careful, independent scrutiny has rendered the most probable are all of them small, yet most of them distinctly indicated. And I propose to adopt as not altogether empirical, although obtained by an exercise of judgment quite as much as of computation, values for the personal equation deduced from other sources than the special comparisons here described. It so happens that the algebraic signs of the numerical values thus employed are the same as by the special comparisons, although the magnitudes of these values are very much diminished.

I cannot but believe that an explanation is here presented of the very perplexing phenomenon, so often, and indeed so generally encountered in the discussion of personal equations, that the values found from the comparison of two observers directly, differ so widely from the results obtained when a third observer is employed as an intermediate standard. Different individuals are affected by any unusual circumstances attending their observations, in degrees differing with their nervous organizations.

Thus in the present case, Mr. Mosman's observations were probably affected but slightly by the stiffness of the key-spring, which apparently affected those of Messrs. Boutelle and Chandler, and myself to so great an extent.

The following values have been adopted as seeming most truly to represent the personal equations between the different observers, while engaged in the regular observations of the campaign:

Gould—Mosman	$=+0^s.02$
Dean—Mosman	$=+0.11$
Goodfellow—Dean	$=+0.02$
Boutelle—Goodfellow	$=-0.14$
Boutelle—Chandler	$=-0.04$

While adopting these values I am far from believing that they are the same for stars in different declinations, or were for stars of different magnitudes. But they do seem to represent, with some approximation to the truth, the average differences between the several observers in determining time.

XI.—FINAL RESULTS FOR LONGITUDE.

1. *Foilhommerum and Heart's Content.*—The longitude deduced from the signals of October 25 depends upon time observations at Valencia by myself, and may therefore be combined with those of the last three nights on which Mr. Mosman determined the time, by subtracting the adopted personal equation. Gould—Mosman = $+0^s.020$. But the longitude of October 28 depends upon the transit-observations of October 28 and 30, on the latter of which dates three of the nine stars were determined by Mr. Mosman. Applying to the observed times of these three stars the correction $+ 0^s.020$, and repeating the solution for two unknown quantities, we shall find the azimuth correction A to be changed by $+ 0^s.011$ and the clock correction Δt by $- 0^s.009$. This increases the interpolated values for the Valencia clock corrections during the period of the telegraphic exchanges by only $0^s.001$, making the resultant longitude larger by this amount, and the subtraction of $0^s.020$ from the result refers the whole series to the observations of Mosman at Valencia, and Dean at Newfoundland, as follows:

	h.	m.	s.
1866—October 25	2	51	56.457
October 28			468
November 5			455
November 6			481
November 9			460

The sum of the squares of the deviations of the several values from their mean is thus slightly reduced. An equal weight seems fairly attributed to all the determinations, excepting the first, in which there is a regular increase in the values deduced from the successive sets, which possibly indicates a variability in the clock rate. This, together with the want of experience necessarily attendant upon the first trial, led me to assign to it but half the weight given to the other four, and we thus attain the mean value of the longitude—

$$\lambda = 2\ 51\ 56.465$$

which, corrected for the personal equation in determining time and for that of noting signals, Dean—Gould = $+ 0^s.03$, Dean—Mosman = $+ 0^s.11$, becomes

$$\lambda = 2\ 51\ 56.54$$

2. *Heart's Content and Calais.*—The time observations from which the longitude between Heart's Content and Calais is deduced by Mr. Boutelle for the second and third series of exchanges, and by Mr. Chandler for the first and fourth. The resultant values on the 11th and 16th December require, therefore, the subtraction of the correction, Boutelle—Chandler = $-0^s.04$, after which the several determinations may be combined, to obtain the value which would have been found, had all the Calais observations been made by Mr. Boutelle alone.

The result of the exchanges, December 12, is very far from trustworthy, as a glance at the computation of the time will show. During the three hours which were requisite for obtaining the transits of seven stars at Calais, the clock lost $1^s.28$, although it had gained $0^s.4$ during the eleven hours preceding, and gained again during the two hours following. Some serious disturbance to the clock evidently occurred about this time. The unfavorable weather prevented Mr. Boutelle from detecting it, in spite of his best endeavors; but the fact is not surprising in a clock so old, and so ill adapted for transportation. It would seem as though the fault were in the compensation, but examination has shown the teeth of the seconds-wheel to have been in bad order, so that a "jump" may have occurred during the course of the observations, without detection at the time, or recognition in the transit-observations themselves. At any rate the result obtained from the exchanges of December 12 seemed entitled to small reliance, before its large discordance from the other values was manifest.

Reducing all the values to Mr. Boutelle, and rejecting that of December 12 from the mean, we thus obtain—

	h.	m.	s.
December 11	0	55	37.93
December 12			[37.53]
December 14			37.84
December 16			37.82
Mean	0	55	37.86

which diminished by $0^s.14$ to correct for the personal equation between Messrs. Boutelle and Goodfellow becomes

$$\lambda = 0^{h.}\ 55^{m.}\ 37^{s.}.72$$

3. *Greenwich and Foilhommerum.*—It has been already stated that the astronomer royal cordially acceded to my request that he would take measures for the determination of the longitude between Greenwich and our station at Foilhommerum. This request was made with diffidence, since Mr. Airy had already determined the longitude of two other points in Valencia with all possible care, Feagh Main, the highest point on the island having been measured chronometrically in 1844, and Knightstown telegraphically in 1862, so that the establishment of our station at Foilhommerum implied the determination of an additional arc in order to connect it with Greenwich, whereas we had hoped to adopt the old station of the astronomer royal at Knightstown, six miles to the eastward.

The arrangements for the telegraphic interchange of signals with Greenwich were made by Mr. Airy, and the reductions were executed under his direction at the Royal Observatory, our own share in the work being limited to the operations at Foilhommerum. Exchanges were attempted on ten nights between the 3d and 15th November, but were successful only on the 5th, 13th, and 14th. On the last occasion the weather precluded us from obtaining any observations for time, so that the result depends upon two night exchanges. These proved, however, very accordant.

The clock at each terminus was made to record itself upon the chronograph at the other for half an hour, and the construction of the chronographic and signal-giving apparatus at Greenwich required our clock-signals to be given by closing an open circuit, not by interrupting a closed one, and the Greenwich signals to be received in a similar way. To meet this need, the relay-magnet was modified, while receiving signals, by transferring the conducting stop of the armature to the rear, so that the currents arriving at each second should interrupt the local circuit of the chronograph-magnet like our own clock-signals. And in sending our own signals to Greenwich the connections of the main and local circuits with the relay-magnet thus modified were respectively reversed, so that an interruption of the local circuit by our own clock produced a closure of the main circuit, which transmitted a current to Greenwich. Thus, no loss of time was entailed in receiving signals: but in sending them an armature-time intervened between the actual clock-signal and its transmission to Greenwich. This was reduced to a minimum by strong tension of the spring, and two series of experiments were made to measure the amount of the delay.

For this purpose the relay-magnet being retained in the chronograph-circuit in the same manner as during the transmission of signals to Greenwich, the two terminals of the instrument (which are in permanent connection with the armature, and its conducting stop, and which, during the sending of signals are connected with the two wires of the main line) were also brought into communication with the chronograph-circuit on the two sides of the recording magnet. The effect of this arrangement was that when the clock signal, which is of course recorded upon the chronograph, released the armature of the relay-magnet by interrupting the galvanic circuit, this armature on its arrival at the outer stop completed a metallic connection by which the chronograph was excluded from the circuit. This was recorded upon the chronograph, like a second interruption, which continued until the tension of the spring was overcome by the re-established current. In this manner two signals were given in each second, the first by the clock directly, the second by the relay after the lapse of the interval required for the armature to reach the outer stop. Then, if the chronograph-magnet be adjusted with all possible delicacy, the length of the record of the total interruption will be increased by the full amount of the delay in question. Series of observations were made for the investigation of this point, on the 4th and 14th of November, and indicate a delay of $0^s.02$ in the communication of signals, being equivalent to a retardation of the clock to this amount in the currents sent, though not in their record; and implying a diminution both of the longitude and of the transmission time by $0^s.01$.

The longitude as deduced from the two nights' exchanges is:

	λ	ε	No. of signals, Greenwich.	No. of signals, Valencia.
	h. m. s.	s.		
1866—November 5....	0 41 33.305	0.115	66	210
1866—November 13....	33.280	0.110	80	70
The mean being	0 41 33.29			

The Greenwich observations were made by different persons on different nights, but were all reduced to Mr. Dunkin in the usual manner.

The line of telegraph passed through Killarney and Mallow to Dublin, thence to Wexford, St. Davids, Cardiff, London, and Greenwich. Its total length must have been very nearly six hundred miles, (nine hundred and sixty-six kilometers,) exclusive of the submarine cable between Ireland and Wales, which is about one-tenth part as long. The length of the cable across the straits of Valencia is about three-quarters of a mile.

Referring the longitude of Valencia to Feagh Main, as the fundamental point adopted for the great European arc of parallel, by means of geodetic reduction of the telegraphic stations, Mr. Airy finds for the longitude of this point west of Greenwich—

				h.	m.	s.
1. By the great chronometric expedition of 1844, the transit instrument being placed on the station of the trigonometrical survey				0	41	23.23
2. By the telegraphic communication of 1862, the time instrument being placed at Knightstown:						
Greenwich to Knightstown	0	41	9.81			
Reduction to Feagh Main........			+13.56			
				0	41	23.37
3. By this telegraphic communication in 1866, the transit-instrument being placed at Foilhommerum:						
Greenwich to Foilhommerum........	0	41	33.29			
Reduction to Feagh Main........			—10.10			
				0	41	23.19
From which he adopts Feagh Main West of Greenwich........				0	41	23.29

The variation of these measures may be accounted for in great degree by the local deviations of the direction of gravity in this hilly region, and their consequent effect upon the geodetic reductions.

4. *Final inferences.*—The combination of the three longitudes thus determined, gives—

	h.	m.	s.
Greenwich—Foilhommerum	0	41	33.29
Foilhommerum—Heart's Content........	2	51	56.54
Heart's Content—Calais	0	55	37.72
Greenwich—Calais	4	29	7.55

The Valencia observations having been made by, or referred to, Mr. Mosman, throughout the whole period, his personal equation is eliminated; the equation between Messrs. Goodfellow and Dean, always small, may be regarded as trustworthy; and by a happy coincidence the personal equations of Mr. Boutelle on the west, and of Mr. Mosman on the east, seem to be almost identical; so that even a total disregard of this quantity would have resulted very nearly in its perfect elimination, the oceanic arc being diminished, and the land arc increased, each by about $0^s.14$.

The only probable influence of personal equation in the entire longitude measurement, comprising as it does three-sixteenths of the entire circumference, lies in the difference between the observations of Messrs. Dunkin and Boutelle.

The longitude of Calais, as heretofore telegraphically determined, is as follows:

	h.	m.	s.
Calais—Bangor	0	6	0.31
Bangor—Cambridge	0	9	22.99
Cambridge—New York	0	11	26.06
New York—Washington	0	12	15.47
Calais—Washington	0	39	4.84

Whence we have

	h.	m.	s.
Greenwich—Washington	5	8	12.39

The Seaton station being 12ˢ.44, and the dome of the Capitol 10ˢ.17 east of the Naval Observatory, to the center of the dome of which the preceding value refers, we have their longitudes from Greenwich—

	h.	m.	s.
Seaton station	5	7	59.95
Capitol	5	8	2.22

XII.—Velocity of Transmission of Signals.

We have seen in Section VII, how an interchange of signals gives the numerical measure of the time consumed in their transmission and registration, upon comparison of the records at the two stations.

Representing the clock-time and its needful correction by T and Δt, denoting the signals from Valencia and from Newfoundland by the subjacent figures 1 and 2 respectively, and distinguishing by an accent those quantities which depend upon the Newfoundland clock, we have, (since the Valencia signals preceded,)

$$x_1 + x_2 = (T_2 - T_1) - (T'_2 - T'_1) + (\Delta t_2 - \Delta_1) - \Delta t'_2 - \Delta'_1).$$

Or in words: the sum of the transmission-times for westward and eastward signals, each increased by the error incurred in the process of recording, is equal to the excess of the recorded interval upon the chronograph at the station whence the first signal was given, increased by the excess in the loss of time by the clock at that station during the interval.

In our experiments the interval in question rarely amounted to so much as one hundred and sixty seconds, and the clock-rates were small. The correction due to difference of rates appears never to have surpassed the thousandth of a second; and since it is certainly a quantity of the second order in comparison with the variation in personal error, we may disregard it, and consider the quantity $x_1 + x_2$ as the excess in the record, upon the eastern chronograph, of the interval between the westward and eastward signals. Or, otherwise stated, it is the excess for eastward signals, above westward ones, of the difference of time recorded upon the two chronographs.

Half of this excess would measure the time required for the transmission and record of a signal assuming the velocity to be the same in each direction, could we assume the personal error in noting to be equal for the two observers. This we have, in Section IX, found not to be the case, but happily we have trustworthy values of the absolute amount of this error for each observer. Deducting the sum of the two errors from the quantity $x_1 + x_2$, we have determinations of the actual time consumed in one westward and one eastward transmission; or, if we assume the velocity in each direction to be the same, we have the measure of twice the time required from the transmission of a signal through the length of the telegraphic cable.

The transmission-time as determined for the dates of the several longitude determinations, has been deduced in Section VII, subject to a correction for the mean personal error in noting signals, which correction we have in Section IX, found to be 0ˢ.303. Applying this to the results obtained we have the following values for the mean time of transmission of signals upon the five nights when the longitude was determined.

1866—October 25	0ˢ.314, cable of 1865, with earth and condenser.
28	.343, cable of 1865, with earth and condenser.
November 5	.280, both cables, no earth.
6	.248, both cables, no earth.
9	0.240, both cables, no earth.

The battery strength on these nights was as follows:

October 25	10 cells at Valencia;	10 at Newfoundland.
28	10 cells at Valencia;	10 at Newfoundland.
November 5	3 cells at Valencia;	3 at Newfoundland.
6	3 cells at Valencia;	10 at Newfoundland.
9	4 cells at Valencia;	10 at Newfoundland.

It was my intention that the battery employed at Newfoundland should in every case be of equal strength with that used at Valencia; but through misapprehension on the part of the observer at Heart's Content this was not the case on either of the last two of the five nights of our longitude exchanges. Yet from the results just given the inferences seem unfavorable that the velocity of transmission is greater when the circuit is direct, and consists of a good metallic conductor exclusively, than when the signals are given by induction, and that an increase of intensity in the electromotive force is attended by an increase in the velocity of propagation of the signal.

From the beginning it was part of my design to arrange and make a series of experiments for obtaining general answer, as far as might be possible, to sundry interesting theoretical questions, to which previous investigations had afforded no satisfactory replies. Among these were:

1. The character of the agency which gives the telegraphic signal, upon the closing or interruption of the galvanic circuit, and the route by which its transmission is effected.

2. The influence exerted upon the conductor by using the earth as part of the circuit, or by putting the complete circuit in electrical communication with the earth.

3. The extent to which the velocity of propagation of the signals is dependent upon the intensity of the electromotive force upon the resistance of the conductor.

4. The equality, or difference, in speed of the signals from the positive and from the negative electrode, wheh the other is connected with the earth; as also the relative velocity of signals given by completing and by interrupting the circuit.

Of course it was not to be expected that satisfactory information could be obtained or crucial experiments devised regarding all these points; but these were the guiding ideas in providing for the additional experiments which were carried out, with the friendly aid of the gentlemen of the telegraphic staff, on the 1st, 10th, and 16th November.

The length of the cable of 1865 is 1,896.5 nautical, or 2,186 statute miles; and that of the cable of 1866 is 1,851.6 nautical, or 2,134 statute miles. Expressed in metric units, the cable of 1865 is 3,518 kilometers, and that of 1866, 3,435 kilometers long.

In each cable the conductor is formed by six copper wires twisted around a seventh central one. It has a diameter of 0.147 inch, or 3.7 millimeters, and weighs three hundred pounds to the nautical mile, or 73.476 grams to the meter. The copper was guaranteed by the manufacturers to have a chemical purity of eighty-five per cent., and its specific conducting power (that of pure copper being 100) was found by test to be 93.1 for the cable of 1865, and 94.6 for that of 1866. Its specific gravity, as determined by Mr. Willoughby Smith, was 8.90.

The electrical tests of the cables, after they were laid and in complete working order, had been made by Mr. Latimer Clark a short time previous, and gave the following values, expressed in terms of the standard unit* adopted by the British Association for the Advancement of Science, and

*This excellent system of measures is derived from the absolute electro-dynamic units of Weber, by multiplying them by such powers of ten as shall refer them to a convenient scale.

The unit of force, f, is that force which, acting during one mean second upon a mass weighing one gram, would impress upon it a velocity of one meter in one second. It differs from the meter-gram, which is the force requisite for lifting a gram through a meter in a second, and is$=9.80868 f$.

The unit of current, c, is that current which, acting through one meter at one meter distance, exerts the force f upon a similar current. It decomposes about ninety-two milligrams of water in each cell in a second, consuming about one-third of a gram of zinc.

The unit of resistance, r, is the resistance of the conductor which transmits the current c in one second.

The unit of electromotive force, e, is the tension which maintains the current c with the resistance r.

The unit of quantity, q, is that amount of electricity which flows in the current c during one second.

These measures, "absolute," in so far as they depend only upon the gram, the meter, and the second, are referred to which promise to become generally accepted as a peculiarly convenient system of electrical measurement.

The cable of 1865 gave* a resistance of 4.01 ohms to the knot; the "insulation," or resistance of the coating, being 2,945 megohms to the knot, and the electrostatic capacity 0.3535 farad to the knot, or about one farad to each three and one-quarter statute miles.

The cable of 1866 showed for each knot a resistance of 3.89 ohms, and an insulation of 2,437 megohms, the electrostatic capacity being essentially the same as in the other.

Thus we have in the cable of 1865, as the total resistance to conduction, about 7,650 ohms; as the total resistance of the insulator 1,505,000 ohms; as the total electrostatic capacity about 670.1 farads. In the cable of 1866 the total resistance is about 7,270 ohms; the total insulation 1,316,000 ohms; the total electrostatic capacity 654.5 farads.

The battery employed by the telegraph company was composed of what are known as Minotti's cells, these being a modified form of Daniell's, in which the zinc rests upon a column of wet sawdust, at the bottom of which is a layer of sulphate of copper, and a copper disk being at the base of all. My friend, Mr. M. G. Farmer, to whom I applied for information, found by experiment the electro-motive force of one of these cells to vary from 0.75 to 0.95, averaging 0.84 volt; while the average of four Daniell's cells of ordinary construction gave 0.923 volt. Hence he estimated that after the full strength of the current is developed, one cell should give on one cable, with earth connection, about one hundred and ten farads in a second.

The experiments made for measuring the velocity of signals it will be well first to describe in their regular order.

On the night of November 1 the first essays were made, after the use of an electromagnet had proved hopeless, but owing to numerous difficulties incident to a first trial only a few signals were exchanged. These were made by employing a battery of twenty cells at Valencia, having its positive electrode to the cable of 1866, while the two cables were connected at Newfoundland without battery, and the signals thence were given by alternately breaking and closing the circuit. In the first set no communication was made with earth, eighteen signals from Valencia and seven from Newfoundland being recorded at both stations. In the second the zincode of the battery was connected with the ground as well as with the cable, and of the signals thus given thirteen from Valencia and three only from Newfoundland were thus recorded.

On November 10 the first two series of experiments were successfully made, as previously arranged in the programme, excepting that during the second series the Newfoundland battery remained without change, Valencia using four cells and Newfoundland twenty. On November 16 the last two series were carried out with four cells at each station.

On the 16th an independent series of experiments was also instituted by causing the cables to be connected without battery at Newfoundland, while signals were given and observed at Valencia, with resistances of various amounts introduced in the circuit, and with variations in the battery power.

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convenient scales in the British Association system, the measures adopted being named in honor of eminent discoverers in electrical science, in accordance with a suggestion of Mr. Clark.

The measure of electromotive force is $10^5 f$, or one hundred thousand times the absolute unit. This has about 0.927 the tension of a Daniell's cell, and is called a *volt*.

The measure of resistance is $10^7 r$, or ten million times the absolute unit. This is about 1.0456 times the Liemen's unit, and is called an *ohm*.

The measure of quantity is $10^{-8} q$, or the hundred-millionth part of the absolute unit. This is called a *farad*.

Consequently, with a tension of one volt, and a resistance of one million ohms, the quantity of electricity would be one farad in each second.

Moreover, since the volt-farad is $10^{-3} fq$, we have 1,000 volt-farads = the absolute unit of work, or 9,808 volt-farads per second = the meter-gram.

One million of ohms is conveniently designated as a *megohm*, and one million of farads as a *megafarad*.

* In the manufactory the resistances found in each knot, at a temperature of 75° Fahrenheit, were 4.27 and 4.20 ohms for the two cables respectively, and the respective insulating capacity of the coverings 349,000,000 and 342,000,000 of ohms to the knot. These data show an increase of conducting power by six per cent. for the cable of 1865, and eight per cent. for that of 1866, while the insulation had been increased in the ratios of 8.44 and 7.13. Hence we may roughly infer the average temperature of the cables to be not far from 5° Centigrade in their ocean bed.

The first question to be investigated is whether the positive and negative signals were transmitted with the same velocity. For deciding this no knowledge of the actual time of transmission is requisite, but a simple comparison of the records of the same signals at the two stations will afford an answer. This comparison gives us the interval T—T′, or the difference of the time indicated at the same moment by the two clocks, diminished by the time of transmission, in the case of signals given from Valencia, and increased by this amount for signals from Newfoundland. This interval is a measure of the longitude, uncorrected for clock errors or for transmission time; but for our present purpose its absolute magnitude is unimportant, since our inquiry is answered by comparing the results deduced from positive and from negative signals with each other. Any excess in the time consumed in the passage of either class of signals should manifest itself by a superior value in the measures of the temporary clock-difference derived from that class, when the signals are sent westwardly. For eastward signals the reverse holds.

It had been intended, as will be seen by the original programme, to measure the velocity of signals while the batteries at both ends were included in the circuit, as well as when only one was employed; but since the construction of the signal-keys rendered this arrangement difficult, and inconvenient in many respects, the plan was not carried out. In all cases the battery at the receiving-station was cut off from the circuit. Consequently all our experiments may, as far as regards the point now in question, be arranged in four classes, according to the character of the ground connection. When, as in the last three of these classes, both cables were included in the circuit, those signals are called positive which put the copper of the Valencia battery to the cable of 1865, or the copper of the Newfoundland battery to the cable of 1866.

A.—*Cable of 1865 only, using condensers.*

	No.	Positive mean interval.	No.	Negative mean interval.	No. cells.	Excess for positive signals.
VALENCIA SIGNALS.		*h. m. s.*		*h. m. s.*		*s.*
October 25, longitude	30	2 52 9.041	28	2 52 9.041	10	0.000
28, longitude	29	10.107	30	10.120	10	—0.013
NEWFOUNDLAND SIGNALS.						
October 25, longitude	30	10.277	29	10.293	10	—0.016
28, longitude	28	11.110	27	11.096	10	+0.014

B.—*Both cables, middle of battery to ground.*

	No.	Positive mean interval.	No.	Negative mean interval.	No. cells.	Excess for positive signals.
VALENCIA SIGNALS.		*h. m. s.*		*h. m. s.*		*s.*
November 10, I. 1	8	2 52 20.862	9	2 52 20.844	4	+0.018
10, II. 1	8	20.887	9	20.864	4	+0.023
16, IV. 1	8	21.179	10	21.163	4	+0.016
NEWFOUNDLAND SIGNALS.						
November 16, III. 1	8	22.234	8	22.262	4	+0.028

C.—*Both cables, zincode (neg. pole) to ground.*

	No.	Positive mean interval.	No.	Negative mean interval.	No. cells.	Excess for positive signals.
VALENCIA SIGNALS.		*h. m. s.*		*h. m. s.*		*s.*
November 1, I. 2	9	2 52 14.119	9	2 52 14.124	20	—0.005
10, I. 2	9	20.692	10	20.869	4	—0.177
10, II. 2	7	20.693	9	20.850	4	—0.057
NEWFOUNDLAND SIGNALS.						
November 16, III. 2	9	22.290	10	22.315	4	+0.025

D.—*No ground connection whatever.*

	No.	Positive mean interval.	No.	Negative mean interval.	No. cells.	Excess for positive signals.
VALENCIA SIGNALS.		*h. m. s.*		*h. m. s.*		*s.*
November 1, I. 3	9	2 52 14.112	9	2 52 14.122	20	—0.010
5, longitude	29	17.294	29	17.294	3	0.000
6, longitude	18	17.203	16	17.214	3	—0.011
9, longitude	30	20.292	28	20.290	4	—0.002
10, I. 3	10	20.748	10	20.790	4	—0.042
10, II. 3	9	20.752	10	20.821	4	—0.069
16, IV. 3	9	21.157	10	21.161	4	—0.004
NEWFOUNDLAND SIGNALS.						
November 5, longitude	30	18.465	28	18.482	3	—0.017
6, longitude	20	18.302	20	18.312	10	—0.010
9, longitude	30	21.369	30	21.365	10	+0.004
10, II. 1	10	21.902	10	21.915	20	+0.013
10, II. 2	10	21.926	10	21.939	20	+0.013
10, II. 3	10	21.922	10	21.918	20	—0.004
16, III. 3	10	22.285	10	21.277	4	—0.008
16, IV. 3	9	22.287	10	21.266	4	—0.021

Our mean values have here been recorded to thousandths of a second, a degree of precision which is of course only nominal, since the accuracy attainable by the mode of observation employed would scarcely warrant any reliance upon the second decimal for the mean of a number of observations much larger than ten. Yet if this be borne in mind no misapprehension can result from the employment of three decimals, while on the other hand this affords a reciprocal control in the figures.

It is manifest that, if we disregard the signals given from Valencia while the zincode was connected with the ground on the 10th November, all the differences are of an order of magnitude which justifies the assumption, already probable from theoretical considerations, that the positive and negative signals travel with equal velocity under the same circumstances. This assumption I will therefore make, postponing any remarks concerning the discordances manifested on November 10.

The speed of the two kinds of signals being thus taken as the same, under similar circumstances, the time required for their transmission is easily deduced, being one-half the difference between the measures of longitudes from the records at the respective stations. The weak point in our determination is, of course, the absence of any automatic record of signals received; but the considerations already presented in the chapter on the personal error in noting signals, afford ground for confidence that the uncertainty here introduced is comparatively small, and that the aggregate personal error of the two observers is very close to $0^s.606$. This value is adopted in the present investigation, and all the measurements hereinafter recorded, with which this personal error is merged, have been corrected by deducting this quantity.

Then for a circuit formed by both cables, without earth connection, we have the following determinations of the sum of the times of transmission for eastward and westward signals derived from the last three series of longitude determinations, and from the second and fourth series of special experiments.

B.—*Middle of battery to ground.*

1866.	Positive signals.		Negative signals.		Mean.	Number of cells.	
	No.	x_1+x_2	No.	$x_1+{}_2x$	$x_1+{}_2x$	Valenc.	Newf'd.
		s.		*s.*	*s.*		
II. 2, November 10	5	0.396	5	0.432	0.414	4	20
	5	0.422	5	0.458	0.440	....	....
		0.409		0.445	0.427		
IV. 1, November 16	....	....	5	0.524	....	4	4
	....	....	4	.558	....	....	....
		....	9	0.541	....		

C.—Zinc to ground.

1866.	Positive signals.		Negative signals.		Mean.	Number of cells.	
	No.	x_1+x_2	No.	x_1+x_2	x_1+x_2	Valenc.	Newf'd.
		s.		s.	s.		
II. 2, November 10	4	0.553	4	0.592	0.528	4	20
	3	.719	5	0.468	0.562		
	7	0.624	9	0.483	0.545		
IV. 2, November 16			5	0.550		4	4
			5	0.486			
			10	0.518			

D.—No ground connection.

1866.	Positive signals.		Negative signals.		Mean.	Number of cells.	
	No.	x_1+x_2	No.	x_1+x_2	x_1+x_2	Valenc.	Newf'd.
		s.		s.	s.		
Longitude, November 5	10	0.562	10	0.617	0.590	3	3
	10	.532	10	.576	.555		
	9	.570	9	.612	.591		
	29	0.555	29	0.602	0.579		
Longitude, November 6	10	0.513	9	0.518	0.515	3	10
	8	.494	7	.458	.476		
	18	0.504	16	0.488	0.496		
Longitude, November 9	10	0.464	10	0.446	0.455	4	10
	10	.472	10	.508	.490		
	10	.500	10	.489	.494		
	30	0.479	30	0.481	0.480		
II. 3, November 10	5	0.572	5	0.482	0.532	4	20
	3	.577	4	.506	0.536		
	8	0.574	9	0.494	0.534		
IV. 3, November 16	4	0.554	5	0.540	0.547	4	4
	5	.494	5	0.458	0.476		
	9	0.524	10	0.499	0.511		

And for a single cable, (that of 1865,) which went to earth at one end, while at the other the electrical equilibrium was disturbed only by means of a condenser through which the battery acted inductively, so that no real charge entered or left the cable at the signal-station, we have, from ten cells at each station:

A.—Induced current.

1866.	Positive signals.		Negative signals.		Mean.
	No.	x_1+x_2	No.	x_1+x_2	
		s.		s.	s.
October 25	10	0.648	8	0.659	0.653
	10	.617	10	.675	0.646
	10	.594	10	.577	0.584
	30	0.620	28	0.635	0.627
October 28	9	0.794	9	0.707	0.750
	9	.691	10	.667	.679
	10	.637	9	.627	.632
	28	0.705	28	0.667	0.686

Let us now consider the experiments made without any earth connection whatever: First, those of November 5 and 16, on which occasions the battery power at the two stations was the same. Each station sent signals with a battery of three Minotti's cells on the 5th and four on the 16th, receiving them with its battery disconnected. The circumstances at the two stations were as nearly identical as possible, and the mean interval consumed in the transmission of the signals appears to have been $0^s.29$ on the former and $0^s.26$ on the latter occasion.

With a battery of three Minotti's cells, each possessing a tension of 0.84 of a volt, and incapable of generating more than 110 farads to the second, when circuit was made through earth and one cable only, the maximum permanent current would not exceed 168 farads in the joined cables, and to develop nine-tenths of this current, more than one and a quarter seconds would be needed. With three Daniell's cells, the maximum current would not exceed 185 farads. Assuredly we cannot suppose that in the lapse of three-tenths of a second, when not more than one-seventh of this current had been developed at the farther station, this battery could have charged the two joined cables, each of which possessed an electrostatic capacity of more than 650 farads. Hence the impulse upon which the transmission of the signal depends must have been propagated along the conductor by some other means than by charging its successive parts electrically, *i. e.*, fully and in the ordinary sense of this expression. The thirty farads, more or less, which could have been generated before the signal arrived at the distant extremity of the cables, would have been consumed in charging the first six or seven hundredths of the conductor.

During my stay at Valencia, messages were effectively and distinctly transmitted in each direction by the use of an electromotor formed by a small percussion-cap containing moistened sand, upon which rested a particle of zinc. The current here evolved could scarcely have amounted to more than six or seven farads, so that nearly two minutes would have been requisite for charging one cable. Yet the transition-time was certainly small, although it was not definitely measured.

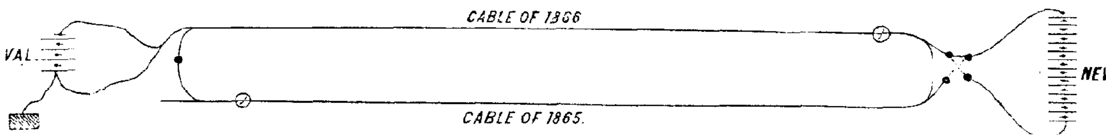
The experiments without earth-connection on November 6 and 9, differed from those of the 5th and 6th only in that the Newfoundland battery consisted of ten cells instead of the same number as was employed at Valencia. The mean times of transmission were respectively $0^s.25$ and $0^s.24$, indicating an increase of speed with the increase of electromotive power. And so far as the experiments on these four days are concerned, we might infer that on the complete metallic circuit formed by the two cables the time required for transmitting the signals through about 3,475 kilometers, or 2,160 statute miles, was not far from $0^s.29$ for a battery of three cells, $0^s.26$ for one of four cells, and $0^s.215$ for one of ten cells.

On the other hand, the transmission-time for signals sent by a current reduced on a single cable, by means of a "condenser" with a battery of ten cells, was on the average $0^s.31$ on the 25th and $0^s.34$ on the 28th October, the mean interval for these two days being $0^s.328$. Each of the condensers used possessed an electrostatic capacity of about twenty farads; so that with a tension of ten cells, or 8.4 volts, their capacity would be not far from 168 farads, or equal to that of about 590 miles (945 kilometers) of cable; or, in other words, a little more than one-quarter of the capacity of one whole cable.

The value of those experiments in which the batteries were connected with the earth is seriously impaired by the series of mistakes made at Newfoundland on the 10th November. On that day twenty cells were used instead of four, and the prescribed connection of the battery with the ground was forgotten, so that both the electromotive and the electrostatic relations became too complicated for any safe inferences as to the results. But apart from these, some other grave error appears to have been committed, by which we are apparently led to the singular result that the average time consumed in the transmission of signals was $0^s.31$ for the positive and only $0^s.24$ for the negative signals, although the only difference between these classes consisted in an interchange of electrodes relatively to the two cables, and although the transmission-time for the two cables is shown by all our other experiments to have been practically equal. The only reason which I can discover for any difference between these two kinds of signals seems inadequate to explain the phenomenon, yet it ought not to be overlooked. It is this:

The construction of the signal-keys was such, that in the only manner in which it was safe to use them for these experiments, the battery circuits remained connected with the cables at the receiving station. The cables were connected with each other without the battery, and the battery was short-circuited independently of them; still a metallic connection did exist between the telegraphic circuit which was formed by the two cables together with their transatlantic battery on the one hand, and the temporarily disused (though closed) local circuit on the other. So long as there is no earth connection in this local circuit, its effect may fairly be left out of all consideration; but so soon as any such connection is introduced the case is changed.

In the experiments of November 10, the zinc of the four-cell battery at Valencia was provided with an earth connection, while the twenty-cell battery at Newfoundland was insulated. And since the galvanometer at each terminus was situated upon that cable to which the platinode was applied for those signals which we term positive, some difference must have existed in the action of the two classes of signals from Newfoundland upon the Valencia galvanometer; for the Newfoundland signals would exert a tension on the cable of 1866 which, on reaching Valencia, might act for an instant inductively upon the local circuit, before the dynamic equilibrium of the main circuit should be established by means of the opposite tension upon the other cable and the signal thus exhibited upon the Valencia galvanometer. Obviously, when the ground connection was made with the zinc of the Valencia battery, this disturbing action would be the greatest for those signals of which the tension would thus be for a moment partially neutralized, namely, for the positive signals.

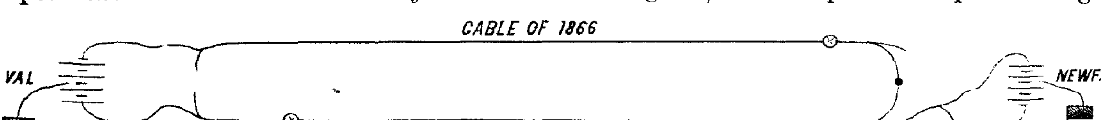


No other explanation than this has suggested itself, and though, as already stated, this scarcely appears adequate, it would yet derive some color from the absence of any analogous differences for the two classes of signals in the first experiment of the same day, in which the ground connection was made to the middle of each battery. On the other hand, a similar though inferior difference does exhibit itself in the third experiment, where no earth contact was made, and it is safer to assume some additional and yet undiscovered mistake in the arrangement of the connections at Newfoundland, and therefore to discard the observations of November 10 altogether, than to attempt to draw any inferences from them. These would contradict the experiments upon other days, when the connections were managed somewhat more effectively, although not without mistakes in the Newfoundland batteries on both the 6th and 9th November.

On November 16 all the arrangements seem to have been correctly made, each battery consisting of four cells, and the earth connections at both stations being made with the zincodes in the second experiment and with the middle of the batteries in the third.

In the former case, all the positive signals found earth at the other extremity of their respective cables without affecting the other cable at all, and therefore without manifesting themselves upon the galvanometer at the distant station, while negative signals, which differed from the positive ones only by an interchange of the cables used for the respective electrodes, were of course received and recorded. Thus we have on this occasion only the "negative" signals, *i. e.*, those in which the platinodes went to the cable of 1866, at Valencia, and to that of 1865, at Newfoundland.

In the latter case the effect of the arrangement would be to substitute two circuits, each consisting of one cable with two cells at each extremity, and earth connections for the one circuit formed by a cable with four cells at the signal-giving station and earth connections, were it not that a very small portion of each of the two first-named circuits is common to the two, being formed by the piece of metal which unites the short circuit of the local battery with the connected or "looped" cables. This will be readily seen from the diagram, which represents a positive signal



from Valencia. Both sets of signals from Valencia were received at Newfoundland, but, contrary to my expectations, only two of the ten positive signals from Newfoundland were perceptible upon the Valencia galvanometer, and these were but weakly indicated, the needle being much agitated.

The results of the recorded signals give $0^s.26$ as the transmission time through one cable with earth return when the ground connection was made with the zinc, and $0^s.27$ when it was made with the middle of the battery, the former corresponding to the use of four cells at one station only, and the latter to two cells at each.

Passing next to the consideration of the velocity of signals given by closing and interrupting the circuit, which for convenience we will term "make-circuit" and "break-circuit" signals, we have some data for the investigation from the first and third series of experiments. For the first series the battery was at Valencia, and the signals from Newfoundland were necessarily given by making and breaking the circuit of the battery at the other station, or, in the language of telegraphers, sending signals against the current. For the third series the reverse was the case, and the Valencia signals were sent by means of the current from Newfoundland. In both instances the signals from the battery station were given in the usual way by the alternation of opposite currents. That such an arrangement was ill adapted for any important electrical investigation is manifest; but the few experiments made were of course entirely subordinate to the object of the expedition, and, as will be seen from the programme, were very crudely indicated in advance. The totally different character of the methods and appliances from those which had come within the previous experience of our longitude parties, as well as the very different nomenclature, rendered telegraphic instructions difficult, ambiguous, and, as the event proved, often ineffective. The circumstances under which our few simple trials were made were embarrassing, in spite of the cordial interest and friendly assistance of the gentlemen of the telegraphic staff on both sides of the ocean. The cables were in nearly constant demand for commercial purposes, although all facilities were accorded which I could conscientiously ask. It nevertheless appeared desirable to make such few essays at measuring the time of transmission as opportunity conveniently allowed, in the hope that at least something of interest might prove deducible. And it will be perceived that our own experience could not be made available at the time, inasmuch as any inferences must be drawn from measurements and collation of chronographic records which could only be brought into juxtaposition by some 3,000 miles of transportation.

Our data, thus obtained, for the relative velocity of the make-circuit and break-circuit signals, leads to the singular inference that the latter traveled most rapidly in the case of Newfoundland signals with Valencia battery, while for the Valencia signals with Newfoundland battery the reverse was the case. For this I have no explanation to suggest. It has been impossible for me to shake off a suspicion that the same error in connections which occasioned the discordance of November 10, already alluded to, may have acted to produce the discrepancies here manifested; but I will confine myself to a statement of the results, and leave any possible reconciliation of the discrepancies to the future.

There are two ways in which the relative velocity of the two classes of signals may be examined. One is by comparing the values of the approximate longitude, as given by the make-circuits and break-circuits respectively, for which purpose all corrections for clock-error and rate may be disregarded, since they affect both determinations alike. The other is by deducing the aggregate transmission-time for each kind of signals taken together with the corresponding ones sent in the opposite direction. This latter method permits the employment of a much larger number of observations, and by use of the value of the transmission-time for positive and negative signals, as previously deduced, it allows a tolerably approximate measurement of the actual time for the signals in question. The former gives only the difference of time consumed by the two classes respectively, but it affords measures of this difference free from the influence of extraneous sources of error. I will state the results from each of these methods.

Beginning with that first named, it will readily be perceived that an excess in the approximate longitudes, as deduced from make-circuit signals, indicates an inferior velocity for these when the signals are from the west, but a superior velocity when they are sent from the east. Yet such an excess is here manifested in both cases, as will be seen from the appended table.

Series I.—Signals from Newfoundland; battery at Valencia.

Experiment.	Date.	Earth-connection.	Make-circuit signals.		Break-circuit signals.		No. cells.	Excess for make-circuits.
			No.	Mean.	No.	Mean.		
				h. m. s.		*h. m. s.*		*s.*
I. 3	Nov. 1	None......	2	2 52 15.515	4	2 52 15.335	20	+0.180
I. 1	Nov. 10	Middle	3	22.293	4	21.997	4	+0.296
I. 2	Nov. 10	Zinc	9	22.293	10	22.040	4	+0.253
I. 3	Nov. 10	None......	10	22.091	10	21.965	4	+0.126

Series III.—Signals from Valencia; battery at Newfoundland.

Experiment.	Date.	Earth-connection.	Make-circuit signals.		Break-circuit signals.		No. cells.	Excess for make-circuits.
			No.	Mean.	No.	Mean.		
				h. m. s.		*h. m. s.*		*s.*
III. 1	Nov. 16	Middle	9	2 52 20.950	10	2 52 20.798	4	—0.152
III. 2	Nov. 16	Zinc	10	21.002	10	20.880	4	—0.122
III. 3	Nov. 16	None......	10	21.082	10	21.030	4	—0.052

The results by the second method of inquiry are obtained by assuming the transmission time for both positive and negative signals from Valencia, November 1, to have been $0^s.214$, and from Valencia, November 10, and Newfoundland, November 16, to have been $0^s.264$ also. Thus we have:

Series I.—Newfoundland signals; Valencia battery.

Experiment.	Date.	Earth-connection.	Transmission-time.		Excess for make-circuits.
			Make-circuit.	Break-circuit.	
			s.	*s.*	*s.*
I_2	Nov. 1	Zinc	0.65	0.39	+0.26
I_3	Nov. 1	None........	0.80	0.61	+0.19
I_1	Nov. 10	Middle	0.54	0.22	+0.32
I_2	Nov. 10	Zinc	0.72	0.30	+0.42
I_3	Nov. 10	None........	0.47	0.31	—0.16

Series III.—Valencia signals; Newfoundland battery.

Experiment.	Date.	Earth-connection.	Transmission-time.		Excess for make-circuits.
			Make-circuit.	Break-circuit.	
			s.	*s*	*s.*
III_1	Nov. 16	Middle	0.44	0.64	—0.20
III_2	Nov. 16	Zinc	0.43	0.56	—0.13
III_3	Nov. 16	None........	0.36	0.34	+0.02

These values are rudely confirmatory of those deduced by the first method. They show, at any rate, a difference between the velocity of the two kinds of signals, which becomes very considerable when the tension at any part of the circuit is disturbed by an earth connection. And they also indicate that a full charge or discharge of the cable is not requisite for a make-circuit or break-circuit signal.

In the experience of the Coast Survey since 1851, the break-circuit signals which have exclusively been employed for longitude determinations have varied comparatively little in their velocity. This question has been investigated in every instance, and in many cases large changes have been made in battery power and in the connections for the purpose of observing the effect upon the transmission time. I have no access to the records of these experiments at present, but the results have in general shown that with a well insulated line of uncoated iron wire of the size ordinarily employed,* the earth forming half the circuit, the time required for the signals to reach their destination is not far from $0^s.07$ for each thousand miles, or, roughly, that their velocity is 22,000 kilometers to the second. The necessary interpolation of repeaters between Heart's Content and Çalais precludes any determination of the velocity of the electrical action, but the average interval of time consumed in the passage of a signal between these two stations was $0^s.277$, he distance being 1,090 miles, and four repeaters being interposed.

During the intervals between the signals, the electrical condition of the cable was undisturbed, and no extraneous influence prevented its return to a state of equilibrium. The signals were a quarter of a second long, as nearly as might be, and intervals of five or of ten seconds elapsed between the successive signals, each pair of "sets" having fourteen intervals 5^s each and five intervals of 10^s. Upon no one of the five longitude nights was there any direct connection between the cable and the earth. The two extremities of the cable were connected with condensers on the 25th and 28th October, and all signals on those occasions were therefore given by induction only; while on the 5th, 6th, and 9th November a complete circuit was formed by the two cables, and the battery at the receiving station was short-circuited. On these last three nights the two cables were not connected at the sending station during the intervals between the signals, but the battery was short-circuited there also. Thus the cables were always resuming their equilibrium between the signals during each of the five nights when the exchanges for longitude were made, there being upon the first two nights only one length of cable used, but upon the last three a double length, through which the adjustment of the perturbation was to be effected.

I will give the results for these five nights in the same form in which they were first presented, viz: The mean difference between the records of the same signals upon the two registers being the resultant value of the longitude, uncorrected for clock errors or for transmission time. The 2^h 52^m which are common to all can be here omitted, only the seconds and fractions of a second being needful for our purpose, and the signals are assorted according to the length of the interval which immediately preceded. On each date three series of twenty signals each were sent from each station, but not all were received. The average number upon which the several values for each day actually depend is sixteen positive and twenty-two negative after the five-second intervals, and six positive and five negative after the ten-second intervals.

Uncorrected values of the longitude, assorted by length of interval preceding the signal.

Date and signal station.	No. cells.	5^s interval.		10^s interval.		All.	
		Pos.	Neg.	Pos.	Neg.	5^s	10^s
		s.	*s.*	*s.*	*s.*	*s.*	*s.*
Oct. 25, Valencia	10	9.075	9.060	9.003	8.975	9.068	9.092
Newfoundland	10	10.235	10.265	10.308	10.332	10.250	10.320
Oct. 28, Valencia	10	10.406	10.388	10.376	10.445	10.397	10.401
Newfoundland	10	11.678	11.667	11.710	11.742	11.673	11.723
Nov. 5, Valencia	3	17.313	17.287	17.272	17.243	17.299	17.261
Newfoundland	10	18.446	18.467	18.481	18.482	18.457	18.480
Nov. 6, Valencia	4	17.214	17.220	17.224	17.185	17.217	17.211
Newfoundland	10	18.285	18.298	18.335	18.372	18.292	18.350
Nov. 9, Valencia	4	20.288	20.281	20.251	20.267	20.284	20.257
Newfoundland	10	21.370	21.350	21.344	21.373	21.359	21.357

* That called in commerce No. 9, weighing about 320 pounds to the mile, or 78.4 grains to the meter.

whence we may infer the sum of the transmission-times in the two directions to have been—

Date.		5^s	10^s	Excess for 10^s interval.		
				Val.	Newf	Sum.
		s.	*s.*	*s.*	*s.*	
Oct.	25	0.576	0.622	−0.024	+0.070	+0.046
	28	0.670	0.716	−0.004	+0.050	+0.046
Nov.	5	0.552	0.613	+0.038	+0.023	+0.061
	6	0.469	0.532	+0.006	+0.058	+0.064
	9	0.469	0.493	+0.027	−0.003	+0.024

Taking next the results afforded by the experiments of November 10 and 16, we find the mean difference between the records of the same signal at the two stations, omitting the $2^h\ 52^m$ as before, to be:

Uncorrected values of the longitude, from velocity experiments.

Exper't and signal station.	No. cells.	Earth conn'n.	5^s interval.		10^s interval.		All.	
			Pos.	Neg.	Pos.	Neg.	5^s	10^s
			s.	*s.*	*s.*	*s.*	*s.*	*s.*
I. 1 Valencia	4	Middle	20.874	20.894	20.840	20.815	20.886	20.830
I. 2 Valencia	4	Zinc	20.698	20.876	20.680	20.840	20.800	20.744
I. 3 Valencia	4	None	20.790	20.792	20.677	20.780	20.791	20.718
II. 1 Valencia	4	Middle	20.893	20.869	20.876	20.845	20.879	20.863
Newfoundland	20	None	21.898	21.921	21.903	21.890	21.911	21.898
II. 2 Valencia	4	Zinc	20.692	20.870	20.690	20.780	20.792	20.735
Newfoundland	20	None	21.918	21.940	21.937	21.935	21.931	21.936
II. 3 Valencia	4	None	20.758	20.827	20.760	20.800	20.798	20.780
Newfoundland	20	None	21.897	21.909	21.960	21.955	21.904	21.958
III. 1 Newfoundland	4	Middle	22.232	22.262	22.260	......	22.251	......
III. 2 Newfoundland	4	Zinc	22.307	22.301	22.247	22.345	22.304	22.306
III. 3 Newfoundland	4	None	22.290	22.270	22.263	22.300	22.279	22.278
IV. 1 Valencia	4	Middle	21.192	21.150	21.157	21.215	21.166	21.180
Newfoundland	4	Middle	......	22.316	......	22.285	22.316	22.285
IV. 2 Valencia	4	Zinc	......	21.195	......	21.180	......	......
Newfoundland	4	Zinc	......	22.315	......	22.300	......	......
IV. 3 Valencia	4	None	21.188	21.164	21.133	21.150	21.174	21.140
Newfoundland	4	None	22.270	22.259	22.317	22.295	22.271	22.308

whence we find the sum of the transmission-times in the two directions in the experiments, when batteries were used at each station, to have been—

Exper't.		5^s	10^s	Excess for 10^s interval.		
				Val.	Newf.	Sum.
		s.	*s.*	*s.*	*s.*	*s.*
II.	1	0.426	0.429	+0.016	−0.013	+0.003
II.	2	.533	.595	+0.057	+0.005	+ .062
II.	3	.500	.572	+0.018	+0.054	+ .072
IV.	1	.544	.499	−0.014	−0.031	− .045
IV.	2	.514	.514	+0.015	−0.015	.000
IV.	3	0.491	0.562	+0.034	+0.037	+ .071

The mistakes, heretofore mentioned, at Heart's Content, in the number of cells and in the connections on the 10th November, put it out of our power to make any definite inferences from the first two experiments of Series II, and the number of signals after intervals of 10^s in the first two experiments of Series IV was so small as to forbid much reliance upon their mean. But the evidence here also indicates that a longer time was consumed in the transmission of signals after the longer interval.

Finally, the first and third series of experiments, in which a battery was employed at one station only, give the following results for the relative speed of the make-circuit and break-circuit signals, four cells being used in every instance:

November 10.—Signals from Newfoundland; battery at Valencia.

Exper't.	Earth conn.	5^s interval.		10^s interval.		Excess of time for make-circuits.		
		Makes.	Breaks.	Makes.	Breaks.	5^s	10^s	Diff.
		s.	*s.*	*s.*		*s.*	*s.*	
I. 1	Middle	22.293	22.000	....	....	+0.293	....	....
I. 2	Zinc	22.260	22.056	22.360	21.975	+0.204	+0.385	+0.181
I. 3	None...........	22.107	21.979	22.063	21.910	+0.128	+0.153	+0.025

November 16.—Signals from Valencia; battery at Newfoundland.

Exper't.	Earth conn.	5^s interval.		10^s interval.		Excess of time for make-circuits.		
		Makes.	Breaks.	Makes.	Breaks.	5^s	10^s	Diff.
		s.	*s.*	*s.*		*s.*	*s.*	
III. 1	Middle	20.920	20.796	21.010	20.935	—0.124	—0.075	+0.049
III. 2	Zinc	21.045	20.876	20.977	20.895	—0.169	—0.082	+0.087
III. 3	None...........	21.067	21.030	21.120	21.030	—0.037	—0.090	+0.053

It is thus manifest that in general a longer time was required for the transmission of signals after an interval of ten seconds than after an interval of five seconds. In those cases where no earth-connection existed, and the signals were alternately positive and negative, the cable was meanwhile resuming its electrical equilibrium, so that a positive signal was transmitted more rapidly through the conductor when it was affected with a larger amount of negative electricity, and a negative signal more rapidly through a conductor containing more positive electricity. This affords new testimony to the erroneous character of the supposition that the conductor must be charged through any portion of its length in order to transmit a signal beyond this portion.

As showing the continued existence of currents (doubtless engaged in re-establishing equilibrium) during the intervals between the signals, it may be of interest to mention that on one occasion, when the two cables had been joined at Heart's Content without battery, and while the Valencia battery had been temporarily disconnected, signals from Newfoundland were distinctly received. They were weak, and the deflections of the needle were scarcely one-fifth as large as usual, yet they were none the less distinct, and a complete set of signals, ten in number, at proper intervals and preceded by a "rattle," was recognized at Valencia. No other record of them was made than the fact of their transmission by alternation of the make-circuit and break-circuit signals, although no battery had been connected with the cable for several minutes.

On the 16th November I made a series of experiments at Valencia, for the purpose of ascertaining the effect of changes in the electromotive force upon the speed of the signals, and whether these signals could, by the interpolation of any resistance between them and the galvanometer, be made to traverse the double length of the cable before reaching the galvanometer at the same station. The results of these experiments may be very briefly stated, after mentioning some details regarding the signal-key, or commutator. The construction of this key was such that very little time was lost in pressing down either button, the interval being, as nearly as I could estimate, about one-seventieth of a second, or approximately $0^s.015$. All signals by which currents were sent were given in this way, but the break-circuit signals were given by removing the thumb from the button, which was then lifted by the tension of the spring. This tension being less than the force of the thumb when the button was pressed down, a longer time was consumed in traversing the distance between the stops, and for this repeated measurements give $0^s.035$ as a near approximation to the average interval. Now since, as already related, the ordinary signals record themselves upon the chronograph when the arm carrying the button leaves one stop, but are not really given until it reaches the other, all the recorded intervals between the instants of giving and receiving make-circuit signals will be too large by about $0^s.015$, while for break-circuit signals the reverse obtains, and the recorded interval will be too small by about $0^s.035$. Consequently, in comparisons between break-circuit signals and others, a correction must be applied, varying with the temporary adjustment of the signal-key, but amounting on the average at Valencia to not far from $0^s.05$. The importance of this connection will be recognized upon inspection of the results of the first four experiments of the following series. It has nevertheless not been applied to any of our results, inasmuch as during the exchanges between Valencia and Newfoundland no measurements or estimates were made to determine this "pass-time" for the Newfoundland key. It must of course be taken into account in any attempts to draw inferences regarding the relative velocity of break-circuit signals.

The signals in these experiments were given by Mr. Mosman and recorded by myself, using the circuit formed by the two cables without any other connections than the same key, galvanometer, and battery at Valencia which had been employed for the other work of the expedition. Care was of course taken that the signals should be neither seen nor heard by myself, except as indicated by the deflections of the galvanometer-needle.

Experiment.	Number.	Mean interval.
		s.
I. Four cells. Circuit made and broken; key between zincode and galvanometer:		
Make-circuits	11	0.257
Break-circuits	11	0.229
II. Four cells. The same, with 126 ohms resistance between key and galvanometer:		
Make-circuits	10	0.279
Break-circuits	9	0.227
III. Four cells. Key and galvanometer upon opposite sides of the battery:		
Make-circuits	13	0.278
Break-circuits	14	0.225
IV. Four cells. The same, with 126 ohms resistance between key and cable:		
Make-circuits	11	0.287
Break-circuits	11	0.220
V. One cell. Positive and negative signals:		
Positive	2	0.240
Negative	8	0.292
Both	10	0.282
(Here the moments for the positive signals were only recognized with difficulty, eight out of ten being lost. The battery power was insufficient to move the needle promptly, with the existing adjustment of its damping magnet. The difference in this respect between the two classes of signals was very marked, although they alternated at the prescribed intervals of five and ten seconds.)		
VI. Two cells. The same:		
Positive	10	0.249
Negative	9	0.242
Both	19	0.246

Experiment.	Number.	Mean interval.
		s.
VII. Four cells. The same:		
Positive	8	0.268
Negative	10	0.290
Both	18	0.279
VIII. Ten cells. The same:		
Positive	10	0.270
Negative	10	0.245
Both	20	0.258
IX. Ten cells. Resistance of 25 ohms interposed between key and galvanometer:		
Positive	10	0.254
Negative	10	0.258
Both	20	0.256
X. Ten cells. Resistance increased to 251 ohms:		
Positive	9	0.287
Negative	10	0.289
Both	19	0.288
XI. Ten cells. Resistance increased to 2,513 ohms:		
Positive	10	0.305
Negative	9	0.286
Both	19	0.296
XII. Ten cells. Resistance increased to 25,130 ohms:		
Positive	11	0.288
Negative	10	0.299
Both	21	0.293

From these experiments it may fairly be concluded—

1. That there was no real difference in the interval for the make-circuit and the break-circuit signals. The mean from the first four experiments gives, after application of the corrections for pass-time of the key, an interval of $0^s.261$ for the make-circuits and $0^s.260$ for the break-circuits.

2. That the relative positions of key, galvanometer, and battery exerted no perceptible influence upon the result when a battery of four cells was employed. The mean intervals from the first two and from the second two experiments are $0^s.258$ and $0^s.262$ respectively.

3. That no appreciable effect was produced by the interpolation of 126 ohms resistance. The mean intervals, with and without this resistance, were $0^s.258$ and $0^s.263$.

4. That no marked diminution of the interval was produced by an increase of the battery from two to ten cells. The results with one cell, although untrustworthy, indicate a somewhat less interval. The others vary by less than their probable errors, yet the interval was certainly not greater with two cells than with ten.

5. From the last three experiments it would appear that the interval was slightly longer after resistances above 250 ohms had been introduced. Yet it was no longer in the twelfth experiment, when the resistance between the key and galvanometer was more than two-thirds greater than the whole resistance of the two joined cables, than in the eleventh, when it was only one-sixth as great as that of the two cables.

6. We have every reason for believing that, in all these twelve experiments, the measures of the intervals were merely determinations of my own personal equation in noting signals, which, as has been shown in Section IX, had been found by special investigation to be about $0^s.275$. The variations from this value amount in but few cases to more than $\pm 0^s.03$, which we have seen to be the normal range.

7. These experiments are entirely confirmatory of what would have been anticipated from theory, viz: that a signal given by closing a galvanic circuit is transmitted in both directions simultaneously and with equal velocity under similar circumstances, so that under no ordinarily practicable circumstances could a signal from either station fail to traverse both parts of the circuit at that station before passing on to the other.

Since the investigations* in 1850 to which I have alluded, the progress of science has thrown light upon many points which were then subjects of doubt or of individual opinion. The condition of an open galvanic circuit is now almost universally conceded not to be essentially different from that of an interrupted conductor to an electrical machine. The velocity of a current is also known to be dependent upon its quantity, and therefore generally upon its intensity as well as upon the resistance of the conductor. But it appears questionable whether the law is so simple as has been supposed by some who have regarded the velocity as inversely proportional to the capacity of the conductor multiplied by its resistance, and therefore in a homogeneous conductor to the square of its length. For the problem, as it now presents itself, does not pertain so much to the time for transmission of a given signal, as to the time for its transmission with a certain force—depending on the sensitiveness of the receiving apparatus; since the electrical impulse or disturbance consists of a continuous series of molecular influences which propagate themselves in every possible direction according to the inverse ratio of their several resistances. And the form of the conductor as well as other conditions may essentially modify the time requisite for the attainment of the prescribed face at the other extremity of the line. A current may thus be temporarily established in part of an open circuit, continuing until the battery and conductors have attained an electrostatic equilibrium. The time required for attaining this equilibrium depends of course simply on the capacity and form of the conductors and on the energy of the battery; but the first electrical impulse may reach the most remote point of the circuit before a portion nearest to the battery has received its full charge. Similarly in a closed circuit the distant extremity of the line may well be supposed to perceive some slight electrical disturbance from a signal before its full force is manifested at intermediate points; so that a signal might be received with a delicate galvanometer at the further extremity before it could be recognized upon an electro-magnet at half the distance; and this, too, apart from any consideration of increasing intensity in the electromotor.

The circuit formed by the two cables might, although broken at Valencia, thus serve to establish what would practically be a momentary current at Newfoundland, when the battery at that station was introduced—deflecting the galvanometer there for an instant; and the change of statical condition in the cables at Valencia would thereupon be manifest to the electroscope. But the closure of circuit at Valencia would be accompanied by instantaneous deflection of the galvanometer with corresponding insensibility of the electroscope. Thus a signal given by closing or interrupting an insulated circuit at any point is instantaneously transmitted from that point in both directions, and at full speed, but the interval before it attains its total force at any other point must depend upon the character of the intervening conductor.

The question as to the route by which signals are transmitted when part of the circuit is formed by the earth is thus disposed of; and the position maintained in the memoir above cited seems entirely corroborated, while it loses its theoretical significance. Professor Kuhn in his learned and valuable Handbuch der Elektricitätslehre,† while doing the fullest justice to the former investigation in other respects, has taken exception to the propriety of my inferences regarding this question; but careful reconsideration has failed to convince me of any flaw in the argument, such as it is, notwithstanding my distrust of any reasoning from which so eminent a physicist would dissent.

Our experiments with the cables are inadequate for any decided deductions regarding the relative velocity when the earth forms a part of the circuit, but it may be well to examine for a moment what they appear to indicate.

The transmission-time for the several signals in our exchanges of November 10 and 16 may be approximately determined by a method different from those which we have thus far employed. Since the experiments occupied but a comparatively short time on each of these days, we may suppose the clock errors to have remained constant during each series. Then from those experiments in which no earth connection was made we may deduce the constant difference of the two clock-times; and a comparison of this quantity with the difference of clock-times as deducible from any set of signals will afford a near approximation to the actual time of transmission.

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* Proc. Amer. Assoc. Adv. Sci., 1850, p. 71; Am. Journ. Sci. XI, 1867, 154.

† Allgem. Encyklop. der Physik. Bd. XX, p. 494. Leipzig, 1866.

Thus we have from II 3 and IV 3, supposing the speed the same in each direction—

Date.	Signals.	Diff. of records.	Error of noting.	True interval.	Diff. of clocks.
		h. m. s.	s.	s.	h. m. s.
November 10	Valencia	2 52 20.790	−0.331	21.121	2 52 21.382
	Newfoundland.	21.917	−0.275	21.642	....
November 16	Valencia	21.184	−0.331	21.515	....
	Newfoundland.	22.266	−0.275	21.991	2 52 21.753

And adopting the values of the difference of clocks, we obtain as the transmission times:

Experiment.	Signals.	Pos. and neg.	Make-circuit.	Break-circuit.
		s.	s.	s.
I. 1	Valencia	0.202	....	....
	Newfoundland.	....	0.633	0.343
I. 2	Valencia	0.271	....	....
	Newfoundland.	....	0.636	0.383
I. 3	Valencia	0.301	....	....
	Newfoundland.	....	0.434	0.308
II. 1	Valencia	0.181	....	....
	Newfoundland.	0.308	....	....
II. 2	Valencia	0.279	....	....
	Newfoundland.	0.288	....	....
II. 3	Valencia	} 0.260	....	....
	Newfoundland.			
III. 1	Valencia	....	0.472	0.624
	Newfoundland.	0.267	....	....
III. 2	Valencia	....	0.420	0.592
	Newfoundland.	0.284	....	....
III. 3	Valencia	....	0.340	0.392
	Newfoundland.	0.252	....	....
IV. 1	Valencia	0.264	....	....
	Newfoundland.	0.332	....	....
IV. 2	Valencia	0.224	....	....
	Newfoundland.	0.262	....	....
IV. 3	Valencia	} 0.238	....	....
	Newfoundland.			

The experiments IV 2 and IV 3 differ only in that the return-circuit is formed by the earth in the former case, and by the second cable in the latter. The transmission time appears in both instances to be $0^s.24$. For the Newfoundland signals in experiments II 2 and II 3, the same difference exists, and the transmission time appears to be $0^s.28$ in the former and $0^s.26$ in the latter case. It would seem therefore that the velocity was but little, if any, affected by this great change in the character of the circuit, with a battery of four cells.

In the first and third series, the signals from one station were given by breaking and making circuit; but from the other, in the ordinary way by alternate currents, so that the second and third experiments of each series differed from one another by the tension of the zincodes having been destroyed in the former by an earth connection, leaving the tension to reach the cables from the platinodes only. The results give—

	Valencia. I.	Newfoundland. III.	Mean.
	s.	s.	s.
Experiment 2..	0.271	0.284	0.278
Experiment 3..	0.301	0.252	0.276

or an average transmission time of $0^s.28$ in each case.

In the first experiment of Series I and III, one-half the circuit was formed by the earth, while the cables had two cells at each end. In the second experiment of the Series IV, the earth formed one-half the circuit and the cables had four cells at the sending station. The results give—

	Valencia.	Newfoundland.	Mean.
	s.	s.	s.
I. 1. III. 1.	0. 202	0. 267	0. 234
IV. 2.	0. 224	0. 262	0. 243

The Valencia signals of Series I were made November 10; all the others were on November 16, without other difference of circumstances than those in the connections as described. No difference in the velocity appears to have been produced by the changed arrangement of the four cells which constituted the battery.

It is not without hesitation that I present the facts and inferences of this section, for I am not unaware of the careful and thorough quantitative investigations of Thomson, Jenkin, and others; and should of course shrink from publishing these relatively crude and very incomplete results, were it to be supposed that I regarded them as comparable with those obtained by these distinguished electricians. But the opportunity of adding some few facts to those heretofore established seemed worth improving; although it was with no special apparatus and was entirely collateral and subordinate to the astronomical purposes of the expedition. And furthermore the question has an especial interest for me, as having been among the first to demonstrate and measure nearly twenty years ago the transmission-time of the galvanic signals which had previously been assumed to be instantaneous.

The duration of our signal-currents was intended to be uniformly one-quarter of a second, but depended upon the skill and care of the observer, no automatic signal-giver having been employed. Every electrician knows how greatly the strength of the current is augmented by an increase of its duration from $0^s.2$ to $0^s.3$; yet the duration of the signals varied frequently through a larger range than this. Still the actual length of each signal is recorded upon the chronograph-register and its average did not vary much from the prescribed duration of $0^s.25$.

It appears manifest that not an electrical charge, or discharge, but simply an electrical disturbance is requisite for transmitting a signal; that an inductive impulse sufficient to deflect the galvanometers employed was transmitted through one cable, having at each end a condenser with ten cells, in somewhat less than the third of a second, five seconds after the transmission of an impulse of the opposite sort; that with a circuit formed by the two cables, a smaller electromotive force sufficed to transmit the signals with yet greater rapidity; that the signals traveled more rapidly through a cable which had not recovered its electrical equilibrium after a current of the opposite character; that the speed of the signals is modified by the earth connections more readily than by changes* in the battery power. And the very marked differences found in the rates of transmission between signals given by completing an interrupted circuit, and those given by interrupting a closed circuit, may perhaps lead to investigations which will afford an explanation.

* Jenkin (Phil. Trans. clii, 982) arrived at the conclusion that the electromotive force of the battery has no appreciable effect on the velocity with which the current is transmitted. But he would doubtless consider that certain qualifications to this general statement should be taken for granted.

APPENDIX No. 7.

REPORT UPON THE COMPARISON OF AN IRON METER FORWARDED TO FRANCE BY THE GOVERNMENT OF THE UNITED STATES OF AMERICA.

[Translation.]

Mr. Barnard, member of the Academy of Sciences of the United States of America, president of Columbia College and of the Mining School of New York, has presented an iron meter belonging to the Philosophical Society to the Conservatoire Impérial des Arts et Métiers, and has requested a comparison of this meter with the original platina standard in the possession of the Conservatoire, which is specially reserved for international verification.

General Morin, director of the Conservatoire, having acceded to his request, M. Tresca, engineer sub-director of this establishment, was directed to make the verifications, which, after several preparatory operations, were made on Saturday, August 24, 1867, in the presence and with the assistance of Mr. Barnard.

The United States meter was contained in a box of varnished oak, which, itself, was placed in a tin box soldered throughout.

The inner box being removed from this case, was only secured by four hooks, and bore upon its lid the following inscription: "AUTHENTIC IRON METER STANDARD BY THE COMMITTEE OF WEIGHTS AND MEASURES IN PARIS."

On the inside of the same lid is another inscription in pencil: "PHILOSOPHICAL SOCIETY."

The bar rested in the box upon four small pieces of cloth glued to the wood.

This meter consists of an iron bar filed and flattened on all its faces. Its width is $0^{m}.0275$, and its thickness $0^{m}.009$.

The two extremities retain the marks of the file, but they both appear to have been slightly oxidized.

The principal face bears three impressions of the stamp which was affixed to the platina meters and kilograms executed by the commission of the year VII. This stamp is an ellipse covered upon three-fourths of its surface with hachures; the remaining fourth is plain, and has near its edge the number 1.0000000, and the trace in dotted line of the mean radius. This last indication, which had not been previously observed, has since been found upon the other articles which bear the impression of the same stamp, and which belong to the Conservatoire Impérial des Arts et Métiers.

Two of these elliptical impressions are placed at $0^{m}.10$ and $0^{m}.12$ from one of the extremities of the bar, and the third at $0^{m}.10$ from the other end.

Upon one of the lateral faces and next to this last impression are three dots .·., which indicate, according to Mr. Barnard, that this meter is the one which was numbered 3 in the series of twelve entirely similar iron meters furnished, upon the institution of the metrical system, to the foreign commissioners.*

The comparison with the platina meter of the Conservatoire was made upon the so-called Silbermann (Jean Thiébauld) comparator constructed by M. Brunner after it was adjusted to a suitable height, in order that the two meters under comparison might be touched by the two abutting pieces (*palpeurs*) of the instrument exactly in the center of the figures of the end faces.

To secure perfect uniformity in the temperature at the moment of observation, the trough of the instrument was filled the evening before with ice, and the two meters to be compared allowed to remain in it. At 5^{h} 15^{m} before this operation, the Borda's bar, which forms the table of the instrument, read 145°.30, the temperature of the room being 24°.30 Cent. The next day, the 24th,

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* Following the indication of Mr. Barnard, this meter is the one which was remitted by the committee of the year VII to M. Tralles, representative of the Swiss republic. M. Tralles gave it to his countryman Mr. Hassler, who carried it to America in 1802 and presented it to the Philosophical Society of Philadelphia.

The survey of the coast having been organized in 1807 under the direction of Mr. Hassler, the meter was placed at his disposal by the society, and it has been preserved since then in the bureau of that service.

It has been adopted as the unit for all the geodetic operations which, since that date, have been executed in the United States, where it is considered as official.

at seven in the morning, the mercurial thermometer, plunged in the trough filled with water and ice, read 1°.40, and the reading of the Borda's bar was 103°.80. After sufficient agitation of the mixture this last indication rose to division 104.

The apparatus having been, as far as seemed necessary, resupplied with ice, and the objectives of the two microscopes being so adjusted that the two observers could make the coincidences perfectly well, the constancy of the temperature had to be continually sustained by the addition of fragments of ice, by drawing off a portion of the water from the bath, and by suitable agitation. While these precautions were being taken there were successively placed upon the table of the comparator: 1, the United States meter; 2, the original standard of the Conservatoire; 3, the United States meter.

The two standards remained always immersed in the bath, and the substitution of one for the other was made without sensible variation in the indication of the Borda's bar, which returned with great rapidity to the same number as soon as the substitution was effected.

The following tables show all the circumstances of the three series of observations.

1. *The United States meter upon the comparator.*

Time.	Temperature of both mercurial themometers.		Borda's bar.	Micrometer reading.
	Top.	Bottom.		
h. m.	°	°	°	°
2 38	0.50	1.25	103.82	329.90
8 44	0.50	1.25	103.79	329.65
8 49	0.50	1.25	103.78	331.00
8 55	0.75	1.50	103.77	328.80
9 03	0.75	1.50	103.78	329.15
9 07	0.80	1.50	103.78	329.20
9 15	0.50	1.30	103.76	329.15
9 24	0.50	1.25	103.74	328.30
9 30	0.50	1.00	103.72	329.80
9 36	0.50	1.10	103.74	329.60
Means....	....	....	103.77	329.455

2. *The Conservatoire standard upon the comparator.*

Time.	Temperature of both mercurial thermometers.		Borda's bar.	Micrometer reading.
	Top.	Bottom.		
h. m.	°	°	°	°
10 10	0.50	1.00	103.46	332.55
10 15	0.50	1.00	103.46	332.20
10 20	0.50	1.00	103.44	332.15
10 25	0.50	1.00	103.45	332.55
10 30	0.50	1.25	103.46	332.45
10 35	0.50	1.25	103.45	331.80
10 42	0.50	1.10	103.44	331.70
10 45	0.50	1.10	103.45	332.20
10 50	0.50	0.90	103.44	331.30
10 55	0.50	1.00	103.44	331.50
Means....	....	....	103.45	332.04

3. *The United States meter upon the comparator.*

Time.	Temperature of both mercurial thermometers.		Borda's bar.	Micrometer reading.
	Top.	Bottom.		
h. m.	°	°	°	°
11 30	0.40	0.40	103.20	335.75
11 35	0.40	0.50	103.20	334.90
11 40	0.40	0.50	103.20	334.50
11 44	0.40	0.40	103.21	334.70
11 50	0.40	0.40	103.19	334.20
11 55	0.40	0.40	103.19	335.45
12 08	0.50	0.50	103.18	334.50
12 14	0.40	0.50	103.17	334.85
12 18	0.40	0.50	103.17	334.00
12 21	0.40	0.50	103.17	334.80
Means....	....	....	103.19	334.765

The results of these three series of observations are as follows:

	Borda's bar.	Micrometer readings.
Standard of the Conservatoire:	°	°
Second series	103.45	332.04
United States meter:		
First series	103.77	329.455
Third series	103.19	334.765
Means..........................	103.48	332.11

From this follows:

1. That the mean temperature indicated by Borda's bar during the observations of the United States meter was identical with that shown during the observations of the standard.

The extreme readings of this bi-metallic bar were, on the 23d, at 5^h 15^m, 145°.30 for 24°.20
On the 24th .... 103°.45 for 0°.00

Differences .... 41°.85 for 24°.20

Each division of the rule therefore represents:

$$41°.85 : 24°.20 = 1°.75.$$

The extreme variations during the observations being comprised between 103°.82 and 103°.17, have never exceeded 0°.37; and this remark confirms the conclusion as to exactness which was drawn from the identity of the means.

The readings of the mercurial thermometer, plunged in the melting ice, were only noted as an accessory means of verification.

2. As the positive differences of the micrometer readings correspond to an increase in length, and each division represents one-thousandth of a millimeter, the United States meter is longer than the platina meter of the Conservatoire by 0^{mm}.000 07.

3. The official report of the 5th March, 1864, which establishes the difference between the original platina meter of the Conservatoire and the original meter of the archives, an exemplar of which is hereunto annexed, having shown that the meter of the Conservatoire des Arts et Métiers is too long by 0^{mm}.003 29, the value of the United States meter is determined to be 1^m.000 003 36 at the temperature of melting ice.

In consequence of the preceding verification, Messrs. Barnard and Tresca have been satisfied that this last number expresses the value of the United States meter. They replaced the meter in its boxes and signed this report of their operations.

Done at the Conservatoire in Paris this 30th of August, 1867.

F. A. P. BARNARD.
H. TRESCA.

PARIS, *September* 7, 1868.

A true copy.

Le Général de Division, membre du l'Institut, Directeur de Conservatoire Impérial des Arts et Métiers:

A. MORIN.

APPENDIX No. 8.

NEW MERIDIAN INSTRUMENT FOR TIME, LATITUDE, AND AZIMUTH, BY GEORGE DAVIDSON, ASSISTANT UNITED STATES COAST SURVEY.

In the geographical reconnaissances by the Coast Survey on the Pacific coast, for the determination of the latitude of numerous points and their difference of longitude from well established stations, accuracy and rapidity were especially demanded.

The instruments used were the 26-inch Wurdemann portable transit and the 45-inch zenith telescope, with a single observer and only one night for observation at each station, frequently landing through the surf at evening and returning to the vessel before morning. The transit was placed in the meridian, and observations for instrumental and clock corrections made therewith; the transit was then replaced by the zenith telescope for latitude observations, which generally embraced twelve pairs of stars.

In 1853 this duty led to the proposition to secure a fine level to one of the finders of the transit—to add a micrometer with vertical movement of the horizontal thread, so that after the completion of the transit observations the same instrument would be at once available for the latitude observations by the zenith telescope method. This involved the lifting of the telescope from its bearings after the observation upon the first star, and reversing the transit axis and directing the telescope to the same zenith distance on the opposite side of the zenith.

In January, 1858, drawings of such an instrument with additional novelties were made for the Superintendent of the Coast Survey, and are on file in the archives.

In the geographical reconnaissance along the coast of Alaska in 1867 the peculiarities of the climate proved that rapidity of adjustment and of observation were essential to success; and a study of the question led to the present form of instrument, whereby the zenith telescope is abandoned, as the new meridian instrument combines all the essentials of the transit and zenith instruments—affording means for the accurate determination of the instrumental and clock corrections, for the determination of the latitude by meridional zenith distances, and for the determination of the astronomical azimuth of a given mark by observations upon a close circumpolar star at any hour angle.

The main idea in this new form is that the horizontal frame of the transit stand is divided into two parts horizontally—that the upper part, for carrying the supports of the transit axis, moves on the lower part by means of a short but large central vertical axis; that the lower part carries the foot screws; that the two can be firmly clamped together directly over each other, or when making a moderately small angle with each other, (15° or 20°;) and that the ends of the frame are parts of the same circle with graduations upon the lower and a vernier upon the upper frame.

The vertical axis has an internal aperture of nearly three inches, by which collimations can be made with a trough of mercury beneath. One of the bearings has a movement in azimuth of two degrees with a finely graduated micrometer screw to measure the amount of movement.

The telescope has two finders, one larger than the other, and furnished with a delicate level for the latitude observations. It has also a fine micrometer capable of ready adjustment in the vertical or horizontal planes.

In order to measure the inclination of the transit axis when the telescope is pointing at or near the zenith, where the ordinary striding level is unavailable, a hanging level has been devised for that purpose.

The first advantage of the double frame is the greater rapidity with which the instrument can be adjusted in the plane of the meridian, or in the plane of the vertical of a close circumpolar star; for when once leveled no change of position of the lower frame is required, and repeated levelings after each approximation are avoided. The telescope, carried by the upper frame, is moved smoothly and rapidly in searching for the star, which, when found, is followed with regularity until within reach of the azimuth screw.

The two frames are then strongly clamped together by four large capstan-headed steel screws. After the transit observations are finished stops are adjusted between the upper and lower frames, by which the position of the meridian is readily found; the four clamping screws are relieved and the upper part of the frame is free to move upon the lower, and observations for latitude are at once commenced and observed in precisely the same manner as with the zenith telescope.

With telescopes of equal power this new form has an advantage over the best form of the zenith telescope in the stability of the support and the larger transit axis of the telescope.

For astronomical azimuths at the main stations of the triangulation the instrument affords peculiar advantages; and the observations may be made with the micrometer of the V support, or with that at the focus of the object glass.

To prevent wearing of the pivots of the transit axis by pressure upon the V's, and by the weight of the level, graduated springs will be secured to the uprights carrying the V's, and press upward on the under side of that part of the pivot which projects outside the V's; and a similar arrangement to the inverted V's of the level, by which means most of the weight will be borne on the outer ends of the pivots.

In the work of geographical reconnaissance the question of size, weight, and portability of the instruments used is an important one. The telescope must bear power to show the stars of the B. A. C. with fair illumination. It has been found that the Wurdemann portable transit with a telescope of twenty-six inches focus will show fairly stars of the sixth magnitude and stand a power of sixty-five. The Troughton & Simm's zenith telescope of forty-five inches focal length sometimes failed to show stars marked of the seventh magnitude, although this has rarely been the case on the Pacific Coast. It was decided to try a telescope of thirty to thirty-two inches focal length, and the stand proportioned thereto. The telescope of the new instrument has a focal length of thirty-one inches, with an object glass of two-and-a-half inches diameter, and gives good definition with a power of ninety.

The drawings and a model of the instrument were made by Mr. Davidson and submitted to the criticism of Messrs. Hilgard, Patterson, Schott, and Wurdemann, of the Coast Survey, and recommended. Although pressed for time to have one ready for the Coast Survey Solar Eclipse Expedition to Alaska, Mr. Wurdemann has finished the instrument with his usual skill and ingenuity of detail. It has been practically tested by Assistant A. T. Mosman at the Coast Survey station at Staunton, Virginia, under very disadvantageous circumstances, and has fulfilled all that was predicted for it.

APPENDIX No. 9.

ON THE USE OF RAILWAYS FOR GEODETIC SURVEYS BY J. E. HILGARD, ASSISTANT IN THE COAST SURVEY.

For a survey of an extended area of the earth's surface, the trigonometrical method has hitherto been the only one practiced with success, and indeed is the only one which it has been possible to apply with the desired precision. In a country with irregular surface traversed by ranges of hills, the lineal measurement of distances is, if not altogether impracticable, at least attended with a great sacrifice of time, money, and precision, while the trigonometrical method is facilitated by the inequalities of the ground. When the heights are wooded, but little clearing is generally required to make the stations intervisible, and in long-settled countries very little difficulty has been met with from its obstruction of forests, because the arable land has long been cleared. Even over the extensive open plains of Russia and India, triangulations have been carried by means of elevated structures in preference to lineal measurement, which, without special preparation of the ground, would have been slow and tedious.

When, however, a flat country, covered in good part with dense forest, is to be surveyed, the trigonometrical method is attended with great difficulties. In addition to structures sufficiently high to overcome the inequalities of the ground and the curvature of the earth, lines of sight require to be opened through the woods, and the work of the axeman becomes a serious item of expenditure. On the coast-line of the United States long lines of sea-beach occur, closely bordered in-shore by dense forest, often growing out of impassable swamps, through which the opening of lines is nearly impracticable. In such cases the method of direct lineal measurement has been resorted to with good success. The distances were measured with the apparatus described in the Coast Survey Report for 1857, (Appendix No. 45,) between points as far apart as the configuration of the shore would permit; the angles between successive lines were measured with a theodolite, and the directions carried forward by measurement of angles between points as far distant as they could be made intervisible. In the measuring apparatus as described, bars of four meters in length were used; but it has since been found in practice that bars, six meters long, can be manipulated with sufficient ease, and by their use the work is proportionally expedited. Still, the measurement with rods is at best a slow process, compared with the rapidity with which it may be effected by a wheel provided with a register of revolutions.

For reconnaissances, the wheel of a wagon has been extensively used; for more accurate mapping, that of a wheelbarrow, more or less equipped with means for recording the changes of direction and level. But, for works comparable in precision with the results of triangulation, it is requisite that the wheel should run on a smooth, unyielding track, and that there should not be frequent changes of direction, which, when they do occur, must be kept account of with all practicable accuracy. The iron track of railways affords the necessary conditions for the successful use of the measuring-wheel, while, by a natural sequence, the roads have straight lines of considerable length and few curves in regions where the absence of hills renders the use of the trigonometrical method difficult.

In many of the States of the Union that lie west of the Allegheny Mountains, the execution of a trigonometrical survey, as a basis for a correct map of the country, would be a hopeless undertaking in the present state of its cultivation. But a careful measurement of the railway lines traversing it in every direction, according to the methods which it is here proposed to develop, would afford a network not inferior in accuracy, and well calculated to furnish valuable additions to our knowledge of the figure of the earth if a proper system of determinations of latitude and longitude were combined with it.

Irrespective of the object of obtaining data for a correct map of the country, the methods here proposed are especially adapted to the measurement of arcs of parallels or meridians—geodetic work properly speaking—a matter in which we are, as a people, greatly in arrears to the demands of modern civilization. While in all nations of Europe eager efforts are making to ascertain the dimensions and configuration of our globe, America is doing nothing in the common cause except what the survey of the coast and of the lakes incidentally accomplish. Some of the railways running north and south in the valley of the Mississippi, and others traversing it in an east and west direction, are admirably adapted for the ascertainment of such data. No more valuable and permanent additions to science could be made by associations desiring to contribute something to the sum of human knowledge than the admeasurement of such arcs—no mode of connecting his name with the history of the human race deserves more the attention of a Mæcenas.

The writer would by no means be understood as advocating the methods he submits in preference to that of triangulation where that is readily practicable. On the contrary, they are to be considered as only supplementary to the latter, which should always be used when the ground is favorable, and which, as will be seen, forms a necessary part of the scheme.

It will not be out of place to mention here that the details have been designed with special reference to a measurement across the neck of the Florida Peninsula, from the point where the triangulation at present terminates to the Cedar Keys, and from the same point to Tallahassee and St. Mark's, whence the triangulation of the coast extends westward—the object being to check the long coast-line triangulation all around the peninsula, and to add to the triangulation of the western Gulf coast the link which will give the length of an arc of the parallel of thirteen degrees extending from Fernandina to Galveston.

The proposed plan comes under two principal heads, the lineal measurement of distances on the line of railway, and the angular measurements for rectifying the line and carrying forward the directions. These will be separately considered.

Lineal measurement.—The measurement by means of a wheel is extremely accurate, when the surface on which it rolls is even, and the wheel is guided straight. In fact, the precision with which the same measurement can be repeated in experiments on a small scale, with well finished surfaces, leaves nothing to be desired. The irregularities of a railway track and the want of perfectly true guidance of the wheel will occasion small errors, the average amount of which, from experiments made, is estimated at two-tenths of a millimeter in 120 meters. This uncertainty, it will be observed, does not increase in the same ratio with the distance measured, as does the error of a base-line where triangulation is used, but being as likely to be in defect as in excess, it will increase in a lower ratio (theoretically in that of the square roots of the distances) by virtue of the compensation of errors. It may fairly be assumed that a mile can be measured within two millimeters, a degree of precision fully equal to that obtained by the most perfect bar apparatus hitherto in use.

In the apparatus designed for this work, the measuring wheel has a circumference of three meters, and is drawn along the track by being attached to the rear of an ordinary four-wheeled hand-car, which serves at the same time for the transportation of the surveying party. The wheel is of bell metal (bronze) cast in one piece; its axle, twelve inches in length, is fixed to it, and runs between conical centers, which are supported by two branches of an arm extending from a strong bar held in journals across the rear of the car. In this way the wheel can promptly rise and fall with the vertical inequalities of the track, while the four-wheeled truck of the car guides it very nearly in the true line. It can be readily detached when not in use. The rim of the wheel is three-quarters of an inch thick, and is rounded on the outside so that its tread is quite narrow. It is protected from the sun by a casing of bright tin, in which is likewise inclosed the bulb of a thermometer. The counting apparatus is simple, registering on a dial the revolutions up to one thousand. It is not necessary to describe the mechanical parts of the apparatus more in detail, as a further experience in practice will doubtless lead to modifications and adaptations which may be hereafter embodied in a full description.

The index line, from which the revolutions are counted, is drawn on a plate let in the side of the wheel so as very nearly to touch the track; a spirit-level attached at right angles to it secures the exact completion of entire revolutions. The line can be transferred to the track by means of a square, or better by means of a prismatic mirror attached to the index plate. The adjustment of the precise revolutions is accomplished without moving the car, by means of a fine screw in the connecting arm. The measurement of odd distances, less than a full revolution, is not provided for by a graduation on the wheel, being very readily performed by means of a beam compass and scale.

The lineal value of a complete revolution is best ascertained by repeatedly rolling the wheel over a very accurately measured distance of at least one hundred times its girth, on a good average railway track. As a practical result a value thus obtained would probably be more reliable than one obtained by experiments on a more limited scale, which on the other hand might be more readily executed. For an assumed circumference of three meters, the comparison of two revolutions with the six-meter standard would be convenient and readily performed. It is of course necessary to secure the terminal points of such a base-line by works that are quite independent of the track, and to which the wheel-measurement can be referred.

This base-line will equally serve for ascertaining the proper temperature correction, by making the measurement with the wheel at different degrees of heat. Special attention is given to making the thickness and diameter of the bulb of the attached thermometer such that in the same exposure to dark heat it will acquire temperature at the same rate as the wheel. It does not appear very difficult, after a few experiments, to effect this condition within the limits required for sufficient precision of the temperature correction. The average temperature indicated should not differ from the actual average temperature of the wheel by more than 1° Fahrenheit, which will insure the accuracy of the correction for temperature within one hundred-thousandth part of the distance measured. The plan of using such a thermometer has been preferred to that of employing a second wheel of different metal, and inferring the required reduction from the difference in the measured distances, because it would be equally difficult to secure the isochronic heating of the two wheels, and because there is but little difference in the expansibility of the harder metals which alone could be employed.

As part of the lineal measurement we must treat the transfer of the marks obtained on the track to points secured in the ground where they will not be disturbed by the passage of trains. Here we begin to encounter the difficulties of our method, and at once lose the extreme accuracy with which we commenced the operations. If it were always convenient to place the mark, at a near distance off, at right angles to the track, it would be easy to provide the requisite means by some optical attachments to the wheel, which have in part been designed. But in general that will not be practicable, and it may often be necessary to make the mark at the distance of a few rods, up an excavation or down an embankment, and the plan adopted therefore is to center a theodolite over the mark on the track, for which purpose the stand is provided with sliding plates and a vertical collimator, to measure the angle between the direction of the track and that of the permanent mark, and to ascertain its distance either by measurement with the beam-compass or by an intersection from another point on the track, one or more revolutions distant from the former one. Fig. 1, Sketch No. 26, illustrates a case where at the terminus a of the right-line track a to b the transfer to the side-point a' is made by laying off at a a right angle and placing a' at the measured distance of three meters, the ground being level; while at the other end the mark b' was established at a convenient point on an elevation, and its position relative to b ascertained by measuring the angle at that point and at another c, fifteen meters distant from it. The method of deducing the length of $a' b'$ from $a b$ by means of these data is too simple to require explanation here.

The measured line follows the grades of the railway, and must of course be reduced to a horizontal plane. In general the grades will be obtained with sufficient exactness from the engineers of the road; when that source of information fails, the levels must be taken, which can be done rapidly, as no great precision is requisite.

Rectification of curves.—The best way to deal with curves, when practicable, is doubtless to continue the longest straight lines to their points of intersection, and measure the distances from the points where the lines leave the track, by some convenient mode possessing sufficient precision. For this purpose the measuring apparatus mentioned in the beginning of this paper is very suitable; but another means of sufficient exactness and quicker application will be found in Paine's steel tapes, which should here be used by stretching them over tripod stands, provided on the top with a piece of soft wood about an inch wide. The steel tapes, when arranged for this use, have at each end an additional length of one foot beyond the marks between which the measure is continued, to bring the hand of the person starting them clear of the stand; a needle point inserted into a small handle is stuck into the top of the stand, by the mark on the band or tape. A simple sight movable vertically, with a spirit-level and graduated arc attached to each stand, serves to note the *inclination to the horizon.* The measuring tapes actually used in this way were twelve meters long, and yielded excellent results; they could with advantage have a length of sixteen meters. No special skill is required to set up a tripod in the required place with sufficient approximation after first sticking an ordinary chaining-pin into the ground at the proper distance.

The method of measuring the tangents *ac* and *bc* to the point of intersection *c*, is illustrated in Fig. 2. The only angular measurement requisite in that case is that of the angle at *c*, between the two tangents, which must of course be that subtended between the points *p* and *q*, marked near their further extremities. It will frequently be more readily practicable to measure the chord *ab*, since some natural obstruction, a hill or a stream, will have given occasion for the curve in the road. In such case we must measure the angles at *a* and *b*, between the chord and the adjacent tangent; and since *ab* is a comparatively short line, great care must be taken in the centering of the theodolite and mark, in order to preserve the requisite precision in carrying forward the direction. It is best to have several similar tripods, on which the theodolite and targets may be mounted in a like manner, so as to be interchanged while the tripods remain in position, which will secure the identity of the points occupied and observed upon.

If we could rely upon the uniform curvature of the track, it would be advisable to dispense with the direct measurement of the chord, and to derive it from the length of the arc measured with the wheel, by computing the ratio of the chord to the arc from the angle subtended at the center, which is the sum of the angles *abc* and *cab*. It is probable that when the whole change in direction does not exceed fifteen degrees, this plan may be resorted to without sensible errors, as small deviations from a uniform circular curve would not materially affect the length of the chord. The inferred value of the latter may be rendered more certain by measuring the offset *d e* from the middle of the arc to the chord, and making the reduction for a parabolic arc, if *d e* is found not to have very nearly the value of the versed sine of half the arc. But when we cannot measure either the tangents or the chord directly, it will in general be preferable to adopt the plan illustrated in Fig. 3; where we resort to triangulation, using a portion of each tangent *a′a* and *b′b* as base-lines from which to fix the position of a point *c*, in reference to *a* and *b*, and obtain the means of carrying forward our system of distances and angles. It is needless to say that if the direction *a b* can be included in the angular measurements, the work will be greatly strengthened thereby.

When a common point *c* cannot be found visible from both tangents, it may be necessary to introduce one or more intermediate triangles, as in Fig. 4, drawn to illustrate the case of a reversed curve.

It will not infrequently happen that a line of road which in its general character is well adapted to this mode of survey crosses uneven ridges of country, when many curves are introduced and deep cuttings cramp the proposed operations. In such cases the lineal measurement should be abandoned and triangulation resorted to for crossing the more difficult country, the measured tangents affording ready base-lines for the work.

Reduction of the measured lines and angles to a simpler system.—When the operations performed involve smaller links than distances of three or four miles, it is desirable to straighten out the work by reducing to one common line all the shorter distances of which it is composed, and by measuring the angles between such successive *guide-lines*, as we will call them, to carry forward the directions independent of the many angles that have entered into the framework of the original measurement. We give an illustration in Fig. 5, showing a line of road of rather unfavorable conditions, drawn to a scale of two inches to the mile. The points on the line are numbered in succession; the distance 1–2 has been obtained by triangulation from the base 2–3, by which the position of A is at the same time determined; 3–4 has been measured directly with the steel tape; 6–6′ is obtained from 5–6, and 6′–7 from 7–8 by triangulation, as shown; between 9 and 10 the tangents have been measured directly to 9′; the chords 11–12 and 12–13 have been derived from the measured arcs and offsets, and finally B is determined from the base 14–15. The lengths of all the right lines along the track have been ascertained with the wheel, and all the angles in the scheme have been measured with the theodolite, including at A and B the angles between the line joining them and the next indivisible distant points Z and C. The broken line A–3–4–5–6′–7–9′–11–12–13–14–B is now reduced to the line A B by multiplying each link with the cosine of the angle which it makes with that line, and taking the sum of the products. We thus obtain the distance A B and its direction with reference to adjacent lines.

The example chosen is purposely an unfavorable one, involving a good deal of work on a short distance, and it may be readily admitted that if the country were moderately open, the same result could better be attained by the ordinary mode of triangulation. But the work detailed can be done by a small force, in almost any condition of the atmosphere, and is not comparable to the felling of a thousand trees required to open lines of sight for a triangulation. Under the conditions predicated for the method in the introductory remarks, the writer is confident that it proves a valuable addition to our methods of geodesy.

No small saving of time and expenditure will be found to result from its convenience of transporting the surveying party, its material and supplies, either by ordinary trains on the road, or on a light truck used as a tender, and attached to the hand-car. The tender will carry, besides tents and camp equipage, a portable tripod and scaffold for observing with the theodolite from an elevation of twenty feet, which is an almost indispensable means of overcoming the minor inequalities of the ground when measuring the angles between stations separated by greater distances.

A careful reconnaissance of the line of road should of course precede any actual survey, in order that the methods to be applied at each particular turn may be known and provided for.

APPENDIX No. 10.

DESCRIPTION OF A REFLECTOR USED AS A SIGNAL IN TRIANGULATION, DESIGNED BY J. E. HILGARD, ASSISTANT UNITED STATES COAST SURVEY.

The most effective signal used for making stations visible at long distances is the heliotrope, which penetrates the haze whenever the outlines of the distant hills have disappeared. The usual form of it is figured in the Coast Survey report for 1866, Plate No. 27. The heliostat, or heliotrope moved by clock-work, is not used, because it requires more careful handling, and its use would not dispense with the services of an attendant, who can equally well be employed in directing the heliotrope. The employment of the heliotrope is on that account expensive, and in remote localities, on the tops of high mountains, it is often difficult to subsist the attendant, and the employment of an additional hand is necessary. On the mountains in California this difficulty is sometimes a very serious obstacle to the use of an otherwise desirable point. The employment of the tin cone or conoid is limited to moderate distances, as the reflection from the tin soon becomes dimmed by exposure to the weather.

The brilliant reflection from the glass globes silvered on the inside by Liebig's method suggested their employment, since such a hemisphere would, for all positions of the sun, throw a reflection to nearly every point in the horizon; but it was found that the image, although very brilliant, was too small in diameter to be readily seen, and in fact was lost, as the light of the stars is lost in the day-time. Owing to the perfect figure of the globe the reflected image of the sun occupies not much more than half a degree of its surface, and it would require a hemisphere of six or eight feet diameter to give a sufficiently large image.

The idea then occurred to me to arrange in parallel rows a series of glass tubes silvered on the inside, bent in an arc of a circle of large diameter, so as to have a curvature of about 24°, and placed with the upper part in a vertical position, as may be better understood by inspecting the illustration on Sketch No. 26. Each of these tubes sends to the horizon in every direction, within a range of 120°, a line of light about an inch in length, which appears near the top when the sun is in the horizon, and gradually travels downward as the sun rises, and at the same time moving across the tube as it changes its azimuth, until the reflection is lost at the bottom when the sun has reached an altitude of twice the curvature of the tube, or about 44°, at which time the heat of the day generally renders observing impracticable. The joint effect of nine of these brilliant lines, distributed over a breadth of six inches, is much the same as if a less intense reflection were evenly diffused over the same surface, and is readily seen for a great distance.

In using these reflectors, two or more faces as described may be set up on a common base, arranged either in regular polygonal order, or, better, so disposed as to give the most advantageous reflections in the directions from which it is to be observed. Several of these reflectors have been used in the field and found to answer their purpose very well.

Their construction is comparatively inexpensive. The tubes are bent into the required form as they are drawn at the glass works, by being curved around a wooden disk of eight feet diameter. It is not necessary that they should be very nearly of the same diameter; those of a half inch internal and three-quarters inch external diameter have been found to answer best. It will not do to have the bore too small, as it is difficult to fill them with the silvering liquids, and they do not contain a sufficient quantity of it to deposit a dense coat of silver. The silvering is effected with facility by the known methods, and presents a very perfect appearance, as the interior of the tubes is fire-clean. The tubes are arranged in simple wooden frames, and secured in position with putty or plaster.

APPENDIX No. 11.

REPORT ON THE FIELD AND OFFICE WORK RELATING TO THE TIDES.

COAST SURVEY OFFICE, *November* 1, 1867.

DEAR SIR: I have the honor to submit the following report on the field and office work performed during the past year by the Tidal Division, now under my charge.

Field-work.—The stations occupied during the past year to make tidal observations for general purposes have been as follows, viz: Owl's Head, Maine; Portland, Maine; Boston, Massachusetts; New York; Old Point Comfort, Virginia; Dry Tortugas, Florida; San Diego and San Francisco, California; and Astoria, Oregon. At most of these stations observations have been kept up for many years, and should be continued long enough to satisfy the conditions requisite for deducing from them the general laws of the tides. Tidal observations have been made at various other places by observers directly connected with hydrographic parties and for their special use, consequently they are generally of short continuance and not reported directly to this division or under its charge. The station at Owl's Head was occupied for the first time on the 17th of July, 1867, and seems to be a very good one. Observations at Portland were discontinued the 1st of November, 1866, and the gauge, after undergoing repairs, moved to Owl's Head. A new series of observations was commenced at the Boston navy yard, with an improved form of Saxton's self-registering tide-gauge, on the 15th of August, 1867, and it will, no doubt, yield results of great importance in relation to the improvements going on in the harbor. If continued long enough, it will be of great interest, too, in a scientific point of view, especially when taken in connection with the previous observations made there.

The observations at Governor's Island and Old Point Comfort have been continued regularly, with the exception of rather serious stoppages by ice, last winter, when the gauge at the former place was frozen up for nearly half a month, and at the latter several days, and the observers had to resort to other means. It is very desirable to prevent, if possible, the recurrence of such stoppages.

Tortugas was occupied several years ago, and used as a station with which to compare others, while a regular series of observations was being made at sets of stations successively occupied along the Florida reefs and the whole northern coast of the Gulf of Mexico, for the general purpose of investigating the anomalies of the tides on that coast. Unfortunately that plan had to be abandoned before the series was finished; but it is to be hoped that it can be resumed and completed soon.

The observations on the western coast have continued to be entirely satisfactory. They are all in charge of the same observers as heretofore, under the supervision of Major G. H. Elliot, of the Corps of Engineers, United States Army. At all these stations the observations have been of excellent character, and the great experience and tried fidelity of the observers give assurance that all that can be accomplished with the instruments in their keeping, will be done.

It is generally to be desired that as soon as it can be properly done, tidal observations be made at a few well-selected stations along the coast farther to the northwest, recently purchased from Russia. Such observations seem to be necessary for clearing up the anomalies which have been observed on the shores of Washington Territory, and the investigation of the cotidal lines on the Pacific coast cannot be completed without them.

It is well to commence the hydrographic survey of a coast by the observation of tides, if it is practicable, since the soundings cannot be exactly laid down on charts without them, and it may happen that the tidal data are quite insufficient for determining the correct plane of reference. If the whole work is based on the tidal observations at the principal points for an entire year, it may be presumed to be good.

Captain A. C. Mitchell is observing tides on the coast of New Jersey in connection with the erection of permanent bench-marks. It is hoped that this work, besides its great importance in the survey of the coast, will eventually contribute to the settlement of some very interesting hydrographic and geological queries which have engaged the attention of scientific men. Captain Mitchell had previously put up the tide-gauges at Owl's Head and Boston.

The following table gives, briefly, a recapitulation of the observations received at the office between October 1, 1866, and November 1, 1867, exclusive of those made by the hydrographic parties primarily for their own use in reducing soundings.

Section.	Name of station.	Name of observer.	Kind of gauge.	Station, permanent or temporary.	Time of occupation.		Total days.
					From—	To—	
I.	Owl's Head, Maine	G. D. Wooster	S. R.	Perm	July 17, 1867	Oct. 31, 1867	107
	Portland, Maine	W. R. Wood	S. R.	Temp	Oct. 1, 1866	Nov. 1, 1866	32
	Boston navy yard	C. Levin, H. Howland	S. R.	Perm	Aug. 15, 1867	Oct. 31, 1867	78
II.	Governor's Island, New York	R. T. Bassett	S. R.	Perm	Oct. 1, 1866	Oct. 31, 1867	396
	Brooklyn, New York	R. T. Bassett	Box	Perm	Oct. 1, 1866	Oct. 31, 1867	396
III.	Old Point Comfort, Virginia	E. F. Krebs	S. R.	Perm	Oct. 1, 1866	Oct. 31, 1867	396
VI.	Dry Tortugas, Florida	H. Benners	S. R.	Temp	Jan. 8, 1867	April 1, 1867	84
X.	San Diego, California	A. Cassidy	S. R.	Perm	Oct. 1, 1867	Oct. 31, 1867	396
	San Francisco, California	H. E. Uhrlandt	S. R.	Perm	Oct. 1, 1867	Oct. 31, 1867	396
XI.	Astoria, Oregon	L. Wilson	S. R.	Perm	Oct. 1, 1867	Oct. 31, 1867	396

NOTE.—The observations at Brooklyn are of day tides, for comparison with those at Governor's Island. Mr. Levin resigned, and Mr. Howland succeeded on the 3d of October.

Office-work.—The ordinary tabulation of the readings from the tide-rolls and reductions of the tidal observations have been made as far as more pressing duties permitted. But these branches of work had to be for the most part postponed during the preparation of the tide-tables. An effort is now being made to bring them up, as it is desirable that they should be executed as soon as possible after the observations are received. All calls for information relative to tides, whether made by other divisions of the office, by field parties, or others not connected with the survey, have been met as speedily as was practicable. The tide-tables giving the predictions for 1867 were completed and published in December last, and those for 1868 have just been finished and printed. These tables give the times and heights of the high waters for about twenty of the principal ports of the United States, and of the low waters for such of them as have large diurnal inequality. Tables of constants are also given, for finding from the above the times and heights for a great number of other places of most interest to navigators. The great demand for these tables is regarded as sufficient evidence of their utility.

Some attention has been given to the discussion of the long series of observations made at Boston. One section of that work was so far matured that its results were used in making the predictions for 1868. A good deal of preparation of data and materials has been made for extending this and other similar discussions, which must soon be demanded.

The persons employed in this division the past year were R. S. Avery, J. Downes, J. Sprandel, D. Schooley, A. Gottheil, M. Thomas, and F. R. Pendleton.

Mr. R. S. Avery continued in charge of the computations made in the division and of the field-work, excepting for a few months, during which Mr. Pourtales resumed the general supervision of the latter. Mr. Pourtales was also frequently consulted with regard to the most important matters. Mr. Avery also inspected the observations as they arrived at the office, and gave much attention to the discussions on which the predictions in the tide-tables are based.

Mr. John Downes was mostly engaged in tabulating and reducing the readings from the self-registering tide-rolls. He assisted also in some discussions, and in computing the tide-tables for 1868.

Mr. J. Sprandel aided in computing the tide-tables for 1867 and in preparing data therefor, and in miscellaneous work. On the 17th of January, 1867, he was transferred to the Hydrographic Division.

Mr. D. Schooley was engaged in computing the tide-tables for 1867, and in preparing data therefor. He resigned on the 22d of November, 1866, to become a captain in the regular army.

Mr. A. Gottheil aided in checking the reductions of the Boston observations and in the general discussion of them. He also made reductions, and assisted in computing the tide-tables for 1868. He joined the division on the 14th of January, 1867.

M. Thomas was chiefly engaged in copying the readings of tide-gauges for preservation in the archives, and in miscellaneous copying and reducing.

F. R. Pendleton resigned on the 30th of April, 1867, and continued till then the ordinary reductions of the western coast tidal observations.

Very respectfully submitted by

R. S. AVERY,
In charge of the Tidal Division.

Prof. BENJAMIN PEIRCE,
Superintendent of the United States Coast Survey.

APPENDIX No. 12.

REPORT OF ASSISTANT HENRY L. WHITING, ON THE SPECIAL SURVEY OF PROVINCETOWN HARBOR, MASSACHUSETTS.

PROVINCETOWN, CAPE COD, MASS., *December*, 1867.

DEAR SIR: The occasion for the recent call from the commissioners, upon the Coast Survey, for a special survey of Cape Cod Harbor, was to secure its results as a basis for the special duties imposed upon them by the act of the legislature establishing their commission.

The purpose of the survey desired is stated in the letter of the commissioners.

The first survey of the harbor was executed by Major J. D. Graham, United States Topographical Engineers, by order of Lieutenant Colonel J. J. Abert, Chief of Topographical Engineers, for the purpose of a military and hydrographical chart of Cape Cod Harbor.

The full and detailed report of Major Graham, together with his accompanying chart, establishes this survey as a standard of the first order. The triangulation and details of topography and hydrography were accurately and elaborately executed. The field-work extended through three seasons, and was completed in 1835. This is the first reliable survey, covering the ground now under consideration, and the lapse of time since it was made, makes a comparison with its results of greater value than any of which we have knowledge or possession.

In 1848, the topographical survey of Cape Cod, from Eastham to Provincetown, was ordered by the Superintendent of the Coast Survey, and executed by the party under my charge. The extremity of the Cape,—Provincetown and that part of Truro embraced in Major Graham's survey—was surveyed by myself, in person. The importance of Cape Cod Harbor, and the complex nature of this section of the cape as a subject for survey, necessitated close and accurate work, which was done, in the approved mode of the standard topography of the Coast Survey, and affords important intermediate comparison of features above the water line.

The hydrography of the Coast Survey was executed, in 1856, by Commander H. S. Stellwagen, United States Navy, assistant. This branch of the survey is for the general purposes of navigation, and, in view of the great water area to be gone over, does not and cannot develop local details with the minuteness of a special survey like that of Major Graham, unless such a survey is so ordered. At the time the hydrography of the Coast Survey was executed, the questions now under consideration were not anticipated. The comparison, therefore, of this survey of Commander Stellwagen's with that of Major Graham's and the one I have just completed, can only cover general, and not particular features.

In 1857, at the request and in behalf of a former State commission, I made, by order of the Superintendent of the Coast Survey, a resurvey of the outlines of the extremity of the cape, embracing the ground of my former survey of 1848, and including the localities now under consideration; but no hydrography was executed at this time.

This survey was based upon the same trigonometrical and topographical points of the former survey, and showed important and extensive local changes to have occurred during the intervening time.

In the spring of 1867, another survey, mainly hydrographic, was made for the board of State harbor commissioners, by A. Boschke, esq., civil engineer. This survey was, again, for a special but different purpose—the location of a harbor line for the limit of wharf structures—and did not, in its case, cover the ground or develop the physical details in question.

The means, therefore, of accurate and minute comparison had not yet been obtained. To procure this end, the present board of commissioners, for the protection and preservation of this important harbor, made their call for the special survey I have just completed under your order.

This survey has been executed in the most accurate and detailed manner, with the knowledge of the value and bearing of such results, only, as were correct. Data of projections and triangulation points have been furnished from the office of the Coast Survey. The field-work is all based upon triangulation and plane-table points. The outlines of high and low water, and some interior details, have been topographically surveyed.

The hydrography has been executed with special accuracy and detail. A series of water-signals along the low water and one-fathom lines, and a series of flag buoys along the five-fathom line, have been determined by shore observations. From these points the sounding-lines have radiated, ranged, and crossed, so as to give a full development of the contour of the bottom. Depths under three fathoms have been measured with a sounding-pole, to feet and tenths; over that depth, with a sounding-line, tested, and corrected for shrinkage and other error, and the depths recorded in fathoms and feet. The tidal observations have been continued through four lunations. Tide-gauges were located in the center of the harbor; at the steamboat wharf; at the inlet of East Harbor; at the center of East Harbor Lagoon; opposite this last position, in the outside harbor; at the head of the meadows, in East Harbor Creek; opposite this last point the tide was observed at high water, without a gauge, on the outer Atlantic side of the beach. Accurate levels have been taken by Hiram F. Mills, esq., civil engineer, referring the outside ocean to the wafers of East Harbor Creek at the head of the meadows, and showing the elevation and extent of the sand beach between them. The tide-gauge at the head of the meadows is referred to the tide-gauge inside the lagoon; this latter gauge, to the gauge in the outside harbor opposite, and to the gauge at the inlet. The tide-gauges at the inlet and at the steamboat wharf have also been referred to permanent local beach marks.

I will here state that, in addition to the charts and plans of my own survey, I have received from the United States Engineer Bureau at Washington, through the favor of General A. A. Humphreys, chief of the corps, a large-scale map, copied from the *original sheets* of Major Graham's survey, showing the high water and low water lines of Cape Cod Harbor and of East Harbor Lagoon, and the one, two, three, four, and five fathom curves. The trigonometrical and topographical points of Major Graham's survey are given on this map, and afford a perfect base for bringing this survey to the same scale and base of the Coast Survey, giving a comparison of every position and detail feature with perfect accuracy.

I have, also, received from the State harbor commission, through the attention of their engineer, A. Boschke, esq., extracts, on vellum, from his large-scale hydrographic chart, and a map reduced to $\frac{1}{10000}$, the scale of the Coast Surveys.

From the Coast Survey office I am furnished with a re-plotting, from original notes, of the hydrographical survey of Commander Stellwagen, also upon the scale of $\frac{1}{10000}$.

Through the kindness of General H. A. Benham, I have had the loan, from him, of maps and tracings of Cape Cod Harbor, made for his use; also, of manuscript and printed reports of the former commissions and boards of engineers who have examined and reported upon the physical condition of Cape Cod Harbor. The results of my own surveys are given in a general original map and chart on $\frac{1}{10000}$, embracing the several localities under consideration, and showing the topographical and hydrographical features of the harbor as they now exist. A reduction, for comparison, of the large scale maps from the Engineer Bureau, has been made to the scale of my own survey, $\frac{1}{10000}$, based upon points common to both surveys.

A re-plotting of my hydrographic work has been made on the same scale of Major Graham's large map, with the shore-line accurately enlarged. Comparative tracings, on vellum, have been made, showing the high water, low water, one, two, three, four, and five fathom lines of all these maps.

A large-scale plan and chart on $\frac{1}{1000}$ has been made by original independent survey, embracing the local ground of the inlet of East Harbor, showing the present bridge and adjacent shores, with soundings in squares of fifty feet, given in feet and tenths, and extending three hundred feet above the bridge, and five hundred feet below the bridge. Upon this plan is projected the position of the proposed dike.

The special ground of my surveys embraces three separate sections, although all are connected in their general bearing on the physique of the harbor.

The questions involved are varied. The first—Long Point and Long Point flats—being that of change, encroachment upon the area of the harbor, or the reverse.

The second: the influences of the tidal current through East Harbor Inlet, and its change of condition, with the practicability and advisability of closing the inlet by an artificial dike.

The third: the changes, and danger of waste, of the narrow strip of beach separating the outside ocean tides and sea from the head-waters of East Harbor Creek.

In discussing these sections in detail, I classify them, as above.

SECTION I.—LONG POINT.

Long Point is the extremity of Cape Cod, and forms, by its long crescent-shaped spit, the bulwark of the harbor, being a natural "mole" presenting a long fore-slope to the action of the sea, with a steep slope inside, declining into from sixty to seventy-five feet of water.

Between this point and the western end of the village of Provincetown, on the western side of the harbor, there are extensive flats, covered at high tide, and terminating in an abrupt decline from low-water line to about fifty feet; quite in contrast with the slope of the north side of the harbor, along the front of the village, which is long and gradual.

The survey of Major Graham shows the formation of Long Point as an irregular neck of sand flats and hummocks, broken by lagoons having several openings on the inside and one on the outside, with a high-water channel passing quite through the neck.

At the time of Major Graham's survey Long Point light-house was on the extremity of a spit, covered at spring high tides, and 1,950 feet beyond the high-water extremity of the main point.

The survey first made shows marked and important changes in the character and extent of Long Point. Some of the lagoons have filled up with sand and the outside opening has entirely closed, and the point generally increased in width and substance.

By artificial structures, and the planting of beach-grass, the low-water spit between the light-house and the former end of the point has been raised to a high-water neck, now covered with beach-grass, and fifty feet wide at its narrowest part. This neck has extended beyond the light-house, in a northeast direction, and the high-water extremity of Long Point is now five hundred and ten feet beyond the center of the light-house. (The extreme point bare at mean low water is five hundred and seventy-five feet beyond the light-house.) This shows *an increase and extension of the Point, above high water, of two thousand four hundred and sixty feet in thirty-two years.*

The recent soundings show the base of this mole of sand to have advanced upon the floor of the harbor two hundred and fifty feet, and with its summit now dry at low water, where, thirty-two years ago, according to Major Graham's accurate determinations, there was a depth of water of seventy-five feet. The slope of the extremity of this mole or spit, like its northern side, is very abrupt; and this abrupt slope is preserved in its steady movement along the floor, and into the deep waters of the harbor, like the advance of an immense dune.

Along the margin or crest of the flats, between Long Point and the western end of the village, the drainage of sand off these flats has projected their low-water margin, or bank, an average distance of two hundred and seventy-five feet, with a lateral extent of five thousand feet, making a superficial area of increase of 1,375,000 square feet.

The outer slope of these flats, which, as before stated, has the character of an abrupt bank, has undergone considerable change; and along its central section has encroached upon the basin of the harbor, the base of the slope or bank having advanced sixty feet. Between the center and southern corner of this bank there is more change than actual increase; in fact, the corner of the bank has receded at the turning point, and assumed a sharper bend.

This indicates that the material of the bank itself is subject to strong under-water influences.

Between the center and northern corner of the bank, where the curve and change from the abrupt slope is more gradual, the comparison of surveys shows more disturbance of contour than actual change; the general position of the bank in relation to the harbor outline remaining as heretofore. The gradual slope along the front of the village also retains its former general ground.

The marked and extensive increase of the summit of this bank between Long Point and the western end of the village, suggests the importance of arresting the moving surface material of the flats behind it.

A fence or dike, constructed from Long Point, near the entrance of Lobster Plain, to House Point Island, and from House Point Island to Stevens Point, would be a favorable line, and would shut off the greater portion of these flats, and ultimately increase the substance of the point.

A fence or dike might be constructed still closer to the edge of the bank, thus cutting off the entire flats, and preventing any drainage toward the harbor.

SECTION II.—EAST HARBOR INLET AND BEACH POINT.

Beach Point is a rift of sand which appears to have been thrown up by the dash of the sea, along the outer edge of a pre-existing flat, and has thus inclosed behind it a large tide-water lagoon, known as East Harbor.

Since the record of former surveys this rift of sand has gradually increased, and advanced in a northwesterly direction, leaving the opening that we observe; an opening which is now preserved by the persistent action of the tidal currents which fill and empty the lagoon within this natural dike. This opening exhibits the usual characteristics of an inlet, with a depression at the chops, an outside bar and an inside swash.

The changes manifested by the comparison of surveys are marked and varied about the locality of the inlet, and within the range of its influence.

Above high water, the extremity of Beach Point has extended, in its general alignment since the survey of Major Graham, one thousand feet. On the opposite side of the inlet some waste of the main shore of the Province land has occurred, amounting to two hundred feet, so that the actual contraction of the width of the inlet, during the last thirty-two years, has been eight hundred feet.

About two thousand five hundred feet of the end of Beach Point seem to have been affected by the dash of the sea and the action of the tidal currents of the inlet, so that the body of the beach has been beaten in, or has swung in, upon the bed of the lagoon. This retreating of the beach is an average distance of two hundred feet, about its general width.

Within the inlet the changes indicated are mainly those of abrasion of the bank and bluffs on the northern shore of the lagoon; with an advance and encroachment of sand dunes upon the flats and marshes above the section of waste.

This abrasion, caused by the tidal currents both at flood and ebb, has cut into the high sand dunes, north of the lagoon, in a deep cove about twelve hundred feet in lateral extent with an average cutting of one hundred and eighty feet, showing a waste of 24,000 superficial yards. But this does not express the amount of material removed; this cut is at the base of dunes which rise abruptly above the shore to the height of at least forty feet, and the whole mass of the dune has been cut away by the undermining of the tidal currents.

Estimating the height from low water to the summit of the dune, we have a vertical waste of fifty-one feet. In other figures, the removal of sand may be stated at 408,000 cubic yards. Beyond this cove the dunes have advanced, as before stated, over the site of former high flats, otherwise unchanged, and now rise abruptly from these flats at the shore-line. This extension covers an area of 800×40 yards$=$32,000 square yards. So evidently is this a dune movement, that the extension and increase cannot be connected with the concave excavation and retreat of the shore at the cove below. It would be reasonable to apply this dune advancement to the ground of the cut or cove referred to, as the whole northern shore of the lagoon is bordered by dunes of the same character and subject to the same wind influences. This would nearly double the figures given above, as the waste and removal of material from the cut or cove described. As these changes indicate, on the one hand, an advance of the shore-line upon nearly the high water plane, and, on the other, the entire removal of material between the surface and bed of the lagoon, its capacity, as a reservoir, has been in so much increased.

Above the inlet, the low water channel has changed its form and direction, but there is no evidence of any less damage than formerly; on the contrary, the channel is deeper and extends far beyond the limit of the flats represented on Major Graham's chart as dry at low water. Unfortunately, the sparse soundings on Major Graham's chart, within the basin of the lagoon, do not admit of a fair comparison. There is no allusion in Major Graham's report to a local plane of mean low water in the lagoon which differs from the plane of the main harbor. Probably no allowance for this difference was made. We have no data, therefore, by which to ascertain the relations of these planes at the time Major Graham's survey was made.

Taking the data given, for comparison, a greater depth of water in the channel at low tide exists now than formerly. The deepest water given on Major Graham's chart is four and a half feet, at a point three hundred feet above the inlet. Near this point there is now four feet. At nine hundred feet above the inlet Major Graham's chart shows three and a half feet; at this point there is now nine and three-quarters feet.

Major Graham's soundings gradually shoal above this point, to three, two, and one and a half feet, this last sounding being nineteen hundred feet above the inlet. At this distance, but in a different position, there is now four and a half feet; and above it two and a half, four and a half, and four and a quarter feet; this last depth taken being three thousand four hundred feet above the inlet.

At the point of greatest abrasion of the shore of the lagoon, at the cove, above referred to, the shore has an abrupt decline from the base of the dunes, which rise as abruptly above it, to the bed of the low water channel. This channel, although narrower than when Major Graham surveyed it, is shown to be deeper, and has probably as much, if not greater scouring capacity than when it was in its former condition.

The comparison of shore-lines has shown the inlet to have contracted from a width of one thousand seven hundred in 1835, to nine hundred feet in 1867, the present time. But a comparison of cross-section shows that in this narrowing no proportional diminution of water-way has occurred.

Major Graham's chart exhibits two depressions in the cross-section, not unlike those at present existing, but of much less depth. The former are, respectively, three feet and one foot, while the latter are fourteen feet and eight feet.

That the artificial structures connected with the bridge and roadway have, by confining the inflow and outflow of the tides to nearly the same pathway, aided in deepening the inlet, no one can doubt.

At the period of Major Graham's survey, no bridge or other artificial obstruction existed.

The subsequent influence of these obstructions must also be given due weight in considering the changes in the positions and magnitudes of the shoals both above and below the inlet.

The drainage current of East Harbor, which may be said to approach the opening along the axis of the lagoon, impinges, as it nears the inlet, upon the bluffs of the main shore, is deflected from its course and turned off through the inlet at rather a sharp angle, after which it pursues a nearly direct course to the sea.

In studying the contours of the bottom, in the section of the harbor off the entrance of East Harbor, as shown by the fathom curves, the influences of the inlet are marked in their effect.

Were there no causes for disturbance, we should expect to find the contours here, as elsewhere, *concave*, and *conforming to the general trend of the shore;* instead of which we find them *convex*.

Upon Major Graham's chart this *protrusion* of the contours, off the entrance of East Harbor, is very evident and extends from the low-water line to the muddy bed of the main harbor.

It is also evident that the projection of these contours is not alone the result of the *pushing out* of sand already existing in this vicinity, or brought here by wave and current action from distant ground; in which case, were this the prevailing action, the sands would be *thrown in* rather than protruded. But the evidence is, that supplies of sand have been brought out from the lagoon by the ebb current; and that these sands, and this tidal current, have been the prevailing causes of this local projection of the under-water shore slope of the harbor.

A comparison of the survey of Major Graham with that just made demonstrates that this projection of sand has continued and increased during the intervening time. We have no data by which to ascertain the increase in *elevation* of the shoals and bars off the entrance of the lagoon within the one-fathom line, and can, therefore, only compare their outlines and lateral extent. Beside the accumulation which may have occurred to increase the elevation of these shoals on either side of East Harbor Channel, the tidal current from the lagoon seems to have had the power to carry material along its path way to the crest of the decline, and project this material over the face of the outer slope. This deposit is marked and extensive as far as the five-fathom curve—the limit of our means of comparison. This increase may be stated in the following terms:

The contour of the two-fathom curve shows an advance, since Major Graham's survey, of an average distance of one hundred and seventy-five feet for a lateral distance of six thousand, equaling 1,050,000 superficial feet.

The three-fathom curve has advanced, in a like manner, an average distance of one hundred and sixty by seven thousand feet, equalling 1,120,000 superficial feet.

The four-fathom curve has advanced one hundred and fifty feet by eight thousand feet, equalling 1,200,000 superficial feet.

The five-fathom curve has advanced one hundred and ten by five thousand feet, equalling 550,000 superficial feet.

The total projection of these curves amounts to an area of 3,920,000 superficial feet.

To ascertain and illustrate this increased deposit, we have taken, only, the curves of the fathom planes, which are the lines usually given on the hydrographic charts of the Coast Survey. But as each of these planes over-laps upon the other, it shows a deposit over the whole section. The distance of the overlap, indicated by the fathom curves, also shows a deposit which would probably average one foot in depth.

Estimating the section between the two and five fathom curves—which equals an average distance of three thousand feet—and including the lateral extent of the deposit, shown upon the chart to be six thousand five hundred feet, we have the extensive area of 30,500,000 superficial feet. In other figures, 30,500,000 cubic feet of sand has been projected over this under-water shore-slope of the harbor, covering an area of seven hundred acres one foot deep with sand.

The *horizontal projection* of this deposit is much greater and more important in its relation to the entrance and navigation of the harbor than this vertical shoaling would seem to indicate.

The most extended projection of three-fathom plane—an important depth in navigation—appears at the extreme limits of the ground affected, so that, at points two miles apart, we find the three-fathom curve to have advanced three hundred feet.

As the intervening ground is broken and irregular, no vessel drawing eighteen feet of water should venture beyond this line, within this lateral distance of two miles.

In applying the consequences of this change in the condition of the harbor to the practical question of navigation, it results: that vessels bound into Cape Cod Harbor, in standing over toward the Truro shore, within this section of two miles, must shorten their range, or tack, by a distance of three hundred feet.

To vessels in distress heavy laden and laboring in stress of weather to make the harbor, every foot of sailing distance gained, and available, under the lee of the Truro shore, is of great advantage.

The present tidal power of the inlet may be further shown by a statement of the capacity of the lagoon, which, at ordinary tides, has an area of four hundred and sixty-three acres. At high spring tides—and Major Graham's tidal records show the rise of a storm tide, with a southeast gale, to have been *sixteen feet*—the whole extent of "the meadows" is overflowed, increasing the area by four hundred and sixty-one acres, making a reservoir capacity of nine hundred and twenty-four acres. The results of observations gauging the flow of water through the inlet, taken by direction of James B. Francis, esq., by A. Savary, esq., civil engineer, shows the mean volume of water flowing on the flood tide to be 7,820 cubic feet per second.

So long as this inlet remains open, the scour of the tidal currents, added to the other activities of nature, will have a tendency to weaken portions of Beach Point and give a general insecurity to the locality. This has already been the occasion of large expenditures upon temporary work of defense.

In making the statements recorded in this report, and presenting the comparative chart showing the changes which have taken and are taking place in the physical condition of the harbor, I will again allude to the character and accuracy of the data upon which these results are based.

The accuracy of the prepared chart furnished from the Engineer Bureau, the accuracy and detail of Major Graham's survey, and of the survey just executed, have rendered these results most satisfactory and unusually close in their determination. In all permanent lines and features the coincidence has been most marked and perfect; as have also been the points, common to both surveys, upon which comparisons are based. The results of these surveys unite in testifying to the encroachment of sands upon the waters of the harbor, and give no reasonable ground for assuming that these causes of injury are declining.

We will not assert that the time may not come when the action of these causes may decline or altogether cease by the filling up of the lagoon and the sanding up of the inlet; but the data thus far obtained afford no ground upon which to predict the ultimate result of these natural changes. The facts show *that the immediate tendencies of the present influences are decidedly injurious*, and justify the anxiety they have occasioned.

There is no seaward scour to the harbor itself and no effort to remove sand of this description has ever proved successful. *The damage to the harbor, therefore, is irreparable.*

SECTION III.

The narrow strip of outside beach which connects the high lands of Truro and Provincetown, and stretches across the head of the meadows, is the remains of what appears to have been a high ridge of sand dunes, formed prior to any record or history we have of this locality. That they have been long undisturbed by wind is evident from the existence of the beach-plum tree, which covers the remaining inner slope of the highest of these dunes or hills.

Without entering into a discussion of the geology of this section of the cape, the consideration of the probable origin and general former condition of this remarkable land is important in judging of its probable future condition and the changes which are likely to take place.

The fact is patent that the Truro land—or main extremity of the cape terminating at "High Head"—was formed at an earlier period, under different influences, and contains material not present in the so-called Province land. This difference is marked by the existence of clay and of boulders, and by the peculiar form of the "bowl and dome" drift, distinguishing it from the Province land, which is of sand only—so free from all earthy matter that it will not even discolor water—while the forms which the dunes and ridges here assume are mainly characteristic of wind drift.

Whatever the original forces may have been that formed this part of the cape, these forces have long since ceased, and changed from an action of *increase* to that of constant and continued *degradation.*

The peculiar position and form of the Province land is that of a spit, thrust out by the tidal currents and thrown up by the dash of the sea beyond the former extremity of the cape, and composed mainly of the insoluble material abraded from the shores of the main cape at Truro and beyond.

A cross-section of the cape, at the Highland Light, shows an abrupt outer bank of about one hundred and twenty feet in height, proving that at a former period the cape at this section was wider than it is now, and that probably the shore-line extended far out into what is now deep water.

The remains of the *inside slope* of what were former high dunes on the Province land, show that these dunes were formed under the lee, as it were, of this former wide and more extended portion of the cape.

It seems to be almost a law—and certainly is the prevailing course in the foundation of such ground as Provincetown—that the first resultant of the creative forces is the *outer bar* or backbone ridge of the spit or neck so formed.

It is therefore reasonable to assume that the outer ridges of the peninsula of Provincetown were the earliest in date, and that the flats, marshes, and ponds now existing are subsequent accumulations and accidents which have taken place under the shelter and eddy influences of the outer hooked bar or beach.

The waste of this beach, with its bluffs and dunes, which forms the isthmus connecting the Provincetown peninsula with the Truro land, is now going on in line with the general waste of the whole outside shore, and more rapidly perhaps at the main bend of the cape along this section than at many other points.

There are now two narrow and weak places in the strip of beach which forms the isthmus of Provincetown—as above described—which I will call in my report and refer to on my charts and plans as the "oblique section" and the "cove section." At each of these points a line of levels has been run from the outside slope of the beach to the inside water level of East Harbor Creek, as stated in the foregoing pages of my report.

By comparison with the extreme high-water line—the one given on Major Graham's chart—a waste of three hundred feet found opposite the "oblique section;" and of two hundred and fifteen feet opposite the "cove section."

The outside beach along this bend of the cape is swept by a strong lateral current, tending toward Race Point, and is also open to the full power of the severest storms, which bring upon the shore the heaviest breakers.

Already these breakers have dashed over the narrow strip of sand beach at what I term the oblique section.

This led to some work of protection to the beach. A jettee of heavy piles was driven on the outer slope of the beach, but was torn up by the sea as soon as made. Some brush hedges have been set and beach-grass planted along the crest of the beach.

These have caused some accumulation of sand and prevented what was already there from being blown away. But nothing has been done to preserve or increase the beach at what I term the "cove section," which is now the weakest point along the line of this sandy isthmus.

The levels taken by Mr. Hiram F. Mills and shown upon his elaborate plan of profiles give the following results:

At the oblique section the outside slope of the beach is seen to be frequently washed by the tide and sea to within about two feet of the highest point of the ridge.

From this line of sea dash the distance through to the inside marsh is four hundred and thirty-seven feet, the line passing over rather irregular ground.

The difference of level between this line of sea dash on the outside slope of the beach and the plane of the marsh inside is nine and nine-tenths feet.

At the "cove section," the form and character of the strip of beach is that of a single bluff, with a steep slope from its outer crest to the sea with a more gradual but simple inside slope toward the marsh.

The dead grass and drift at the outer edge of this bluff shows that the breakers often reach its summit.

The little cove of inside marsh—from which I name the section—reduces the width of the sand ridge constituting the entire isthmus at this point to ninety feet.

The survey by Mr. Mills was made at a season of ordinary tides and in ordinary weather, but there is always a heavy sea on the outside shores of this section of the cape.

From the line of high-water sea-dash on the outer slope of the beach to the same level on the inside slope, the distance across this strip of beach is sixty-five feet.

The elevation of the little intervening bluff above this line or plane is six and six-tenths feet.

Opposite this cove of marsh East Harbor Creek makes its nearest bend toward the outside beach with a small lateral creek extending still nearer to it, so that the corresponding waters are but three hundred and one feet apart.

The relations of these waters in their tidal epochs are peculiar at this point.

The long path which the inside tide has to travel first in passing through East Harbor Inlet, then, after filling the lagoon, finding its way through the windings of the creek to nearly the head of the meadows, makes the *time* of high water in the creek $1^h\ 29^m$ later than the outside ocean tide.

Our tidal observations and the profiles of Mr. Mills also show the level of the water in East Harbor Creek at the time of high water outside to be eleven and one-tenth feet below the plane of ordinary sea-dash on the outside beach opposite.

In these results we have before us this physical condition of the case:

The only barrier which now prevents the waves of the outside ocean from dashing into and upon the creek and meadows of East Harbor, which are on a plane eleven feet *below* the summit of the breakers, as they come rolling in, is a strip of sand beach sixty-five feet wide with a little outside bluff six and a half feet in height.

That this strip of beach and this little bluff are steadily diminishing, both in width and elevation, is beyond a doubt. The question seems to be simply one of time. We find in thirty-two years that two hundred feet of this beach have washed away to ninety feet now left remaining.

If it be a fact that this outside beach or bar is antecedent to the flats and marshes which have formed under its protection, then, when this protection is removed, we have a condition and relation of things which has not before existed or occurred.

In view of the vast power of ocean breakers, culminating with storm tides and gales, it is vain to predict the consequences which may result should they break over and through this beach.

In the storm that carried away the first Minot's light-house, a breach was made in the outside beach at Nansett, which, when the storm subsided, was over five hundred feet in width with a channel eleven feet in depth. This opening remains to this day; although the tendencies to close, by the formation of a new outside beach, are as strong, and the inside influences to keep an inlet open less favorable than at the ground in question—which presents an unobstructed pathway through the entire cape, while the calm waters of Cape Cod Harbor are always below the summit level of the breakers on the outside shore.

But assuming that no change in the existing condition of land or water should result from the wearing or breaking away of this strip of beach:

It is evident that without this barrier, at periods of high tides the sea would dash over for many hours into the basin of the meadows

This surplus water in its outflow at ebb tide would tend toward the harbor as readily as it would discharge itself through the ocean inlet, should one be made.

The scour and cutting power of East Harbor Inlet would therefore be increased at each ebb tide, by a volume of water not accumulated by its own flood-tide capacity.

That this augmented water-power would increase all the evil influences of the inlet is beyond a doubt.

In view of this contingency, the closing of East Harbor Inlet, as proposed by the present board of State commissioners, fulfills a double purpose, in stopping the injury it is now doing, and in presenting a breakwater between the ocean and the harbor waters, should the outside beach break through.

In addition to a dike at the inlet of East Harbor—which I should strongly recommend—a guard dike at the narrow part of the meadows, near the "wading place," would give increased protection.

It is impracticable, even impossible, to resist the forces of the ocean, on such a coast as this, at the point of its attack. Security must be obtained by rear defences.

Without further comment upon the facts and questions I have above presented, I am constrained to add, that in all my knowledge of the coast, and in the results of the many surveys I have made, involving questions of harbor improvement and protection, I have found no case which, in my judgment, calls more strongly for the attention and action of the general government and of the State than this of Cape Cod Harbor.

Its value to commerce, its location, its accessibility, its shelter as a harbor of refuge, are unequalled on the Atlantic coast of the United States.

Before closing my report, I would particularly mention the conference and consultation I have had with Henry Mitchell, esq., of the Coast Survey, who has been twice to Provincetown during the term of my field-work there.

Mr. Mitchell has, personally, gone over all the ground under consideration, and with me made some experimental tests of the harbor and East Harbor currents. The lateness of the season, and the limited time available for such investigations, however, rendered a proper series of observations impracticable.

Mr. Mitchell concurs with me in the general views expressed and the deductions made from the data and comparison of my surveys.

I would also mention the services of Mr. Gershom Bradford, of the Coast Survey, who has executed the hydrographic work under my general charge; Mr. Bradford's experience and skill as an hydrographer have secured results, and given data of the first order.

The extracts from the surveys of the State harbor commission, executed and furnished to this special commission, by their engineer, A. Boschke, esq., have served to connect the detached portions of my own local surveys.

The correspondence and agreement of the data given on Mr. Boschke's chart add proof and illustration consistent with the results of my own surveys.

Tidal data, references and explanations, will be found in notes given upon the charts and plans accompanying this report.

All of which is respectfully submitted.

HENRY L. WHITING,
Assistant United States Coast Survey.

Professor BENJAMIN PEIRCE,
Superintendent United States Coast Survey.

APPENDIX No. 13.

REPORT TO THE SUPERINTENDENT OF THE COAST SURVEY ON THE TIDES AND CURRENTS OF HELL GATE, BY HENRY MITCHELL, CHIEF OF PHYSICAL HYDROGRAPHY, UNITED STATES COAST SURVEY.

SIR: I beg leave to submit the following report upon Hell Gate:

General scheme of tides and currents.—Of the two entrances to New York Harbor, that which communicates with Long Island Sound may be classed specifically with *arms of the sea*, while that which opens from the ocean at Sandy Hook has an essentially different character.* In the former the water is constrained by the rocky bed and banks; in the latter the yielding sands submit themselves to the action of the waves and currents. Although the rocks of the East River bear many traces of the action of running water, these may at once be recognized as subsidiary and insignificant features—the depression through which the currents now flow is antecedent to, and essentially independent of, the activities which we now witness. The tidal currents which now traverse the eastern entrance are, by the channel way, forced from their natural disposition into complications peculiarly local in character; giving rise to those whirlpools and reactions of the water which bewilder the navigator and render the pass dangerous often to the most expert pilot.

It is quite otherwise with the Sandy Hook entrance, where nearly every physical feature presented to the observer may find a parallel or counterpart in his experience or knowledge of other portions of our coast. Unlike the Hell Gate passage, where *permanence* is the leading characteristic, the bar and channels at Sandy Hook have undergone continual variations within the brief period of our history. In the contest between the currents and the waves of the sea, the former busy in the scour of the channels, the latter equally busy in their destruction, we have seen, from the comparison of actual surveys extending over a century, new channels developing and older channels deteriorating. We have seen Gedney's Channel improve, and we are now witnessing the filling up of the Main Ship Channel by the advance of Sandy Hook.

There are evidences that Raritan Bay was once open to the sea from the Highlands of Navesink to Flynn's Knoll, at least, and that Sandy Hook has advanced from these highlands under the action of the waves of the sea which drive diagonally from the southeast—that is to say, there are reasons for supposing that the lower harbor of New York is a *bight*. The older portions of Sandy Hook have a considerable admixture of green sand which no doubt comes from the Navesink deposit. The fresh supply of material which is extending the point of the Hook is known to come up along the outer shore, and is believed to be derived from the neighborhood of Long Branch, where the sea is encroaching upon the land quite rapidly.

On the other hand, the present aspect of New York Bar is that of a broken cordon of sand stretching from the coast of New Jersey to that of Long Island, giving to the present opening some of the characteristics of an *inlet*.

If the lower harbor of New York is a *bight*, the bar may be regarded as a recent formation, and the extension of Sandy Hook may be expected to continue. The tendency of a *bight*, to speak in the most general language, is towards *inclosure*. The rift of sand, which at early stages converts it into a sheltered harbor, tends ultimately to cut off the basin from the sea; and it is not until a late period that the *bar* appears—not until the opening is so confined that the current through it is so quickened as to be able to bear away or push seaward a portion of the sands. It may be properly argued that the land waters which find their way into New York Harbor will always force an outlet from the lower harbor, because the Hell Gate Pass is too indirect, and, in times of great freshets, too confined; but an adequate outlet for these back waters would fall far short of the present opening. In our opinion the conservation of ample channel ways at Sandy Hook is due in some measure to the tidal circulation which the Hell Gate entrance permits. This circulation is

* I shall use the terms *arm of the sea*, *inlet*, *bight*, *&c.*, with the technical meanings given to them in the recent report of the committee of the National Academy appointed to investigate the causes of decline in the harbor of San Juan del Norte.

the life-blood of the harbor, cleansing its channels from the silts of its rivers, as well as from the sewerage of its cities, and even sweeping the sands from its grand avenue to the ocean.

The purpose of this report is neither a general discussion of the physics of New York Harbor nor even an essay upon the great tidal circulation to which we have referred. My special topic will be the tidal phenomena of Hell Gate; and it is only because these phenomena depend so entirely upon the coexistence of the two entrances that I have been tempted into the preceding speculations upon the past history of these.

New York Harbor is visited by two derivations from the tide-wave of the ocean, one of which approaches by way of Long Island Sound, the other by the way of Sandy Hook Entrance. These two tides meet and cross or overlap each other at Hell Gate; and since they differ from each other in times and heights, they cause contrasts of water elevations between the sound and the harbor, which call into existence the violent currents that traverse the East River.

In the course of our laborious tabulations of the data from my physical surveys of 1857 and 1858, it has become apparent that the general order or scheme of the tidal interference is very simple, and that the apparent complications result from the mingling of local peculiarities; for this reason I deem it essential to offer a general view of the scheme denuded of all its details before inviting you to follow through tables and diagram to the phenomenon actually observed.

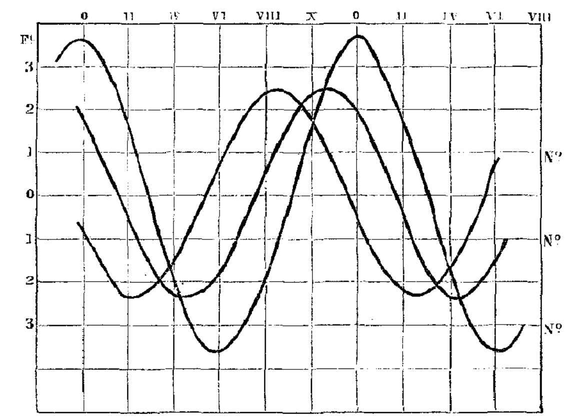
If the entrance from the sound were closed at Throg's Neck, the tide which comes in over the bar would prevail all over New York Harbor, and we should have on the west side of Hell Gate a tide of four and a half feet range, with its time of high water about one-half hour later than at Sandy Hook, *i. e.*, eight and a half hours after the southing of the moon. In passing through the Gate and spreading out upon the broader spaces beyond, this tide would essentially lose its wave character and become very much reduced in range, so that at the Brothers Islands it would probably be scarcely sensible.

If, on the other hand, the sound entrance were to remain open and the Sandy Hook entrance be closed, a very different order of tides would prevail. On the east side of Hell Gate the tide would have a range of about seven feet, and high water would occur there about twelve hours after the moon's transit. In passing the Gate it would suffer degradation, but not very rapidly, till it had advanced beyond the Blackwell's Island channels. In the basin of the upper harbor, however, it would become very small and essentially waste itself and disappear in the lower harbor. If these two suppositions are correct, we ought, with both entrances open, to find at Hell Gate a tide whose times and heights are intermediate between those now observed at Sandy Hook on the one hand and Throg's Neck upon the other; while at other points the proportions would be unequal, according as our place of observation was more distant from the meeting point on either side.

In the subjoined table and its accompanying sketch, we give the two tides as they would appear at Hell Gate separately, and also as they would appear combined.

No. 1.—*General scheme of tidal interference.*

Hour.	No. 1. West side of Hell Gate.	No. 2. East side of Hell Gate.	Difference.	Mean.	Sum.	No. 3. (Sum)× 0.65.
	Feet.	*Feet.*	*Feet.*	*Feet.*		
O	—0.62	+3.65	—4.27	+1.56	+3.03	+1.97
	—1.20	+3.54	—4.74	+1.17	2.34	+1.52
I	—1.70	+3.17	—4.87	+0.74	1.47	+0.96
	—2.08	+2.59	—4.67	+0.26	0.51	+0.33
II	—2.33	+1.82	—4.15	—0.26	—0.51	—0.33
	—2.40	+0.95	—3.35	—0.72	—1.45	—0.94
III	—2.33	0.00	—2.33	—1.17	—2.33	—1.52
	—2.08	—0.95	—1.13	—1.56	—3.03	—1.97
IV	—1.70	—1.82	+0.12	1.76	—3.52	—2.29
	—1.20	—2.59	+1.39	1.90	—3.79	—2.46
V	—0.62	—3.17	+2.55	1.90	—3.79	—2.46
	0.00	—3.54	+3.54	1.77	—3.54	—2.30
VI	+0.62	—3.65	+4.27	1.56	—3.03	—1.97
	+1.20	—3.54	+4.74	1.17	—2.34	—1.52
VII	+1.70	—3.17	+4.87	0.74	—1.47	—0.96
	+2.08	—2.59	+4.67	0.26	—0.51	—0.30
VIII	+2.33	—1.82	+4.15	0.26	—0.51	+0.33
	+2.40	—0.94	+3.34	0.72	1.46	+0.94
IX	+2.33	0.00	+2.33	1.17	2.33	+1.52
	+2.08	+0.95	+1.13	1.56	3.03	+1.97
X	+1.70	+1.82	—0.12	1.76	3.52	+2.29
	+1.20	+2.59	—1.39	1.90	3.79	+2.46
XI	+0.62	+3.17	—2.55	1.90	3.79	+2.46
	0.00	+3.54	—3.54	1.77	3.54	+2.30
O	—0.62	+3.65	—4.27	1.56	3.03	+1.97
	—1.20	+3.54	—4.74	1.17	2.34	+1.52
I	—1.70	+3.17	—4.87	0.74	1.47	+0.96
	—2.08	+2.59	—4.67	0.26	0.51	+0.33
II	—2.33	+1.82	—4.15	0.26	—0.51	—0.33
	—2.40	+0.95	—3.35	0.72	—1.45	—0.94
III	—2.33	0.00	—2.33	1.17	—2.33	—1.52
	—2.08	—0.95	—1.13	1.56	—3.03	—1.97
IV	—1.70	—1.82	+0.12	1.76	—3.52	—2.29
	—1.20	—2.59	+1.39	1.90	—3.79	—2.46
V	—0.62	—3.17	+2.55	1.90	—3.79	—2.46
	0.00	—3.54	+3.54	1.77	—3.54	—2.30
VI	+0.62	—3.65	+4.27	1.56	—3.03	—1.97



No. 1 is the curve of sines for mean range of Sandy Hook tide, and No. 2 is a similar curve for mean range of Throg's Neck tide. The hours are counted from the transit of the moon.

If we were to suppose a dam with a narrow lead through it thrown across Hell Gate at Hallet's Point, the tides No. 1 and No. 2 would be those which would occur on the west and east sides respectively, and the heights in the column marked "Mean" would be those in the *lead*. On the other hand, if we suppose No. 1 and No. 2 to be waves meeting in the ocean, we must expect them to be superimposed and their compound represented by the column marked "Sum." In the interference of tides in shallow waters or narrow channels the composite tide at their meeting point is neither the sum nor mean, but falls between these.* I have used 0.65 for the coefficient in computing the composite curve, No. 3, which appears in our diagram; and this curve corresponds (in a general manner) with that actually observed in Hell Gate.

From the foregoing table and sketch, we may discover the causes and the characteristics of the currents of Hell Gate. Premising that *all currents are caused by disturbances of the surface level*, we may see, without effort, that in harbors visited by a single tide wave, (not materially distorted in its figure from point to point,) *slack current* must follow the *stand* of the tide, since at this

* Even upon the outside of Nantucket the compound of the northern and southern tides is nearer the mean than the sum of their components.

time the surface level is restored. Again, for this single tide, the maximum velocity must occur near the time of half-tide, because at this time the greatest rise or fall, and consequently the greatest filling or draining is taking place. In the neighborhood of Sandy Hook or at Throg's Neck the currents do follow, in the manner we have stated, the local tide; but in the East River where two tide waves approach from opposite directions, the changes of surface level, and consequently the currents, bear no direct relation to either tide wave considered by itself, but depend upon the nature of the "interference," as it is called. The two tides of our table are supposed to meet at Hell Gate, and give rise to those contrasts of level which appear in our column of "differences." These differences are the vertical measures of the slopes—tidal *heads*, if we may use this term so loosely—and they increase from zero to maximum (4.87 feet) in about three hours, then decline to zero in about the same time. I have distinguished between the dip towards the sound and the dip towards the harbor, by giving to the former the plus and to the latter the minus sign. We observe on entering our table at 0 hours (*i. e.*, at the instant of the moon's transit) that the surface of the sound is above that of the harbor and that the disparity of elevations is increasing. The current should therefore be running westward through Hell Gate. A little before IV hours the sound and harbor find themselves upon a level and there being no *head* to induce horizontal motion, the westwardly current must soon cease. But this equilibrium is again disturbed by the dissimilar changes of the two tides, and the harbor becomes in its turn higher than the sound, so that an eastwardly current must soon be engendered which continues till checked by the next restoration of level which takes place at about the X hour, &c. The two currents to which I have referred are respectively known to pilots as "ebb" and "flood." I purpose not to use these terms because they can not properly be applied to *interference* currents whose epochs bear no necessary relations to high and low water.

There is another prominent feature disclosed by our table and diagram to which I ought to refer in this prelimenary sketch, because I shall have occasion hereafter to give it importance among the physical peculiarities of Hell Gate. I refer to the *absolute* elevations of the water at the periods of slack and maximum currents. As I have said, the level is restored between the sound and the harbor on the IV hour and again on the X hour; but the former takes place at one and three-quarters foot *below* our datum plane, while the latter takes place as much above. In other words, if the conditions of our tables were realized, the depth of water at the slack preceding the easterly current would be three and one-half feet greater than that which would obtain at the slack preceding the westerly current. So also the maximum velocity for the westerly current would find nearly three feet more water than that for the easterly.

Actual observation does not present the scheme of interference with the simplicity that I have given to it in the preceding pages; it will, however, be perceived hereafter that I have given, as an introduction to the subject, not a mere hypothesis but a generalization from mature study.

The following summary of the leading points which I have attempted to illustrate will serve as my guide in the arrangement of my observed data:

First. Two tide waves visit New York Harbor, meeting and overlapping at Hell Gate.

Second. Near the meeting point of these two tides the observed heights and times of the compound tide are intermediate.*

Third. The currents of Hell Gate are called into existence by the variations in the relative heights of the sound and harbor; their epochs have no direct relations with those of the local tide or its components, and their velocities do not depend upon the local rates of rise or fall of tide.

Fourth. The current flowing westward through Hell Gate occupies a greater section than that flowing to the eastward, because the former prevails during higher stages of the local tide than the latter.

OBSERVATIONS AND RESULTS.

I do not propose to describe in detail the field-work which forms the basis of this discussion, because the annual reports of the Coast Survey may be referred to for this information; but I ought perhaps to state briefly the history of the inquiries in Hell Gate. The first systematic observations were made in the year 1845 by the party under the command of Lieutenant Commanding Chas. H. Davis, assistant in the Coast Survey, under instructions from Professor A. D. Bache, Superintendent. Four

* Here and hereafter I shall use the word *intermediate* in its wider significance and not as synonymous with midway or mean.

tidal and nine current stations were occupied during a brief period. At one of the tidal stations the observations were kept up continuously, but at each of the other stations a single day's observations were recorded. The results from this survey were subsequently mapped out by Lieutenant Commanding D. D. Porter and forwarded by Professor Bache to the New York Chamber of Commerce, which had solicited the information.

The courses and velocities of the currents as well as the tide-tables upon the Coast Survey chart, now in the market, are from the first survey; the subsequent more elaborate surveys added few new features, although they were requisite to develop the laws of the phenomena.

In the year 1857 Professor Bache instituted a detailed survey of Hell Gate, and intrusted the execution of the work to myself. During the spring and summer of 1857 four tidal stations were occupied for continuous and simultaneous observations through more than one entire lunation, besides a few temporary stations occupied for single days. At the same time observations of the currents were made at eight stations. At three of these current stations observations every half hour were kept up over seven days; at others for twenty-four hours and over. The next season, 1858, further observations were made. A tide gauge was set up at Throg's Neck to work in conjunction with that at Governor's Island and continued in imperfect operation for a lunation; meanwhile eighteen current stations were occupied covering the space from Green Point to Execution Rocks. The largest series at any one current station was eight days. Observations upon the courses and velocities of free floats through Hell Gate were also made; and a few temporary tidal stations were occupied.

The tables that I shall introduce are compiled from the observations of 1857 and 1858; but it is proper to remark that with these before me I have looked back over the diagrams of the first survey, or reconnaissance, and found in them all the leading features distinctly exhibited.

The first table from actual observations that I can offer is that giving the general elements of the tides at selected points along the inside route from New York Bar to Throg's Neck, to which is added the distances of the stations measured along the sailing line, from Sandy Hook.

No. 2.—*Tides, from stations selected as characteristic for New York Harbor and its approaches.* 1857–'58

	Sandy Hook.	Governor's Island.	HELL GATE. Hell Gate Ferry.	HELL GATE. Hallett's Point, (east side.)	HELL GATE. Pot Cove.	Throg's Neck.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
High water / Low water } Mean interval after preceding transit of the moon	VII, XXIX.	VIII, XIII.	X, VI.	XI, VII.	XI, XXIX.	XI, XX.
	Ft.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
Average rise of tide (from the mean level of the sea)	2.4	2.2	2.2	2.6	2.9	3.7
Average fall of tide (from the mean level of the sea)	2.4	2.2	2.2	2.6	2.9	3.7
Rise of spring tide (from the mean level of the sea)	2.8	2.6	2.5	....	3.1	4.6
Fall of spring tide (from the mean level of the sea)	2.8	2.6	2.5	....	3.1	4.6
Rise of neap tide (from the mean level of the sea)	2.0	1.7	1.8	....	2.5	3.1
Fall of neap tide (from the mean level of the sea)	2.0	1.7	1.8	....	2.5	3.1
Distances, in miles, from Sandy Hook.	0.0	13.0	19.3	19.8	20.1	26.8

It will be observed that the wave which enters at Throg's Neck is about four hours behind that which enters at Sandy Hook, while at intermediate points, in Hell Gate, the compound of these two waves gives us intermediate times of high and low water. Again it will be observed that the mean range at Throg's Neck is about fifty per cent. greater than at Sandy Hook, while from Governor's Island to Hell Gate Ferry it falls below either of the extremes.

If we look more closely at our table we discover that the low-water phase at Throg's Neck is relatively more tardy than that of high water, because in deeper water. In our studies of other harbors we have familiarized ourselves somewhat with the different rates of travel of the different phases of the tide, and observed that the distortions thus produced in the profile, vary in the range from springs to neaps, from a. m. to p. m. tides, &c. This, of course, would be expected from the alterations in the depth. As we follow a tide wave into a bay or sound, we usually observe that its range alters from point to point, and that the magnitude of its diurnal and half monthly inequalities undergoes alterations. It is reasonable to suppose that the reflections or resistances which would alter the range would not equally affect waves of different masses or velocities. Table No. 2 furnishes illustrations of this. If we compute the ratios of springs to neaps, we have for heights: Sandy Hook, 1: 1.40; Governor's Island, 1: 1.53; Hell Gate Ferry, 1 : 1.39; Pot Cove, 1 : 1.24; Throg's Neck, 1: 1.49. If the two waves met in the open sea we might expect to resolve the interference by simply subtracting from the intermediate compound tide one of the extremes, and find the residual corresponding to the other extreme tide. This I have tried without satisfaction. There is no permanent meeting point of the tides, *i. e.*, no point where t e two components enter constantly with equal weight into the observed tide. Not only do the half-monthly inequalities cause shiftings of the meeting points, but the diurnal inequalities do the same—it may even be said that different phases meet at different points. But these difficulties, while they bar the way to the solution of an interesting problem and the determination of the law, in no way disturb the march towards those results which have a practical bearing upon navigation, and upon the possibilities of improving the channel.

I give upon diagram* the observed tides of Hell Gate Ferry, Hallett's Point, and Pot Cove for a period covering one lunation, at a quiet season of the year.

The most precise statement that we can make from an inspection of the diagram* and table No. 2 is, that between Hell Gate Ferry and Pot Rock, the two tides always meet. It is in this space that the most rapid change from high or low water interval occurs—about 1^{h} 30^{m} in a space of less than three-quarters of a mile—and it is in this space that the ranges alter most rapidly, 1.40 feet. It is also in this space that the greatest disturbance of level occurs; on the average 1.30 feet for the maximum contrasts of heights on each tide.

In the introductory remarks of this report I have stated that between the meeting tides the maximum difference of level ought to be 4.87 feet; and this contrast of height actually occurs, but is not confined to the narrow limit of Hell Gate, but in fact is divided over a space of perhaps twenty miles.

Advancing from Sandy Hook we first detect the intermingling of the Sound tide in the slight distortions of the Governor's Island tidal profile.† This distortion becomes marked by the time we reach a station at the foot of Fifty-third street near the west end of Blackwell's Island. In diagram* I offer a comparison of the tidal profiles at the two extremities of the western Blackwell's Channel from simultaneous observations. Upon the same diagram I have plotted the residual from a subtraction of one of these observed tides from the other. It will be seen that this develops a curve which is at once recognized as a fractional multiple of the Sound delayed (as its interval would indicate) about one hour in its journey from Throg's Neck. The range of this multiple of the Sound tide is about 3½ feet; we conclude from this that full one-half of the Sound tide loses itself in traversing this channel. If this is so, we cannot conceive this Sound tide to be an independent wave. It was observed, in tracing the interferences of the two tides of the Vineyard Sound, that after meeting at West Chop each tide suffered a rapid decline, and was to be distinctly followed but a short distance into the domain of the other. In this place as in Hell Gate the two tides have acquired such distinct forms that in their compound their relative position can be detected by the eye on the plotted profile. I conceive that the contrasts of heights presented by the waves have been in part accommodated by the local action of gravity, not reduced to a regular slope, however, because the time is limited.

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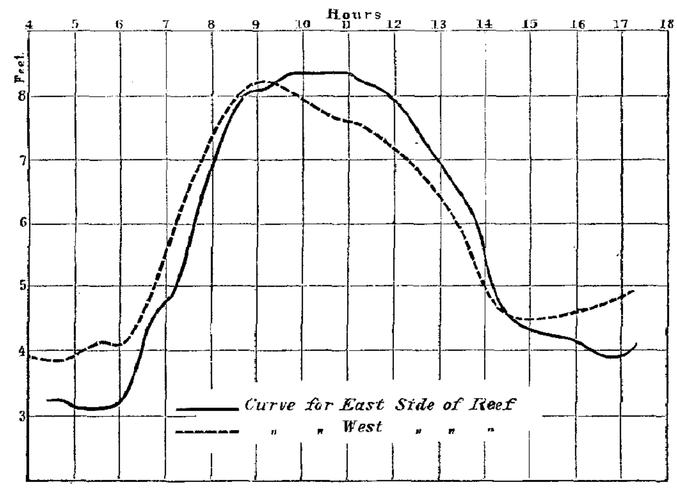
* Lost.

† I am here tempted to attribute the diminished range of the tide at Governor's Island to the interference of the Sound tide much delayed; but I cannot in this way account for the continuation of this diminished range between this point and Hell Gate Ferry, so I am obliged to conclude that the tide wave from the southward becomes reduced by its expansion upon New York Bay after passing the Narrows.

From a single day's observations that I have plotted below,

Tidal curves in Hell Gate, observed at stations only 100 feet apart on either side of the Hallet's Point Reef.



it appears that we may narrow down the meeting place of the tides to a space of about one hundred feet off Hallett's Point. In this small space, on the 6th of June, 1857, the intervals of high water differed two hours, and the heights, at maximum, one foot.

If we examine closely the observations of Pot Cove, we discover there as little trace of the western tide as we do of the eastern at Fifty-third street. In other words, the eastern tide is followed with equal distinctness eight times as far from the meeting point as the western. The greater range of the eastern tide accounts for this in great measure; but even if the two waves had the same range, their relations of time might be expected to give rise to different effects. For instance, as the western tide proceeds towards the sound, its times of high and low water approach coincidence with those of the sound tide; while, in the order of things upon the other side of the meeting point, the case is reversed, the sound tide is more and more widely separating from the western tide as it approaches New York Harbor. It is obvious that at periods of great diurnal inequality the evidences of interference ought to be discernible a greater distance to the eastward of the meeting place of the two tides.

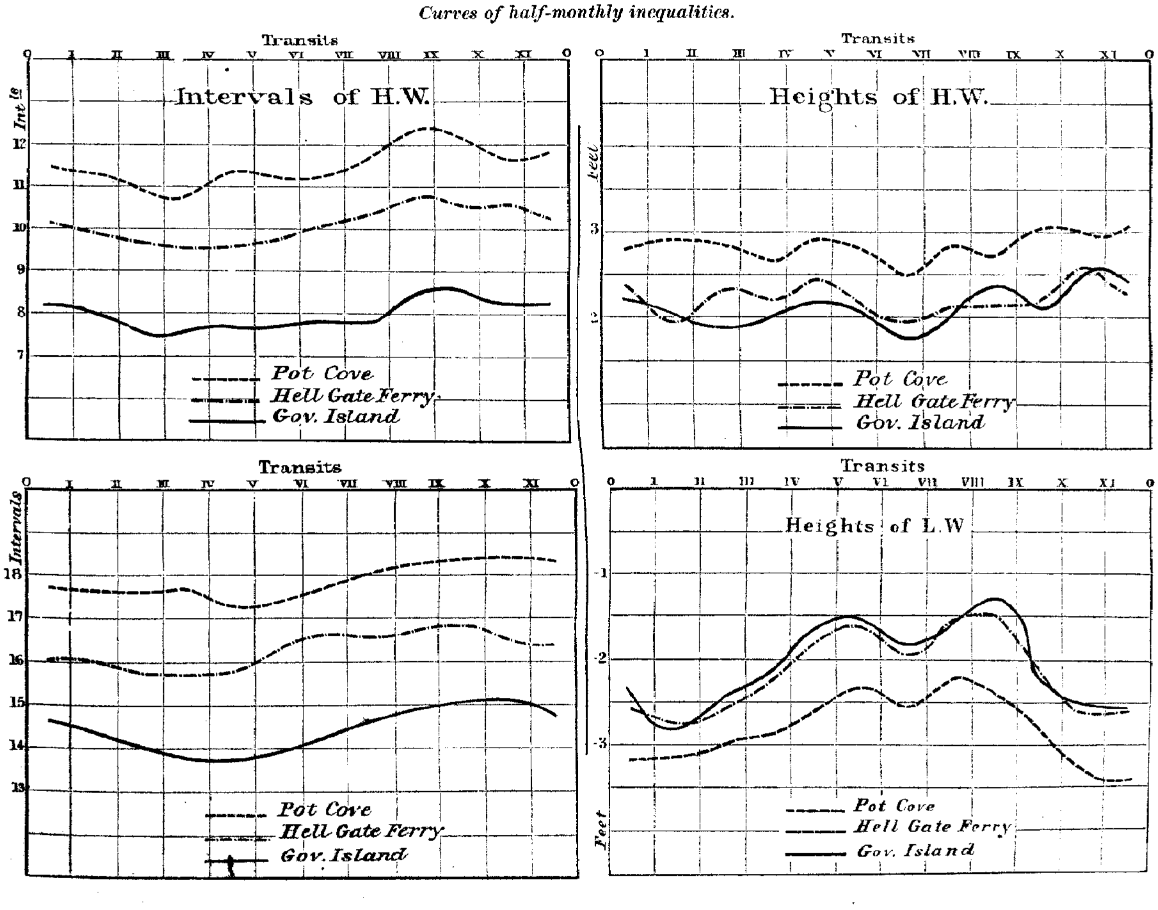
The effects of interference upon the ranges on either side of the meeting place of tide waves of different intervals, ought to be the reverse of each other. The range of one should be augmented, the other diminished. We do not recognize these contrasts of effects in the two approaches to Hell Gate, and I am convinced that the reason why we do not is that the two tides lose in great measure their original *wave* character and submit to the local action of gravity which, as I have before said, tends to reconcile all contrasts of elevation.

In table 3 and accompanying diagrams I give the curves of half monthly inequalities for Governor's Island, Hell Gate Ferry, and Pot Cove:

No. 3.—*Intervals and heights of tides from simultaneous observations, May and June, 1857, arranged according to hour of transit.*

Hour of transit.	HIGH WATER.						LOW WATER.					
	Governor's Island.		Hell Gate Ferry.		Pot Cove.		Governor's Island.		Hell Gate Ferry.		Pot Cove.	
	Intervals.	Heights.	Intervals.	Heights.	Intervals.	Heights.	Intervals.	Heights.	Intervals.	Heights.	Intervals.	Heights.
	h. m.	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*	*h. m.*	*Feet.*
,0 30	8 12	2.24	10 06	2.41	11 30	2.82	14 41	—2.45	16 12	—2.56	17 52	—3.24
I 30	7 59	2.06	9 51	1.93	11 18	2.97	14 29	2.83	16 02	2.81	17 46	3.15
II 30	7 29	1.88	9 47	2.34	10 54	2.92	14 05	2.44	15 57	2.59	17 38	3.00
III 30	7 35	1.90	9 33	2.20	10 44	2.71	13 49	2.19	15 52	2.31	17 45	2.95
IV 30	7 42	2.14	9 33	2.45	11 25	2.92	13 48	1.67	15 47	1.80	17 17	2.52
V 30	7 36	2.07	9 45	2.19	11 09	2.78	13 58	1.55	16 26	1.66	17 30	2.30
VI 30	7 50	1.75	10 03	1.90	11 10	2.47	14 25	1.83	16 38	2.07	17 48	2.60
VII 30	7 47	1.99	10 21	2.13	11 36	2.78	14 39	1.69	16 31	1.66	18 11	2.25
VIII 30	8 31	2.42	10 53	2.16	12 27	2.70	14 58	1.29	16 48	1.58	18 22	2.43
IX 30	8 30	2.08	10 30	2.16	12 05	3.03	15 05	2.21	16 49	2.23	18 25	2.86
X 30	8 23	2.52	10 34	2.63	11 39	2.91	15 04	2.55	16 29	2.68	18 28	3.32
XI 30	8 22	2.48	10 18	2.23	11 50	3.04	14 56	2.57	16 28	2.64	18 28	3.42
an.	8 00	2.13	10 06	2.23	11 29	2.84	14 29	—2.11	16 20	—2.22	17 58	—2.84

Curves of half-monthly inequalities.

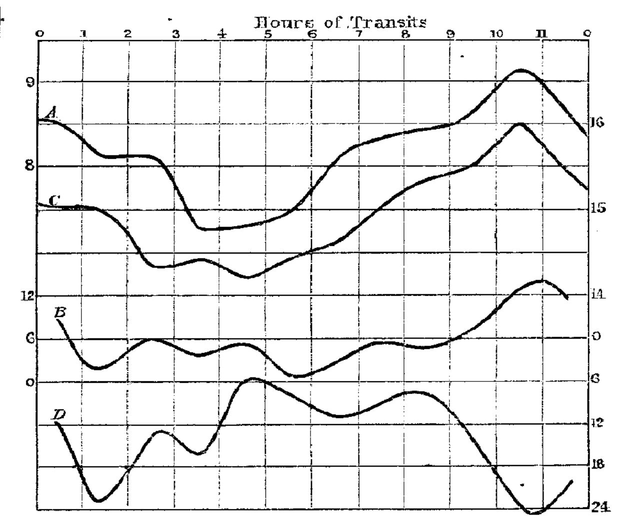


Some of the larger tides of Hallett's Point and Throg's Neck were lost, so that we have thought it best to omit the imperfect curves for these stations.

In table No. 4, I give the lunar intervals and heights at which the surface levels are restored in Hell-Gate; and, in table No. 5, the intervals and velocities of the currents. The surface of the Gate becomes level about one hour before the slack preceding the westerly current, and about forty-four minutes before the slack preceding the easterly current. If we compare these times with those of the tide, we find the first slack over two hours before the local high water, and the second slack two hours before the low water.*

No. 4.—*Restoration of level in Hell Gate, between gauges at Hell-Gate Ferry and Pot Cove*, 1857.

Transit of moon.	Restoration preceding beginning of westerly current. A. Interval.	B. Height.	Restoration preceding beginning of easterly current. C. Interval.	D. Height.	Difference of heights.
h. m.	*h. m.*		*h. m.*		
0 30	8 51	0.9	15 00	−1.2	2.1
1 30	8 13	0.1	15 00	−2.4	2.5
2 30	8 13	0.6	14 32	−1.4	2.0
3 30	7 25	0.3	14 39	−1.6	1.9
4 30	7 33	0.5	14 17	−0.6	1.1
5 30	7 44	0.0	14 47	−0.8	0.8
6 30	8 15	0.3	14 55	−1.1	1.4
7 30	8 31	0.5	15 09	−0.9	1.4
8 30	8 42	0.4	15 36	−0.8	1.2
9 30	8 59	0.7	15 42	−1.5	2.2
10 30	9 16	1.3	16 00	−2.5	3.8
11 30	8 53	1.0	15 35	−2.1	3.1
	8 23	0.6	15 06	−1.4	2.0



During the *easterly* current the maximum difference of level is—average for a lunation, 1.37 feet; and during the *westerly* current, 1.24 feet.

The springs and neaps stand as follows: 1.90 and 1.00 for easterly current, 1.24 and 1.00 for westerly current.

* Stations "Hell-Gate Ferry" and "E. side of Hallett's Point" are used for local tide.

No. 5.—*Currents of New York Harbor.*

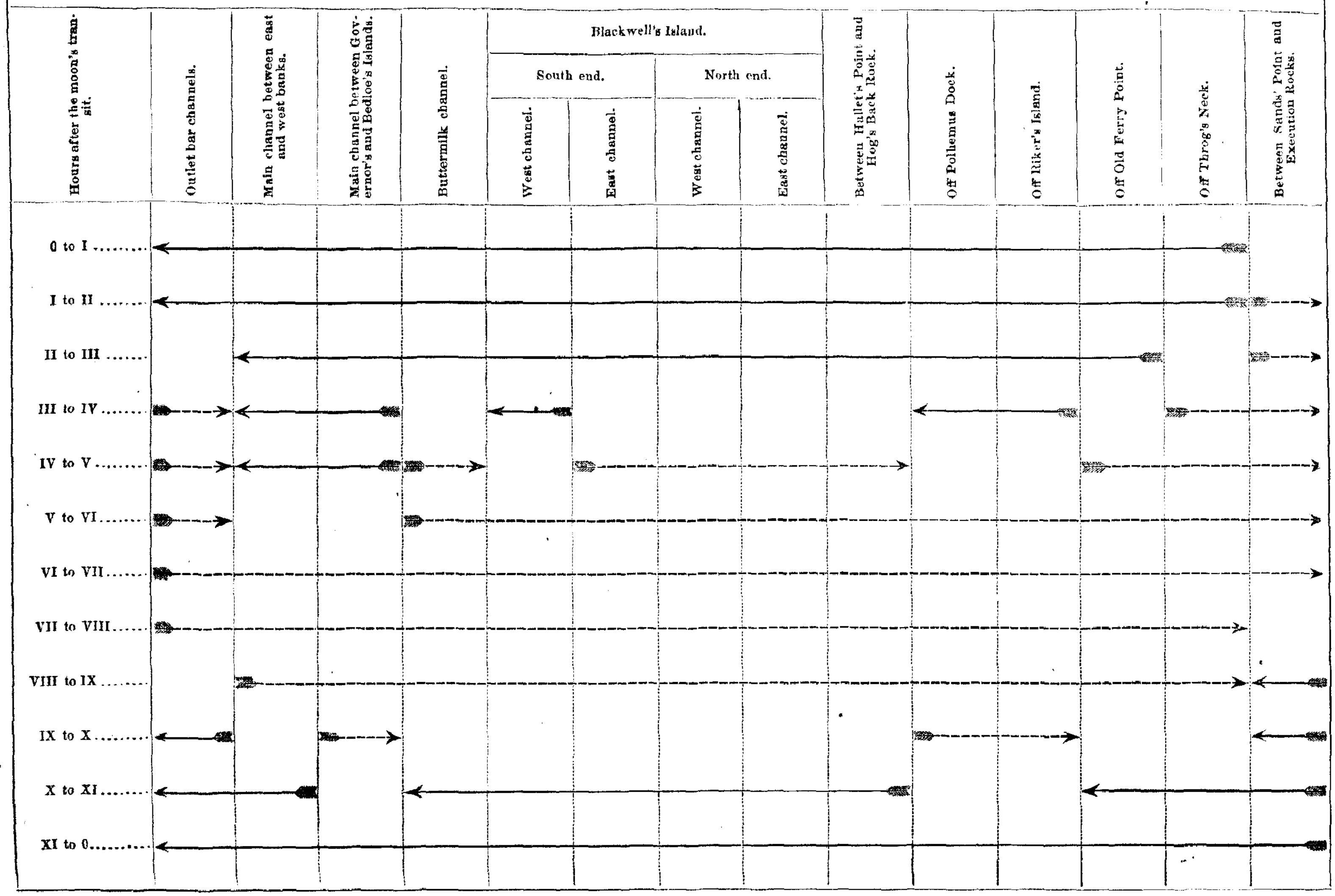
Locality.	The current turns after the moon's transit.		Durations.		Maximum velocities.			
	Flood to ebb.	Ebb to flood.	Flood.	Ebb.	Flood.	Direction.	Ebb.	Direction.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*Degrees.*	*h. m.*	*Degrees.*
Gedney's Channel	8 33	14 55	5 58	6 22	1 47	102	2 18	282
South Channel	8 36	14 50	6 06	6 14	1 25	110	2 13	312
Junction of Swash and Gedney's Channels	8 45	15 03	6 02	6 18	1 15	99	1 22	287
Central portion of Swash Channel	....	....	....	....	0 95	123	1 67	304
Channel connecting Gedney's and Eastern Channels	8 50	14 36	6 34	5 46	0 88	153	1 13	280
Main Ship Channel, (off Sandy Hook)	7 52	14 56	5 16	7 04	2 00	80	2 13	264
Main Channel, (East of Knoll's)	Uncertain	....	....	....	0 92	60	0 85	318
Western Entrance to Swash Channel	Uncertain	....	....	....	9 30	84	0 72	{ 262 { 324
Eastern Channel	8 47	15 33	5 84	6 46	1 35	119	1 25	308
Fourteen-feet Channel	9 28	15 28	6 20	6 00	0 96	130	1 21	297
Main Channel, (between East and West Banks)*	9 46	17 21	4 45	7 35	1 09	206	1 97	352
Coney Island Channel, secondary Channel	8 44	14 10	6 54	5 26	1 60	.... (†)	1 50	.... (‡) ....
West Bank Channel, secondary Channel	10 06	14 40	7 44	4 36	1 10	.... (†)	0 62	.... (‡) ....
Narrows	9 17	16 56	4 41	7 39	1 08	.... (†)	1 86	.... (‡) ....
Main Channel, (off Quarantine)	9 39	16 57	5 02	7 18	1 35	.... (†)	1 80	.... (‡) ....
Main Channel between Governor's and Bedloe's Islands	10 21	17 48	4 53	7 27	0 94	.... (†)	1 72	.... (‡) ....
Hudson River, (Forty-first street)	11 45	18 32	5 33	6 47	1 29	.... (†)	2 31	.... (‡) ....
Between Battery and Governor's Island	9 43	15 52	6 11	6 09	1 75	....	2 12	....
Buttermilk Channel	9 11	15 05	6 26	5 54	1 43	.... (†)	1 77	.... (‡) ....
Off south end Blackwell's Island, (West Channel)	9 35	16 07	5 46	6 34	2 71	.... (†)	3 22	.... (‡) ....
Off south end Blackwell's Island, (East Channel)	9 29	15 30	6 19	6 01	2 15	.... (†)	2 68	.... (‡) ....
Off north end of Blackwell's Island, (West Channel)	9 32	15 49	6 03	6 17	4 24	.... (†)	4 33	.... (‡) ....
Off north end of Blackwell's Island, (East Channel)	9 27	15 42	6 05	6 15	4 30	.... (†)	3 96	.... (‡) ....
Between Hallet's Point and the Hog's Back Rocks	9 26	15 50	5 56	6 24	8 54	.... (†)	4 40	.... (‡) ....
Hell-Gate, (off Polhemus's Dock)	10 09	16 16	6 13	6 07	3 07	.... (†)	2 30	.... (‡) ....
Off Riker's Island	10 21	16 38	6 06	6 14	1 50	.... (†)	1 22	.... (‡) ....
Off Old Ferry Point	9 33	15 07	6 46	5 34	1 55	.... (†)	1 05	.... (‡) ....
Off Throg's Neck at neap tides	10 34	14 52	8 02	4 18	0 75	.... (†)	0 70	.... (‡) ....
Off Throg's Neck at spring tides	7 39	13 12	6 47	5 33	1 48	.... (†)	0 83	.... (‡) ....
Between Sand's Point and Execution Rocks	7 38	12 58	7 00	5 20	0 65	.... (‡)	0 50	.... (†) ....

* The currents in the path of the Hudson River vary greatly with the river discharge; the flood current is sometimes altogether destroyed upon the surface.

† Flood follows the channel. ‡ Ebb follows the channel.

In the foregoing table (No. 5) I have given the epochs and velocities of the currents in New York Harbor and approaches, from selected stations occupied along the pathways of the tides from Sand's Point to the outer bar; and upon the following diagram, I offer a general scheme of the results to assist in the conception of the activities at different hours of transit:

General scheme of currents in New York Harbor and its approaches from observations—1857-'58.



We observe that during most of the period of rising tide in the harbor, the current is flowing in from the sea at Sandy Hook and out into the Sound at Hell Gate; and during most of the falling tide it pursues the reverse course. The pilots, therefore, call the inflow from the Sound "*ebb*," and the outflow "*flood*." I do not use these terms, because they are not correctly applied and are calculated to mislead, as will be apparent on closer inspection of our diagram.

During the first hour after the moon's transit (and while the tide is falling over our entire field) a continuous current flows from Long Island Sound by way of Throg's Neck, Hell Gate, and the East River, through the Upper into the Lower Harbor, and out to sea over the Bar at Sandy Hook.

During the second hour after the moon's transit this continuous stream still prevails, except near Sand's Point, where the easterly (ebb) current of the Sound prevails. The neighborhood of the Stepping Stones is at this time the scene of a separation of two grand streams from a summit.

During the third hour the summit is at Throg's Neck, and from this point a stream flows eastwardly through the Sound, and another stream taking the opposite direction flows through New York Harbor. Both are continuous in opposite directions to the ocean, in which the tide has commenced to rise rapidly.

During the fourth hour after transit the streams are broken up through Hell Gate, and Raritan Bay is receiving supplies of water from the Hudson River and from the ocean.

During the fifth hour after transit the Hudson River is still pouring into Raritan Bay a failing stream, and a local current to the eastward through Hell Gate commences.

During the sixth hour after transit the Upper Harbor in the path of the Hudson becomes slack, while a stream sets into it from the Lower Harbor, and another stream sets out of it into Long Island Sound.

During the seventh hour the current becomes continuous from the ocean through New York Harbor into the Sound. The tide is rising throughout our entire field.

During the eighth hour high water occurs at Sandy Hook, and the half-tide stage is reached in Hell Gate. The current is a continuous flow towards the Sound as far as Sand's Point, where a depression exists towards which the currents from either direction are flowing.

During the ninth hour the movement over the Outer Bar ceases; the Upper Harbor reaches its maximum elevation and commences to fall, but still a steady stream sets into the Sound upon the one hand, and up the Hudson upon the other.

During the tenth hour high tide occurs from point to point along the East River and at Dobbs' Ferry, in the Hudson. A pretty general slacking up of the Upper Harbor drifts takes place, although the Hudson inflow still obtains.

During the eleventh hour after transit the Hudson inflow ceases; but a stream flows from the East River, (as far as the Gate,) and, uniting with an ebb stream of the Harbor and that of Raritan Bay, makes the flow continuous to the ocean.

During the twelfth hour the current from the Sound, uniting with that of the Harbor, flows into the sea as a continuous stream.

NOTE.—October, 1869.—Just before sending this report to press, it was discovered that a portion of the manuscript was missing, including two diagrams. In a future report I shall restore the lost portion and add other matter.

HENRY MITCHELL.

APPENDIX No. 14.

REPORT UPON SURVEYS IN THE MERRIMACK RIVER, MADE IN 1867 BY HENRY MITCHELL, ASSISTANT U. S. COAST SURVEY.

BOSTON, *October* 31, 1867.

DEAR SIR:—I respectfully announce to you the completion of the surveys in the Merrimack River as far as at present required by the Pentucket Navigation Company, at whose expense the work has been executed; and I have the honor to submit herewith a physical map of Mitchell's Falls, (map No. 2,) together with numerous tables, to which I shall hereafter refer in this report.

Mr. H. L. Marindin, of the Coast Survey, who was assigned by you to execute surveys under my direction, commenced measuring base lines on the 3d of September. From these bases he developed both shores of the river for a distance of two miles, from Ring Bolt Rock (about a mile and a half above Haverhill) to Kimball's Island, and fixed the positions of stakes about one hundred and fifty feet apart on either side of the river. In the course of this preliminary work he also determined the positions of all the important rocks in the river—those visible and those made apparent by their ripples. There are about one hundred such rocks plotted upon the map, besides those found and fixed in position during the soundings, which followed later. I deemed it essential that these principal obstructions should be accurately laid down, not only because they were to be avoided, as far as might be, in projecting the course of the proposed artificial channel, but also because they indicate to the eye the nature and causes of the rapids. It was often necessary to send a signal man to these rocks so as to enable the observer at the plane table to distinguish them from his different positions, and to plot them more exactly. The stakes along the river, to which I have referred, were designed to serve as points of departure and termination for the sounding lines where these were not otherwise fixed in position by boat angles.

In order to ascertain the elevations and slopes of the river's surface and bed, and to correct the soundings so as to give a truthful representation of the depths throughout our field at a given time or stage, I established four gauges at the outset, and ultimately increased the number to ten, (designated by Roman numerals upon the chart.) Each gauge was referred to a local bench, and finally all were reduced to the same datum. The ten benches on the right bank of the river, designated by B^1, B^2, B^3, &c., upon the chart, are all marked by holes drilled in the tops of boulders; and the relative elevations of these, given in Table No. 1, are the results of three accordant lines of levelings, with the foot of the staff resting over the *drilled hole* in each case.

The plane-table work, the soundings, and the levelings were executed by Mr. Marindin, in a very creditable manner, and in a much shorter time than I had expected. He was favored by fine weather, and he found in Mr. Koppmann and Mr. McClintock excellent and willing co-operators. Mr. Dominicus Koppmann was temporarily employed because of his talents as a faithful draughtsman, and his acquaintance with some of the Coast Survey methods. Mr. McClintock, a new appointment upon the Coast Survey, discovered at once a disposition and an ability to make himself useful, as the field-books will show.

Before proceeding to point out the results reached by the survey, it behooves me to state the claims which the map has to your confidence. It is not based on the Coast Survey triangulation, and the only instruments used have been the plane-table, sextant, and level. Nevertheless the distances and all the visible features of the river are correctly represented. The only misgivings I have are with regard to rocks. I am afraid that some important boulders, hidden in the turbid waters of the channel-way, may have escaped our search. With some experience of the requirements of navigation, and some also of the wants of the marine engineer, we have endeavored to make a faithful survey upon which plans and estimates may be safely based. Beyond these practical objects we have not ventured.

A.—Mitchell's Falls is the general name for the locality covered by the map, which embraces three sets of rapids, no one of them deserving the title of *falls*. Two of these rapids are known, respectively, as Upper and Lower Falls; and the third, having no recognized name, we call

Hazeltine Rapids. The obstructions at the Upper Falls are confined to a distance of about seven hundred and eighty feet, those at the Lower Falls to a distance of about seven hundred and forty feet, and those of the Hazeltine Rapids to a distance of about one thousand feet.

The foot of the Upper Falls is the limit of the tide, which enters our field with a range of four feet at the station near Ring Rock. There was no *flood current* in any part of the field during our stay. At and above the Upper Falls the changes of elevation during the day are simply those due to variations of river discharge caused by the opening and shutting of the mill gates of Lawrence.

As high water, at mean, visits this portion of the Merrimack at 11 to 12 o'clock, and as at this time of day the discharge reaches a nearly uniform stage, I have found it convenient to take for the plane of reference the surface of the river at this time. The chart then exhibits the *ordinary high water conditions at mid-day when the moon is in octants.* In sub-sketches, I have given the depths on the rapids at 7 and 9 a. m., when low-water spring tides prevail. The river is usually at its minimum discharge in the morning during summer—the gates being closed during the night.

B.—In Fig. 1 I have given a section of the river along its line of greatest depression, showing the elevations of the bottom, the form of the plane of reference, and, in dotted line, a profile of the low-water plane to which the sub-sketches are reduced. In this section the least depths are, at Upper Falls, three feet for high stage, and two feet for low stage; at the Lower Falls, five feet for high water, and three and a half feet for low water; and at Hazeltine Rapids, nine feet for high water, and five feet for low water. The numerical data for this section will be found in Table No. 2. This line of greatest depression, although it is that of the thread of the current at low water, does not give a characteristic view of the bed of the stream; I have therefore given another section (Fig. 2) which is characteristic of a belt one hundred feet wide along the middle of the river. The least depth at Upper Falls is two feet for high water, and one foot for low water; at Lower Falls, two feet at high water, and three-fourths of a foot at low water; at Hazeltine Rapids, four feet at high water, and half a foot at low water. (See Table No. 3, for elements.)

The excavations which should render the river navigable would follow neither of the sections we have given throughout. It would properly follow both of them in a general way at Upper Falls, the line between them at Lower Falls, and the line of greatest depression at Hazeltine Rapids. At the Lower Falls the first section line lies too close to the shore and at too sharp a curve, at some points, to make it a practicable track for towage in the midst of a strong current.

C.—Upon the sections referred to above, (Figs. 1 and 2,) I have given the velocities in nautical miles per hour, at the two stages over the two falls. These are not the extreme velocities observed, but the reduced averages for the spaces covered by the figures.

On the Lower Falls we made current observations near times of high and low water, and measured the slopes. For period near time of high water we found a mean velocity of 1.90 nautical miles per hour, corresponding to a slope of 0.41 feet per 1,000; at period near low water a mean velocity of 2.9 nautical miles with a slope of 2.1 feet per 1,000. With the general expression

$$\text{Velocity}=a\sqrt{p}$$

we have for high water coefficient 2.93, and for low water coefficient 2.00. I think that these coefficients are practically near enough to the truth for use in calculating mean velocities for other slopes which may occur at other stages of the river and tide. In the lower chute of these falls the maximum velocity was found to be 6.6 miles per hour at low water, but at high water only 2.5 in the same place.

On the Upper Falls the greatest velocity was found near the foot of the decline, (not in the shallowest water,) and amounted to four miles at low stage, and 5.5 at high stage. It will be observed that the velocity at the Upper Falls is greater for the *higher stage*, while at the Lower Falls it is greater for the *lower stage.* There is nothing strange in this; the friction declines greatly as the water rises in the Upper Falls, while on the Lower Falls the high tide diminishes the slope at the period I use.

The low-water slope given upon Figs. 1 and 2 for Lower Falls is the greatest I observed, although the gauges were compared for other dates when the low tide fell at hours of the day corresponding to higher stages of the river; it will, however, be remembered that these were tides of less range, *the mid-day low tides being those of neaps*, or nearly so.

D.—The relations of water elevations from point to point at different hours of the day may be understood from Fig. 3 of the Physical Map, in which I give the observations of September 27 and 28 combined. This figure represents the conditions from 8 a. m. to 6 p. m. for ordinary river discharge combined with the spring tide. It is plotted from Table No. 4.

It will be observed that Station I is visited by the phases of the upper half of the tide; that the rise is tidal for a space of nearly three hours, from 11 a. m. till $1\frac{3}{4}$ p. m. The fall is more tardy, as in all tidal rivers, and I cannot say at what hour it ceases to be tidal. The change of elevation due to the tide of this station is about four feet. At the next station, situated three thousand five hundred feet higher up the river, and above the Hazeltine Rapids, the rise is distinctly tidal for less than one hour and a half, and the change of elevation due to tide is at this station about one and a half foot. At the next station (III) we find the elevation parallel to those just mentioned at II. At Station IV, between the two chutes of the Lower Falls, we have positive indications of the tide, but not well defined phases. At Stations V and VI we have still the tidal rise, but ill defined.

As we mount the Upper Rapids, we lose at Station VII not only all traces of the tide, but, at the hour when high water should occur, we have a depression caused by the shutting of the mill gates of Lawrence at dinner-time, (12 to 1.) At the other gauges above we have changes nearly parallel to those already noticed at VII. In all of these the dinner depression is well marked, but is sharpest at VIII, a station on the Upper Falls.

The feature which will interest you most in this diagram (Fig. 3) is the rise of the tidal plane. You will observe that in the space of *one mile* above Station I the absolute height of high water increases a half foot. In the Hudson River we found a rise of only *three feet* in *one hundred and forty miles.*

E.—In Figs. 4, 5, 6, and 7, I have given sections of the Upper and Lower Falls. I perceived that cross sections, vertical to the river banks, would not represent characteristic features of the bottom, and would convey very erroneous impressions of the capacity of the stream; I therefore carried the section across in the directions of *strike* and *dip*. (See Tables.)

At the Lower Falls a ledge is partially uncovered, and appears to have formed the nucleus of the accumulation that now constitutes the dam and causes the rapid. At the Upper Falls there is no visible ledge, but it is a suggestive fact that the bar which causes the rapid has a strike not widely at variance with that of the aforesaid ledge, the former having a course south $14\frac{1}{2}^{\circ}$ east, the latter south $10\frac{1}{2}^{\circ}$ west, while the general courses of the river at the two points differ about 142°.

The field-books of this survey have been properly duplicated and sent to the Coast Survey archives at Washington.

I am convinced that this river can be made navigable for barges of four feet draught, without locks or other expensive structures. After the requisite depth is obtained by excavations, the single difficulty is the strong currents at the rapid. These currents will probably be stronger than now, in the narrow excavation, because the friction will be lessened without material lessening of the slope. That towage over these rapids is impracticable with the usual appliances, I consider too patent to admit of discussion; there is, however, a simple way of getting the barges up which I take the liberty to mention, in the crude form that the idea has occurred to me. I should cut straight passes through each of the rapids and place buoys (or rings in the rocks) above and below the chute. On arriving at the lower mooring, I should secure the barges, then pay out my hawser and run to the upper mooring; secure the steam-tug here, then bring the hawser to the windlass, and, connecting the latter with the engine, haul the barges up to the same point. Of course the windlass and its connection with the engine should be arranged with special adaptation to the purposes mentioned. No excavations need be made nor moorings provided at the Hazeltine Rapids, until the commerce shall become too great to admit of the delay, near time of low water, that the present conditions make necessary.

In looking back upon this very interesting work, and forward to its ultimate objects, I find cause to regret that the company should have hesitated to afford the means for the further development of some of its details; because ***a dollar spent in properly basing a project is worth ten in the execution.***

Very respectfully, yours,

HENRY MITCHELL,
Assistant United States Coast Survey.

Professor BENJAMIN PEIRCE,
Superintendent United States Coast Survey.

No. 1.—*Relative positions of benches.*

Benches.	Distances.	Elevations.	Remarks.
	Feet.	*Feet.*	
B^1	....	10.00*	At Ring Rock, about 1½ mile above Haverhill.
B^2	1,858	7.75	
B^3	3,658	9.69	Foot of Lower Falls.
B^4	4,647	11.28	
B^5	5,348	9.56	
B^6	7,211	12.70	
B^7	8,086	12.03	
B^8	8,726	10.72	
B^9	9,270	14.94	Foot of Upper Falls.
B^{10}	10,517	13.96	On east shore, opposite north end of Kimball's Island.

* Assumed *datum plane*, ten feet below B^1.

Benches B^1, B^3, B^4, B^6, B^9, B^{10} are too large and heavy to be affected by the frost at any time; others may be started.

The distances are measured along the course of the river.

The benches are each marked by a hole drilled into the top of a rock, and in determining the elevations the foot of the leveling staff was placed so as to cover the hole.

No. 2.—*Elements for sectional view of the Merrimack River along line of greatest depression.*

Distances in feet.	Elevations of bottom.	Elevations of low-water surface, springs, 8 a. m.	Elevations of mean high-water surface, 12 m.	Depths at low-water, springs.	Depths at mean high water, 12 m.	Variations of depths daily.	Distances in feet.	Elevations of bottom.	Elevations of low-water surface, springs, 8 a. m.	Elevations of mean high-water surface, 12 m.	Depths at low-water, springs.	Depths at mean high water, 12 m.	Variations of depths daily.
000	− 2.94	3.20	7.56	6.14	10.50	4.36*	6,000	− 6.20†	7.83	8.80	14.03†	15.00†	0.97
1,000	− 1.88	3.25	7.62	5.13	9.50	4.37	7,000	−10.12†	7.85	8.88	17.97†	19.00†	1.03
1,250	− 2.37	3.47	7.63	6.00	10.00	4.00	8,000	− 6.10	7.87	8.90	13.97	15.00	1.03
1,500	− 1.85	3.70	7.65	5.88	9.50	3.62	9,000	− 1.07	7.88	8.93	8.95	10.00	1.05
1,750	− 3.84	4.25	7.66	8.26	11.50	3.24	9,500	− 3.94	7.90	9.06	11.85	13.00	1.15
2,000	− 1.33	4.80	7.67	6.13	9.00	2.87	10,000	+ 2.20	7.96	9.20	5.76	7.00	1.24
2,500	− 5.80	5.50	7.70	11.00	13.50	2.50	10,250	+ 2.15	9.06	9.65	6.91	7.50	0.59
3,000	− 3.77	5.60	7.73	9.37	11.50	2.13	10,500	+ 3.10	9.15	10.10	6.05	7.00	0.95
3,500	− 7.20†	5.63	7.80	12.82†	15.00†	2.18	10,750	+ 7.65	9.65	10.65	2.00	3.00	1.00
4,000	− 4.13	5.65	7.87	9.78	12.00	2.22	11,000	+ 6.70	10.15	11.20	3.45	4.50	1.05
4,500	− 0.05	5.80	7.95	7.85	8.00	2.15	11,250	+ 8.29	10.31	11.29	2.02	3.00	0.98
4,750	+ 3.22	6.45	8.22	3.24	5.00	1.76	11,400	+ 5.38	10.45	11.38	5.07	6.00	0.93
5,000	+ 0.98	7.10	8.48	6.12	7.50	1.38	12,000	+ 2.38	10.45	11.38	8.07	9.00	0.93
5,500	− 1.28	7.80	8.72	9.08	10.00	0.92	12,500	+ 2.38	10.45	11.38	8.07	9.00	0.93

* Off Ring Rock. † No bottom.

No. 3.—*Elements for sectional view of the Merrimack River, along the middle of the stream.*

Distances.	Elevations of bottom.	Elevations of low-water surface, springs, 8 a. m.	Elevations of mean high-water surface, 12 m.	Depths at low-water, springs.	Depths at mean high water, 12 m.	Variations of depths daily.	Distances.	Elevations of bottom.	Elevation of low-water surface, springs, 8 a. m.	Elevations of mean high-water surface, 12 m.	Depths at low-water, springs.	Depths at mean high water, 12 m.	Variations of depths daily.
000	— 1. 69	3. 20	7. 56	4. 89	9. 25	4. 36*	7, 000	— 6. 87	7. 85	8. 88	14. 72	15. 75	1. 03
1, 000	+ 1. 62	3. 25	7. 62	1. 63	6. 00	4. 37	8, 000	— 2. 10	7. 87	8. 90	9. 97	11. 00	1. 03
1, 250	+ 3. 13	3. 47	7. 63	0. 50	4. 50	4. 00	8, 500	+ 2. 92	7. 87	8. 92	4. 96	6. 00	1. 04
1, 500	+ 2. 65	3. 70	7. 65	1. 38	5. 00	3. 62	9, 000	+ 4. 93	7. 88	8. 93	2. 95	4. 00	1. 05
1, 750	+ 2. 16	4. 25	7. 66	2. 26	5. 50	3. 24	9, 250	+ 3. 49	7. 89	8. 99	4. 40	5. 50	1. 10
2, 000	+ 3. 17	4. 80	7. 67	1. 63	4. 50	2. 87	9, 500	+ 4. 06	7. 90	9. 06	3. 85	5. 00	1. 15
2, 250	+ 3. 69	5. 15	7. 69	1. 32	4. 00	2. 68	9, 750	+ 1. 63	7. 93	9. 13	6. 50	7. 50	1. 20
2, 500	+ 2. 20	5. 50	7. 70	3. 00	5. 50	2. 50	10, 000	+ 5. 20	7. 96	9. 20	2. 76	4. 00	1. 24
3, 000	— 2. 19	5. 60	7. 73	7. 79	9. 92	2. 13	10, 250	+ 2. 65	8. 55	9. 65	6. 90	7. 00	1. 10
3, 500	— 4. 86	5. 62	7. 80	10. 48	12. 66	2. 18	10, 500	+ 6. 00	9. 15	10. 10	3. 05	4. 00	0. 95
4, 000	— 0. 97	5. 65	7. 87	6. 62	8. 84	2. 22	10, 620	....	....	....	1. 03	2. 00	0. 97
4, 500	— 0. 05	5. 80	7. 95	5. 58	8. 00	2. 15	10, 750	+ 4. 65	9. 65	10. 65	5. 00	6. 00	1. 00
4, 750	+ 2. 72	6. 45	8. 22	3. 74	5. 50	1. 76	11, 000	+ 5. 70	10. 15	11. 20	3. 45	4. 50	1. 05
5, 000	+ 5. 73	7. 10	8. 48	1. 37	2. 75	1. 38	11, 250	+ 5. 79	10. 31	11. 29	4. 52	5. 50	0. 98
5, 250	+ 6. 60	7. 45	8. 60	0. 85	2. 00	1. 15	11, 400	+ 4. 88	10. 45	11. 38	5. 57	6. 50	0. 93
5, 500	— 2. 78	7. 80	8. 72	10. 58*	11. 50	0. 92	12, 000	+ 2. 88	10. 45	11. 38	7. 57	8. 50	0. 93
6, 000	— 6. 20	7. 83	8. 80	14. 03†	15. 00†	0. 97	12, 500	+ 5. 38	10. 45	11. 38	5. 57	6. 00	0. 93

* Ring Bolt Rock.

No. 4.—*Water elevations at different hours of the day, at spring tides, Mitchell's Falls, Merrimack River, September 27 and 28, 1867.*

Time.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
8.......	3. 20	5. 70	5. 76	7. 41	7. 86	7. 85	8. 16	8. 92	9. 96	10. 50
	3. 20	5. 94	6. 02	7. 61	8. 06	8. 02	8. 44	9. 25	10. 10	10. 69
9.......	3. 30	6. 22	6. 32	7. 76	8. 21	8. 21	8. 60	9. 40	10. 20	10. 79
	3. 40	6. 43	6. 54	7. 86	8. 31	8. 31	8. 76	9. 57	10. 28	10. 94
10.......	3. 55	6. 58	6. 69	7. 91	8. 36	8. 44	8. 95	9. 75	10. 30	11. 00
	3. 75	6. 68	6. 80	7. 96	8. 41	8. 48	9. 00	9. 80	10. 46	11. 10
11.......	4. 10	6. 76	6. 86	8. 01	8. 46	8. 52	9. 05	9. 85	10. 49	11. 12
	4. 75	6. 82	6. 94	8. 10	8. 51	8. 57	9. 09	9. 90	10. 53	11. 21
12.......	5. 70	6. 92	7. 03	8. 21	8. 56	8. 61	9. 16	9. 98	10. 55	11. 22
	6. 60	7. 22	7. 32	8. 26	8. 56	8. 65	9. 20	10. 00	10. 56	11. 22
13.......	7. 40	7. 73	7. 82	8. 36	8. 61	8. 66	9. 20	9. 90	10. 47	11. 17
	7. 95	8. 16	8. 22	8. 43	8. 63	8. 67	9. 06	9. 73	10. 37	11. 00
14.......	8. 00	8. 28	8. 36	8. 48	8. 71	8. 77	9. 19	9. 90	10. 50	11. 16
	7. 50	7. 98	8. 04	8. 41	8. 66	8. 76	9. 26	10. 03	10. 67	11. 34
15.......	7. 05	7. 67	7. 76	8. 26	8. 61	8. 71	9. 23	10. 00	10. 65	11. 35
	6. 65	7. 43	7. 54	8. 20	8. 60	8. 66	9. 20	9. 96	10. 57	11. 25
16.......	6. 30	7. 28	7. 39	8. 15	8. 60	8. 67	9. 20	9. 96	10. 57	11. 25
	5. 90	7. 17	7. 31	8. 15	8. 60	8. 67	9. 23	9. 96	10. 62	11. 29
17.......	5. 60	7. 08	7. 22	8. 16	8. 61	8. 68	9. 24	9. 98	10. 57	11. 27
	5. 40	7. 05	7. 15	8. 15	8. 60	8. 66	9. 21	9. 96	10. 55	11. 25
18.......	5. 10	6. 98	7. 10	8. 11	8. 56	8. 62	9. 17	9. 92	10. 53	11. 23
Distances	000	3, 416	4, 584	4, 863	5, 492	7, 277	9, 968	10, 422	10, 705	11, 403

In the preceding table the heights are referred to a common datum, ten feet below the bench at Ring Rock.

No. 5.—*Section of ledge at Lower Falls along its strike plane of reference, ten feet below bench No. 1.*

Distances.	Heights.	Bottom.	Distances.	Heights.	Bottom.	Distances.	Heights.	Bottom.
Feet.			*Feet.*			*Feet.*		
000	000	Shore line.	798	—1.80	Ledge.	912	— 1.26	Ledge.
10	—1.500	Boulders.	804	—1.43	Do.	918	— 1.58	Do.
175	—6.000	Do.	810	—2.10	Do.	924	— 1.98	Do.
262	—9.000	Do.	816	—1.70	Do.	930	— 1.59	Do.
399	—5.500	Do.	822	—1.74	Do.	936	— 1.64	Do.
563	—1.000	Rock.	828	—1.96	Do.	942	— 0.98	Do.
720	—1.80	Ledge.	834	—1.41	Do.	948	— 0.77	Do.
726	—2.34	Do.	840	—1.43	Do.	954	— 1.63	Do.
732	—1.87	Do.	846	—0.22	Do.	960	— 1.73	Do.
738	—2.00	Do.	852	+0.40	Do.	966	— 1.39	Do.
744	—1.84	Do.	858	—2.14	Do.	972	— 0.50	Do.
750	—2.16	Do.	864	—2.02	Do.	978	— 1.03	Do.
756	—2.24	Do.	870	—1.54	Do.	984	— 0.80	Do.
762	—2.39	Do.	876	—1.44	Do.	990	— 0.14	Water's edge.
768	—2.03	Do.	882	—1.40	Do.	1,003	+ 8.46	
774	—1.46	Do.	888	—1.10	Do.	1,006	+17.00	
780	—1.59	Do.	894	—2.20	Do.	1,029	+20.80	Ancient water margin.
786	—1.83	Do.	900	—1.83	Do.	1,061	+19.60	Foot of back slope.
792	—1.20	Do.	906	—1.81	Do.	1,100	+21.70	Side of hill.

No. 6.—*Lower Falls, section in direction of dip of ledge.*

Distances.	Elevations of bottom.		Distances.	Elevations of bottom.	
000	000	Shore line below St. No. 20.	260	—2.00	
10	—3.00		332	—2.00	
30	—7.00	Channel.	410	—3.00	
55	—7.00		436	—3.50	
73	—6.00		497	—3.50	
103	—4.00		527	—1.50	
117	—3.00		598	—2.50	
150	—2.00		705	—1.00	
200	—2.50		725	000	Shore line below St. C.

No. 7.

Upper Falls.—Section in strike of bar.			Upper Falls.—Section at right angles to bar.		
Distances.	Elevations of bottom.		Distances.	Elevations of bottom.	
Feet.	*Feet.*		*Feet.*	*Feet.*	
000	+3.00		000	+3	Stake L.
35	0.00		12	0.00	
258	—1.00		77	4.50	
347	—2.00		143	6.75	
422	—2.00		224	3.00	
445	—1.25		257	2.00	
643	—2.00		337	2.00	
680	—3.00	Channel.	368	3.00	Channel.
730	—2.50		427	4.75	
768	—4.00		518	3.00	
810	—2.50		558	2.00	
854	—3.50		583	....	Gauge VIII.
889	—3.00		603	0.00	
950	—2.75				
1,024	—2.00				
1,109	—1.75				
1,123	0.00				
1,143	+2.00				

APPENDIX No. 15.

REPORT OF ASSISTANT HENRY MITCHELL ON SOUNDINGS MADE TO DEVELOP THE CHARACTER OF THE STRAIT OF FLORIDA, BETWEEN KEY WEST AND HAVANA.

BOSTON, *August* 5, 1867.

DEAR SIR: Under date of April 20, I had the honor to receive from you instructions "to continue the investigations which were begun last year in the Gulf Stream, between Florida Reef and the coast of Cuba, with a view to determine the best line for a telegraph cable between Key West and Havana," and if possible to push the observations beyond this immediate object, so as to add to our general knowledge of the stream.

The Coast Survey steamer Corwin, with the surveying party on board, under command of Acting Master Robert Platt, United States Navy, was placed at my "disposal," and Captain L. F. Pourtales, of the Coast Survey, was directed to accompany us and lend his knowledge of natural science to the enterprise.

Captain Platt's party was already at work on the Florida Reef, and Mr. Pourtales and myself, having prepared our equipments very much to our satisfaction, joined the steamer at Key West on the 13th of May. Although we felt, at the outset, some misgivings because of the lateness of the season, the interest and early success of our operations very soon wholly engrossed our minds, and our own enthusiasm seemed to communicate itself to all others on board till the appearance of yellow fever amongst the crew, and the fatal termination of some of the cases, put an abrupt barrier upon further progress. Our communications were cut off by quarantine, and rather than remain idle in a sickly climate we decided to anticipate your orders for our return. We, therefore, left for Port Royal on the 7th of June. Our action has received your cordial support, and we feel that this was due.

I shall proceed to report upon the fragment of work accomplished.

After the necessary preparations for active work, such as coaling, unpacking apparatus, &c., we left Key West for Havana on the 17th of May. Finding the sea unusually smooth beyond the reef, and that we were likely to have a calm day, we decided to lie to on the one hundred fathom line and test our instruments. By using different lines and weights, and suffering the registration to go on without resetting, we determined the coefficients of our indicators. We also drilled our men in all the manœuvers with the deep-sea lines and leads, and satisfied ourselves that in a depth of one hundred fathoms, at least, a *dredge* could be used with facility and success.

While these trial observations were going on we kept a close watch upon the drift of the ship, and for short periods anchored a boat and measured the currents. We discovered that the current ran five or six hours to the westward, and afterwards to the eastward, in other words, that we were drifting with *tidal currents.* The most singular circumstance about these currents was that the *falling tide ran to the westward* and *the rising to the eastward*, the reverse of what I should have expected. We designed to repeat these observations at other stages of the moon but had not the opportunity. Our position was ten miles south of Sand Key light. The eastwardly flow was four times the velocity of the westwardly drift, showing the influence of the Gulf Stream.

I am convinced that good service to navigation may be done by series of observations made from anchorage stations along the coast within the Gulf Stream. If there are, as has been so often stated, counter currents to the Gulf Stream which sweep in upon soundings, our coasters ought to know them, and our charts ought to show them for systematic observations. I have often been impressed with a conviction that the coastwise tidal currents are mistaken for these counter Gulf Streams, and that upon investigation their velocities and epochs may be determined. The space between Hatteras and Cape Canaveral deserves the earliest attention from this point of view. A well-found fishing vessel with a competent sailing master, and a Coast Survey officer in charge, could make many stations in one quiet season. I offer these suggestions for what they are worth, or for what they may be worth when the Coast Survey can afford these details.

After the day's work above mentioned, we went over to Havana and delivered to the United States vice-consul, Mr. Savage, an unofficial letter from Mr. Seward. Through Mr. Savage we obtained from the Captain General, after some delay, a permit to rendezvous at Chorrera, the proposed landing place of the cable.

Chorrera is a little basin at the mouth of the Almendaraz River. It is quite open to the north and has no bar or other obstructions at its entrance. The anchorage in three to five fathoms would scarcely accommodate a half dozen vessels, and the holding-ground is at best but coral sand. The river, two miles perhaps from the basin, falls ten or twelve feet perpendicularly, and for some distance below hurries on in rapids. The banks are generally very high, and covered with dense foliage except where the rugged and cavernous limestone rock crops out.

The rather low coast in the vicinity of Chorrera entrance is very ragged, the blackened coral rock being honey-combed and worn in pot-holes by the sea. But beyond the water-line the bottom is comparatively smooth, and falls off rapidly. The measurement of this decline of the reef apron was fixed upon as a first essay.

The season was already too far advanced for us to expect a continuous quiet weather, but we found the general rule to be, between daylight and 10 a. m., a smooth sea and calm; between 10 a. m. and 4 p. m. a sea breeze from eastward, at times quite strong, with a sharp sea.

After 4 o'clock, heavy squalls with torrents of rain usually occurred, and sometimes accompanied by water spouts.

Upon Table No. 1 and its accompanying profile diagram I have given the results of our soundings from Chorrera, northward, to a point beyond the one-thousand-fathom line, yet scarcely twenty miles from the shore. Señor Don Enrique de Avantave, Sub-Inspector General of telegraphs for the Island of Cuba, supplied us with excellent base lines, comprising the relative positions of Fort Chorrera, (east angle,) Fort Principe, (flag-staff,) and Moro Light. Upon Fort Chorrera we placed Mr. Bissell, an aid of Captain Platt's, with instructions (which he carefully followed) to angle upon the steamer with his theodolite at regular intervals whenever in sight; and Messrs. Bradford, Glass, and Lee, from the paddle-boxes or mark-heads of the steamer, took angles with sextants, not only upon the determined points as long as visible, but also upon prominent mountains, so as to check their positions upon the Spanish map in our possession. There are only three stations on this table that lie beyond sight of the determined positions given by Mr. Avantave. These are the last three, and are quite near enough for any purpose for which this table is likely to be used, especially as there is nothing peculiar about the profile so far out.

The most precipitate slope actually measured lies about one-half mile from the shore, where the decline is *one* vertical to *one and three-tenths* horizontal. This is in the neighborhood of the one-hundred fathom line. Between the one and the two-hundred fathom lines the slope is still very great, one in *two and seven-tenths*. Beyond this the slope is more gradual, and at two hundred and seventy fathoms we have a flat space, the top of a terrace. This terrace is remarkable, not only because it presents a decided feature in our diagram of the profile, but also because it was here that Mr. Pourtales's dredge, on two occasions, brought to light organic forms in great abundance and variety. In one of these trials, nearly a peck of material was emptied upon the deck, in which appeared living corals, sponges, shell-fish, &c., together with other species of the same, apparently long dead, and perhaps not of local origin. It seemed to me that success in the use of the dredge depended upon an acquired skill in the proper loading and dragging of the apparatus, and that it might be used in any depth after a little experience. Hereafter, the only use that the "specimen cup" of the lead need be put to is to furnish indisputable evidence of the bottoms being reached.

The fore slope of the "terrace" has at first a steep decline, *one* in *two and six-tenths*, but further on becomes more gradual, *one* in *ten*, as it approaches the four-hundred fathom curve two and a quarter miles off shore. And here we seem to be on the brow of another terrace, far beyond; in a space of a mile and a quarter the *average* slope is as great as *one* in *three and a half*, with soft *mud* at seven hundred and eighty-two fathoms. As it is improbable that mud can, under any circumstances, lie at the slope we have mentioned as the *average*, we are obliged to conceive that the reef apron terminates precipitately. While the ship was drifting from the four hundred and sixteen fathom cast, we cast the dredge and hauled it in from a position which plots about where the six hundred fathoms should be. We had paid out but five hundred and fifty fathoms of line, so the dredge must have been on bottom but a short time. We found in it only black branches of coral, long dead.

It would have been to me a point of the highest interest to endeavor to follow the forms of life to the extremity of the reef apron, and to gratify the curiosity that I have felt to connect the phenomena of life with those of the temperature and pressure of the sea, and to find, perhaps, in these terraces the limits of range for certain species; since the discovery of life, at great depths, has shaken somewhat my preconceived ideas as to the great age and thickness of the reef.

As we have said, the sounding in seven hundred and eighty-two fathoms lay quite beyond the extremity of the reef apron in soft mud. I find, consulting the record, that "our lead buried itself two feet (nearly half its length) in a white mud." From this point to the curve of one thousand fathoms (the greatest depth yet obtained in the Straits of Florida) the decline was found on the average about *one* in *seventy-four*, about the natural slope of muds deposited on the borders of tidal channels in our harbors and bays.

Current observations.—Perhaps there is no locality which offers greater facility for an intimate study of the Gulf Stream than the neighborhood in which we have been working. Here the stream is narrow, and presses close in upon the coast, and here the variations of depth are most rapid. As we have seen from the table of soundings, the thousand fathom line is scarcely out of sight of the high lands of Cuba, and there is ample testimony from different explorations that the variations of temperature with the depth are here most decidedly marked.

Although I do not assume that the phenomena presented in a limited section of the Gulf Stream, however well defined, must necessarily reflect the conditions of its whole course, I offer our results in Table No. 2 as a few positive facts which are beyond cavil, notwithstanding that they stand in contradiction to an accepted theory in defense of which I have myself offered *circumstantial evidence* heretofore.* I allude here to the theory of a *polar current* under-running the Gulf Stream and counter to its course. I am rather surprised that this theory, however plausible to explain the low temperature and support the *heat origin* of the Gulf Stream, should never have been tested by simple observations upon the facts. The evidence of this table is that *the Gulf Stream has a nearly uniform velocity, and constant course for a depth of six hundred fathoms, although its temperature varies in this depth 40° Fahrenheit.*

The means we employed for obtaining the directions and rates of the sub-currents were similar to those described in Appendix No. 26 of the Coast Survey Report of 1859. For *detecting* the *existence* of counter currents or for measuring the changes varying uniformly with the depth, our means will bear criticism.

During our stay at Chorrera the inner edge of the stream was occasionally well defined, and lay a few hundred feet from salient points of the ragged shore line. We were, however, told by the fishermen that it occasionally receded a long distance. It may be seen by our table that we repeated the coastwise current observations, and on the 23d and 31st, actually traversed the same line with our floats with large variations of velocity. These variations may bear some relation to the tide. On the 23d we observed at and soon after low water, while on the 31st we worked at the high water of an unusually great tide.

Our table indicates a diminution of velocity with distance from the two hundred and seventy fathom line; and our reckoning at stations still further out (not given in our table) indicates the same, so that we could but regard the westward bound coasters as following blindly a traditional custom when we saw them "*hug the shore*" to avoid the Gulf Stream.

In preparing my outfit considerations of economy led me to lay in but few detaching leads, especially as I could not comprehend their advantage. From the best testimony and reasoning that I could command it appeared that the principal resistances to be overcome in hauling up, were those of friction along the line, and those resulting from the abrupt figure of the lead; so that seventy to one hundred pounds could make but little difference except that it might snap the line in a sharp sea by its *dead weight.* I therefore reduced my lines to the minimum size, and gave to my leads the most attenuated forms. But experience has taught me that *the form of the lead is unimportant, but that its weight is all-important.* With eight hundred fathoms of line to haul in, fifty per centum more power was required when the seventy-five pound lead failed to detach, than when the line and spindle only remained; and at less depths the difference was even greater. I purpose to make the forms and weights of leads, in their relation to the resistances to hauling in, matters of special experiment, because it appears to me that some anomalies present themselves here.

In comparing our recent work with that of last year, I am struck with the evidences of im-

* Am. Jour. Science, Jan., 1867, page 73.

proved manipulation. I think that Captain Platt and his executive officer, Mr. Dimon, have developed a great deal of skill in meeting the difficulties of deep sea-work; and I have suggested to the former to write a report on every detail of a working day, that his experience may benefit others. Reports on manipulation are, to my mind, of very great value when carefully written.

I have presumed that Mr. Pourtales would write out his descriptions of the organisms brought up from the bottom, and communicate them directly, so I have not asked him to join me in this report.

Very respectfully yours,

HENRY MITCHELL,
Assistant United States Coast Survey.

Prof. BENJAMIN PEIRCE,
Superintendent United States Coast Survey.

No. 1.—*Soundings in the Gulf Stream near the Coast of Cuba,* 1867.

Date.	OBSERVATIONS.				PROFILE ON LINE RUNNING N. 8° W.			
	Distance.	Direction.	Depth.	Kind of bottom.	Distance.	Depth.	Slope.	Bottom.
	Miles.	° ′	*Fathoms.*		*Miles.*	*Fathoms.*		
May 25	0.22	N. 30 W.	0.00	*Coral rock.	0.26	General coast line.		
	0.54	19 20	27	Coral	0.58	27	1 : 12	
	0.69	13 35	124	"	0.70	124	1 : 13	
	0.85	12 14	188	"	0.87	188	1 : 2.7	
	0.87	18 13	187	Coral sand	....	....	1 : 2.7	
	0.89	10 39	199	Coral......	0.90	199	1 : 8.2	
May 24	1.51	6 30	271	Coral sand.	1.48	271		
	1.56	14 35	Successful dredging.	Livi'g coral sponges and shell fish.	....	....	A reef or level space. Liv'g coral.	
May 29	1.58	1 16 E.	Successful dredging.					
May 24	1.66	3 24 W.	270	....	1.60	270	1 : 26	
May 25	1.73	8 09	321	....	1.73	321	1 : 99	
	2.66	7 59	416	Hard......	2.66	416		
	2.91	9 32	Successful dredging.	Dead coral.	....	....	1 : 3.5	
May 27	3.92	2 36	782	Mud	3.92	782		
May 28	9.50	14 27	925	"	9.50	925	1 : 39	
	13.80	10 20	952	"	13.80	952	1 : 161	
	19.80	10	1,001	"	19.80	1,001	1 : 124	

* East point of entrance to Chorrera Harbor.

NOTE.—The distances are measured from Fort Chorrera.

For the last three stations the *reliable* points on shore were out of sight, so that the distances cannot be depended on within a mile.

No. 2.—*Gulf Stream.—Current observations.*

Date.	Distance from Fort Chorrera.	Depth of observation.	Velocity.	Direction true.	Depth of sea.
1867.	*Miles.*	*Feet.*	*Naut'l miles.*	° ′	*Fathoms.*
May 23	1.5	3	0.96	N. 52 E.	270
May 30	0.7	1	1.10	92	
	0.8	1	1.06	83	
May 31	1.6	1	1.43	61	270
May 27	3.7	1	1.10	62	
	"	1,800	1.10	"	
	"	2,400	1.10	"	
May 29	6.4	1	1.02	72	
	"	3,600	0.94	"	

REMARKS.—The depths are interpolated from table of soundings.

The temperatures of the sea are observedas follows: Surface = 81° to 82°; at 274 fathoms = 59°; 492 fathoms = 45°; 555 = 42½°. Density of the water = 1.023.

APPENDIX No 16.

REPORT ON THE FAUNA OF THE GULF STREAM IN THE STRAIT OF FLORIDA.

CAMBRIDGE, *October* 18, 1867.

SIR: In your instructions of April 20 you had assigned to me the duty of making an exploration of the Gulf Stream in a section from Key West to Havana jointly with Assistant H. Mitchell. The part of the work assigned to me was the examination of the fauna of the Gulf Stream, both at the surface and at the bottom, and if possible of the water at different depths.

For that purpose I had provided myself with dredges of a small size, as I was afraid larger ones would be unmanageable in great depths; in consequence, some of the casts were not as successful as they perhaps might have been. As it proved that there was no greater difficulty in hauling up the dredge than the sounding lead, I shall in future use them of the ordinary size. For the surface, tow-nets of bunting, stretched over rings of strong wire, were used. They were made of different sizes, so as to be used at different velocities of the steamer.

I shall now give a statement of the contents of the dredge at each cast, but without entering into a detailed zoological description of the animals obtained, which would be too technical for the present purpose.

The first dredgings were made on May 17th, about five miles south-southwest of Sand Key, in depths of from ninety to one hundred fathoms, chiefly for the purpose of practice. Specimens of about thirty species of animals were obtained, classed as follows:

ARTICULATA.	MOLLUSCS.	RADIATA.
Crustacea—	Gasteropods, 3 species, dead.	Asteroids, 2 species, living.
Brachiura, 2 species, living.	Pteropods, 4 species, dead.	Actinians, 2 species, living.
Anomalura, 1 species, living.	Acephala, 1 species, living.	Hydroids, 3 species, living.
Amphipods, 1 species, living.	Bryozoa, 1 species, (?).	
Cirrhipeds—		Foraminifera, 5 species, (?)
Balanus, 1 species, dead.		
Annelids—		
Annelids proper, 4 species, living.		
Gephyrians, 1 species, living.		

Further dredgings on that side of the straits were postponed until our return from the Cuban coast, but could not be resumed, as you know, on account of the epidemic which broke out on board.

On the coast of Cuba our first cast of the dredge was made on the 24th of May in a depth of two hundred and seventy fathoms; only few and mostly dead specimens were obtained.

ARTICULATA.	MOLLUSCA.	RADIATA.
Annelids, 2 species, living.	Gasteropods, 1 species, dead.	Echinoids, 1 species, dead.
		Crinoids, 1 species, frag., fresh.
Cirrhipeds, 1 species, dead.	Pteropods, 1 species, dead.	
		Corallaria, 4 species, living.
	Brachiopods, 1 species, dead.	Hydroids, 1 species, living.

On this and subsequent days several specimens of a siphonophora were found attached to the sounding lines, generally in its lower part, but it is not possible to say at what depth they were floating. They were never found in the dredge.

On the 25th a cast of the dredge was made in a depth estimated at the time as three hundred and fifty fathoms, five hundred and fifty fathoms of line being run out. Mr. Mitchell's plotting seems to indicate deeper water. Very little was obtained and that mostly dead, viz: some sprigs of dead corals of a genus allied to oculina, a fragment of the silicious skeleton of a sponge and a few deep-sea foraminifera.

The next cast was obtained on the 29th, in the depth of two hundred and seventy fathoms and near the position occupied on the 24th. This was by far the most successful, the dredge being nearly full and the specimens mostly living, belonging to between seventy and eighty different species.

VERTEBRATA.	ARTICULATA.	MOLLUSCA.	RADIATA.
Shark's tooth.	*Crustacea*— Macrura. 2 species. living. Amphipods, 2 species living. *Annelids*, 9 species, living. Cirrhipeds, 1 species dead.	Gasteropods, 5 species dead. Gasteropods, 1 species, living. Pteropods, 7 species. dead. Brachiopods. 2 species, living. Bryozoa, 5 species. living.	Echinoids, { 2 species, living. 2 species, dead. Asteroids. 3 species. living. Crinoids, 1 species, living, (?). Corallaria. 11 species, living. (Hyalonema spicules.) Hydroids, 4 species, living. Sponges. 11 species. living. Foraminifera. 9 species. Polycystinae.

Besides these, nodules of limestone were brought up in the dredge composed entirely of the same species fossilized and conglomerated. No diatoms were detected in the sand, which is mostly calcareous, with a very slight admixture of silicious grains. Vegetable life appears to be very deficient in these depths, only a few diatoms and a small piece of a minute seaweed (*Centrocerus clavulatum*, Agh.) having been found in the dredge. This is in accordance with the experience of observers in other seas. In consequence of that fact most of the animals of the deep-sea fauna must necessarily be carnivorous.

The discovery of so varied a fauna at such great depth is an unexpected result in the history of the geographical distribution of organized beings. The examination of numerous specimens of sea-bottom brought up by the lead has made us acquainted with a fauna very rich in individuals, though poor in species, and indeed confined almost entirely to one of the lowest classes of the animal kingdom, the foraminifera. The dredge has shown us now that they form but the lowest step, and that above them rise representatives of all the higher branches, except perhaps the vertebrata, (fishes,) and of the presence or absence of the latter we have no proof, probably only because we have as yet employed no means to procure it.

I have still to mention some specimens of mud brought up by the lead from depths ranging between nine hundred and twenty-five and one thousand fathoms. They are of the same character as those obtained in former years in the same region and in a larger part of the Gulf of Mexico, viz: a soft calcareous mud, white near the Florida coast, and somewhat darker as you approach Cuba. It is almost entirely soluble in acids, leaving a flocculent residuum, probably of no organic matter. It seems to be composed of the debris of foraminifera, a few of which are still found entire, of the forms usually found in the deepest water, of which globigerina and rotalina cultrata and truncatulinoides form the bulk.

The surface of the sea was found during the whole cruise remarkably barren, contrary to expectations based on former experience in those seas. Even the large Physalias, (Portuguese men-of-war,) and allied species, usually so common, were very rarely seen. The fauna of the surface helps in a small proportion to build up the strata of the bottom by its debris; thus we find the delicate shells of the pteropods in nearly every small portion examined, some of the species of creseis and spirialis being the most common. Valves of the barnacles which live attached to the gulf-weed are also found occasionally. A small and very delicate globigerina, the only floating foraminifera which I have found thus far, probably sinks also after death, but I have not yet recognized it at the bottom.

In a geological point of view these investigations of the sea bottom present a peculiar interest, as showing that there the formation of several kinds of sedimentary rocks is going on at the present day. Thus we have off the coast of South Carolina greensand forming from foraminifera; all the stages of transformation being plainly traceable, as has been shown by Professor Bailey and myself. Again, we have just seen a highly fossiliferous limestone forming on the coast of Cuba, which bears in color and structure a great resemblance to the limestone forming the hills on the adjacent coast, only the latter is mainly formed of the large shoal-water corals and shells.

The white calcareous mud mentioned above, would, if we were able to penetrate it deeper, probably be found to consolidate into chalk, or perhaps more compact limestone, with few or no large fossils.

In closing this report, based on a mere beginning of researches which I hope to have the privilege to pursue, I must acknowledge the great obligations I am under to Professor Agassiz. His library and collections, and, what is far more valuable, his advice and counsels, have been and are still at my disposal in the working up of my results.

I wish also to express my thanks to my associates, Assistant H. Mitchell and Captain Platt and his officers, for assistance rendered in the dredging operations.

Very respectfully, your obedient servant,

L. F. POURTALES,
Assistant United States Coast Survey.

Professor BENJAMIN PEIRCE,
Superintendent United States Coast Survey.

APPENDIX No. 17.

LETTERS OF PROFESSOR AGASSIZ ON THE RELATION OF GEOLOGICAL AND ZOOLOGICAL RESEARCHES TO GENERAL INTERESTS, IN THE DEVELOPMENT OF COAST FEATURES.

NAHANT, *September* 11, 1867.

DEAR SIR: Far from considering your request a tax upon my time, it gives me the greatest pleasure to have an opportunity of laying before you some statements and reflections, which I trust will satisfy you that geology and natural history can be made subservient to the great interests of a civilized community to a far greater extent than is generally admitted.

The question of the Harbor of Boston, for instance, has a geological and a zoological side which has thus far only been considered indirectly. In order to ascertain whence the materials are derived which accumulate in the harbor, the shores ought to be studied geologically with a kind of accuracy and minuteness never required by geological surveys made for economical purposes. The banks of the harbor, wherever it is not rock-bound, consist of drift which itself rests upon the various rock formations of the district. Now this drift I have ascertained to have extended formerly many miles beyond our present shores, and it is daily washing away by the action of tides, winds, and currents. Until you know with precision the mineralogical composition of the drift of this immediate vicinity, and so accurately as to be able to recognize it in any new combination into which it may be brought when carried off by the sea, all examinations of soundings may be of little use. Should it however be ascertained that the larger amount of loose materials spreading over the harbor is derived from some one or the other of the drift islands in the bay, a sea-wall to stop the denudation may be of greater and more immediate use than any other operation. Again, it is geologically certain that all the drift islands of the harbor have formed by the encroachment of the sea upon a sheet of drift which extended in unbroken continuity from Cape Ann to Cape Cod and further south. This sheet of drift is constantly diminishing; and, in centuries to come, which, notwithstanding the immeasurable duration of geological periods, I trust may be reached while the United States remain a flourishing empire, it will be removed still further, so far, indeed, that I foresee the time when the whole peninsula of Cape Cod shall disappear. Under these circumstances it is the duty of a wise administration to establish with precision the rate and the extent of this destruction, that the coming generations may be forewarned. In this connection I would advise the making of a thorough survey of the harbor, to ascertain the extent of rock surface and of drift, and the relative position of the two, with maps to show their relations to the different levels of the sea, whereby the unequal action of the tides upon the various banks may be estimated.

The zoological side of the question relates to the amount of loose materials accumulating in consequence of the increase of animal and vegetable life, especially of those microscopic beings, which, notwithstanding their extraordinary minuteness, form, in course of time, vast deposits of solid materials. Ehrenberg has shown that the harbor of Frishhaff, on the Prussian coast of the Baltic, is filling, not in consequence of the accumulation of inorganic sediments, but by the rapid increase and decay of innumerable animalcules. To what extent such deposits may accumulate has also been shown by Ehrenberg, who ascertained many years ago that the city of Berlin rests upon a deposit of about eighteen feet in thickness, consisting almost exclusively of the solid parts of such microscopic beings. These two cases may suffice to show how important a zoological investigation of the harbor deposits is likely to be.

I need hardly add that the deposits flooded into the harbor by the numerous rivers and creeks emptying into it, ought to be investigated with the same care and minuteness as the drift materials. This investigation should also include the drainage of the city.

But this is only a small part of the applications I would recommend to be made of geological and zoological knowledge to the purposes of the Coast Survey. The reefs of Florida are a subject of the deepest interest, and the mere geodetic and hydrographic survey of their whole range would be far from exhausting the subject. It is my deliberate opinion that the great reef of Florida deserves to be explored with as much minuteness and fullness as the Gulf Stream, and that the investigation will require as much labor and time as has thus far been bestowed upon the Gulf Stream. Here again geological and zoological knowledge is indispensable to the completion of the work. The reef consists mainly of the accumulated solid materials of a variety of animals and a few plants. The relations of these animals and plants to one another while alive in and upon the reef, ought to be studied more fully than has been the case before, in order to determine with certainty the share they have in the formation of these immense submarine walls, so dangerous to navigation. The surveys, as they have been made thus far, furnish only the necessary information concerning the present form and extent of the reef. But we know that it is constantly changing, increasing, enlarging, spreading, rising in such a way and at such a rate that the surveys of one century become insufficient for the next. A knowledge of these changes can only be obtained by a naturalist familiar with the structure and mode of growth of animals. The survey I made about fifteen years ago, at the request of your lamented predecessor, could only be considered as a reconnaissance, in view of the extent and importance of the work. I would, therefore, recommend to you to organize a party specially detailed to carry on these investigations, in connection with and by the side of the regular geodetic and hydrographic survey. Here, also, would geological knowledge be of great advantage to the explorer; and in confirmation of my recommendation I need only remind you of a striking fact in the history of our science: More than thirty years ago, before Dana & Darwin had published their beautiful investigations upon the coral reefs, a pupil of mine, the late Amant Gressly, had traced the structure and mode of growth of coral reefs, and atolls in the Zura Mountains, thus anticipating by a geological investigation what zoologists did afterwards by dredging in the ocean. The structure of the reefs of our shores is therefore more likely to be fully understood by one who is equally familiar with zoology and geology than by a surveyor who has no familiarity with either of these sciences.

There is another reason why I would strongly urge upon you the application of natural sciences to the work of the survey. The depth of the ocean is a great obstacle to a satisfactory exploration of its bottom. But we know now that nearly all dry land has been sea bottom before it was raised above the level of the water. This, at least, is the case with all the stratified rocks and aqueous deposits forming part of the earth's crust. Now it would greatly facilitate the study of the bottom of the sea, if, after ascertaining by soundings the general character of the bottom in any particular region, corresponding bottoms on dry land were examined and both better appreciated by a comparison of the one with the other. The shoals of the southern coast of Massachusetts have been surveyed, and their position is now known with great accuracy; but their internal structure, their mode of formation, is only imperfectly ascertained, owing to the difficulty of cutting into them and examining in situ the materials of which they are composed. Nothing, on the contrary, is easier than to explore the structure and composition of the drift-hills, which are cut through by all our railroad tracks. Now the shoals and rips of Nantucket have their counterpart on the main land; and even along the shores of Boston Harbor, in the direction of Dorchester and Milton, such shoals may be examined far away from the waters to which they owe their deposition. Here, then, is the place to complete the exploration for which soundings and dredgings give only imperfect information.

I need not extend these remarks further to satisfy you of the importance of geological and zoological researches in connection with the regular operations of the Coast Survey. Permit me, however, to add a few words upon some points which seem to me legitimately to belong to the Coast Survey, to which sufficient attention has not yet been paid. I allude, first, to the salt marshes of our shores, their formation and uses, as well as their gradual disappearance under the advancing progress of the sea; second, to the extended low islands in the form of reefs stretching along the coast of the southern States, the basis of which may be old coral reefs; third, to the form of all our estuaries, which has resulted from the conflict of the sea with the drift formation, and is therefore, in a measure, a geological problem; fourth, to the extensive deposits of foraminifera along the coast, which ought to be compared with the deposits of tripoli found in many tertiary formations; fifth, to the general form and outline of our continent, with all its indentations, which are due to their geological structure. Indeed, the character of every harbor is the result of the conflict of the ocean with the rock formations of the land, and therefore as much a question for geology as for geodesy to solve.

Should the preceding remarks induce you to carry any of my suggestions into practical operations, be assured that it will, at all times, give me the greatest pleasure to contribute to the success of your administration by advice not only, but by actual participation in your work whenever wanted. The scientific men of America look to you for the publication of the great results already secured by the Coast Survey, well knowing that this national enterprise can only be benefited by the high-minded course which has, at all times, marked your intellectual career.

Ever truly your friend,

L. AGASSIZ.

Professor BENJAMIN PEIRCE,
Superintendent United States Coast Survey.

CAMBRIDGE, MASS., *June* 11, 1867.

DEAR SIR: The striking and unexpected results obtained by the United States Coast Survey party, now at work between Florida and Cuba, suggest some remarks, which I take the liberty of submitting to you.

When visiting the Florida Reefs in behalf of the Coast Survey, in 1852, it was my good fortune to throw some light upon the mode of formation of the reefs and their relations to one another and to the shore bluffs; but very little could be learned concerning *rate of growth* of these formations. The materials I collected only showed a very slow increase. It has occurred to me that you might now avail yourself of the presence upon the same ground of gentlemen interested in natural history, as well as in the operations of the Coast Survey, to secure all the information possible concerning the growth and increase of corals. This may save untold trouble and labor in the future. The mode of proceeding appears to me very simple. From one end of the reef to the other, between Cape Florida and the Tortugas, innumerable structures have at different times been erected below the level of the sea, and the time when these structures were put up must be known with tolerable accuracy. All that is therefore required, in order to ascertain the rate of growth of the corals, is to collect in the different places the largest specimens of the different kinds of corals fixed upon a basis, the date of the submersion of which is positively known. The sea-walls of the forts upon Garden Key, and in Key West, the wharves everywhere, the beacons, concretes, bricks, &c., the immersion of which is known, ought to be searched with the greatest care, and everything scraped up that may throw light upon the growth of the corals. If, in the same locality, there are structures of different dates, they would afford the most valuable means of comparison.

Suppose that near the landing of Fort Jefferson, or Fort Taylor, or near the light-houses of Sand Key, or of Carysfort, bricks or other building materials have been thrown overboard in different years, and the localities are known as well as the dates, the size of the corals grown upon them all would at once show the rate of increase, since such materials rarely remain for any length of time without being covered with corals. But it would not be amiss to ascertain beforehand which materials form the most desirable basis for corals to grow upon, by examining very recent piles of heterogeneous materials, and finding out which are first covered. Of all these things, large numbers of specimens in every stage of growth should be collected, as the survey would place scientific institutions, all the world over, under great obligations by providing them with specimens exhibiting the results thus secured. If I am not mistaken, the Florida Reefs are the only ones which have thus far been regularly surveyed; at all events they are the only ones upon which regular observations are making, and may be made in all future times. For that reason I hold that a careful survey of every feature of the reef should be furnished to civilized nations, with the information necessary to meet the exigencies of the many new settlements which are annually forming in various regions of the world where coral reefs grow.

With reference to future investigations I would recommend the marking of some characteristic stocks of the different kinds of corals growing in sheltered places, the size and condition of which should be recorded accurately for comparison at successive future periods.

Permit me a few more general remarks. In collecting specimens of corals with the view of *ascertaining their rate of growth*, every species growing upon the reef should be gathered, in every stage and upon the various bases upon which it may be found growing. Specimens a few weeks old may be found upon materials recently thrown overboard; specimens at most a year upon materials submerged for that time or more, and so on. In all our museums we have thus far only preserved *dwarf specimens*. The world at large, nay, scientific men themselves, hardly know to what dimensions coral heads may grow. It would be well, therefore, whenever practicable, to bring in the largest possible specimens, especially when their age can be ascertained approximately; their exhibition in our museums would be very attractive. As most of the coral species living on the coast of Florida are directly or indirectly *reef builders*, this investigation strictly belongs to the Coast Survey, and in a manner far more direct than has thus far been considered. The little porites, oculinas, menicinas, and caryophillias, which grow on the flats, ought therefore not any more to be neglected than the astroans, moandrinas, millepores, madrepores, &c., of the outer reef, or the alcyonoid polyps, *gorgonia*, *mammilleria*, &c., that grow between them.

There is another feature which ought not to be neglected—*the parasites upon the reef*. Under this head I understand all the animals that live upon or within the reef, and which by boring undermine the structure, and in that way, in a measure, check the normal increase of the reef. These parasites are chiefly sea urchins, boring shells, and worms. Their whole economy is a subject full of interest, and as these animals are in a measure the assistants of man in overcoming the increase of coral reefs, their history should be studied to the extent of ascertaining how far their multiplication may be fostered.

Of all these things sufficient numbers should be collected to supply other institutions, especially the headquarters of the Coast Surveys of other empires. When on the reef fifteen years ago I collected a considerable amount of coral rocks, coral sands, and other specimens illustrating the structure of the reef, which I had intended to distribute in that way, but I never had time to put up sets of them. Should you wish for these materials to add to what you may cause to be collected in conformity with the above suggestions, you are quite welcome to them.

With highest regard, ever truly your friend,

L. AGASSIZ.

Prof. BENJAMIN PEIRCE,
Superintendent United States Coast Survey.

APPENDIX No. 18.

REPORT OF ASSISTANT GEORGE DAVIDSON RELATIVE TO THE RESOURCES AND THE COAST FEATURES OF ALASKA TERRITORY.

COAST SURVEY OFFICE,
Washington, D. C., January 15, 1868.

SIR: As requested in the department letter of the 9th instant, I have the honor to transmit herewith a copy of the report addressed to me by Assistant George Davidson, comprising the results of his reconnaisance of the coast of Alaska, and his remarks on the natural features and prospective resources of the Territory.

Very respectfully, yours,

BENJAMIN PEIRCE,
Superintendent United States Coast Survey.

Hon. H. MCCULLOCH, *Secretary of the Treasury.*

UNITED STATES COAST SURVEY STATION,
San Francisco, California, November 30, 1867.

DEAR SIR: I herewith submit the report of the operations of my party on the geographical reconnaissance of Alaska.

The first part exhibits the inception and plan of work proposed, and the details of execution; then follow descriptions of the coast, of the great oceanic currents of the North Pacific, and the discussion of their influence upon the routes between Japan and China and the Pacific coast of the United States; of the climate, vegetable productions of the country, the minerals, fisheries, furs, &c., and of the inhabitants and their prospective relation to the new order of rules and trade, with official statements of their numbers. Details of the coast line, harbors, bays, headlands, &c., are given, in part from personal observation, but principally from the descriptions of Vancouver, Mearer, Portlock, Dixon, Lisiansky, &c. A list of four hundred and thirty-four geographical positions is given in the appendix.

Geographical determinations depending upon the field computation of Assistant Mosman's astronomical observations are given for the stations occupied.

The general coast map, not yet finished, is compiled from the maps of Tebenkoff, from manuscript maps, kindly furnished me by Prince Maksoutoff, governor of the late Russian colonies, and from examinations of my own.

I also propose a plan of carrying on the work in this new region, where the refined methods of more favorable coasts must be modified, and instruments improved to obtain observations rapidly with our usual precision. The mode of working, means by which accurate results can be obtained, and the proper season for field parties, have been especially studied, and I am sure that in these matters alone the Coast Survey has obtained information and experience which will more than save the cost of our operations on this expedition in the next season's work.

The appendixes contain information that could not well be introduced in the body of the report, and yet of interest and value.

Throughout the report all bearings are true, unless otherwise specially mentioned, and distances are in nautical miles. Even on a coast with prevailing good weather and control of the steamer's movements, the amount of labor for a full season would have been large for a party limited to five persons; but on a coast comparatively unknown to us, and proverbial for thick, rainy, and heavy weather, it could not be expected that all would be accomplished in less than three months of a working season. The intention was to cover the ground as far as practicable, and accomplish whatever the means at our command and the shortness and unfavorableness of the season would permit. A very important desideratum was to obtain a clear and comprehensive view of the nature of the country, so that judgment could be pronounced upon the best method of conducting the survey of this coast in connection with the developments of the fishing banks.

On the 18th of May you telegraphed asking me to undertake the labor of conducting this new enterprise, and I confess I did so contrary to my own judgment and the advice of my physician; but, willing to make any sacrifice for the benefit of the work, under your instructions I left New York on the 11th of June, and as no vessel under my direction was specially assigned for this work, they contemplated my receiving transportation and assistance from the United States revenue cutter Lincoln, then under orders to proceed to Alaska upon special duty of the Treasury Department. Captain William A. Howard, United States revenue cutter service, had the sole direction of the vessel's movement in the execution of his special duties, and received from the honorable Secretary of the Treasury "instructions, in accordance with your request, to receive on board the Lincoln a Coast Survey party of five officers with their instruments, equipments, and such supplies as they may consider necessary for the voyage, and also to render every assistance and facility in his power to enable them to carry out the instructions of the Coast Survey Office."

I reached San Francisco on the 3d of July, and at once proceeded to reorganize my party, which had lost a valuable member by the drowning of Julius Kincheloe, sub-assistant, upon the bar of Tillamook, while in the discharge of his duty. He had served with me in California in 1860, and I had been very favorably impressed with his energy, faithfulness, and integrity.

We were detained eighteen days in San Francisco waiting the completion of repairs, &c., upon the steamer, and a small house having been built forward to accommodate four persons, I was enabled, through the kindness of Captain Howard, to carry a larger number of assistants than originally contemplated. The party was composed of myself, A. T. Mosman, sub-assistant for astronomical work, with Stehman Forney, aid, as his assistant; George Farquhar, sub-assistant, as draughtsman and hydrographer; William Hamel, temporary aid, as draughtsman, interpreter, and assistant in making local surveys and taking views; Albert Kellogg, M. D., temporary aid, as botanist; W. G. W. Harford, temporary aid, as conchologist and naturalist; Theodore A. Blake, temporary aid, as geologist and mining engineer; and John Leeds as tidal observer for Sitka, during the absence of the party westward, and for continuing a complete series of tidal observations during the winter. Myself and three assistants were accommodated in the forward-deck house, four assistants in the ward-room, and the tidal observer on the berth deck.

The Mercantile Library Association, the Odd Fellows' Library, and several citizens of San Francisco, cheerfully lent me numerous volumes of travels and explorations on the northwest coast, and scientific works of natural history and reference.

George H. Mumford, esq., president of the California State Telegraph Company, kindly permitted photographs to be taken of the maps of exploration to the Stakeen River, constructed under the direction of the Russian Telegraph Company. At a later date I received from him a general map of the explorations through the Kwichpak, and one of the details of the exploration within a radius of five hundred miles of Sitka. He also very liberally placed at my service the use of the telegraph line to Victoria for the determination of the difference of longitude. Unfortunately the line had not sufficient repeaters, and the weather was too wet to work through without them, as had been done in dry weather.

To Captain Oliver Eldridge, agent of the Pacific Mail Steamship Company, I acknowledge the obligations of the survey for permission to trace the courses of the China and San Francisco steamships between the latter port and Yokahama. On our homeward voyage he directed the steamer to sound on the extensive bank south of the Cortes Shoal, as laid down on the French chart No. 1997; and Captain Lapidge, of the Golden City, entered into the investigation with his usual interest and spirit, but we were unsuccessful in obtaining bottom with two hundred fathoms of line. As no observations had been obtained since leaving San Francisco, the vessel had doubtless been set off by the currents from the Santa Barbara Channel, so that we may have passed the outer edge of the bank.

Captain Eldridge has also promised to direct the use of the patent log, to be used in combination with astronomical observations, for the determination of the ocean currents on the routes to Panama and to China, so soon as I arrange a system of observations and record, and I am assured of the hearty co-operation of the commanders and officers of the line. Admiral Thatcher, United States Navy, commanding the North Pacific squadron, supplied me with eight of the best chronometers belonging to the navy, and not then in use. All these chronometers are of American manufacture, and it will be a matter of interest to know, from the final discussion of the results of our observations, their value in comparison with foreign instruments. The field computations indicate the superiority of the American instruments. Four coast survey chronometers, that have been many years upon this coast, were also taken. No special provision was made for the location of these chronometers on the vessel, and nine of them, placed in a well padded box of nine compartments, were secured under a small table in our room, while three had to be placed in the washstand.

To cover all contingencies on such distant duty, I had provided a double set of instruments for observing time and latitude: a Würdemann transit for time alone; another, with the usual means of obtaining time, and my improvement for latitude observations by the method of the zenith telescope. As the reported normal condition of the weather was cloudy, a ten-inch Gambey vertical circle was added for time and latitude observations. Instruments for determining the magnetic elements, for making local triangulations, &c., were added. Unfortunately, no accommodation was provided for them on the vessel below deck, and throughout the expedition they were secured on the quarter-deck and covered with old canvas, which proved an inadequate protection against the weather, as some of the boxes were opened on different occasions with two or three inches of water in them.

I furnished a liberal outfit for collecting and preserving specimens of the botany, natural history, and mineralogy of the country, feeling satisfied that you would approve of this outlay, which was not in my estimate of expenses, as the original number of my party was limited to five. Box tide-gauges had been provided for the establishment of permanent tidal stations at Sitka and our westernmost limits of exploration, and it is a pleasure for me to repeat what I telegraphed you upon my arrival at San Francisco, that the portable observatory, transit blocks, tide and chronometer boxes were nearly completed under the direction of Assistant A. F. Rodgers upon my arrival, and that he had secured for me nearly every available map relating to the northwest.

During the delay consequent upon the vessel's repairs, Mr. Mosman established a secondary astronomical station on Russian Hill, mounting his transit upon the transit block of Mr. Thomas Tennant's observatory, and obtained the error of the chronometer up to the last night of our stay. He observed the transits of forty-four stars upon seven nights. Upon our return to San Fancisco I obtained permission from Judge H. P. Coon, mayor of this city, to establish the observatory in Washington Square and avoid the necessity of carrying the observing chronometers to Russian Hill. In return for this privilege Mr. Mosman established a meridian line within the limits of the square, whereby the variation of the compass may be observed by the surveyor of the city at any time. Observations were made upon thirteen stars on two nights.

On the 21st of July we left San Francisco with strong head winds and heavy sea for thirty-six hours, quite sufficient to change the stationary rates of the chronometers. The subsequent weather was beautiful, and as the vessel kept the coast close aboard, I had a very favorable opportunity of refreshing my memory with the appearance of the coast and coast range, making additional descriptions for the Directory of the Pacific Coast of the United States.

We arrived at Victoria on the 27th. The observatory was set up and instruments mounted. The series of observations upon two nights was broken, but sufficient data obtained to give good errors to the chronometers. Latitude observations were not made because my plan contemplated the connection, by triangulation, of the station at this place with the coast survey station at Point Hudson. Mr. Mosman observed the transits of five stars upon two nights, watching his chances between the showers of rain and breaks in the clouds. Twenty-four observations with the vertical circle were made upon the sun for time.

From San Francisco I had telegraphed Assistant James S. Lawson to proceed to Victoria with the United States coast surveying brig Fauntleroy and await my arrival, that I might fully communicate to him, and verbally explain the work to be executed during my absence to the northward. The old work of triangulation, topography, and geographical determinations in the Canal de Haro and Rosario Strait, embracing, among others, the island of San Juan, executed by me in 1853 and 1854, had never been connected with similar and subsequent work of mine commencing at New Dungeness, and extending through Admiralty Inlet nearly to Steilacoom, on Puget Sound. To make this connection I laid out a scheme of triangulation that should connect this disjointed work, embrace the astronomical station at Victoria, and also afford bases for the incidental determination of the heights and geographical positions of prominent peaks among the Olympus range, to be used in my future reconnaissance for the main triangulation. The latest value of the latitude and longitude at Point Hudson was furnished to Assistant Lawson to enable him to compute the L M Z's of the triangulation by the time of our return.

Should the travelling rates of the chronometers from San Francisco to Victoria be found unsatisfactory from the very boisterous weather with which we started out, and might encounter on our return in the season of southeast gales, this connection, with the "best geographically determined position on the northwest coast," north of San Francisco, would give us a new initial point, as the programme contemplated our returning to Victoria. Another object was to determine the difference of longitude between San Francisco and Victoria upon our return, should the telegraph line be in good order, for which I had the free use of the line. It is hardly necessary to say that daily comparisons of the chronometers were regularly made by the coincidence of beats between the mean and sidereal time chronometers, as also before and after every series of observations.

Leaving Victoria on the morning of the 29th of July, the vessel was detained a few hours by running aground on one side of the channel to Victoria; passed through the Canal de Haro and the Swanson Channel inside Pender, Saturna, and Mayne Islands, and into the gulf of Georgia by the Active Pass; steamed all night through this gulf and entered Johnstone's Straits in the morning. Within a few miles from the entrance the width of this passage is contracted to half a mile, and the vast body of water rushes at certain stages of the current with a velocity of six to nine knots per hour. At this point, when the overfall was very great, a fog suddenly shut down upon the strait, and the vessel was driven with great velocity towards the perpendicular rocky walls of the passage, and for an instant placed in imminent danger. In other reaches of the straits we measured the velocity of the current seven and a half miles per hour.

From Queen Charlotte Sound, at the north end of Vancouver, we entered Fitzhugh Sound, in latitude 51° 25′. No published surveys exist northward of Vancouver Island, except those depending altogether upon the examinations of Vancouver and the points forming the southwest point of the entrance to Fitzhugh Sound, being corrected in outline by us, and a view of it taken as we approached it. I have proposed to call it Cape Mosman. The English government has, within the last ten years, made a reconnaissance from Washington Sound to the north end of Vancouver Island, and the work is nearly completed thence to Fort Simpson, in 54° 34′.

At Belbella, one of the anchorages among these straits, where the vessel anchored for a couple of hours, Mr. Mosman managed to obtain between rain squalls six observations upon the sun with the vertical circle for time, but the vessel left before noon, so that the latitude was not determined. Pending the publication of the English maps it is assumed at 52° 10′.

In Milbank Strait, in about latitude 53° 12′, where the channel is not over a mile wide, Vancouver frequently sounded with one hundred and sixty-five and one hundred and eighty-five fathoms of line half a ship's length from shore and found no bottom. I was anxious to measure the actual depth of these fine inland passages, bounded as they are by precipitous mountains measuring from three thousand to six thousand feet in elevation; but as it was reported advisable not to stop the vessel, on account of a leak in the boiler needing attention, my request could not be gratified. The steepest slopes of these mountains are covered with large spruce trees from the water's edge to an elevation of two or three thousand feet. High among their masses are large lakes discharging their waters down the steep rocky sides, and forming a beautiful variety in the grand scenery forever overshadowing these waters.

At Lawson Bay, about latitude 54° 02′, the geologist of the party found the first change from the uniform granitic character of the formation through which all the sounds are apparently cut. Numerous low wooded islands, hence northward, are composed of slate.

In passing through these straits, many views of the scenery were taken by Mr. Hamel.

On the evening of the 3d of August we reached the anchorage off the Hudson Bay Company's trading station and stockade at Fort Simpson, located on the English map No. 2426, in latitude 54° 34′ and longitude 130° 25′ 30″.

During the repairs to the vessel the observatory was put up within the stockade by permission of the factor then in charge, Mr. Mosman having been unable to find a location sufficiently firm to plant the transit block.

The great amount of rain-fall in this region, and the absence of much direct sunlight, keep the earth in a thoroughly soaked condition, and covered with a sphagnous morass over a foot in thickness. The weather was cloudy and rainy until our departure on the morning of the 10th, no observations for latitude were obtained, and but four broken transits of stars on the night of the 4th for time, and twenty-four observations upon the sun with the vertical circle. I put up the magnetometer for determining the magnetic declination, but never obtained an observation for azimuth. The departure of the vessel was delayed upon my account, as I was very anxious to determine this position and make it the starting point for our coast reconnaissance.

Up to this place the botany, geology, and conchology of the various anchorages had been faithfully examined by the party, although outside the limits of our territory.

On the morning of August the 10th the vessel started for Sitka by the outside route in such thick fog and rain that it was next to impossible to determine the position of any points on the north shores of Dixon Sound; but a few cross bearings were made upon the rocks lying in Chatham Sound to the southward. The unknown but strong currents passing through the channels of the Alexander Archipelago, the thick weather, and the great number of courses run by the Russian pilot, were complete drawbacks to anything like accurate work. About 5 p. m. the sun broke out for a few moments, and I observed a dozen altitudes for time, and made comparisons of the chronometers in hopes of seeing Cape Kygàne, the southwestern point of the new territory; this we were fortunate in doing in an hour or two, passing close to it, but unable to see more than two hundred feet elevation, as thick rain-clouds covered the higher parts. The strong current-rips indicated that no great dependence could be placed upon the log distances.

Thence heavy southeast weather carried us by the evening of the 11th to Sitka Sound, which we entered without seeing either head or any land since sighting Forrester's Island; and after moving about among reefs and islets the vessel anchored in thirty-five fathoms water closely surrounded by wooded islets, with very thick weather. Next morning after the fog lifted we saw Sitka lying to the north-northwest, about three miles distant. The expedition was well received by Prince Maksoutoff, governor of the Russian colonies, who promised me every assistance. The observatory was set up in the town, and observations made at every available moment during our stay. The weather during this time was incessantly rainy and cold, as exhibited by the meteorological record and tables annexed. We were informed that it was the wettest season that had been known for many years; and a comparison of many years' records substantiated the assertion.

Sub-Assistant Farquhar was directed to select the site for a base for the stations and set up signals for a local triangulation, but I finally undertook it myself and made a small triangulation to include the eastern and western roadsteads or harbors. The weather was so excessively bad that but little could be accomplished, and at each effort all hands returned soaking wet, and the instrument drenched. Incidental observations were made to determine the positions and elevations of the surrounding mountain peaks. The weather was too thick to see Mount Edgecumbe during our stay, and too rough to risk a boat in the search for the Zenobia Rock and other dangers not accurately laid down on existing charts. Mr. Mosman was unable to get a single observation upon any star; in fact there was not a sufficiently clear interval in which to put the transit in the plane of the meridian. By dint of constant watching he managed to obtain seventy-two observations with the vertical circle upon the sun for time, but none for latitude. The magnetometer No. 6 was set up on Japonski Island, near the magnetic and meteorological observatory of the Russian-American Company, and several days' observations obtained for absolute magnetic declination, but a very unsatisfactory observation was obtained for azimuth; a better one was measured upon our return from Unalaska.

From the governor I obtained the use of the printed records for fourteen years of the observatory of the company at Sitka, and have tabulated the monthly and yearly means for the height of the barometer, dry and wet thermometers, the force of aqueous vapor, the rainfall, and the annual number of days on which rain, snow, and hail fell, or on which fogs prevailed. This is appended to my report, and forms a very instructive datum for the study of any plan of work.

I located a permanent tidal station at Sitka, and Mr. Forney superintended the placing and securing of the box tide-gauge. Upon the authority of the English admiralty charts, which state the rise and fall of the tides at full and change of the moon at five to seven feet, these box-gauges were made fifteen feet long; but we soon found that the rise and fall reached as much as thirteen feet, and consequently two boxes and rods were spliced to make one, which by permission of Prince Maksoutoff was secured at the end of the wharf, where I subsequently built a house for the protection of the observer during the winter, as it was impossible to obtain board and lodging for him in the immediate vicinity.

Mr. Mosman made a permanent bench-mark for reference, and connected it by leveling with the reading wires of the staff.

During my absence on the exploration to Kadiak and Unalaska, tidal observations were made every ten minutes from one and a half hour before to one and a half hour after every high and low water, and from 7 a. m. to 6 p. m. at every half hour between the above series. The record appears to have been faithfully kept.

The observer being well drilled to his duty, and the weather being very severe during the winter, I have directed that for every high and low water the observations shall be made every ten minutes for three-quarters of an hour before and three-quarters of an hour after the expected epoch; also that a regular series of meteorological observations be kept up. This will afford the observer time to make up his duplicates.

I think little trouble will be experienced here on account of water freezing inside the box, but have directed that a gallon or two of petroleum be poured down the box, and the supply be kept up, in case there is a tendency to freeze or coating of ice around the inside of the box and impede the action of the float.

A marine clock and watch were left with the observer; the former is compared regularly with one of the mean-time chronometers of the Russian-American Company, and thus accuracy secured in time.

A few days since I received notice that the tide-gauge had been carried away in the severe storm of October 28; but having left a spare box, rod, and float, to cover such contingencies, and General Jeff. C. Davis, United States Army, military governor of Alaska, having promised his assistance to repair any damages, I am satisfied that the observations are again under way.

From Sitka, Mr. Blake, the geologist of my party, made several boat expeditions to examine localities reported as affording silver ore, bismuth, &c., but the information we received was either designedly untrue or based upon the hopes rather than the knowledge of the informants. These trips were made in the usually shocking weather. In one of them an extensive deposit of fine, white marble was found about fifteen miles from Sitka, cropping out upon the water's edge, with deep water close to it. This will furnish good material for the construction of light-houses.

Dr. Kellogg, botanist, was unremitting in his examinations of the botany of the vicinity. Prince Maksoutoff directed that specimens of the different woods be obtained for me by our return.

Mr. Harford, conchologist and naturalist, seized every opportunity of adding to our collection of shells, and obtained and preserved the specimens of birds shot.

On the 22d of August the vessel left Sitka by the middle channel, with rainy weather and southeast squalls. Her destination was the Russian factory of Fort Constantine, in Port Etches, at the southeast point of the entrance to Prince William Sound, in latitude 60° 21′, longitude 146° 53′. The course was laid to run over the reported position of Pamplona Rock, and the reef reported just to the westward of it. On the trip several attempts were made to obtain soundings with two hundred fathoms of line, but no bottom found. This important reef is laid down on different maps with longitudes differing 39′ and latitudes ranging 3′. The vessel's course in the vicinity of this danger was to the northward and eastward of it, and she passed the locality at 5 a. m., about three miles north of the northern assigned position; but no rocks were seen and no special examination attempted, although birds were seen and heard that do not go far from land. To determine the position of this danger was one of the duties of my original plan, as some doubts are expressed of its existence, even by the navigators of the Russian-American Company; but I refer you to my descriptive report of this coast for particulars.

From Sitka to this place we had a current in our favor of about ten miles in forty-three hours.

From the Pamplona Rock a course was laid to pass near the assigned position of the Sea Otter Banks, especially as it would only increase the distance to Port Etches half a dozen miles; but during the day, the weather looking squally from the southeast, and the pilot reporting the general prevalence of bad weather at the entrance, the programme was changed, and the vessel headed for St. Paul on the island of Kadiak, which we reached August 26, through thick weather. On this trip observations for time and latitude were made by Mr. Mosman upon every opportunity.

In approaching the northern and eastern part of Kadiak from the direction of Kayak or Middleton Island, the same bank was found that Portlock got one sounding of seventy fathoms upon in 1788, in latitude 58° 10′, and longitude 149° 14′, over one hundred miles from St. Paul. The first sounding from the Lincoln was eighty fathoms, over a bottom of small stones, mud, and sand. Fishing-lines were got over, but nothing took the bait, which we subsequently found taken with avidity in another locality. Thence to St. Paul the soundings decreased to forty-five fathoms in thirty-five miles, increasing again half-way to St. Paul to ninety-five, with no bottom. At the various localities where bottom was reached, the lead showed broken pieces of rock, black pebbles, &c., always associated with mud. I have named this the Portlock Bank.

At St. Paul the observatory was at once landed, and the astronomical station selected on the bluff at the south side of the Chagavka Cove, about half a mile northeast of the town. Mr. Mosman succeeded in obtaining the first really good observations since leaving San Francisco. During our stay of five days, thirty-seven transits of stars were observed on three nights for error of chronometers, and one hundred observations on nine stars upon two nights, with the vertical circle, for latitude. Observations were made for absolute magnetic declination with the magnetometer, and azimuth observations made in connection therewith.

I twice measured a base of 432.37 meters, and selected and occupied points for a local triangulation of the northern channel from the northwest point of Wooded Island to the flag-staff in St. Paul; we had only one and a half days' fair weather in which to do the work. Bearings upon the dangerous reef called Williams Bank, off the entrance to the north channel, were obtained. The locality of a dangerous rock in the middle of the entrance to this channel was given to me by Captain Archimandritoff, who lost a vessel upon it. I refer you to my letter No. 21, August 31, 1867, for a description of the harbor of St. Paul, which was formerly the first, and is now the second post of importance of the Russian-American colonies.

From General Pavloff I obtained a specimen of the volcanic ashes that fell in March, 1867, over this island to the depth of half an inch. The nearest volcano is that of the Redoubt, eleven thousand two hundred and seventy feet high, on the west shore of Cook's Inlet, and distant in a straight line one hundred and sixty-five miles.

I was very anxious to establish a tidal station at this place, but while it was difficult if not impracticable to obtain a competent observer, I deemed it more important to establish one on the westernmost island we should visit. It was proposed to visit St. Paul Island in the Behring Sea, and subsequently Cook's Inlet, both demanding study and consideration as tidal stations.

From St. Paul I reported to you upon the aids necessary to navigation in approaching that anchorage.

On the 31st of August we started for Unalaska, passing out of the north channel of St. Paul through a narrow strait, between Kadiak and Spruce Islands; then through the northern strait between Kadiak and Afognak Islands; then through the Petries or Chelekoff Strait, between Kadiak and the southeast shores of the peninsula of Alaska. It was impossible to determine the relative positions of the headlands along the northwest shore of Kadiak, as the weather had shut down thick, squally, and rainy before getting through the northern strait, and by evening, when we were off the western point of the island, the bad weather had increased, with heavy rain, fog, and squalls from the southeast. At night *compasants* played about the stern davits.

On this trip the second of the patent logs was lost, and the third could not be made to record reliably.

At noon on the 4th of September the vessel suddenly and unexpectedly made the southeastern part of Sannakh Reef, only a couple of hundred yards ahead, in a dense fog, with light winds and heavy swell from the southward. For a minute or two she was in the most imminent danger.

On the morning of September 15, with variable weather, bottom was found in fifty fathoms, and observations for longitude obtained by Mr. Mosman. At noon the weather was very thick and drizzly, with a heavy swell from the southward, and bottom found with sixty-five fathoms of line, upon which was a baited hook. The lead was allowed to remain upon the bottom a few minutes, and when brought up had a fine cod upon it. All the available lines were soon in requisition; the fish bit so rapidly and eagerly that frequently two and in some cases three were brought up on one line.

We drifted all the afternoon along this bank to the northward and westward, with the same depth of water, the fish biting well, though all were in capital condition and full of food. Their maws were full of a variety of fish, among others the halibut, squid, sea lice, &c. The smallest fish weighed about twelve to fourteen pounds, the heaviest being twenty-seven pounds. We obtained no further observations that day, nor the next, on account of the same thick, disagreeable weather; but from Mr. Mosman's observations I place that part of the bank where we caught the cod in latitude 53° 30′, longitude 164° 30′, lying sixty-five miles east-southeast true from the middle of the Akutan Pass, and forty miles south-southeast from the Unimalski Pass. The longitude is better than the latitude. The weather was altogether too unfavorable to make an extended examination of the locality. At four in the afternoon of September 6 we anchored in the entrance of Ulakhta Harbor, in the bay of Unalaska, and a couple of miles outside the village and harbor of Illoolook For a full description of this locality I refer you to my letter number 22, dated September 12, when reporting upon the best position for a light-house in this bay.

Mr. Mosman established the astronomical station on the extremity of the boulder tongue forming the harbor of Ulakhta, and during the seven days of our stay obtained eleven transits of stars for time upon two nights, sixty upon the sun with the vertical circle for latitude, and six for azimuth in connection with the observations for absolute magnetic declination. As at all former stations, Mr. Forney assisted Mr. Mosman as recorder, and as magnetic observer after the instrument was placed in position.

I commenced the work for a local triangulation, to embrace Ulakhta and Illoolook Harbor and approaches, but after setting up nearly all the signals and measuring a base of 540 meters on the first day, was taken violently ill and confined to my berth three days. When the weather permitted the remaining signals were set up, and observations made by Sub-Assistant Farquhar, and by Mr. Hamel, with Mr. Forney as recorder. During my illness Mr. Forney set up the box tide-gauge at the usual landing place in front of the village of Illoolook. When able to visit the village I ascertained that this situation was not available in winter, on account of the swell coming in directly from Behring Sea, not very violently, but too great for the tide-box to withstand, or to obtain satisfactory results with an untrained observer. A study of the few tides observed here, averaging not over four feet, and therein differing so greatly from the large tides at Sitka and Kadiak, satisfied me of the importance of this station, where the Pacific Ocean and Behring Sea intercommunicate. For a permanent station I selected a position at the northwest end of the point formed by the stream behind the town and the bay in front, and made a contract with the factor of the Russian-American Company to construct a pier, as per accompanying written agreement, together with a wharf to connect it with the shore, and also to assist the observer in removing the gauge from its present position and setting it up at the proposed site. I paid him half the contract money in advance. Mr. Mosman established a bench mark upon the church, and determined the difference of level between it and the top of the gauge. This difference of level should receive frequent attention, because the earthquakes have in some cases depressed particular localities. I was shown one part of the point, near that selected for the future station, where the ground had sunk about one foot. At the time of our visit no one was competent to undertake this duty.

The tidal observer for this station is an Aleute, named Paul Panshin, surgeon of the Russian-American Company at this place; besides his regular tidal duties, which are similar to those described for the Sitka observer, he will make a regular series of meteorological observations, embracing the barometer, wet and dry bulb thermometers, temperature of the water, sky covered, force and direction of the wind, &c. I left with him one Coast Survey mean-time chronometer, aneroid barometer, three thermometers, books, paper, &c., lantern, hatchet, nails, and some pieces of scantling, because no wood is found on the island. Lest the tide-box be carried away by storms or ice, I left with him a fifteen-foot open gauge, divided to feet and tenths. His instructions, of which I furnish you a copy, were translated into Russian. The dates of observation will be those of the United States. In addition to these duties he is to collect at his own expense and preserve for the Coast Survey specimens of the skeletons and skins of land and water animals. For all these services I engaged to pay him ten dollars per month in gold, and took his voucher for three and a half months' advance pay. The priest of the Unalaska district has promised to advise him if any difficulty should arise.

From Innocent Shayesnikoff, priest of the Unalaska district, residing at Illoolook, I obtained a copy of his original meteorological observations from October, 1866, to May, 1867, and should have received much more but that our time was limited, and he was not aware at first of my wish to gather all such information. He is a man of sagacity in observing natural phenomena, and would be a valuable person in such a region for collecting information. He gave me a sketch of a paraselene which he observed February 19, 1867, from 8¾ a. m. to 2 p. m. I append sketch of the same, merely as a specimen. From this bay I directed Messrs. Blake and Kellogg to make the ascent of the volcano of Makúshin, and furnished them with barometers to determine the elevation. Two officers and two men from the ship formed part of the expedition, and several Aleutians accompanied them to pack their provisions and tent. The summit of the volcano was reached in three days, and the party had a short glimpse of the great crater, whence are constantly emitted vast volumes of sulphurous vapor, steam, &c. The mountain is covered with eternal snow, and from its side towards Captain's Harbor, (the western half of Unalaska Bay,) a small glacier works down the valley to a point about 2,100 feet above the ocean; the snow level is about 3,100 feet above the ocean, and the line of vegetation ceases at 2,450 feet. The elevation of the peak was made 5,691 feet by one of the barometers—two having reached the limit of their range a thousand feet lower. At daylight of the morning of their ascent, Mr. Mosman fortunately obtained some measures of the zenith distance of the peak with the vertical circle; but they remained uncomputed until the distance from his station is known. I append the observations made upon the trip.

At this harbor the proposed trip to the island of St. Paul, about two hundred and forty miles to the northward in the Behring Sea, was abandoned by Captain Howard, and also that to Cook's Inlet, on account of the lateness of the season, the short supply of coal, and the anticipated bad weather. Therefore our destination was Sitka direct, that the vessel might take part in the ceremonies attending the transfer of the territory, and the raising of the American flag by the commissioner. We started from Ulakhta on the 13th of September, with a fine day and a beautiful view of the volcano of Makúshin, from the crater of which were rolling volumes of cloud-like vapor. The vessel passed through the narrow strait between Unalaska and Unalga Islands; the heavy swell of the Behring Sea was lost, and the Pacific entered without perceptible motion. From the Pacific approach to this entrance, the view was magnificent; far to the southwestward stretched the mountains of Unalaska; both passages and boundaries were sharp and distinct. The volcanic peak of Akutan, 3,532 feet high, was alone enveloped in cloud, while far to the north and northwest were visible the snow-clad volcanic peaks of Devastation, 5,525 feet elevation; Shisháldin, 8,953 feet, and between these were smaller peaks and a snow-covered range; beyond Shisháldin another curiously-shaped snow-clad peak was visible. Grewingk calls it the volcano Khaginak. The first two mountains were distant from sixty-five to ninety-five miles. Captain Archimandritoff, who had served thirty years in the employment of the Russian-American Company, informed me that he had never seen the sea so calm, nor such an extensive line of island shores visible at any one time.

A view of the straits was taken by Mr. Hamel, and to insure accuracy of detail I measured all the horizontal and vertical angles. When in latitude 53° 38′, longitude 165° 24′, we sounded in one hundred and four fathoms over a bottom of black sand, the middle of Akoutan Straits bearing north 43° west, distant thirty-three miles.

The vessel, after some heavy weather from east, round by the south to west, reached Sitka Sound on the evening of the 20th of September, passing through the western channel, in very thick weather, late at night; being guided in part by the light upon the governor's house, which was lighted in answer to our signal gun.

On the 21st the observatory was again set up at Sitka, and during our stay, until October 13, when we started for Chilkaht River, Mr. Mosman obtained seventy transits of stars for time upon nine nights; one hundred and sixty-eight observations with the vertical circle on the sun for latitude and time; and two hundred and seventy-six observations with the vertical circle upon eighteen stars for latitude. Observations for azimuth, to determine the magnetic declination, were also made. In this work he was assisted by Mr. Forney, as recorder. For local triangulation, Mr. Farquhar set up two or three signals towards the west channel, and occupied two stations. I measured the base twice.

September 23 was arranged for the geologist and botanist of my party to make a boat excursion to the south end of Partovshiskof Island in search of some magnetic iron ore, the locality reported to have affected the compass so much as to reverse the direction of the needle; but the programme was changed by the steamer carrying the whole party and agreeing to return next night. At night the vessel anchored in Kotleana Bay; the next day she went into Little Noquashinski Bay, and getting aground, Messrs. Mosman and Forney sounded through the channel to the northwest entrance, while the vessel returned and passed into Olga Strait, anchoring there with rainy, thick weather. But even with this disagreeable weather, Mr. Blake went to the reported locality of iron ore and returned unsuccessful.

On the 25th we had the first clear day for a week, and the vessel anchored in Little Noquashinski Bay in sixteen fathoms over soft muddy bottom, abreast of a low, flat space on the south side of the bay, one mile from the northwestern entrance. This low ground was bordered on both sides by small streams, and was covered with a heavy carpet of water-soaked sphagnum, forming almost a bog. The trees which had been growing on this space many years before had evidently been torn away by their roots, and the holes are now filled with water. The extent of this comparatively cleared ground is about twenty-five acres, and its greatest elevation above water about twenty feet; in front the shore is low and flat; behind it is a narrow valley with great mountains at the head. I have described this small valley because it has been proposed to the military governor of Alaska as a suitable location for a military post. Around this part of Noquashinski Bay, on either side and abreast the entrance, the borders are comparatively low and densely wooded.

From this place I was very anxious to return at once to Sitka for transit observations, to obtain the traveling rates of the chronometers for the last month, but, not having power to do so, Messrs. Mosman and Forney, after making twenty-four observations upon the sun with the vertical circle for time, made an examination of the Newski passage leading to Salisbury Sound and Peril Strait. I went up the arm of the bay making in from the north, and found the depth of water across the inlet sixteen fathoms, with soft black mud bottom. Mr. Blake again made search for the iron ore, and incidentally made some soundings in the bay at the south end of Soukoi Strait, of which he furnished a sketch.

After heavy rains during the afternoon and night of the 25th, the weather cleared a little on the 26th, and the vessel went to St. John's Bay, about eight miles distant to the northward. Mr. Blake made an examination of the small stream coming in here, and reported to me that his experiments upon specimens found there indicated the existence of good coal. An expedition was agreed upon for the next day, when the vessel went towards the entrance of Salisbury Sound, and upon returning left Messrs. Blake and Harford with an armed boat's crew in Newski Strait to return to the bay, make further examination and report to me at Sitka, where we arrived a. m., September 29. Messrs. Blake and Harford made one day's examination in a very heavy rain and storm of wind, and reported to me on the afternoon of the 29th with specimens of coal. I refer you to his report on this subject.

The 30th of September was the first fine day we had seen, and I was anxious to make a personal examination of the position of the Zenobia Rock, at the entrance to the west channel to the harbor of Sitka, but could not procure a boat for this duty. Transit observations for time were obtained by Mr. Mosman.

On the 8th of October the vessel carried General Dana to the Redoubtski in Oserski Bay, at the outlet of Gloubokoe Lake; the weather was too thick and rainy for astronomical observations, but on the trip I made observations upon the summit of Mt. Edgecumbe, to determine the diameter of the rim of the crater. The next day the vessel started for Sitka, and I left Messrs. Hamel and Blake, with one sailor granted from the vessel, to make a sketch of this entrance and to examine the geology of the bold gorge in which the lake lies and at whose head is an immense glacier. On the 12th I obtained from the governor a pilot to accompany a boat from the vessel to bring back this party, who reported to me next day.

On the evening of October 9 we obtained our first letters from the Atlantic since June 21.

On the 13th the vessel started for the mouth of the Chilkaht River, in latitude 59° 14′, at the head of Chatham Straits. That night we anchored at the south entrance to Olga Strait, but the weather was cloudy and we got no observations. The next night we anchored under Point Skalitch, at the eastern entrance to Peril Straits; again the weather was cloudy and no chance for observing. On the 15th we anchored in Barlowe Cove, at the head of Admiralty Island, in very heavy squally weather. As we were rounding the northwest point of the cove we saw an immense glacier through the thick weather, and got a bearing upon it north 15° east by compass. The geology of the cove was partially examined in very squally weather. On the 16th we anchored at the mouth of the Chilkaht with very squally and rainy weather, and no chance for observing. Soundings made in Chatham Strait, about latitude 58° 32′, with one hundred and fifty fathoms of line, gave no bottom. On the 17th Mr. Blake made a short visit to the glacier on the west side of the strait, in latitude 59° 07′ approximate, and during the day and evening Mr. Mosman made one hundred and twenty-six observations upon five stars and the sun with the vertical circle for time and latitude. The station is upon a small island without trees, about two miles from the mouth of the river, and named Stony Island. His results place it seven miles further north, and three minutes of arc east of Tebenkoff's position, and seven miles north and eleven minutes east of Lindenberg's. We reached Sitka on the 19th, and Mr. Mosman got good transit observations, after which the weather was very bad for many days.

Four stations were occupied by Mr. Farquhar in extending the local triangulation of Sitka harbor. Mr. Mosman made his last observations at Sitka on the 26th, obtaining on this last visit twenty-five transits of stars on five nights.

From the tidal observations I computed the mean rise and fall of tides at Sitka for two months; and Mr. Forney the times of the moon's transits.

Mr. Mosman was engaged in reducing field-work for the difference of longitude between Sitka and Kadiak, Unalaska, and Chilkaht.

On the 27th of October the vessel started for Victoria by the inland route, and was at anchor in Little Naquoshinski Inlet when the heavy southeast gale of the 28th swept over Sitka, driving three or four vessels ashore, and nearly foundering the United States steamer Ossipee at sea. Captain Dall, of the steamship John L. Stephens, has informed me that during the gale he steamed through the throat connecting the two harbors, to the eastern one, and anchored there in nine and a half fathoms, trailing well to the northern shore abreast the hospital, and held on by a single anchor of two thousand pounds throughout the blow. His vessel stands very high above water, having been built for the trade between Panama and San Francisco; therefore the gale had a large amount of surface to act upon. When her anchor was got, after great labor, it brought up a large quantity of very tenacious mud. He pronounces the bottom capital holding ground; whereas the Russian navigators of the company have held that it is not good, being gravel, with a coating of mud, and that a vessel lies uneasily; but the Stephens discharged the remainder of her army freight from this anchorage. The Russians acknowledged that the gale was the heaviest that had visited Sitka for many years. As the eastern anchorage is larger than the western, and free of sunken rocks, the adoption of it as the better anchorage for large vessels may be confidently recommended. On the 29th of October the vessel again anchored at Skalitch, the southeast point of the entrance to Peril Strait from Chatham Strait; weather thick and no observation. On the 30th anchored at Kaik Harbor; weather unfavorable, rain and clouds. October 31 anchored in Wrangel passage; weather cloudy and thick. On the 1st of November anchored off the north end of Wrangel Island near the mouth of the Stakeen River, and remained here two nights, but got no observations on account of rainy weather. November 3 we anchored in a small basin at the north entrance to Tangas Narrows, but the night was thick and cloudy, with rain. November 4 we were at Fort Simpson, with rain and thick weather. November 5, we anchored near Lawson Bay during a very heavy squall from the southeast, accompanied by the lowest barometer reading of the season—28.94 inches. November 6 we anchored in Horne Bay with the *John L. Stephens*, and thick rainy weather. November 7, at Belbella, with rain, thence through Queen Charlotte Sound, Johnston Strait, Gulf of Georgia, Active Pass, Swanson Channel, and Canal de Haro to Victoria, where we anchored on the 11th, when Mr. Mosman set up his observatory and transit, and during the afternoon got twenty-four observations on the sun for time with the vertical circle, and transits of two stars during the evening, which closed in cloudy and rainy. On the 12th a good series of transits was observed, and the observatory and instruments were taken down.

I have received Assistant J. S. Lawson's report of the work on the triangulation connecting the work of Washington Sound and Admiralty Inlet with the present astronomical station at Victoria, and thus bringing forward the latitude and longitude of my old astronomical station at Point Hudson "the best geographically determined position on the northwest coast," north of San Francisco.

In the plan I proposed for this work I urged upon Mr. Lawson the necessity and expediency of adopting the light-houses as triangulation stations, and occupying eccentric points. In his table of L M Z's, embracing seventeen stations, nine or ten of them had been previously occupied by me between 1853 and 1857, but some of them have been necessarily reöccupied. His computation places my astronomical station, on Laurel Point, at Victoria, in latitude 48° 25′ 30″.61 and longitude 123° 22′ 05″.92, or 8^h 13^m 28^s.39.

The vessel arrived in San Francisco on the night of the 18th of November, and several nights were lost on account of rain; but Mr. Mosman finally obtained good sets of observations, thus giving us the means of determining the difference of longitude between San Francisco and all the Washington Territory stations, Victoria, Belbella, Fort Simpson, Cape Kygáne, Sitka, Kadiak, Unalaska, and the Chilkaht, by means of eleven and twelve chronometers.

The following results of Mr. Mosman's field computations are given as approximate, but sufficiently close for most practical purposes.

Assuming station at San Francisco to be in longitude 8^h 9^m 33^s.3, we have the following, together with the observed latitudes and variations:

Coast Survey stations.	Latitude.	Longitude.	Magnetic variations.
	° ′ ″	h. m. s.	
San Francisco		8 09 33.3	
Victoria	48 25 31	8 13 20.3	
Belbella, Fitzhugh Sound	52 07	8 32 31.3	
Fort Simpson, Buccleugh Sound	54 34 42	8 41 35.1	
Sitka	57 02 52	9 01 08.3	28° 50′.8 E.
Naquoshinski Bay, near Sitka	57 14 30	9 01 43.8	
St. Paul, Kadiak Island	57 47	10 09 15.7	26° 04′.1 E.
Ulakhta Point, Unalaska Island	53 53 58	11 05 51.5	19° 47′.4 E.
Mouth of Chilkaht River	59 11 45	9 01 36.6	

Mr. Mosman is under instructions to reduce all his work this winter, unless you otherwise direct.

The report of W. G. W. Harford, conchologist of my party, is annexed, and I cannot refrain from commending him as an earnest, conscientious worker, ever ready and willing to execute any duty assigned to him.

Dr. Kellogg, botanist, has made a preliminary and popular report of the woods, &c., of the regions visited, and will send his final report by the next steamer. He has been indefatigable in the execution of his duties, which he has pursued with enthusiasm.

Theo. A. Blake, geologist and mining engineer, is preparing his report, and will forward it by next steamer. He was always ready and anxious to undertake any boat expedition whenever the interests of the survey could be advanced in his department. His opportunities for work as a geologist were particularly bad, on account of the almost impassable nature of the country, its covering of sphagnum, and the short time we could spare at any station.

For Mr. Mosman, I can speak in the highest terms of his efficiency and proficiency in the different branches of the work of such an expedition. The discussion of his observations will show his ability as an observer, and cannot but indicate his aptness and ingenuity in overcoming details of execution under adverse circumstances. His watchfulness in such an unfavorable climate frequently saved many days by quickly seizing opportunities that an ordinary observer would let slip. Without his assistance the geographical results of the expedition would have been meager, or taxed my strength to the uttermost; and I cannot do less than earnestly recommend him for promotion at the close of the expedition.

Mr. Forney has diligently performed all the duties assigned him, and has exhibited a constant desire to thoroughly understand the different operations of the survey.

Mr. Hamel, who had been in the party of Assistant A. F. Rodgers, was of great service to me in his acquaintance with the Russian language, both in translating and interpreting. All the views made on the trip were executed by him; the computation of the local triangulations and the plotting of most of the work. All that he undertakes is done faithfully and cheerfully.

Mr. Farquhar was engaged in reducing Tebenkoff's charts, and in reducing manuscript maps obtained from the governor and navigators of the Russian-American Company. He kept the regular meteorological record of the expedition.

My assistants generally have always endeavored to lighten my labors and given a hearty support to all my undertakings, and I thank them sincerely for the sympathy they ever displayed.

THE COAST OF ALASKA—GENERAL DESCRIPTION.

The Pacific coast of Alaska commences at the southward, in latitude 54° 40′, forming the north shores of Dixon Sound, and sweeps in a long, regular curve to the northward and westward for five hundred and fifty miles, to the vicinity of the entrance of Prince William Sound, and thence seven hundred and twenty-five miles southward and westward to the extremity of Alaska Peninsula, where the line of islands generally known as the Aleutian stretches towards the coast of Kamtschatka in a long curve, with the convexity to the south.

The highest point of the great bend of the main coast line north of Sitka is in latitude 60½° and longitude 145½° at Controller's Bay; and the western and southern point of Alaska Peninsula is in latitude 55° and longitude 163°, where it is separated by the dangerous strait of Isanotsky from the extensive but nearly snow-clad island of Unimak, marked with great volcanic peaks covered with eternal snow.

From Isanotsky Strait the Aleutians sweep in a very regular curve to the southward and westward for seven hundred and fifty miles, reaching the latitude of 51½° in longitude 180°, and thence northward and westward three hundred and twenty-five miles towards Behring's Island, in 55° of latitude and 195° of longitude; but Altú, the western of the Aleutians, and Copper Island, just east of Behring Island, are separated by a strait two hundred miles wide, through the middle of which the boundary line of the treaty passes.

The Aleutian Islands are the summits of the mountain range which sweeps along the American coast from the southward, thence round the head of Prince William Sound and Cook's Inlet, and down the Alaska Peninsula. The peninsula and islands are marked by many volcanoes in activity, and reaching elevations as great as 12,000 feet on the west shores of Cook's Inlet, 8,953 feet on Unimak, 5,691 on Unalaska, 4,852 on Atkha, 6,975 on Tanaga, 3,700 on Kyska, and 3,084 on Altú.

North of the peninsula of Alaska the coast has a general direction northward to latitude 66° in the Arctic Sea, indented by four large bays or sounds, respectively named Bristol, Kouskovin, Norton, and Kotzebue; and receiving among others the great river Kwichpak, having its sources about the one hundred and thirtieth degree of west longitude in British America.

The extensive sheet of water north of the Aleutians to Behring's Strait in latitude 65½°, and between the American and Asiatic continents, is known as the Behring Sea, and, so far as sounded, consists of a very extensive submarine plateau of remarkable evenness of surface at a very small depth. It is marked by several large islands, upon two of which, St. Paul and St. George, are located Russian factories.

Off the southeastern shore of the Alaska Peninsula lies the large island of Kadiak, which has numerous adjacent islands separated by narrow and navigable straits. North of Kadiak, and forming part of the eastern shore of the Alaska Peninsula, is Cook's Inlet, one hundred and fifty-nine miles long and from fifty to twenty miles in width, penetrating the territory to latitude 61°, longitude 150°, and receiving a large river near its head.

The great extent of water lying in the curve of the coast between Dixon Sound and the south part of Kadiak has been named, by the Superintendent of the Coast Survey, the Gulf of Alaska.

From Dixon Sound, in 54° 40′, to the Chilkaht, in 59° 14′, the main land is guarded by a vast archipelago of very large islands, most of them having high mountains throughout, and all covered with a dense growth of large spruce and cedar. The dimensions of this assemblage of islands averages about seventy-five miles east and west, and two hundred and sixty-five north-northwest and south-southeast, divided by numerous navigable passages, one of which, named by Vancouver Chatham Strait, stretches in a straight line one hundred and ninety-five miles nearly north-northwest from Cape Ommaney, in latitude 56° 10′, to the mouth of the Chilkaht, in latitude 59° 14′, with an average width of seven or eight miles, and great depth of water. This great strait has numerous anchorages and small bays, and several large passages connecting it with the other straits to the eastward, and two important ones with the sea to north of Sitka. Of the latter, one passes through Peril Strait and Salisbury Sound to the Gulf of Alaska, about twenty miles north of Sitka Sound, with a navigable branch to Sitka, and the second through Cross Sound, or Icy Strait, to Alaska Gulf, about seventy-five miles north of Sitka Sound. The north shore of Cross Sound is the southern part of the peninsula of the main land lying between Chatham Strait and the Gulf of Alaska, and the termination of the great range of coast mountains that embraces Mounts St. Elias, Fairweather, and Crillon.

To the above extensive archipelago, embracing a shore line of nearly eight thousand statute miles, I would suggest the name of "Alexander Archipelago," in honor of the Emperor of Russia.

From Icy Strait the coast is very slightly indented by bays up to the extreme northern part of the Gulf of Alaska, in longitude 142°. Here the extensive area of water, islands, and peninsulas, known as Prince William Sound, stretches inland to the base of the great mountains for sixty miles, with a width of nearly the same distance.

One hundred miles westward of that sound is Cook's Inlet, and the peninsula lying between them is denominated the Kenai Peninsula.

GENERAL APPEARANCE OF THE COAST.

The sea-coast of the Alexander Archipelago is formed of very irregular outline on account of the numerous bays, straits, and islands. The south coast, facing upon Dixon Sound, and extending eighty miles from the mouth of Portland Canal to Cape Kygáne, exhibits headland, shore, and mountains covered with Sitka spruce and yellow cedar to their summits. The mountains attain an elevation of two or three thousand feet, with no valleys for cultivation between them. The same description applies to the coast from Kygáne to Icy Strait.

It is remarkable that outside the seacoast line of this archipelago but two islands are laid down, both being small, and ten to fifteen miles off the island of Prince of Wales. The same absence of coast islands westward of Icy Strait is remarked as far as the eastern mouth of Copper River, in longitude 144°, being a distance of five hundred miles of coast from Kygáne.

Westward of Icy Strait the coast mountain range attains an elevation of about eight or nine thousand feet, covered in most part with perpetual snow; with some magnificent snow peaks reaching the great height of nearly fifteen thousand feet, and frequently seen at a distance of over one hundred and fifty miles at sea.

The immediate sea-coast west of Ltuya Bay, thirty-two miles northwestward from Icy Strait to Prince William Sound, is comparatively low, wooded ground, but close backed by icy-faced steeps that come down from the high mountain range, and, as at the head of Behring's Bay and Icy Bay, frequently reaching the coast line.

A great part of the immediate shores of Prince William Sound is low, as are most of the projecting arms and some of the islands on the western side. The extreme northwestern arm of this sound stretches through what is laid down on the map as low ground, to within ten miles of the head of Turn-again Arm of Cook's Inlet.

The western shores of Kenai Peninsula are low and well wooded, but rise to bold mountains a few miles back. Although the elevation of this spur or peninsula is less than that of the Mount St. Elias range, yet it is sufficiently great to develop numerous glaciers, which work down to the waters of the sound and to the heads of the bays on the southeast coast. A very large one exists on the lake at the head of the river, debouching into Cook's Inlet about latitude 60° 20′.

The peninsula of Alaska appears to be formed by a continuation of the Mount St. Elias range, broken or deflected at Prince William Sound, and embraces some very high and volcanic peaks. The southeast shores of the peninsula are generally bold and rocky, and as far westward as abreast of the island of Kadiak there is timber on the low margin of the coast, but gradually becoming scarcer to the west of Kadiak, when it ceases altogether. With the narrowing of the peninsula many bays indent its shores on both sides, and numerous lakes, connected by small streams, exist among the mountains. The northwest coast is low and sandy, and backed by a narrow, low belt of land covered with herbage. For the last sixty miles to the westward the peninsula is comparatively low, and nearly divided into islands by deep bays indenting its shores.

The chain of mountainous islands thence westward to the coast of Kamtschatka commences with the high and extensive one called Unimak, having near its eastern extremity the great volcanic peak of Shishaldin, said to have an elevation of nearly nine thousand feet. Further westward the islands diminish in extent and frequency, yet among them are many high volcanic peaks. The climate also changes, judging from the appearance of the snow upon the high range of Unimak in September, when there was no snow on the mountains of Unalaska, except on the peak of Makushin, with its five thousand seven hundred feet of elevation and small glacier. This modification of climate should naturally be expected when the warmer waters and winds of the Pacific can pass fully through the numerous straits. West of Unalaska we should expect a colder climate from the influence of the Behring Sea current flowing south, unless more than counterbalanced by the warmer south winds from the Pacific.

Abreast of the southern coast of the peninsula of Alaska, for one hundred miles from its extremity, lie numerous large and high islands, extending as far off shore as sixty miles, and reaching the latitude of 54° 39′ in longitude 159°. Some of the Russian navigators inform me that the positions of these islands are poorly determined, as their business rarely called them among them.

Broad off the southeast coast of the peninsula, towards Cook's Inlet, and separated from the peninsula by the Petries or Chélekoff Strait, twenty-five to thirty-five miles wide, lies the large and important island of Kadiak, with Spruce, Afognak, and other islands to the northeastward, and the Trinity Islands off its southwest extremity.

The elevation of the mountains of Kadiak rises probably over three thousand feet, as some were trigonometrically measured that were twenty-four hundred feet high quite near the coast of Chiniak Bay.

This island and its accessories may be really considered a prolongation of the peninsula of Kenai parallel with the peninsula of Alaska, and the Chélekoff Strait, a continuation of Cook's Inlet. The north end of Afognak Island is only forty miles from the south end of Kenai Peninsula, with a cluster of high barren islands lying between them.

That extensive banks exist well out to sea, off the south and southeast coast of Alaska Kadiak, and some of the Aleutians, there can remain little doubt, from the few observations of the old navigators and the determinations made upon this expedition. The limit of that off the northeast end of Kadiak, discovered by Portlock, in 1786, has been extended; and an important fishing bank, situated off the Akutan and Unimak Straits, heretofore unknown, has been sounded upon, and its position approximately determined, in very thick weather. Soundings obtained thirty miles off the Shumagin Islands indicate a bank in that vicinity. Other banks, frequented by the codfishing vessels from San Francisco and Victoria, exist in the western part of the Gulf of Alaska and toward the Shumagin Islands, but their exact position is kept a secret by the parties interested, and we visited this region too late in a bad season to fall in with any of the fishing vessels. Part of the fishers visit the sea of Ochotsk, abounding in cod.

Of the waters adjoining the coast very little is known with accuracy. The currents have been only incidentally determined; the surface and deep-sea temperatures have not been investigated, and the general results are obtained from the practical experience or opinions of navigators, in a region where the opportunities for determining a vessel's position are very limited indeed on account of the large percentage of thick weather.

From the navigators of the Russian-American Company I have obtained much valuable information, and I desire to especially mention Captains Paul Lemasheffsky and Illarion Archimandritoff for their log-books, extending over fifteen years, and for tracings of manuscript maps. These logs are forwarded to you with the collections of the expeditions. From Captains Newbaum and Kadin I obtained many interesting facts and descriptions, and some manuscript maps and tracings.

In consulting the works of the old navigators I find many important descriptions of headlands, bays, &c., scattered through their voluminous pages, but it would require more time than is at present at my disposal to collate them. Yet it is a matter that should be undertaken at once, and every authority scrupulously searched that may possibly afford a single fact, because I am convinced that it would take years of labor of a few parties of the Coast Survey in such a climate to amass this straggling information. Such a compilation would also indicate the points specially needing examination.

Considering the means at their disposal, and the special objects of the Russian-American Company, they have added very much to our stock of general geographical knowledge, and I am satisfied that the archives of the company would reveal much more. In matters of minute detail their surveys are deficient, but their general results are good.

CURRENTS OF THE NORTH PACIFIC.

The North Pacific presents a peculiarly striking analogy to the North Atlantic in the existence of a great warm current, which sweeps along the eastern coast of Asia to the northeastward, crosses the Pacific, and washes the northwest coast of America, affects the climate of the whole coast, and gives a much higher temperature along the seaboard than would exist under normal circumstances. The map herewith appended, exhibiting the tracks of the San Francisco and China steamers, shows the general direction of this ocean stream.

The Japanese have long been well aware of this great current, which washes the southeastern shores of their empire, and have given to it the name Kuro-Siwo or Black Stream, from its deep blue color when compared with the neighboring waters of the Pacific. It has been noticed by nearly all the old navigators and explorers, and a systematic series of observations was undertaken by the United States expedition to Japan under Commodore Perry.

This singular current, with the water at an average maximum temperature of 86°—being that of equatorial waters, and the same as the Gulf Stream of the Atlantic—affords a solution to the fact of the Bonin Islands, in the latitude of 27½°, having an exclusively tropical vegetation, the cause of which was long a mystery to naturalists. It also accounts for the productiveness of the southern islands of the Japan group in sugar and other products, usually confined to intertropical regions.

The results of observations, corroborated by the fact of the high temperature above stated, show very satisfactorily that the Japan stream has its origin in the great northern equatorial current.

This great northern equatorial current, leaving the coast of Lower California and the Gulf of California between the latitudes of 15° and 25°, sweeps across the whole Pacific, with its axis two or three degrees south of the Sandwich Islands, and thence continuing on the parallel of 15°, and coming gradually northward until it passes the position of the Ladrone Islands, in latitude 17° and longitude 214° west, is gradually deflected to the north and northeast, along the Asiatic coast, but apparently with decreased velocity; although Beechey says that, when between the south end of Formosa and the island of Botel Tobago Sima, lying sixty miles eastward, he experienced a current which carried the vessel north 56° west twenty-six miles in the night, or two and a half miles per hour. He does not state the temperature of the water; and several leagues off the Vele Rete Rocks, situated off the south end of Formosa, the weather being nearly calm, the vessel was drawn into a very strong current rip, and continued in it several hours, during which no bottom could be found with one hundred fathoms of line. Experiments with a buoy gave a current to the southeast of seven-eighths of a mile per hour, but he doubts the accuracy of the results. The water was much agitated and made considerable noise, and had a vessel seen it or heard it in the night she must have taken it for breakers and put about. On Beechey's voyage from the Sandwich Islands to the

Ladrones he kept outside the northern limit of the great equatorial stream, and experienced a counter current to the eastward of nearly seven miles per day.

At one hundred and twenty leagues eastward of Formosa the Monsoon current of the Caroline Islands runs northward and then northeast, to add its waters to those of the great Japan stream.

The combined waters of the Caroline and equatorial streams are thrown against the island of Formosa, in latitude 22° and longitude 239° west, almost in the same latitude as the narrowest part of the Gulf Stream of the Atlantic, and 160° of longitude west; thence deflected to the northward and northeastward, and in the parallel of 31° strike the southern extremity of Japan, and pass close along the northeastern coasts of Niphon. Off the south and east point of Niphon, in latitude 35°, longitude 220° west, the stream begins to spread, and by the time it reaches latitude 38° and longitude 210°, it has been divided or split into two by the intrusion of the cold polar current. The contact of the cold and warm waters gives rise to the constant fogs that exist in this region. One branch of the stream, called the Kamtschatka current, moves to the northeast nearly parallel with the coast of Japan, the Kurile Islands, and the coast of Kamtschatka, its axis passing just east of Copper Island, in latitude 55°, longitude 191°, and running directly for Behring Strait. The other and greater branch follows the parallel of 35° eastward, being deflected a degree or two toward the south in longitude 180° by the impinging of the cold Behring Sea current, running southward through the Fox Islands; but in longitude 170° it regains its latitude, and finally reaches the latitude of 45° to 50°, in about longitude 148°, where it appears to again divide. The main body of the stream stretches directly towards the coast of America, runs down the east coast of Oregon and California, and finally sweeps back into the great northern equatorial current. The existence of this current is well demonstrated by the wrecks of Japanese junks upon the coast of Washington Territory and Oregon. Many years ago, upon the beach south of Point Adams, at the entrance to the Columbia River, there was cast away a Chinese or Japanese junk, with many hands and a cargo of beeswax. The ship was totally lost, but the crew saved. In support of this Indian tradition pieces of this wax, coated with sand and bleached nearly white, are occasionally thrown upon the beach after great storms. Formerly a great deal was found, but now it is rarely met with. In 1851 we saw many pieces of it. In 1833 a Japanese junk was wrecked near Cape Flattery, of which accounts can be found in Belcher's narrative, and in that of the United States exploring expedition. Within the last four years a Japanese junk was found in mid-ocean by the bark Aukland, and the crew brought to San Francisco. These wrecks are abundant evidence of the force and direction of this great current, in conjunction with the prevailing summer winds.

Of the northern branch of this great stream, flowing towards Alaska, I will speak hereafter.

The Kamtschatka current after passing through Behring Strait stretches towards the coast of America, as is fully proved by the existence of drift-wood along the American shores and in the waters of the current, while none is found on the Asiatic coast or in the waters adjacent. I have this season conversed with American whaling captains who left the Arctic as late as October 12, and their experience of years confirms the above statement. The interesting fact may here be stated that there has rarely been such an open season in the Arctic as that just passed. Captain Williams went as far westward as 188°, and had then nothing but open sea before him. Captain Thomas went as far north as 72° 55′. From both I have many facts of importance in regard to the locality of Herald Island, &c. This current passes through the Behring Strait with a velocity ranging from one and a half to three knots per hour. It is hardly probable that it can run with much greater velocity, as the whalers can generally work against it with a head wind. The ice that sometimes moves southward through the strait is not fairly attributable to a change in the current, but to the fact that the warmer water of the Kamtschatka current striking the American coast permits the ice to form on the shores northwest of East Cape, and even to overlap the cape. A heavy northwest wind arising will break up this point of ice and force it southward against the current.

The great body of water carried into the Arctic Ocean, through the Behring Strait, doubtless assists in forming the current which runs out of Davis Strait into the North Atlantic, forming the cold polar current that hugs the eastern shore of America as far south as the peninsula of Florida, and even underruns that current.

Among the tangible proofs of the origin and existence of the Kamtschatka current are the following: In September, 1862, a Japanese vessel was wrecked on the island of Attú. She had been driven off the coast of Japan two or three months before with a crew of twelve men, of which she had lost nine before going ashore, and had thus been drifted eighteen hundred miles in this current. "Among the floating bodies which the sea drives upon the shores of Copper Island, the true right camphor wood, and another sort of wood very white, soft, and sweet-scented, are occasionally found."

But the whole of the waters of the Kamtschatka current do not pass through Behring Strait. Striking against the south shore of the large island of St. Lawrence, part of the waters are deflected to eastward, southward, and finally westward of south, casting their floating wood on the American coast and the north shores of the Aleutian Islands. Navigators assure me that when passing south of the Aleutians, between 175° and 185° of longitude, they encounter a cold current from the northward, bringing with it masses of sea-weed, doubtless torn from the shores of the islands. In the vicinity of the island of St. Lawrence the temperature of this return stream is 47°; north of the Aleutians it is also 47°; near these islands and south of them it is 49°, southeast of them 51°.

Between the Kamtschatka current and the Asiatic coast and islands is a cold polar counter current, coming from the Behring Sea. It follows the coast of Kamtschatka, the trend of the Kurile Islands, gives rise to the currents flowing west into the south part of the Ochotsk Sea, and strikes the northern and eastern part of the coast of Japan.

A small amount of the water of this current passes into the Japan Sea through the Tsugar Strait, but the greater part keeps along the east coast inside, and probably underrunning the great Japan stream, the northwestern edge of which is strongly marked by a sudden depression in the temperature of the water, amounting to 16° and 20°, while the borders of the stream where it chafes are marked by strong current rips, often resembling heavy breakers on reefs and shoals. This difference of the thermal condition of the waters of these two streams causes the harassing prevalence of fogs.

Near the origin of the great Japan current the stream is usually confined between the islands of Formosa and Majicio-Sima, with a width of one hundred miles, but to the northward of the latter it rapidly expands on its southern limits and reaches the Loo Choo and Bonin groups, attaining a width to the northward of the latter of five hundred miles. Its southern and eastern limit is not distinctly defined, there being a gradual thermal approximation to that of the air and water. The velocity of the stream varies much, and we have no reliable data whatever of its velocity towards the coast of America. The United States Japan expedition determined its velocity between the south end of Formosa and the straits of Tsugar, a distance of nine hundred miles, at thirty-five to forty miles per day; and upon one occasion, off the Gulf of Yeddo, in latitude 34°, its maximum strength was recorded as high as eighty miles per day. In the latitude of 35°, at seventy leagues from the coast, its direction is east-northeast, and its rate forty-eight miles per day; while at twenty-five leagues from the coast in the same latitude it is seventy-two miles per day, corroborating the above maximum velocity. King also assures us that in these latitudes he found it running at the rate of five miles per hour. The rate and direction vary with the season as well as the distance from the coast. In November its course becomes more northerly, and in July more easterly.

The western body of the Behring Sea current from the north strikes this great stream in about latitude 39° and longitude 205° west, and splits it, but being too feeble to overcome it, passed beneath it and is gradually brought to the surface upon reaching shoaler water. We have thermal observations in proof of the existence of a cold sub-stream between Florida and the Bahamas, and we also know clearly the existence of "cold walls" working, as it were, against and through the stream of the Atlantic. The whirls and eddies observed in the middle of the great Japan stream, off the coast of Japan, indicate the existence of a similar cold sub-current; and walls of cold water are indicated by the observations of the United States expedition. Beechey's thermal observations in the axis of the stream in latitude 35° and longitude 134½° west, corroborate these indications, for he found the temperature of the water at seven hundred and sixty fathoms 28° colder than at the surface; and two days later, when on his course north-northwest to Petropaulski, in the fork between the Kamtschatka and Japan streams, "the temperature at one hundred and eighty fathoms was as cold as at five hundred fathoms in the above position; and also that it was 20° colder at three hundred and eighty fathoms in this position than it was at seven hundred and sixty fathoms in the above." Thus at three hundred and eighty fathoms he found the temperature 48° colder than the surface water of the great stream which had already left the coast of Japan twelve hundred miles. Of course, under such thermal conditions, Beechey found himself enveloped in dense and continuous fogs and drizzling rains all the way to Petropaulski, with the exception of one day in latitude 50°.

While there is no doubt whatever that the greater body of water of the great Japan stream flows to the eastward after dividing off the coast of Japan, the fact is also evident from the decreased velocity of the Kamtschatka current off the coast of that peninsula, where Tessan found it, in the latitude of Petropaulski, running at the rate of only seven to ten miles per day in an east-northeast and northeast direction. The observations upon the western limit of the cold Behring Sea current also indicate the contracted width of this current. On the contrary, the eastern and main branch has, in the longitude of 165° west, a breadth of 20° of latitude from 22° to 43°. On the southern limit the temperature is 78°, or four degrees above that of the great equatorial current returning from the California coast; and its northern limit of 64°, or 11° to 13° greater than the variable currents to the northward.

The passages of the China and San Francisco steamers will, in time, afford us means of determining many peculiarities of this current.

In the vicinity of the great northern curve of this current, about longitude 150° and latitude 44°, all navigators have found drift-wood, seal, sea-otter, land birds, and many indications of land. I have collected many notices of this character, and will submit them to you in a separate report. Between this great bend and the Sandwich Islands lies what is called Flieureus whirlpool or eddy.

Neither the great stream, nor any part of it, is laid down as passing as far north as latitude 50°, and hence is not supposed to pass into the Gulf of Alaska; but it is reasonable to suppose that, while the great body of the stream sweeps round and follows the direction of the western coast of America to the Gulf of California, a branch continues direct towards the Alexander archipelago, and striking the southern part of that coast is deflected to the northward and westward, and follows the trend of the coast round the Gulf of Alaska to the westward, and, finally, to the southwestward. Upon no other supposition can we reasonably account for the high isothermal line that exists directly upon this coast. The current to the northward, westward, and southwestward, along the coasts of the Gulf of Alaska, is well known to navigators, and is generally conceded to have a velocity of ten to twenty miles per day. One of the Russian navigators informs me that he has found it running at least thirty-six miles per day. Upon our trip from Sitka to the Pamplona Rocks, on a straight course, we found but little current in our favor, but between the Shumagin Islands and the Sannakh Island and reef it was very strong to the southward along the coast. If the position of the reef is correctly laid down, we experienced a current of not less than four or five knots per hour, between eight o'clock a. m. and half-past twelve p. m., on the 4th of September.

A study of the tides of Alaska will aid in solving the problem of the existence of this extreme northern branch; and an exploration of the region of the ocean where the divide takes place may develop causes for the division of the great stream and the deflection of each part.

There is doubtless an eddy between this Alaska branch when sweeping westward and the main stream running eastward; for Lisiansky, on his voyage from Kadiak to Sitka, in June, 1805, which he made in six days, to within a few miles of Mount Edgecumbe, with fair winds, had an "easterly current which had pushed him forward, during the last five days, and still flowed in the same direction."

I have been thus extended in my investigations upon this great Japanese stream and its branches, that its effects upon the climate of Alaska may be properly understood, and also its effect upon the question of the great circle route from San Francisco to China.

These currents, their effects upon the weather, and the prevailing westerly winds, will, in the absence of the strongest advantages, decide the question against the great circle route from San Francisco to Yokohama, or even to Hakodadi. Observation has demonstrated the almost continuous state of foggy and thick weather resulting from the meeting of the cold waters of the Behring Sea current with the northern edge of the great Japan stream flowing eastward. The experience of the steamship Colorado, of 4,100 tons, on her first voyage from Yokohama to San Francisco, in attempting to run along the great circle route, was so fearful as to deter the vessels of the line again attempting the northern passage. The Colorado had to run southward to reach good weather.

The local and very variable currents about the Aleutians, the thick weather, and the supposed existence of islands south of the chain, combine to render an approach to them extremely hazardous; but, with fine weather, no coast affords better marked outlines and landmarks.

A vessel, making the great circle-track to the eastward, would have the great Japan stream in her favor to about latitude 43°, longitude 204° west, or about 1,440 miles; then the cold Behring Sea current and the end of the Alaska current to latitude 47° and longitude 157° west, or 1,980 miles; finally to San Francisco, about 1,860 miles, passing through the great bend of the Japan stream where so many indications of land have been recorded, and where the weather is almost invariably thick and bad in summer, and cold and boisterous in winter. On this track the summer winds would generally be favorable, and, with good weather, it would be altogether the desirable route, but, with thick, foggy weather for nearly the whole of this distance, undetermined velocity and direction of the currents except in general terms, great variability of climate to passengers and cargo, and extra hazard and risk to life and ship, some great and positive advantage over all these must exist to warrant the adoption of it. The westward trip would have heavy, adverse winds nearly the whole distance; large sea and adverse currents for two-thirds the distance. In such a case, a few days' extra bad weather would consume the vessel's coal and run the supply short just when in the axis of the main stream.

The greatest inducement for adopting the great circle, under such circumstances, would be the discovery of deposits of good coal among the Aleutian Islands, or within a reasonable distance of the harbor nearest the great circle route.

The commercial advantages of the steam route to China, through the warmer and more equable latitudes, must always outweigh any merely theoretical and shorter but more hazardous route. A study of the currents, winds, and weather, on the lower latitude route, will lead to the conclusion that is being solved practically. From the south end of Japan to San Francisco, a course very little north of a direct line on a Mercator projection carries a vessel across the great Japan stream, in part through the axis of the main branch flowing eastward, across the northern part of Flieureus whirlpool, and across the California stream, with favorable or light winds the greater part of the distance. In returning, the course should be southward of the direct course, taking advantage of the California stream and favorable northwest winds, and entering the upper limit of the waters moving westward to the longitude of the Sandwich Islands, to form part of the great northern equatorial current, thence westward, through variable and feeble currents, until the upper limits of the western part of the equatorial current are entered. The other advantages of this route are fine weather and an equable and warm temperature. This line is already competing for the passenger travel between France and England and China, and it is an important consideration with the company that the passengers will not have to undergo a rapid transition from the heat of the tropics to the penetrating fogs of the North Pacific.

Should good coal be developed near Sitka, a depot for the company could be readily established on some of the islands near the present route of the ships, and supplied from Alaska. By taking advantage of the ocean currents and the prevailing northwest winds, much quicker time could be made by the coal-ships than the distance would lead us to suppose.

Of the smaller and local currents in the Behring Sea and among the Aleutes, it is hardly necessary to enter into detail, as mention of them will be made when describing the features of the coast.

THE CLIMATE.

The experience and observations of a few months upon this coast can do little towards determining the average conditions of the climate; but, through the kindness of Prince Maksouloff, I have been able to compile much valuable recorded information, and have received many interesting facts from the personal knowledge of the Russian navigators.

The existence of a branch of the Japan stream, carrying to this coast its waters, with a high thermal condition, imposes, at the outset, the necessity of a high isothermal line along the whole northwest coast of America. The records of the state of the thermometer establish the fact, and the botany of the whole region adds its certain confirmation.

On our passage inside of Vancouver's Island, from Victoria to Fort Simpson, in 54° 34′, the temperature of the surface water, in the latter part of July and early part of August, was 52°.1; that of the air, 54°.9. Outside the Alexander Archipelago, from Fort Simpson to Sitka, in 57° 03′, the temperature of the surface water was 52°.1, air 54°.9. In Sitka harbor, where the cold waters of the mountains affect the waters of the sound, our observations, from August 13 to 22, gave 50°.5 for the surface water, and 53°.4 for the air. On the voyage from Sitka to Kadiak, August 22 to 26, the surface water was 49°.4, and the temperature of the air 53°.5—the temperature of the water decreasing from 50°.6 to 47°.1, but irregularly. In the harbor of St. Paul, from August 26 to 31, the surface water was 45°.8, air 49°.5. On the voyage from Kadiak to Unalaska, August 31 to September 6, the surface water was 45°.9, and very uniform, the lowest being 45°.1; the temperature of the air was 48°.9. In Ulakhta harbor, in Unalaska bay, from September 6 to 12, the surface water was 45°.4, and air 51°.0—the temperature of the water reaching as low as 42°.9. From Unalaska to Sitka, September 13 to 20, the surface water was 49°.4, rising from 46° to 50°. In Sitka harbor, from September 21 to 26, the surface water was 49°.4, and the air 51°.6. At the mouth of the Chilkaht River, at the head of Chatham Strait, in latitude 59° 12′, and sixty miles east of Mount Fairweather, October 17 and 18, the temperature of the water was 39°, and the air 42°.2. At Sitka, on the 27th of October, when the mountains were covered with snow, and snow and hail had fallen on the water, its temperature was 41°, and that of the air 44°. In all these cases it is remarked that the temperature of the air was nearly three degrees higher than that of the water. Lisiansky, on his voyage from Kadiak to Sitka, August 16–20, 1804, with fresh westerly winds, found the temperature of the air 59°, and barometer 29.5 inches, but he records no observations for the temperature of the water. June 15–22, 1805, on his voyage from Sitka to Kadiak, with moderate easterly winds, the temperature of the air was 53°, barometer 29.5 inches; November 11 to 15, 1804, on the voyage from Sitka to Kadiak, with fresh easterly gales, the temperature of the air was 46°, barometer 29.2. The observations of Lisiansky have a certain value, but the temperature of the water would have added greatly to their importance. We see in those regularly recorded by my party, three times a day, that a great body of warm water exists off the coast; for we hardly reach sixty miles inside the Alexander Archipelago before the temperature decreases from 46°.5 to 39°.

The whole southeast coast of the Alaska Peninsula is bathed by these same waters which retain a high temperature to Kadiak; thence westward this temperature decreases, although the latitude decreases.

The report of Dr. Kellogg exhibits a flora that could not exist in this latitude without an unusually high isothermal condition, accompanied with a great condensation of vapor and precipitation of rain.

Our collection of shells has not yet been studied sufficiently to afford data on this point, but we have the authority of S. P. Woodward's Manual of the Mollusca for saying that among the Aleutian Islands "the influence of the Asiatic current is shown in the presence of two species of *Haliotis*, while affinity with the fauna of W. America is strongly indicated by the occurrence of *Patella*, (*scurra*,) three species of *Crepidula*, two of *Fissurella*, and species of *Bullia*, *Placunomia*, *Cardita*, *Saxidomus*, and *Petricola*, which are more abundant and range further than their allies in the Atlantic;" p. 373.

So far separated from works of reference on this distant expedition, I have not been able to obtain much data concerning the climate of the interior of Alaska. From gold miners who have been nearly ten years on the Stakeen River, debouching into the Alexander Archipelago, in latitude 56°, I learn that east of the Coast range of mountains the summers are dry and comparatively warm, the winters very severe, with heavy falls of snow that completely stop mining operations. The country is sparsely covered with a growth of small trees. Major Pope, engaged in exploring the inland route for the Russian-American Telegraph line, reports that in latitude 55° and longitude 126°, two degrees south of Sitka, and one hundred and sixty miles east of Queen Charlotte Sound, "ground ice" can be found at any time of the year at a depth of from six to eight feet below the surface, and in that region the surface usually freezes to the depth of two feet in the winter, leaving an intervening stratum of unfrozen soil from four to six feet thick. This ground ice does not prevent the growth of vegetables, a fact confirmed by Seeman in his "Botany of H. M. S. Herald, 1845–'51," *in western Esquimaux land.* In that region he found vegetation flourish where the ground ice was but two feet from the surface.

CLIMATE OF SITKA.

Appendix H gives much valuable meteorological information condensed from the full and detailed observations made at the Sitka Magnetic and Meteorological Observatory, on Japonski Island, sustained by the liberality of the Russian-American Company since 1847. The later published records have not been received from St. Petersburg, but I have been able to obtain those up to 1862 inclusive. By this abstract it will be seen that the mean temperature of the year at Sitka, in latitude 57° 03′, derived from twelve years' observations, is 42°.9 Fahrenheit.

Beginning with the month of March, we can judge of the temperature of the different seasons by the following scheme:

Months.	Degrees.	Season.
March	35.5	Spring. 41°.3
April	41.2	
May	47.9	
June	51.7	Summer. 54°.3
July	55.3	
August	55.8	
September	51.2	Autumn. 44°.2
October	44.2	
November	37.8	
December	31.7	Winter. 31°.9
January	31.1	
February	32.9	

In the general table will be found one month of unusually cold and extraordinary clearness of weather. In November, 1853, the mean temperature of the month was only 19°.85, but 0.451 inch of snow fell upon parts of six days, and the month was marked by strong northeast winds. The highest mean for any month in twelve years is 58°.3 for July, 1860, during which month nine days are recorded upon which rain fell, but no record appears of the amount.

The mean of all the minima taken from the daily observations for nine years of the above period is 38°.6, and of the maximum for seven years 48°.9, showing a remarkably equable climate, whilst its humidity is demonstrated by the small differences of the wet and dry bulb thermometers.

The same appendix exhibits the monthly and yearly amounts of rain, melted snow and hail that have fallen for fourteen years, and also the number of days in each month upon which rain, snow, or hail fell, or thick fogs prevailed.

The average annual amount of rain, melted snow and hail that fell in 14.09 years was 83.39 inches, or within a fraction of seven feet, (yet six inches less than what falls at the mouth of the Columbia River,) and the average annual number of days upon which rain, snow, or hail fell, or heavy fogs prevailed, was 245, or two days out of every three, while it does not follow that the other days have a clear sky.

The following scheme exhibits the rain-fall for the different months:

No. of years.	Months.	Inches.	Seasons.	Rainy days.
14	March	4.84	Spring. 14°.0	19
13	April	5.02		18
13 4.5	May	4.14		18
13¼	June	4.04	Summer. 15°.4	22
14	July	4.10		21
15	August	7.28		23
15	September	10.46	Autumn. 30°.8	23
15	October	11.87		26
14	November	8.49		23
14	December	8.21	Winter. 22°.9	19
14	January	7.64		20
14	February	7.08		18

The greatest amount of rain that fell during any one year, according to the tabulated appendix, was 95.8 inches, or 8 feet, in 1850; the smallest was 58.6 inches, in 1861. The most that fell in any one month was 19.5, in October, 1853; the smallest was 0.5 inch, in November, 1853. But Appendix K shows that a rain-fall of 21.3 inches took place in August, 1867; 16.0 inches in September, and about 15 inches in October, or quite 52 inches of rain during the period of our expedition to Alaska.

Appendix K gives in detail the daily means for the months of May, June, July, August, and September, 1867, indicating, in part, the weather we have unfortunately encountered, and the amount of clear sky, from means of nineteen hourly observations each day.

Lutke has given interesting tables, compiled from two years' observations in 1828 and 1829, wherein we find there were, on an average, each year, 170 days calm, 132 days with moderate winds, and 63 days with strong winds. Also, an average of 74 fine days, 174 days on which rain or snow had fallen at intervals, and 117 days on which rain or snow had fallen continually.

The enormous amount of rain-fall along a seaboard essentially cloudy throughout the year, has its normal effect upon the class of vegetation that will succeed in ripening under such conditions of climate. The whole extent of country subject to these rains is covered with sphagnum from one to two feet in depth, and even on the steepest hillsides this carpet is saturated with water, and renders progress through it very slow and difficult, especially when there is a heavy growth of wood and underbrush. At Fort Simpson, the Stakeen, Chilkaht, Kadiak, Unalaska, and the islands westward, this morass exists to the summits or snow line of the mountains. In no part of the country, except on two or three mountain sides on Chatham Strait, between the eastern entrance of Peril Strait and the mouth of the Chilkaht, have we seen herbage or trees destroyed by fire, as is so universally resorted to in Washington and Oregon, both by the natives and by the settlers. At our different stations we attempted to obtain the temperature of the earth three feet below the surface, but never penetrated a foot before the hole was filled with water.

The prevailing winds in winter are easterly, and if from the southward are accompanied with rain and snow; when from the northeast the weather is generally clear and cold. The stormy weather commences in October; storms and tempests are frequent in November and December, and from the vicinity of Sitka the aurora borealis is seen frequently and very brilliant during clear, cold nights. The winter weather breaks up about the end of March, and the Russian-American Company's vessels are ready for their first fur trading early in April, when the weather is cold but comparatively dry. March, April, May, June, and July, and sometimes August, are good months, with an average monthly rain-fall not much greater than that on the Atlantic coast.

The general opinion of the old navigators and fur traders, who visited and sometimes wintered on this coast, was, that after the middle of September it was next to impossible to continue their examinations or trading trips, and they either sought more southern latitudes or wintered in some well-sheltered harbor. The latter was generally avoided, on account of the losses sustained in their crews by the ravages of scurvy. It is to be noted, however, that these trading vessels for discovery alone rated only from 100 to 320 tons burden.

The weather in Cook's Inlet, north of 60° of latitude, is said to be much better in summer than along the coast generally. When fogs and rain are prevailing along the seaboard and at the entrance to the inlet, clear skies and pleasant weather exist twenty miles within the inlet, unless very heavy southeasters be blowing. Dixon reports that from July 19 to August 30, 1786, he observed the mean state of the thermometer to be 58½°. Unless exceptional, this is warmer than Sitka. Most of the old navigators speak of the pleasant aspect of its shores and its summer climate. The company's navigators all combine to commend it. Unfortunately we have not any available records of meteorological observations at the Russian factory of St. Nicholas, on the east side of the inlet, at the mouth of the river Kakny, in latitude 60° 32′. Tebenkoff says the climate of Cook's Inlet is more expressed than the rest of the colonies. The thermometer in summer frequently rises to 95°, (28° Reaumur,) and in winter falls as low as 58° below zero, (—40° Reaumur,) when the inlet freezes as far south as Katchetmakski Bay. In the spring the great tides break up the ice, which very often lifts rocks of considerable size and scatters them over the bay and its shores.

We have no regular record of the temperature at Prince William Sound, one hundred miles east of Cook's Inlet. The following extracts from Meares's introduction to his narrative must be taken with the knowledge that he wintered here under very unfavorable circumstances, in a small bay, close under the north flank of high mountains that did not allow the rays of the sun to reach him. He had at noon in midwinter but a faint and glimmering light, the meridian sun not being higher than 6°—he was in latitude 60° 30′—and that obscured from them by hills reaching 22° high to the southward; snow covered the earth to a great depth. He ran short of good provisions, and lost most of his crew by scurvy.

On the last day of October, 1786, the thermometer fell to 32°, with the mornings and evenings sharp.

In November, the thermometer ranged from 26° to 28°, and ice formed from the vessel to the shore.

In December, the temperature fell to 20°, where it continued most of the month.

In January and February, 1787, the temperature continued for the greater part of that time at 15°, although it sometimes fell to 14°. In the first half of January were heavy falls of snow.

March was cold as January and February, with much snow; the temperature continued for the most part at 15° to 16°, although it sometimes rose to 17°.

The first part of April was frosty, accompanied with violent southerly winds.

At the end of the month the thermometer in the sun rose to 32°; at night it fell to 27°.

To the middle of May the thermometer in the shade stood at 40°, and at night fell to 32°, with thin ice, and the main body of ice with which his vessel was surrounded began to loosen from shore.

Reflecting upon the high latitude of this sound, its waters embraced by high mountains on three sides, chilling it with the eternal snows and glaciers of the Mount St. Elias range, we may be surprised at the comparatively high temperature of the winter, especially in the location he selected, out of the reach of all sun influence for a couple of months. At this high latitude the lowest record he gives is 14° Fahrenheit, but the uniformity is remarkable, and especially as continuing below 32° for six months.

Tebenkoff (1848) gives a dark picture of the appearance and climate of Prince William Sound, calling it desolate, gloomy, and deserted; surrounded by rocks and pine forests; mountains covered with eternal snow, and enveloped in perpetual fog, or invisible with drizzling rain. Rain falls sometimes for a whole month, and there are not more than sixty or ninety sunny days in the year. During the months of July and August the thermometer showed 59° on fair days and 46° on rainy days. The frost in winter is very severe, but of short duration, for the south winds change it suddenly to thaw and rain.

CLIMATE OF KADIAK.

I was unable to obtain any meteorological record at St. Paul, and our knowledge of it is extremely limited. In general terms we know that it is warmer in summer than at Sitka, and colder n winter; and this is corroborated by the fact that ice obtained at Sitka for the San Francisco market was found unfit for commerce on account of being full of air-holes, &c., by which it rapidly melted, and recourse was had to the ice formed by the colder winters of Kadiak. The yearly supply to San Francisco for the whole interior and seaboard consumption is about three thousand two hundred tons, of which nearly one-half is lost by melting; and it is a curious fact that the demand is no greater now than it was fourteen years ago.

The following information concerning the ice crop was obtained at San Francisco and St. Paul: The ice lake is about five hundred yards from the shore and nearly surrounded by wood, so that the spray from the ocean beach does not reach it. It is partly artificial, having been increased in area and depth by the formation of a dam sixteen feet high, which gives the lake an extent of two thousand two hundred feet, by seven hundred, and a depth of twenty-two feet. The surplus water drives an overshot wheel giving motion to a saw-mill. The ice crop comes to maturity by December; the cutting commencing when there is twelve inches thick of clear, solid ice, and ending in February, when it has generally increased to eighteen inches. The cold is uniform, and the ice has not been known to make more than one and a half inch per night, although the thermometer has been only once recorded as low as 18° below zero during the last five or six years. During these unusual cold epochs the air is quite calm and labor practicable. The average fall of snow is three feet and lasts until June, when it disappears very quickly, and grass springs forward with remarkable rapidity.

In the latter part of August we found grass growing from the sphagnum and having an average height of not less than two feet, while in many places it was fully three feet. It is usually cut about the first of August, and cures well and rapidly with a few warm days. Some stacks we examined were in as fine condition and as sweet as any we have seen on the Atlantic slope. Western men with us corroborate our botanist in saying that this is really a fine grazing country, and capable of sustaining a very large number of cattle. The condition of the cattle we saw about St. Paul and on Spruce Island, at the freedmen's settlement, was fine, and the flavor of the beef we obtained was good.

Lisiansky mentions barley having been sown in 1804, and that it succeeded in many places; but the dark and rainy weather is unfavorable to agriculture. Cabbages, carrots, turnips, and potatoes are successfully raised, and the natives have many well-fenced gardens on the low ground abreast of Chagavka Cove. Potatoes were in bloom when we left, August 31.

The clearness of the weather depends entirely upon the direction of the winds. Fine weather accompanies winds from the south, round by the west, to north; with easting in them, fogs and rain prevail. During the month of December, though the winds blew from the north, the weather was tolerably mild. The thermometer was not lower than 38° till the twenty-fourth, when it sunk to 26°. The ground was then covered with snow and remained so several months. The winter, however, was not supposed to set in till the beginning of January. During its continuance, a few days of February excepted, the air was dry and clear, with fresh winds from the points between west and southwest. The severest frost was on the 22d of January, when the thermometer fell to zero. The last days of February and the beginning of March were also so cold that the mercury stood between 13° and 14°. During this period I purposely measured the thickness of ice in the ponds near the settlement, and found it to be eighteen inches. On the 9th of March commenced the return of spring. (Lisiansky, page 171.) The winter we passed here was an exceptionally dry one. (Page 190.)

The navigators of the Russian-American Company assure me that the most violent winds are those coming in great gusts from the mountains behind the town, sometimes even unroofing the houses and driving the vessels from their moorings. The old archives of the company doubtless contain much valuable information about the climate and productions of this place, as St. Paul was originally their principal establishment, and only yielded to Sitka on account of the warlike character of the Koloschians, and the greater abundance of sea otter about the Alexander Archipelago.

During our stay at Kadiak, from August 26 to 31, the mean temperature of the air was 49°.5, and of the water 45°.8.

CLIMATE OF THE ALEUTIAN ISLANDS.

Our stay at Unalaska was too limited to enable us to judge of the climate except in the influence it has upon the botany of the islands.

There are no trees of any size whatever upon any of the Aleutian islands. A few Sitka spruce brought to Unalaska Bay, and planted upon an island in the western roadstead, or Captain's Harbor, some thirty years since, are said not to have grown as many inches in that time; but it appears to me quite probable that if trees were placed in good situations at first, and properly attended to, they would succeed. This single and unsuccessful attempt well exemplifies the retarding effect which the single and sole aim of fur trading has had upon the development of the colony. Bishop Veniaminoff says that great numbers of dead willows are found among the mountains of Unalaska.

Not a stick of timber can be procured nearer than Kadiak, and every bit of drift-wood is eagerly seized upon for fuel, for which the inhabitants are dependent upon the heavy growth of sphagnum covering mountain and valley. Grasses grow luxuriantly, and when cut and cured are used to feed the small Siberian breed of cattle through the winter.

The barometer observations of my assistants made during the ascent of the active volcano of Makushin, September 7 to 11, place the line of perpetual snow on that mountain at three thousand one hundred and ten feet, while the lowest limit of the small glacier was one thousand feet lower; and vegetation ceased at two thousand four hundred and fifty feet above the sea, except the low form of vegetation known as "red snow."

On the 13th of September, when we passed through the Unalga Strait to the Pacific, the whole outline of mountain summits to the east and west was sharply and clearly defined against a beautifully clear sky, and snow had not yet appeared upon them; but the published meteorological observations of the Greek Bishop Veniaminoff, made at Illoolook, between the years 1825 and 1834, afford such useful material from which to draw fair conclusions of the climate that I have rearranged his abstracts and placed the results in the Appendix I, but present some of the results in this place. The dates are reckoned according to "old style." The mean temperature of the year, from nine years' observations, is 38°.03, or 4°.9 below that of Sitka.

Months.	Degrees.	Season.
March	29.9	Spring. 34°.9
April	33.4	
May	41.3	
June	46.2	Summer. 49°.6
July	50.6	
August	51.9	
September	43.7	Autumn. 37°.6
October	36.7	
November	32.4	
December	29.0	Winter. 30°.1
January	29.6	
February	31.6	

The mean range during the day, from the morning to the afternoon observation, is only 5°.0. The highest temperature recorded is 77° upon two occasions, and the lowest 0°.6 below zero; but only upon nine occasions is it recorded less than ten degrees above zero.

The mean height of the barometer for nine years is 29.74 inches; the highest reading during that period being 30.71 inches, and lowest 28.37 inches. The barometer reaches its highest monthly mean 29.91 inches in July, when winds from the southeast to southwest prevail; and its lowest 29.60 inches in November, when westerly winds prevail. The fluctuations of the barometer are very great throughout the year, averaging 1.78 inch in each month; the greatest range being 2.31 in December, and the least 1.07 in July.

The clearest months, without clouds, are December, January, and February, when the north and northwest winds prevail.

August, September, and October are the months in which the most rain falls, during which time winds from the south to west prevail. The rain-fall is not recorded; but he says that rain falls during some part of the twenty-four hours upon one hundred and fifty days of each year, and estimates the total fall at only 27 inches, which must be much underestimated.

Snow falls some time in every month except June, July, and August, and is recorded in every month except July.

Thunder-storms are very rare, only seventeen being recorded in seven years and none in winter.

Earthquakes are comparatively frequent, no less than thirty-two being recorded in seven years.

The clearest month is January, and at any season clear weather accompanies or follows north winds. Very strong winds prevail from October to March.

At Unalaska the aurora borealis is rarely seen, it being recorded but once during the above period of observation, when it appeared like the dawn of day on the 16th of February, 1831, O. S. On the horizon it was dark, but higher up the sky was lighter.

It was my pleasure at Illoolook to make the acquaintance of the Rev. Innocent Shayesnikoff, priest of the Unalaska district, and to receive from him a copy of his meteorological journal from October, 1866, to March, 1867. I have had it translated and arranged in Appendix J. He has a full series of observations, but his time was too short and too much occupied to copy more than the above before our departure. As he expressed a desire to add to our stock of knowledge of this region, I furnished him with some official envelopes addressed to you.

VEGETABLE PRODUCTIONS.

At Sitka fruit trees were introduced in the governor's garden, and special attention devoted to their culture, but they have not borne fruit, except a few small specimens that never matured. Berries abound throughout the country in great abundance and of large size, but generally lack flavor, on account of the absence of direct sunlight. Most of the berries were ripe when we left for Kadiak, August 22, and potatoes were in full bloom. The potatoes yield well, but are of small size and watery. Cranberries grow wild, are quite small and well-flavored, but not in abundance about Sitka; they might be easily cultivated here, and would form a valuable addition to the California market, which now receives its supplies from the northern coast. None of the cereals are cultivated, and it is very doubtful if they would succeed. In fact, except a few very small gardens belonging to private individuals, nothing is cultivated, the population trusting mainly for their food to the annual supplies brought from San Francisco and St. Petersburg by the company's vessels. There is no space cleared about Sitka for the raising of grass, and there are few horses and cattle demanding it; but there appears no difficulty in raising as large crops of grass as at Kadiak, if the land were cleared of wood and the increase of cattle demanded it.

The prevailing forest tree is the Sitka spruce, growing to great size and covering every foot of ground, and climbing the steepest mountain sides to the height of two thousand or two thousand five hundred feet above the sea. We have measured felled trees of this spruce that were one hundred and eighty feet long and four feet thick at the butt, while adjacent standing trees measured over six feet in diameter, and were branchless for over fifty feet. Hemlock, alders, and willows are found, but the most valuable wood of the country is the yellow cedar, with a fine, even texture, fragrant smell, good size, and greater strength than the spruce. I first called public attention to the Port Orford white cedar, in 1851, and, while admitting its many good qualities, have no hesitation in saying that the yellow cedar of Alaska is a much superior wood. It is readily worked, takes a smooth surface, and is remarkably durable. It will make a valuable addition to the cabinet woods of the California market, is superior as a ship timber to any on the coast, and, from our short examination, we are satisfied that it may be obtained of ample size for frames and knees of ordinary-sized vessels. At Skalitch anchorage one was measured eighteen feet in circumference, and estimated over one hundred and twenty-five feet in height. I have obtained and forwarded to you part of the keelson and frame of one of the Russian-American Company's small vessels, which was constructed of this wood over thirty-two years ago, and has been lying a wreck upon the beach for several years. It exhibits not the least sign of decay or teredo attacks; the wood around the copper and iron bolts is nearly as well preserved as on the day they were driven, and the bolts are in good preservation.

The hulls of all the trading and fishing vessels on this new coast may be constructed of this durable wood upon any of the innumerable bays of the Alexander Archipelago.

While the vast forests of wood exist upon the waters of Puget Sound, Admiralty Inlet, and the Straits of Fuca, it may be commercially unprofitable to cut and ship even this yellow cedar to the California market, unless native labor can be obtained at low rates to get it out; yet, even if unavailable at the present time, it affords an inexhaustible resource in future, and will prove of the greatest importance as the supplies decrease to the southward.

This timber is found from the southern boundary of Alaska to the furthest point northward we examined in Chatham Strait.

The spruce, yellow cedar, hemlock, &c., cover the coast as far north as Ltuya Bay, whence westward to Prince William Sound very little is known, all navigators reporting a very forbidding low coast, covered in part with wood, but closely backed by the great St. Elias range, with its summits averaging from 8,000 to 9,000 feet, and every gorge filled with snow or glaciers. The Russian Company has no factory along this stretch of coast, and their explorers report numerous small streams running through it to the ocean.

On Prince William Sound, notwithstanding the severity of the winters, vegetation is reported to spring up with great rapidity, and berries of every variety and in great abundance flourish where the low shores are not densely covered with spruce, alder, and birch.

The same remarks apply to Cook's Inlet, with its warmer summer and more vigorous vegetation. Its western shores are covered with timber.

Similar products continue to Alaska Peninsula and the northern part of the island of Kadiak, although on this island we found the trees smaller and shorter, and growing only in the valleys or low grounds, and in comparatively small areas along the northern coast lines. We saw none covering the mountain sides. Mention has already been made of the productions of Kadiak, in the vicinity of St. Paul. At this place and upon the lands about the settlements on Spruce Island my assistants estimated the number of cattle at two hundred.

The vegetable productions of Unalaska were found similar to those of Sitka and Kadiak; but no trees exist west of the middle of Kadiak and the peninsula abreast of it. Turnips and potatoes are cultivated by a few of the Aleutians, after removing the covering of sphagnum from the soil; and were there any proper and cultivated incentive to industry and improvement, no one can doubt the capability of the soil affording fair quantities. Bishop Veniaminoff says that the potato yields from four to seven fold and attains "great size," from three to ten making a pound weight! He is our authority for saying that among the mountains of Unalaska are found great numbers of dead willows.

I found growing in Unalaska Bay, in great quantities, in certain localities, the pea called by botanists *Pisum maritimum*, and from its luxuriance and size have little doubt but that it could be readily cultivated. It was found in all the stages from flowering to the ripe fruit on the 7th of September. Seed was procured for growing on the Atlantic coast. Captain Bryant has found this pea growing as far north as Norton Sound, in latitude 64°. Throughout the whole country the fields are brilliant with many-colored flowers, gratifying the eye, and satisfying the explorer that the country has a moderate climate.

The navigators of the Russian-American Company inform me that the productions of all the islands to the westward are similar to those of Unalaska. Tebenkoff says that the potato is cultivated by the inhabitants in every village of the country.

I have no available sources of information concerning the vegetation northward of the peninsula of Alaska from Bristol Bay, in 58°, to the mouth of the Kvichpak, in 63°.

Further to the northward we have the evidence of Seeman, in his "Botany of the Voyage of her Majesty's ship *Herald*, 1845–'51," to show that the coast even in this high latitude has a vegetation due to a much lower latitude. He says the climate is considerably milder than that of the eastern shores of America in the same parallel. The proofs we need not deduce from artificial tables; nature herself has written them on the face of the country. The abundance of animal life, the occurrence of many southern plants, and, above all, the limit of the woods, if compared with the opposite shores, furnish indisputable evidence. On the eastern side of America no forests are found above the mouth of the river Egg, above the 60th degree of latitude; on the western they extend as far as latitude 66° 44′, or nearly seven degrees further towards the pole. "The summer sets in most rapidly, and the landscape is quickly overspread with a lively green; flocks of geese and ducks arrive from the south; the plover, the snipe, and many other birds enliven the air with their notes." "The sun is now always above the horizon, and the rays falling continually upon the surface of the earth prevent the temperature from cooling down too much; and thus, notwithstanding the low altitude of the sun, a degree of warmth is produced which, under other circumstances, would not be possible, the thermometer rising as high as 61° Fahrenheit. With the sun shining throughout the twenty-four hours the growth of plants is rapid in the extreme. The snow has hardly disappeared before a mass of herbage has sprung up, and the spots which a few days before presented nothing save a white sheet are teeming with an active vegetation, producing leaves, flowers, and fruit in rapid succession."

The whole country, from Norton Sound to Point Barrow, is a vast moorland, whose level is only interrupted by promontories and isolated mountains. The rain and snow-water, prevented by a frozen soil from descending through it, form numerous lagoons, or when the formation of the ground opposes this, bogs, the general aspect and vegetation of which do not materially differ from those of northern Europe, being covered with a dense mass of lichens, mosses, and other uliginous forms. Places are covered with plants and sometimes difficult to pass. "Wherever drainage exists, either on the shores of the sea, the banks of the rivers, or the slopes of the hills, the ground is free from peat. Such localities are generally clad with a luxuriant herbage, and produce the rarest as well as the most beautiful plants."

"The aspect of some spots is very gay. Many flowers are large, their colors bright, and though white and yellow predominate, plants displaying other tints are not uncommon. Cape Lisburne, (in latitude 68° 52',) one of the most productive localities, looks like a garden."

"About Norton Sound groves of white spruce trees and *Salix speciosa* are fragrant; northward they become less abundant, till in latitude 66° 4', on the banks of the Noatak, the *pinus alba* disappears."

To prevent the ravages of scurvy, the Esquimaux "collect for their winter stock raspberries, whortleberries, and cranberries, which are placed in boxes and preserved, by being frozen into such a hard mass that in order to divide it recourse must be had to the axe."

"In the sub-arctic regions there are plants which the eye is accustomed to meet in the plains of more temperate climates, * * * * besides annuals and biennials, and shrubs and trees." "A peculiar feature of the vegetation is its harmless character. The poisonous plants are few in number, and their qualities by no means virulent."

It is a curious fact, that throughout our exploration no reptile, toad, lizard or similar animal was seen, and Seeman states the same in regard to the arctic and sub-arctic regions.

Captain Thomas informs me that this season (1867) has been remarkably open, and that he reached the latitude of 72° 55'. From the position of "Plover Island," north of 71°, he skirted the low coast to the north-northwest and to the west-southwest, and saw it stretching far westward to include the "extensive high peaks" of the maps. So this "Plover Island" is only a hill forming the eastern termination of a very extensive land, which was covered with a very luxuriant coat of green in August and September.

MINERALS.

Of these little is known, and Prince Maksoutoff confessed that the Russian-American Company had been so persistently engaged in procuring furs and studying the best methods of keeping up the supply that no thorough mineralogical exploration had been made, although a large cabinet of mineralogical specimens for comparison had been furnished by the company to the chief establishment at Sitka. Under his direction the very few in possession of the servants of the company were transferred to me and referred to the geologist.

The great desideratum of the Pacific coast is coal, and we had been led to suppose that some of the reported deposits in Alaska were really coal, but the specimens from the island of Unga, given to me by the governor of the Russian colonies, are nothing more than lignite, thickly marked with iron pyrites. Moreover, at the worked out-crop in Coal Harbor it exists in veins of rarely more than a foot in thickness. This coal has been faithfully tried on the Russian steamers, and after very many experiments has been abandoned and recourse had to the Nanaimo coals from Vancouver's Island. The navigators and engineers of the Russian steamers inform me that it is very light, burns with great rapidity, and leaves very much ash and clinker. The same general remarks apply to the coal obtained from English Harbor, at the entrance to Cook's Inlet, and first found and reported by Portlock. But I am informed that at the northwest point of the entrance to Tchugatchek Bay, under the Anchor Point of old navigators, there is an unworked vein of coal of seven feet in thickness, and this or similar veins crop out upon the shore of Cook's Inlet for twenty miles to the northward towards Anchor Point. This coal has not been opened, and I forward to you a manuscript map by one of the Russian captains showing its position. I also send a manuscript map of English Harbor.

Two positions on Chatham Strait are reported to furnish coal. One has been worked and tried by the Russians and condemned; the other depends upon Indian reports. Should petroleum come to be used as a steam-producing fuel on steamships, there is a prospect of a supply being obtained from the southeast shore of Alaska Peninsula, at or near Katmay Bay, in latitude 58° 01', longitude 154° 54', and abreast of Kadiak Island. I have been furnished with a specimen of the crude oil obtained there two or three years since. The finder reports that he found three streams in the above locality covered with petroleum. It also remains to be seen whether the specimens of bituminous coal which were discovered by the geologist of my party will lead to the discovery of a deposit of this coal sufficient in quantity and quality to make it available. So favorable are all the geological surroundings that I would respectfully urge upon the government the necessity of having a thorough and exhaustive examination made of this locality. Such exploration could be aided by an escort of the troops from Sitka, under the guidance of scientific men. I refer you to Mr. Blake's report for the geological indications which suggest the strong probability of a large deposit of good coal.

Specimens of pure copper have been gathered from various localities, but the principal source is on the Atna or Copper River, about twenty-five or thirty miles above its mouth, where discovery and research are retarded on account of the reported hostility of the natives. I have obtained from Mr. Klinkofstrom, Russian consul at San Francisco, a specimen of this copper, and masses of about a cubic foot are obtained from the river. All the peculiarly-figured copper-plates of the natives, twenty-six inches by fifteen inches, and so much prized as heir-looms by the Indians as far south as Vancouver's Island, are hammered out of pure copper obtained from this river.

Copper combined with quartz is found in several localities, and Bishop Veniaminoff says that near Makushin Bay, between the distant pass and the Tarasoosky Bay, there exists a lake high among the mountains, and that metallic copper is found along the shores of the lake.

Silver has been reported in several places, but when my assistants sought the localities the guides could not point them out. At St. Paul I found specimens of quartz with sulphate of iron and lead. Upon analysis in San Francisco, kindly made for the Coast Survey free of charge by John Hewston, jr., M. D., it was found to contain only $4 15 per two thousand pounds, and had in it a trace of gold.

Gold is found on the Stakeen River, and even with very crude means of working the miners report that they can make from $2 to $7 per day, but the climate forbids them working more than six months of the year. Proper methods of working the fine gold placers of this river would yield twice the above amount. Gold is reported on the Kakny River, which enters Cook's Inlet on its eastern side about latitude 60° 32′, at the Russian station of St. Nicholas, but I have no authentic information on the subject beyond the statement by Tebenkoff. While we were at Sitka experienced miners made two prospecting tours over part of Baranoff Island, but without finding the "color." The slate and quartz formation around Barlowe Cove, at the head of Admiralty Island, on Chatham Strait, in latitude 58° 24′, is almost an exact counterpart of many rich gold localities in California, but the heavy weather that prevailed while we were there a few hours prevented any other than a casual examination of one view of quartz five feet thick cropping out upon the shore. It was much disintegrated and abounded in iron pyrites.

In Little Naquoshinski Inlet, fifteen miles from Sitka, my party discovered very fine marble in inexhaustible quantities, and at the mouth of the Chilkaht specimens of marble of a very coarse grain, and others of a remarkably fine crystallization, were discovered, all being white, very pure and unmarked.

On the flank of the mountain Verstova, which attains an elevation of 3,381 feet, bismuth of remarkably pure quality is said to be found, my informant being one of the Russian-American Company's officers. The weather was so shockingly bad and the season so late that it was impracticable to send a party of exploration, although the time would occupy but one day. The specimen I obtained was said to have come from the Koloshes River, but that appeared doubtful, as it was not water-worn, and Mr. Blake made two explorations of the river for two or three miles without discovering any signs.

Iron ore is reported in the vicinity of Sitka, but after two searches in the localities indicated the examination was abandoned; yet in this case I attribute the failure to our informant's inaptitude for topographical description.

The hot springs, lying on the southwest part of Sitka Sound, about fifteen miles from Sitka, were not visited, and we know nothing more than from the meagre descriptions of others. They are of very high temperature, sulphurous, and reported to effect cures in rheumatic affections.

FUR-BEARING ANIMALS.

Of the number and value of the different varieties of skins obtained from the Indians by the Russian-American Company it is impossible to form an opinion, as the very existence of their trade depended upon the secrecy with which it was conducted. That the company has been able to maintain a large establishment in persons and material is strong circumstantial proof of the value of the trade. The almost absurdly small amount of trading articles paid to the Indians for their most valuable skins is so marvellously low that it would astonish those who have to pay such enormous prices for the manufactured furs in our large cities. The company itself must realize over a thousand per cent. upon the first cost of the skins, and then it must be considered that the coast Indians are not engaged solely in hunting, but act as intertraders between the company's agents and the interior Indians, who are never permitted to visit the coast. The Hudson's Bay Company has had a purchased right to trade in certain localities on this coast, and their traders have availed themselves to the uttermost to obtain the greatest possible supplies. From the mouth of the Chilkaht alone they took this year over twenty-three hundred martens or "Russian sables."

It is useless for me to enter into the description of the different kinds of furs upon the coast or of the habitat and relative abundance of the different animals. The governor of the company had a map in colors exhibiting at a glance the localities of every fur animal and its frequency. This map was obtained for the government by Captain Howard.

The policy of the company has been to maintain a regular supply, and to this end they place restrictions upon the trade, even designating islands and localities where the animals shall not be taken. When the supply of any animal is running short, or an island is found peculiarly adapted to support certain kinds, a stock is placed upon the island and the natives forbidden to hunt there for a series of years.

The use of fire-arms is prohibited in the pursuit of certain animals, as the noise is certain to drive them away. The number of sea-otter skins now annually obtained does not amount to over eleven hundred, where the supply seventy years since, in the Alexander Archipelago alone, was eight thousand, of which it was confessed that the American fur traders secured over sixty per cent. Between Yakutat Bay and Dixon Sound, Tebenkoff says that not a single sea otter is found, attributing their absence not so much to their destruction as to the noise of fire-arms.

An important consideration in sustaining the value of the fur trade, and thereby continuing an industrial pursuit to the natives, will be the rigid governmental direction of the proper seasons for killing the different fur-bearing animals, and to a certain extent the manner of taking them. Where the practice is to kill by spears and arrows, without guns, it will be wise to continue the custom, at least until the inhabitants have become accustomed to the new order of things, and the habits of the traders. Where the practice prevails to kill with fire-arms, it appears politic to permit the sale of inferior powder and arms in prescribed quantities, otherwise those natives obtaining fur-bearing animals and game by these means will be at a loss to keep up the supply with bows and arrows, which they have abandoned many years. Every Indian in the Alexander Archipelago and along the main possesses one or more muskets, and one or two single or double-barrelled pistols; bows and arrows are unknown, except as mere matters of trade as curiosities, and for those purposes obtained from interior or very distant tribes.

In a few years the whole fur trade will degenerate into an illicit traffic with whisky smugglers, unless the most rigid and inflexible means are employed to suppress it. The Indians themselves give aid and comfort to the smuggler by timely warning of approaching danger by false information to the officers of the law, and by secreting the small vessels of the smuggler when being searched for. The thousand harbors of the coast, the thick weather, and the multitude of channels and straits, many of which are not even yet laid down, give the advantage to the smuggler.

THE FISHERIES.

Next to the fur trade, in its legitimate pursuit, the fisheries of the coast of the new Territory will prove the most valuable and certain; in fact, I consider them the most important acquisition to our Pacific coast. As the banks of Newfoundland have been to the trade of the Atlantic, so will the greater banks of Alaska be to the Pacific; inexhaustible in supply of fish that are equal if not superior in size and quality to those of the Atlantic; and the pursuit thereof developing a race of seamen yearly decreasing, as our steam marine, commercial and naval, is increasing.

We have the reiterated and disinterested statements of all the old navigators and fur traders that every part of the coast abounds in cod, halibut, salmon, and every variety of fish inhabiting comparatively cold waters, and the experience of the present expedition established the truthfulness of their descriptions.

Salmon.—At some of the entrances to shallow fresh-water streams the water is packed with salmon, and the bears come down in numbers to feed upon them, selecting the heads only. On some of the beaches, near these streams, the seine will take them in thousands. In the bays leading to the small streams at their head, on the southeast side of Alaska Peninsula, the salmon are crowded so thickly that the progress of a boat is impeded, and should a southeast storm arise at such times the fish are driven on the beach in innumerable quantities; one of the Russian navigators assures me that he has seen the beach strewn two to three feet thick with the stranded salmon.

I forward you a sketch of the outlet of Gloubokoe or Deep Lake, on the south side of Sitka Sound, where the Russian-American Company have built dams, traps, foot bridges, houses, &c., in the most substantial manner. The dams and traps lie across the upper part of the rapids, which have a fall of nine feet over rocks. The traps are large rectangular spaces made with stakes placed perpendicularly and near enough to each other to allow a free flow of water, and yet prevent the salmon passing between them. The side of the trap towards the descent has an opening like the entrance to an ordinary rat-trap on a large scale. The fish rushes up the rapids and passes through this opening to the staked inclosure, where it remains swimming against the moderately strong current. When several salmon have entered they are lifted out by a kind of wicker basket and placed in large boxes lying between the traps, of which there are six, with means of adding as many more. The last year's catch that was packed for market amounted to five hundred and twenty barrels, containing from eighteen to twenty-five salmon each. As high as one thousand salmon have been taken in one day.

The great winter food of the natives is dry and smoked salmon, of which they lay in very large supplies.

Cod.—But the most valuable fish on the coast is the cod, and, so far as ascertained, it has already been very profitable to those interested in it, although in one or two instances losses have occurred by finding the cargo improperly cured. Those persons interested in it refuse to give detailed information of their outfit, catch, profits, or of the banks where the fish are caught. It is, however, generally understood that the principal fishing grounds are about the Shumagin Islands, while some fish off the island of Kadiak, and a few go as far as the Ochotsk Sea; fishing along the western shores of the peninsula of Kamtschatka, where the fish average about twelve pounds each.

In our voyage to Kadiak and Unalaska, and returning to Sitka, we saw none of the numerous fishing fleet that was out this season; probably on account of the lateness of the season, but more likely because we passed through the Petries or Chelekoff Strait, between Kadiak and the peninsula. The Portlock bank, which we sounded over, off the northeast part of Kadiak, is possibly not a favorable ground for cod on account of the muddiness of the bottom, although certain localities may afford good feeding grounds.

In 1866 twenty-three vessels, comprising barks, brigs and schooners, started from San Francisco for the various fishing grounds, but concealed their particular destinations; their time for leaving San Francisco is as early as March, arriving on the grounds in April; and they should leave about September.

Two or three small schooners sailed from Victoria and made fair catches, so much so that the importation of cod into the ports of British Columbia has ceased.

The amount of fish brought into the San Francisco market in the season of 1866 was estimated at from eight hundred to a thousand tons, which would appear a very low estimate, as all the vessels reported full cargoes. No tongues and sounds were quoted, and were evidently not saved; and only a small quantity of cod-liver oil was saved by one of the vessels from Victoria.

The supply from the Alaska banks has stopped the importation of codfish from the eastern ports to San Francisco, and when the curing process is properly understood and carried out, the Pacific coasts of America and Asia will become consumers.

The fish have not been cured on the Aleutian Islands because the territory belonged to Russia, but were kept in salt as long as six months, or until the return of the vessel to San Francisco, evidently to the injury of the cargo. Many of the persons engaging in the business knew nothing of the manner of catching or of curing the fish, yet the prices commanded were from thirteen to seven and a half cents (gold) per pound; and last February the average rate was nine and a half cents. One vessel carried her full cargo direct to Australia, and received eight cents per pound.

The large amount of fish consumed in California, where the population is largely Catholic, has always created and sustained a large demand, and the new cargoes are quickly disposed of at rates ranging as high as thirteen cents per pound. The southern coasts of America are almost wholly Catholic in their population, and so soon as the fish are well cured, the demand from that source will increase. It is doubtful whether we can compete with the Asiatic fishermen in their own ports.

Some of the vessels are said to commence fishing along the Alaska coast north of 54° 40′, and to work northward along numerous banks which they appear to have found. The fish are taken in from fifteen to forty fathoms of water; the best fish in the deepest water.

It has been found practically that the Ochotsk sea is too distant from San Francisco, and the fleet of 1867 from San Francisco were supposed to be bound generally to the vicinity of the Shumagin Islands. They report that wherever the water is sufficiently shoal the cod is very abundant. In 1866 the largest takes were off the Shumagin Islands, off which we got soundings this year in forty and fifty fathoms at a distance of thirty-five miles.

The soundings of Portlock, of Vancouver, and of this expedition prove the existence of a comparatively shoal bank, extending along the southeastern coast of Afognak and Kadiak, with a deep pocket of ninety fathoms, no bottom, twenty-five miles east of St. Paul. The shoalest water obtained on this bank by this expedition was forty-five fathoms in latitude 58° 16′, longitude 149° 42′, according to Mr. Mosman's observations. It is fair to assume that this bank extends along the southeast shore of Kadiak, as incidental and unconnected observations indicate. South by east fourteen miles from the eastern end of the easternmost of the Trinity Islands, Vancouver found bottom at fifty fathoms. Soundings on the English chart 2172 give fifty-five fathoms nearly midway between the Trinity Isles and Ukamok Island, which lies on the prolongation of the longer axis of Kadiak, fifty miles from the Trinity. Fifteen miles south of Ukamok Vancouver got seventy-five fathoms, sand and shell bottom. Thirty-five miles east from the south end of the island of Niuniak, the southernmost of the Shumagin Islands, we obtained coral and sand bottom in forty fathoms of water; the position as determined by Mr. Mosman is in latitude 54° 38′, longitude 158° 30′. Ten miles further westward the depth of water was fifty fathoms. In neither of these localities were any attempts made to fish.

Tebenkoff gives soundings of 45 fathoms fifty miles south 83° west of the southernmost point of the Shumagins, on the line and nearly half way towards the dangerous reef and island of Sannakh. From that position the nearest islands to the northward are about thirty-five miles distant. In latitude 54° 20′ and longitude 162° 30′, about nine miles southeast from the Sannakh reef, we got bottom in thirty-five fathoms, rock and barnacles being brought up by the lead. But the exact point of the reef from which we took our departure was not known, on account of the dense fog prevailing when we unexpectedly made it.

The bank where trial was first made for fish was found on the fifth of September, during a prevalence of thick weather. Mr. Mosman fortunately seized an opening and obtained good observations for longitude; with an approximate latitude, the position is in latitude 53° 35′ and longitude 164° 10′, and near it soundings were obtained in fifty fathoms of water, the lead bringing up sand and a small star-fish. With thick drizzly weather the vessel drifted to the northwest by compass, until sixty-five fathoms were struck with sandy, pebbly bottom. Here the lead-line was baited, and while on the bottom the first cod took the hook. The fish proved very plenty, fat, and bit eagerly; frequently two were brought up on a double-hooked line, and sometimes three were brought up on a line with three hooks. The largest measured thirty-seven inches in length, and several reached thirty-six inches. The finest was thirty-six inches long, twenty-three inches girth, and weighed twenty-seven pounds; was very fat and certainly of as fine if not finer flavor than cod I had eaten eleven months before, freshly caught on the south coast of Newfoundland.

The vessel drifted to the northwestward all the afternoon over this bank, with the same depth of water and fish biting well, although all appeared in capital condition and their maws full of food, such as squid, halibut head, fish the size of a herring, sea-lice, &c. We got no observations that noon or afternoon, nor any all the next day, on account of thick, foggy, drizzling weather, but the vessel could not have been far from latitude 53° 40′ and longitude 164° 30′, lying sixty-five miles east-southeast true from the middle of the Akoutan Pass, and forty miles south-southeast from the Unimal Pass. The weather was altogether too unfavorable to make an extended examination of this locality. The fifty-fathom position is forty miles broad off the nearest island of the Kriniatzkin group, lying between Unimak and Unalaska. Much deeper water, one hundred and four fathoms, over a bottom of black sand, was subsequently found in latitude 53° 38′, longitude 165° 25′, forty-three miles westward of the above cod bank, and twenty-five miles broad off the islands.

In addition to the already acknowledged success of the cod-fishers from San Francisco and Victoria, and our own experience, I add that of Captain Bryant, formerly a whaler in the North Pacific, and now an influential member of the Massachusetts legislature, quoting from your notes of May 26: "Behring Sea is a mighty reservoir of cod and halibut, so that he never threw over his lines without bringing up fish in whatever part of the sea he might happen." The soundings of this sea, and of the Arctic Ocean north of Behring Strait, indicate it as the most remarkable submarine plateau of such great extent yet known. On the eastern half of this sea soundings of less than fifty fathoms are found over an extent of eighteen thousand square miles.

"South of Alaska, at a distance of say fifty miles from shore, there are banks running parallel to the coast, admirable for cod-fishing; these banks can usually be recognized by the lighter color of the water."

The fishing smacks carry their bait from San Francisco at a cost of about one hundred dollars in gold for a one-hundred-ton vessel. We fished with clams, the *Schizotherus nuttallii*, obtained at Fort Simpson on our way up; but there are plenty of small fish, herring, clams, &c., suitable for bait, in all the harbors along the coast.

The importance of the possession of these islands can hardly be overestimated; not only can our fishermen enter and fish in every bay when heavy weather compels them to leave the banks, but they give ample opportunities for the successful curing of the fish, certainly as great, if not greater, than I saw on the south shore of Newfoundland. Instead of making the long trip to and from San Francisco, and of keeping the fish so long in salt, especially if imperfectly cleaned, it appears feasible to make a general depot and curing establishment, as at Kadiak, whence vessels could carry the catch of all the smacks, which might readily refit in winter and be ready for the opening of the next season. I mention Kadiak as affording the nearest available timber for repairs and as already a depot for the ice crop of the Pacific.

In conversation with the governor of the Russian colonies upon the value of the cod fisheries, he acknowledged that the Russian government had not been aware of the extent, value and importance of the cod grounds as a new industry in the Pacific. While its commercial value is so great to us, it will prove of great service to the Aleutians, who are patient, skillful, and fearless in their fishing. Under proper guidance they may be very profitably employed in the taking and curing of fish; and in order that our fishermen may know where to find labor among these islands, I procured from the priest of the Unalaska district the population of every village from Attú to Unga. These statistics will be found under the head of population, &c.

Herring.—In September, when drawing the seine for salmon at Illoolook Harbor, several herring were obtained of large size, fatter and of much finer flavor than the herring caught on the California coast. No information was obtained of the season when they visit the coast. They are found in the vicinity of Sitka, and doubtless visit the whole seaboard. Portlock mentions that, "when hauling the seine, he caught large quantities of herring and some salmon. The herrings, though small, were very good, and two hogsheads of them were salted for sea store."

The herring, besides its own intrinsic value, has an important bearing on the question of the cod fisheries in supplying bait, which is now carried from San Francisco for that purpose at large prices.

Whale.—The waters surrounding the Territory of Alaska have always been celebrated for their whale fisheries, and the Russian-American Company formerly paid some attention to this branch of industry and profit, and had surveys made in Cook's Inlet for ascertaining the proper anchorages and harbors for their whalers in winter. They even established a ship-building station in Resurrection Bay, on the eastern shore of the Kenai Peninsula. But as the whaling was not so remunerative as the fur trade, their whole efforts were directed to the full legitimate development of that business. Some of the Russian navigators inform me that their best whaling ground, from the middle of June to the middle of July, was in the region named Fairweather Ground by the American whalers, and lying between the Pamplona Reef and the shores off Mount Fairweather. The richness of this locality is confirmed by all the old navigators and fur traders, who found these waters abounding in whales, especially in the region of the Barren Islands, between the Peninsula of Kenai and the Island of Kadiak. As early as June 4, (1787,) Dixon, when four or five leagues off Port Mulgrave, found many whales playing about his ship. Captain Bryant, in his notes, says that Fairweather Ground is at proper seasons the great receptacle of the mollusk called "whale's food," the *clio*, a minute animal about the size of a flax seed, and having a gelatinous consistency it covers the ocean like a scum.

"This mollusk drifts along with the coast current towards the west at the rate of about one mile per hour. During this season the sea and all the adjacent bays are filled with the whale. The mollusk collects under the lee of the submarine range of Pamplona. The whaling season continues from the last of June to the middle of July."

It becomes an interesting question to trace back the path of this mollusk; the indications of whale in the vicinity of the divide of the Japan current, about latitude 47° and longitude 147°, are such as to suggest the probability of the mollusk being brought by the great stream towards the coast. The old navigators notice many whales in that region as early as April.

The *Clio borealis*, a small animal with a flat head, body, and tail like a tadpole, but having in addition a pair of wings, by means of which it progresses, inhabits the Arctic seas, and when the weather is calm is so abundant that the surface of the ocean is covered by them. They swarm in such myriads as to serve as the great part of the food for whales.

About Unalaska we saw numbers of sperm whale in September, and in August the sperm whaler, William Gifford, was entering the north strait of Kadiak to fill up, reporting as having left the coast of Queen Charlotte Island, where four other sperm whalers were fishing this season. The Gifford had been out from New Bedford since November, 1863, her time being five years. She had sent home 2,700 gallons of sperm oil, worth $90,000 in gold, and had on board four hundred barrels more, intending to take nothing but sperm whale, until near the end of her cruise.

The command of all the bays and straits of the northwest coast resorted to by the whale gives very great advantages to our whalers, that need only be mentioned to be appreciated: fishing at all seasons, opportunities to winter and refit, depots for cargoes, and regularity in transshipping them to the east or to the Pacific ports.

A great many whales are found in the straits of the archipelago Alexander, but the very deep water is a drawback to successful fishing.

For the last six years the whaling fleet of the Arctic has averaged not less than eighty vessels, of which seventy belonged to the United States. Their average catch in those waters amounts to not less than twelve hundred barrels each, and about 20,000 pounds of whalebone, reckoning the latter at sixteen pounds to the barrel of oil. One reason given to me by the whalers for preferring the Arctic regions over the Gulf of Alaska is the shallower water. In the Arctic Ocean and Behring Sea the depth of water is about thirty fathoms, and the whale, in "sounding," after being struck, drives his head into the muddy bottom, and has it covered with mud when he rises. The whaler learns readily where and when he will rise in such a depth; but in the deeper waters of the Gulf of Alaska, the whale does not strike bottom in sounding, and it is very difficult to estimate where he will rise, and not unfrequently sounds again and again, and thus draws the boats far from the vessel.

WALRUS IVORY.

Coal Harbor, on the north side of the island of Unga, has been the point for receiving the walrus tusks, obtained from the Walrus Islands, on the north side of the Alaska Peninsula. During the winter the walrus is said to be driven on great bodies of ice into the larger bay, thirty miles long and ten miles wide, embracing the Walrus Islands. Here the Indians kill them, secure the tusks, and trade them to an employé of the Russian-American Company stationed at the storehouse in Moller Bay, at the mouth of a small stream in latitude 55° 55′, and longitude 160° 41′. Thence the stock was carried on the shoulders of the natives, or on dog-sledges, across the peninsula to the head of Portage Bay, twelve miles deep by four miles wide, and lying north-northwest and south-southeast by compass, and directly north of Unga Island. In Portage Bay they are met by another body of Indians in their bidárkas, or skin canoes, from Coal Harbor, whither the tusks are transported. In some seasons ten tons of these tusks are secured by the Indians, and they are valued at seventy cents (gold) per pound at Sitka. Large quantities of the tusks are obtained in trade and capture by the Arctic whalers, who also try out the oil.

The systematic hunting of the walrus, prompted by better prices than have been paid by the barely life-sustaining tariff of the Russian-American Company, will develop this valuable branch of industry. Arctic whalers just from those waters assure me that the number of these animals is incalculable.

POPULATION AND GENERAL CHARACTERISTICS OF THE INHABITANTS.

It is not necessary to enter into an elaborate account of the divisions and subdivisions of the Indian races that inhabit the seaboard of Alaska, although I have had translated and gathered materials upon that subject; nor is it expected that I will give any account of the manners and customs of the people.

The annexed official table of the population of Alaska, excluding Esquimaux, Koloshes, and inland tribes, has been obtained, through the kindness of Prince Maksoutoff, from the archives of the Russian-American Company, at Sitka, and includes the Russian half-breeds, (known throughout this Territory as Creoles,) the Aleutians, which embrace the Aglemootians of Alaska Peninsula, and the natives of Cook's Inlet or Kenai Bay, Prince William Sound, and Copper River. The inhabitants of Lemusin, Behring, and Copper Islands, are embraced by the table; but in arriving at the numbers now subject to the laws of the United States, they and the Russians are excluded from the final enumeration. The total adult and minor population then stands 4,511 males and 4,505 females.

The Koloshes are inhabitants of the Alexander Archipelago, and extend as far west as Yakutat Bay, and many of them visit the Copper River every season for the purpose of trade. They are supposed to number four or five thousand, although Tebenkoff places them at forty thousand, and describes them as a fierce and treacherous race. Bishop Veniaminoff estimates the number of Koloshes, from Yakutat Bay to Dixon Sound, as five thousand eight hundred and fifty.

The Esquimaux, north of Norton Sound and round the Arctic shores, are estimated by Beechey to number twenty-five hundred.

Through the courtesy of the officers of the company, I am able to further subdivide the sums given in the table among their respective islands and districts.

On the island of Àttú, 115 male and 105 female Aleutians.

On the island of Atkha, 146 male and 159 female Aleutians.

On the island of St. Paul, 147 male and 136 female Aleutians.

The population of the islands and villages of the Unalaska and Unga districts was kindly furnished me by the priest of Illoolook, and differs slightly from the records at Sitka. It is here given *in extenso*, as indicating to our fishermen and traders where labor can be procured. It is compiled for the year 1867.

	Males.	Females.	Total.
UNALASKA DISTRICT.			
On Unalaska Island:			
In the Illoolook settlement	153	156	309
In the Makushinski Village	23	26	49
In the Koshu-ghin-ski Village	36	33	69
In the Tcheruofski Village	33	29	62
In the Setshekinski Village	21	28	49
In the Imagwinski Village	17	15	32
Making a total on Unalaska Island of			570
On Biorka Island	43	42	85
On Akou	50	49	99
On Avatanok	22	23	45
On Fidulga	21	22	43
On Svin-noy	13	9	22
On Umnak	50	51	101
Making the total population of Unalaska district			965
UNGA DISTRICT.			
On Unga Island	80	84	164
On Korovinski	20	12	32
On Ascension	11	15	26
On Unimak	28	29	57
On the Peninsula of Alaska:			
In Pavlofski Village	19	21	40
In Belkofski Village	65	103	168
In Morjheski Village	33	38	71
Making the total population of Unga district			558
OTHER PLACES.			
On St. Paul Island	156	150	306
On St. George Island	64	75	139
Making the total population under the charge of the priest of Unalaska			1,968

Upon the islands of Kadiak and Afognak there are of Russians, 50 males; of Creoles, adult males, 209, children, 240; adult females, 216, children, 196; of Aleutians, adult males, 628, children, 326, adult females, 560, children, 324; making a total of 2,499. The Koloshian colony, at St. Paul, formed of redeemed slaves of Sitka, is not enumerated; judging from the number of houses, they probably number sixty people.

On Alaska Peninsula, opposite Kadiak, there are of Aglemootians, 439 adult males, and 311 children; of adult females, 422, and 261 children; making a total of 1,433.

The Indians about the entrance to Cook's Inlet, and round to Copper River, number 223 adult males, and 151 children; 225 adult females, and 113 children.

The Indians in the northern part of Cook's Inlet number 324 adult males, and 167 children; 393 adult females, and 203 children.

The Aleutians are very distinct, in their looks, manners, language, and customs, from all the other Indians of the northwest, and many of them bear a close resemblance to the less marked of the Japanese, so much so that the question at once arises whether this people has not been directly derived from cast-away or shipwrecked inhabitants of Japan, carried thither by the Kamtschatka branch of the great Japanese stream; some of the names of their islands, the name of their chief, and other peculiarities strongly indicate this origin, but it is not our province to investigate the problem in this place. They are a quiet, patient people, gifted with a great deal of ingenuity, and always trusted implicitly by the Russians. The priest of the Unalaska district is an Aleutian, and a man of more than ordinary natural ability and taste. The surgeon of the company service at Illoolook, now the Coast Survey tidal observer, is also a full-blooded native, who will, I feel satisfied, acquit himself creditably in his observations. Many of the block-houses of the Russian Company are constructed by the Aleutians; and the church at Illoolook is a good specimen of their workmanship; even the capitals of the interior wooden columns were carved by them with rude means. They make skillful mechanics, and the principal mechanician and instrument-repairer at Sitka is an Aleutian, who early displayed talent, and was sent at the company's expense to St. Petersburg, where he learned the business of an optician. His workmanship exhibits talent that needed a large field to develop. This man's wife, a full-blooded Indian, and their daughter, attended by command the ball given to the United States officers by the Prince and Princess Maksoutoff, during our stay at Sitka. The thirty-eight charts of Tebenkoff's atlas were engraved upon copper by an Aleutian.

The bidarkas or skin canoes of the Aleutians, constructed for one, two, or three persons, are fine specimens of ingenuity and form; the light frame is constructed of wood, where the article is so scarce that it must be brought from Kadiak, or sought for on the beaches. In the management of these canoes they display cool courage and thorough knowledge of their capabilities. In the early days of the first sea-otter hunters, they made coast voyages of a thousand to fifteen hundred miles with them, traveling from Unalaska as far as Sitka Sound. Vancouver found seven hundreg of these canoes, with fifteen hundred natives of Unalaska and Kadiak, as far eastward as Behring Bay. Baranoff took six hundred of these canoes and one thousand men to Sitka in 1804. As models they are not excelled by any of those I have seen on the Pacific coast; and as simple mechanical constructions, they are vastly superior to any southward.

Their large skin boats, baidars, capable of carrying from forty to sixty persons, were used in trading between distant islands as far as St. Paul and St. George, when the Russians first reached the country. They are still in use, and were employed at Ulakhta Harbor to coal the steamer Lincoln.

The Aleutians are very ingenious in their traps for catching the smaller fur-bearing animals, very neat in their spears, walrus barbs, and sinew twine, and apt in adopting the simplest means to obtain their ends. I have a specimen of their application of the cam in so trifling an article as a clasp for holding the edge of any fabric which they are sewing. They soon become very handy with the use of ordinary tools, do good blacksmith work, use the lathe, &c.; but unfortunately have had few incentives to continued industry and improvement. The great number of officially recognized holidays during the year—eighty-six besides Sundays—has a very bad effect upon their industry, and tends to keep them close acquaintances with poverty. In fact, the want of incentive for industry is the great drawback to development in general on this coast, and would appear to have been the unexpressed but inevitable policy of the Russian-American Company.

In carving figures from walrus tusks, or the tusks of the fossil mammoth found on Kotzebue Sound, the Aleutians display patience, and in many cases considerable ingenuity, constructing out of walrus tusk small figures of hunters, rocks, seal, and fish, representing the practice of seal hunting, making mimic representation of their dancing and musical entertainments, &c.

In hunting the sea otter and seals they exhibit their tenacity of purpose by watching for days at a time rather than lose the object of their pursuit. They do not use the bow and arrow but the small ivory-headed spear, thrown with the aid of a hand-board, and their exhibitions of skill proved their expertness and proficiency. Most of the crews of the Russian Company's vessels are composed of Aleutians, but they do not make the hardy sailor that the European or American does.

Another peculiarity we noticed in their favor at Unalaska: whenever a woman was one of two or three persons in a bidarka, she was not compelled to use the paddle, as we have heretofore invariably seen on the Pacific coast. The women make very nice specimens of sewing, and those of Unalaska have been always noted for their skill.

No murder has been committed among the Aleutians for the last fifty years, and when one did occur the whole race was horror-struck.

Of the Koloshies, of the Alexander Archipelago, we have seen comparatively little. They have forty large houses outside the stockade at Sitka, averaging thirty feet front by fifty deep and twenty in height, constructed mostly of boards from two to four feet wide, which they make from the spruce and cedar. Enormous posts and beams form the frame, and they are roofed with boards similar to the sides, but have no chimneys, only an opening in the roof for the escape of the smoke. Some of them have pretensions to comfort and cleanliness inside, having well-scrubbed boards laid for a floor, round the center space of six or seven feet square, which is filled in with pebbles and used as the fireplace. Their canoes, hollowed from the trunks of trees, display much less ingenuity and grace than those of the Chinooks of the Columbia River, or the Clallams of the Straits of Fuca and Admiralty Inlet. They have always been a fighting race, attacking the early traders and discoverers whenever they could do so at an advantage. They attacked Vancouver's boats upon several occasions, and in 1798 attacked and destroyed the first settlement of Sitka, a few miles westward of the present location. In 1804 they had a stockaded village and fort at the present site of Sitka, with several four and six-pounders worked by American traders, and sustained an attack from the Neva under Lisiansky. The error in all the past policy of treating with them has been to acknowledge the importance and power of their chiefs, so as to secure their trade in furs from rival traders. This error has been continued to the present day, and upon the slightest opportunity, or for fancied slight, they assume immense airs, swagger with cool insolence and threaten war. The practice of the Russian-American Company of selling to them certain quantities of rum has transmitted to our government a legacy pregnant with many evils. The policy of trading fire-arms, powder and ball to them for temporary gain in trade has assisted in degenerating the race and effectually destroyed their natural wealth, the sea-otter.

The problem to be solved is a peculiar one, and it would be out of place in me to make suggestions as to the best policy to be pursued in treating them, especially as the present military governor, Major General J. C. Davis, combines the requisites for success in managing and controlling them, although his policy must suffer much derangement by the illicit introduction of spirituous liquors, so readily and secretly effected through the hundreds of harbors and channels of this archipelago, especially as the Indians, from a love of rum, assist in warning and hiding the smugglers. Uniform kindness, strict justice, prompt decision, and rigid execution of purpose are the corner-stones of any policy by which they can be humanely governed.

As traders they are shrewd, long in deciding, exacting presents after a bargain is made, and do not hesitate to break any contract. On the Stakeen River they caused some annoyance to the early miners, but of late they have not proved troublesome, especially since the death of two prominent hostile chiefs. The Indians from the neighborhood of Kaik are the same that sent a canoe load of fighting men, about the year 1856, all the way from the Clarence Strait to Whidbey Island, in Washington Territory, to behead ex-Collector of Customs Ebey, in retaliation for the killing of one of their chief men when the United States steamer Massachusetts opened her batteries on the temporary encampment of Stakeen or Kaik Indians, on the sand point opposite the saw-mills of Port Gamble, where the men were employed as laborers.

Two or three years since some of the sub-tribes, twenty or thirty miles west of the Stakeen, captured the English trading schooner Royal Charlie, murdered her crew, and plundered and scuttled the vessel. In May, 1862, between two hundred and fifty and three hundred of the Indians on the west side of Chatham Strait, and about twenty-five miles north of Icy Strait, seized the captain and chief trader of the Hudson's Bay Company's steamer Labouchere, of seven hundred tons, on the quarter-deck, and taking possession of the vessel drove the crew forward. But parleying took place, and the crew having a large gun trained aft, agreed to fire off their rifles, the Indians afterwards doing the same, and finally leaving the vessel, which at night quietly steamed away and was afraid to return for a year. It is but just to the Indian chiefs to say that when the vessel returned they covered her deck with fine sea-otter and other skins as a present to the captain and trader and a token of peace. One or two other instances of attack upon small traders have been brought to my notice, but enough has been stated to show that these Indians must be treated with firmness.

The commercial rivalry that has existed between the traders of the Russian-American Company and the Hudson's Bay Company, which held a trading lease of part of the Russian sea-bound territory, has tended to keep alive and engender excited feelings on the part of the Indians. Illicit traders, with whisky in their cargo, will heighten all the bad passions of the race. Tebenkoff says the Koloshes are treacherous, proud, and fond of gain, but that the first quality has been gradually controlled since the introduction of steamers in the fur trade, the Indians acknowledging that these vessels can find them out promptly and punish them.

The natives inhabiting the coast between Yakutat or Behring Bay and Prince William Sound are called Ogalentz; they are not numerous, reckoning only about thirteen hundred souls, and living upon fish and the products of the soil and trade.

The coast Indians on the southwestern part of the Alexander Archipelago are Hyders, and belong to the nation that occupies the Queen Charlotte's Islands. From Portland Canal south ward towards Vancouver Island, along the main and the bordering archipelago, the Chim-chæ-an nation holds the country nearly to Milbank Sound, where the Belbellas commence and continue down Johnstone Straits.

Of the characteristics of the natives of Prince William Sound, Cook's Inlet, and Alaska Peninsula we have no recent information. They doubtless have changed in many respects since the fur trading has given them means of clothing and luxury, to which none of them are averse.

DIRECTORY OF THE COAST OF ALASKA.

DETAILED DESCRIPTION OF CAPES, BAYS, HARBORS, ISLANDS, ETC.

It would be almost impossible, within reasonable limits, and certainly beyond the labor of one person in the time allowed, to give a detailed description of the great number of known harbors and anchorages, rocks, islands, and points that abound in the Alexander Archipelago. Indeed so numerous are they that many of them are yet unexplored or known only in general characteristics to the trader. From Icy Strait and the mouth of the Chilkaht to the head of Puget Sound, this great labyrinth of waters stands unequalled in the world for safe and bold inland navigation. The scherries of Finland and the fiords of Norway sink into insignificance before the great dimensions of these straits and sounds. They are magnificent navigable "Yo-sémites." The extent of shore line of the archipelago is nearly 8,000 statute miles, and by their exploration and description Vancouver is entitled to indisputable celebrity. A number of harbors have been partially examined and preliminarily surveyed by the old navigators and by the officers of the Russian-American Company. Many of these have been already published in detached form in books and maps, and charts of travel, but no attempt was made to arrange them in any sort of order until Tebenkoff undertook to aggregate the labors of Vancouver, La Perouse, Kotzebue, Beechey, and others, with the numerous Russian explorations, in an atlas of thirty-eight charts published in 1848. His descriptive memoir does not fill the requirements of a directory of the coast, but is more occupied with the names of the officers who made certain explorations. Many of these tentative examinations were made in their searches for new fields of traffic, for winter harbors for the whalers of the company, and also to instruct the mates in such duties, and to familiarize them with the different parts of the coast.

By very numerous voyages and systematic reports, combined with comparatively recent English and French explorations, they have improved the general geographical positions of prominent points and harbors along the whole coast and on the line of the Aleutians, although a vast amount of general, and especially of detailed labor, is yet to be accomplished. In fact there is not even a small map of any part of the coast, or of any harbor, which can be counted as worth more than a reconnaissance or preliminary survey. The shortness of the working season and its uncertainty, combined with the paramount object of the fur trade, accounts for the lack of geographical knowledge of this coast, and in consideration of these drawbacks the company deserves great credit for the amount of geographical work its officers have accomplished.

DIXON SOUND.

This sheet of water, opening upon the Pacific Ocean, lies between the north side of Queen Charlotte Island and the south capes and shores of the Alexander Archipelago, between the latitudes of 54° 10′ and 54° 35′, and longitudes 131° and 133½°. From the north part lead several straits and sounds; from the northeastern part, which was originally named Buccleugh Sound by Meares in 1789, leads the channel to the Portland Canal, the southern dividing line between British Columbia and Alaska.

Dixon Sound opens southward upon extensive waters leading southward among the islands. It is comparatively free from dangers, having, however, a few rocks on the north side that are reported to be not well laid down.

It is named on some maps Granitza Sound, and on others Kygane Strait. It was discovered and named by Dixon.

PORTLAND CANAL.

This extensive arm of Dixon Sound forms the southeastern dividing line between British Columbia and Alaska; commences in latitude 54° 41′ according to Vancouver's map, and the entrance lies between Point Maskelyne, on the mainland near Fort Simpson, and Point Wales, upon an island lying northwest from Point Maskelyne. Vancouver places the latter in latitude 54° 42½′, longitude 130° 15′ west, (Vol. II, p. 327,) while the position of Point Wales from the map is in 54° 41½′, and longitude 130° 20′. "The entrance is not more than two and a half miles across, and this, at the distance of a few miles, seemed to me materially contracted." From the entrance the canal runs north 35° east twenty miles, with an average width of three miles, with channels breaking off to the east and west, where it receives Observatory Inlet, a large branch which comes about forty miles from the north-northeast. The north point dividing the inlet from the canal was named by Vancouver Point Ramsden, and placed in latitude 54° 59′, and longitude 129° 57½′ west, (Vol. II, page 336.) At first, when entering upon the survey of the canal and inlet, Vancouver was "uncertain which to consider the main branch." (Vol. II, p. 330.)

The canal continues from the above point with the course north 23° west, for seven miles; then north 30° east, for thirteen miles; north 20° west, for thirteen miles; north 7° west, for ten miles; north 27° east, for nine miles, and terminates in latitude 55° 45′, and longitude 129° 54′, (Page 340, Vol. II.)

The distance, on the above courses, taken from Vancouver's map, sums up seventy-two miles and in his narrative he says the total "distance from its entrance to its mouth is about seventy miles; which, in honor of the noble family of Bentinck, I named *Portland's Canal*." (Page 371 Vol. II.)

"The shores of this inlet were nearly straight, and in general little more than a mile asunder, composed mostly of high rocky cliffs covered with pine trees to a considerable height; but the more interior country was a compact body of high barren mountains, covered with snow, (July 29, 1793.) As we pursued this branch, salmon in great plenty were leaping in all directions; seals and sea-otter were also seen in great numbers, even where the water was nearly fresh, and which was the case for upwards of twenty miles from its termination." (Vol. II, p. 340.) The entrance to Portland, according to Vancouver and Russian authorities, is in latitude 54° 42′, longitude 130° 25′.

CLARENCE SOUND.

From the north side of Dixon Sound, in longitude 131½°, Clarence Sound opens with a width of fifteen to twenty miles; runs in a general northwest-by-north direction for one hundred and twenty miles; thence westward twenty miles; and finally south-southeast for twenty-five miles, with the large islands called Coronation and Warren, at its western entrance, where it mingles its waters with those at the entrance to Chatham Strait. The average width of the whole sound is about seven miles, but at some places its available channel is much reduced by islets and rocks. In a measure it surrounds the island called Prince of Wales, the southern point of which is the initial point of the boundary line between Alaska and British Columbia. Numerous straits are reported to exist through parts of this large island, dividing it into an extensive group, and is hence sometimes called the Prince of Wales Archipelago. From the eastern side of Clarence Strait great arms penetrate in a general direction to the northeastward until they reach the base of the coast mountains; these arms or inlets are known as the Boca-de-Quadra, Behm Canal, a large one not named, Ernest Sound, Stakeen Sound, Wrangel Strait, &c. Their waters are navigable, the shores generally very bold and covered with timber; and the whole forming an intricacy of inland navigation difficult to describe in detail, and best studied on the chart. The southwestern and parts of the eastern shores of Wales Archipelago have remained unexplored since the examinations of the Spaniards, who left little more than numerous names to prominent capes, points, unexplored bays and straits. In many cases it is very difficult to reconcile the descriptions of the old navigators.

Clarence Sound forms part of that vast and unparalleled system of deep inland navigation extending from latitude 47° 03′ to 59° 15′.

The southeasternmost anchorage and Indian village in Alaska is on the main land just east of Cape Fox, and about fifteen miles northwest from Fort Simpson, with an intricacy of small bays and channels leading north and east, and connecting with the Portland Canal; it is Tchesonity Harbor, in latitude 56° 46′, longitude 130° 35′, from a Russian manuscript chart.

FORT SIMPSON.

The most available anchorage in this vicinity at present known is in the cove abreast of Fort Simpson, in latitude 54° 33′ 42″, longitude 130° 23′ 46″, where the Hudson Bay Company have a stockaded trading post, the principal one for all the extent of country north of Beaver Harbor. The longitude was determined by the United States Coast Survey.

A small sketch showing the anchorage and the approaches for two miles has been published by the British admiralty; chart No. 2426.

CAPE NORTHUMBERLAND.

This is the southern point of the entrance to Clarence Sound and lies between it and the Tangas Narrows. It is the extremity of the group of islands called the Gravina Group; is low, close to the water, but rises to high ridges of a thousand or fifteen hundred feet, wooded from the water's edge to the summits. When coming out of the Tangas Narrows a low wooded islet is seen lying off the cape. Vancouver describes the dangers around the cape as follows: (Vol. II, p. 380.) The southernmost of the rocks lying off Cape Northumberland is a round lump of barren rock, very small, always above water, and which has some breakers lying at a little distance off its southeast side. The southeasternmost of these rocks lies from the south rock north 43° east, distant four and a half miles, and is a low, flat, double rock, always above water, but has much broken ground in the neighborhood. The southwesternmost rocks are two small rocks above water, with much broken ground to the north and northeast of them and in a direct line to the southeasternmost rocks. They bear from the south rock north 44° west, distant five and a half miles. Between these and the eastern shore lie many dangerous rocks and breakers; but no dangers appeared northward of the south rock, between it and the other rocks, where the channel to all appearance appeared to be free from impediments. He does not give the distance of that southernmost rock from the cape, but puts it in latitude 54° 44′. On the chart it is placed seven and a half miles south of Northumberland Cape. Tebenkoff places the southernmost islet in latitude 54° 46½′, longitude 131° 13′, and five miles south of the cape, with the track of the Russian vessels on either side.

PORT GARDNER.

The first bay and anchorage in the entrance to Clarence Sound is Port Gardner, on the western side, and eight miles north-northeast of the southeastern extremity, Cape Chacon of Wales Island—Prince of Wales Island of Vancouver. The entrance is in latitude 54° 49′, longitude 131° 45′, and on Tebenkoff's atlas is laid down about a mile wide and two miles deep, expanding into an ample basin inside the mouth, which has an islet and rock in it. The course to enter this bay is marked on another Russian chart as on the north side of the islet. No depth of water or details are given.

Another bay and anchorage is indicated as a stopping place for trading vessels about two miles further northward, along the same shore

Tchitchagoff Bay.—In latitude 55° 01′ there is marked another small bay and anchorage on the south side of the southeast point of the entrance to Moira Sound. No name is given to this anchorage, but the large bay filled with islands just to the southward is called Tchitchagoff by the Russians.

TANGAS BAY.

This large bay is on the eastern side of the sound, on the middle one of the three large islands forming the Gravina group lying between Tangas Narrows and Clarence Sound. There are two entrances to this harbor, separated by a large wooded island, or rather by a group of five or six smaller islands. Both entrances are in latitude 54° 59′, and the islands separating them are in longitude 131° 23′, and have an extent of two miles each way. Point Davison (named by Vancouver) is the southwest point of the Gravina Island, and forms part of the shore to the western entrance. There is an extensive reef off this point, stretching southwestward about a mile and a half. The eastern point, being the south point of the island in the entrance, is named Point Percy, and the passage between these points is two miles wide and runs about northeast for four miles, contracts to a mile in width, when it runs north one mile, northwest two miles, where it suddenly contracts to a very narrow passage to the west for half a mile, and expands to a large basin two miles long, north and south, and one and a half wide, east and west, with ten to fifteen fathoms of water in it. Where the channel is first contracted to one mile in width the soundings range from thirty to twenty fathoms, with anchorages of fifteen to twenty fathoms in several places. There are several small islets in the channel, but they have deep water close to them. The geographical position of the inner anchorage, according to Etolin, is latitude 55° 03′ and longitude 131° 25′.

Rough plans are given of this bay by Tebenkoff and in other Russian charts from that of Etolin. The rise and fall of tide is stated at fourteen feet.

GRAVINA ISLANDS.

The three large islands and numerous small ones designated as the Gravina group have never been outlined. Two large channels pass through them from Clarence Sound to the Tangas Narrows, which opens into the sound in latitude 55° 26′, longitude 132° 42′, and has several anchorages throughout its length, with a very pretty basin on the east side of the northern entrance and two or three miles inside the northern point. This basin has a small islet in its entrance, and anchorage is obtained in twelve to fifteen fathoms of water over a muddy bottom.

At the north entrance to Tangas Narrows the north arm of Behm Canal leads from Clarence Sound to the north-northeast.

MOIRA SOUND.

The entrance to this sound lies in about latitude 55° 02′, is about two miles in width, and has several islets off each point. It penetrates Wales Island about six miles to the southwest; then turns sharply to the northwest for six or eight miles, and terminates near the heads of Cholmondeley Sound, which comes from the north-northeast, and Tliakak Bay, which comes from the southwest from Cordova Bay.

"The land in the neighborhood of Moira Sound is high and rather steep towards Clarence Sound; but north of Wedge Island, (in latitude 55° 07′,) the straight and compact shores are moderately elevated, and the interior country is composed of lofty though uneven mountains, producing an almost impenetrable forest of pine trees from the water side nearly to their summits, but by no means so high as we had been accustomed to see in the more inland country." (Vancouver, Vol. II, p. 381.)

CHOLMONDELEY SOUND.

In latitude 55° 17′, Point Tchasine, or Watch Point, runs two miles directly west to the eastern side of the entrance to Cholmondeley Sound, one or two miles wide, and off which lie several islands. This sound runs south-southwest for ten or twelve miles and opens into several unexplored arms. The head of the main body of water lies near the heads of Moira Sound and of Tliakak Bay, which opens into the northeast part of the unexplored bay of Cordova. On the inside of the entrance to the sound and on the eastern side lies the native settlement of Chasintzeff.

KAZARN BAY.

An anchorage is laid down at the entrance of Kazarn Bay, the opening to which lies in latitude 55° 27′, longitude 132° 01′, one and a half mile inside the point eastward of it. A large island lies northeast of this point; while a broad unexplored arm of the sound runs westward of Kazarn. The bay is four miles long, about one mile wide, runs about south-southwest, and has a settlement at its head.

A second bay lies just west of Kazarn and is represented as unexplored. The great arm running to the westward is said to bend to the northwest, and finally to bend to the eastward, opening again upon Clarence Sound in latitude 55° 40′, where the Russian chart has an anchorage, and another five miles to the southeast.

PORT STEWART AND ADJACENT SHORE.

In the north arm of Behm Canal, which opens into the east side of Clarence Sound, in latitude 55° 30′, at the head of Tangas Narrows, lies Port Stewart, of which the islet three-eighths of a mile northwest of the south point lies in latitude 55° 38′ 15″, longitude 131° 45′, on the western side of the canal. From the south point the north point bears north by west one and a half mile.

The general direction of the bay is northwest, and the depth two miles; but the upper part of the bay, receiving a small stream, is nearly filled by a flat at its western part, leaving a small bay in the north part land-locked with from six to nine fathoms of water, and one-quarter of a mile in extent; this has a narrow channel with seven fathoms close to the north shore, and rocks and shoal ground to the south of the channel.

The islets on the south shore are nearly connected by shoals only visible at low water; but good entrance may be had in fifteen to twenty fathoms to the northward, and between them and a row of three smaller islets one-quarter of a mile off the northern shore. One-quarter of a mile south of the north point is a rocky patch with deep water all around.

On the same side of Behm Canal, six miles north of Port Stewart, lies the opening to an extensive bay running four miles west-northwest, with islets and rocks in the entrance, and an extensive settlement noted at the head on Tebenkoff's chart. This bay has no name on the charts.

The point of land making out between Behm Canal and Clarence Sound is called Cape Caamano by Tebenkoff; it lies in latitude 55° 29′, longitude 131° 51′.

The south point of the entrance to Ernest Sound is called Point Mesurier, and is situated in latitude 55° 46′, with a rock lying over a mile west-northwest from its extremity. From the point the shore runs east four miles to the entrance of a small bay not yet named, and running to the southeast two miles. It is one of the anchorages of the Russian steamers.

The low wooded point called Tonkoi, on the western side of Clarence Sound, and seven miles west-northwest from Point Mesurier, has an anchorage on the north side, about one mile inside the point. The depth of water is not marked. This point lies abreast of the mass of islands forming the southern point of York Island, (Duke of York, Vancouver,) and Clarence Sound is here contracted to a width of four miles.

From Tonkoi Point the shore runs northwest by west for six miles, to the narrow opening of a large basin which Tebenkoff marks as an anchorage. It has a small islet in the entrance.

ETOLIN HARBOR.

In latitude 56° 15′ the large arm called Stakeen Strait makes into Clarence Sound from the northeast. This strait leads to the mouth of the Stakeen River by two arms. There is no station immediately at the mouth of Stakeen River, but on the northwest part of Wrangel Island (Kachanna on Tebenkoff) is the small harbor of Etolin, in latitude 56° 31′ 30″ and longitude 132° 23′ 30″, where the Russians formerly had a stockaded factory. The harbor is very contracted, only five hundred yards wide, opens to the northwest and runs to the southeast for about six hundred yards, but has good soundings, regularly decreasing from ten fathoms at the entrance to three and a half well inside the bay, abreast of the small island. A plan of this is given in the Russian chart No. 10 of the Pacific Ocean series. This harbor is within two miles of the north end of the island, off which lies a small islet, between which and the point we anchored in about sixteen fathoms, and found disagreeable counter currents running. From this islet the mouth of the Stakeen River, fronted by very extensive sandflats, lies nearly north eight miles distant. These flats extend southward from the mouth for six miles, and westward six miles, from the main to the islands forming the north shores of Stakeen Sound, and thus block a straight wide passage to Frederick Sound, (Prince Frederick's Sound of Vancouver,) except for boats at high water. The river has a channel through these flats close along the main shore to the southward. The geographical position of the southeast point entrance to the river is latitude 56° 40′, longitude 132° 20′.

STAKEEN SOUND.

The broad sheet of water leading westward from the Stakeen River to the northeast bend of Clarence Sound is named Stakeen Sound by Tebenkoff. It is four miles wide and about twenty miles in length, with a large number of islands near its eastern end, and lying directly off the flats of the Stakeen.

STAKEEN RIVER.

This river is reported by the Russian-American Telegraph Company to be navigable for boats for one hundred and fifty miles, to the mouth of the great cañon, where the river bursts through a narrow gorge three hundred feet deep, and said to be only seven feet across at the top, but wide at the present bed of the stream.

Glaciers reach the river in several places from the gorges and flanks of the mountains, but all of them come down upon the right bank of the stream.

The general course of this river is laid down on the photographic maps forwarded to you, and on larger maps obtained from the Russian-American Telegraph Company.

WRANGEL STRAIT.

It would serve no practical purpose to endeavor to describe the intricacy of islands and sounds south of Frederick Sound and east of Chatham Strait. There is only one available channel between Clarence and Frederick Sound east of Coronation Island, and that is Wrangel Strait, opening from the northwestern part of Stakeen Sound, in latitude 56° 35′ and longitude 132° 48′. It is tortuous, very narrow, has low wooded shores, broad beaches, and a mid-channel depth of not less than four or five fathoms. A sketch of this, on a large scale, is given on sheet No. 10*b* of the Russian charts of the Pacific Ocean series. This sketch is not very accurate, but can be used, especially at low water, when a few rocks not laid down upon it show themselves.

From the north end of Wrangel Strait is visible the first great glacier that we have seen upon the shores of these waters, although two are reported even south of Fort Simpson, on the arms penetrating the continent in that vicinity. This glacier is on the north side of the eastern part of Frederick Sound; and from two islands, about three miles northwest of Wrangel Strait, it bore north by west true distant ten or fifteen miles, as well as we could judge through the mist and rain. Rain clouds completely enveloped the tops of the mountains between which it flowed. It was seen over a low point on the north and east side of the sound, and apparently opened upon the shore in the bay east of Point Vandeput, about latitude 57° 06′, longitude 132° 54′. In this vicinity one of the early ice ships from San Francisco filled with glacier ice in the winter of 1853–'54.

Anchorage is laid down on the west side of Point Vandeput, but no depth is marked.

CAPE KYGÁNE.

Returning to Dixon Sound, and following the Pacific shores northward, we first notice Cape Kygáne or Muzon, the extreme southwest point of the Territory of Alaska, in latitude 54° 42′, longitude 132° 43′.8, according to the Coast Survey approximate determination. Tebenkoff gives a very indistinct view of it at a distance of twenty miles from the direction south 43° west.

On the 11th of August we saw the cape within the distance of a mile, but covered with rain-clouds nearly to the water. A view of the cape as it appeared to us was secured. No description of this important headland is found in any of the narratives within reach.

Very fortunately I was able to obtain sextant observations near the cape in a momentary break in the clouds, and hope the results will allow us to consider its position moderately well determined.

The water around the cape appeared bold, but showed strong current markings inside our position, which was about one mile distant.

CORDOVA BAY.

Between this cape and Cape Nunes, eighteen miles eastward, is an extensive unexplored bay called Cordova, extending northward into Wales Island about fifteen miles, and filled with wooded islands, bare islets, and rocks. From the northwestern part of this bay an unexplored strait is said to lead to the southeasternmost arm of the extensive waters called Bucarreli Bay, or Sound.

KYGÁNE HARBOR.

On the east side of Cape Kygáne, and about two and a half miles northward of its extremity, after passing a great number of islets close along the shore, three harbors open to the eastward upon Cordova Bay, and two and a half miles west of the southern point of the first large island (unnamed) in the bay. The soundings in the approaches to the harbors are about forty fathoms. The southern harbor is about three-eighths of a mile wide, runs west-northwest for one and a half mile, and has a large islet inside and towards the southern shore. Up to this islet the soundings are not less than thirty fathoms, and thence gradually decrease towards the head.

The second entrance, less than half a mile north of the southern one, is the opening into two arms of one bay, divided by a long narrow island lying west-northwest. The southern arm is that used as an anchorage; is one mile deep and less than a quarter of a mile wide, with soundings of six fathoms at the entrance, increasing to sixteen fathoms, and then diminishing to eight at the head, where there is quite a snug boat cove on the south side, and a narrow passage to the northern arm on the north side.

The northern arm or harbor has almost the same dimensions as the other, with deeper water at the entrance, (twenty-eight fathoms,) and a basin with six to eight fathoms at the head.

The anchorage in the middle harbor or southern arm of the two northern harbors is placed in latitude 54° 46′ and longitude 132° 45′ 30″, according to the chart of Etolin, given on the Russian map No. 10. Tebenkoff gives 54° 42′, and 132° 39′, with a rise and fall of tide of sixteen feet.

KAZAN BAY.

The west shore of Cape Kygáne is indented by many small bays open to the ocean swell. In latitude 54° 48′, eleven miles west-northwest of the cape, is the entrance to the large bay of Kazan, divided into two by the large island called Dolgoi, or Long Island.

The bay is three miles wide at the entrance, and stretches eight miles east-northeast, and at its head is filled by a large number of small islands. Between the south shore and Long Island the width of the bay is about one mile, and from the southwestern point of the entrance, called Cape Bazan, runs east-northeast for five miles, having soundings of twenty fathoms in the entrance, with ten to fourteen until the east end of the island approaches a point from the southern shore, when a depth of eight fathoms is found in the passage half a mile wide. The anchorage is to the east of the point of the main, with bottom in fifteen fathoms. The Russian navigators inform me that in southwest gales a heavy swell rolls into this bay, which is exposed directly to the ocean, yet the chart clearly indicates that perfectly safe anchorage is to be had here.

This is the "Port Meares" of Meares, who anchored here in twenty-three fathoms, over sand and shells. He placed it in latitude 54° 51′, and thirty-five miles east of Forrester Island, (page 329.) Meares gives also a rough sketch of the place.

Zarelbo places Cape Bazan in latitude 54° 48′, and longitude 132° 54′, and states the rise and fall of tide at fourteen feet. He gives a rough eye-sketch of it in chart No. 9.

FORRESTER ISLAND.

The south end of this island lies in latitude 54° 48′, longitude 133° 29′, distant thirty miles west 12° north from Cape Kygáne, sixteen miles broad off the coast and twenty miles south of Cape Bartolomo. Tebenkoff lays it down as a high island, five miles long by one and a half mile wide, with rocks off the south end, and rocks and islet off the north end. We passed it in the night of the 11th of August, in thick, rainy weather, and got a very indistinct glimpse of it. The following description is from Meares, page 327, August 13, 1788:

"Douglas Island is a small island about two miles in circumference, and there are two or three small, low, and rocky islands lying off its north and south ends. It is very high, and covered with verdure, and may be seen at the distance of sixteen or seventeen leagues. It lies ten leagues from the main land, in the latitude of 54° 58′ and longitude 133° 17′."

Dixon does not refer to it in his narrative, but named it Forrester in his view and in his map, where he locates it in latitude 55°, and longitude 133° 42′. In the sketch, where it is represented as a high island with several rounded hills, he places it in latitude 55° 12′, and longitude 133° 42′.

Vancouver simply calls it a small high island. Tebenkoff gives a poor view of it at the distance of twenty-five miles.

WOLF ROCKS.

In latitude 55° 01′.6, longitude 133° 24′, Tebenkoff lays down a small islet and rocks distant nine miles north 17° east from the north end of Forrester Island.

Vancouver describes it, Vol. II, p. 299, thus:

"From Cape Bartolomo, in latitude 55° 12½′ south 21° east, distance fourteen miles, and twelve miles from the nearest shore, lies a very low, flat, rocky islet, surrounded by rocks and breakers, that extend some distance from it."

From its isolated position he considers it "one of the most dangerous impediments to navigation that he had met with on the exterior coast, and hence it obtained the name of the Wolf Rock."

Meares speaks of it thus: "Between Douglas Island and the main there is another island of lesser extent, which is rocky, barren, and almost level with the water. Between these two islands he steered his course by compass east-southeast, but could get no soundings with fifty fathoms of line."

It is reasonable to assume that he referred to the land to the northward as the main land.

CAPE BARTOLOMO.

Forrester Island and the Wolf Rock are nearly on the prolongation of the long, narrow peninsula stretching southward and terminating in Cape Bartolomo in latitude 55° 12′, longitude 133° 33′, to the eastward of which peninsula lies a large archipelago, in great part unexplored, but through which the Russian vessels are accustomed to pass. The cape is called Cherekoff on some of the Russian charts. Close to its southern extremity are marked sunken rocks with very deep water outside.

BUCARRELI SOUND.

The sound eastward of the peninsula, of which Cape Bartolomo is the southern termination, is very extensive and filled with large islands, between which pass wide channels with deep water. From it pass two or three channels or straits merely indicated on the chart of La Pérouse, who has soundings along the shores of the greater part of it. This examination extended for twenty-five miles northeast, and covers an area of nearly four hundred miles. Within this extensive sound are numerous bays with soundings indicating good anchorages. In the absence of a copy of La Pérouse's work, we are compelled to compile from a Russian reduction of his chart.

This sound is the Puerto del Baylio Bucarreli of Quadra, 1775, and deserves examination, as the indications upon the Russian chart No. 10 of the Pacific series, and upon Tebenkoff's chart No. 9, are that inside channels lead from Cordova Bay into this sound, and thence from the north of it through another unexplored channel whose northern entrance opens nearly opposite Warren Island at the northwest entrance to Clarence Sound, and of course abreast of the south entrance to Chatham Strait. An anchorage is laid down on the north side of an island lying off the north entrance of the last mentioned unexplored strait, in latitude 55° 55′. Meares entered this sound through one of the southern channels.

CAPE ADDINGTON.

This cape is the westernmost point of the island forming the western boundary of Bucarreli Sound, and lies seventeen miles north 28° west from Cape Bartolomo. "A conspicuous promontory," (Vancouver, Vol. II, p. 299,) laid down by Tebenkoff in latitude 55° 7½′, and longitude 133° 45′, and described by Meares as "a high bluff land lying in the latitude 55° 28′, longitude 133° 39′," and named by him Cape Adamson.

From it the general trend of the shores of the islands forming the north boundary of Bucarreli

Sound is northeast for fifteen miles, where numerous rocks are laid down; thence the trend is northwest for twenty miles to the eastern end of Warren Island, lying in the eastern part of the entrance to Clarence Sound.

From Cape Addington the western end of Coronation lies north 30° west thirty-one miles distant, and Cape Ommaney, at the western side of the entrance to Chatham Strait, lies nearly on the same course at a distance of fifty miles. It will thus be seen that Capes Bartolomo, Addington, Coronation Island, and Cape Ommaney lie nearly on the same course, which is the general trend of the outer coast and headlands from Cape Kygáne, in 54° 42′, to Cape Fairweather, in 58° 51′.

CAPES POLE AND DECISION.

The northwestern entrance to Clarence Sound lies between Coronation Island on the west and Warren Island on the east. It is about six miles wide, and in mid-channel there is no bottom with one hundred and twenty fathoms of line.

Cape Decision, on the west, lies in latitude 56° 3′, and Cape Pole in 55° 58½′, lying about east-southeast and west-northwest, eleven miles from each other.

Coronation Island lies five miles south of Cape Decision, with some large islands between them, but affording a passage one and a half mile wide between the cape and nearest island by which vessels pass between Chatham and Clarence Sounds. Coronation Island is high, eight miles long east-northeast and west-southwest, by four miles wide, and the western point is laid down by Tebenkoff in latitude 55° 55′, and longitude 134° 10′. Between the northeast part of the island and the nearest island an anchorage is laid down in one of the Russian charts, but no depth of water given.

Warren Island is four miles east-southeast and west-northwest by two miles in width. Between it and Cape Pole, which is distant two miles to the eastward, lie several lurking rocks and islets. One and a half mile south of the middle of the island are several rocks; five miles south from the northwestern point of the island several rocks are laid down, and south by east six miles from the northwest point lies a small islet. (Vancouver.)

HAZY ISLANDS.

These islets lie eight miles west of Coronation Island, and "form a group of small rocky islets about a league in extent, lying south 7° east at a distance of sixteen leagues from Cape Ommaney." (Vancouver, Vol. III, p. 298.) This is evidently an error of the text of Vancouver, who places them fifteen miles south of Ommaney and in latitude 55° 54½′.

Tebenkoff places them sixteen miles south of Ommaney and in latitude 55° 55½′, longitude 134° 25′.

In 1787 they were named by Dixon, who placed them in latitude 55° 55′. Tebenkoff calls them the Timanof Islands.

CAPE OMMANEY.

This headland lies in latitude 56° 10½′, longitude 134° 28½′, and forms the western point of the entrance to Chatham strait, which is sometimes called Christian's Sound at its mouth. The eastern point of entrance is Coronation Island. Abreast of Ommaney the strait is twelve miles wide, and the eastern shore remarkably broken by bays and guarded by rocks.

This cape is the southern extremity of Baranoff Island, upon which Sitka is situated. It "constitutes a very remarkable promontory, that terminates in a high, bluff, rocky cliff, with a round, high, rocky islet lying close to it, and by its shores on its eastern side taking a sharp northerly direction it becomes a very narrow point of land, which, having been seen by Captain Colnett in his mercantile expedition to this coast, was by him named Cape Ommaney, and the opening between it and Cape Decision, Christian Sound," being the entrance to Chatham Sound. (Vancouver, Vol. III, pp. 266, 267.) This rocky islet "was named Wooden's Rock." (Vancouver, Vol. III, p. 298.)

PORT CONCLUSION AND PORT ARMSTRONG.

Between five and six miles northward from Cape Ommaney, on the western shore of Chatham Strait, or Christian Sound, lies the entrance to Port Conclusion, whose southern point is formed by an island about a quarter of a mile long, north-northwest, with deep water all around it, except towards the main point southwest of it; between these lie an islet and sunken rocks. From this island to the north point of the bay the direction is north, and the distance one mile, with seventy-five fathoms of water in mid-entrance. From the middle of the entrance the bay has a direction south 27° west for two and three-quarters miles, contracting for the last mile to a little over a quarter of a mile in width, with fourty-four fathoms of water. No rocks are known to exist in the bay and the deepest water is eighty-seven fathoms. About half a mile west by north from South Point Island, three-quarters of a mile inside the south point, there is a small cove, one-quarter of a mile in extent, facing north, with anchorage over irregular bottom in from five to fifteen fathoms. One and a quarter mile inside the entrance is a very narrow cove, one-quarter of a mile long, about one-eighth of a mile in width, with four fathoms of water, and opening to the southwest or contracted head of the bay. In this cove Vancouver anchored. The head of this cove is separated by only one-quarter of a mile from the head of another bay southeast, and leading from the strait. It is one mile long, runs nearly north, and has a very narrow entrance, with four fathoms. Inside are soundings in seven or eight fathoms. The Russian chart designates this as Alexander Bay.

The latitude of the north point of the island, forming the south point of Port Conclusion, is 56° 16′, and longitude 134° 27′.

The north point of Port Conclusion, called Point Eliza, also forms the south point of Port Armstrong, which has an opening to the east from the strait of less than a quarter of a mile in width for half a mile in length, with soundings from ten to seven fathoms. Inside this narrow channel the bay expands to a basin one mile long by half a mile wide, with thirty-four fathoms of water, decreasing to twelve and eight close to the shores. The general direction of this port and its entrance is south 70° west, and extends one mile and a quarter.

Vancouver gives a plan of it and describes it in Vol. II, pp. 268, 269.

PORT MALMESBURY.

This bay lies directly east of Port Conclusion, on the eastern shore of Chatham Strait, and sixteen miles north 60° east from Cape Ommaney, and twenty-three miles north of the west point of Coronation Island. Between Cape Decision and the harbor the intermediate shore is deeply indented by many small open bays and guarded by numerous rocks. The harbor is easy of access by keeping near the southern shore, and affords very excellent shelter, with soundings from seventeen to thirty-four and twelve fathoms of water. From the entrance its direction is northeast for three miles, then south-southeast for three miles, with some rocks and islets in it. It is conveniently situated to the ocean, and has its north point in latitude 56° 17½′, and longitude 134° 07′. Its north point is called Point Harris, and rendered very remarkable by being a projecting point on which is a single hill, appearing from many points of view like an island, with an islet and some rocks extending nearly to the southwest of it. (Vancouver, Vol. III, p. 286.) He gives no plan of it.

PORT PROTECTION.

This bay is situated on the northwest extremity of Wales Island, where the Clarence Sound turns from its north and south course abruptly to the east. It opens to the northwest, and its southern extremity or head lies at the base of a very remarkable barren, peaked mountain, which Vancouver named Mount Calder. This extinct volcano is conspicuous in many points of view, not from its superior elevation when compared with other mountains on the main, but from its height above the rest of the country in its immediate vicinity, and from its being visible in various directions at a great distance. Point Baker, at the northern part of the bay, is on an islet close to the shore from the northeast point of entrance, from whence the opposite point lies south 27° west, at a distance of three-quarters of a mile. The channel is good and free to enter, yet there is one lurking rock, visible only at low tides, lying south 13° east six hundred yards from Point Baker. The kelp upon it will give warning at high water, and on all sides there is a depth of from eight to twelve fathoms close to it.

This harbor has a general direction from mid-entrance south 36° east, for about two and a quarter miles; its width from one thousand to six hundred yards; and the upper part terminates in shallow coves and a basin. The soundings are irregular, from thirty to fifty fathoms, and where Vancouver places the anchorage in twenty-one fathoms, the rock in the channel bears north 33° west, Point Baker north 25° west; the western point of the bay north 82° west, and a small islet, with rocks off its northwest point, lies east less than a quarter of a mile distant. On the east and southeast of this islet is anchorage in twenty to fourteen fathoms, but with contracted space. The bottom at the anchorage of Vancouver is hard and rocky, and the position exposed to north and northwest winds, but well protected from southeasters. The shores are in most places steep, rocky, and covered with an impenetrable forest of spruce and other trees. Several streams of fresh water are found, and halibut were caught by Vancouver.

Vancouver found the latitude of Point Baker 56° 20′ 30″, and Tebenkoff gives the longitude 133° 32′.

Vancouver gives a plan of the harbor.

About a mile to the north of Point Baker is situated a bank on which soundings are irregular from fifteen to thirty-two fathoms, and at the meeting of the tidal currents causes a race and rip that appear dangerous, especially at the flood, but numerous soundings detected no less than fifteen fathoms upon it, and sixty fathoms between it and the shore.

Tebenkoff has a rock near mid-channel of the sound, lying about two miles west of the westernmost point of Port Protection; and another three or four miles southwest of the same point. They are not in Vancouver.

The foregoing descriptions give all the details that need be compiled at present. Numerous harbors and anchorages exist throughout Chatham Strait, Frederick Sound, Stephen Strait, Peril and Icy Straits, but no details have been given of them, as they are known only to the traders of the Hudson Bay and Russian-American Companies. These anchorages and the general route of the trading vessels are laid down on the accompanying charts, with such additions as have come to my knowledge while passing through these waters.

General sketches obtained from the governor of the Russian colonies are being arranged for transmission to you, and for incorporation in the maps.

However, a few general items of interest may be introduced here.

The shores on both sides of the Wrangel Straits are generally low and flat, covered with spruce, and cut by numerous sloughs, affording water-courses from the high mountains in the background.

In latitude 56° 51′ lies the southwest point of the entrance, nine miles wide, of Frederick Sound from the Chatham Strait, and running in a general direction to the mouth of the Stakeen.

From the north side of Frederick, thirty miles from its entrance, opens Stephen Strait, that runs north-northwest for about sixty miles parallel to Chatham Strait, separated therefrom by Admiralty Island twenty-five to thirty miles wide, and enters the Chatham Strait in latitude 58° 24′, where a fine bay exists on the north point of the island, open to the north, and about five miles deep. We anchored near the head of this bay in sixteen fathoms over soft, muddy bottom. It is called Barlow Cove.

TAKOÚ RIVER.

From the northeast part of Stephen Strait an arm runs north by east for fifteen miles, receiving the river Takoú, up which the Hudson Bay Company carry their supplies to the interior.

CHILKAHT RIVER.

North of Admiralty Island the Chatham Strait is usually designated Lynn Canal, at the head of which enters Chilkaht River on the west, separated by Seduction Tongue from a deep bay on the east.

The astronomical station of the Coast Survey was on the small treeless islet off the mouth of Chilkaht, and Mr. Mosman found the position to differ from the survey of Lindenberg, of the Russian-American Company. The correction in latitude is seven miles. The field computation places the above islet in latitude 59° 11′ 45″ and longitude 135° 24′ 10″.

The Chilkaht River has a bar at its mouth that is bare at low tide, and the influence of the tides is felt but a few miles above the bar. An Indian village of twelve large houses exists inside the bar on the left or eastern bank of the river. Bishop Veniaminoff estimates the Koloshes on the Chilkaht at two hundred souls.

A sketch of Chilkaht River and approaches, showing anchorage, &c., is given on the Russian map No. 10, of the Pacific series. The bottom is a very tenacious blue mud, affording capital holding ground.

In latitude 59° 7′, abreast of Seduction Tongue, a magnificent glacier named Davidson comes from between high, bold, snow-covered mountains on the western shore, and has forced out a low point, now covered with spruce trees, into the canal. When we passed it, going northward, the fog hung over it so closely that we could see, over the timber, only a part of its deep scarred front. Southward of the main glacier a small branch comes through a crooked ravine to the water's edge. From our anchorage, abreast of Stony Island, measurements were made of the part of the glacier visible east of the mountain's flanks. Assuming its distance at six statute miles, the part exposed was fifty-seven hundred feet long; of this, forty-two hundred and sixty-five feet had a very uniform and regular inclination of 4° 43′ 21″, and the height of the part cut by the mountain-side, or fifty-seven hundred feet from its front, was six hundred and forty-five feet. Part of the ice was obtained and the melted water added to our collection.

From the same anchorage, a remarkable snow-clad peak bore across the strait south 46° east, true, rearing its head far above its fellows in the range, and attaining an elevation of six thousand feet by estimation. From the striking resemblance which the upper northern profile presented, it was very appropriately named the Lion Head.

PERIL STRAIT.

In latitude 57° 27′ Peril Strait opens from Chatham Strait to the westward, giving an inland navigation thereby to Sitka Sound, and also opening through Salisbury Sound into the Gulf of Alaska, in latitude 57° 19′. The navigation of this strait, until better known, should be made under the direction of a pilot, and at or near slack-water low-tide, as there are several narrow places where the currents and counter-currents are very strong, irregular and dangerous to a side-wheel steamer.

From the northern side of Peril Strait, about midway through, an unexplored passage is reported to exist, leading northward to the south shores of Icy Strait.

ICY STRAIT.

In latitude 58° 9′, Icy Strait (the Cross Sound of Vancouver and Forest Strait of Tebenkoff) opens from the west side of Chatham Strait and communicates through broad waters to the Gulf of Alaska, in latitude 58° 09′. It is also said to communicate with Peril Strait through an unexplored channel indicated on the chart, while another unexplored channel leaves the former and opens upon Chatham Strait at a point midway between the entrances of Icy and Peril Straits.

SPASKAII HARBOR.

Several harbors are reported to exist along the southern shores of Icy Strait. Five miles within the southeast point of entrance from Chathan Strait the Russian traders have an anchorage laid down in Spaskaii Harbor. The extreme northwest point is two miles north of the entrance of the bay, which runs west-southwest about one mile, with thirty-five fathoms in mid entrance, diminishing to four over a level bottom half way up the bay. The Russians anchor in a very small cove just within the southeast point of entrance, in four fathoms water. The latitude of this point is given by Tebenkoff as 58° 06′ and longitude 135° 08′. A sketch is given on the Russian map No. 20.

CHATHAM STRAIT.

This magnificent arm of the sea stretches in a straight line through the northern part of the Alexander Archipelago. From Cape Ommaney, in latitude 56° 10′, where it is twelve miles wide, to the head of the eastern arm, in 59° 20′, it maintains a nearly uniform width of seven or eight miles, with no dangers except close along the shores. The depth of water is very great, and no soundings have ever been laid down on it. In latitude 58° 32′ we found no bottom with one hundred and fifty fathoms of line. Its general direction is north 13° west for two hundred miles, and if the chart of Tebenkoff is correct, a course drawn throughout its length would not touch either shore. From it branch the great straits eastward and westward, leading to the base of the coast range of mountains and to the Pacific Ocean. Its northern termination is in a higher latitude than Mount Fairweather, while the peninsula between them, terminating on the north shores of Icy Strait, is a region unexplored, and from all indications the home of the glaciers.

FROM CAPE OMMANEY TO CAPE EDGECUMBE.

From Cape Ommaney, in latitude 56° 10′, to Cape Edgecumbe, in latitude 57° 01′, longitude 135° 46′, the distance is sixty-six miles, and the general trend of the coast north 40° west, indented with numerous bays of large and small extent, and generally bounded by a bold, rocky shore covered with spruce to the water's edge, and backed by a high mountainous country very much broken and filled with timber.

RED CAPE.

Fourteen miles north 46° west from Cape Ommaney is Red Cape, the southwest point of a large arm of the sea making six miles into the land northward and having a width of two miles. Three other deep bays indent the shore between Cape Ommaney and Red Cape.

PORT BANKS.

Thirteen miles north-northwest from Red Cape is the south point of the three-miles-wide entrance to Port Banks, with three large arms penetrating the island, one of them nearly crossing to Chatham Strait. The north arm is a continuation of the main bay, which stretches about north-northeast for nine or ten miles, and in this arm the Russian navigators inform me there is anchorage. Four miles within the entrance along the southeast shore, and one mile before rounding the point opening the two interior arms, Tebenkoff gives a well-protected anchorage and deep bay opening towards the north. The soundings in this anchorage are fifteen fathoms.

Tebenkoff calls this bay Whale Bay, but it is the Port Banks of Dixon, who entered it in June, 1787. He gives a sketch of it, and the details of the South Harbor appear better than those of Tebenkoff. He says, page 193: "On our approaching the land the channel ahead had the appearance of a river from the north, but the tide setting strongly out of it, and the wind shifting to the northward, we stood into a fine harbor which now opened to the southeast. At the entrance we had soundings from fifty to sixty-five fathoms of water over a rocky bottom; but as we advanced further in the soundings lessened to twenty-one fathoms with mud, on which we came to anchor, being completely land-locked and within musket shot of the shore both to the northward and southward." He gives nineteen fathoms at the entrance, which is to the eastward of two small islands abreast the west point; and he has four islets inside, and also a stream, not laid down by Tebenkoff. The south point of the entrance from the ocean he calls Point Lander; the north point is unnamed. The geographical position of Point Lander according to Dixon and Benzeman is latitude 56° 33′, longitude 134° 58′.

This port should be examined and its capabilities known, as it may afford good refuge and protection to a vessel unable to make Sitka Sound by stress of northwest winds or heavy southeast weather coming up.

The north point of Port Banks forms the south point of a broad open bay six or eight miles deep and ten miles across. The shore runs north for eleven miles, and then west-southwest for six or seven, forming this unnamed bay, with a cluster of large islets near the middle of it, and extending out to the general line of the coast. They are called the Egg Islands, but I can find no description of them.

Thence to Biorka Island, the south point of Sitka Sound, the coast is cut by several narrow arms running deeply into the shore, and guarded by great numbers of islets and rocks laid down only in a general manner.

SITKA SOUND.

Between the south point, formed by Biorka Island and Cape Edgecumbe, lying north 46° west and south 46° east, thirteen miles from each other, lies the entrance to Sitka Sound, having a depth of ninety fathoms outside the middle of the entrance, and very bold water in every direction.

Biorka Island is comparatively low and wooded, about two miles in extent, north and south, and the same east and west. It has a sunken rock one mile south of its south point, and several islets, but along its west and north faces the water is thirty fathoms deep close in shore. On the north face of Biorka, one and a half miles east of the northwest point, is a small cove, opening to the northward, with soundings of eleven, nine, and seven fathoms laid down inside the heads. Off the entrance to this cove are soundings in twenty-five fathoms sandy bottom. The Russian navigators affirm that this would make a good pilot station.

Two miles west of the islet which lies off the northwest point of Biorka is a single sunken rock, where a heavy sea breaks only once every five or six minutes. It is said to have ten feet of water on it, and if so, must be very pointed. The Russian navigators report that they have repeatedly watched the break upon it, and that the rocky patch of nearly a mile in extent laid down on the English chart No. 2337 of Sitka Sound does not exist. It breaks only in one spot, and but once in five or six minutes.

All the adjacent islands are low and wooded, but the main land is well marked by very high mountains.

Cape Edgecumbe is notedly marked by the extinct volcano of Mount Edgecumbe, bearing north 52° east, four miles distant from the extremity of the cape. The shores are covered with timber to the edges of the bold high bluffs of rock and lava, fringed with innumerable rocks. The cape presents the appearance of a wooded plateau, extending to the base of the mountain, interrupted only by two small hills between the cape and mountain. But the great feature and landmark is the mountain itself, which is peculiarly marked, and has no counterpart in this region. It rises 2,855 feet above the sea, and the top, forming the rim of an ancient crater, appears nearly horizontal, and has a diameter of two thousand feet by the Coast Survey measurements. The sides from the summit down have a gentle and regular inclination of about twenty-five degrees, are marked by deep furrows, destitute of trees or herbage, and present in sunlight a dull, reddish appearance. In winter it is covered with snow. It is situated upon Pitt or Krouzof Island, of which the south and eastern sides form the north and west shores of Sitka Sound and the passages northward, while its north side forms the south shore of Salisbury or Klokacheva Sound. Tebenkoff gives a view of the mountain and cape.

From Cape Edgecumbe, the north shore inside the entrance to the sound runs a general and nearly straight course of north 85° east for seven miles to Otmoloi Point, or Point of Shoals, off which, at the distance of a mile, lie the Low Island and rocks, with a passage reported between the point and island. Nearly midway between these points, and one and a half miles off shore, lies the moderately high wooded island of St. Lazara or Cape Island, with from twenty to five fathoms of water between it and the shore.

The south shore, inside the entrance to Sitka Sound, is broken by innumerable rocks and low wooded islets, and indented by large bays. The whole shore is covered with spruce, making it difficult to distinguish the islands. No sunken rocks are known to exist nearer the entrance than Williams Bank, five and a half miles north-northeast from the northwest point of Biorka, and lying some distance off the low islands inside. The bank appears to consist of four or five sunken rocks, upon some of which the sea invariably breaks.

Within the entrance the sound contracts its width to six miles between Point of Shoals and Williams Bank, with deep water to and inside that line. From Point of Shoals to Bouranof Point, forming part of the south shores, the bearing is south 80° east, the distance seven and a half miles; and on this line the sound is contracted by the Low Island and rocks, one mile distant from Point of Shoals; by the Vitskari and adjacent rocks, three miles distant; by the Kulichoff Rock and adjacent sunken rocks, five miles distant from this same point. Deep channels exist between Low and Vitskari, Vitskari and Kulichoff, and Kulichoff and the islets off Bouronof Point, with, however, dangerous rocks in the latter. Between Vitskari and Otmoloi, Lisianski gives soundings in eighteen, seventeen, twenty, and seventeen fathoms. But the channel invariably used by the Russians is that between Vitskari and Kulichoff. On the English chart this channel is erroneously contracted by the laying down of a sunken reef extending one mile east of Vitskari, nearly on the line towards Kulichoff. The Russian captains assert that they can and have passed Vitskari along its southeast face within half a cable's length when steering a direct course to Mochnati, a course north 62° east, true. We have made it close aboard when coming in at evening, with very thick, heavy weather from the southeast, and saw no breakers to indicate such a reef; in fact, were misled by not finding the breakers laid down on the British Admiralty chart No. 2337. We have also seen it from the south-southeast when there was no breaker off its eastern face, but the breakers on the reef one mile north of it really appeared to be breaking off the eastern face of the rock. It appeared, from the distance of a mile or two, to be about forty yards long and ten feet above high water, with a rough irregular surface. In smooth weather it has been landed upon, and it has been recommended that a light be placed upon it, as from this point it would illuminate an arc of the horizon beyond the sound from south 56° west toward Biorka Island, south 88° west toward Cape Edgecumbe, and be a guide to clear the rock off Biorka. From the northwest point of Biorka it bears north 6° east, distant seven miles. From the rock off Biorka it bears north 21° east, distant seven and a half miles.

Kulichoff Rock is laid down on the English chart south 10° east, two miles from Vitskari. It is about twenty feet high, and less in extent than Vitskari. There are sunken rocks to the north and southwest of it, about half a mile distant, and one towards Vitskari, about a quarter of a mile off, with deep water and dangerous sunken rocks between the Kulichoff and the islets off Point Bouranof. But Tebenkoff and the old Russian charts place the Vitskari and Kulichoff three miles apart, while the latest unpublished Russian examinations about Kulichoff place the reef a short distance north of the rock, with a passage of twelve fathoms between them and close to the rock, and one of the Russian captains reports passing through this channel. The English chart places Kulichoff more than two miles from Bouranof, but the latest Russian determination makes it only one and a half mile.

For four miles inside of Vitskari Rock we find clear, deep water, up to the range of wooded islands and rocks lying for two miles outside of Sitka. Through this barrier of islands there are three channels to the anchorages east and west of the town. These passages are known as the eastern, middle and western, the former being the longest, and the middle one the shortest, to either anchorage. In approaching these islands in thick weather, the officers of the company endeavor to find the island of Mochnati, which is from twenty to thirty feet high, rocky, and covered with a thick growth of spruce, whose dark foliage, with the black rocks beneath, brought out in relief by the surf breaking along its front and on the outlying rock, makes it discernible through the fog when other islands are invisible. This islet lies five miles north 62° east from Vitskari, and between the middle and western channels, and a vessel making it can take either, and safely run for the anchorage. When the fog is lifting, from the coming in of a westerly wind, this island appears first. Abreast of Mochnati the western channel is about three-quarters of a mile wide, with a large reef, bare at low water, forming the western side; and the middle channel is contracted by sunken and exposed rocks to a much narrower entrance.

The English chart, based upon that of La Pérouse, gives a good idea of the channels and the anchorages, which should only be entered under the guidance of a pilot, or with good local knowledge.

The indications of the Coast Survey local triangulation about Sitka harbor proper would seem to show that the base line of the original survey was erroneous, and this may possibly explain the announcement on the English chart that "there are discrepancies between this chart and the plan of Sitka (2348) which cannot be adjusted."

The harbor of Sitka is very contracted, and, in the western anchorage, numerous mooring buoys have been laid down by the Russian-American Company near the town, although this part of the harbor is narrow and marked by three sunken rocks. The eastern harbor receives the greater sweep of the southeasters, and a heavy swell is said to be brought in from the sound, so that the company's vessels prefer to anchor in the western, as they can discharge more readily, and especially because, during the winter, the officers and crews are taken from the ships, which are left with only one keeper. But the British men-of-war use the eastern harbor.

In the great gale of October 28, 1867—the severest at this place for very many years—three or four vessels broke adrift from their moorings and several were driven ashore. The steamship John L. Stephens dragged her anchor, but having steam up and getting her anchor, steamed through the throat connecting the two anchorages, and anchored in nine fathoms in the eastern harbor, where she rode out the gale easily, and afterwards experienced great difficulty in getting her anchor, so firm a hold had it taken in the tenacious bottom of mud and shell. The Stephens is an old Panama steamer, very high out of water, and had but one anchor, of two thousand pounds.

From the Coast Survey tidal observations of two months, from August 21 to October 21, we find the mean rise and fall of the tide to be seven and eight-tenths feet, and at the full and change of the moon eleven and nine-tenths feet. The extreme range observed during the above period was thirteen feet, and the least range two and one-tenth feet. The Russian charts and authorities give the rise and fall between fourteen and fifteen feet, and this is the accepted fact. The English chart states "H. W. F. and C. 0^h 34^m; spring rise five to seven feet." Our determinations of the tide give, therefore, an important correction to establish opinions and authorities upon this subject. The following table embraces the result of the observations for tides and the means of determining the times and heights of high and low waters:

Tide-table for Sitka.

The two tides of the same day are generally unequal in proportion to the moon's declination. The time and height can be obtained approximately from the following table:

Moon's declination.	Moon's upper meridian passage.				Moon's lower meridian passage.			
	High water.		Low water.		High water.		Low water.	
	Interval.	Height.	Interval.	Height.	Interval.	Height.	Interval.	Height.
	H. m.	*Feet.*	*H. m.*	*Feet.*	*H. m.*	*Feet.*	*H. m.*	*Feet.*
Greatest north....	12 8	9.5	19 13	—0.2	13 26	7.5	18 35	4.1
Zero	12 38	9.3	18 46	1.0	12 38	9.3	18 46	1.0
Greatest south....	13 26	7.5	18 35	4.1	12 8	9.5	19 13	—0.2

The interval is to be added to the time of the moon's meridian passage to give the time of high or low water. The time of the moon's upper-meridian passage is given in the almanac, and the time of its lower meridian passage is the middle between two successive upper passages.

The heights are given in feet and tenths, and show the rise above the level of the average of the lowest low waters, to which level the soundings on the chart are given.

SPRING TIDES.—At the full and change of the moon the high waters will be 1.1 foot higher than the above and the low waters 1.1 foot lower.

NEAP TIDES.—At the moon's first and last quarters the high waters will be 1.1 foot lower, and the low waters will not fall as low by 1.1 foot.

Sitka is the principal establishment of the Russian-American Company, and comprises about one hundred and twenty good block-houses, storehouses, barracks, workshops, saw-mills, churches, hospital, and the governor's headquarters. It contains nine hundred and sixty-eight inhabitants, of which three hundred and forty-nine are Russians, and the remainder creoles or half-breeds and Aleutians. Outside the stockade are forty large Indian houses, facing the western harbor, and occupied by not less than one thousand Koloshes during the winter. The site of the town is cramped, and it is a mere question of time and expansion when these Indian houses will be removed. For years the Russians have had about a dozen guns directed along the face of the Koloshian village.

The geographical position of the Coast Survey astronomical station, at the head of the ship-yard, and near the new United States barracks, is: latitude, 57° 02′ 52″; longitude, 135° 17′ 05″; or, in time, 9^h 01^m $08^s.3$; *magnetic declination, 28° 50′.8 east, in August, 1867.*

The harbor of Sitka being contracted, exposed to severe southeast gales, difficult of access, and having no extent of land fit for cultivation, the question has been raised whether a better harbor cannot be found in the vicinity affording safe anchorage, of easier access, and greater space, with surrounding soil that may be cultivated. In 1775, Quadra called Sitka Sound the Bay of Terrors.

It would be useless to attempt to describe the labyrinth of channels and islets passing in every direction, like tentacula from the sound, yet a few items may not be without interest.

A good passage exists between the north part of the sound and the eastern end of Salisbury Sound, which enters from the Gulf of Alaska, in latitude 58° 20′, and continues through Peril Straits to Chatham Straits. We have made several examinations through these waters, and changed materially their shapes on the English chart. Cross Bay was furnished, in manuscript, by Prince Maksoutoff, and that of Hayward Harbor was made by the Coast Survey, when examining that locality for reported magnetic iron ore.

The Newski passage, between Olga Strait and Peril Strait, is quite narrow, and has sunken rocks upon its shores. The Coast Survey made a series of soundings through it, indicating plenty of water. This rough sketch, from compass bearings throughout, in a rain-storm, makes the strait narrower than laid down on the charts. With a thorough survey of this strait and of Salisbury Sound, another entrance is afforded to Sitka Sound to vessels driven north of Cape Edgecumbe by heavy southeasters, or by the currents in light airs.

ST. JOHN'S BAY.

This harbor may be considered the southeast termination of Salisbury Sound, and nine miles from its entrance. It is also at the north entrance to Newski passage, and has good anchorage near the head in sixteen fathoms of water. The shores are bold and rise to mountains covered with spruce to the water's edge. The stream at the head comes into the bay through a narrow low valley between high mountains. It is seventeen and a half miles from Sitka and is reached through Olga and Newski Straits. We anchored here in October, 1867, and discovered specimens of the best bituminous coal on the Pacific.

COAST LINE.

From Cape Edgecumbe the general trend of the coast to Cape Phipps, in latitude 59° 30′, longitude 139° 42′, forming the southeast point of the entrance to Behring or Yakutat Bay, is north 40° west, and the distance one hundred and ninety miles; with the greatest deviation from this course at the entrance to Icy Strait, whose north point is twenty-six miles northeast from the above course.

From Cape Edgecumbe the general trend to Cape Fairweather, in latitude 58° 50′.2, longitude 137° 48′, is north 30° west; the north point of the entrance to Icy Strait lying fifteen miles northeast from this line.

From Cape Edgecumbe to Sturzy Bay, twenty-three miles southeast of Fairweather Cape, the coast is bold, rugged, and rocky, bounded by great numbers of rocks and rocky islets and indented by numerous small bays, and the larger entrances into Chatham Strait.

From Cape Edgecumbe to the island forming the northwest point of the entrance to Salisbury Sound, the direction is north and distance twenty miles.

SALISBURY OR KLOKACHEFF SOUND.

The entrance to this sound from the Pacific lies between latitude 57° 18′ and 57° 22′. The south point, named Cape Georgiana by Portlock, is narrow, comparatively high and wooded, with the Morskoi Sea Rock lying one mile north 63° west from it, with twenty-seven fathoms between them. The north point, named Cape Klokacheff, lying north one-half west from the south point, appeared from the inside of the sound to be about two hundred and fifty feet high and covered with spruce trees, with high mountains lying to the northeast. These mountains are covered with wood half way up, but bare and rocky at their summits.

The sound runs directly east five miles, contracting at its narrowest place to one mile, between the rocks off the north and south shores. It opens into Fishing Bay and Peril Straits at the northeast, and into Newski Strait and St. John's Bay at the southeast. Of the north shore the rocky islets extend half a mile, the southernmost lying three and a half miles inside the entrance, and are low and bare. Nearly abreast of them, off the south shore, lies the low wooded island of Sinitsin, with rocks off its north point.

Between Cape Georgiana and Sinitsin Island a small bay, named Kaliñiña, makes in to the southeast, and then to the southwest for a mile and a half, and is said to afford good shelter in seven fathoms of water well in. But from its position it is probable that the heavy swell of southeast and southwest gales would be felt. On its eastern side a wooded mountain, about fifteen hundred feet high, rises very abruptly.

Sinitsin island nearly touches the southern shore of the sound, and rocks are laid down between them. To the southeast of this island the shore is laid down straight on the maps, but from our position in the middle of the sound the shore appeared to retreat well to the south, heading in a low valley, with the high mountain that flanks Kaliñiña Bay to the west, and a wooded hill of about six hundred feet high on the east. Two rocks appear in the entrance of this apparent bay, yet it might afford a good harbor of refuge.

In the middle of the eastern part of the sound we found fifty-five fathoms of water.

This sound is the Bay of Islands of Cook, the Salisbury Sound of Portlock, whose boats in 1787 passed through it and by Hayward Strait or Soukoi Inlet to the north part of Sitka Sound.

Cape Georgiana was subsequently named Point Amelia by Vancouver, and is designated as Siouchi Point on recent English charts.

Hayward Strait was discovered by Portlock.

MARY BAY.

Between Capes Edgecumbe and Georgiana the shore is deeply indented by a large open bay named by Vancouver, but never entered by him. One of the Russian captains reported that he was compelled to anchor in the southern part of it for three days, during heavy southeast and southwest gales, at great hazard. A rough sketch of this anchorage is given on the Russian chart No. 9 of the Pacific series, where it is called Chelekoff Bay.

From the north point of Salisbury Sound to Cape Edward, in latitude 57° 39′, longitude 136° 15′, the general trend of the coast is north 40° west, and the distance twenty-four miles, with a slightly retreating shore of bold cliffs and innumerable rocks.

KHAS BAY.

Six miles northward of Cape Klokacheff, Tebenkoff has a bay called Khas, entering the land about three miles eastward, but has rocks marked in the entrance. No details or information can yet be had respecting it.

From Salisbury to Icy Strait the coast is bordered by low wooded islands, among which Portlock says there appear several places of good shelter. The mountains, rising almost directly from the coast, are quite high and irregular, some well wooded and others quite bare. Between the Khas Bay and Cape Edward the bold coast line recedes a few miles, but the general direction is maintained by the great number of outlying islands; to this bend of the shore Tebenkoff has given the designation, Bay of Islands.

Vancouver says that off Cape Edward lies a cluster of small islets and rocks. Tebenkoff has the islets and rocks, and lays the cape down as broad, extending two miles north and south, bold, high, and rocky.

From Cape Edward to Cape Spencer, in latitude 58° 12½′, longitude 136° 34′, forming the northwest point of the entrance to Cross Sound, the general direction of the coast is north 16° west, and the distance thirty-four miles, passing tangent to Cape Cross, in latitude 57° 56′.

POINT BINGHAM.

This rocky headland, in latitude 58° 03′, longitude 136° 27′, forms the southwest point of the entrance to Icy Strait, and lies south 16° east, eleven miles from Cape Spencer. Between it and Cape Edward the coast is bold and rocky, guarded by islands, indented by two bays three or four miles deep, and by a broad entrance to Icy Strait ten miles south of Point Bingham and six miles south of Cape Cross.

The bays were judged by Portlock to afford good shelter, but the vast number of wooded and bare islands and rock that extend to the distance of three or four miles from the shore will render entering such harbors unpleasant and hazardous until better known and described.

PORTLOCK HARBOR.

This large bay has been fully described by Portlock, but his sketch of it is merely a rough estimate, and he makes no mention of determining its latitude, although his map places it in 57° 45′, and Vancouver says that about six miles north of Cape Edward the harbor that appeared of easiest access was considered Portlock harbor, in latitude 57° 44′, but the weather was thick, foggy, and rainy, and the shores not well seen.

Portlock says: "On drawing near the opening, and about two miles from the shore to the northwest of it, we had twenty to twenty-five fathoms of water over a muddy bottom, and just in the entrance were some high, barren rocks."

The following is the best description that can be drawn up from Portlock's sketch and text: The opening to Portlock harbor lies between two points lying northwest and southeast from each other and distant from three to four miles apart. This entrance is, however, divided into three passages by two large, bluff, wooded islands lying directly between the points. The southeast island received the name of Hogan, and that to the northwest, Hill. The south passage is about half a mile wide, with bold shores and twenty fathoms of water. The middle passage is a mile wide at the outer part, but at the inner part is contracted to half a mile, with ten fathoms of water, by two bare islets and rocks from the southeast point of Hill Island. The northern passage is narrow, and no soundings are given. Rocks lie off the southeast point of the bay and off the south point of Hogan Island, and bare, rocky islets and rocks off the northwest point of Hogan Island. The south side of Hill Island is "low land, forming itself into several small bays, from whose points are breakers at no great distance," with bold rocks extending nearly half a mile off the southeast point.

The deepest water in the middle passage between Hill and Hogan Islands is forty-six fathoms over rocky bottom; the length of this passage is about a mile; has bold, rocky shores, and the course through it is nearly northeast by east. The best course in would be to steer east northeast for a wooded islet inside, and lying half a mile north-northeast from the north point and islet of Hogan Island; between this wooded islet and Hogan Island a depth of thirty-two fathoms is given. The southeast passage is about a mile in length.

Immediately upon passing the bold rocks off the southeast point of Hill Island the water deepens very quickly to thirty and forty fathoms, and a most spacious and excellent harbor opens to view, trending to the northwest and southeast, and running deep into the northward, with a number of small islands scattered about. Running up towards the northwest part of the harbor, and after passing the small island close to the north side of the northeast point of Hill Island, Portlock anchored in thirty-one fathoms of water, muddy bottom; the rocks off the east part of Hill Island being just shut in by the small island, and bearing south three or four miles. (According to the sketch they bore about south-southeast, distant one mile.)

The country adjacent to Portlock Harbor abounds with white cedar, which was cut and sawed into sheathing-boards. (Page 262.) This is evidently the yellow cedar of Alaska.

Tebenkoff's chart gives no idea of a deep bay in this locality, although he has the name in latitude 57° 45′.

ICY STRAIT OR CROSS SOUND.

The entrance to this strait is wide, open, and unobstructed by rock, shoal, or island. This appears to be the case for ten miles within the heads, and Vancouver says that, if it possesses any navigable objection, it is the unfathomable depth of water which everywhere exists except very near the shores, along which in many places are detached rocks, lying, however, out of the way of navigation, and sufficiently conspicuous to be avoided.

The entrance is eleven miles wide between Cape Spencer on the north and Point Bingham on the south, bearing south 16° east from the former. Inside of Cape Spencer the strait expands into a great bay running fifteen miles north-northwest, and from ten to four miles wide. Six miles inside of Point Bingham a passage two miles wide opens to the south-southeast and runs ten miles in that direction, when it turns abruptly to the west-southwest, and reaches the ocean in about six or eight miles.

This sound has been called Icy Strait, and appears to well deserve the appellation. Tebenkoff says that ice is found there all the year, impeding navigation; and in July and August Vancouver's officers found part of the passage almost closed with the ice. Frequently the masses of ice are detached from the face of the glaciers, covered with gravel and earth, and these drifting in the sound are often taken for rocks awash. Upon the chart have been marked the positions of the different glaciers that come down from the terminal spur of the Mount St. Elias and Fairweather range to the heads of the bays opening upon the north shore.

The general direction of the strait is north 60° east for thirty miles, then south 56° east for twenty-four miles to Chatham Strait. Point Bingham is in latitude 58° 03′, longitude 136° 27′, and Cape Spencer in latitude 58° 13′ and longitude 136° 34′.

PORT ALTHORP.

Vancouver has given a sketch of this bay, the entrance to which is situated on the south shore of Icy Strait, ten or eleven miles north 41° east from Point Bingham, and ten miles east 6° south from Cape Spencer. The entrance to the bay, opening from the sound, lies between two islands north and south of each other, and is bordered by a number of rocks and islets. It has nine fathoms of water in it. "The channel is clear, free from danger, and is one and a quarter mile in width, with a tolerably snug cove, just within the entrance and off the south face of the western part of the island that forms the north point of entrance." Here Vancouver anchored in fourteen fathoms, a cable's length from shore. Tebenkoff puts the anchorage down in ten fathoms, sandy bottom. "This high, narrow island affords great protection to the bay, which is two and a half miles wide just inside. Nearly in the middle of the bay, and one league southeast by south from the anchorage, are some detached rocks. The island forming the south point of entrance is about two miles long, and stretches to the south-southeast towards Point Lucan, from which it is separated one mile, but the space is filled with numerous islets. At Point Lucan, which is situated from the anchorage south 23° east four and a half miles, the width of the harbor is two miles, from whence it extends south 36° east about six miles, and terminates in a small basin that affords good and secure anchorage, the best passage into which is on the eastern shore, rocks and an islet guarding the west." Vancouver gives the latitude of his anchorage 58° 12′ 00″; Tebenkoff gives the longitude 136° 12′.

The surrounding country is covered with spruce trees.

ISLANDS IN ICY STRAIT.

The islands that lie north-northeast from Port Althorp contract the middle of the strait very much, and almost close the passage to the east. Between these islands and the shores that form the north and south sides of the strait there are two narrow channels; the northernmost, being the widest, is nearly a mile across; the southernmost is about half that width, both of which are free from rocks and shoals or any other obstructions than the large masses of floating ice which at that time of the year (July) rendered each of these channels very dangerous to navigate. The track of the Russian steamers is laid down through the southern passage.

FOREST CAPE.

Fifteen miles northwest from Cape Spencer is Forest Cape, having a small open bay on the eastern side making in a mile or two to the northward, and distinguished by having the most southern sea-coast glacier at the northeast side of it. A small islet lies well up in the bay, and Tebenkoff has one nearly a mile south of the cape.

LTUYA BAY.

Thirty-two miles northwest from Cape Spencer is the narrow and dangerous opening to this bay, which extends inland north 55° east for six miles, and spreads into two arms at right angles to the former course, and each arm extends about three miles, with an average width of one to two miles.

The entrance lies two or three miles northwest of the termination of the rocky, bold bluffs of the coast coming from the southward. On Tebenkoff's chart the immediate coast is represented as low and sandy, yet, on the enlarged chart taken from La Pérouse, it is bold and rocky, with rocks stretching across the entrance from the west point nearly to the southeastern point. The southeast point of entrance is placed in latitude 58° 35′, longitude 137° 16′. The best anchorage is immediately behind and inside the north point; a second anchorage is laid down a mile and a half beyond the north point and under the northwest shore. In Shiltz's report to Baranoff, (July, 1776,) he says: "The entrance to Ltuya Bay is most dangerous; the strong currents, rushing over hidden rocks, form rapids which almost entirely conceal the channel, and thus add to the danger. In fair weather my vessel was being towed in when the water before me appeared one and a half fathoms higher than in the bay, and we shot the descent with irresistible speed and great danger. Once inside, all immediate danger ceased. The bay is large and filled with rocks and sands; no wood at the immediate entrance, and no position fit for a settlement. The bay is destitute of fish except halibut, which abound only in spring and summer. In the winter the bay abounds in sea lions, (*Phoca jubata*,) but the common seal (*Phoca vitulina*) is very seldom seen."

Other navigators pronounce the entrance dangerous. The shores a short distance inside the entrance are described as "composed of enormous cliffs eight and nine hundred feet high, overhanging fathomless waters; the glacier ice, forced from the mountain gorges, covers the surface of the water all the year round. No sound but the fall of great masses of ice disturbs the silence of this terribly grand but gloomy gorge."

Three miles inside the entrance is a large wooded island called Egg Island, with soundings of thirty fathoms close to it.

In 1786 La Pérouse anchored in this bay and named it French Port; but it is not known that any other vessels than those of the Russian-American Company have visited it. We have not the voyages of La Pérouse from which to describe the bay.

Northwest from the northern arm of Ltuya Bay, in the direction of Mount Fairweather, is a similar mountain, though not so high, named Chillon, by La Pérouse; its latitude as determined by him is 58° 18′ and fifteen minutes of arc east of Fairweather, which will place it in longitude 137° 12′. It is nine miles from the nearest shore. The natives call both these mountains Ltuya peaks. Tebenkoff gives a view of them from a distance of one hundred and five miles.

About two and a half miles north of the entrance to Ltuya Bay a small river enters the sea, and at the proper season salmon enter and ascend it in great numbers.

CAPE FAIRWEATHER.

From Ltuya Bay to this cape the distance is twenty-two miles northwest, the immediate shores low and sandy, with a margin of low ground covered with trees, running a few miles to the foot of the snow range of Mount Fairweather.

It is situated in latitude 58° 50′ and longitude 137° 48′. Vancouver says: "This cape cannot be considered a very conspicuous promontory; it is most distinguishable when seen from the southward, as the land to the west of it retires a few miles back to the northward, and there forms a bend in the coast; it is the most conspicuous point we noticed eastward of Cape Phipps. It is terminated by a low bluff cliff on a sandy beach, near which are a few detached rocks." A small stream enters about a mile east of the extremity of the cape.

The magnificent peak of Mount Fairweather, lifting its eternally snow-covered head to an elevation of 13,946* feet above the ocean, and frequently visible at a distance of one hundred and fifty miles at sea, lies in latitude 58° 57′ and longitude 137° 27′, and nine miles from the nearest shore and twelve from Cape Fairweather.

Six miles north of Cape Fairweather a small stream enters the ocean. Tebenkoff has a glacier marked upon it one or two miles inland.

CAPE FAIRWEATHER TO CAPE PHIPPS.

The general direction of the coast from Fairweather to Phipps, the south point of the entrance to Yakutat Bay, is north 62° west, and the distance seventy-one miles. The shore leaves this general direction as much as seven miles, about ten miles north of Fairweather Cape, where is the eastern boundary of Dry Bay.

Tebenkoff describes this stretch of coast from the details of the head-men of the parties sent to hunt the sea-otter, and says the shore is a "narrow strip of land, low, level, and covered with

*Captain Vasilieff, of the Oikritic, (Discovery,) determined this altitude. Another Russian authority gives 13,846 feet. British Admiralty Chart has it 14,708 feet.

wood. Its breadth between the sea-shore and the foot of the mountains is five to seven miles, and many rivers and streams enter the narrow plain in different directions, and serve as so many canals for the purpose of inland navigation: but all the rivers are small and shallow. The most important of them is the river Alsekh, which at twelve or fifteen miles from the shore is divided into five branches, which flow through such low ground that the high waters very frequently cover a great extent of it, and at such times really form a shallow bay, having a width of twelve miles upon the ocean, and extending inland to where the Alsekh divides. In the middle of this Dry bay is a rocky island two or three miles in extent and covered with wood; it is called Kanika-Kaghee.

From the mast-head Vancouver saw lagoons over the low beach of this coast and communicating with the ocean through breaks in the breach, across which the surf broke with much violence.

The range of mountains forming a snow-clad barrier behind the coast hence to Prince William Sound, is said by Tebenkoff to attain an elevation of eight or nine thousand feet, and from all their gorges great glaciers force their irresistible way upon the low land. A notable interruption of these mountains is mentioned by Cook and by Vancouver, who describes it as a plain composed of a solid mass of ice, or frozen snow, inclining gradually to the low coast border: it was remarkable for its apparent smoothness, uniformity, and the clean appearance of its surface. It was forced through this great valley or interruption from the accumulating mass of ice on higher ground beyond. No position is given by Vancouver for this break.

YUKUTAT, OR BEHRING BAY.

Cape Phipps, in latitude 59° 33′, longitude 139° 42′, forms the southeast point of the entrance to this bay, but it should be borne in mind that this outer cape is called on the Russian maps the Ocean Cape, and that they designate the point three miles northward of it as Cape Phipps. The northwest point of the bay is Cape Manby, in latitude 59° 43′, longitude 140° 06′, and bears north 47° west from Cape Phipps, distant eighteen miles.

Vancouver says that, "off Point Manby the water was found to be discolored at the distance of four miles from shore, where no bottom could be found with the hand-lead." Puget says, (Vancouver, Vol. III, p. 237,) "The dangers in Behring Bay, particularly between Cape Manby and the island forming Port Mulgrave, are considered to be numerous, since several rocks were seen just showing their heads above water." Tebenkoff does not refer to any such danger, and it is quite probable that Puget mistook for rocks detached and floating masses of ice covered with earth or stones, such as he subsequently met with in Icy Strait.

Tebenkoff's chart represents the north shore as low and sandy and covered with wood to the base of the mountains, from which flows a stream emptying into the bay fifteen miles north by east from Cape Phipps, and having an extensive sand-bar at its mouth. In the text of his work he says that Manby or Great Cape is high, and at some places steep and rocky; that the shores of Yakutat are mountainous, woody, and in many places cut by glaciers; but the climate is better than that of Prince William Sound.

The southest shores are broken and fringed by numerous wooded islands with low shores, and forming a great number of small bays and anchorages with very deep water in most of them. The entrances to these anchorages have strong currents, and are represented by the Russians as difficult of access for sailing vessels.

Inside of Cape Phipps of the Russians, and three miles south, half east, is a low wooded point called Point Turner, with very deep water quite close to it, and a reef of rocks parallel to it running along its eastern face a little more than a quarter of a mile distant. Between this reef and the long point the depth of water varies from twenty to ten fathoms, and the anchorage is well up the shore of the point to avoid the very strong currents that rush past it. This and the adjacent waters comprise the Port Mulgrave of Vancouver. Tebenkoff gives a sketch of the islands and channels, &c. The depth of water between Cape Phipps and Cape Turner is from fifty to eighty fathoms, and the currents are said to run with great rapidity. The tides rise seven or eight feet.

A spur from the Coast Mountain range comes towards Ocean Cape parallel and close to the southeastern shore of the bay; its southern extremity reaches within two or three miles of the coast, where the low shore is cut by a connected series of lagoons and streams, leading ten miles east-southeast from Port Mulgrave.

Cape Phipps and the Ocean Cape are represented as low and sandy, and wooded a short distance back, but the whole point or peninsula is an intricacy of crooked channels, with from one to four fathoms of water in them. For five miles inside the point the shores are low, cut up by lagoons, covered with wood, and in many places the shores are covered with water in the rainy season.

The general direction of the bay is north 34° east for twenty-four miles, diminishing from eighteen to two miles in width, four miles from the entrance to Digges Sound at the head, which Tebenkoff says receives a "small stream which comes from between enormous masses of ice; the mouth of this stream is in latitude 59° 54′, longitude 139° 23′. Here Malespina, being disappointed in finding the northwest passage, called the harbor Assurance Bay, and its entrance Ferrero, (Maldonado's Christian name.)" Vancouver has described the bay, and says the progress of Puget was barred at the entrance to Digges Sound by a solid barrier of ice. The Russian chart represents its shores as masses of ice, and named it Disenchantment Bay.

Cape Turner is laid down in latitude 59° 33′ longitude 139° 35′, by Lipinski, and Tebenkoff's sketch is compiled from the examinations of Booligin and Knomtchenko; the first of whom laid down the anchorage in Yakutat northeast of Khantak Island, and the latter those on the south side in 1823.

The Russians formerly had a post on the lagoon inside Cape Phipps, but it has been abandoned.

CAPE PHIPPS TO CAPE SUCKLING.

From Cape Phipps to Cape Suckling the course is north 78° west, and the distance one hundred and twenty-five miles, with the coast curving northward of this line as much as twenty miles, especially at the entrance to Icy Bay. This stretch of coast is a low fringe of level plain lying between the ocean and the foot of the mountain range to Mount St. Elias. The soil is sand and gravel covered with sphagnum, through which grows the spruce, and from which grass springs. No wood, however, exists between Cape Manby and Cape Riou, and Vancouver describes it as presenting a naked barren country, composed of apparently loose unconnected stones; gradually the surface assumes a brownish appearance as if from vegetation. The average width of this skirting is only about three miles; where it reaches the mountains the ravines are filled with eternal ice, and all the streams cutting through it are small and shallow, and come from the glaciers. From the description of this mountain range, its approaches, glaciers, &c., this low border of stony coast line may be considered simply as a great combined moraine from all the glaciers.

The depth of water close in shore is generally from five to twelve fathoms at two cables length, and at two miles is from thirty-five to forty fathoms. The coast current is to the westward, as has been noticed by all navigators.

ICY BAY.

From Cape Phipps to Cape Riou the distance is fifty-one miles and the direction north 65° west; Cape Riou, in latitude 59° 53′, and longitude 141° 14′, forms the southeast point of Icy Bay, which runs nearly north for seven miles from the middle of its entrance. Vancouver describes the point as low, well wooded, with a small islet detached at a little distance to the westward of it, and not laid down by Tebenkoff, nor seen by Belcher, who says that the point is a low sandy or muddy point with a rough and dirty-colored ice-base.

The north point is called Icy Cape, and lies north 52° west, distant seven miles from Riou. The eastern shore is low, and backed by a large lake; the western shore is a compact mass of ice, and terminates towards the ocean in a high, abrupt, cliffy point; inside the entrance of the bay Tebenkoff gives soundings in twelve and fifteen fathoms, at the head the depth is five fathoms. There can be no anchorage here with southerly winds, which would set the whole force of the swell into it.

Vancouver gives a view of the western shores of Icy Bay, with Mount St. Elias in the background. Belcher says, "The whole of this bay, and the valley above it, was found to be composed of (apparently) snow-ice about thirty feet in height at the water-cliff, and probably based on a low muddy beach." The soundings of Tebenkoff demonstrate the existence of the bay; while Vancouver was within a league of Cape Riou and saw into the bay.

It is probable that the glacial formation on the bay may sometimes fill it; and that the island which Vancouver saw was a mass of earth-covered ice aground.

MOUNT ST. ELIAS.

This great snow peak lies in latitude 61° 22½′, and longitude 140° 54′, and rises to an elevation of 16,938 feet, according to Tebenkoff.* According to the British Admiralty chart No. 2172, it is 14,970 feet high, and is situated twenty-nine miles from Icy Cape, and twenty-three miles from the head of Icy Bay, which receives a stream from the flanks of this range. This remarkable pyramid of eternal ice is acknowledged by all the old navigators and discoverers as a magnificent spectacle from the sea, especially when the whole coast range to Mounts Fairweather and Crillon is visible. In 1839 it began to emit volumes of smoke and vapor from a crater opened on its northeast side, and in 1847, when the earthquake occurred at Sitka, Mount St. Elias ejected ashes and flames. There appears to have been a general subterranean disturbance at this epoch, for Mount Baker, in Washington Territory, in latitude 48° 45′, was in a state of eruption, and shocks were felt along the Aleutian islands. An earthquake was felt on Agamok, one of the Shumagin group, and in Alaska peninsula Pavloff Peak ejècted ashes and flame.

The mountain is visible over a hundred and fifty miles at sea, and has been sketched by Vancouver and others.

CAPE YAKTAGA.

This is a low, rounding point of land, twenty-three miles west of Icy Cape, and is the first point along this low shore where outlying rocks have been noted. Three or four miles southwest of the southern extremity of the cape, Tebenkoff lays down sunken rocks with thirty-five fathoms of water outside of them. It is in latitude 59° 48′, longitude 142° 22′, according to Tebenkoff's chart.

LAEDA REEF.

Sixty-nine miles west from Icy Cape is the southern extremity of an extensive reef, stretching six miles south of a short space of rocky shore-line. It is in latitude 59° 58′, longitude 143° 43′, and called Laeda by Tebenkoff. No soundings are given in the vicinity. Between it and Cape Yaktaga, two or three streams enter the sea. Vancouver, who was close in with the land at this place, notes a sand point lying off two or three miles.

From Cape Suckling this reef lies east seventeen miles, and from the south point of the reef making south of Kayak Island, it bears north 72° east, distant thirty-six miles.

CAPE SUCKLING.

Between Kayak Island and the Laeda Reef lies the low point called Cape Suckling, its eastern extremity laid down in latitude 59° 59′, and longitude 144° 11′. The south face of the cape is nearly east and west for five miles, and from its eastern limit commences that long reach of low, sandy beach, from five to ten miles in width, which runs hence bordering the coast to Hinchinbrook Island, a distance of seventy-five miles. This extensive sandy flat is cut through by numerous streams finding their way from the low shores to the ocean. At the distance of one or two miles from its outer edge the depth of water is not more than five to ten fathoms. Small streams fed by lakes and by rivulets from the glaciers abound along the shores; and one large river, to be hereafter mentioned, finds its outlets between Kayak and Hinchinbrook Islands.

KAYAK ISLAND.

The southern point of this island lies in latitude 59° 49′, longitude 144° 53′, with an island and reef off it. It is called Cape Hamond by Vancouver, and St. Élias by Tebenkoff. Grewingk,

* Another Russian authority gives an elevation of 17,854 feet.

quoting Belcher, says Kayak Island, as seen from the east, appears as two islands. The southern point is a high table rock, bare of vegetation, of a white color; the other is a high land of moderate elevation, with three naked peaks, the bases of which are covered with timber.

The west side is nearly straight, and runs northward twelve miles. The eastern face of the island runs from the south point, where it is very narrow, to the northward; and in latitude 59° 38′, where it is three miles wide, runs east-northeast for six miles. Off this eastern point lies a rocky reef, stretching two or three miles to the broad sandy beach west of Cape Suckling.

Tebenkoff gives a view of this island, which is represented as having a mountain at each end from his point of view.

Vancouver describes the north shore of the island as a low tract of land, well wooded, and that it is indented by small coves.

WINGHAM ISLAND.

Off the northwest point of Kayak Island lies Wingham Island, about two miles distant, with six fathoms of water between them, but a bar of two fathoms connects the southeast point of Wingham with the north shores of Kayak. Wingham Island is low, four miles long north and south, by two miles wide. Off its north point are laid down some rocks, but on its eastern side, reached by passing its north end from the west through a narrow channel and close to the shore, Vancouver says it forms a tolerably well-sheltered roadstead even against the easterly winds and that good anchorage will be found to the southward of the first small beach from its north point at a commodious distance from the shore; at this anchorage the northeast point of Kayak bears south 63° east, and Cape Suckling north 76° east.

The nearest point of the main shore lies north, seven miles distant from the north end of Wingham Island, and is called Cape Hey.

CONTROLLERS BAY.

The indentation in the coast north and east of Kayak Island, and west of Cape Suckling, was called by Vancouver Controllers Bay, into the northwest part of which enters a small river called the Chilkaht, emptying into a larger lake of the same name.

In the middle of the northwest part of this bay, and six miles off the mouth of the Chilkaht, lies the island of Kanak, two or three miles in extent and overgrown with wood. South of this island, and towards the edge of the great flats, are many shoals covered with grass, and having the appearance of small, low islands.

A DOUBTFUL ROCK.

Tebenkoff gives all that is known of a rock or bank supposed to exist in latitude 59° 36′, longitude 144° 50′, and in the track of vessels bound to Port Etches from the position of the Pamplona Rock. "Tradition says that south of the island of Kayak there exists a rock. Mate Zaykoff in 1781, being with Alexander Newski, states in his report that 'being afraid to run in the fog further south on account of a bank situated south of Kayak, we were compelled to lay to.' Guided by this remark, I locate it on my chart with a doubtful sign, thirteen miles south of the southern extremity of Kayak Island."

PAMPLONA ROCKS.

Many doubts have been expressed about the existence of these rocks, and especially as to their being visible. Captain Bryant says that there is a submarine range in the vicinity of the position usually assigned to it, but this can hardly be the case if they are the resort of the sea-otter, as will be shown to be the case.

Tebenkoff says: "In the approximate latitude of the Dry Bay (latitude 59° 03′) there exists a rock discovered in 1779 by a Spaniard, Captain Arleiga, which he called Rock Pamplona. In 1794 Mate Talin, in the ship Orel, (Eagle,) saw it and named it after his vessel, but did not determine its position."

The navigators of the Russian-American Company are divided in opinion about it, but agree that one of their number reports seeing it as a three-pointed rock; another informs me that he sailed over the longitude laid down by Tebenkoff and did not see it, although the day was clear and a man aloft on the lookout.

On the various charts in our possession, the position ranges three miles in latitude, and thirty minutes of arc in longitude.

In August, 1867, the United States revenue steamer Lincoln intended to search for it, and when about twenty miles south 60° east of its supposed position hove to and sounded with one hundred and eighty fathoms of line, but found no bottom. She drifted to the ascribed latitude about three o'clock in the morning, but a dozen miles to the eastward, then steered a course that passed four miles north of its ascribed point, at five o'clock a. m., with a clear horizon. At seven and three-quarters a. m., in latitude 59° 12′, and longitude 143° 05′, no soundings could be had with one hundred and eighty fathoms of line. No other efforts were made to find it, although the noise of birds frequenting land had been heard during the early morning.

Vancouver's account of this rock is as follows: George Portlock informed us that a very dangerous rocky shoal, about fifteen miles in length, lies by compass in a direction south by west sixty-three miles from a place called by them *Leda Unala*. This Mr. Puget conceived to be near the point that had been named Point Riou, the eastern cape of the entrance to Icy Bay. Portlock himself had been on this shoal, taking sea-otters, and stated that the first discovery of it was owing to a Russian galliot having had the misfortune some years before to be wrecked upon it; two of the crew were drowned, but the rest escaped in their boats. Since that period an annual visit has been made to it for the purpose of killing sea-otters, which are there met with; and as it generally proves advantageous, Portlock meant to stop there on his return. "From the Spaniards, also, I afterwards became acquainted that a very dangerous rock existed in this neighborhood, the situation of which they had taken great pains to ascertain, and had found it to be south 41° east from Cape Suckling at the distance of thirty-six miles, and which was called by them Roca Pamplona. When this was delineated on our charts it appeared to lie in the direction south 77° east distant eight miles from the rocky shoal described by Portlock. Hence it may be inferred that Portlock and the Spaniards intended the same shoal, although it is not stated by the latter to be so extensive as by the former.

"It is without doubt dangerously situated for the navigation of this coast." * * * * The circumstantial evidence appears too strong to doubt the existence of this rock.

OTCHEK, OR MIDDLETON ISLAND.

The longitude of this island is not positively determined. It was visited in 1838 by one of the mates of the Russian-American Company, and he reports that it is above seven miles long from north to south, with a breadth of about three miles. The north end is in latitude 59° 30′, longitude 146° 30′. Off both extremities of the island are reefs extending three miles on the prolongation of the longer axis. Off the northern reef is a rock upon which the water breaks in great jets, giving it the form of a pillar, even with a comparatively smooth sea, and it has been appropriately named the Fountain.

On the west side is a rock situated southwest three miles from the northern point of the island and north-northwest of the place used for anchoring, where a small cove exists with thirteen fathoms of water over a gravelly bottom.

The surface of the island is comparatively low, and quite level, (see the sketch on Tebenkoff's chart,) but the shores are craggy. A few huts are scattered about the island, and serve as shelter for the natives temporarily sojourning here for the purpose of collecting sea-weeds and hunting seals. Several small lakes, places of refuge for birds of passage, are found along the eastern shore.

None of the early traders or explorers saw this island.

SEA-OTTER BANK.

This bank lies nearly equally distant between the north end of Otchek and south end of Kayak islands, being north 50° east, twenty-three miles from the former, and south 80° east, thirty-two miles from the latter. It is laid down as two rocks east-northeast and west-southwest of each other, with twenty and forty fathoms close to them, and a line of soundings is laid down with depths of forty, fifty, fifty-five, and sixty-five fathoms, extending southwest by west for nine miles.

The reef was discovered in 1798, with the announcement that to the "southeast of Hinchinbrook Island (Khtagalook) there exists a bank which the Tsuga natives assure us abounds in sea-otter." The existence of this bank was doubted for a long time. However, in 1842, mate Lindenburg, of the Russian-American Company, saw it, but having an overcast sky, he determined its position approximately from Nutchek Island, and obtained latitude 59° 44′ and longitude 145° 57′.

ATNA OR COPPER RIVER.

From Cape Kanak, in latitude 60° 13′, longitude 144° 56′, the coast runs west by north one-half north for thirteen miles to the eastern mouth of the Copper River, situated in latitude 60° 17′, longitude 145° 20′, thence northwest to the broad mouth of the same stream, passing several smaller mouths of the river before reaching it. This principal mouth is a wide, shoal bay, opening upon the broad, low, dry coast line, and extending in a general direction north-northeast to the great bend in latitude 60° 40′, and longitude 145° 45′, where it is two miles wide; thence it sweeps to the south-southeast for twenty-three miles parallel to and about three miles from the ocean shore, around the spur from the mountain chain to an island where the two principal streams divide, at a distance of six miles from the mouth of the eastern one. The whole of the low delta formation is attributed to the debris brought down by the Copper River, which has been partly traced by officers of the Russian-American Company, several degrees northward having been reached by an expedition following Kneek River, flowing from Lake Plavejno, in latitude 62° 10′, and longitude 149°, into Cook's Inlet, and from the lake ascending Tlisheetno River reached Copper River.

The current of the lower reaches of the river is slow, and the delta, thirty miles in extent, is overgrown with willow. Tebenkoff says that in the principal mouth of the river a small rocky islet of one mile in extent is situated half way to the great bend.

Grewingk says that the gorges bordering the river are filled with ice twenty fathoms thick and one mile wide near the river. In some places this ice is covered with a fertile soil, upon which mass bushes and berries are growing. In the middle of the river ice masses are often seen covered with fresh green bushes and ripe berries. One hundred miles above the rapids of the Atna the Tchetchitna enters from a lake one hundred miles east of its mouth.

The name is given to the river on account of the deposits of native copper on its banks. The inhabitants have tried to retain the secret of its location, and several parties have been murdered or held slaves in attempting to explore the country; but one of the officers of the company reports that the copper is found about twenty-five or thirty miles above the eastern mouth, and in various-sized masses of pure copper.

The natives call the river, especially the eastern mouth, the Atna. From its mouth it runs one hundred miles northward, then to the north-northeast and northeast. Its banks are mountainous, particularly the right one, where the mountains form precipices with glaciers in all the gorges. The noise of avalanches may be heard for many miles along its course.

The Russian trading post is in latitude 61° 28′ 06″, longitude 145° 16′, and the officers report the river as scantily peopled.

The natives inhabiting the coast between Yakutat and Prince William Sound are called Ugalentz, and number about thirteen hundred souls. They have their own language, and inhabit the banks of the streams, living upon fish and such berries and vegetables as they can gather or grow.

PRINCE WILLIAM SOUND.

This extensive body of water has an area of about twenty-five hundred square miles, and has a somewhat triangular shape, reckoning the base from Cape Puget to the head of Cordova Bay, and the apex at the head of Port Wells, in latitude 61° 09′.

The easternmost part of the sound is the head of Cordova Bay, whose waters reach within four miles of the great bend of Copper River, with an intervening low wooded peninsula. Many of the islands and of the projecting points are low and covered with wood; but behind these rise eternal barriers of ice mountains, especially to the north. The waters of the sound are very deep, the rise and fall of the tides quite large, and the currents in the different channels are very strong, with strong tide ripplings in the entrance between Port Etches and Montague Island. The waters of the sound are chilled by the large amount of ice-water from the glaciers; and, in consequence of this and the colder air from the mountains, meeting the warmer waters and warmer vapor-laden airs from the Gulf of Alaska, the weather is very changeable, and sudden squalls of wind and thick fogs prevail.

North and west of the sound lies an elevated range of mountains, stretching from Mount St. Elias and inclosing the sound round to the north. The highest peak is about eighty miles distant from the shores; and Tebenkoff saw the range in 1848 in all its grandeur, but remarked no indication of any active volcanoes. On the north shore glaciers come down to the heads of the bays, and Whidbey says that such great masses are sometimes detached from their faces that the noise of the shock passes over the sound like dull, heavy thunder, and he felt the earth tremble at a distance of six miles from the locality of one of these concussions.

There is communication between the western part of the sound and Cook's Inlet, and Vancouver understood that a party he met with had crossed from Turnagain Arm of Cook's Inlet to Passage Canal of Prince William Sound, and Tebenkoff says that looking at the short distance which separates these waters, it would seem as if the isthmus were the best route of intercommunication; but the natives prefer to take either of the outside routes, or a portage of eight miles from Resurrection Bay, in latitude 60° 07′, to the lake whence the Kakny River rises, and descend to Cook's Inlet, in latitude 60° 32′, where the Russians have the stockaded post St. Nicholas.

The passage on the isthmus passes through a ravine between two mountains, and the ravine is covered with ice, beneath which flows a stream. During summer this ice melts, and leaves a continuous cavern adorned with icy stalactites overhanging the stream. Some courageous natives during their winter travel take the isthmus route, when the ravines and precipices are covered with drifted snow.

CAPE HINCHINBROOK.

The southeast extremity of this cape, forming the northeast point of the entrance to Prince William Sound, is north 65° west, distant sixty-four miles from the south of Kayak Island, and is designated the Ocean Cape on Tebenkoff's chart. It lies in latitude 60° 16′, longitude 146° 47′. From this point the shore stretches west-northwest and then northwest for three miles to the entrance to Etches Harbor, (Nutchek of the Russians.)

The cape is the south point of Hinchinbrook Island, whose southeast face runs about north 50° east, seventeen miles, towards the great mouth of Copper River, and is laid down as a bold shore terminating at and connecting with the southwest point of shoals making out from the west point of Copper River entrance by low flats. From four to seven miles eastward of the northeast point of Hinchinbrook, named Cape Bentinck, two or three small islets are laid down in Tebenkoff on the edge of the shoal sandy flat.

SEAL ROCKS.

A group of small rocky islets lies off Cape Hinchinbrook, on the prolongation of the southeast shore of the island, and seven miles south 52° west from the eastern part of the cape; and also seven miles broad off the southeast shore of Montague Island. In this vicinity of much fog they form a dangerous impediment, directly in the mid entrance to Prince William Sound. Tebenkoff has a view of them.

PORT ETCHES, OR NUTCHEK BAY.

The north point of the entrance to Port Etches, situated on the southwest part of Hinchinbrook Island, is in latitude 60° 21′, and longitude 146° 52′ 50″. From it the southernmost of the Porpoise Rocks lies south 56° west, one and a quarter mile distant; the nearest land directly south two miles; the narrowest part of the entrance southeast one and a half mile; and the inner part of Cape Hinchinbrook, south 25° west, three and three-quarter miles. Bold water exists around the shores, and also in the immediate vicinity of the Porpoise Rocks, but soundings are wanting on the north side of these rocks. Between Porpoise Rocks and the south shores the soundings range from sixty to thirty fathoms; in the middle of the entrance fifty fathoms, decreasing to thirty-five.

The bay runs north 57° east for five and a half miles, diminishing rapidly in the last two miles to a narrow shallow bay. The southeast shore is bounded by high mountains, skirted along the immediate shore with a narrow belt of wooded land. The northwest shore is bold, and for the first two miles formed by the southeast face of a high peninsula, terminating at the northeast by Cape Phipps, where a narrow channel separates it from the main and gives passage to a large inner bay or lagoon, the head of which stretches southwest towards the sound, from which it is separated by a beach only a few hundred yards wide. This lagoon is about two miles long and nearly one wide, with shallow water occupied by flats, but affording a channel of twelve feet water, nearly to Fort Constantine, which lies north only two-fifths of a mile from the north point of the entrance to Etches.

Where the passage leads from Port Etches to Constantine, or Brook Harbor, as the lagoon is called, the shores recede and form a bay a mile wide, northeast and southwest, and nearly three quarters of a mile deep, with anchorage in from five to seven fathoms of water half a mile from shore, and over very even bottom. At the best anchorage Point Phipps bears west and three rocky islets north. A small stream empties from the north into this indentation north of the above rocks.

The Russians have an anchorage in the cove on the southeast shore, east-southeast from Point Phipps, with two small streams entering it. It appears well protected and has regular soundings in five and four fathoms. Portlock anchored here in 1787, and called the island protecting it Garden Island, because he planted a variety of garden seeds upon it. This anchorage affords an abundance of muscles and crabs, and the Indians supplied Portlock's vessel with plenty of cod and halibut caught in the bay. He named Constantine Harbor Brook Harbor.

The English chart by Belcher gives a depth of two and a half fathoms as the least water into Constantine Harbor, but a rock having only six feet at low water is laid down in mid-channel on the Russian survey by Chornoff. The current through the strait, which is only two hundred yards wide, sometimes runs four knots per hour. On the outer bay they are also quite strong, and the rise and fall of tide is stated to be nine and a half feet.

Fort Constance serves as a defense of the Tchugatz Indians against the encroachments and attacks of the Koloshes and Ugalentz.

At this bay Portlock cut sticks for spare topmasts, mizzenmast, and mainyard, besides getting out boards, &c. His men caught fine cod and halibut in plenty, large quantities of herring, and as many as two thousand salmon at each haul of the seine.

SNUG CORNER COVE.

Twenty miles north of Port Etches entrance is the south point of a long, low wooded peninsula, stretching well into the sound from the east-northeast, and formed by Port Fidalgo on the north and Port Gravina on the south. Off this point lie rocks, and a large islet off its west point. The northwest point of this peninsula forms the western point of the entrance to the Snug Corner Cove of Cook, where the Discovery was anchored. We have not Cook's narrative for the description of this place.

MONTAGUE ISLAND.

This large and high island may be said to lie broad in the entrance to Prince William Sound, with passages thereto at the northeast and southwest extremities of the island. It is forty-five miles long, with an average width of seven miles, and lies northeast by north and southwest by south, its southern point, named Cape Cleare, stretching well out into the Gulf of Alaska, and situated in latitude 59° 46′, longitude 148° 01′. The northern point lies abreast of the entrance to Port Etches, about five and a half miles distant, forming the principal entrance to the sound, and through which the currents rush very strongly. The currents through the entrance west of the southern extremity of the island are represented as running three and four knots per hour, and quite irregularly.

The immediate shores of the island are well wooded, and much lower on the northeastern side than on the eastern.

On the northwest shores are two or three open anchorages, protected from the heavy southeast winds by the high lands to the eastward.

Off a low projecting point, covered with wood, on the southeast face of the island, fifteen miles from Cape Cleare, lies a group of six small islets. They are composed of steep cliffs, nearly level on their tops, and may serve as a guide in thick or gloomy weather. They are tolerably well wooded, and thereby not liable to be mistaken for the Chiswells, which are entirely barren. This is Tebenkoff's opinion, but the Chiswells lie nearly sixty miles to the west-southwest. In his map, Portlock places a line of rocks and soundings in four to eight fathoms one mile off Cape Cleare, designating them as "coral rocks." Dixon gives a view of Montague Island.

PORT BASIL, OR M^cLEOD HARBOR.

This bay is situated on the northwest shore of Montague Island, twelve miles within the southwest point of the island, and nearly abreast of the island Latouche, that forms the west side of the channel. It is in latitude 59° 58′, longitude 147° 54′. Portlock says that after a boat examination he hauled in for it, and anchored in twenty fathoms, over a muddy bottom. In running into the bay, just off the south point, the soundings were seven and eight fathoms, over a bottom of black mud and sand. This bank appeared to me nearly across the mouth of the bay, and, after passing it, the water deepened to twenty-one fathoms; and with this depth the south point of the entrance bore southwest by south, about one and a half mile; the north point bore northwest by west half west, about one mile; and the distance from the nearest northern shore was about a mile.

His rough sketch of this bay shows that it lies about northeast by east for three and a half miles, with irregular soundings from the seven-fathom bar across the entrance to twenty-two fathoms in spots, and carrying ten fathoms to the head. In the extreme northeast part is a small indentation, half a mile in extent, with four and a half to six fathoms water; and a stream flows into the eastern part of this cove. The whole east head of the harbor is an extensive flat. A vessel can lie in the cove in four and a half to five fathoms, about a cable's length from shore, with the south point of the harbor just shut in by the point forming the cove. This point may be taken close aboard, as the water is quite bold.

The south point of the entrance is named Point Bryant; the northern, Point Woodcock; their distance apart, about two miles, bearing northeast by north and southwest by south.

The only wind to which this bay is exposed is from the southwest, and then a vessel may run up into the cove and anchor in four and a half fathoms.

From McLeod Harbor, in sounding across the channel towards Latouche Island, fifty and sixty fathoms are found over a muddy bottom soon after quitting the harbor; no bottom in mid-channel with seventy fathoms. Close to the shore of Latouche Island, within a cable's length, the soundings are from forty to fifty fathoms, and these are carried to the north extreme of the island.

HANNING BAY.

Northeastward from McLeod Harbor the shores of Montague Island are bold, with soundings of thirty fathoms over a muddy bottom, about a mile from land. About five leagues from McLeod Harbor, Portlock says he came to a deep, wide bay where vessels may safely ride at anchor in from twenty to ten fathoms, muddy bottom. With ten fathoms the anchorage is near the bottom of the bay, and about half a mile from shore, but the best anchorage seems to be nearest the south side, and no nearer the shore than in from ten to twelve fathoms water. A fresh-water stream enters into the south part of the bay, where Portlock drew his seines, and in one tide caught a quantity of salmon sufficient to load two boats.

GREEN ISLES.

These islands lie four miles westward of the entrance to Chalmers Harbor on the northern part of Montague Island, and the soundings in the channel to the sound vary from thirty-five to twenty fathoms, until nearing the Green Isles, when the water shoals, and frequently seven and eight fathoms were found by Portlock, with rocky and shell bottom. Patches of kelp were numerous near the shoal soundings.

CHALMERS HARBOR.

The north point of this harbor lies in latitude 60° 16′, longitude 147° 22′, and is named Point Gilmour. Rocky patches with kelp lie off the entrance, and two islets off the south part; the inner and larger one is called Wilby Island; the outer islet, half a mile off shore, lies about west-southwest, two-thirds of a mile from Point Gilmour. Outside the entrance and kelp patches, the soundings are regular for two miles, when seventeen fathoms are found.

The entrance is one-half a mile wide, with twenty-one fathoms off Point Gilmour, and muddy bottom. The harbor extends about one and a half mile to the northeast, and has a landlocked cove one mile from the entrance, with capital anchorage in seven fathoms, muddy bottom. Along the northwest half of the bay the soundings are ten to fifteen fathoms; rocks exist in the eastern part of the bay.

Where Portlock anchored, with twenty-one fathoms of water, a small island, being the westernmost part of the bay, bore southwest half a mile distant; the north part of the bay, being the point off Stockdale Harbor, bore northwest three-fourths north, distant three and a half miles; and the bottom of the bay northeast by east two miles. The westernmost of the two rocks between which his vessel entered was just above water, and bore west three-fourths south more than a mile distant, and the easternmost rock was covered, the tide being then two-thirds flood. He says that it would not be prudent for any vessel to run through this passage in thick weather; but when the weather is clear it is tolerably safe, with a good lookout, the lead going, and keeping nearly in mid-channel.

In the inner harbor Portlock removed the larger stones, and then beached his ships for cleaning and repairing.

ZAIKOFF BAY.

Tebenkoff has two large indentations in the north end of Montague Island; the western one is evidently unexplored, and the eastern one, with rocks and an islet on its east shore, lies abreast of the entrance to Port Etches or Nutchek Bay, eight or nine miles distant. It is named Zaikoff Bay, and no soundings are given.

CAPE CLEARE.

This is the southern head of Montague Island, but I find no description of it is given in the works at our command. It is situated in latitude 59° 46′, longitude 140° 01′, according to Tebenkoff's chart, and Portlock lays the coral rocks one mile off its extremity. Cook placed it in latitude 59° 36′, but Portlock says he made it 59° 47′, and is certain of being right within a mile or two. From this point Cape Puget lies north 58° west, distant eighteen miles, while between these capes lie two large islands, with an opening between Latouche and Montague of nine miles at the entrance, diminishing to four miles in about eight. Two other openings exist, of about a mile and three miles wide, respectively, leading through comparatively narrow channels to Prince William Sound. Little is known of their peculiarities and availability.

POINT ELRINGTON.

This is the south point of the middle island between the south end of Montague Island and Cape Puget, and lies five miles east of the latter. It is thus described by Vancouver: "A high, steep, barren promontory, of small extent, connected to the south end of the island by a narrow isthmus."

POINT PYKE.

North of Point Elrington about five or six miles is the south point of an unnamed island. It is bold and rocky, with a number of islets lying off it, and was named by Vancouver, who states that it is remarkable for its sugarloaf form. To the north of Point Pyke is a tolerably well-sheltered bay, surrounded on all sides by lofty abrupt, snowy mountains. To the north of this there is a second bay, and also a narrow opening ten miles long to the northeast.

KENAI PENINSULA.

The western shores of Prince William Sound form the northeast part of the peninsula of Kenai, of which the outer or gulf shore commences with Cape Puget. The termination of the peninsula is named Cape Elizabeth.

From Cape Puget to Cape Elizabeth the shores have been very well explored by the Russian navigators, searching for good harbors and shelter for the Russian whalers. Their reports show that the line of coast is broken by bays and coves, but none offering good anchorage, there being very close to the shores not less than thirty to fifty fathoms of water. The coast is very rocky and steep and mountainous, yet covered with wood, while the ravines and gorges between the mountains contain in many places glaciers which stretch back from the heads of the bays even to the gorges descending towards Cook's Inlet.

CAPE PUGET.

This cape, forming the southwest point of the entrance to Prince William Sound, is in latitude 59° 55′, longitude 148° 34′, and from this point the coast has a general trend for one hundred and ten miles to the Tschugatz islands, formerly known as Cape Elizabeth. There is a glacier at the head of the bay just west, and forming the cape, and in the second bay, seven miles westward, a large glacier comes down into the ocean, and is represented by the Russian navigators as a very beautiful and grand object, when seen in a clear day. We find no description of Cape Puget, but Tebenkoff's map represents it as a bold, high, rocky head, with a face two miles long towards the southeast, and having a line of rocks in front, with an islet off the eastern termination.

RESURRECTION BAY.

This extensive arm of the sea, from fifteen to twenty miles long, and six to three miles wide, lies twenty-five miles west of Cape Puget and northeast of the Chiswell Islands. It was well known in the last century and selected as the future ship-yard of the Russian-American Company; but it does not present the proper facilities, on account of the great depth of water, the severity of the climate, and the wild nature of the coast. In Vancouver's time four English shipwrights were conducting the ship-building of the company at this place.

By frequent explorations of the company's officers the position of this bay is well known, but we have found no detailed description of it. Tebenkoff represents the western shore as low, the head as shallow, with a glacier at the northeast part; the eastern shore as bold and rocky, and Cape Resurrection, the eastern point of entrance, as a long, moderately low, narrow point, but rocky and abrupt. Three large, low islands lie, respectively, southwest, west, and northwest of this cape, while the Chiswell Islands form a large group fifteen miles southwest of it.

CHISWELL ISLANDS AND SEAL ROCKS.

Forty-seven miles south 75° west from Cape Cleare, the south point of Montague Island, Tebenkoff locates the Seal Rocks five miles outside of the Chiswell Islands. Fifteen miles off these Vancouver obtained soundings in seventy-five fathoms, and Portlock gives seventy-six fathoms over a muddy bottom forty-five miles south 60° east from them.

The recession of the coast line between Cape Puget and the seal rocks is named Blying's Sound, indented by several large bays open to the south.

Of the Chiswell Islands Vancouver says: "We passed them and found the center of the southernmost group in latitude 59° 31′; from these the easternmost, which is a single detached rock, lies north 54° east about a league distant, and the northernmost which the hazy weather permitted our seeing, having several less islets and rocks about it, lies north 150° east, five miles distant. These were all we saw of the Chiswell Islands, which are a group of naked, rugged rocks, seemingly destitute of soil and every kind of vegetation. The southern group is named the Seal Rocks by Tebenkoff, and the middle and principal one of the five is placed in latitude 59° 34′, longitude 149° 32′. What Vancouver called the Chiswells proper is in reality a group of islets, and the broken and numerous points of two long, low, wooded promontories, stretching southward and forming Ayalik Bay, off which lie the Chiswell Islands, north by west five miles from the Seal rock.

PYE ISLANDS, NUKA BAY.

Seventy-six miles south, seventy-two west from Cape Cleare, lie the Pye Islands, forming part of the eastern shore of the deep bay of Nuka, fifteen miles long and six to two miles wide. This bay has a general direction to the north-northeast, with alternately low and bold rocky shores, while the main arm has several smaller ones. The head of the eastern one, seventeen miles north-northeast from the southernmost of the three Pye Islands, is formed by a glacier. The other main arm extends to the north-northwest, and then north-northeast, and is much more extensive than the eastern. The shores of both are wooded. Vancouver says: "The southernmost part of the Pye Islands, from several points of view, forms a very conspicuous peak, which, though not remarkable for its great height, yet from its singular appearance is not easily to be mistaken in the neighborhood, as it descends with great regularity from its summit to the water's edge. Its southern extremity, by our observations, is situated in latitude 59° 19′." He says that a group of rocks lying south 75° west, nearly four miles distant from the southernmost of the Pye Islands, must be very dangerous in thick weather, especially as at high water, during the spring tides, it is probably overflowed. Tebenkoff says the rocks lie south 60° west, six miles distant from the southernmost part of the Pye Rocks, and two and a half miles square off the large rocky islands forming the western side of the entrance to Nuka Bay. The approximate geographical position of the southern point of Pye Islands, according to Tebenkoff, is latitude 59° 20′, longitude 150° 28′.

Nine miles east by north of the Pye Islands Vancouver gives soundings in seventy-five fathoms. Vancouver says the coast in this vicinity is in most places very mountainous and descends rather quickly into the ocean, except in those places where it is broken into valleys, some of which are extensive and gradually incline to the water side. These, in some instances, in the middle of May were buried in ice, and some within a few yards of the wash of the sea, while here and there some of the loftiest pine (spruce) trees showed their heads through this frigid surface. The whole of this exterior coast wore a more wintry aspect than the shores of Cook's Inlet in much higher latitudes.

PORT DICK.

Half way from the Pye Islands to Cape Elizabeth the outer cape is called Point Gore, in latitude 59° 19′, longitude 150° 58′, and the three-miles-wide entrance to the west of it is the opening to Port Dick, which runs northward ten miles, with a broad arm ten miles long penetrating to the west. The immediate shores of this bay are low and wooded, with streams coming into the head of each arm, and no glacier laid down on Tebenkoff.

TCHUGATZ ISLANDS.

Three large islands, from two to three miles off the southern end of the Kenai Peninsula, are disposed in a curve around it. The eastern and western are large, three or four miles extent, and lie twelve miles apart. The middle one is smaller, and lies half way between them and a little to the southward. Three islets are laid down one mile off the western side of the eastern island; rocks above and below water one and a half mile off the west side of the middle one, and rocks one mile off the southeast face of the western one. We find no detailed description of these islands, but Tebenkoff represents them on his chart as high and bold. They form the northeast shore to the entrance to Cook's Inlet. The southernmost one lies in latitude 59° 05′, longitude 151° 35′.

CAPE ELIZABETH.

The western point of the western island of the Tchugatz is named Cape Elizabeth, and is formed by high land. Tebenkoff lays it down in latitude 59° 9′, longitude 151° 51′. In the strait between the Tchugatz Island and the main or Kenai Peninsula there is a good anchorage and shelter, according to Portlock, whose boats traversed all these waters; but Vancouver doubts the existence of a channel to the southward and eastward through these narrow straits, as he discovered some low, lurking rocks, which had the appearance of being connected with a cluster of rocks above the surface of the sea, lying from the cape south 50° east, at the distance of three or four miles.

It is important this locality should be examined, on account of the possible development of coal in this vicinity and the extraordinary numbers of whales visiting this neighborhood. Portlock says that near the shore of Cape St. Hermogens the whales were visible in every direction, as far as the eye could see, in great numbers, (August 18, 1786.) Moreover, these narrow straits may be available for the passage of small vessels and steamers when the tide rips are dangerous in the main straits.

COOK'S INLET.

The entrance to this great arm of the sea lies between Cape Elizabeth on the east and Cape Douglas on the west which lies south 71° west forty-seven miles distant from the former. The entrance is broken by the northern islet of the Kadiak group, of which the northern extremity is named Point Banks; and nearly midway between this point and Cape Elizabeth lie the Barren Islands, in two principal groups, the extreme eastern and western points of both being thirteen miles apart, in a general east by north and west by south direction, and bounded by latitudes 58° 53′ and 58° 59′ and longitudes 151° 53′ and 152° 19′, with a channel three miles wide between the groups, and supposed by Portlock to have a great depth of water.

The Barren Islands are very high and totally barren, and the vicinity reported by Portlock to be full of whales in vast numbers. Dixon says that near St. Hermogens their blowing looked like breakers on an extensive reef of rocks.

From Cape Elizabeth to the eastern of the Barren Islands, called Amatuli, the course is south 17° west, and the distance ten and a half miles. This strait is called the eastern passage and has bold shores and a depth of ninety-five fathoms over coarse sand in mid-channel. The currents rush through here with great velocity, and, for an hour, at certain changes in the tides occasion great rips, which Tebenkoff magnifies into something very alarming; but we cannot find evidences of their exceedingly dangerous character elsewhere. Portlock says that in passing from the Barren Islands for Cape Bede (northeast of Cape Elizabeth) he passed several strong ripplings of a tide. Tebenkoff says: "The tide rips, however dangerous, do not extend across the whole entrance, but are experienced for about an hour, in the middle.

"The sea suddenly rises and boils with a tremendous noise, and forms high, short, and irregular waves, which topple with all their volume over the vessel that happens to be among them; even during a strong, fair wind the lower sails flap against the mast, while the upper ones are perfectly filled; the vessel refuses to obey the helm, and the hatches must be battened down."

CAPE DOUGLAS.

The formation of this cape is sand and rock, and is a low sandy point stretching westward five miles into the sea from the base of very lofty mountains wrapped in snow, which, as late as May, covers the surface of the low margin of shore to the water's edge. Tebenkoff gives a view of the cape, wherein it appears moderately low and rocky, and without wood, but no signs of it being sandy.

The south side of the cape has soundings laid down in six, eight, nine, and eleven fathoms, with two reefs of rocks lying, respectively, seven and eleven miles to the south and the south-southwest, with passages between them and the shore, off which they lie about three and one miles, respectively. On the north shore three miles from the point of the cape is Dry Bay, an indentation with a broad shoal just inside its heads, which are one mile apart. Southwest from the cape, about sixteen miles, and seven miles inside the nearest shore, Tebenkoff lays the "Four Peaked Mountain." Seven or eight miles north, 39° west from the cape, lies a very low, flat island, four or five miles long, in a north and south direction, and about a mile wide; off its north end, Tebenkoff lays down sunken rocks for a mile and called it Kamishak. Vancouver named it Shaw's Island. The geographical position of Cape Douglas is latitude 58° 53′, and longitude 153° 16′; from it Cape Elizabeth bears north 71° east, distant forty-seven miles; the western point of the Barren Islands, east thirty miles; and Point Banks south 65° east, thirty-two miles; and the eastern side of the island of Augustine north 9° west, distant twenty-eight miles.

POINT BANKS.

We can find no description of this northernmost point of the Kadiak group, which form the eastern shore of Chelekoff Straits. The point lies south 65° east, thirty-two miles from Cape Douglas.

COOK'S INLET.

The general direction of this great arm of the sea is north-northeast, and its length one hundred and sixty miles. Within the Capes Douglas and Elizabeth it expands to sixty-five miles in width; in fifty-five miles from the entrance it contracts suddenly to twenty-five miles, whence it gradually diminishes to twelve or fifteen, with the channel contracted by several extensive flats off the rivers emptying into it. Its extreme northern point is in latitude 61° 16′, at the mouth of the Suchitna River coming from the north, and "abounding in slate."

Cook's Inlet is the great boast of the Russian navigators and authorities as the best part of Alaska, and has been favorably noticed by nearly all the old discoverers. The well-known existence of coal upon its shores and in its bays may make it a very valuable acquisition to the Pacific Coast. The eastern shore of Cook's Inlet, after passing Tchugatchek Bay, is undulating, and this characteristic extends fifteen miles inland to the base of the mountains. It has a pleasant, green appearance in summer, covered with herbage and dotted with patches and clumps of timber. But the character of the soil is marsh and peat. The same sphagnum covers it that is found throughout the Alexander Archipelago, Kadiak and Unalaska. Eastward of this comparatively low ground rises the mountain range that extends through the length of the Kenai Peninsula, and filled with glaciers on both flanks. The western shores have a narrow border of low wooded land at the foot of the Alaska Mountains. Westward of Mt. Augustine Island the shores appear the margin of "an extensive low country lying before the base of these rugged mountains." (Vancouver.) Northward of this island the shores are "indented and broken into coves and small bays that appear capable of affording anchorage." "The points of the entrance of these bays are in general steep and rocky, behind which rises a compact mountainous country to a considerable height, clad in perpetual snow. A narrow flat margin along the shore is tolerably well wooded." Twenty miles northwest by west from the northeast point of Augustine, is a small bay opening to the southeast, with a small islet on the south side of the mouth. At the head of this bay is a factory of the Russian-American Company, from which a trail leads about seven miles through a gap in the mountains, to a series of small lakes discharging within a distance of fifteen miles into the great lake of Illiamna, which empties through the Kvichak River into Bristol Bay, on the northwest side of the peninsula of Alaska.

The great volcanic peaks of Illiamna and Redoubt, rising to 12,066 and 11,270 feet elevation, respectively, (see views in Tebenkoff chart,) lie in the range of compact, connected and very high mountains binding the western shores of the inlet, but throughout these waters the shores are well wooded, and north of the Redoubt the mountains retreat well to the northwest.

Twenty-eight miles northwest of Cape Douglas is the eastern point of Mt. Augustine Island, about eight miles in diameter and nearly round. Between it and the shores to the south-southwest, sixteen miles distant, lies the Bay of Kamichak, with soundings from seven to thirteen fathoms on a line directly across it from north and south, and passing tangent to the west side of the island.

MOUNT AUGUSTINE ISLAND.

This forms a very remarkable island, rising with a uniform ascent from the shores to its lofty summit, which is nearly perpendicular over the center of the island, inclining, however, a little to the eastern side. Towards the south side the shore is very low, from whence it rises with a regular but steep ascent and forms a lofty, uniform, conical mountain, presenting nearly the same appearance from every point of view, and clothed down to the water's edge with snow and ice, (May, 1794,) through which neither tree nor shrub protrude. Great fragments of rock line its northeast, north, and northwest shores, which are steep and rugged. The natives say these rocks are borne there and deposited by the great masses of ice driving out of the inlet when it breaks up, and they affirm to noticing the increase within not remote times.

The width of the passage between the western side of the island and the nearest jutting, rocky point of the mainland to the west-northwest is six miles, through which Vancouver's boats passed half a league west of the island in seven, five, and nine fathoms, and anchored on the northwest side in twelve fathoms, over muddy bottom.

The shores of this bay, named Bourdien's Bay by Vancouver, as well as the shores of the whole inlet, have been closely examined and well delineated by the officers of the Russian-American Company.

In the mid-channel of Cook's Inlet, before reaching the great contraction of the bay abreast of Anchor Point, in latitude 59° 51′, the depth of water is thirty-three fathoms, and decreases very regularly to ten fathoms at the head, in 61° 06′, where the approximate rise and fall in spring tides is twenty-seven feet.

The extremity of the peninsula of Kenai, for the last fifty miles towards Cape Elizabeth, is only twenty miles wide, owing to a long arm of the inlet, called Tchugatchek Bay, making in the southwest point and nearly parallel with the peninsula. The southwest and northwest shores of the extremity of the peninsula are indented by several good harbors, now assuming importance on account of the deposit of coal well known to exist there, and of others previously known only to the Russian authorities, and on this expedition communicated to the Coast Survey with manuscript maps.

PORT CHATHAM.

This is the first bay inside of Cook's Inlet on the shores of the Kenai Peninsula, and the southern points of its entrance may be said to be formed by Cape Elizabeth. Vancouver gives a plan of it which has been copied by Tebenkoff.

From that cape, marked by a small islet off it, the southwest point of the inner entrance to the harbor bears north 45° east, distant five and a half miles, and half a mile before reaching that point there is a rocky patch marked by an islet. Inside the entrance the harbor extends about ten miles east, and has an average width of one mile. The passage into it after leaving Cape Elizabeth is free from all obstructions but such as are sufficiently conspicuous or easily avoided. These consist principally of shoals that extend a little distance from each point of the harbor. Even between the islet and rocky patch southwest from the south point of the entrance, a passage exists that has from seven to twelve fathoms of water.

The soundings in general in Port Chatham are tolerably regular from five to twenty-five fathoms; the bottom a stiff clay. The shores are in most places a low border, very well wooded with spruce and some shrubs. This border forms a narrow margin between the shore and the foot of the mountain, up which to a certain height trees and plants grow; but the tops of the mountains are covered with snow. (May, 1794.) The anchorage on the south shore is one and a half mile inside the point, in latitude 59° 14′. The rise and fall of the tides near the changes of the moon is fourteen feet, and neaps about eleven feet, but they are greatly influenced by the force and direction of the winds.

Vancouver considers this harbor, with reference to its proximity to the ocean, ease of access, egress, and convenient communication with the shores, superior to any in these regions. But he never examined Tchugatchek Bay, where the currents are not so uncertain and variable, where the bay is four or five miles wide, and especially where bright clear weather exists while the whole of the Cape Elizabeth region is in fog and drizzle. Russian and American captains give the preference to the northern bays.

GRAHAM HARBOR.

Eleven miles north 27° west from Cape Elizabeth is the long, rounding, low, wooded point named Point Bede, guarded by some rocks. Off this point the ebb current sets from the north by compass, at the rate of two knots per hour; the flood sets from the south, and runs nearly at the same rate; the rise and fall of the tide is reported at fourteen feet.

For five miles beyond Point Bede the shore runs about northeast by east to the south point of the Graham harbor of Portlock, (the English harbor of the Russians.)

Through the kindness of the Russian officers we are enabled to forward you a tracing of a manuscript chart of this bay, with rocks laid down that have been very recently discovered. This harbor is the one where coal was first discovered on this coast by Portlock, and the anchorage close under the north point was named by him Coal Bay. He gives a sketch of the harbor and a view exhibiting the locality of the coal seams.

The entrance to the harbor is formed by Dangerous Cape on the north and Russian Point on the south, the former lying north 18° east, two and a quarter miles from the Alexander settlement on the latter. A rocky reef extends one mile northwest from Dangerous Cape, and detached rocks with intervening deep passages stretch out three-quarters of a mile southwest from the same cape.

There is a Russian station and an Aleutian village on Russian Point, and a "pleasant piece of land about two hundred yards wide stretches southward and westward of this point for one mile, bordered by a good sandy beach on one side, and on the inside by a small lake of fresh water, which empties itself into the sea" three-quarters of a mile from the station. This lake or lagoon is one of a chain of lakes reaching well inland. This "beach terminates at each end in high points of land, which form a snug bay where small craft might lie with safety." From Russian Point an extensive shoal makes broad off the shores of the above beach for one mile, with part of it, just under the point, bare at half tide.

The general direction of the bay is south 62° east for four and a half miles; then south-southeast for two miles, ending, however, in very extensive mud flats, receiving several small streams, which Portlock entered with his boat at high water. These streams were filled with salmon, which the bears came down to feed upon.

One mile within the entrance, and nearly in the middle of the bay, lies Passage Island, about half a mile long in the direction of the bay, and a quarter of a mile broad. Abreast of the inner point of this island the harbor contracts to one mile in width, maintaining that width for the next three miles.

From the southwestern point of Passage Island a long reef extends over a mile west-southwest, nearly across the south channel to Russian Point, off which a very narrow passage exists, and Portlock says he examined it and found plenty of water.

The passage on the north side of the island is the better one, with rocks off each point for a couple of hundred yards, but leaving a channel of five hundred yards wide, with seventeen fathoms of water over a muddy bottom.

In entering this bay by the north channel Portlock says he found a "strong outset current, although the tide was flood," and upon leaving it "with the flood tide was carried out very rapidly by currents to the northward past Dangerous Cape."

Three-quarters of a mile inside the northeast point, abreast of the east end of Passage Island, a number of sunken rocks stretch across the harbor about half way. The Russian sketch exhibits one rock in this ledge above water, and three and five fathoms over the rest. It will be well to pass a quarter of a mile east of Passage Island to clear a sand tongue making out from it, and then haul southward for the southern shore towards a house on the beach.

Safe anchorage may be had anywhere in the harbor, and towards the head in ten fathoms water, where the bottom is muddy.

Close under Dangerous Cape is Coal Bay, a small anchorage of less than half a mile in extent, with soundings from twelve to five fathoms over fine black sand. To enter this cove and clear the reef off the cape, run for Passage Island until the cape bears north by east one half east (true) about one mile distant, and steer north 30° east (true) towards the middle of the cove. It will not be safe to bring the cape anything to the north of the first course, as a rock with one and a half fathom at low water lies north 50° west, one mile from the north point of Passage Island. A village is located on the small stream in the southeast part of the cove.

A second cove, twice as large as Coal Bay, lies one mile south-southeast from the latter, with good anchorages in ten to fifteen fathoms of water. The northern shores of this cove, which is about three-quarters of a mile wide, are bold and rocky, and guarded by rocks, but at the head of it there is a fine smooth beach, near which is a run of good water. Another opening, close under the point at the south, is the entrance to a salt-water lagoon or lake, called Selenic Lake. Here Portlock reports wood of different kinds in great abundance, such as pine, (spruce,) black birch, witch hazel, and poplar. Many of the pines are large enough for lower masts of vessels of four hundred tons, and in every place were plants and shrubs of many varieties growing with great strength and vigor.

The latitude of the village in Cove Bay is given by Captain Archimandritoff as 59° 24′, and the longitude 151° 49′ 33″, the latter depending upon that of Sitka. At the Alexander port the latitude is 59° 21′ 50″, longitude 151° 52′ 15″. The variation of the compass is stated to have been thirty degrees east in 1848.

From the entrance to Graham Harbor the direction to Anchor Point is north, and the distance twenty-seven miles, forming the broad gulf to the mouth of Tchugatchek Bay. The general direction of the coast line from Graham Harbor to the head of this bay is north 50° east, and distance thirty-nine miles, this course being very nearly that of the south shore of the gulf and bay.

Six and a half miles northeast by east of Dangerous Cape is the opening of a small bay with shallow water, but anchorage is had close under the western point in four or five fathoms. According to Tebenkoff's chart, there is six fathoms in the entrance of the bay, which is about three miles long, north and south, and two-thirds of a mile wide. Rocks are laid down on the manuscript map close to each point, which are represented as bold and rocky. The points lie northeast and southwest of each other.

Three miles east-northeast of the eastern point of the latter bay is a bold, rocky point, forming the southwestern point of the entrance to a broad bay full of islands, with a long arm penetrating some miles to the southeast, but unexplored. Twenty-five fathoms are noted in the entrance, and anchorages designated close under the western point.

TCHUGATCHEK BAY.

Nineteen or twenty miles north 54° east from the reef off Dangerous Cape is the north point of the entrance to Tchugatchek Bay. This point is low, three miles long, and over half a mile wide, stretching from the north shore half way across the entrance. In approaching this point the manuscript map obtained from the Russian officers locates two sunken rocks that are almost in the middle of the approaches to the bay. The first one bears south 66° west, five and a half miles from the extremity of Entrance Point, and the second south 59° west, distant two and three-quarter miles from the same. Tebenkoff does not give them on his chart. Close off the point ten and fifteen fathoms are given, and twenty-seven in the middle of the entrance.

From this point the bay has a general direction north 47° east for nineteen miles to the head, but the last four miles are occupied by a broad flat, with an island in it, although Tebenkoff gives four fathoms around this island. This flat carries a broad margin along the whole northwestern shore, even to Entrance Point. Along the inside of this tongue (Entrance Point) the beach or flat extends nearly half way to the point, contracting the anchorage bay, but still leaving it about one and three-quarters of a mile in extent, with seven fathoms of water. Upon this tongue, abreast of the broad beach or flat, is a long, narrow lagoon. Outside of the point, to the northward, is a broad beach for some miles to the northwest. Inside this tongue of land, and abreast the anchorage, there is found an extensive coal seam, seven feet thick, and not yet worked by the company, because it opens upon the beach at low tide, and will require outlay of capital to develop and work it. This, or similar seams, crops out on the shore between the bay and Anchor Point in two places for an extent of several miles.

From Entrance Point three miles south 75° east there is an islet joined to the southern shore by a low sand tongue; this decreases the actual width of the entrance of the bay. East of that islet are two or three coves, but no soundings are given for them, except at the entrance of the second, where twenty-seven fathoms is laid down in the approaches.

The geographical position of the extremity of Entrance Point is latitude 59° 37′ 10″, and longitude 151° 22′ 10″.

From Entrance Point the coast runs nearly straight for twenty-one miles north 50° west to Anchor Point, in latitude 59° 51′, longitude 151° 53′.

The climate of this bay is much preferable to that at Graham Harbor. Navigators report that they have anchored here, and had clear, beautiful weather, while they could see the thick, heavy masses of fog and rain clouds along the mouth of the inlet in the vicinity of Cape Elizabeth. In winter it is, however, very cold, and in excessively cold winters the whole inlet freezes nearly or quite as far south as Anchor Point.

The Coast Survey has been furnished with a manuscript chart of the coast, including Tchugatchek Bay, from Russian Point to Anchor Point.

This subject is brought to an abrupt termination at this date, (December 27,) because it is necessary to close at some point, as the description of the whole coast hence to the Arctic Ocean, including the Aleutian Islands, &c., will require several hundred pages, and demand the searching of all the old and recent navigators for the details of headlands, bays, &c., scattered through their narratives. Such materials are very valuable, but inaccessible to the navigator, the whaler, and the fisherman, yet should be gathered by the Coast Survey, especially as it would require years of examination in such a climate, and with such short working seasons, to aggregate a thorough descriptive memoir of the coast. Most of the descriptions are meager and indefinite, but they could remain until supplanted by the minute accuracy of the survey as the work progresses, just as the compiled charts will gradually yield to our exact determinations.

There is yet a large amount of interesting information to communicate during the reduction of observations for the determination of geographical positions, upon the probability of islands in the Gulf of Alaska and adjacent waters, currents, &c. It will, however, require much time and study to place it in proper shape, but will be communicated as early as practicable. It may, however, be mentioned here that during the voyage home the places were ascertained where the vessels engaged in cod-fishing principally fish. The waters between Alaska Peninsula and the Shumagin Islands are well protected from the heavy swell of the Pacific, and the San Francisco vessels have generally resorted there, and it is their practice on Saturday nights to run for Coal Harbor, on the north end of Unga Island, and remain there over Sunday night, when they again start for a week's fishing.

The proposed plan of operations for the Coast Survey work demanded on the coast of the new territory, where new means and methods must be devised to insure progress with the necessary precision of the Coast Survey, has not been incorporated with this report, because, upon reflection, it is deemed advisable to develop it in a separate communication in detail, that would have little interest outside the organization of the work.

Very respectfully and truly, yours,

GEORGE DAVIDSON,
Assistant United States Coast Survey.

Professor BENJAMIN PEIRCE,
Superintendent United States Coast Survey, Washington, D. C.

APPENDIX A.

The following list of the geographical positions of four hundred and twenty-four places, principally upon the coast of Alaska, has been compiled chiefly from Russian authorities. In its preparation the intention was to introduce all determinations of position that appeared to have been made by actual observation, even when the localities are quite close. In the archipelago Alexander most of Vancouver's latitudes have been introduced, although in such waters they are not of great practical value.

It is believed the latitudes are generally within two miles of the actual position; and in many cases where several observers had determined them independently, the errors may be less than a mile. The longitudes of harbors regularly visited by vessels of the Russian-American Company appear to be fairly determined, except toward the western termination of the Atlantic chain, where large discrepancies, reaching 30′ of arc, are exhibited by the comparison of results between Russian authorities and the United States exploring expedition to the North Pacific in 1855.

Positions by different authorities are given in some instances to show these discrepancies.

The comparison of the latitudes and longitudes at Victoria, Fort Simpson, Sitka, Chilkaht, Kadiak, and Unalaska, between English and Russian and the United States Coast Survey determinations, exhibits larger errors than might have been expected.

The uncertainties that exist in the geographical positions of many islands, headlands, straits, and reefs; the great dissimilarity of outline and extent of recent examinations of some of the Western Aleutians; their want of reliable data concerning the tides, currents, and winds; the almost total want of detailed descriptions of headlands, reefs, bays, straits, &c.; and the circumstantial testimony of the Aleutian fishermen concerning islands visited by them and not laid down upon the charts, point to the great necessity for an exhaustive geographical reconnaissance of the coast, as was done for the coast of the United States between Mexico and British Columbia.

List of geographical positions.

Name of place.	Latitude.	Longitude.	Authority.
	° ′ ″	° ′ ″	
San Francisco, *California*	37 47 52.8	122 23 19	United States Coast Survey.
Victoria, Vancouver Island	48 25 30.3	123 20 05	United States Coast Survey.
Bellabella, Fitshugh Sound, B. C		128 07 50	United States Coast Survey.
Fort Simpson, Kygáne Strait, B. C	*54 33.7	130 23 46	United States Coast Survey.
Rose Point, Kygáne Strait, B. C	54 12.0	131 23.0	Chroutschoff.
Northwest Point, Lazara Island, Kygáne Strait, B. C	54 20.0	133 09.0	Chroutschoff.
ALASKA.			
ALEXANDER ARCHIPELAGO.			
Entrance to Portland Canal	54 2.0	130 25	Vancouver, Tebenkoff's Atlas.
Head of Portland Canal	55 45	130 02	Vancouver, Tebenkoff's Atlas.
Village in Tchesonsity Harbor	54 46	130 35	Vancouver, Tebenkoff's Atlas.
Devil's Bank, Kygáne Strait	54 39.0	131 34	Chroutschoff.
Cape Chacon, Kygáne Strait	54 42.0	131 53.0	Chroutschoff.
Point Nunez, Kygâne Strait	54 42.0	132 06	Admiralty Chart No. 2431.
Cape Kygáne or Muzon	54 42.0	132 39.0	Chroutschoff.
Anchorage in the middle one of the Kygáne harbors	54 46	132 45.5	Etolin.
CLARENCE SOUND AND ITS ARMS.			
Gardner Harbor	54 49	131 45	Tebenkoff's Atlas.
Tchitchagoff Bay	55 01	131 45	Tebenkoff's Atlas.
Anchorage Tangas Harbor	55 03	131 25	Etolin.
Kazarn Bay	55 24	132 00	Etolin.
North entrance to Tangas Narrows	55 26	132 42	Tebenkoff's Atlas.
Cape Caamano	55 29	131 51	Vancouver, Tebenkoff's Atlas.
Port Stewart, South Point	55 38.2	131 45	Vancouver, Tebenkoff's Atlas.
Entrance to Red Bay	56 19	133 07	Admiralty Chart No. 2431.
Etolin Harbor, Wrangel Island	56 31.5	132 20	Zarelbo.
Southeast point entrance to Stakeen River	56 40	132 20	Admiralty Chart No. 2431.
Port Protection, southwest point	56 19.2	133 32	Vancouver, Tebenkoff's Atlas.
CHATHAM STRAIT, FREDERICK SOUND, ICY STRAIT, AND THEIR ARMS.			
Cape Decision, Kou Island	56 02	134 58	Vancouver, Tebenkoff's Atlas.
Cape Ommaney, Baranoff Island	56 10.5	134 28.5	Vancouver, Tebenkoff's Atlas.
Port Malmesbury, north point, (Point Harris,) Kou Island	56 17.5	134 07	Vancouver, Tebenkoff's Atlas.
Port Conclusion, southeast point Baranoff Island	56 16.0	134 27	Vancouver, Tebenkoff's Atlas.
Point Ellis, Kou Island	56 31	134 14.7	Vancouver, Admiralty Chart No. 2431.
Point Sullivan, Kou Island	56 38	134 16.5	Vancouver, Admiralty Chart No. 2431.
Point Gardner, south end of Admiralty Island	57 01	134 27	Vancouver, Tebenkoff's Atlas.
Skalitch Point, southeast point of entrance to Peril Strait, Barnoff Island	57 24	134 47	Manuscript Russian Map, Tebenkoff's Atlas.
Point Parker, Admiralty Island	57 37	134 40	Vancouver, Tebenkoff's Atlas.
Point Augusta, southeast point of entrance to Icy Strait, Tchitchagoff Island	58 03.5	135 00	Vancouver, Tebenkoff's Atlas.
Point Converden, northeast point of entrance to Icy Strait	58 12	135 03	Vancouver, Tebenkoff's Atlas.
Point Retreat, northwest point Barlowe Cove, Admiralty Island	58 24	134 59	Vancouver, Tebenkoff's Atlas.
Point Whidbey	58 35	135 13	Vancouver, Tebenkoff's Atlas.
Point St. Mary, north point of Berner Bay	58 43.5	135 02	Vancouver, Tebenkoff's Atlas.
Small Island	58 54	135 22.5	Vancouver, Tebenkoff's Atlas.
United States Coast Survey astronomical station on Sandy Island, mouth of Chilkaht River	59 11 45	135 24 10	United States Coast Survey.
Point Macartney, Kuprianoff Island	57 01.5	133 56	Vancouver, Admiralty Chart No. 2431.
Burnt Point, west side of entrance to Pereresnaya Bay, Kuprianoff Island	57 03.3	133 10	Manuscript Russian Chart.
Point Napean, Admiralty Island	57 10	134 02	Vancouver, Tebenkoff's Atlas.
Cape Fanshaw	57 11	133 25	Vancouver, Admiralty Chart No. 2431.
Islet off Point Pybus, on Admiralty Island	57 18	133 47	Vancouver, Admiralty Chart No. 2431.
Point Windshaw	57 31	133 29	Vancouver, Tebenkoff's Atlas.
Point Styleman, north point of Port Snettisham	57 53	133 42	Vancouver, Tebenkoff's Atlas.
Point Salisbury, west side of entrance to Takou Arm	58 11	134 05.5	Vancouver, Tebenkoff's Atlas.
Mouth of Takou River	58 27	133 54	Tebenkoff's Atlas.
East point of Spaskaii Harbor, Icy Strait	58 06	135 06	Manuscript Chart, Tebenkoff's Atlas.

* Latitude from Admiralty Chart No. 2426.

List of geographical positions—Continued.

Name of place.	Latitude.	Longitude.	Authority.
	° ′ ″	° ′ ″	
Anchorage, Port Frederick, Icy Strait	58 10	135 28	Tebenkoff's Atlas.
Point Adolphus, Icy Strait	58 18	135 41	Vancouver, Tebenkoff's Atlas.
Anchorage Port Althorp, Icy Strait	58 12.0	136 12	Vancouver, Tebenkoff's Atlas.
PACIFIC COAST.			
ALEXANDER ARCHIPELAGO.			
Cape Kygáne, or Muzon	54 42.0	132 39.0	Chroutschoff.
Port Zarelbo, South Cape	54 48.0	132 54.0	Meares, Zarelbo.
Forrester Island, South Point	54 48	133 29	Vancouver, Tebenkoff's Atlas.
Wolf Rock	55 01.6	133 24	Vancouver, Tebenkoff's Atlas.
Cape San Bartolomo	55 12	133 33	La Pérouse, Tebenkoff's Atlas.
West Point, Dolores Bay, Bucarelli Sound	55 18	133 24	La Pérouse, Tebenkoff's Atlas.
Cape Addington, or Adamson	55 27	133 45	Meares, Tebenkoff's Atlas.
Coronation Island, west point	55 55	134 10	Tebenkoff's Atlas.
Hazy Islands	55 55	134 25	Dixon, Tebenkoff's Atlas.
Cape Decision	56 02	134 58	Vancouver, Tebenkoff's Atlas.
Cape Ommaney	56 10.5	134 28.5	Vancouver, Tebenkoff's Atlas.
Red Cape	56 20	134 49	Tebenkoff's Atlas.
Point Lander, south point of Port Banks, or Whale Bay	56 33	134 58	Dixon, Benzeman.
Point Woodhouse, Biorka Island, Sitka Sound	56 53.0	135 29.2	Vasilieff.
Cape Edgecumbe, Sitka Sound	57 00.4	135 46.0	Vasilieff.
Mount Edgecumbe, 2,855 feet high, extinct volcano, Sitka Sound	57 02.8	135 40.1	Vasilieff.
United States Coast Survey astronomical station, Sitka*	57 02 52	135 17 05	United States Coast Survey.
Cross on Greek Church, Sitka	57 02 52	135 16 59	United States Coast Survey.
Cupola of governor's house and light-house, Sitka	57 02 47	135 17 08	United States Coast Survey.
Mount Verstova, east-northeast of Sitka, 3,381 feet high	57 03 23	135 12 57	United States Coast Survey.
Lincoln Harbor, Noquashinski Bay	....	135 25 56	United States Coast Survey.
Cape Georgiana, south point of Salisbury Sound	57 17.5	135 45.6	Portlock, Tebenkoff's Atlas.
Cape Edward	57 39.0	136 15.0	Vasilieff.
Portlock harbor, (approximately)	57 45	136 12	Portlock, Tebenkoff's Atlas.
South Point of Ilina Bay	57 46	136 16	Ilina.
Point Bingham, south point of Icy Strait, or Cross Sound	58 03.5	136 27	Vancouver, Tebenkoff's Atlas.
Port Althorp anchorage, Cross Sound	58 12.0	136 12	Vancouver, Tebenkoff's Atlas.
Cape Spencer, north point of Icy Strait	58 12.5	136 12	Vancouver, Tebenkoff's Atlas.
Ltuya Bay, or French Port, south point	58 34.5	137 16	La Pérouse, Lipinski.
Ltuya Mount, or Mount Crillon	58 48.5	137 11.5	La Pérouse, Lipinski.
Cape Fairweather	58 50.2	137 48.0	Vancouver, Lipinski.
Mount Fairweather, 13,864, 13,946, 14,708 feet	58 57.0	137 27.0	Vancouver, Lipinski.
Cape Phipps, south point of Yakutat or Behring Bay	59 33.0	139 42.0	Vancouver, Lipinski.
Cape Turner, Khantaak Island, Behring Bay	59 33.0	139 35.0	Vancouver, Lipinski.
Elenora Harbor, Behring Bay	59 43.0	139 21.0	Malespina, Tebenkoff's Atlas.
Point Latouche, entrance to Disenchantment Bay, Behring Bay	59 51	139 25.5	Vancouver, Tebenkoff's Atlas.
Point Manby, western point of Behring Bay	59 43	140 06.0	Tebenkoff's Atlas.
Cape Riou, east point of Icy Bay	59 53	141 14	Vancouver, Tebenkoff's Atlas.
Mount St. Elias, 14,970, 16,938, 17,854 feet high	60 22.6	140 54.0	Vancouver, Tebenkoff's Atlas.
Pamplona Reef	59 03	142 39	Position very uncertain.
Cape Yaktaga	59 58	142 12	Tebenkoff's Atlas.
Laeda Reef	59 58	143 43	Tebenkoff's Atlas.
Cape Suckling, eastern part	59 59	144 11	Vancouver, Tebenkoff's Atlas.
Cape Hammond, or St. Elias, south end Kayak Island	59 49	144 53	Vancouver, Tebenkoff's Atlas.
North Point, Wingham Island	60 05.5	144 57	Vancouver, Tebenkoff's Atlas.
Sea-otter Banks	59 44	145 57	Lindenberg.
North Point, Otchek or Middleton Island	59 30	146 30	Netzeroff.
Eastern mouth of Copper or Atna River	60 17	145 57	Tebenkoff's Atlas.
Alaganik Village, Copper River	60 41.3	145 49	Serebrianskoff.
Western mouth of Copper River	60 30	145 54	Serebrianskoff.
Cape Hinchinbrook	60 16	146 47	Vancouver, Tebenkoff's Atlas.
Fort Constantine, Port Etches	60 20 18	146 52 50	Chornoff, Belcher.
Cape Cleare, south point Montague Island	59 46	148 01	Vancouver, Tebenkoff's Atlas.
McLeod's Harbor, Montague Island	59 58	147 54	Vancouver, Tebenkoff's Atlas.
North point of Chalmer's Harbor, Montague Island	60 16	147 22	Vancouver, Tebenkoff's Atlas.
Cape Resurrection	59 51.5	149 13.4	Archimandritoff.
Seal Rocks, south of Chiswell Islands	59 34	149 32	Tebenkoff's Atlas.
Pye Islands, southernmost	59 20	150 28	Tebenkoff's Atlas.
Tchugatz Island, south point of the eastern one	59 06	151 25	Vancouver, Tebenkoff's Atlas.

* Magnetic declination observed August 7, 1867 = 28° 50.8 east.

List of geographical positions—Continued.

Name of place.	Latitude.	Longitude.	Authority.
COOK'S INLET.	° ′ ″	° ′ ″	
Cape Elizabeth	59 09	151 51	Vancouver, Tebenkoff's Atlas.
Anchorage in Port Chatham	59 13.5	151 42	Vancouver, Tebenkoff's Atlas.
Point Bede	59 19.5	151 58.6	Archimandritoff.
Village in Coal Bay, Graham Harbor	59 24.0	151 49.5	Archimandritoff.
Coal Point, Tchugatchek Bay	59 37.2	151 22.6	Archimandritoff Manuscript Chart.
Anchor Point	59 50.9	151 52.8	Chernoff and others.
Fort St. Nicolas, Kakny River	60 32.2	151 19.3	Heldt.
East Foreland	60 43.0	151 27.3	Vancouver, Malachoff.
Point Possession	61 03.5	150 25.5	Vancouver, Malachoff.
Islet near Turnagain Arm	60 57.7	150 01.6	Vancouver, Tebenkoff's Atlas.
Point Worouzow, entrance to Kneep River	61 08.0	150 07.5	Vancouver, Tebenkoff's Atlas.
Turnagain Island, west point	61 08.0	150 15	Vancouver, Tebenkoff's Atlas.
West point Suchitna River	61 16.5	150 39	Tebenkoff's Atlas.
North Foreland	61 04.0	151 07.5	Vancouver, Tebenkoff's Atlas.
West Foreland	60 44.0	151 45.9	Tebenkoff.
Northwest point Kalghin Island	60 33.0	151 57.0	Tebenkoff.
Redoubt Volcano, 11,270 feet, (snow-covered)	60 28.0	152 38.0	Tebenkoff.
Illamna Volcano, 12,066 feet, (snow-covered)	60 05.6	153 07.5	Tebenkoff.
Illamna Village, portage to Illamna Lake and Bristol Bay	59 42.0	154 11.0	Ustiugoff.
Mount San Augustine, on Blackbrown Island	59 22.0	153 30	Vancouver, Tebenkoff's Atlas.
Cape Douglas	58 52.5	153 16	Vancouver, Vasilieff.
Portlock Bank, 80 fathoms, 120 miles north 73° east from St. Paul	58 22	148 44	United States Coast Survey.
KADIAK ARCHIPELAGO, AND PETRIES OR CHELEKOFF STRAIT.			
East point of Amatuli Island, Barren Islands	58 57.6	151 53.0	Benzeman and others.
Southwest point of Ugatchtu Island, Barren Islands	58 54.0	152 19 7	Benzeman and others.
Point Banks, north end of Portage Island	58 39.5	152 19.5	Benzeman and others.
Sea-otter Island	58 32.0	152 13.5	Vasilieff.
North Point of Afognak Island	58 29.5	152 31.5	Vasilieff.
Afognak Rocks	58 21.6	151 49.9	Benzeman.
South point St. Hermogenes Island	58 09.5	151 52	Vancouver, Benzeman.
Pillar Point	58 08.6	152 04.8	Benzeman.
Cape Ijoot, (Pentacost)	58 06.3	152 17.0	Murashat.
Rubetz Village, Marmot Bay	58 01.3	152 41.0	Archimandritoff.
Northeast point Ketoy Island, Northern Strait	57 59.5	152 39.0	Benzeman.
Chiniak Point Reef, west entrance Narrow Strait	57 55.8	152 31.0	Archimandritoff.
Southeast point Spruce Island	57 53.0	152 20.0	Archimandritoff.
Vasilieff or Williams Bank	57 50.2	152 07.0	United States Coast Survey, (approximate.)
Spruce Point	57 49.6	152 16.1	United States Coast Survey.
United States Coast Survey Observatory, south point Chagavka Cove, St. Paul Harbor*	57 48 00	152 18 56	*United States Coast Survey.
Flagstaff, St. Paul Village	57 47 45	152 20 57	United States Coast Survey.
Pillar on Mount St. Paul, 1,001 feet high	57 47 38	152 21 59	United States Coast Survey.
North Peak of Devil's Mountains, 2½ miles northwest of St. Paul, 2,057 feet high	57 49 30	152 23 41	United States Coast Survey.
Ice depot on Wooded Island	57 46 57	152 18 37	United States Coast Survey.
Station near north end of Wooded Island	57 42 36	152 16 58	United States Coast Survey.
Chiniak Point, Chiniak Bay	57 37.2	152 07.0	Archimandritoff.
Cape Greville	57 34.5	152 04.9	Vancouver, Archimandritoff.
Low Cape	57 25.7	152 14.0	Archimandritoff.
Noisy Cape	57 23.5	152 30.0	Archimandritoff.
Ugak Island, southeast point	57 22.2	152 13.0	Archimandritoff.
Southwest cape of Kilionda Bay	57 14.3	152 50.6	Archimandritoff.
Cape Barnabas	57 10.0	152 48.0	Vancouver, Archimandritoff.
Harbor of Three Saints	57 06 08	153 25.5	Lisianski, Archimandritoff.
Misofski Cape	57 00.0	153 14.0	Archimandritoff.
Double Headed Point, Nazikak Island	56 53.6	153 34.2	Vancouver, Archimandritoff.
Chachkak Village	56 50.7	153 48.0	Archimandritoff.
East point of Geese Islands	56 45.8	153 48.0	Archimandritoff.
Cape Trinity, east point of Trinity Islands	56 35.3	153 53.0	Vancouver, Archimandritoff.
South Cape of Trinity Islands	56 24.0	154 42.0	Archimandritoff.
North Point of Ukamok or Chirikoff Island	55 54.9	155 24.0	Kashevaroff and Lindenberg.

* Observed magnetic declination = 26° 04.1, August 28, 1867.

List of geographical positions—Continued.

Name of place.	Latitude.	Longitude.	Authority.
	° ′ ″	° ′ ″	
Cape Tolstou, south point Chirikoff Island	55 45.6	155 28	Kashevaroff and Lindenberg.
Village in southwest cove of Chirikoff Island	55 48.0	155 34.0	Kashevaroff and Lindenberg.
Naigak Rock	55 50.0	155 38.0	Kashevaroff and Lindenberg.
South island of Simidin group	56 04.5	156 21.5	Tebenkoff's Atlas.
Agayak Island, northern of Simiden group	56 15.0	156 26.0	Kashevaroff and Lindenberg.
South point Kadiak Island	56 45.0	154 09.0	Archimandritoff.
Cape Alitak, west point of Alitak Bay	56 52.2	154 17.6	Archimandritoff.
Low Cape, Alitak Bay	56 59.0	154 28.0	Archimandritoff.
Cape Icolik	57 17.0	154 42.3	Archimandritoff.
Karlook Village, mouth of Karlook River	57 34.6	154 24.5	Archimandritoff.
Cape Uyak, southwest point of Uyak Bay	57 43.0	154 06.0	Archimandritoff.
Cape Kuliougmiout, northeast point of Uyak Bay	57 50.9	153 51.1	Archimandritoff.
Cape Ugat	57 53.8	153 38.7	Archimandritoff.
Cape Uganik, Northern Strait	57 58.9	153 12.0	Archimandritoff.
Raspberry Cape, Northern Strait	58 02.3	153 20.0	Benzeman.
Steep Cape, Afognak Island	58 12.6	153 04.9	Vasilieff.
Cape Paramonoff, Afognak Island	58 17.0	152 57.3	Vasilieff.
Black Cape, Afognak Island	58 25.0	152 45.0	Vasilieff.
SOUTHEAST SHORES OF ALASKA PENINSULA AND ISLANDS OFF IT.			
Petries or Chelekoff Strait.			
Southeast point Kaughpaulik Island	58 36	153 33	Tebenkoff's Atlas.
Village north side Kukak Bay	58 21	154 05	Tebenkoff's Atlas.
Cape Atutchagbik	58 04.7	154 19.7	Vasilieff and others.
Katmay Village, on Katmay River and Bay	58 02.6	154 52.8	Vasilieff and others.
Cape Kubugakchli	57 52.6	155 00.0	Vasilieff and others.
Mount Batscharaff	57 30.6	155 55.0	Vasilieff and others.
Olay Peak	57 26.0	156 10.0	Vasilieff and others.
Tchughiunayak Peak	57 05.0	156 35.0	Vasilieff and others.
Augnak Rock	56 54	156 21	Tebenkoff's Atlas.
Cape Kumliut	56 33.2	157 26.0	Vasilieff and others.
Sutkhum Village, Kudjulik Bay	56 31.9	157 28.0	Voronkoffski.
East point Amkulik Island	56 18.0	157 24	Tebenkoff's Atlas.
Tulioumniut Point	56 15.0	157 46.0	Kuritzin and others.
Itkhi Cape, east side of Kuioukta	55 58.0	158 27.0	Kuritzin and others.
Anchorage Kupreyanof	55 45.8	159 15	Voronkoffski.
Cape Ivanoff	55 33.0	159 30	Vasilieff and others.
West point of Korovenski Island	55 25.2	160 23.5	Kashevorofski and others.
Unga Harbor, house on west shore of bay, Unga Island	55 24	160 49.0	Tebenkoff's Atlas.
Village in Delaroff Bay, southeast point of Unga Island	55 10.8	160 27	Kashevorofski and others.
North point Tiagkhinak Island	54 55.0	159 13	Kashevorofski and others.
South point of Nuniak Island	54 39.0	159 31	Kashevorofski and others.
Chumagin Bank, 40 fathoms, coral and sand, 35 miles east of south point of Nuniak Island	54 38	158 30*	United States Coast Survey.
South point of Bird Island	54 46.5	159 40	Kashevorofski and others.
Mountain Cape, south end of Nagay Island	54 51.0	160 06	Kashevorofski and others.
Seal Point	55 20.0	161 09	Kuritzin and Garder.
Village Pavlof, in Pavlof Bay	55 29.7	161 31.5	Kuritzin and Garder.
Volcano Pavlof, west side of Pavlof Bay	55 26.0	161 49.0	Kuritzin and Garder.
Village Belkofski, south of Medvidnikof Bay	55 05.0	161 54.0	Kuritzin and Garder.
Amagat Island	54 52.4	162 50.0	Kashevorofski and others.
Cape Peter, west end Sannakh Island and Harbor	54 28	162 52	Pavlof.
Cape Pankoff, south point of Ukatok Island	54 38.5	162 58	Tebenkoff's Atlas.
Cape Khabutch, east point of south entrance to Isanotski Strait	54 48.5	163 12.0	Voronkoffski.
ALEUTIAN ISLANDS.			
UNIMAK ISLAND.			
Cape Isanotski, southwest point of entrance to Isanotski Strait	54 47.4	163 14.0	Voronkoffski.
Cape Lazaref, southeast point of island	54 35.5	163 30.2	Voronkoffski.
Cape Kitchnak, south point	54 20	164 33	Voronkoffski, Tebenkoff's Atlas.
Khitkhuk Cape, Unimak Strait	54 21.1	164 47.0	Voronkoffski, Tebenkoff's Atlas.
Western Head, Unimak Strait	54 30.0	165 01.5	Voronkoffski.
Cape Mordvinoff	54 47.0	164 38.7	Kuritzin.

* Approximate.

List of geographical positions—Continued.

Name of place.	Latitude.	Longitude.	Authority.
	° ′ ″	° ′ ″	
Red Creek Point, northwest point of entrance to Isanotski Strait	55 05.9	163 33.0	Kuritzin.
Chunoff Point, Isanotski Strait	55 02.0	163 24.5	Voronkoffski.
Volcano Shishaldin, 8,953 feet high, (snow-covered)	54 48.0	163 59.5	Kuritzin.
Volcano Devastation, 5,525 feet high, (snow-covered)	54 39.0	164 32.0	Kuritzin.
Cod Bank off Krinitzin Islands, south 35° east from Peak of Ukamok Islands, 50 fathoms gravel and sand	53 36	164 12	United States Coast Survey, (approximate.)
* Remarkable peak near northeast point of Ukamok Island, Unimak Strait	54 16.9	164 47.1	Beechey.
* East point of Ukamok, south side Strait of Unimak	54 12.0	164 45.0	Kuritzin.
North Cape of Akun Island, southwest point of Unimak Strait	54 16.5	165 34.0	Kuritzin.
Southeast Cape of Tigalda Island	54 03.5	164 57.0	Tebenkoff's Atlas.
Sigakh Cape, north end of Akutan Island	54 12.2	165 54.0	Kuritzin.
South Cape Akutan Island, north side Akutan Strait	54 01.5	165 59.2	Kuritzin, Tebenkoff's Atlas.
North Cape Unalga Island, south side Akutan Strait	53 58.6	166 03.0	Kuritzin.
UNALASKA GROUP.			
Ugalgan Island, southeast point Beaver Bay	53 52.3	166 00.0	Kuritzin, Tebenkoff's Atlas.
Entrance of Udagakh Strait, to Beaver Bay	53 42.5	166 07.5	Tebenkoff's Atlas.
Southern extremity of reef off Cape Kungitak	53 19	166 42	Kuritzin.
Entrance to Kilioulionk Bay	53 25.5	166 49	Saritcheff.
Southwest point of Unalaska	53 18.7	167 33.0	Kuritzin.
North Cape Chernofski Bay	53 26.0	167 17.5	Saritcheff.
Crown Cape, North point of Crown Bay	53 44.5	166 49.5	Tebenkoff's Atlas.
Loaf Cape	53 50.0	166 58.0	Kuritzin.
† Cascade on east side Cape Cheerful	53 58 58	166 32 47	United States Coast Survey.
Light-house site on north head of Amuknak Island	53 55 38	166 27 44	United States Coast Survey.
‡ United States Coast Survey astronomical station, Ulachta Harbor, Unalaska Bay	53 53 58	166 27 52	United States Coast Survey.
Cross on Greek Church, Illoolook Village, Unalaska Bay	53 52 39	166 29 06	United States Coast Survey.
Cape Kalekhta, 1,500 feet high, east point of Unalaska Bay	54 00.2	166 20 13	United States Coast Survey.
Volcano Makushin, 5,691 feet high	53 52.5	166 45	Tebenkoff's Atlas.
Volcanic Island Bogosloff, or Providence, about 1,000 feet high	53 52.0	167 39.0	Kuritzin.
UNIMAK ISLAND.			
Cape Tannakh, north point of the island	53 31.0	167 35.0	Kuritzin.
Tulikskaya Peak, near north end of island	53 23.0	167 46.0	Kuritzin.
Vseridoff Peak	53 14.0	168 09.0	Kuritzin.
Vseridoff Island, eastern point	53 00.3	168 06	Kuritzin.
Cape Sagakh, southwest point of Umnak	52 45.5	168 49.0	Kuritzin.
South point of Samalga Island	52 41.0	168 57.0	Kuritzin.
ISLANDS OF THE FOUR VOLCANOES.			
Peak on Kagamil Island	52 57.0	169 25.0	Kuritzin.
Peak on Chuginadak Island	52 45.0	169 21.0	Kuritzin.
South Point Chuginadak Island	52 40.9	169 44.9	Kuritzin.
Northeast peak Yunaska Island	52 40.5	170 12.0	Gavriloff.
Southwest peak (volcano) Yunaska Island	52 38.0	170 21.5	Gavriloff.
Chugul Island, middle of peak	52 38.0	170 47.0	Gavriloff.
Middle of Amuchta Island, Amuchta Strait	52 35.5	170 52.0	Gavriloff.
Signan Island, northeast point Amuchta Strait	52 25.0	172 09.0	Ingeström and others.
Signan Island, southwest point Amuchta Strait	52 18.0	172 25.0	Ingeström and others.
East point of Amlia Island, a high rock off it	52 06.2	172 46.7	Salamatoff and others.
Southwest point Svetchnikoff Bay, south side of Amlia Island	52 02.3	173 10.5	Salamatoff and others.
West point of Amlia Island, Amlia Strait	52 06.5	173 51.3	Salamatoff and others.
Idaluk Point, middle of north side of Amlia Island	52 08.7	173 19.0	Salamatoff and others.
ATKHA ISLAND.			
Cape Utalug, southeast point of Atkha Island, Amlia Strait	52 08.0	173 54.7	Salamatoff and others.
Anchorage in Nazarn Bay, east side of Atkha Island	52 10.5	174 00.5	Salamatoff and others.
Cape Tadlukh, south side of island	51 58.0	174 42.0	Ingeström and others.
Cape Kigun, west point of island	52 00.0	175 40.0	Ingeström and others.

* These positions cannot be reconciled; the peak should be about a mile south of the cape.
† Summit of Cape Cheerful is an extinct volcano, about 2,000 feet high.
‡ Magnetic declination observed September 10, 1867=19° 47′.4 east.

List of geographical positions—Continued.

Name of place.	Latitude.	Longitude.	Authority.
	° ′ ″	° ′ ″	
Broad Cape, north side of island	52 06.5	174 45.1	Ingeström and others.
Salt Island	52 10.0	174 31.5	Ingeström and others.
Egg Point, south point of Korovenski Bay	52 11.9	174 22.5	Vasilieff.
Priest's house, Nicolski Village, Korovenski Bay	52 17.2	174 17	Etolin, Gibson.
Cape Korovenski	52 18.5	174 21.7	Pavloff.
Korovenski Peak, extinct volcano 4,852 feet high	52 23.5	174 02.0	Pavloff.
North Cape	52 25.3	173 58.7	Pavloff.
East Cape	52 16.0	173 48.5	Pavloff.
Konionji Island, middle	52 13.6	175 00.8	Ingeström and others.
Swallow Island, middle	52 12.0	175 26.5	Ingeström and others.
Ogmodakh Island, Atkha Strait	51 58.0	175 21.5	Tebenkoff's Atlas.
Sitkhin Peak, Sitkhin Island, extinct volcano 5,033 feet high	52 03.5	176 06.4	Ingeström and others.
ADAKH ISLAND.			
Cape Odagdakh, north point of island	52 01.0	176 36.3	Salamatoff and others.
Cape Kagigikhakh, south point of island	51 31.5	176 46.7	Salamatoff and others.
Cape Yakhakh, southwest point of island	51 32.5	177 06.0	Salamatoff and others.
KANAGA ISLAND.			
Northwest Cape, Kanaga Island	51 57.0	177 19	Salamatoff and others.
Kanaga Peak, near Northwest Cape	51 54.5	177 16	Salamatoff and others.
Cape Chun, south point of Kanaga Island	51 38.0	177 36.5	Salamatoff and others.
Peak of Sea-otter Island, extinct volcano with marked terraces	51 55.3	177 30.5	Salamatoff and others.
TANAGA ISLAND.			
Cape Sudakh, northeast point of island	51 52.0	177 38.0	Salamatoff and others.
Point Saslikh, south point of island	51 34.0	177 56.0	Salamatoff and others.
Anchorge in Pride of Russia Bay, west side of island	51 47.0	178 02.0	Salamatoff and others.
Northwest Cape of Island	51 53.0	178 17.6	Salamatoff and others.
North cape of Goroloi Island, volcano, very high	51 50.0	178 46.0	Salamatoff and others.
South cape of Goroloi Island, volcano, very high	51 43.5	178 44.0	Salamatoff and others.
Illakh Island, Tanaga Strait	51 26.6	178 22.5	Salamatoff, Gibson.
Amatignakh Island, highest part	51 19.0	179 08.5	Gibson.
	51 12.0	179 05.0	Salamatoff.
North point of Semisopokh, or the Seven Peaked Mountain. Active volcano on this island	52 02.0	180 22	Zarembo, Gibson.
West cape of Semisopokh Island, 1,411 feet high	51 57.5	180 30.5	Gibson.
	....	180 24	Klinkofström.
Sugarloaf Peak, south point of island, 1,760 feet high	51 54.0	180 21.5	Gibson.
	....	180 16.0	Klinkofström.
East Cape of Amitkhitka Island	51 24.2	180 29.5	Gibson.
	51 20.0	180 27.0	Klinkofström.
Cape Ptikhi, west point of Amitkhitka Island, 1,008 feet high	51 38.0	181 22.0	Gibson.
	51 37.0	181 08.0	Klinkofström.
Anchorage in Kiriloff Bay, north side of Amitkhitka Island	51 25.5	180 45.0	Gibson.
	51 36.0	180 41	Instromom.
South point Constantine Bay, northeast part of Amitkhitka	51 24.0	180 38.0	Gibson.
	51 24.0	180 37.0	Klinkofström.
South point Little Sitkhin Island	51 54.5	181 31.5	Gibson.
	51 55.5	181 14.8	Tebenkoff's Atlas.
Peak on Little Sitkhin Island	51 58.0	181 28.0	Gibson.
East point of Rat Island	51 46.0	181 43.0	Gibson.
	51 37	181 23	Tebenkoff's Atlas.
Peak of Davidoff Island	51 58.6	181 42.2	Gibson.
Peak of Khrostoff Island, 1,873 feet high	52 08	181 41	Gibson.
Southwest peak of Chugul Island	52 07	181 57	Gibson.
	51 58.0	181 37.0	Klinkofström.
Middle of Tanadak Island	51 56.5	182 09.5	Gibson.
	52 00.0	182 02.0	Klinkofström.
Northeast cape of Great Kyska Island, 1,987 feet high	52 11.0	182 22.4	Gibson.
	52 10.0	182 10.0	Chernof.
Kyska Bay, mouth of stream east side of island	51 59.1	182 34.0	Gibson.
	52 03.0	182 19.5	Ingeström and others.

List of geographical positions—Continued.

Name of place.	Latitude.	Longitude.	Authority.
	° ′ ″	° ′ ″	
Southwest Cape of Kyska Island	51 53	182 51	Gibson.
	52 01.0	182 24.0	Ingestrëm and others.
East Cape Buldir Island, 302 feet high	52 34	184 11	Gibson.
	52 24	184 10.4	Ingestrëm and others.
West point of Alaid Island, of the Simitkhi group, 818 feet high	52 45.4	186 09.5	Gibson.
	52 45.4	185 37.0	Etolin.
Northeast Cape Agattu Island	52 27.6	186 24	Benzeman and others.
Cape Sabakh, southeast point of Agattu Island	52 19.0	186 21	Benzeman and others.
West Cape of Agattu	52 25.8	186 54	Benzeman and others.
ATTU ISLAND.			
East Cape	52 51.6	186 36.7	Gibson.
	52 50.6	186 15.0	Etolin.
Tchitchagoff Harbor, flagstaff	52 55.7	186 47.3	Gibson.
	52 56.1	186 36.5	Etolin.
Cape Cross, northwest part of Island, 2,281 feet high	52 02.4	187 24.0	Gibson.
	52 02.5	186 52.0	Benzeman and others.
* Cape Wrangell, west point of the island	52 58.0	187 34.0	Gibson.
	52 57.0	187 08.0	Benzeman and others.
Massacre Point, west side of Massacre Bay	52 49.8	186 55.0	Gibson.
	52 48.8	186 25.0	Benzeman and others.
NORTH COAST OF ALASKA PENINSULA AND WEST SHORES OF AMERICA TO THE ARCTIC OCEAN.			
Point Krenitzin, northeast point of the entrance to Isanotski Strait	55 04.2	163 15.0	Staninkovitch.
South point of Amak Island	55 25.0	163 01.5	Staninkovitch.
Cape Glazenap	55 14.8	162 50.7	Staninkovitch.
East point Wolf Island, Moller Bay	56 00.7	160 41.0	Staninkovitch.
Cape Seniavin	56 23.7	160 02.7	Staninkovitch, Botscharoff
Black Peak	56 35.2	158 46.6	Botscharoff.
Cape Strogonoff	56 48	158 46	Khoudobine.
BRISTOL BAY.			
Cape Menschikoff	57 30.4	157 58.5	Staninkovitch.
Mouth of Sulima River	57 38	157 48	Khoudobine.
Mouth of Ugatchak River	58 12.7	157 30.0	Staninkovitch.
Village Pongoik, mouth of Naknek River	58 42.8	157 01.4	Staninkovitch, Khoudobine.
Mouth of Kvitchak River	59 00.0	156 58.0	Wrangel, Ustigoff, and others.
Cape Etolin	58 38.0	158 06.0	Wrangel, Ustigoff, and others.
Fort Alexander, on Nutchagak River	58 57.1	158 18.4	Wrangel, Ustigoff, and others.
Cape Constantine	58 24.2	158 44.0	Wrangel, Ustigoff, and others.
Kayatchek Island, middle	58 37.0	159 44.0	Vasilieff and others.
Calm Cape, southeast point of Hagemeister Island	58 35.0	160 48.0	Vasilieff, Cook, and others
Cape Newenham	58 42.0	162 05.0	Vasilieff, Cook, and others.
COAST.			
Northwest point of Goodnews Bay	59 03.9	161 47.0	Khramtchenko.
Village Chinyagmiout, left bank Kuskovim River	59 52	161 43	Russian Admiralty Chart No. 6.
	60 08	....	Russian MS. Chart.
Cape Rumiantzof	61 52.0	166 17	Etolin.
NORTON SOUND.			
West point Stuart Island	63 35.5	162 32.6	Tebenkoff.
South point Stuart Island	63 30.6	162 13.0	Kellett.
Highest point of Stuart Island	63 35.0	162 21.5	Tebenkoff.
Fort St. Michael	63 28.0	161 51.9	Kellett.
Factory at mouth of Unalaklit River	63 52.6	160 40.0	Kashevaroff.
Besborough Island, middle	64 06.6	161 07.0	Khramtchenko.
Cape Denbigh	64 22.0	161 24.0	Khramtchenko.
Cape Darby	64 17.6	162 38.0	Khramtchenko.
Rocky Cape, Golovnin Bay	64 21.0	162 55.0	Tebenkoff and others.
Cape Nome	64 23.0	165 05.0	Tebenkoff and others.

* This is the westernmost point of the United States.

List of geographical positions—Continued.

Name of place.	Latitude.	Longitude.	Authority.
BEHRING STRAIT.	° ′ ″	° ′ ″	
Azgiak or Sledge Island, middle	64 29.6	166 01.5	Tebenkoff and others.
	....	166 08	Beechey's Chart.
Cape Rodney	64 39	166 18	Beechey's Chart.
Cape Spencer, Kaviyayak Bay, Port Clarence	65 16.7	166 47.8	Beechey's Chart.
*Cape Nitkhta, or Prince of Wales	65 33.5	167 59.2	Beechey's Chart.
ARCTIC OCEAN.			
KOTZEBUE SOUND.			
Cape Espenberg	66 42	163 34	Beechey and others.
Peak of Chamisso Island, 231 feet high	66 13.2	161 46.0	Beechey and others.
Cape Blossom	66 49	162 24	Beechey and others.
Cape Kruzenstern	67 09	164 37	Beechey and others.
COAST.			
Point Hope	68 19.5	166 46	Beechey and others.
Cape Lisburne, 849 feet high	68 56	166 08	Beechey and others.
Cape Beaufort, (vein of coal)	69 13	163 34	Beechey and others.
Icy Cape	70 20	161 40	Beechey and others.
Point Belcher	70 43	159 36	Beechey and others.
Point Barrow, highest latitude of the United States	71 27	156 15	Beechey and others.
Tangent Point, east cape of Dease Inlet	71 10	154 50	Beechey and others.
Cape Halket	70 49	152 16	Admiralty Chart No. 2435.
Manning Point	70 07.5	143 42	Admiralty Chart No. 2435.
Demarcation Point, eastern point of the United States on the Arctic Coast	69 40	141 07.5	Admiralty Chart No. 2435.
ISLANDS OF THE BEHRING SEA.			
ST. GEORGE ISLAND.			
Waterfall Cape, or southeast point of the island	56 34.3	169 31.5	Archimandritoff's MS. Chart.
East Cape	56 37.1	169 27	
West Cape	56 38.3	169 44	
ST. PAUL AND ADJACENT ISLANDS.			
Fur Seal Isle	57 03.0	170 19	Archimandritoff.
	....	170 00	Tebenkoff.
Walrus Isle	57 11.5	169 49.5	Archimandritoff.
	57 09.9	169 34.6	Tebenkoff.
Anchor Cape, south point of St. Paul	57 08.0	170 12	Archimandritoff.
	57 06.2	169 54.6	Tebenkoff.
North cape of St. Paul	57 16.4	170 00.2	Archimandritoff.
West cape of St. Paul	57 11.2	170 19.3	Archimandritoff.
	57 10.2	170 01.1	Tebenkoff.
Highest peak of St. Paul	57 11.4	170 06.4	Archimandritoff.
	57 09.6	169 49.0	Tebenkoff.
ST. MATTHEW AND ADJACENT ISLANDS.			
Pinnacle Isle, 930 feet high	60 13.0	172 34.5	Lutke.
Cape Upright, southeast point of St. Matthew	60 18.0	172 04.0	Lutke.
Sugarloaf Peak, 1,350 feet high	60 19.2	172 29.0	Lutke.
Cape Glory of Russia, north point of St. Matthew	60 38.0	172 41.0	Lutke.
North Cape of Walrus Island	60 44.0	172 52.0	Pavloff.
NANITOK ISLAND.			
Cape Ignatieff, south point of island	59 48.0	166 13.0	Vasilieff.
Cape Vasilieff, southeast point of island	59 57.7	165 24	Tebenkoff's Atlas.
Cape Boyle, west point of island	60 11.5	167 07.6	Vasilieff.
Cape Etolin, north point of island	60 31	165 50	Tebenkoff's Atlas.
Peak of Ukivok Island, 586, 756 feet high	64 58.5	167 58.0	Khramtchenko and others.
ST. LAWRENCE ISLAND.			
Southeast Cape	62 57.0	169 24.	Pavloff.
Cape Anderson, east point of island	63 17.0	168 35.0	Pavloff.
Northwest Cape	63 51.2	171 29.0	Beechey.

*This is the westernmost point of the Continent of America.

List of geographical positions—Continued.

Name of place.	Latitude.	Longitude.	Authority.
	° ′ ″	° ′ ″	
Southwest Cape	63 20.4	171 33.0	Tebenkoff.
Anchorage off Kiallagak Village, near Southeast Cape	63 09.4	169 19.5	Pavloff.
North point of Punuk Isles	63 05.0	168 42.8	Pavloff.
DIOMEDE ISLANDS, BEHRING STRAIT.			
Ugiyak or Fairway Isle, middle	65 38.7	168 43.7	Beechey.
South point of Ingaliouk Island	65 46.3	168 55.2	Beechey.
Middle of channel between the Diomede Islands, being the boundary between Russia and the United States	65 48.6	168 56.5	Admiralty Chart No. 2435.
	65 47.8	168 58.0	Tebenkoff's Atlas.
RUSSIA.			
DIOMEDE ISLANDS AND ADJACENT COAST.			
Northwest point of Imaklit Island	65 51.2	169 03.7	Beechey.
East Cape of Asia	66 03.1	169 43.8	Beechey.

APPENDIX B.

UNITED STATES COAST SURVEY STATION,
Sitka, Alaska, August 21, 1867.

DEAR SIR: In accordance with your instructions, I make the following report upon the aids necessary to navigation in Sitka Sound, and the approaches to the harbor of New Archangel or Sitka:

The heads forming the entrance to Sitka Sound are south point of Kruzov Island, called Cape Edgecumbe, and the northwest point of Biorka (Birch) Island; the latter bearing east by south one-quarter south (compass) eleven and a half miles from the former, which is the rocky, bluff shore of the wooded plateau making out from the base of the extinct volcano, Mount Edgecumbe, situated about four and a half miles north-northeast from the cape, and having a very extended horizontal summit, the rim of the crater, and 2,855 feet above the ocean, with regularly sloping sides. Thus far I have seen it in thick weather only, and consider it a remarkable and characteristic land-fall for this port. It has been esteemed such by navigators of all countries, there being nothing similar to it in this region. The navigators of the Russian-American Company inform me they consider it the most recognizable headland along this coast, being readily known fifty miles at sea. The immediate shores of Cape Edgecumbe are formed of high, bold, and rocky bluffs, mostly of lava, and guarded by many rocks.

The southern end of Kruzov Island, forming the north side of Sitka Sound, runs from Cape Edgecumbe a general course of northeast three-quarters east for seven miles, to Otmoloi Point, or Point of Shoals. Nearly midway between these points and one and a half mile off the shore lies the wooded islet of St. Lazara, or Cape Island, with from twenty to five fathoms between it and the shore. From Otmoloi Point, on a line directly across the sound, to Bouronov Point, on the island of Baranoff, the bearing is east by north three-quarters north, and distance seven and a half miles, being the narrowest part of the sound, which is further contracted on this line by dangerous reefs and rocks, leaving, however, between them three passages, with deep water, and each nearly one and a half mile wide. Among these dangers lies Vitskari Rock, or rocks, with adjacent sunken reefs. The principal rock, I judged in passing it, to have an extent of over one hundred feet, and about ten feet above high water, with an irregular and broken surface. Upon the English chart No. 2337 a reef is laid down as stretching out one mile to the northeastward; but Captain Lemaschaffski, of the Russian-American Company, informs me that on a north-northeast course he has passed, in very deep water, one-quarter of a mile from Vitskari. As I saw it, the breakers do not extend far from the rock. From Otmoloi Point it bears east by north three-quarters north about three and a quarter miles, and from the northwest point of Biorka northwest by west three-quarters west, seven and a quarter miles, Biorka Island is about two miles long, in a northwest and southeast line; comparatively low, with rocky, bluff shores, especially marked on the north side, and a couple of islets off the northwest point. It is covered with low trees. The navigators of the Russian-American Company inform me that there is a narrow, contracted harbor, about one mile and a half east of the northwest point of Biorka, with ten, seven, and five fathoms of water, affording protection from the southeast swell. This would doubtless afford a capital anchorage for pilot-boats.

On the English map 2337, there is laid down, two miles northeast by east one-half east from the north end of Biorka Island, a rocky patch, of half a mile in extent, having ten feet of water upon it at low water. Captain Lemaschaftski informs me that he has watched this rock when a very heavy but smooth swell was rolling in, and that it breaks only in one single spot, and then only every few minutes, (say five or six.) He expresses his conviction that there is no more than one rock in this situation, with deep water around it.

For four miles inside the Vitskari and Kulichoff Rocks the sound is free from dangers up to the range of numerous islets and rocks lying for two miles outside the anchorage of New Archangel. Through this mass of islets there are three channels leading to the anchorage, known as the eastern, middle, and western channels, the former being the longest. In approaching these islands in thick weather, the navigators of the Russian-American Company endeavor to make the island of Mochnati, which is from twenty to thirty feet high, rocky, and covered with a thick growth of spruce, whose dark foliage, with the black rocks beneath, brought out in greater relief by the surf breaking around its base, and on the outlying sunken rock, makes it discernible through the fog when other islands are unrecognizable. This islet lies between the entrances of the western and middle channel, and a vessel making it can take either, and safely run through for an anchorage. When the fog is lifting from the coming in of a westerly wind, or otherwise, this island appears to stand out clearly before the others do. When abreast of Mochnati, the western channel is about three-quarters of a mile in width, with a large reef, bare at low tide, and two or three rocks, visible at high water, forming the western side of the channel. The middle channel is contracted by sunken and exposed rocks to a much more limited entrance. From Vitskari Rock to Mochnati, the bearing is northeast by north, and the distance five miles. The best anchorage is in the eastern harbor where deeper water, greater extent, and good bottom are found.

I would therefore recommend that two lights be established in Sitka Sound; one on the Vitskari Rock and the other on Mochnati; that the building on the former be painted black, as being much more readily made out in thick weather, especially with breaking water around it. The buildings on Mochnati should be white, if the mass of trees is retained, as should be the case. If these trees are cut down, it will be a serious mistake. If the tower is built higher than the tops of the trees, (which I judge to rise seventy-five feet above the island,) the upper part should be painted black.

The light on Mochnati should be of about the same order as that on Fort Point, in the Golden Gate, and, I think, need not rise more than eighty feet above the water.

The light on Vitskari should be about one hundred feet above the sea, and thus be visible from a ship's deck about sixteen miles in clear weather. It would command an arc of the horizon of seventy degrees from southwest by west, round the south to south-southeast, a few degrees of this arc being intercepted by the island of St. Lazara. A vessel from the southward would thus open it by Biorka Island, when well in with the coast. I think the light should be about the same order as that of Point Boneta, at the entrance to the Golden Gate. The present arrangement of an approaching vessel's gun in thick weather, or at night, being answered by a gun and light from the governor's house, might well be retained in part, by answering a vessel's gun from Vitskari, if practicable.

It was impossible to land upon Vitskari during our stay at New Archangel, on account of continued bad weather, either to measure its extent or to ascertain the nature of the rocks, and the difficulties of working there; but from our examination of the rocks on the adjacent islands, there is no doubt of its affording secure and ample foundation.

Of building material there is quite a variety in the vicinity of Sitka; the best we have discovered is a marble formation of great extent and fine texture only fifteen miles from New Archangel, outcropping to the water's edge, with a bold, high hill behind it, and a narrow channel with six fathoms water in front of it, and three fathoms directly at the shore at high water. On the other side of this narrow channel is a broad flat, bare at low water, making out from the opposite shore.

I have not referred to the Kulichoff Rock (twenty feet out of water, with adjacent reefs) as requiring argument against its claims for a light-house site in preference to Vitskari, because I consider the Vitskari the more dangerous locality, and on that side of the sound which vessels would prefer to work in, as the southern and eastern shores of the sound are broken up by innumerable islets and rocks.

In addition to lights it may be necessary to add buoys upon the edges of the Vitskari and Kulichoff reefs, but this will require a detailed examination to determine the necessity, and whether buoys can be anchored here. On the edge of the reef forming the west side of the entrance to the western channel I recommend a buoy, or the building of a beacon (stone) on the outer extremity of the part uncovering at low water. The whole extent of this ledge is about one-quarter of a mile northwest and southeast, and one-eighth of a mile wide.

Upon the rock in mid-channel north-northwest of the west end of Japonski Island, and northeast one-half east from the west end of Battery Island, uncovering at half tides, I would propose that a beacon of dark stone be built. This would save the expense of replacing and repairing buoys, and be a much better and more readily recognized mark in thick weather. I think it should have a base of about twenty feet diameter, and rise in the form of a frustum of a cone to twenty feet elevation.

Upon the rock in the channel abreast the western part of the Indian village, I recommend that a mooring buoy be affixed. The rock is marked as out of water on the British Admiralty chart 2348, but it is covered at high and ordinary low waters.

At the entrance to the middle channel lies the Polivnoi Rock, about four feet above high water, with a passage of deep water on either side.

In the eastern channel are several sunken rocks. Simpson Rock, with two and three-quarter fathoms, one quarter of a mile south by west from the end of Quitoway Island, and over half a mile from Pig Rock, with the main channel between them, and ten fathoms close to it.

About five-eighths of a mile northwest by west from Simpson Rock lies the Tzaritza Rock, with one fathom of water, and upon which the sea sometimes breaks; it has ten fathoms close to it. This rock bears northwest three-quarters, distant one-half mile from the northwest point of Oshipki Island, with a deep channel between them.

The Zenobia Rock, reported to have from eight to fifteen feet water upon it at low water, is laid down by one of the captains of the Russian-American Company to the eastward of the line joining Pig Rock and Kulichoff Rock, and reports it as a bayonet rock. On the English chart 2337, it is placed half a mile west of the above position. Another navigator of the Russian-American Company could not find this sharp rock, but found one having a flat top in a slightly different locality. The position of this rock can only be found and determined in good smooth weather, either by sweeping or watching for eddies around it. There is a depth of ten to seventeen fathoms close alongside. From the south side of Dolgoi Island it bears one-quarter south (compass) and distant nearly a mile from the west end of the island. It will be necessary to make a detailed examination of this locality for the position of a buoy.

If a complete system of lights was warranted by the commercial importance of this sound, it would be necessary to locate a light upon Cape Edgecumbe, and another on Biorka Island in addition to the foregoing; but under present circumstances I think the inner lights and aids to navigation are sufficient and first needed. If only one were to be located I would recommend the Vitskari rock as the best position.

The geographical position of the Coast Survey station at Sitka is latitude 57° 02′ 52″, longitude 135° 17′ 05″, and the observed magnetic variation, August 7, 1867, was 28° 50′.8 east.

Very respectfully and truly yours,

GEORGE DAVIDSON,
Assistant United States Coast Survey.

Professor BENJAMIN PEIRCE,
Superintendent United States Coast Survey, Washington, D. C.

APPENDIX C.

UNITED STATES COAST STATION AT ST. PAUL HARBOR,
Kadiak Island, Alaska, August 31, 1867.

DEAR SIR: In accordance with your instructions I make the following report upon the aids to navigation necessary for the approaches to the harbor of St. Paul, Kadiak Island.

This station of the Russian-American Company was formerly their chief depot, but now ranks next in importance to that of New Archangel or Sitka. It is situated near the northern extremity of the island of Kadiak and the flag-staff of St. Paul is in latitude 57° 47′ 45″ and longitude 152° 20′ 57″ from our observations, and the observed magnetic declination on August 28, 1867, was 26° 04′.1 east.

The island of Kadiak, one of the most important in the newly acquired Territory, lies broad off the southeast side of the peninsula of Alaska, separated therefrom by the Petries or Chelekoff Strait, twenty-five miles wide. It lies in a north-northeast and south-southwest direction, having a length of about eighty-five miles and an average width of forty-five miles. At either end are groups of islands which give an aggregate length to the Kadiak group of 155 miles.

The harbor of St. Paul is formed by a group of islands lying in the northwest part of the extensive bay of Chinyak. To the northwestward of it lie extensive bays and straits formed by the islands of Afognak, Evrashechey, White Spruce, &c.

At the town of St. Paul there are about one hundred well built log-houses and stores belonging to the Russian-American Company, with one Greek church. One of the islands forming the harbor is the location of the improvements of the Russian Ice Company. An extensive pond has been dammed up beyond the reach of salt spray, and the supplies of ice to the San Francisco market require the services of five or six vessels for the transportation of about thirty-five hundred tons of ice annually.

The immediate shore of Kadiak, forming the west side of the harbor, is broken by rocky bluffs, and stretches from White Spruce Cape to the head of Women's Bay, nearly south for twelve miles; but from White Spruce Cape to the town the distance is only three and a half miles, the shore being bold and rocky, except one small cove (Chagavka) with low pebbly beach, two miles within the point. The channel abreast the town is very contracted, being not over two hundred and fifty yards wide, with mooring buoys put down for the company's vessels, of which one only can lie at the storehouse landing, while one or two others are in the stream. For large vessels there is room for one only.

The length of this narrow part of the channel is nearly one mile and is formed by Near Island on the southeast, about one and a half mile long, lying almost parallel with the shore of Kadiak, and attaining an elevation of one hundred and fifteen feet, whence a quite extensive view is had of the surrounding bay and islands; but the horizon cannot be seen over the larger and outer islands, called the Wooded and Bare or Long Island. The western shore of Wooded Island is nearly straight, and alternately rocky bluff and pebbly beach for one and a half mile northward, nearly parallel to the shore of Kadiak, and five-eighths of a mile distant therefrom, forming an outer anchorage of a large extent, with plenty of water, but irregular bottom. Vessels anchor off the small cove Chagavka in fifteen fathoms southwest by south from the north end of Wooded Island; but in this position they are exposed to the winds drawing directly in the north channel from the north and northeast.

The point of Wooded Island, where the ice company have their improvements and wharf, is a low pebbly beach one mile east of the north entrance to the narrowest channel of St. Paul. Abreast of this point the counter currents are very strong, and are said to run six miles per hour, making a short, disagreeable sea, with the wind from southeast. Two of the three buoys abreast the wharf have been torn away by vessels moored to them in southeast weather.

To the south of St. Paul an anchorage is formed by Near Island and two others giving a space within the three-fathom curve of one mile and three-eighths of a mile wide, with water from four to ten fathoms. This is not generally used, because vessels do not enter or leave by that channel into Chinyak Bay—the eastern approaches to it, one mile and a half distant, being contracted by rocks. The officers of the Russian-American Company inform me that a very heavy disagreeable swell rolls into this anchorage from the open bay of Chinyak. The two entrances to St. Paul Harbor generally adopted are designated the northern, round the north end of Wooded Island, and the southern, round the south end of the same island. Both ends of this island have extensive reefs off them.

Wooded Island is somewhat the form of a lozenge, being two and a half miles long, north-northwest and south-southeast, and one and a half mile across. Its surface is undulating, and diversified by open spaces covered with herbage and masses of timber and shrubbery, giving it a pleasant appearance from sea. The shores are generally bold, rocky bluffs, that attain on the outer face an elevation of about one hundred feet. The island in the highest part may be about two hundred and fifty feet above the sea. To the eastward and seaward of it, and separated by a channel one mile wide, lies Long or Bare Island, which is nearly four miles long, north-northeast and south-southwest, averaging a mile in width, with alternate low and bold shores that rise to two hundred feet, the surface rolling, and varied by herbage and a few scattering patches of trees. It has extensive reefs off its north and south points, and the channel between it and Wooded Island has not been sounded out, but is said to afford deep water. Its northern extremity lies four and a half miles east of White Spruce Cape, and has a trident shape. On the west side, and one mile within the northwest point, is the opening to an extensive land-locked harbor with from three to ten fathoms water. It is about three-quarters of a mile long and one-quarter of a mile broad. Here the Russian-American Company at one time had a small settlement, and a place for making bricks, abandoned on account of the inferior character of the bricks. The north point of the island is about two hundred or two hundred and fifty feet high, with bold, rocky shores; the surface rolling and covered with herbage. We passed close to it when entering St. Paul by the south channel, and I had a fair chance to judge of its availability and importance as a position for a light-house. We left by the north channel, close around White Spruce Cape, and confirmed our first impressions. It would be seen by vessels coming out of Narrow Strait to the west-northwest, and from Marmot Bay, when clear of Spruce Island. A reef with a small islet makes off three-quarters of a mile from the point, while a reef and islet lie half a mile southeast from the south end.

Both channels have dangers in their approaches; the northern channel has a sunken ledge called "Williams Bank," lying three miles north of the north end of Long Island. It has deep water around it. Upon it were formerly two buoys, red and blue. The bearings I obtained upon the breaker on this bank, from my station on Near Island, place it half a mile nearer the northwest point of Long Island than it is laid down on the charts; and from that station, recommended as a second light-house site, it bears north 44° 12′ east (compass.) Between it and the reef off the northwest point lies a sunken, sharp, isolated rock, not on any map, and having but ten feet of water upon it at low water, with very deep water around it, and no breaker seen upon it. One of the Russian-American Company's vessels, the Kadiak, struck upon it in April, 1860; her bottom pierced, when she filled and was lost. Its position was afterwards determined, the locality having been found by watching the swirling of the currents. It is two miles north-northwest from the northwest point of Long Island, and with Williams and the reef off the point, lies on the prolongation of the shore of the west side of the island. One mile north-northeast from White Spruce Cape is a rock and reef.

In the southern approaches lies a single rock, called the Humpback, eighteen feet above water, having bold water around it, and bearing south 63° east, three miles from the south point of Long Island. Other dangers near the entrances of the harbor are exhibited in the accompanying sketch. To avoid these inner dangers, and also to give a vessel's position by cross-bearings upon two objects to avoid Williams Bank and the Humpback, I would recommend a harbor light to be located upon the high ridge at the northern end of Rocky Island, abreast of the town. From my station, about one hundred and fifteen feet above the sea, I saw the flat-topped islets off Chinyak Point, about one hundred and twenty feet high, over the south end of Wooded Island; am not certain that I saw the Humpback, but feel sure that a slight elevation of the light would be seen from a vessel's deck near the rock, over the bluff, south point of Wooded Island. The light would be seen up to the anchorage off the ice company's wharf by both channels, and also for the whole bay of Chinyak and the channel to the south and east.

The reefs in the entrance to the channels to the southeastward of Near Island have generally some large rock showing above water; but a buoy would be needed on the north end of the reef, making nearly half a mile northward from the extremity of Toposkoff Islet, with seven fathoms water close to its extremity. A buoy should also mark the extremity of the reef making north from the north point of Near Island, and forming one side of the entrance to the narrow harbor of St. Paul. A shoal spot of rock, covered with barnacles, and showing white, (locally attributed to chalk,) with nine feet of water on it at low water, is laid down by the navigators of the Russian-American Company one-half a mile south by east from the south point of Wooded Island, and one-half of a mile southwest three-quarters west from the inner Humpback rock, lying off the reef at the south end of Wooded Island. About half way between this inner Humpback and the south end of Long Island, on a line of deep soundings, lies a rock with four feet, but it will always be avoided by keeping outside that line.

There is no doubt but that the approaches and entrances to this harbor need extensive and detailed examination.

The two lights recommended are amply sufficient to mark the approaches and entrance to the harbor, however important it might become. Should only one be built, I recommend that upon Bare or Long Island.

The materials for the light on Long Island could be very safely landed in the land-locked bay on the west side of the island, and thence transported to the site, about one mile distant. Upon Near Island a roadway would have to be made along the steep sides of the island for carrying up stone and materials; probably the stone composing the island might be adapted for building purposes; it crops out at the summit of the island.

Stone for buildings is found in the harbor of St. Paul; it consists of a highly metamorphic sandstone; in some places very much shattered into fragments too small for use; in other places it can be found in available quantity. The general character of the stone in this vicinity is slate. I know of no limestone here for the making of lime.

Very respectfully and truly yours,

GEORGE DAVIDSON,
Assistant United States Coast Survey.

Professor BENJAMIN PEIRCE,
Superintendent United States Coast Survey, Washington, D. C.

APPENDIX D.

UNITED STATES COAST SURVEY STATION,
Ulakhta Harbor, Unalaska Bay, September 12, 1867.

DEAR SIR: In accordance with your instructions I make the following report upon the aids to navigation necessary to Unalaska Bay in Unalaska Island, one of the group of Fox Islands of the Aleutian chain.

Unalaska Bay lies on the north side of Unalaska Island, which has a length of nearly sixty-five miles southwest by west and northeast by east, (compass,) and an average width of fifteen miles. Cape Kalekhta, the eastern point of the entrance to the bay, lies about ten miles west-southwest from the middle of Akutan Strait, lying between the Island of Akutan on the northeast and Unalga Island on the southwest, and connecting the Pacific ocean with the Behring Sea. The middle of the passage, which is three miles wide, lies in latitude 54° and longitude 166°, both approximate. Cape Kalekhta is a rocky precipitous headland, rising to an elevation of about fifteen hundred feet, and well marked when seen from the strait by a high pinnacle rock close to its base, while about half a mile outside of it lies a rocky ledge not laid down on the charts. The western head is high, bold, and forms a long, curving shore line for two or three miles. It is called Cape Cheerful, and, upon approaching it from the northward and eastward, is readily recognized by a large cascade of one hundred and fifty feet high plunging directly into the sea from the base of an extinct volcano about twenty-five hundred feet high; from Cape Kalekhta it bears west-southwest about eight and a half miles.

The general direction of the bay is about south-southwest for eleven miles, contracting to a small harbor called Captain's Harbor. The bay, about half way inside the entrance, is divided by a bold, high island called Amoknak, rising precipitously to an elevation of eighteen hundred feet, and stretching southward with decreasing elevation to Captain's Harbor, so as to form Illoolook Harbor on its eastern side, eight miles inside Kalekhta Cape. From the northeast point of this island a long, narrow, low bowlder tongue, covered with coarse herbage, makes out and stretches southward for one and a half mile, and about one-half mile from the island, forming another fine land-locked harbor, called Ulakhta Bay, having from fifteen to twenty fathoms of water throughout. Near the extremity of this tongue is a half-finished house. On the extremity was established the secondary astronomical station of the Coast Survey, where Sub-Assistant Mosman obtained good observations for latitude, longitude, and magnetic declination. Between this tongue and the eastern shore, which is twenty-one hundred feet high and precipitous, lies the entrance to Illoolook Harbor, one mile wide, with a depth of water from twenty to seven fathoms, over irregular bottom. The rock laid down on some maps nearly in mid-channel is really quite close to the eastern shore. The village of Illoolook lies at the head of the harbor, about eight miles from Kalekhta Cape, and two and a half miles from Amoknak Head, and faces the Behring Sea. At this village I established a tidal station, at which Mr. S. Forney, aid, erected a box-gauge, as will be detailed in my report.

The location for a light-house for Illoolook Harbor proper would be on the bluff, about one mile north of the village, and three-quarters of a mile south of our observatory, on a prolongation of Ulakhta Tongue; but it affords a very limited arc of visibility, and, on account of the extent of the harbor and bay, and their freedom from hidden dangers, I do not deem it advisable to locate a light so far inside, but would recommend the adoption of a point on the outer face of the precipitous head of Amoknak, as marked in the accompanying sketch.

After putting up the signals for the local survey of Illoolook, and examining around the base of this cliff for light-house purposes, I was taken ill and confined to my berth so that I could not extend the examination, but confirmed my judgment when leaving the bay on the steamer.

On the outer face of this head the light would have an arc of visibility extending from north 70° west (compass,) tangent to Cape Cheerful, round by the north to north 24° east, tangent to Cape Kalekhta. In this situation it would possess the advantage of guiding a vessel into Captain's Harbor, on the west side of Amoknak Island, and would be seen after passing seven or eight miles westward through Akutan Strait.

A position would have to be selected about one hundred or one hundred and fifty feet above the water, where the wall-like cliff begins to slope inward, and possibly a cutting made to give space for the base of the tower, which should be painted white, as it would be projected against the dark, rocky mass behind it. To reach the position that would open Cape Cheerful, a roadway would have to be made for about half a mile from the lowland at the head of Ulakhta Bay, where a vessel can anchor in ten fathoms, rocky bottom, close to shore. The dwelling could be located here, where some of the Aleutians have small patches of garden for raising turnips, potatoes, cabbage, &c.

The geographical position of the site for the light-house, deduced from our observations on Ulakhta Tongue, is latitude 53° 55′ 38″, longitude 166° 27′ 44″, and the magnetic variation September 10, 1867, was 19° 47′.4 east.

This bay may become an important point for the curing of the codfish caught on the bank we discovered in this vicinity. It is sometimes visited by whalers, but no supplies are at present obtainable to induce their visits. Upon our coming out of this bay and passing eastward through the narrow strait of Unalga, lying between the small island of Unalga and Unalaska, we counted ten sperm whales within an hour. Upon our entering, a week previous, we saw nearly as many to the east-southeast of the straits.

In my report will be found a more particular description of these straits, accompanied by a view taken of them from the southeastward.

Very respectfully and truly yours,

GEORGE DAVIDSON,
Assistant United States Coast Survey.

Professor BENJAMIN PEIRCE,
Superintendent United States Coast Survey, Washington, D. C.

APPENDIX E.

SAN FRANCISCO, *November* 30, 1867.

DEAR SIR: I have the honor to present to you a report, based upon geological notes made by me as geologist of the recent expedition to Alaska. I regret that it is not more complete, but must plead as an excuse the hurriedness of our trip, few opportunities for exploration, and the short time allowed for its preparation.

Hoping that it may meet with your approval, I remain your obedient servant,

THEO. A. BLAKE,
Aid United States Coast Survey.

GEORGE DAVIDSON, Esq.,
Assistant United States Coast Survey and Chief of Expedition to Alaska.

GENERAL TOPOGRAPHICAL AND GEOLOGICAL FEATURES OF THE NORTHWESTERN COAST OF AMERICA, FROM THE STRAITS OF JUAN DE FUCA TO THE PARALLEL OF SIXTY DEGREES NORTH LATITUDE.

By a glance at the charts of the northwestern coast of America it will be seen that the entire coast between the straits of Fuca and about the sixtieth parallel is cut up into a vast archipelago of islands, between which are narrow and intricate channels, abounding in good anchorages, and affording peculiar facilities for inland navigation.

The shores of the mainland are deeply indented with long and narrow inlets, bordered by high and abrupt mountains, generally wooded from near their summits down nearly to the water's edge, presenting natural views of the wildest and most impressive character.

Of the islands, the largest and most important is Vancouver. Further north is the large and outlying island of Queen Charlotte. The city of Victoria is situated upon the southeastern extremity of the former, at the head of a narrow inlet from the straits of Fuca.

The land on the western and northern coast of Vancouver Island is high and mountainous, while on the southeastern shore, particularly in the neighborhood of Victoria, it presents a gently undulating surface of large extent.

The southern shore of the Straits of Fuca is very bold, being bordered by the Olympic range of Snowy Mountains, in Washington Territory, the peaks of which attain an altitude of seven thousand eight hundred feet above the sea.

The shores of Vancouver in the vicinity of Victoria are rocky but rarely high. The prevailing rock is highly crystalline, granitic in appearance, but consists of feldspar and foliated hornblende or pyroxene, and is probably igneous in its origin. It is well exposed along the shores of the harbor and on the summits of the hills back and to the east of the city.

The most prominent geological feature is the grooved, scooped, and rounded surfaces of this rock; no angular summits or pieces *in situ* are to be found; the rocks everywhere present the same rounded summits and smooth surfaces. Perhaps the most striking example of this is to be seen in the small, barren, rocky island off the southeastern extremity of Vancouver, known as Trial Island, which we passed in approaching Victoria upon the return of the expedition. I measured the direction of several of the grooves along the shore east of the Hudson Bay Company's store, and found that it was quite uniform, not varying much from north 10° west. In some places they are a foot or more in width and of equal or greater depth.

In the outskirts of the city, between it and Beacon Hill, at the head of the small inlet which forms the harbor, is quite a large area of level alluvial land.

A ditch or drain recently dug through this for a considerable distance, the bottom of which I should estimate to be at least twenty feet above high water, has exposed an ancient sea beach. The marine shells which occur there are all of existing species.

The existence of this beach proves a comparatively recent upheaval and its deposition subsequent to the extensive denudation and erosion caused by glacial action on the underlying rocks.

The eastern coast of Vancouver, as well as the shores of the small islands to the eastward, are fringed with recent deposits, horizontally stratified, soft and friable. Upon these the sea is constantly encroaching, as shown by the piles of debris under the steep banks, which are generally not over fifty feet in height.

Erratic boulders of rock, the material of which is foreign to their present position, are of frequent occurrence. On the left shore of Active Pass, going north, is one which contains, by estimate, at least eighty cubic yards of stone.

Seventy miles distant from Victoria, on the eastern side of Vancouver Island, extensive deposits of coal occur, known as the Nanaimo Mines. These mines were opened in the year 1852 by the Hudson Bay Company, but have since passed into the hands of other parties.

The total shipments of coal from them from the year 1852 to the present time probably exceed two hundred thousand tons, and, according to Macfie,* amounted at the end of the year 1861 to one hundred and twenty-three thousand nine hundred and thirteen tons.

The coal is highly bituminous, well suited for family use and steaming purposes. The beds are known to belong to the cretaceous period, and are much upheaved and faulted, rendering their exploration difficult and expensive.

The coal is furnished on the wharf at Nanaimo at six dollars (gold) per ton.†

The following is a statement of analyses showing the composition of this as compared with the other coals of the Pacific Coast, given by J. D. Whitney, in his report upon the Geology of the State of California, Vol. I, p. 30:

	MOUNT DIABLO MINES.								
	Clark & Co.	Black Diamond.	Cumberland.	Peacock.	Corral Hollow.	Bellingham Bay.	Nanaimo.	Coose Bay.	San Mateo.
Water	13.47	14.69	13.84	14.13	20.53	8.39	2.98	20.09	17.54
Bituminous substances	40.36	33.89	40.27	37.38	35.62	33.26	32.16	32.59	35.93
Fixed carbon	40.65	46.84	44.92	44.55	36.35	45.69	46.31	41.98	43.00
Ash	5.52	4.58	0.97	3.94	7.50	12.66	18.55	5.34	3.53

The mines known as the Bellingham Bay coal mines are located in Washington Territory very nearly opposite those of Nanaimo, and are probably of the same geological age.

Entering the Gulf of Georgia, which for a considerable distance separates Vancouver Island from the main land by the Active Pass, we cross the forty-ninth parallel or northern boundary of Washington Territory; but a few miles north of this line is the mouth of Frazer River, upon the head-waters of which, in British Columbia, are the gold mines that caused in the year 1858 the great gold excitement in California. This river rises in about 55° north latitude and 122° west longitude, and running in a southerly direction for four hundred miles in the valley between the Rocky Mountains and the prolongation of the Cascade range, breaks through the latter at about 50°, and, flowing through a comparatively broad alluvial valley in a westerly direction, empties into the Gulf of Georgia.

I have been unable to ascertain the total amount of gold shipments made by Wells, Fargo & Company from Victoria, which would give an approximate idea of the yield of these mines; but those from the year of discovery, 1858, to the year 1861, inclusive, amounted to $3,750,111 30.‡

Howe Sound, a few miles above the mouth of Frazer River, is the first of a series of long, narrow, and deep inlets, bordered by high and rugged mountains, with which the whole coast of British Columbia and that of the southern part of the new Territory of Alaska are deeply indented.

* Vancouver Island and British Columbia, by Matthew Macfie, F. R. G. S. London, 1865.

† A qualitative analysis of this coal was made—not a quantitative.

‡ Vancouver's Island, its Resources and Capabilities, by Charles Forbes, M. D., surgeon royal navy. Victoria, 1862.

At the head of the Gulf of Georgia, Vancouver Island approaches nearer the main land, and is separated from it and the adjoining islands, first, by Discovery Passage, and afterwards by Johnstone Straits, which end near Queen Charlotte Sound, north of Vancouver.

The land bordering these channels is high, particularly on the southern shore of Johnstone Straits, where it varies from one to five thousand feet in elevation, Mount Palmerston being the highest summit, (five thousand feet.)

A few miles below Fort Rupert four beds of good coal are said to exist, and on the opposite side of the island, in Quatsino Sound, (sometimes spelled Koskeemo,) five beds, varying from three to six feet in thickness, are reported to have been found.

The inlets which occur at the head of the Gulf of Georgia, northeast of Vancouver Island, are worthy of special remark. They are from forty to sixty miles in length, from one to two miles only in breadth, and are walled with abrupt mountains from four to eight thousand feet in height, the highest being Superb Mountain, (eight thousand feet,) at the head of Butte Inlet.

According to the accurate charts of Captain Richards, royal navy, there are places in these fiords, within one-half mile or less of shore, where no bottom was found at three hundred fathoms.

Going through the narrow channel, east of Hope Island, we crossed Queen Charlotte, and entered Fitzhugh Sound and Fisher's Channel, near the head of which is the Indian town of Bella-bella. At this place the rocks are metamorphic, as shown by the regularly stratified slates occurring there.

About twenty-five miles northeast from the entrance to Milbank Sound is a high pyramidal mountain, estimated at three thousand feet in elevation, wooded to the summit, with the exception of a white streak some three hundred feet broad at its base, and extending from the bottom to within perhaps three hundred feet of the summit. This is probably the scar of an avalanche that has laid bare the rocks that have been afterwards stained white with the wash from decaying vegtable matter, though its appearance at first suggested a limestone formation.

The mountain masses around Carter Bay are apparently made up of a hard and highly quartzose granite.

The scenery in the narrow channel going north from Carter Bay is very remarkable. Huge granitic mountains rise on either side to heights estimated from twenty-five hundred to three thousand feet; in many places bare rocky surfaces are exposed, but in general they are densely wooded with evergreen trees nearly to their summits, on which, and in the shaded ravines on their northern slopes, lie patches of snow.

The winter accumulations of snow on these mountains must be very great, for their sides are furrowed with channels produced by running water, and scarred by avalanches or snow slides, which have cut huge swaths in the thick timber. Another prominent feature in this channel is the great number of cascades to be seen in passing; the larger and more imposing ones are the outflows of lakes situated high in the mountains, and but a short distance from the channel itself.

At Lawson Bay, opposite the mouth of Skeena River, the rocks are metamorphic slates, sandstones, and shales, trending northwest and southeast; some small barren quartz veins accompany the slates.

Fort Simpson, an important trading post of the Hudson Bay Company, is situated on the northern part of Chemsian Island, at the head of Chatham Sound, within a short distance of the southern limit of the new Territory of Alaska.

The islands in the immediate neighborhood to the southwest are comparatively low, though to the north and northwest high snow-capped mountains are to be seen. The rocks in the vicinity of the fort are regularly stratified mica schists, generally garnetiferous, and sometimes pyritiferous; these pass into gneiss and granite. Their trend, as examined along the shore near the fort, is nearly northwest and southeast, (mag.,) and their dip is thirty degrees to the northeast.

The schists are seamed with numerous intercalated quartz veins, in some instances highly charged with iron pyrites. According to the factor of the Hudson Bay Company at this post gold is to be found by panning almost anywhere in the vicinity; repeated trials which I made at different points, particularly in the bed of a small stream two miles northeast from the fort, failed to establish the correctness of his assertion.

On the Stachin River, one hundred and fifty miles north of Fort Simpson, which for the last thirty miles of its course flows through our Territory, deposits of auriferous gravel have been worked for several years. The principal mining camp is at Shakesville, in British Columbia, on the river, one hundred and fifty miles from its mouth. The gold is generally fine and smooth; the yield has been from two to eight dollars per day to the man, working in the simplest way with a rocker. Owing to the rigorous winter climate, depth of snow, and necessity of transporting provisions from the mouth of the river in the winter months, to afford subsistence during the spring and summer, the mining season is necessarily short.

According to information received from a Mr. Sargent, at Sitka, and fully corroborated by other intelligent parties, a remarkable cañon exists on the Stachin River, commencing a short distance above Shakesville, and extending for fifty miles further back into the interior, at places two hundred feet and over in depth, and varying from seven to forty feet in width at top, though the channel through which the river flows is wider.

According to information received from different miners, who have spent many years on the Stachin, the timber in the interior is superior to that along the coast.

On the east side of Mangel Island, near the telegraph company's station, the rocks are regularly stratified, and consist of clay slates and a micaceous sandstone.

A miner, recently from Shakesville, states that three miles above the town, on the river, is a vein or bed of good anthracite coal; this lacks confirmation.

On the islands north of the mouth of the Stachin River, and east of Sitka Island, are considerable areas of level alluvial land, particularly at the head of Mangel Straits, the narrow and intricate channel through which we passed en route for the Stachin River.

SITKA AND ADJOINING ISLANDS.

Sitka, or Baranoff Island, lies between the parallels of 56° 10′ and 57° 38′ north latitude, and the meridians of 134° 20′ and 125° 26′ west longitude. The town of the same name, at present the most populous in the Territory, is situated about midway on the western coast at the head of Sitka Bay. On the northwest side of this bay, and lying between Sitka Island and the ocean, is Edgecumbe Island. The volcano of Edgecumbe, which forms a prominent landmark for navigators in entering the Bay of Sitka, rises from the broad and gentle slope terminating in Cape Edgecumbe, on the southern part of the island.

Between the islands of Edgecumbe and Sitka are the smaller islands of Krefstoffsky and the more northerly one, Portowtschikof.

West of the town of Sitka, at the head of the bay, is an archipelago of small islands that forms an effectual barrier against the sea, but through which the approach is somewhat difficult.

The island itself is very mountainous. The summits have a peculiarly sharp and jagged appearance. Snow and ice—glaciers of limited extent—are to be seen on the flanks of the mountains in various directions.

For an elevation of at least two thousand feet the island is covered with a dense growth of evergreen trees, the principal varieties of which are the Sitka spruce, giant arbor-vitæ, and the hemlock.

Immediately behind the town, on the east side of a small stream called Indian River, Verstova Mountain, a sharp angular peak, rises to the height, trigonometrically determined, of three thousand three hundred and seventy-four feet. This, Grewingk, in his book on the northwest coast of America, incorrectly states to be the highest mountain on Sitka Island, which is one mass of rugged mountains, many of which are capped with eternal snow.

The character of the shore line is but a reproduction on a smaller scale of that of the northwest coast already described, being very much cut up by narrow inlets and deep bays.

I made, during our stay at Sitka and its vicinity, several excursions to various points, embracing a range of coast from twenty miles north to twelve miles southwest of the town.

The rocks upon which the town of Sitka is built consist of a hard conglomerate or grit, sometimes coarse, but generally fine, often passing into argillite; this formation extends from the Deep Sea, twelve miles southwest from Sitka, of which I shall speak more in detail, to the northern end of Portowtschikof, and, according to Grewingk, over the northern end of Edgecumbe Island; the island of Krefstoffsky, as well as the smaller islands west of Sitka, being composed of rocks of the same general character.

Grewingk* states (p. 20) that "the Russian engineer Doroschin found in Naquashinski Bay, opposite the island of Krefstoffsky, limestone, also silver and iron ores in remarkable quantities; more accurate information in regard to this is wanting."

I visited the limestone locality, which proved to be in Naquashinski Bay, opposite to the north-eastern end of the larger island, (which, as far as I could learn, had no name,) east of Krefstoffsky, and separated from it by Olga Straits.

No silver or iron ores were found by me, and I doubt their existence in that locality.

According to Dr. Tilling, a gentleman of high culture and of scientific attainments, large deposits of magnetic iron ore occur on the coast of Edgecumbe, opposite the island of Krefstoffsky; owing to an error in pointing out on the chart the exact position of the locality, mistaking the island Portowtschikoff for Krefstoffsky, it was not found, though some time was spent in searching for it. He afterwards corrected the error; but circumstances were such as to prevent further exploration, and the report was not verified.

About ten miles southwest of Sitka is what is known as the Deep Sea, a long and narrow fresh-water lake, ten miles in length and rarely over three-quarters of a mile in breadth. This deep lake trends northeast and southwest; is nine feet above tide-water, with which it is connected through a break in the mountains on the northwest side about midway of its length.

It discharges its surplus water into Oyerskoi Bay, an inlet making into the southeast from Sitka Bay, at the head of which is located the fishing station called the Redoubt.

The lake is bordered by high and precipitous mountains, varying by estimation from fifteen hundred to three thousand feet in height; the summits on the northeast side are generally sharp, while those opposite are rounded. Abrupt and nearly vertical cliffs of sienitic granite are to be seen near the head of the lake on the southeastern side.

At its head is a narrow valley covered with a thick growth of alders and wooded with heavy timber.

The view of the snow-capped and ice-covered mountains beyond, once the foreground of autumnal tinted foliage, and through the tops of the lofty evergreen trees, is very remarkable for its extreme beauty. I have no doubt as to the existence of an extensive glacier on its flank, though the limited time at my command did not admit of my continuing on up the valley.

The reconnaissance of the shores which I made, shows that the rock on the southeastern side is sienitic granite, while that on the northwestern is a grit similar to that at Sitka.

The line of separation seems to cross the lake obliquely; at least within one mile of the north-eastern end sienitic granite is to be found on both sides.

The origin of this deep lake is to be ascribed to glacial action; it may have formerly existed as an inlet from the ocean, and by upheaval became a fresh-water lake, a supposition not at all unlikely, for traces of volcanic action still exist on the narrow strip of land which separates its southern end from the ocean, in the hot sulphur springs occurring there. The incrustation deposited by these waters consists mainly of sulphur.

While exploring along the course of a small stream which empties into St. John Bay, north of Sitka, in the granite detritus, along its banks I found pieces of coal; these were largely intermixed with rock, to which their preservation was undoubtedly due.

In company with Mr. Harford, the conchologist of the expedition, a more extended exploration was made. Owing to the great difficulty of the traveling and unfavorable weather, we were unable to pursue investigations for a greater distance than seven miles from the mouth of the stream. It was our intention to camp for the night and explore the branches of the creek, but the impossibility of starting a fire in the drenching rain, everything being perfectly saturated with water, and our own condition from constant wading in the stream, by which alone we had been able to penetrate as far as we did, rendered this impossible, and we were compelled to retrace our steps to our camp on the bay.

*Beitrag zur Kenntniss der orographischen geognostischen Beschaffenheit der Nordwest-Küste Amerikas mit den anliegenden Inseln, von Dr. C. Grewingk. St. Petersburg, 1850.

The general course of the stream is east and west; its rise for the first four or five miles is not very rapid; along its banks are small areas of flat alluvial land, particularly near its mouth. The channel often separates into two or three, inclosing small islands on the level bottom land. The rocks *in situ* are rarely exposed, but at two points on the stream fine black shales and soft friable sandstones, without fossils, however, were seen trending approximately northeast and southwest, and inclined at a high angle. Pieces of coal, much intermixed with foreign substances, principally limestone of greater or less size, were found along the course of the stream for a distance of four miles. Highly crystalline limestone, white, streaked with gray, was also found in the detritus. The dense growth of timber, thick masses of fallen and decaying trees, covered with deep moss, thickets of the thorny shrub, *Panax honida*, and the general mountainous character of this locality, will render its future exploration exceedingly difficult.

On examination the coal found proves to be bituminous, but the bed or beds from which it was broken will, if discovered, afford coal of vastly superior quality to any heretofore known to exist in the Territory.

The eastern coast of Sitka Island presents an almost unbroken front of snow-covered mountains, showing a marked climatic difference from that of the western, the climate of which is of course modified by its proximity to the open sea, and probably by a warm current setting from the Asiatic Coast, analogous to the Gulf Stream of the Atlantic.

The only opportunity of examining the rocks on the eastern side was at Schelich Bay, on the northeastern extremity of the island, where the rock is sienite and, I judge, metamorphic.

I had no opportunity of visiting the extinct volcano of Edgecumbe, but during our stay at Sitka had several fine views of it. It is a very symmetrical volcanic cone, two thousand eight hundred feet in height. Its angle of slope is about twenty-five degrees.

According to Lisiansky the crater is three miles in circumference, and its depth two hundred and eighty feet, which Grewingk remarks is twice as large as that of Stromboli.

There is but little vegetation on its steep slope, though it is well-wooded at its base. Grewingk states that the western coast is composed principally of basaltic lava, while on the eastern shore the rocks are found to be a porous andesite or feldspathic lava, and a mixture of glassy feldspar with pitchstone, when compact resembling porphyry.

Accounts as to its activity in former times differ. Lisiansky was on the summit in 1804 and found no evidences of recent volcanic action.

Along the shores of Barlow Bay, at the northern extremity of Admiralty Island, on the east side of Chatham Straits, are numerous quartz veins. Our time there being very short and the weather exceedingly inclement, I was enabled to visit but one of them, which is exposed in the high rocky bluff on the western side of the bay. Its course is the same as that of the regularly stratified, fine-grained mica schists which inclose it, viz., northwest and southeast, magnetic dip vertical. The only metalliferous ingredient which I found was iron pyrites.

The Indian settlement Chilkaht is located at the head of Lynn Channel, on the eastern side of the western bay, the head of the inlet being divided into two bays by a peninsula projecting to the southward.

Our time at this locality was very short, but particularly interesting on account of an opportunity of visiting the extensive and beautiful glacier which issues from a narrow gorge on the west side of the channel, nine or ten miles south of Chilkaht.

After leaving the ravine it spreads itself into a vast fan-shaped mass from two to three miles broad. At its base is a low flat a quarter of a mile in breadth, made from the wash from the deposits at the foot of the glacier, which are composed of fragments, sometimes of great size, of slate, sienitic granite, and a finely crystalline, beautiful white marble.

Two moraines are to be seen on its northern slope, showing it to be made up by the confluence of at least three, and perhaps four, smaller ones.

Its angle of inclination, determined from calculations on observations made by yourself, from where it issues from the ravine to its base, is 4° 23′, the distance being three-quarters of a mile.

On the east side of Lynn Channel, stretching for twenty miles along the shore, is a lofty range of snow-covered and sharp-pointed mountains, in which every marked depression has its glacier of greater or less extent.

KADIAK, AND ADJOINING ISLANDS.

The island of Kadiak lies east of the peninsula of Alaska, between the parallels of 56° 45′ and 58°, and is separated from it by Chelekoff Straits.

The settlement of St. Paul is on the northeast coast of the island. The general appearance of the country is strikingly different from that of the coast north and south of Sitka. Though the island is generally mountainous, the valleys are broader than on the island of Sitka. The growth of trees (Sitka spruce) is apparently confined to within narrow limits, none being noticed at a greater elevation than from three to four hundred feet, and these being in groups and clusters, not covering the entire face of the country as at Sitka.

In the vicinity of the settlement of St. Paul, and along the shores to the north of it, the rocks are metamorphic, shales and sandstones trending twenty-three degrees to the west of north, (true.)

The finely-comminuted shales give to the beaches in the vicinity a peculiarly black appearance. The sandstone, which is hard and durable, is much shattered, though pieces one cubic foot in size, for building purposes, may readily be obtained.

A mile or more north of the town a small quartz vein, highly charged with iron pyrites, galena, and blende, is to be seen in the bluff along the shore. An assay of a small sample of this, made at the laboratory of the San Francisco assaying and refining works, by Mr. John Hewston, shows it to contain four dollars and some cents in silver to the ton, as well as a trace of gold.

The small island east of St. Paul, called Doljoi, also Wooded and Spruce Islands, seem to be made up of the same material as that occurring at St. Paul's. Lines of stratification in the mountains back of town, at the head of the bay to the west, are distinctly visible. It is doubtful if any volcano exists on the island of Kadiak; no evidences of it were seen in passing through the narrow straits to the north of the island. According to Grewingk, graphite occurs in small veins on the western coast.

I was informed by Captain Paul Lemascheffsky, of the Russian-American Fur Company, that lead ore, probably galena, occurs in considerable quantities in Eagak, or Orloffsky Bay, on the east side of Kadiak, latitude 57° 13′, and that a good article of roofing slate is to be found at the same locality.

ISLAND OF UNALASKA.—EXPEDITION TO AND ASCENT OF THE VOLCANO MAKUSHIN.

The shores of Unalaska, as seen from the Akutan Pass, are bold and rocky; the hills and mountains are covered with grass, but not a tree is to be seen on the island.

The eastern shore of Captain's Bay, at the head of which the chief settlement of the island, Illoolook, is situated, is formed of hills varying from one thousand to eighteen hundred feet in height, the mass of which consists of porphyries and volcanic breccia. These rocks are frequently intersected with narrow trapdikes cutting them in all directions.

The town itself is situated on a narrow strip of low land, formed of volcanic detritus, between which and the main island a small stream runs and empties into Captain's Bay.

The few days that were spent by the expedition at Unalaska were employed in an exploration and ascent of Mount Makushin, an active volcano on the northwest part of the island.

The party, composed of Dr. Kellogg, botanist of the expedition, Lieutenants Hodgson and Ball, officers of the Lincoln, and myself, started on the morning of the 7th of September, passed through the narrow passage between the long narrow island in Captain's Bay and the main island, the shores of which are entirely composed of volcanic rocks, and landed on the beach at the head of Captain's Bay.

A valley, at the head of which Makushin is located, some miles in length and at the beach one mile and one-half in width, lay before us. This gradually narrows down to one-half a mile in breadth five miles to the westward, its course being nearly due east and west. On either side, high, steep, and grass-covered hills rise to heights estimated from eight to fifteen hundred feet, the sides of which are gullied by streams from the patches of melting snow on or near their summits.

A river one hundred feet wide at its mouth, and having its main source in the snows and glacier of Makushin, winds through the valley, approaching the northern more than the southern bordering hills, and finally flows into Captain Bay, quite near the southern limit of the valley.

The alluvial land is covered with a luxuriant growth of grass, very dense and often breast high, and although much of it is a marsh, it is probably susceptible of drainage. A small willow shrub covers considerable area along the banks of the stream.

We camped for the night on the north side of the valley, four miles distant from the beach. The morning of the following day we ascended the grassy range of hills north of our camp. Opposite this point, on the southern side of the valley, is a bold volcanic range, with sharp and angular peaks, rising from a ravine which enters the valley from the southwest. Its serrated summit is marked by snow in patches, from which the water flows, marking its flanks with silver threads, which contrast beautifully with the dark frowning crags and bare rocky surfaces.

Passing over a series of slight elevations and depressions, we reached the foot of a bare conical hill, made up of volcanic ashes. The ascent was soon made, and we beheld, for the first time, a panoramic view of the surrounding country and waters: the island, with its deeply indented shores and intricate channels; its complex system of mountain peaks, with here and there a volcanic cone rising in beautiful symmetry and overshadowing the sharp and more angular summits of surrounding hills; the bold and rocky shore line, produced by the action of the water cutting the hills away at their base, causing extensive cavings and slidings—an action greatly assisted by the sharp and frequent shocks of earthquakes which occur here. Another prominent feature is the numerous trap-dikes which stand out in bold relief, owing to their superior hardness, and stretching out into the water form rocky reefs, on and over which the sea is constantly breaking. To the west, the valley, which had narrowed down at the point before mentioned, lay beneath us. The stream, which had run nearly upon a level with its banks, now tumbled and foamed through deep rocky gorges and channels which it, with its own power, had cut through the volcanic debris and lava outflows, while further west it spreads out into a fan-like form and drains the vast amphitheater of mountains which flank the grand snow-covered volcano. A glacier, with imperfectly formed moraines, curves gracefully around a sharp ridge formed by an outflow from the side, which reaches to within, perhaps, one thousand feet of the summit.

Descending this small volcanic cone, which by barometrical measurement is nineteen hundred and twenty-seven feet high, and following the summit of the ridge, we gained the side of a rocky spur which juts from the flank of the main mountain, and from thence passed to the deposits of the glacier which have accumulated in enormous quantities at its foot. The finer material is constantly being removed by running waters, leaving large angular masses of porous basaltic lava piled in heaps.

We had now gained the lowest limit of the glacier, at an elevation of nineteen hundred and sixty-nine feet.

On either side of the glacier vertical walls of lava rise from one to two hundred feet in height, which from a distance resemble huge fortifications. But little difficulty was experienced in traversing the ice, the inclination being small and the crevasses generally narrow. The line of perpetual snow was reached at an elevation of two thousand nine hundred and seventy-nine feet.

We camped for the night at an elevation of three thousand two hundred and eighty-seven feet; the thermometer stood at 34° before morning.

During the night we heard subterranean noises in the direction of the crater, and experienced a heavy gale, which threatened to carry away our tent.

To the northwest of our camp, looking across the snow-field and a wild chasm, a bold and rugged wall of lava forms the western side of a bay making in from the north.

The mist and fog rolling in from the sea made the view rather uncertain, but I am quite confident that a much deeper bay exists to the north of the volcano than is indicated upon the charts.

On the morning of the 9th, leaving our camp, we started for the summit with a good prospect for a comparatively clear day, but before 9 a. m. we were enveloped in a thick fog, and it was only by the change of slope and sound of running water in the crater that we were made aware of our final success.

The slope, which to our camp had not exceeded twelve, became much steeper, from fifteen to seventeen, and near the summit was twenty-five degrees.

The fog lifting for a moment gave us a view of the crater, two thousand feet broad by estimate, and filled with snow, in the northwest portion of which was an orifice giving vent to clouds of smoke and sulphurous fumes.

The thermometer indicated 32°, or the freezing point.

The return to camp was made by compass, the fog being so thick as to obscure objects twenty feet distant.

We reached the point on the beach from which we started on the morning of the following day, retracing with some unimportant variations the route by which we went.

The observations for elevation were made with three aneroid barometers, which, to an elevation of about four thousand feet, corresponded very closely; beyond that point one ceased to indicate, though the others continued to work satisfactorily to the summit.

The height of Makushin, as determined by these observations, is five thousand nine hundred and sixty-one (5,961) feet.

At least three extinct volcanic cones are to be seen on the peninsula northeast from Makushin volcano; one rises from the water near the entrance to and on the northeast side of Captain Bay.

On the morning of our departure from Unalaska, after passing to the south through the Akutan passage, we had a most magnificent view of the snow-covered volcanic peaks on Unimak Island, and the vast intermediate snow-fields, glaciers reaching down nearly to the sea.

The accompanying sketch gives but a poor illustration of the view, but will serve to indicate approximately the relative positions of the volcanoes, two of which are remarkable for their symmetry and height, Pogromnaja and Shishaldin.

Destruction Peak, so called from the destruction of life caused by its eruption in 1863, is between the two just mentioned.

KNOWN FOSSILIFEROUS LOCALITIES OF ALASKA—MINERAL RESOURCES—VOLCANOES AND GLACIERS.

According to Grewingk, fossils of the carboniferous age occur at Cape Beaufort, on the Arctic coast, of the jurassic period, at the bay of Katmai, on the east coast of the peninsula of Alaska.

Tertiary fossils have been collected at Sacharow and Igatskoi Bays, on the island of Kadiak, at Pawlowsky Bay, on the peninsula of Alaska; also on the island of Unalaska, at the north-northwest foot of Makushin.

Mastodon bones and teeth are found at Eschotty Bay, Kotzebue Sound, and on the Bibülow Islands in Behring Sea.

Exaggerated ideas have been formed of the *known* mineral wealth of Alaska. Beds of coal are known to exist at several localities: on the eastern shore of Cook's Inlet, on the Kenaian Peninsula, all the way between Fort Nicholas and Tschuwatichick Bay, are two coal beds visible at low water, which are said to be from four to five feet in thickness.

I am indebted to Captain Paul Lemascheffsky, of the Russian-American Fur Company, for the following information: On the coast of the peninsula of Alaska, opposite the island of Kadiak, latitude 58° 10′, longitude 154° 17′, is a bay in which the company's steamer Constantine, under command of Captain Luidfoos, anchored, in 1865. He found there a vein of good coal, two feet in thickness.

On the island of Unga are two workable beds, one of twenty-six inches, the other of thirty inches in thickness, according to the measurements made by Mr. Shröder (an employé of the Russian-American Company) for the Russian government. They are exposed in a high bluff, and are inclined at an angle of eight degrees.

Coal is also known to occur in the neighborhood of Cape Beaufort, on the Arctic Ocean, and it is probably of good quality, but its position is such as to render it of no commercial importance.

The coal from Cook's Inlet and the island of Unga is of known poor quality, being nothing more than lignite, and is of the most recent geological age. With regard to that on the peninsula of Alaska, accounts are contradictory, but the probability is that it will be found to have had a contemporaneous origin, and to be of the same lignitic character.

The entirely different character of the pieces recently found on the island of Sitka would induce the expectation of the ultimate discovery of coal on that island of an earlier geological age, similar to that found at Nanaim, and on Queen Charlotte Island, further south.

Extensive deposits of iron ore are reported, though none as yet are known to have been found.

I received from Mr. Kadin, in Sitka, some small specimens of galena, said to have been brought by the Indians from Whale Bay, about twenty miles south of Sitka.

Gold.—It is doubtful if gold occurs on the Stachin River, within the limits of the new Territory, in sufficient quantity to pay for working. Its existence is reported on the Takoo River, north of the Stachin; on the Copper, and with more certainty on the Kaknoo River, the mouth of which, on Cook's Inlet, the Russian fort St. Nicholas is located.

Copper.—Masses of metallic copper, many pounds in weight, have been brought from Copper River, though little or nothing is known of its original locality; expeditions which have been undertaken for the exploration of that river having either been driven back, or the members murdered by the Indians.

As far as could be ascertained, no silver ores, proper, have been yet found in the Territory; at least in such quantity as to give promise of profitable working.

It is to be remarked here, that considerable dfficulty was experienced in ascertaining facts in regard to the localities of ores, minerals, &c., either on account of the extreme reticence on the part of the Russians, induced by the hope of future personal gain, or by the restrictions under which they may have been placed.

A volcano on the northern part o Prince of Wales Island, latitude 56° 10′, is the commencement of a series of volcanoes extending along the coast a distance of two hundred and fifty miles, culminating in Mount St. Elias, the elevation of which, as given on the chart, is 14,970 feet.

On the western side of Cook's Inlet is the commencement of another series, Goryalaya and Illiaminsk Mountains, respectively 11,270 feet and 12,066 feet in elevation, which stretches to the southwest, forming the peninsula of Alaska and the long chain of Aleutian Islands, extending far towards the peninsula of Kamtschatka. The trend of the rocks, both on the western coast of British Columbia and of the southwestern part of Alaska, as also those east of the peninsula of Alaska on the island of Kadiak, is parallel to these two great lines of upheaval.

Glaciers, which have played such an important part in the configuration of the northwest coast, cutting it up into such a vast labyrinth of channels and islands, are quite numerous along the coast and inland waters north of Sitka Island; these, perhaps, attain their grandest proportions on the flanks of Mount St. Elias, where, I am told, there is one thirty miles in width, reaching to the sea.

The lowest known limit of existing glaciers on the coast is at the head of the narrow inlets to the east of Fort Simpson, inBritish Columbia, latitude 54°, approximately.

APPENDIX F.

SAN FRANCISCO, CALIFORNIA, *November* 29, 1867.

DEAR SIR: I submit herewith a report of the collections made by me in the various departments of natural history. The limited time previous to your departure for the east prevents a more complete report from being made, and also renders it impossible to identify all the species collected.

The birds, fishes, &c., are sent forward as collected, the localities in each case being correctly given and attached to the specimens. The mollusca, being more particularly within my department of study, are, with the exception of three or four species, identified and properly labeled according to the present standard, and conforming to the labeling of the collection of the California Academy of Sciences; the collection of the State Museum, made by the geological survey of this State; and the private collection of Mr. R. E. C. Stearns, of San Francisco; to the latter gentleman, to Dr. J. G. Cooper, and to Professor J. D. Whitney, State geologist, I gratefully acknowledge attentions and facilities afforded to me in making up the list of shells.

It is unnecessary to remind you that the limited number of species and specimens collected at the various points at which the Lincoln stopped is due to want of opportunity and the unfavorable condition of the weather and the tides.

The conchological collection is not without interest, as we have detected several of the boreal forms of the north Atlantic, and a few species identical with the species of the northeast coast of North America.

I regret exceedingly that the collections are so meager.

In closing, permit me to acknowledge the consideration and kindness which I have met with from yourself as chief of the Coast Survey party in this expedition.

Very respectfully, your obedient servant,

W. G. W. HARFORD,
Aid United States Coast Survey.

GEORGE DAVIDSON, Esq.,
Assistant United States Coast Survey, San Francisco, Cal.

List of shells collected—W. G. W. Harford, Collector.

1. Saxicava pholadis, (Linn.,) var. arctica; Sitka, Belabella, Kadiak, Unalaska.
2. Mya arenarid, (Linn.;) Kadiak.
3. Schizothæries Nuttalii, (Cour.;) Sitka, Kadiak.
4. Machæra patula, (Dixon;) Kadiak, Unalaska.
5. Macoma naseeta, (Cour.;) Kadiak.
6. Macoma inquinata, (Desh.;) Fort Simpson, Belabella, Kadiak, Spruce Island.
7. Macoma inconspicua, (Br. and Sb'y;) Fort Simpson, Chilkaht, Kadiak, Spruce Island.

7ª. Maera Salmonea, (Cpr.;) Kadiak.

8. Standella planulata, (Cour.;) Kadiak, Unalaska.
9. Tapes staminea, var. Petitu, (Desh.;) Fort Simpson, Chatham Sound.
10. Tapes staminea, var. ruderata, (Desh.;) Fort Simpson, Carter's Bay, Sitka, Belabella, Kadiak, Spruce Island, Unalaska.
11. Saxidomus Nuttalii, (Cour.;) Fort Simpson, Carter's Bay, Sitka, Kadiak.
12. Cardium corbis, (Mart.;) Sitka, Belabella, Carter's Bay, Kadiak.
13. Cardium claudum, (Gould;) Sitka, Kadiak, Unalaska.
14. Serrapes grœnlandicus, (Chem.;) Kadiak, Unalaska.
15. Kellia laperousii, (Desh.;) Unalaska.
16. Lasea rubra, (Mont.;) Sitka.
17. Mytilus edulis, (Linn.;) Fort Simpson, Carter's Bay, Belabella, Sitka, Kadiak, Spruce Island.
18. Modiola modiolus, (Linn.;) Sitka, Unalaska.
19. Modiolaria lævigata, (Gray;) Unalaska.
20. Acila castrensis, (Hinds;) Sitka.
21. Placunanomia machochisma, (Desh.;) Kadiak, Unalaska.
22. Helix columbiana, (Lea;) Sitka, Chilkaht River, 59° 9′ north.
23. Helix vancouverensis, (Lea;) Sitka.

23ª. Helix, (Sp.;) Unalaska.
23ᵇ. Helix; Sitka, Unalaska.
23ᶜ. Vitrina glauca (?); Unalaska.
23ᵈ. Yua lubrica, (Mull;) Sitka, Kadiak.

24. Siphonared (probably) thersites, (Cpr.;) Fort Simpson.
25. Katherina tunicata, (Wood;) Sitka.
26. Tonicea lineata, (Wood;) Fort Simpson.
27. Tonicea submarinored, (Midd;) Fort Simpson.
28. Mopalia muscoza, (Gould;) Vancouver's Island.
29. Mophalia wossnessenski, (Midd;) Fort Simpson.
30. Mophalia lignosa, (Gould;) Fort Simpson.
31. Acinæa patina, (Esch;) Kadiak, Fort Simpson, Unalaska, Sitka.

32. Acinæa pelta, (Esch ;) Sitka, Kadiak, Unalaska.
33. Scurria metra, (Esch ;) Sitka.
34. Glyphis aspera, (Esch ;) Sitka.
35. Haliotes kamtschatkana, (Jonas;) Sitka.
36. Calliostoma costalum, (Mart.;) Sitka.
37. Margarita papilla, (Gould;) Fort Simpson, Belabella, Unalaska.
38. Margarita helicina, (Mont. ;) Unalaska.
39. Phorcus pulligo, (Mart. ;) Sitka.
40. Crepidula grandis, (Midd ;) Captain's Harbor, Kadiak, Unalaska.
40a. Crepidula navicelloides, (Mutt ;) Belabella.
41. Bittium filosum, (Gould ;) Fort Simpson, Carter's Bay, Belabella, Sitka.
42. Littorina sitkana, (Phil.;) Chatham Sound, Carter's Bay, Belabella, Sitka, Kadiak.
43. Lacuna solidula, (Leon ;) Unalaska.
44. Isapis fenestrata, (Cpr. ;) Unalaska.
45. Natica clausa, (Br. and Sb'y;) Fort Simpson, Kadiak, Unalaska.
46. Lunatia pallida, (Br. and Sb'y;) Captain's Harbor, Unalaska.
47. Prime oregonense, (Redf. ;) Unalaska.
48. Amycla gausapata, (Gould ;) Fort Simpson.
49. Amphissa corrugata, (Roe ;) Fort Simpson, Carter's bay.
50. Purpura crispata, (Chem. ;) Fort Simpson, Belabella, Lawson's Harbor, Carter's Bay, Sitka.
51. Purpura canaliculata, (Ducl. ;) Chatham Sound, Carter's Bay, Belabella, Sitka, Kadiak, Spruce Island, Unalaska.
52. Purpura saxicola, (Val. ;) Unalaska.
53. Purpura saxicola var. fluscata, (Tb's. ;) Fort Simpson, Carter's Bay, Belabella, Sitka.
54. Ocinebra interfossa, (Cpr. ;) Carter's Bay, Belabella, Sitka.
55. Cerastoma foliatum, (Guel ;) Belabella, Sitka.
56. Trophon multicostalus, (Esch. ;) Unalaska.
57. Chrysodomus dirus, (Roe ;) Chatham Sound, Fort Simpson, Carter's Bay, Belabella, Sitka.
58. Chrysodomus liratus, (Mart. ;) Chilkaht, Kadiak, Unalaska.
59. Volutharpa ampullacea, (Midd. ;) Unalaska.
60. Volutharpa, (?) (species ;) Captain's Harbor, Unalaska.
61. Fusus, (species;) Kadiak.
62. Buccinum, (?) (species ;) Fort Simpson, Belabella, Sitka, Kadiak, Unalaska.
63. Yoldia, (species ; Stomach of Halibut;) Kadiak.

APPENDIX G.

[From Lisiansky's Voyage Round the World in 1803, 1804, 1805, and 1806.]

Vocabulary of the languages of the natives of Kadiak, Unalaska, Kenai, and Sitka.

NOTE.—In the vocabulary of Unalaska the letters *nh*, printed in italics, and *k* and *n*, when final letters, should be half sound only. The inhabitants of this country have this singularity that they pronounce the *th* with the same facility and precisely like the English. The Sitkans observe three tones in every word of length, of which the middle one is the lowest. The language of Kenai is very difficult to be expressed; *k*, with an asterisk preceding it, has a sort of double sound, not unlike the clucking of a hen.

English.	Unalaska.	Kadiak.	Kenai.	Sitka.
A.				
Apple tree				Kootst.
Arrow	Ahathak	Hok	Iz-zeen	Choonet.
Autumn	Sakoode Ki*nh*am	Ooksvoak	Nak-16	Takooneehaté.
B.				
Bad	Machheedolekan	Aseelnok	Tsooheelta	Sliakooshkó.
Bargain	Toomhidada	Youoho		Naoo.
Basket	Abiahatsak	Haggek	Hakki	Hinahkakaakee.
Basin	Kalukak	Aludak		Tseek.
Bath		Maggeyveek	Nallee.	
Bathe yourself	Keecheeheeda	Hohé		Etashooch.
Bay, the	Oodok	Kanhiak	Botnoo	Key.
Bear	Tanhak	Pagoona	Hank-ta	Hoots.
Beat	Toovvada	Ahtoho	Neelchah	Chok.
Believe	Looceda	Ookheekeen		Klehakek avaheen.
Belly	Sanhoon	Akechka	Schboot	Kayu.
Berry		Keeoolhet	Kakká	Knatagget
Birch tree		Kadzouleek	Tshoo*kia	Attaggé.
Black	Kahchehzeek	Toonhoohalee	Taltashé	Toochahetó.
Blackberry	Ooneehnok	Tshoovavak	Kaantsa	Kanettá.
Bladder	Sa*nh*ook	Keelmak	*Kbis..	Athooktee.
Block of wood	Yahamkaka	Kobohak	Keyheytsakh	Shaak.
Blood	Amak	Aook	Kootaalthin.	
Board	Aleiok	Alcku	Opitgaaló	Ta.
Boots	Oleeheek	Peenadeek	Sestlia	Hvon.
Bow	Saeheek		Tsalthan	Saks.
Boy	Anektok	Tanohak	Ts*kanik-na	Hattakoo.
Bracelets	Tameek	Talik vahhat		Chicatooh
Bragger, a	Adaluke	Sahkvatoolee	Htahootetnash	Hatektsaátee
Brave	Ehatooleekan	Chak fiak	Astsa*kan	Hikaaká.
Brother	Aheetoken		Kallá	Ahhonoh.
Brother, eldest	Luthan	Angaha.		
Brother, youngest	Kee*ah*een	Oouaga.		
Burn		Kvahkaho	Teenhkiutó	Kaheekan.
Bush		Iliahenot	Kankya.	
Buy	Akeeda	Youoho		Hanasliahoon.
C.				
Canoe	Ek-yak	Palayak	Ktsekooa	Yakoo.
Cap	Chahoodak	Shaliohnok	Stcheekeetsá	Saahva.
Catch	Sooda		Inlhkit	Alshit.
Cheat	Adalúceda	Eklunváho		Kooltooehiheneska.
Cheek	Oolloohak	Taholakok	Shinkoosha	Kavvosh.
Child		Oodzveelhak	Shareehkahan	Tookonahee.
Chin	Inlakoon	Tamelok	Shtoonee	Kakatatsahi.
Come here	Athemeenahkada	Tykeena maoot	Oontsa	Atkoon kehekoot.
Copper	Kannooyak	Kanooya	Choochoona	Esk.
Cough		Kooek	Khas	Iskohok.
Coward	Ehatoolik	Mamoo keelnok	Chaitsk	Kootliahitchan.
Cry	Kithada	Keya	Nehah	Kaah.
Cure	Oohaeda		Shtatnooliah	Ootoohanakoo.
Cut, a	Teenoonhaseeteé	Kiléhtok	Hootnaanltoo.	
Cut down	Toohoda	Chaggidzu	Kitsalg	At-hoot.

Vocabulary of the languages of the natives of Kadiak, &c.—Continued.

English.	Unalaska.	Kadiak.	Kenai.	Sitka.
D.				
Dance	Aiuhahada	Seelga		Atieh.
Darkness	Kahihakaiuleek	Tamleek	Heelhaklé	Knoocheekeet.
Day	Anneliak	Ahanok	Chaan.	
Day, to	Vanaeeneliak	Aganahoák	Chaan	Ittat.
Devil	Ahlikay	Yack	Tskannash	Tseekiekaoo.
Die		Togoo	Cheennah	Eenena.
Dig	An*h*oobeda	Hahoo	Kookeelia	Ekahek.
Dog	Aykok	Piuhta		Kekle.
Door	Aheelrek	Ommeek	Tooka*k	Voldt-haak.
Down, lay it	In*h*anoonahada	Ley hue	Neeneeltalh	Chavveke.
Drink	Idhootsiá	Tanha	*Keet-noo	Itanná.
Drown		Keeten	Tgataalnan	Ootahoo.
Dry	Keechheeda	Keenhtsiaho	Nooletsooh	Kahook.
Ducks	Sakeedak	Saholheet	Tinaaltga	Kaoohoo.
E.				
Eagle	Tehlok	Koomaheak	Youkh	Chyak.
Ear	Tootoosak	Chiune	Stseel-oo	Kakook.
Ear-rings	Neetokák	Akhleetot	Stsakeel-a	Ahkookootlee.
Ear-rings for the nose	Suklook	Mydak	Sneeh-a.	
Ears	Tootoosakeen	Chiudok	Noolteehastseel-oo.	
Earth	Chekeke	Nooná	Alshnan	Sleenkeetaanee.
Eat	Kada	Peedoho	*Keeoolh	Hha.
Ebb	Agook	Keendok		Hinnahlene.
Eggs	Samlokamnaholik	Manneet		Kooto.
Ermine		Ameetadook	Kaholgena	Taa.
Evening	Anneliak Kin*h*an	Akfoak	Haalts	Hanna.
Eye	Thak	Inhalak	Shnash-a.	
Eyebrows	Kamteenchnáneen	Kablute	Sheentook	Kaatsá.
Eyelids	Thankah-senee	Koomoogaenga	Snoutootsa	Kaokahekhoo.
Eyes		Inhaliok	Shnashaika	Kavvák.
F.				
Fall, let	It-heeda	Ihtshu	Nootthilneeh	Nakeek.
Farewell	Ang-an	Hvy-ey	Nootheetoosh	Tekooshkee.
Father	Athak	Adaga	Tookta	Kyesh.
Father, a grand	La-Tohen	Abaga	Chata	Ahleelhkoo.
Father-in-law		Chaggiga	Shpatsa	Ahgoo.
Feather	Samaká	Chooluke		Taoo.
Fever		Oknehvahtok		Kootsiti-iet.
Find	Ilhada	Igoohoo	Nooinlheesh	Akakooshee.
Fingers	At-hooneen	Svaánga	Slutska	Katlek.
Finger, fore	Choohvahozik	Teekhá		Katlehonee.
Finger, middle	Teeklok	Agoolpaga		Katlehtlen.
Finger, third		Ahanovyaha		Katlaekakoo.
Finger, little	Icheelokacheedon	Iggelekogá		Kavoonkachek.
Fire	Keyhnak	Knok	Taaz-ee	Haan.
Flood	Chehdootoóleek	Tooneehtok		Takeenatén.
Flower	Chehogniac	Pateehnet.		
Fool, a	Dahkaheholuke	Oosvilnok		Khleakooshké.
Foot	Keetok	Jo-oga		Kahooss.
Footstep	Cheemek	Toomeet		Kahoosieté.
Forehead	Tannyak	Tatka	Sheent-hooboonoo	Kakah.
Fox	Ookcheen	Kabiák	*Kanoolsha	Nakatsé.
Frost	Keychók	Nunhlá		Koossaát.
G.				
Gather	Tahseda	Aohkee	Inhtat	Kooteet.
Get up	Ankada	Nanhahtoon	Htaneelcheet	Keetan.
Girl, a young	Achadok	Aggeahak	*Keisen kooya	Shaact.
Give		Taho	Shla*kanhoot	Ahcheeté.
Give me to drink	Teen taanak chheda.	Tanhamook cheeggeedna.	Hashnoosheet-ye	Atevat-heen.
Give me to eat	Teen achhooda	Nakmeek cheeggidna.	Hashoolhinda	Ahchatneté.
Go	Icha	Keada	Htsaneeltooh	Kooshté.

Vocabulary of the languages of the natives of Kadiak, &c.—Continued.

English.	Unalaska.	Kadiak.	Kenai.	Sitka.
Go away	Inahanehooda	Aooha	Tsaneeltoosh	Ahkootsoohoo.
Go, let	Ihneeda	Peedzu		Cheennah.
God	Ahoh	Ahyun	Na*kteltaanó	Els.
Good	Mach-heeseleek	Aziglee	Pohallen	Tooaké.
Gown or Parka	Sakeen	Atkook	Shtak-a	Koototst.
Gown made of intestines.	Cheechdan	Kanahluk	Keystah-a	At-hoshtee.
Grass	Keyhak	Booit	*Katshan	Chookván.
Green	Chidhaiok	Choonhahlee	*Kteelt-heen	Neeheentecahenté.
Gull, a sea	Slookak	Kadaiat	Baach	Kekliatee.
Guts	Anhek	Kelut	Shintsika	Kanassi.
H.				
Hail	Tahenem daks keetoo.	Kouhdat	Choochoon kalt*ka	Katetst
Hair	Imleen	Neoet	Stseahoo	Koshahaoo.
Hand	Chian*h*	Taleha	Shcoona	Kacheen.
Head	Kamhek	Naskok	Shangg-e	Ashaggee.
Healthy	Anhahaseehelek	Chacheedok	Pohallen	Klekahluneekoo.
Heart	Kannuheen	Oongooatagá	See*ktee	Cateh.
He or she	Ikoon	Ooná	Hhoon	Youta.
High	Kaelik	Kanahtoolee	Treélhnoz	Klyahie kooleeké.
Hill, a small		Poonhok mihienok	Koonalthishi	Koocha.
Hold your tongue	Toonook Talhada	Nuhneelu	*Ktooteelcheet.	
Hook, a fish	Imhazeen	Sagoliak	Ekshak	Shalhootet.
House, a	Oollon	Naa or Chekhliok	Youiah	Hent.
How much	Kannahen	Kouhcheen	Toonaalt-hé	Koousa.
I.				
Iron	Komly ahook	Chyavik	Tayeen	Kayez.
J.				
Just	Adaloohooluke	Eklunoinok		Klekilhyitnek.
K.				
Knee	Cheedheedak	Chiskoohka	Scheesh	Kakeeh.
Knot of a tree	Yahhoomtalee	Avyak	Kzeekna.	
Know, do you not, me.	Teen ahkatahkoh-teen-ee.	Nalsvahpoon haka	Heet a shitneetoo	Hateesekooggé.
L.				
Lake	Hanyak	Nanooak	Ban	Aaká.
Leaf	Yahamoleé	Pelu	*Kat-coon	Kahanee.
Lie, to		Eklu	Heentseet	Hataakeehoon.
Light	An*h*alyak	Aggiek	Keetsool	Ooteckaan.
Lion, a sea	Kavooak	Adahluk	Atahhlut	Taan.
Lips	Athek	Hluhká	Ezak	Kahak-a.
Liver	Ahhek	Aunga	Sezzeet	Kakeykoo.
Live, where do you	Kananhoon a-koothin.	Nanee-cheet	Ndah tokee-eetgan	Kooksehheté.
Loose	Ihkeecha	Tamaho	Keeliahtoonah	Kotooveeh.
Louse	Keetok	Naaeta	You	Betst.
Low	Kasloken	Achahkeelnok	Tzeelhkats.	
Lungs	Hoomehek	Kamaganok	Stsat-tska	Kakahakoo.
M.				
Men	Tayaho	Shook	Teenná	Chackleyh.
Mat	Sootok	Pehat		Toots.
Moon	Tooheedak	Yaalock	Ne-ó	Teess.
Morning	Keelyam	Oonoak		Keskhé.
Morrow, to	Kelliohen	Oonoago	Neelkoonda	Sekanneen.
Moss		O-ot	Naan	Tsikahá.
Mother	Annak	Anaha	Anná	Aklee.
Mother, grand	Kookan*h*	Maga	Choota	Ahlilhkoo.
Mother-in-law	Satemheen		Sh-o	Ahchaan.
Mountain	Koothook	Poonhok anhlee	Teheylé	Shahata.
Mouth	Aheelrek	Kanok	Shnaan	Kak-e.
Murderer	Aleet-hoozok	Tohodgisnooleé	Cheekilhuhe	Chakooté.
Muscles	Vyhak	Kabeeliot		Haak.

Vocabulary of the languages of the natives of Kadiak, &c.—Continued.

English.	Unalaska.	Kadiak.	Kenai.	Sitka.
N.				
Nails	Kaahelren	Stoonga	Skanna	Kakahoo.
Neck	Oouk	Ooyakoga		Kasetá.
Needle	Inukak	Meenhon	*Klean*kheen	Taakatel.
Nephew	Omnin	Ootsooga	Shooja	Ahkeelk.
Net, a fish	Koozmahek	Agaloo	Tahveelh.	
Night	Amak	Oonuke	*Kaa*k	Taat.
Nose	Anhozin	Keenaga	Tsanalleetga	Kaclu.
Nostrils	Anhozin Hookik	Padzifahka	Shneek	Kaslutoo.
O.				
Oar	Ahkadvoozeek	Chaheeyoun	Khaneetsté	Ahhá.
Old	Ollek	Kaneehlak	Keychee	Ooteeshen.
Otter, a river	Aakooya	Aakooya	Tact-him	Kooshta.
Otter, a sea	Cheenatok	Ahná	To*k-es	Youhch.
P.				
Palm of the hand	Chankala	Toomága	Slya¹ka	Kachentak.
Pay, to		Nalsyaho	Kiusbilhnah	Agakenesnee.
People	Tayahoumnaholeeh	Shoot	Koht-ana	Hsleenkeet.
Pillow	Kan*h*eetak	Aggin	Tset-aazdeen	Shehet.
Pine fir		Anknahaleet	Tspaalla	Aasé.
Plant, to	It-heeda	Lseelahkee		Tankanakoo.
Play, to	Meehkada	Vooamee	Cheenleool	Achkoolhiat.
Poor	Itonasak	Nakheenahalee	Pa*khool	Slshaan.
Poplar tree		Cheehoo	Esnee	Tokoo.
Porpoise	Alladok	Manhak	Koousheó	Chee-each.
Pregnant	Idmaheleek	Aksaluke	Halkhoon	Hetehahoo.
Q.				
Quick	Ayahohodooleek	Choogalee	Naheylhkeet	Chayoukoo.
Quilt, a bed	Kallooheen	Oolik.		
R.				
Rain	Chehtak	Kedok		Seevva.
Raspberry	Halohnak	Alagnak	Koolhkaha	Kleakoo.
Raven	Kalkahyon	Kalnhak	Cheenahla	Els.
Red	Oolluthak	Kaveeglee	Tahalteley	Hanlaheté.
Reindeer	It-Hayok	Toondoo	Patchih	Tavvé.
Rejoice	Kaanooda	Noonaneehsaha	Nookooeelthoonh	Nashook.
Rich	Toohkooleek	Kaskok	Kashkaulan	Antlinkintee.
River	Chébanok	Kooyk	*Katnoo	Hateen.
Roe of fish	Kamheesoo	Chijoot or ahmajoot	Kin	Kaakoo.
Roof	Oolankamoo*nh*een	Padoo	Kan*ka	Hanatané.
Root		Nooggihluke	Chan	Ahbaátee.
Rope	Oomnak	Cavahtsee	*Keelh	Tikh.
Rude	Koosootooleek	Kamanahlee	Tggeeknash.	
S.				
Sack, a		Haggek	Oolks	Koelh.
Sand	Choohok	Kabea	Soohoo	Klue.
Sea	Allaook	Eemák	Noot-hé	Teyké.
Seal, a	Izok	Izuik	Kootsaheyls-é	Tsa.
Sell	Nooahada	Aggeechakue		Ihoon.
Send	Ahkáneeda	Tyskue		Koonaká.
Shoot	Toomheda	Peedeedzue	Teehkat	Atoont.
Sick	Takeehzeek	Knal-ha	Cheennah	Haneekoo.
Sing	Oonuhada	Atoová	Katalyash	Atkashee.
Sister	Oon*h*een		Ootalla	Ahklyak.
Sit down		Agomee	Neetsoot	Kannoó.
Sky	Innyak	Keliok	Youyan	Haats.
Sleep	Sahada	Kahvá		Nattá.
Slow	Aiahohlokan	Chookalnok	Tsoonaheylkeet	Takeynah.
Slumber		Kavahanee	Neeltseelh	Ahekho.
Snow	Kanneeh	Annué	Ajjah	Kleyt.
Snuff	Ihdooteen	Proshka	Ktoona.	

Salt Lagoon

Etl-aku

Vocabulary of the languages of the natives of Kadiak, &c.—Continued.

English.	Unalaska.	Kadiak.	Kenai.	Sitka.
Soft	Ka*nh*a Heydoloken	Oonelnok		Katlyaheté.
Son-in-law	Naahoon	Neengouga		Ahcehoh.
Spark	Keyhnak Kalmeeh-zeek.	Kalski	Chatalahi	Heektlya.
Spoon	Tahozek	Alugoon	Spata	Shelh.
Spring	Kaneekee*nh*an	Oobnohkak	Klek	Takooité.
Stars	Stan	Ageke	Sceen	Kootahanahá.
Steal	Chhada	Teegleeha	*Knazzeen	Ataoo.
Step	Keeton Keydhoneen	Toomeenha		Kakoostak.
Stick	Ayaook	Pekhodák	Tgats	Knats.
Stone	Koovvanak	Yamak	Kaleekneekee	Té.
Straight	At-hádeehaleek	Nalekeeglee	Tsehalkhé	Klyakavoostiek.
Strong	Kayoutooleek	Tookneelee	Talt-hey	Hleetseen.
Summer	Saakoodak	Kiek	Shaan	Kootaan.
Sun	Abhapak	Madzak	Channoo	Kakkaan.
Swim	Hoochihada	Quima	Niba	Echkootetecha.
T.				
Tail	Samchehcheheteen-ee*nh*.		Pka	Koohoó.
Take	Suda	Tehoo	Ilhkeet	Shee.
Take away by force	Ilyasuda	Aloodzhu	Ktooshecheet	Ashtseet-henesnee.
Tear	Oo*nh*áseda	Chaktaho	Chaanhklut	Astcheetoot-hoot.
Teeth	Keahoozeen	Hoodeit	Shreek-ha	Kaooh.
That		Ooná	Keenee	Eta.
That is mine	Vaya-myou*nh*	Hvy Pigá	Shish-iti.	
That is yours	Inne-yemayou*nh*	Hvy Ispitpin	Non-iti.	
Thief	Chhaaheleek	Tooglunagalee	*Kaneesh	Ataootsaté.
Thin	Annatoolookan	Ameelnok	Trelteet	Klyahiekoossá.
Thread made of the intestines of the whale.	Ihachahsyak	Keepak	Kattsah	Tehkatassé.
Throw	Anooséda	Idzhoo	Yatsteeltuh.	
Thumb	Hooták	Kamlugá	Slukts	Kaakoosh.
Tongue	Ahnak	Oolue	Stseelue	Katnoot.
Touch, do not	Anehtaganan	Chagnilu	Tgaa.	
Touch me, do not	Teen anehtahanok	Chahin nilnha	Ltoosilhan	Henka tetsen.
Tree	Yahak	Kobohak tsbalakua	Tsbalacooya	Shaak.
U.				
Urchins, sea	Ahoknok	Ootoot		Neets.
V.				
Valley	Chanhanak	Maak		Shecheekeeka.
Vein	Ya-meekhap	Noogak	Tsah	Tass.
Venereal		Idoonak	Tsooeestat	Katluke.
Volcano	Kiehozim Keegnáhee.	Inhyak	Tokoge-hnoohalley.	
W.				
Walk		Quinhdeen	* Kanoontoosh	Haacacoo.
Wash	Cheoohoda	Ohtokó	Tnoonleah	Naootst.
Water	Tanak	Tanak	Veelhneé	Ieen.
Weak	Kauhaleeken	Toolneelnok	* Ktakhooleen	Klekhleetseen.
Wet	Chahtakohalik	Moodzok		Ooteekek.
Whale	Allok	Agvok		Yaaga.
What		Chashtoon	Tsatoo	Vasaet.
What are you afraid of.	Alkok Ehagteleetheen	Chay aleeksiu	Tsatsaeentsk.	
What is your name		Namathoon	Nteeneegee	Coosisaggé.
Where are you going	Kananoomeen	Natmenayouit	Ndah teenue	Kootéseheena kooh.
Where were you	Kanaliok Teleetheen.	Nahin puden	Ndah toozitoo	Kooteseheekooteen.
White	Oommeleek	Katogalee	Talkaé	Kletyaheté.
Why	Alkomeen	Chalooden	Tsatskoo	Takotkaasa.
Wide	Slakseek	Ayanahtooleé	Trelt-han	Klyakié-koohoo.
Wind	Kycheek	Kyauk	Kakneeoon	Keelhcha.
Winter	Kanák	Ookseeok	Hhee	Taakoo.
Wipe	Kidhooda	Alshue	Knin*kash.	

Vocabulary of the languages of the natives of Kadiak, &c.—Continued.

English.	Unalaska.	Kadiak.	Kenai.	Sitka.
Wise	Akamkahek	Oodzveetoolee	Heet-aneezzan	Hakootsekó.
Wizard	Koohok	Tonanok	Chaanchoo	Eht.
Woman	Anhahenak	Aganák	Mokelan	Shavvot.
Work	Avvada	Chená	Heetnoo	Echenené.
Wound		Keeye	Skoo*kha	Eeyetó.
Y.				
Year	Elok	Cheeoolek	Shantto.	
Yellow	Madelohnok	Choonhahlee	Taltsahé	Kandgcheenyahenté.
Young	Soohonazak	Soonhak	Kooteehazalheen	Isvat.
NUMERALS.				
1	Atoken	Ataoodzek	Tseelgtan	Klek.
2	Arlok	Azlha	Nootna	Teh.
3	Kankoo	Peengasvak	Too*k-e	Notsk.
4	Seecheen	Stameek	Tan*k-e	Tackoon.
5	Chaan	Taleemeek	Tskeel-oo	Keecheen.
6	Atoon	Ahoi-lune	*Koojtonee	Ketooshoo.
7	Oolloon	Malehonheen	Kants-e-hé	Tahatoushoo.
8	Kancheen	Inglulun	Ltakool-e	Neetskatooshoo.
9	Seecheen	Koolnhooen	Lkeetseet-hoo	Kooshak.
10	Atek	Koolen	*Klujoon	Cheenkaat.
11	Ateem atoken seehnohta.	Athahtok		Cheenkaat avanhak klek.
12	Ateem arlok seehnota.	Malhognook		Cheenkaat avanhak teh.
13	Ateem kankoo seehnota.	Pingu-you-nook		Cheenkaat avanhak notsk.
14	Ateem secheen seehnohta.	Stamanook		Cheenkaat avanhak tackoon.
15	Ateem chaan seehnohta.	Talee-manook		Cheenkaat avanhak keecheen.
16	Ateem atoon seehnota.	Ahoyelooggenook		Cheenkaat avanhak ketooshoo.
17	Ateem oolloon seehnohta.	Mals-honheenook		Cheenkaat avanhak tahatoushoo.
18	Ateem kancheen seehnohta.	Inglu lugnook		Cheenkaat avanhak neetskatooshoo.
19	Ateem secheen seehnohta.	Kooln hooyanook		Cheenkaat avanhak kooshak.
20	Alhatiah	Koolnook or svinák	Tsilhatna	Klek-ka.
30	Kankoodem atek	Sveenák koolnook azluke.	Toot klujoon.	
40	Seecheedem atek	Sveenák mallok	Tange klujoon.	
50	Chaanheedeematek	Sveenák mallok koolnook pin ha youlook.	Tskil-oo klujoon.	
60	Atoonhidim atek	Sveenet pinhaion	Koojts klujoon.	
70	Oolloonheedeem atek.	Sveenet pinhaion koolnook.	Kankehoh klujoon.	
80	Kancheenheedeen atek.	Sveenet staman.		
90	Seecheenheedeem atek.	Sveenet staman koolnook.		
100	Seesak	Sveenet taleómaloot	Tgastlun.	
200	Alhim seesak	Sveenet kooleen.		

APPENDIX H.

Meteorological abstract for Sitka from 1847 to 1862.—Rain and melted snow fall at Sitka, in inches, with the number of days upon which rain, snow, or hail fell, or when thick fog prevailed.

COMPILED BY GEORGE DAVIDSON, ASSISTANT COAST SURVEY.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total inches.	Yearly rain and snow.	Total rainy days.
1847. Rain	(a)	....	....	....	2.20	2.50	2.80	3.25	10.00	8.65	5.45	4.95	39.80		
Snow	(a)	....	....	....	0	0	0	0	0	0	1.41	3.20	4.61	(h)44.41	
Rainy days	(a)	....	....	....	(b) 13	19	17	17	23	23	25	26			(h) 163
1848. Rain	7.75	1.30	1.60	7.15	8.40	2.15	0.90	8.55	12.50	12.55	11.70	1.95	76.80		
Snow	1.00	4.50	2.95	1.55	0	0	0	0	0	0	0	4.45	14.45	91.25	
Rainy days	18	19	20	17	(c) 12	(c) 13	(c) 7	(c) 17	(c) 22	24	(c) 22	(c) 15			207
1849. Rain	0.50	4.15	0.05	(a)	(a)	2.09	4.16	9.808	14.327	11.119	4.657	2.469	53.332		
Snow	0.95	3.80	4.85	(a)	(a)	0	0	0	0	0.288	0.976	1.115	11.979	65.311	
Rainy days	(c) 5	(c) 9	(c) 16	(c) (a)	(c) (a)	20	24	27	26	25	19	18			189
1850. Rain	0.101	7.732	0.652	3.628	3.715	9.798	3.143	10.310	15.226	14.067	9.336	5.593	83.301		
Snow	3.420	3.567	1.455	3.016	0	0	0	0	0	0	0.745	0.294	12.497	95.808	
Rainy days	18	24	16	19	23	23	13	22	23	27	24	20			252
1851. Rain	6.239	4.649	4.486	4.042	1.577	5.336	4.673	2.684	2.434	13.778	8.099	8.059	66.056		
Snow	1.852	2.553	1.185	0.201	0	0	0	0	0	0	0.294	0.314	6.399	72.455	
Rainy days	20	21	19	14	14	20	20	16	13	24	27	13			222
1852. Rain	11.234	5.168	3.420	2.244	4.719	(d)2.630	1.891	8.543	12.615	12.503	5.119	0.537	70.623		
Snow	0.148	2.683	1.120	0.920	0	0	0	0	0	0	0.492	1.177	6.540	(e)17.163	
Rainy days	27	21	13	18	20	22	17	23	22	24	21	9			(e) 232
1853. Rain and snow	15.028	4.055	3.610	3.100	5.079	6.164	4.124	7.181	6.735	19.527	0.451	15.883	90.934	90.934	
Rainy days	30	15	21	13	19	20	22	20	19	26	(a) 6	28			237
1854. Rain and snow	2.504	6.289	10.091	3.395	7.812	4.478	4.895	3.969	8.417	11.550	14.712	9.059	87.171	87.171	
Rainy days	15	22	23	27	27	22	22	22	20	23	30	21			247
1856. Rain	4.438	12.508	6.047	5.451	2.793	5.080	8.114	3.071	12.727	11.140	7.378	5.079	83.826		
Snow	0	0.056	0.551	1.250	0	0	0	0	0	0	0.399	1.432	3.688	87.514	
Rainy days	24	21	23	30	21	22	23	23	30	26	23	16			285
1857. Rain	0.638	0.000	1.023	6.562	2.600	5.795	10.889	6.441	8.076	9.858	12.696	14.815	79.393		
Snow	2.480	2.035	1.048	0	0	0	0	0	0	0	0	2.463	8.026	87.419	
Rainy days	16	12	14	23	21	26	29	20	21	24	21	26			253
1858. Rain and snow	8.807	4.223	8.794	4.465	1.306	3.781	5.195	5.790	7.861	9.186	14.245	8.120	81.776	81.776	
Rainy days	24	17	25	21	15	21	18	21	21	28	26	17			254
1859. Rain	15.275	4.490	3.135	6.140	5.793	2.525	2.335	13.405	9.145	6.830	2.825	8.860	80.758		
Snow	0.695	0	0.630	0	0	0	0	0	0	0.135	0.110	0.045	1.615	82.373	
Rainy days	25	11	16	20	25	16	21	24	21	24	10	24			237
1860. Rain	11.885	11.130	2.920	5.095	2.220	(a)	(a)	11.663	14.545	9.750	(a)	(a)	69.208		
Snow	1.085	2.670	1.580	0.500	(f)	(a)	(a)	0	0	0	(a)	(a)	5.835	(g) 75.043	
Rainy days	24	22	21	21	12	17	9	25	18	24	18	(a) 7			218
1661. Rain	7.129	5.455	4.230	3.395	1.550	0.901	2.715	6.350	6.119	13.073	4.665	(l)	55.572		
Snow	1.259	0.275	(i) 0	(i) 0	0	0	0	0	0	0	0.990	2.572	5.096	60.668	
Rainy days	16	21	16	17	12	8	19	15	21	24	17	16			202
1862. Rain	0.800	4.820	0.789	2.044	4.926	2.492	1.504	8.144	15.924	14.021	12.039	10.967	78.474		
Snow	1.790	0.998	1.485	1.058	0.622	0	0	0	0	0	0	1.522	7.475	85.949	
Rainy days	15	16	19	20	15	13	14	23	25	20	24	28			232
Totals	107.007	99.106	67.701	62.206	55.312	55.720	57.340	109.159	156.951	178.025	118.788	114.925	(j)		
Monthly mean rain-fall	7.643	7.079	4.836	5.016	4.142	4.038	4.103	7.277	10.461	11.868	8.485	8.209	83.33		(k)
Mean rainy days	20	18	19	18	18	22	21	23	23	26	23	19			245

In 1847 and 1848, and in 1857, 1858, 1859, 1860, 1861, and 1862, observations were made every hour; in 1849, 1850, 1851, 1852, 1853, 1854, and 1856, they were made from 4 *h.* to 20 *h.*

a No record.
b A clear month.
c No record of the hours upon which rain or snow fell.
d Only twenty-four days' observations.
e Eleven and four-fifths months.
f No record after the 10th.
g For seven and one-third months.
h For eight months.
i Half month clear.
j Average for 14.09 years.
k Average.
l All snow.

Barometer at Sitka, in inches, from 1847 to 1862.

Year.*	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.	Pressure of the dry air.	Mean of 3 obs. 6 a.m., 2 and 10 p.m.	Pressure of dry air.
1862	29.931	29.902	29.664	29.854	29.965	29.908	29.930	29.906	29.828	29.850	29.862	29.618	29.852	29.630	....	......
1861	26.695	29.507	29.790	29.634	29.871	29.854	29.830	29.938	29.814	29.729	29.564	29.640	29.739	29.994	....	......
1860	29.582	29.639	29.618	29.775	29.900	30.022	29.920	29.854	29.834	29.626	29.642	29.806	29.768	29.516	....	......
1859	29.660	29.510	29.489	29.929	29.852	29.822	29.897	29 910	29.735	29.656	29.800	29.792	29.754	29.518	....	......
1858	29.860	29.828	29.932	29.691	29.877	29.887	29.988	29.882	29.866	29.602	29.563	29.478	29.702	29.462	....	......
1857	29.786	29.705	29.735	30.012	29.878	29.742	24.930	29.842	29.750	29.664	29.741	29.428	29.764	29.560	....	......
1856	29.644	29.831	29.870	29.556	29.885	29.855	29.932	29.990	29.768	29.710	29.718	29.688	29.788	29.529	....	......
1854	29.998	29.676	29.852	29.690	30.018	29.780	30.108	29.900	29.846	29.850	29.580	29.684	29.878	29.582	29.828	29.584
1853	29.388	29.830	29.878	29.926	29.938	29.938	30.020	29.992	29.862	20.606	†29.812	29.602	29.816	......	29.816	......
1852	29.794	29.882	29.898	29.600	29.967	29.980	29.972	29.906	29.988	29.640	29.744	29.864	29.846	29.594	29.844	29.600
1851	29.580	29.538	29.844	30.087	30.048	30.053	30.016	30.060	30.054	29.772	29.778	29.888	29.918	29.658	29.917	29.612
1850*	29.630	29.686	29.758	30.106	29.991	29.892	30.036	29.954	29 931	29.678	29.484	29.862	29.830	29.590	....	......
Means	29.712	29.784	29.844	29.822	29.932	29.894	29.965	29.928	29.856	29.699	29.691	29.696	29.721	29.603	....	......

* From 1857 to 1862 the observations were made hourly; from 1851 to 1856 the means are given of 17 observations each day at 6 a. m to 10 p. m., inclusive.

† A remarkably clear month, with continuous winds from the northeast, (true;) in 1850 the means are formed from the daily means derived from the three observations each day, at 6 a. m., 2, and 10 p. m.

Thermometer at Sitka, 1847–1862, (Fahrenheit.)

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly means.	Mean of the minima from the observations.	Mean of the maxima from the observations.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1862	*25.1	26.8	34.9	36.5	42.8	50.5	55.8	54.9	48.2	41.2	41.0	36.7	41.22		
1861	*31.8	37.0	37.4	41.4	47.5	54.0	56.7	56.7	54.0	44.4	34.2	23.2	43.2	28.7	57.2
1860	*34.7	34.5	37.3	39.4	46.6	51.6	58.3	56.1	51.8	46.0	41.6	29.5	43.92		
1859	*33.1	27.5	34.7	40.6	46.0	52.7	54.3	54.1	51.4	40.1	28.8	37.3	41.4	36.96	46.62
1858	*28.4	28.2	37.3	41.0	47.1	51.8	54.7	54.5	50.4	43.7	40.0	28.0	41.9	37.17	47.07
1857	*29.1	29.3	37.2	43.6	48.7	52.0	54.5	55.9	50.9	46.1	41.7	37.0	43.7		
1856	†37.8	39.2	41.0	44.0	49.6	52.0	52.9	55.4	51.4	43.0	39.0	31.3	44.4	40.0	48.3
1854	†28.6	32.7	33.6	42.3	45.8	51.1	54.7	56.7	51.8	43.0	43.2	33.7	42.9	‡41.9	
1853	†33.2	36.3	36.5	42.1	48.9	50.0	53.4	53.9	51.1	43.2	§19.85	34.9	41.9	40.8	
1852	†39.7	33.8	32.1	41.9	47.5	52.0	57.4	56.8	52.7	46.4	35.6	24.4	43.2	42.4	47.5
1851	†30.0	34.7	37.6	43.7	50.2	53.2	56.5	58.8	52.5	48.9	41.9	29.1	45.8	43.5	49.3
1850	21.4	34.9	26.7	38.4	45.5	49.9	54.5	55.6	50.0	44.2	39.0	36.0	41.4	¶36.3	46.7
Means	31.1	32.9	35.5	41.2	47.2	51.7	55.3	55.8	51.3	44.2	37.1	31.7	42.9	38.6	48.9

* Observations hourly.
† Means of 17 observations each day, at 6 a. m. to 10 p. m., inclusive.
‡ *Daily means from three observations.*
§ The means are formed from the daily means derived from the hree observations each day, at 6 a. m., 2, and 10 p. m.
¶ Minimum for three observations.

Elasticity of aqueous vapor at Sitka, 1847 *to* 1862.

Year.*	January.		February.		March.		April.		May.		June.	
	e''	$\frac{e''}{e}$	e''	$\frac{e''}{e}$	e''	$\frac{e''}{e}$	e''	$\frac{e''}{e}$	e''	$\frac{e''}{e}$	e''	$\frac{e''}{e}$
1862	0.123	0.086	0.139	0.081	0.148	0.073	0.150	0.068	0.203	0.075	0.277	0.076
1861	.158	.086	.178	.081	.180	.081	.200	.078	.249	.076	.323	.078
1860	.187	.090	.180	.088	.170	.080	.191	.076	.242	.077	.312	.084
1859	.176	.090	.135	.086	.161	.081	.204	.082	.238	.081	.294	.077
1858	.146	.090	.140	.083	.184	.086	.204	.081	.255	.080	.312	.083
1857	.135	.080	.137	.083	.170	.077	.233	.083	.277	.080	.318	.083
1856	.197	.084	.212	.088	.225	.088	.209	.083	.274	.078	.311	.081
1854	.140	.087	.171	.090	.159	.081	.205	.077	.248	.084	.302	.083
1852	.211	.087	.176	.087	.134	.073	.192	.079	.261	.084	.299	.083
1851	.155	.086	.184	.091	.186	.082	.201	.072	.275	.077	.325	.082
1850	.108	.085	.180	.088	.128	.078	.194	.086	.244	.082	.296	.087
Means	0.158	0.086	0.167	0.086	0.168	0.080	0.198	0.079	0.251	0.079	0.306	0.082

Year.*	July.		August.		September.		October.		November.		December.		Yearly means.	
	e''	$\frac{e''}{e}$	e''	$\frac{e''}{e}$	e''	$\frac{e''}{e}$	e''	$\frac{e''}{e}$	e''	$\frac{e''}{e}$	e''	$\frac{e''}{e}$	e''	$\frac{e''}{e}$
1862	0.347	0.079	0.349	0.082	0.286	0.085	0.224	0.085	0.212	0.082	0.188	0.085	0.221	0.080
1861	.368	.082	.382	.085	.365	.088	.257	.088	.165	.081	.112	.083	.245	.082
1860	.394	.082	.395	.090	.317	.084	.271	.093	.222	.085	.157	.085	.253	.085
1859	.361	.087	.379	.092	.342	.091	.211	.083	.135	.081	.196	.090	.236	.085
1858	.368	.087	.369	.089	.310	.088	.239	.084	.217	.088	.142	.089	.242	.086
1857	.378	.091	.374	.086	.318	.086	.266	.090	.235	.089	.198	.090	.253	.085
1856	.341	.087	.375	.088	.337	.090	.238	.086	.214	.089	.161	.087	.258	.086
1854	.354	.084	.379	.086	.331	.087	.241	.086	.246	.089	.184	.087	.246	.085
1852	.369	.085	.393	.092	.336	.091	.277	.091	.180	.087	.113	.080	.250	.083
1851	.378	.084	.410	.084	.335	.086	.288	.084	.228	.086	.137	.088	.260	.084
1850	.362	.086	.393	.090	.330	.092	.255	.089	.201	.085	.189	.089	.240	.084
Means	0.365	0.087	0.382	0.088	0.328	0.088	0.252	0.087	0.205	0.086	0.162	0.087	0.247	0.084

NOTE.—e'' expresses the force of aqueous vapor existing in the air, and e that which would exist if the air was saturated.

* In 1850 the means are formed from the daily means derived from the three each day at 6 a. m., 2 and 10 p. m.; from 1851 to 1856 the means are given of seventeen observations each day at 6 a. m. to 10 p. m., inclusive; from 1857 to 1862 the observations were made hourly.

APPENDIX I.

Observations of the barometer at Illoolook, Unalaska, reduced to 14° Reamur, 63°. 5 Fahrenheit, 1825 to 1834.

Years.	January.			February.			March.			April.			May.			June.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1825	30.09	28.45	29.041	29.51	28.42	28.983	29,71	28.19	28.958	29.88	29.84	29.242	29.90	28.95	29.416	29.79	28.88	29.364
1826	29.59	28.58	29.030	30.19	29.49	29.588	29.94	28.49	29.243	30.02	28.56	29.219	29.92	29.02	29.498	29.89	29.04	29.491
1827	30.04	28.49	29.218	29.97	28.49	29.279	30.01	28.77	29.320	30.04	28.70	29.414	......	......	....	......	......	....
1828	29.94	28.77	29.47	29.84	28.35	29.17	30.08	28.72	29.42	29.74	28.98	29.32	30.06	28.94	29.50	29.78	28.96	29.44
1829	29.73	28.36	29.29	28.69	28.55	29.20	29.98	28.51	29.08	29.24	28.44	29.55	30.11	28.80	29.43	29.89	29.05	29.55
1830	29.96	28.97	29.455	30.38	28.87	29.592	30.12	28.93	29.639	30.20	28.75	29.360	30.01	28.92	29.505	29.86	28.87	29.542
1831	30.14	28.26	29.307	30.05	28.27	29.107	30.00	28.15	29.309	30.03	25.66	29.501	29.90	28.90	29.559	30.10	29.13	29.642
1832	30.22	29.03	29.743	30.25	29.07	29.697	30.11	29.28	29.778	29.97	28.98	29.533	29.85	29.04	29.500	29.89	29.23	29.604
1833	29.59	28.40	29.030	30.08	28.67	29.246	30.06	28.50	29.302	30.11	28.60	29.573	29.80	29.17	29.518	......	......	....
1834	30.26	28.90	29.579	30.39	28.49	29.599	30.26	29.17	29.860	29.99	28.79	29.499	30.00	29.44	29.713	29.99	29.07	29.528
Means	29.96	28.90	29.317	30.03	28.66	29.341	30.03	28.57	29.416	30.02	28.73	29.429	29.95	29.02	29.464	29.89	29.04	29.520
Highest and lowest of this month.	30.26	28.26	....	30.39	28.27	....	30.26	28.15	....	30.24	28.44	....	38.11	28.80	....	30.10	28.87	....

The mean of all the above observations, nine full years, is 29.421 inches. The highest observed reading in the above time was 30, 39 inches, and the lowest 28.05 inches.

Years.	July.			August.			September.			October.			November.			December.			Yearly means.
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
1825	29.81	28.98	29.501	29.86	28.75	29.409	29.84	28.74	29.400	29.87	28.17	29.202	29.76	28.31	29.065	......	......	......	29.299 11-12
1826	29.78	28.99	29.447	29.85	29.21	29.551	29.64	28.41	29.100	29.79	28.15	29.105	29.70	28.07	28.991	30.14	28.56	29.553	29.318
1827	......	......	......	......	......	......	......	......	......	29.85	29.01	29.23	30.08	38.60	29.44	30.26	28.87	29.65	29.373 7-12
1828	29.82	29.18	29.56	30.00	29.20	29.65	29.77	28.74	29.41	29.82	28.45	29.16	29.85	28.66	28.20	30.38	28.71	29.83	29.43
1829	29.78	29.19	29.578	30.22	29.09	29.519	29.79	28.50	29.161	30.05	28.87	29.521	30.31	28.57	29.669	30.23	28.88	29.709	29.438
1830	30.03	29.04	29.653	29.87	28.95	29.457	30.15	28.54	29.402	30.05	28.94	29.518	29.93	28.05	29.076	29.92	28.07	29.328	29.460
1831	30.04	29.13	29.571	29.93	29.02	29.493	30.06	28.95	29.176	30.04	28.59	29,586	29.91	28.21	29.542	29.55	28.11	28.892	29.397
1832	30.05	29.05	29.685	29.95	29.00	29.511	29.89	28.90	29.538	30.01	28.45	29.536	29.82	28.46	29.214	30.32	28.64	39.428	29.572
1833	30.00	29.16	29.712	30.04	29.11	29.611	29.82	28.49	29.259	20.65	28.51	29.019	29.63	28.65	29.388	30.22	28.07	29.392	29.368
1834	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	29.629 6-12
Means	29.91	29.09	29.588	29.97	29.04	29.537	29.87	28.66	29.307	29.99	28.57	29.319	29.88	28.39	29.287	30.13	28.57	29.475	....
Highest and lowest of this month.	30.05	28.98	......	30.22	28.75	......	30.15	28.41	......	30.05	28.15	......	30.31	28.05	......	30.38	28.07	......	....

NOTE.—The barometer by which the above observations were made is marked Benjamin 94 XV, and was compared in 1827 with the barometer of the discovery vessel Seniavin under ——, and found to read 0.32 inch lower; therefore all these observations must be increased by that amount.

Temperature observations at Iloolook, Unalaska, from 1827 to 1837, (1825 to 1834, old style.)

Year.	January.						February.						March.						Yearly means.
	A. M.	Noon.	P. M.	Mean.	Observed. Max.	Observed. Min.	A. M.	Noon.	P. M.	Mean.	Observed. Max.	Observed. Min.	A. M.	Noon.	P. M.	Mean.	Max.	Min.	
1827	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1828	......	......	......	40. 3	......	......	......	......	......	32. 8	......	......	......	......	......	31. 8	......	......	......
1829	......	......	......	28. 6	......	......	......	......	......	31. 1	......	......	......	......	......	32. 2	......	......	......
1830	20. 5	23. 8	19. 8	21. 30	39. 9	2. 7	26. 1	33. 0	26. 1	28. 4	44. 4	—0. 6	17. 1	24. 8	17. 9	19. 9	45. 5	0. 5	......
1831	28. 2	30. 5	28. 1	28. 93	41. 0	9. 5	26. 8	29. 4	26. 1	27. 41	47. 7	10. 2	26. 8	30. 9	24. 5	27. 43	42. 6	7. 2	......
1832	25. 2	30. 3	24. 3	26. 60	41. 0	7. 2	34. 0	36. 9	33. 2	34. 77	48. 9	25. 2	33. 9	37. 8	32. 3	34. 65	63. 5	18. 5	......
1833	29. 8	33. 2	29. 6	30. 86	40. 3	18. 5	32. 6	35. 8	32. 2	33. 49	42. 1	18. 5	30. 2	36. 9	28. 9	32. 00	58. 4	19. 6	......
1834	29. 6	32. 3	30. 1	30. 31	39. 4	16. 2	31. 8	36. 6	30. 9	33. 10	45. 5	20. 7	29. 7	36. 4	28. 4	31. 53	48. 4	15. 1	......
Means	26. 66	30. 02	25. 98	29. 56	40. 32	10. 82	30. 18	34. 34	29. 7	31. 58	45. 72	14. 8	27. 54	33. 36	26. 4	29. 93	51. 66	12. 18	......
	April.						May.						June.						
1827	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1828	......	......	......	36. 7	......	......	......	......	......	41. 2	......	......	......	......	......	46. 8	......	......	......
1829	......	......	......	33. 8	......	......	......	......	......	41. 2	......	......	......	......	......	46. 8	......	......	......
1830	36. 9	40. 8	34. 8	37. 5	50. 7	29. 7	39. 5	42. 6	37. 3	40. 0	55. 6	32. 7	45. 7	46. 3	42. 3	44. 8	56. 7	40. 3	......
1831	31. 7	38. 2	29. 8	33. 21	46. 2	16. 2	37. 2	41. 0	35. 6	37. 94	52. 2	27. 5	45. 0	48. 1	42. 0	45. 02	57. 9	34. 2	......
1832	36. 3	39. 3	34. 4	36. 66	47. 7	25. 9	45. 3	45. 5	38. 6	42. 59	61. 2	32. 7	47. 2	50. 4	45. 4	47. 64	66. 9	42. 1	......
1833	36. 8	39. 3	34. 4	36. 81	47. 7	18. 5	43. 2	45. 2	40. 6	43. 0	61. 2	36. 5	45. 7	48. 2	43. 2	46. 21	66. 9	43. 2	......
1834	34. 2	38. 3	33. 5	35. 33	53. 4	26. 4	40. 6	49. 3	39. 0	43. 0	58. 3	31. 3	......	......	......	......	......	......	......
Means	35. 18	39. 18	33. 38	35. 72	49. 14	23. 34	41. 16	44. 72	38. 22	41. 28	57. 70	32. 14	45. 90	48. 25	43. 22	46. 21	62. 1	39. 95	......
	July.						August.						September.						
1827	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1828	......	......	......	50. 9	......	......	......	......	......	56. 7	......	......	......	......	......	45. 9	......	......	......
1829	49. 5	53. 8	47. 5	50. 3	67. 8	43. 2	47. 6	51. 7	46. 4	48. 5	64. 6	38. 3	45. 3	48. 5	43. 8	45. 7	56. 9	30. 9	......
1830	50. 4	53. 3	47. 0	50. 4	71. 4	42. 1	53. 9	56. 9	50. 3	53. 7	77. 0	43. 9	42. 5	46. 1	42. 3	43. 3	50. 0	28. 6	......
1831	46. 6	48. 2	43. 8	46. 19	64. 6	39. 4	46. 6	51. 3	44. 4	47. 45	61. 2	40. 3	39. 9	43. 1	37. 9	40. 32	52. 2	32. 0	......
1832	51. 4	54. 5	49. 0	51. 66	70. 2	43. 2	53. 6	58. 4	52. 5	54. 90	77. 0	42. 1	40. 1	45. 5	40. 1	41. 90	59. 0	25. 9	......
1833	53. 9	57. 5	51. 1	54. 17	76. 3	44. 8	49. 8	53. 8	47. 0	50. 20	73. 6	38. 1	43. 3	47. 9	43. 4	44. 87	54. 5	32. 0	......
1834	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Means	50. 36	53. 46	47. 68	50. 60	70. 06	42. 54	50. 3	54. 42	48. 12	51. 91	70. 68	40. 54	42. 22	46. 22	41. 40	43. 66	54. 48	29. 88	......
	October.						November.						December.						
1827	......	......	......	35. 8	......	......	......	......	......	36. 5	......	......	......	......	......	35. 4	......	......	......
1828	......	......	......	38. 5	......	......	......	......	......	31. 8	......	......	......	......	......	25. 0	......	......	38. 05
1829	37. 6	40. 5	37. 0	38. 3	54. 5	26. 8	33. 2	36. 5	32. 8	34. 2	54. 5	18. 5	29. 0	31. 5	27. 9	29. 40	46. 6	12. 0	36. 41
1830	35. 9	38. 3	36. 0	36. 7	46. 6	24. 6	28. 7	31. 9	28. 6	29. 7	43. 9	14. 7	24. 8	27. 1	23. 7	25. 20	42. 1	7. 9	35. 51
1831	35. 1	38. 7	34. 4	36. 05	45. 5	23. 0	32. 0	34. 6	31. 8	32. 76	39. 9	19. 6	29. 9	32. 8	29. 3	30. 65	39. 9	12. 9	35. 46
1832	34. 1	37. 6	35. 1	35. 60	48. 9	24. 1	33. 5	35. 2	33. 7	34. 13	47. 7	26. 4	29. 3	31. 3	30. 1	30. 26	45. 5	18. 5	38. 52
1833	34. 7	39. 2	34. 3	36. 07	48. 9	20. 8	26. 3	31. 4	26. 3	27. 99	37. 2	6. 1	26. 7	29. 0	26. 1	27. 30	38. 7	5. 0	37. 73
1834	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Means	35. 48	38. 86	35. 36	36. 72	48. 88	23. 86	30. 74	33. 92	30. 64	32. 44	44. 64	17. 06	27. 94	30. 34	27. 42	29. 03	42. 56	11. 26	37. 28

Observations of the weather at Illoolook, Unalaska, for seven years, 1825, 1826, 1829,* 1830, 1831, 1832, 1833, 1834,* *old style.*

Months.	Without clouds.	Clear, with clouds.	Changeable.	Cloudy.	Rain.	Snow.	Fog.	Total thunder-storms.	Total earthquakes.
January	11	32	111	55	58	118	15	0	5
February	9	33	86	69	51	94	29	0	2
March	3	26	112	76	51	134	10	2	3
April	4	26	104	76	91	96	16	2	4
May	2	29	105	81	106	31	49	1	1
June	6	24	95	85	83	4	76	0	1
July	0	22	118	77	75	0	75	1	1
August	5	29	106	77	113	2	62	2	4
September	2	28	107	73	143	39	33	3	3
October	2	21	115	91	113	90	18	5	7
November	3	29	88	90	84	126	9	1	1
December	6	13	116	82	47	132	6	0	0
Total	53	312	1,263	932	1,015	866	398	17	32

* Part of each of these years. Three observations each day.

Thunder-storms and earthquakes noted in the above period, as follows:

Year.	Thunder-storms.	Earth-quakes.
1825	1	7
1826	2	5
1830	0	2
1831	4	4
1832	6	7
1833	4	4
1829 and 1834	0	3
Total	17	32

Observations for direction of wind at Illoolook, Unalaska, for 1825, 1826, 1827,* 1828, 1829,† 1830, 1831, 1832, 1833, 1834, *old style.*

Months.	DIRECTION.									FORCE.				
	North.	Northeast.	East.	Southeast.	South.	Southwest.	West.	Northwest.	Calms and high airs.	Light.	Moderate.	Fresh.	Strong.	Very strong.
January	120	22	52	74	88	29	49	60	138	236	137	59	41	12
February	58	20	81	66	74	45	48	62	148	227	114	63	36	8
March	81	16	48	83	84	66	83	98	81	254	167	80	46	7
April	53	32	63	81	81	87	79	67	90	250	167	95	33	5
May	40	42	78	76	68	63	87	81	113	272	187	66	21	0
June	34	38	56	84	89	77	41	47	130	330	112	43	9	1
July	21	23	17	72	94	130	73	22	141	279	104	53	13	0
August	37	16	15	74	76	85	101	54	176	265	145	48	9	1
September	67	19	25	58	55	82	114	63	149	206	131	85	46	2
October	52	13	29	54	55	94	92	107	156	209	139	79	46	8
November	68	18	37	57	57	69	122	73	133	234	115	77	54	4
December	139	20	47	39	50	52	55	114	134	217	116	82	73	8
Separate obs. in 1827, 1828, and 1829	196	113	219	242	256	143	144	154	642	......	......	......	......	......
Total	966	401	767	1,060	1,127	1,022	1,089	1,002	2,231	2,980	1,634	830	427	66

* January, February, March, April, October, November, December. † First 6 months. In this time about 160 observations lost.

REMARKS.—For force of wind three observations per day were made for seven years. On the 17th of March and 29th of October, 1833, the wind was extraordinarily strong.

APPENDIX J.

Journal of meteorological observations at the village of Illoolook, island of Unalaska, from October, 1866, to April, 1867, by Rev. Innocent Shayesnikoff, priest of the Unalaska district.

Date.	Hours.	Therm., Fahr.	Daily mean.	Direction and force of the wind.	Weather.
1866.		Deg.	Deg.		
October 29	8 a.m.	40	......	NW., moderate	Sunshine and clouded.
	Noon	50	......	W. NW., moderate	Sky interchanging the whole day.
	8 p.m.	42	44.0	....do	
30	8 a.m.	40	......	S. SW., light	Sunshine and clouded.
	Noon	48	......	S. SE., moderate	Sky interchanging.
	8 p.m.	46	44.7	S. SW., moderate	Overcast or gloomy.
31	8 a.m.	40	......	....do	Clear.
	Noon	43	......	W. SW., moderate	Sunshine.
	8 p.m.	41	41.3	....do	Clear and at times rain.
*November 1	8 a.m.	40	......	W. SW., fresh	Sunshine and clear all day, but
	Noon	42	......	Do.	in the evening rain.
	8 p.m.	39	40.3	Do.	
2	8 a.m.	38	......	W., moderate	Sunshine and clear, but at times
	Noon	40	......	Do.	a wet snow falling.
	8 p.m.	36	38.0	Do.	
3	8 a.m.	36	......	E., very strong	Overcast or gloomy, and much
	Noon	38	......	E. SE., very strong.	wet snow and strong rain.
	8 a.m.	40	38.0	S. SW., moderate	Clear and at times rain.
4	8 a.m.	40	......	S. SE., fresh	Clear and sunshine; showers.
	Noon	44	......	S. SE., moderate	Clear and sunshine.
	8 p.m.	41	41.7	....do	Clear and sunshine, with showers.
5	8 a.m.	39	......	W. NW., fresh	Overcast, wet snow.
	Noon	38	......	NW., very strong	Overcast, hail.
	8 p.m.	33	36.7	....do	Do.
6	8 a.m.	33	......	W., moderate	Sunshine and at times hail, clear,
	Noon	39	......	SW., moderate.	and clouded.
	8 p.m.	36	36.0	S. SE., light.	Overcast and fine snow.
7	8 a.m.	30	......	NW., moderate	Sunshine; at times snow.
	Noon	38	......	....do	Clear and sunshine.
	8 p.m.	30	32.7	....do	Overcast; at times snow.
8	8 a.m.	29	......	NW., moderate	Clear and sunshine, without cl'ds.
	Noon	41	......	Do.	
	8 p.m.	38	36.0	E. SE., fresh	Overcast, and wet snow.
9	8 a.m.	39	......	Calm	Overcast and dark.
	Noon	44	......	W. SW., light	Clear and sunshine, without cl'ds.
	8 p.m.	38	40.3	S. SW., light.	
10	8 a.m.	33	......	....do	Do.
	Noon	44	......	N. NE., light	Do.
	8 p.m.	29	35.3	....do	Do.
11	8 a.m.	35	......	....do	Cloudy and at times snow.
	Noon	41	......	....do	Clear and sunshine.
	8 p.m.	29	35.0	....do	Clear and without clouds.
12	8 a.m.	26	......	....do	Do.
	Noon	33	......	....do	Clear, sunshine, and without cl'ds.
	8 p.m.	26	28.3	....do	Clear and without clouds.
13	8 a.m.	36	......	N. NE., fresh	Do.
	Noon	37	......	....do	Do.
	8 p.m.	36	36.3	....do	Do.
14	8 a.m.	34	......	....do	Do.
	Noon	35	......	....do	Clear, sunshine, clouds.
	8 p.m.	32	33.7	N. NW., fresh	Clear and variable.
15	8 a.m.	29	......	MW., moderate	Clear and occasional snow.
	Noon	36	......	W. NW., moderate	Do.
	8 p.m.	33	32.7	W., moderate	Do.

*Mean temperature for November, 36.1 degrees. Wind, N. NE. Rain; snow.

Journal of meteorological observations, &c.—Continued.

Date.	Hours.	Therm., Fahr.	Daily mean.	Direction and force of the wind.	Weather.
1866.		*Deg.*	*Deg.*		
November 16	8 a. m...	27	......	N. NE., light	Clear and without clouds.
	Noon....	41	......	....do..........	Do.
	8 p. m...	32	33.3	N. NW., fresh..........	Clear and occasional snow.
17	8 a. m...	32	......	N. NE., moderate.....	Clear and without clouds.
	Noon....	39	......	....do....	Clear, sunshine, clouds.
	8 p. m...	32	34.3	....do....	Do.
18	8 a. m...	38	......	SE., very fresh........	Gloomy and at times snow.
	Noon....	40	......	E. SE., very fresh	Overcast and wet snow.
	8 p. m...	40	39.7	....do....	Overcast and rain.
19	8 a. m...	41	......	E., very fresh....	Do.
	Noon....	42	......	....do....	Do.
	8 p. m...	38	40.3	E. NE., very fresh.....	Do.
20	8 a. m...	40	......	E., fresh	Do.
	Noon....	41	......	E. NE., fresh....	Do.
	8 p. m...	38	39.7	N. NE., very fresh.....	Cloudy and at times rain.
21	8 a. m...	39	......	NE., moderate..........	Overcast and at times rain.
	Noon....	42	......	E. NE., moderate	Do.
	8 p. m...	39	40.0	....do....	Clear and at times rain.
22	8 a. m...	32	......	N. NE., moderate......	Clear and cloudy.
	Noon....	42	......	....do....	Do.
	8 p. m...	41	38.3	....do....	Overcast and rain.
23	8 a. m...	37	......	NE., moderate..........	Do.
	Noon....	42	......	....do....	Do.
	8 p. m...	41	40.0	....do....	Do.
24	8 a. m...	39	......	N. NE., light	Overcast and wet snow.
	Noon....	40	......	....do....	Do.
	8 p. m...	35	38.0	N. NE., moderate	Do.
25	8 a. m...	35	......	W., moderate..........	Clear and clouds.
	Noon....	42	......	....do....	Do.
	8 p. m...	35	37.3	W. NW., very fresh ...	Overcast, wet snow.
26	8 a. m...	30	......	NW., fresh............	Clear and at times snow.
	Noon....	34	......	....do....	Clear and sunshine.
	8 p. m...	30	31.3	....do..............	Clear and at times snow.
27	8 a. m...	29	......	W. NW., moderate	Do.
	Noon....	40	......	N. NE., light....	Clear and without clouds.
	8 p. m...	34	34.3	E. NE., fresh	Overcast; snow.
28	8 a. m...	34	......	NE., fresh.............	Do.
	Noon....	38	......	NE., moderate.........	Do.
	8 p. m...	36	36.0	N. NE., fresh	Clear and at times hailing.
29	8 a. m...	26	......	Calm...................	Clear and sunshine.
	Noon....	35	......	....do....	Overcast; snow.
	8 p. m...	34	31.7	N. NE., fresh	Clear and at times snow.
30	8 a. m...	31	......	....	Do.
	Noon....	31	......	....	Clear; clouds.
	8 p. m...	29	30.3	....	Do.
*December 1	8 a. m...	29	......	....	Clear and at times snow.
	Noon....	28	......	....	Gloomy, and thick snow.
	8 p. m...	25	27.3	....	Gloomy and at times snow.
2	8 a. m...	24	......	....	Clear and at times snow.
	Noon....	24	......	....	Do.
	8 p. m...	25	24.3	....	Do.
3	8 a. m...	20	......	....	Do.
	Noon....	34	......	....	Clear and sunshine.
	8 p. m...	25	26.3	....	Cloudy and thick snow.
4	8 a. m...	21	......	....	Clear and at times snow.
	Noon....	30	......	....	Do.
	8 p. m...	24	25.0	....	Cloudy and at times snow.
5	8 a. m...	24	......	....	Clear and variable.
	Noon....	28	......	....	Do.
	8 p. m...	28	26.6	....	Cloudy and pouring rains.

* Mean temperature for December, 33,87 degrees.

Journal of meteorological observations, &c.—Continued.

Date.	Hours.	Therm., Fahr.	Daily mean.	Direction and force of the wind.	Weather.
1866.		*Deg.*	*Deg.*		
December 6	8 a. m...	32	......	....	Cloudy and pouring rains.
	Noon....	39	......	....	Cloudy, rain, and snow.
	8 p. m...	39	36.6	....	Cloudy and rain.
7	8 a. m...	39	......	E., fresh..............	Overcast, rain, and snow.
	Noon....	40	......	N. NE., light	Clear and at times rain.
	8 p. m...	38	39.0	....do.....	Do.
8	8 a. m...	39	......	S. SE., moderate	Clear and variable.
	Noon....	40	......	....do.....	Do.
	8 p. m...	39	39.3	SW., moderate	Do.
9	8 a. m...	33	......	....do......	Clear; sunshine.
	Noon....	35	......	....do.....	Do.
	8 p. m...	36	34.6	SE., fresh......	Clear and cloudy.
10	8 a. m...	38	......	E. NE., very fresh.....	Overcast and much rain.
	Noon....	42	......	....do.....	Do.
	8 p. m...	40	40.0	....do.....	Cloudy and fine rain.
11	8 a. m...	39	......	S. SW., very fresh.....	Cloudy and at times rain.
	Noon....	40	......	SW., very fresh	Cloudy and heavy rain.
	8 p. m...	38	39.0	S. SE., moderate.......	Clear and at times rain.
12	8 a. m...	36	......	....do.....	Do.
	Noon....	44	......	....do.....	Do.
	8 p. m...	33	37.6	....do.....	Cloudy and at times rain.
13	8 a. m...	37	......	....do.....	Clear and at times rain.
	Noon....	41	......	....do......	Cloudy and at times rain.
	8 p. m...	38	38.6	....do......	Clear and at times rain.
14	8 a. m...	35	......	S. SW., moderate......	Clear and cloudy.
	Noon....	39	......	....do.....	Clear, sunshine, and at times rain.
	8 p. m...	35	......	....do.....	Do.
15	8 a. m...	37	......	E., very fresh.	Dark, and fine rain.
	Noon....	38	......	E. NE., very strong....	Cloudy, and wet snow.
	8 p. m...	38	37.6	E. SE., very fresh	Clear and at times rain.
16	8 a. m...	39	......	E., very fresh..........	Cloudy and heavy rain.
	Noon....	43	......	....do......	Do.
	8 p. m...	41	41.0	....do......	Do.
17	8 a. m...	36	......	NE., light.............	Cloudy and thick snow.
	Noon....	39	......	Calm..................	Clear and sunshine.
	8 p. m...	36	37.0	S. SE., moderate	Clear and at times rain.
18	8 a. m...	36	......	....do.....	Do.
	Noon....	39	......	....do.........	Do.
	8 p. m...	35	36.6	....do.....	Do.
19	8 a. m...	35	......	Calm..................	Cloudy and heavy snow.
	Noon....	39	......	....do.......	Fog and fine snow.
	8 p. m...	37	37.0	E. NE., moderate	Clear and cloudy.
20	8 a. m...	34	......	SW., moderate	Clear and at times rain.
	Noon....	39	......	S. SW., moderate......	Do.
	8 p. m...	36	36.3	S. SW., fresh..........	Do.
21	8 a. m...	31	......	N., fresh	Clear and cloudy.
	Noon....	30	......	N., very fresh.....	Cloudy and at times snow.
	8 p. m...	26	29.0	....do....	Clear and cloudy.
22	8 a. m...	26	......	Calm..................	Do.
	Noon....	29	......	NE., fresh.............	Dark; pouring rains.
	8 p. m...	34	29.6	E. NE., very fresh	Do.
23	8 a. m...	30	......	N. NE., moderate......	Clear and no clouds.
	Noon....	37	......	N. NE., light	Clear and sunshine.
	8 p. m...	34	33.3	E. NE., fresh	Clear and cloudy.
24	8 a. m...	30	......	N. NE., fresh	Clear and without clouds.
	Noon....	35	......	....do.....	Clear and at times snow.
	8 p. m...	26	30.3	N. NE.. light	Clear and without clouds.
25	8 a. m...	25	......	....do.......	Do.
	Noon....	35	......	....do.......	Clear, sunshine, clouds.
25	8 p. m...	35	31.6	N. NE., fresh	Clear and cloudy.

Journal of meteorological observations, &c.—Continued.

Date.	Hours.	Therm., Fahr.	Daily mean.	Direction and force of the wind.	Weather.
1866.		*Deg.*	*Deg.*		
December 26	8 a. m...	37	......	NE., moderate.........	Dark; rain.
	Noon....	42	......	....do................	Do.
	8 p. m...	37	38.6	N. NE., very fresh.....	Dark and wet snow.
27	8 a. m...	34	......	....do................	Do.
	Noon....	30	......	N. NW., very strong...	Dark and at times snow.*
	8 p. m...	29	31.0	NW., very strong......	Dark and snow.
28	8 a. m...	31	......	W. NW., fresh.........	Dark and at times snow.
	Noon....	33	......	....do................	Do.
	8 p. m...	36	33.3	W., fresh..............	Do.
22	8 a. m...	30	......	W. NW., fresh.........	Do.
	Noon....	31	......	....do................	Do.
	8 p. m...	30	30.3	....do................	Do.
30	8 a. m...	23	......	N. NE., light...........	Clear and without clouds.
	Noon....	31	......	Calm..................	Clear and sunshine.
	8 p. m...	36	30.0	E. NE., moderate......	Clear and at times rain.
31	8 a. m...	36	......	E. SE., moderate.......	Do.
	Noon....	39	......	E. SE., fresh...........	Do.
	8 p. m...	36	37	E. NE., fresh..........	Dark and wet snow.
1867.					
*January 1	8 a. m...	35	......	E., moderate...........	Dark, and heavy rain.
	Noon....	36	......	E. SE., moderate.......	Clear and at times rain.
	8 p. m...	36	35.6	E., moderate...........	Dark, and heavy rain.
2	8 a. m...	36	......	S. SE., light...........	Clear and at times rain.
	Noon...	39	......	S. SW., moderate......	Do.
	8 p. m...	36	37.0	E. SE., very fresh.....	Dark, and fine snow.
3	8 a. m...	36	......	S., fresh...............	Clear and at times snow.
	Noon....	37	......	....do................	Do.
	8 p. m...	36	36.3	S. SW., moderate......	Do.
4	8 a. m...	32	......	....do................	Do.
	Noon....	39	......	S., moderate...........	Do.
	8 p. m...	35	35.3	N. NE., very fresh.....	Dark and wet snow.
5	8 a. m...	35	......	N. NE., light...........	Do.
	Noon....	38	......	....do................	Clear and sunshine.
	8 p. m...	36	36.3	N. NE., fresh..........	Clear and cloudy.
6	8 a. m...	34	......	....do................	Dark, and fine snow.
	Noon....	35	......	....do................	Clear, and fine snow.
	8 p. m...	32	33.3	N. NW., moderate.....	Clear and without clouds.
7	8 a. m...	32	......	N., very fresh.........	Clear and cloudy.
	Noon....	33	......	....do................	Dark, and fine snow.
	8 p. m...	34	33.0	N. NE., very strong....	Dark and heavy.
8	8 a. m...	33	......	W., very fresh.........	Dark, and fine snow.
	Noon....	35	......	W. SW., fresh.........	Dark and snow at times.
	8 p. m...	33	33.3	S. SW., fresh..........	Do.
9	8 a. m...	33	......	S. SW., moderate......	Clear and snow at times.
	Noon....	37	......	....do................	Clear and sunshine.
	8 p. m...	28	32.6	S. SW., light..........	Clear and without clouds.
10	8 a. m...	27	......	....do................	Clear and clouds.
	Noon....	38	......	S. SE., light...........	Do.
	8 p. m...	35	33.3	E. SE., light...........	Do.
11	8 a. m...	35	......	E. NE., moderate......	Dark and snow.
	Noon....	36	......	NE., moderate.........	Dark, and fine rain.
	8 p. m...	37	36.0	N. NE., moderate......	Do.
12	8 a. m...	34	......	....do................	Dark and rain.
	Noon....	41	......	....do................	Dark and snow.
	8 p. m...	43	36.0	N., fresh...............	Do.
13	8 a. m...	30	......	....do................	Clear and without clouds.
	Noon....	32	......	....do................	Do.
	8 p. m...	29	30.3	N., very fresh..........	Do.
14	8 a. m...	26	......	N. NW., very fresh....	Clear and at times clouds.
	Noon....	27	......	....do................	Do.
	8 p. m...	26	26.3	N., very fresh.........	Do.

* Mean temperature for January, 31.66 degrees.

Journal of meteorological observations, &c.—Continued.

Date.		Hours.	Therm., Fahr.	Daily mean.	Direction and force of the wind.	Weather.
			Deg.	*Deg.*		
January	15	8 a. m.	25	......	N. NW., very fresh	Clear and at times snow.
		Noon	24	......	....do	Do.
		8 p. m.	24	24.3	N., very fresh	Do.
	16	8 a. m.	30	......	N. NE., fresh	Clear and sunshine.
		Noon	31	......	....do	Clear and clouds.
		8 p. m.	28	29.6	....do	Do.
	17	8 a. m.	26	......	....do	Do.
		Noon	30	......	....do	Do.
		8 p. m.	31	29.0	N. NW., very fresh	Clear and at times snow.
	18	8 a. m.	25	......	N., fresh	Clear and at times clouds.
		Noon	29	......	....do	Do.
		8 p. m.	26	26.6	N. NW., fresh	Clear and cloudy.
	19	8 a. m.	29	......	N. NW., moderate	Clear and at times snow.
		Noon	35	......	N., moderate	Clear and sunshine.
		8 p. m.	26	30.0	....do	Clear and without clouds.
	20	8 a. m.	19	......	N. NE., light	Do.
		Noon	32	......	....do	Clear and sunshine.
		8 p. m.	28	26.3	Calm	Clear and at times clouds.
	21	8 a. m.	26	......	....do	Do.
		Noon	38	......	....do	Clear and sunshine.
		8 p. m.	29	31.0	....do	Clear and without clouds.
	22	8 a. m.	31	......	....do	Do.
		Noon	37	......	E. NE., moderate	Do.
		8 p. m.	29	32.3	Calm	Do.
	23	8 a. m.	25	......	N. NE., moderate	Clear and at times clouds.
		Noon	34	......	....do	Do.
		8 p. m.	30	29.6	E. NE., moderate	Clear and cloudy.
	24	8 a. m.	34	......	NE., fresh	Overcast or dark, and fine snow.
		Noon	35	......	....do	Overcast, and heavy snow.
		8 p. m.	33	34.0	....do	Overcast and at times snow.
	25	8 a. m.	34	......	N. NE., moderate	Clear and cloudy.
		Noon	34	......	N., fresh	Do.
		8 p. m.	23	30.3	....do	Clear and without clouds.
	26	8 a. m.	27	......	NW., moderate	Clear and cloudy.
		Noon	33	......	W. NW., moderate	Clear and sunshine.
		8 p. m.	25	28.3	N. NW., moderate	Clear and without clouds.
	27	8 a. m.	25	......	Calm	Clear and at times clouds.
		Noon	32	......	W., moderate	Clear and at times snow.
		8 p. m.	26	30.6	....do	Clear and at times clouds.
	28	8 a. m.	35	......	....do	Clear and without clouds.
		Noon	36	......	SW., moderate	Clear and at times snow.
		8 p. m.	35	35.3	Calm	Do.
	29	8 a. m.	36	......	E., fresh	Clear and without clouds.
		Noon	38	......	....do	Clear and cloudy.
		8 p. m.	35	36.3	NE., very strong	Do.
	30	8 a. m.	36	......	E. NE., very strong	Dark, and wet snow.
		Noon	38	......	NE., fresh	Dark, and fine snow.
		8 p. m.	35	36 3	....do	Dark and at times rain.
	31	8 a. m.	29	......	N., gale	Dark, and fine snow.
		Noon	27	......	....do	Clear and cloudy.
		8 p. m.	21	25.6	....do	Cloudy and snow.
1867.						
*February	1	8 a. m.	20	......	N., gale	Clear and at times snow.
		Noon	22	......	N. NW., fresh	Cloudy and at times snow.
		8 p. m.	20	20.7	NW., fresh	Do.
	2	8 a. m.	15	......	....do	Do.
		Noon	16	......	....do	Clear and at times snow.
		8 p. m.	13	14.7	....do	Do.
	3	8 a. m.	17	......	....do	Do.
		Noon	20	......	N. NW., fresh	Do.
		8 p. m.	13	16.7	N., very fresh	Do.

* Mean temperature for February, 33.32 degrees.

Journal of meteorological observations, &c.—Continued.

Date.	Hours.	Therm., Fahr.	Daily mean.	Direction and force of the wind.	Weather.
		Deg.	*Deg.*		
February 4	8 a. m...	16	......	N. NW., fresh	Clear and cloudy.
	Noon....	20	......	....do	Clear and at times snow.
	8 p. m...	17	17.7	W. NW., moderate.....	Clear and cloudy.
5	8 a. m...	27	......	E. NE., very fresh	Dark and snow.
	Noon....	31	......	....do	Dark.
	8 p. m...	34	30.7	NE., moderate..........	Dark and snow.
6	8 a. m...	30	......	Calm....................	Clear and without clouds.
	Noon....	44	......	....do	Clear, sunshine, and clouds.
	8 p. m...	33	35.7	....do	Cloudy and at times snow.
7	8 a. m...	32	......	....do	Do.
	Noon....	49	......	....do	Do.
	8 p. m...	34	38.3	S. SE., moderate.......	Clear and at times clouds.
8	8 a. m...	30	......	S. SW., moderate.	
	Noon....	44	......	SW., moderate.	
	8 p. m...	33	35.6	E. SE., very fresh.	
9	8 a. m...	39	......	S., fresh.	
	Noon....	42	......	SW., fresh.	
	8 p. m...	33	38.0	Do.	
10	8 a. m...	32	......	S. SW., fresh.	
	Noon....	36	......	SW., fresh.	
	8 p. m...	32	33.3	E. SE., fresh.	
11	8 a. m...	36	......	S. SE., moderate.	
	Noon....	45	......	Do.	
	8 p. m...	35	38.6	Calm.	
12	8 a. m...	27	......	W. NW., very strong.	
	Noon....	28	......	NW., fresh.	
	8 p. m...	26	27.0	N. NW., fresh.	
13	8 a. m...	29	......	Calm.	
	Noon....	34	......	Do.	
	8 p. m...	36	33.0	SW., moderate.	
14	8 a. m...	44	......	S., moderate...........	Clear and cloudy.
	Noon....	45	......	....do	Do.
	8 p. m...	48	45.6	....do	Do.
15	8 a. m...	40	......	....do	Do.
	Noon....	52	......	....do	Clear and without clouds.
	8 p. m...	43	44.6	....do	Clear and at times rain.
16	8 a. m...	37	......	S. SW., fresh	Clear and at times hail.
	Noon....	37	......	SW., fresh	Dark and at times snow.
	8 p. m...	34	36.0	S. SW., fresh	Clear and without clouds.
17	8 a. m...	26	......	Calm....................	Do.
	Noon....	42	......	....do	Clear, sunshine, and clouds.
	8 p. m...	34	34.0	E. NE., fresh	Clear and cloudy.
18	8 a. m...	34	......	E. NE., very fresh	Dark, and wet snow.
	Noon....	36	......	SW., very fresh	Do.
	8 p. m...	35	35.0	....do	Do.
19	8 a. m...	34	......	W. NW., fresh.........	Clear and at times cloudy.
	Noon....	38	......	W. NW., moderate....	Clear and without clouds.
	8 p. m...	29	33.3	N. NE., moderate	Do.
20	8 a. m...	39	......	S., fresh................	Clear and cloudy.
	Noon....	44	......	....do	Dark, and fine snow.
	8 p. m...	42	41.6	....do	Clear and cloudy.
21	8 a. m...	44	......	S., fresh................	Clear and cloudy.
	Noon....	48	......	....do	Do.
	8 p. m...	38	43.3	S., moderate	Clear and dark weather.
22	8 a. m...	37	......	SW., fresh	Clear and without clouds.
	Noon....	44	......	W. SW., fresh.........	Do.
	8 p. m...	34	38.3	....do	Clear and cloudy.
23	8 a. m...	35	......	W. SW., moderate	Clear and without clouds.
	Noon....	36	......	W., moderate	Clear and at times snow.
	8 p. m...	34	35.0	SW., fresh	Do.

Journal of meteorological observations, &c.—Continued.

Date.	Hours.	Therm., Fahr.	Daily mean.	Direction and force of the wind.	Weather.
1867.		*Deg.*	*Deg.*		
February 24	8 a. m...	26	......	W. NW., very fresh....	Clear and cloudy.
	Noon....	25	......	N. NW., very fresh.....	Do.
	8 p. m...	21	24. 0	N., fresh	Do.
25	8 a. m...	26	......	Calm..................	Clear and without clouds.
	Noon....	29	......	.... do	Do.
	8 p. m...	17	24. 0	.... do	Do.
26	8 a. m...	32	......	.... do	Clear, sunshine, without clouds.
	Noon....	35	......	E. SE., moderate	Do.
	8 p. m...	33	33. 3	SE., fresh	Clear and cloudy.
27	8 a. m...	39	......	S. SE., fresh...........	Do.
	Noon....	41	......	.... do	Do.
	8 p. m...	35	38. 3	.... do	Do.
28	8 a. m...	36	......	.... do	Clear, sunshine, at times clouds.
	Noon....	40	......	.... do	Do.
	8 p. m...	34	36. 6	SE., fresh	Clear and without clouds.
*March 1	8 a. m ..	35	......	S. SE., light	Clear, sunshine, without clouds.
	Noon....	39	......	Calm..................	Do.
	8 p. m...	32	35. 3	.... do	Do.
2	8 a. m...	33	......	.... do	Do.
	Noon....	43	......	.... do	Do.
	8 p. m...	28	34. 6	.... do	Do.
3	8 a. m...	32	......	.... do	Clear and cloudy.
	Noon....	45	......	.... do	Clear and without clouds.
	8 p. m...	32	36. 3	.... do	Clear and cloudy.
4	8 a. m ..	32	......	N. NE., moderate	Clear and without clouds.
	Noon....	36	......	.... do	Clear, sunshine, without clouds.
	8 p. m...	32	33. 3	N. NE., fresh	Clear and at times clouds.
5	8 a. m...	35	......	NE., moderate.........	Dark, and fine snow.
	Noon....	43	......	.... do	Dark, and wet snow.
	8 p. m...	36	38. 0	E. NE., moderate	Dark, and rain.
6	8 a. m...	37	......	.... do	Dark, and wet snow.
	Noon....	39	......	E., moderate	Dark, and heavy rain.
	8 p. m...	35	......	E. NE., light...........	Dark, and fine snow.
7	8 a. m...	39	......	SW., fresh	Clear and cloudy.
	Noon....	41	......	.... do	Clear and sunshine, no clouds.
	8 p. m...	29	36. 3	Calm..................	Clear and without clouds.
8	8 a. m...	35	......	E. NE., fresh	Dark, and fine snow.
	Noon....	37	......	E., very fresh..........	Dark, and fine rain.
	8 p. m...	35	35. 6	.... do	Dark, and heavy rain.
9	8 a. m...	38	......	E. SE., very fresh......	Do.
	Noon....	40	......	.... do	Clear and at times rain.
	8 p. m...	36	38. 0	E., very fresh..........	Gloomy, and heavy rain.
10	8 a. m...	36	......	SE., fresh	Cloudy and at times rain.
	Noon....	45	......	S. SE., fresh...........	Do.
	8 p. m...	34	38. 3	.... do	Clear and at times rain.
11	8 a. m...	32	......	E. NE., fresh	Dark, and thick snow.
	Noon....	42	......	S. SE., fresh...........	Clear and at times snow.
	8 p. m...	34	35. 6	S. SE., moderate.......	Cloudy and at times snow.
12	8 a. m...	31	......	Calm..................	Clear, sunshine, without clouds.
	Noon....	43	......	.... do	Do.
	8 p. m...	29	36. 3	.... do	Do.
13	8 a. m...	37	......	.... do	Do.
	Noon....	42	......	.... do	Do.
	8 p. m...	32	36. 0	.... do	Do.
14	8 a. m...	34	......	S. SE., fresh...........	Clear and cloudy.
	Noon....	39	......	.... do	Do.
	8 p. m...	37	37. 0	NE., fresh..............	Do.
15	8 a. m...	35	......	N. NE., fresh	Dark, and thick snow.
	Noon....	47	......	N. NW., moderate	Clear and cloudy.
	8 p. m...	35	39. 0	W. NW., light	Do.

* Mean temperature for 30 days in March, 36.81 degrees.

Journal of meteorological observations, &c.—Continued.

Date.		Hours.	Therm., Fahr.	Daily mean.	Direction and force of the wind.	Weather.
1867.			*Deg.*	*Deg.*		
March	16	8 a.m.	33	......	Calm	Clear and cloudy.
		Noon	48	......	do	Clear, sunshine, and cloudy.
		8 p.m.	35	38.6	E. NE., fresh	Dark, and wet snow.
	17	8 a.m.	40	......	S. SE., moderate	Clear and cloudy.
		Noon	45	......	S. SE., light	Do.
		8 p.m.	36	40.3	do	Cloudy and at times rain.
	18	8 a.m.	38	......	do	Do.
		Noon	40	......	do	Clear and at times rain.
		8 p.m.	31	36.3	Calm	Clear and without clouds.
	19	8 a.m.	38	......	do	Clear and cloudy.
		Noon	44	......	S. SE., light	Do.
		8 p.m.	37	39.6	E., fresh	Gloomy, and heavy rain.
	20	8 a.m.	45	......	S., fresh	Clear, sunshine, at times clouds.
		Noon	46	......	do	Do.
		8 p.m.	42	44.3	E. SE., fresh	Dark, and rain.
	21	8 a.m.	44	......	S. SE., fresh	Clear and at times rain.
		Noon	45	......	do	Clear, sunshine, at times clouds.
		8 p.m.	40	43.0	E. SE., fresh	Gloomy and heavy rain.
	22	8 a.m.	42	......	S. SE., fresh	Clear and at times rain.
		Noon	49	......	do	Clear and cloudy.
		8 p.m.	39	43.6	S. SW., fresh	Do.
	23	8 a.m.	38	......	S. SE., fresh	Do.
		Noon	43	......	do	Clear, sunshine, without clouds.
		8 p.m.	42	41.0	E. SE., fresh	Dark and rain.
	24	8 a.m.	41	......	SE., fresh	Do.
		Noon	44	......	do	Clear and cloudy.
		8 p.m.	37	40.6	S. SW., moderate	Do.
	25	8 a.m.	42	......	do	Dark, and fine snow.
		Noon	43	......	do	Clear and cloudy.
		8 p.m.	36	40.3	W., moderate	Do.
	26	8 a.m.	32	......	do	Dark and snow.
		Noon	34	......	W. SW., moderate	Do.
		8 p.m.	28	31.3	NW., fresh	Clear and cloudy.
	27	8 a.m.	25	......	N., gale	Do.
		Noon	23	......	N., very strong	Cloudy and at times snow.
		8 p.m.	21	23.0	NW., fresh	Dark and at times snow.
	28	8 a.m.	23	......		Clear and cloudy.
		Noon	35	......		Do.
		8 p.m.	27	28.3	SE., fresh	Dark and snow.
	29	8 a.m.	37	......	SW., fresh	Clear and at times snow.
		Noon	42	......	do	Clear, sunshine, without clouds.
		8 p.m.	35	38.0	W., very fresh	Dark and snow.
	30	8 a.m.	29	......	N., fresh	Clear and cloudy.
		Noon	36	......	do	Do.
		8 p.m.	24	29.6	SE., moderate	Do.

RÉSUMÉ.

Month.	Mean temperature.	Daily maximum.	Daily minimum.	No. of cloudless days.
November, 1866	36.1	41.7	30.3	2
December, 1866	33.9	41.0	24.3	0
January, 1867	31.7	37.0	24.3	0
February, 1867	33.3	45.6	14.7	0
March, 1867	36.8	44.3	23.0	4

Meteorological observations made during the ascent of the volcano Makushin, island of Unalaska, under the direction of George Davidson, Assistant Coast Survey, September 7–11, 1867.

Date.	Hour.	On steamer in Oolachta Harbor.			On the expedition to Makushin Volcano—Observer Theo. A. Blake.								Remarks.
		Aneroid bar.	Green's No. 81 thermometer.	Wind and weather.	Sacks's No. 7 thermometer.	Aneroid barometers. Small.	Open face.	No. 73.	Mean inches.	Corrected for hourly variation.	Resulting elevations above beach.		
1867.											*Feet.*		
September 7	Noon	29.82	56.0	Southeast, cloudy, pleasant	72.0	29.80	29.79	29.82	29.803	29.760	....		Mean of barometer readings at start and return taken as point from which to compute heights from all intermediate readings, 920 feet assumed, equal to one inch of barometer change. Starting from beach at mouth of valley leading to Makushin, west side Captain Harbor.
September 7	2 p. m.	.82	56.0	do	59.5	29.70	29.75	29.76	29.737	.726	72		Two and one-quarter miles from beach, by estimation; weather pleasant; light fleecy clouds.
September 7	3 p. m.	.82	55.5	Southeast, sprinkling rain	61.0	29.65	29.66	29.67	29.660	.659	134		Three and one-quarter miles from beach, by estimation; weather pleasant; light fleecy clouds.
September 7	4 p. m.	.80	54.8	Southeast, cloudy, pleasant	59.5	29.60	29.61	29.62	29.610	.610	179		Three and one-half miles from beach, by estimation; weather pleasant; light fleecy clouds.
September 7	7 p. m.	.82	52.8	....	52.0	29.40	29.40	29.40	29.400	.388	384		Four miles from beach, by estimation; camped for the night; head of valley near small stream running into left beach; during the night heavy rain and strong wind.
September 8	7 a. m.	.86	53.0	South-southeast, cloudy, pleasant	53.0	29.175	29.22	29.21	29.202	29.152	601		Obervations at camp.
September 8	8 a. m.	.87	54.0	do	50.7	28.495	28.50	28.42	28.472	28.416	1,278		On summit of hill above camp.
September 8	9 a. m.	.90	56.5	do	48.0	28.25	28.32	28.27	28.280	28.219	1,459		On this level snow lies in patches.
September 8	10 a. m.	.90	57.0	do	51.0	27.85	27.86	27.60	27.770	27.710	1,927		On summit of extinct volcanoes. The bearing of station, 8 a. m., is approximate north 10° east compass, and by estimation 1½ mile distant.
September 8	11 a. m.	.90	56.5	do	58.0	27.95	27.98	27.92	27.950	27.898	1,755		On the return of the party they found the earth, six inches below the surface, at the foot of this volcano, so hot that no one could bear the hand in it; no observation of temperature; surface cool.
September 8	Noon	.90	56.5	do	54.0	29.70	27.75	27.67	27.707	27.664	1,969		About the level of lowest ice limit.
September 8	1 p. m.	.89	58.0	do	50.0	27.05	27.15	27.05	27.083	27.057	2,528		On the glacier; no vegetation above this; ascending along the glacier.
September 8	2 p. m.	.89	58.5	do	48.0	26.50	26.58	26.42	26.500	26.489	3,051		Traveling on snow for last 200 yards; angle of inclination 10°–12°. Thermometer broken; another substituted with no index error.
September 8	3 p. m.	.89	56.3	do	47.0	26.25	26.30	26.15	26.233	26.232	3,287		At 4 p. m. camped for night. Day has been cloudy and pleasant, with but little wind.
September 9	5 a. m.	.....	.....	....	35.5	26.15	26.24	26.08	26.157	26.126	3,385		Camped, by estimation, 25 feet higher than 3 p. m. station. Wind blew violently during the night.
September 9	6 a. m.	.....	.....	....	38.0	26.00	26.08	25.94	26.007	25.966	3,532		At camp; morning pleasant; ascending along snow ridge.

Meteorological observations, &c.—Continued.

Date.	Hour.	On steamer in Oolachta Harbor.			On the expedition to Makushin Volcano—Observer Theo. A. Blake.							Remarks.
		Aneroid bar.	Green's No. 81 thermometer.	Wind and weather.	Sacks's No. 7 thermometer.	Aneroid barometers. Small.	Aneroid barometers. Open face.	Aneroid barometers. No. 73.	Aneroid barometers. Mean inches.	Corrected for hourly variation.	Resulting elevations above beach.	
1867.											*Feet.*	
September 9	7 a. m.	29.86	47.8	Southeast, cloudy, pleasant	35.7	25.17	25.55	25.09	25.095	25.045	4,379	Angle of inclination 15°–17°; weather squally; some little snow and rain.
September 9	8 a. m.	.86	49.0	......do	35.5	24.55	25.54	24.40	24.475	24.419	4,955	Angle of inclination 25°.
September 9	9 a. m.	.86	54.0	......do	30.5	24.50	25.54	23.68	23.68	23.619	5,691	Summit of Makushin; the peak to north is 75 feet lower by G. Davidson's observations of vertical angles, and the crater lies between the peaks and 25 feet below the northern.
September 9	11.45 a. m.	.88	51.5	Northeast, cloudy, rainy	40.0	26.40	26.42	26.40	26.407	26.362	3,168	Observations at snow limit on return of party; weather cloudy.
September 9	0.30 p. m.	.87	51.8	......do	44.0	27.35	27.46	27.44	27.417	27.382	2,229	Ice limit; weather cloudy; no wind.
September 9	3.10 p. m.	.86	54.0	West, cloudy, rainy	45.0	28.07	28.10	28.10	28.090	28.098	1,589	Camped at station 7 p. m. of September 7; weather cloudy; rained hard during night.
September 9	7 p. m.	.86	50.5	Southwest, cloudy, rainy	46.0	29.30	29.34	29.40	29.347	29.335	432	At beach; frequent showers and gusts of wind from northwest.
September 10	11 a. m.	29.98	51.0	South-southwest, cloudy	54.0	29.90	29.88	29.93	29.903	29.851	....	From summit saw part of the crater for a few minutes, when dense fog arose, with strong northwest wind; the northern peak was not seen; volumes of steam and sulphurous vapors from crater.

APPENDIX K.

Daily meteorological record at Sitka, Alaska, from May 1 to September 29, 1867.

Date.		Barom'r in inches, reduced to 62° Fahr.	Thermometer Fahr.					Rain in inches.	Wind.	Sky clear in tenths.
			Dry.	Wet.	Highest observed.	Lowest observed.	Black bulb exposed at noon.			
1867.										
May	1	29.586	46.19	43.11	50.6	41.9	59.7	.065	E., NE., NW........	0
	2	29.702	43.45	41.71	49.6	38.7	....	.275	SW., W., E..........	0
	3	29.926	43.13	40.75	49.4	33.8	....	.050	SW., NE., E........	5
	4	29.511	45.80	41.43	47.3	43.0	....	.035	E., NE., SE..........	0
	5	29.547	42.35	40.32	45.9	40.1	....	.450	S., SE., E..........	0
	6	29.717	43.58	42.89	50.3	37.4	....	.040	SE., NE., NW.......	1
	7	29.970	46.71	43.25	53.4	33.8	71.5	....	SW., NW., NE......	9
	8	30.135	46.40	41.74	52.2	38.5	67.5	....	W., NW	5
	9	30.228	43.29	40.77	47.5	38.7	67.5	.210	SW., NW., NE......	0
	10	30.255	43.90	42.05	47.7	38.7	....	.025	SW., NE.............	1
	11	30.239	44.73	42.64	50.0	38.7	59.0	.040	SW., SE., NE.......	2
	12	29.997	47.02	46.42	54.5	36.5	74.7	....	SW., NE.............	10
	13	29.930	51.37	47.00	58.1	42.8	67.0	....	SW., NE.............	3
	14	29.880	52.96	47.99	60.1	42.8	88.6	....	SW..................	3
	15	30.004	50.29	46.98	55.6	42.1	73.6	....	S., W................	2
	16	30.083	49.44	46.23	53.6	40.1	76.	....	W....................	5
	17	29.976	54.41	50.35	60.3	46.0	81.5	....	S., N.................	10
	18	29.943	58.77	51.82	68.2	46.4	101.3	....	SW., var...........	9
	19	29.885	56.59	51.03	64.8	50.1	101.7	....	Var..................	4
	20	29.901	50.90	47.18	55.4	41.0	67.5	....	S., NE...............	7
	21	29.756	54.14	50.68	58.6	47.7	87.6	....	S., E., W., var......	5
	22	29.769	52.81	49.76	60.1	45.5	....	....	E., NW.............	3
	23	29.600	55.96	50.62	62.6	50.1	75.0	....	NE., NW............	3
	24	29.709	49.53	45.83	52.7	43.7	....	.190	Calm.................	0
	25	29.788	49.38	46.04	52.9	44.6	....	.015	Calm.................	0
	26	29.775	45.85	43.88	50.9	40.8	....	.665	SW., NE., E.........	0
	27	29.910	46.44	44.15	50.4	42.8	....	.160	S., SW., E..........	0
	28	29.988	48.22	45.86	51.8	44.1	....	.290	SW., NE., E.........	2
	29	29.915	49.61	46.24	51.8	46.4	....	.025	SE....................	0
	30	29.880	46.16	43.26	50.1	43.2	....	.590	SE....................	0
	31	29.921	46.85	43.23	48.2	41.0	....	.320	Var., calm..........	0
Means.......		29.949	48.59	45.56	....	....	....	3.445		
June	1	29.893	47.03	44.41	52.2	36.5	....	....	Var., calm...........	5
	2	29.888	49.98	45.63	54.9	42.8	83.7	.025	SW., W., NW.......	2
	3	29.859	49.96	46.60	54.7	44.6	76.6	.030	SSW., W., NW.....	2
	4	29.818	47.56	43.36	51.3	42.3	56.3	.175	SW., N., NE........	0
	5	30.025	47.39	45.98	50.9	44.4	....	.005	NW., N., NE., E.....	0
	6	30.049	50.66	45.99	52.2	44.6	62.6	....	Calm, NE., E........	0
	7	29.888	50.43	45.95	52.0	47.3	....	.160	E., S.................	0
	8	29.988	50.41	46.71	52.5	46.2	....	.290	E., S.................	0
	9	29.951	49.53	46.87	52.7	43.9	....	.220	Var., calm...........	0
	10	29.956	50.26	46.98	53.6	46.3	....	.070	SW., E., NW	0
	11	29.947	49.94	46.24	52.5	46.0	....	....	NW., W	0
	12	30.085	51.53	50.12	54.9	45.5	69.8	....	SW., S., calm.......	1
	13	30.159	51.33	49.81	55.4	41.7	62.1	....	SW., NE............	5
	14	30.067	54.23	50.99	60.8	45.5	86.0	....	S., W., SW..........	8
	15	29.928	54.81	51.48	59.2	43.5	86.0	....	S., W., calm.........	10
	16	29.857	56.01	52.96	64.0	47.7	90.0	....	SW., S...............	4
	17	29.861	51.14	50.45	55.2	46.6	....	....	SW., calm...........	0
	18	29.772	54.90	52.63	58.6	47.7	81.9	....	SW., W.............	9

Daily meteorological record at Sitka, Alaska—Continued.

Date.		Barom'r in inches, reduced to 62° Fahr.	Thermometer Fahr.					Rain in inches.	Wind.	Sky clear in tenths.
			Dry.	Wet.	Highest observed.	Lowest observed.	Black bulb exposed at noon.			
1867.										
June	19	29.800	51.57	50.79	58.3	47.3	82.4	.010	W., S.	1
	20	29.863	50.22	49.61	52.5	49.6	....	....	SW.	0
	21	29.999	50.43	47.61	52.7	46.6	....	.015	SW., W., NW.	0
	22	30.053	52.68	50.19	60.6	43.9	66.2	....	SW., calm, NW.	5
	23	29.870	60.14	54.66	64.6	54.5	68.7	....	SW., calm, NE.	3
	24	29.833	56.79	53.98	61.7	54.0	83.7	.065	SW., calm, W.	0
	25	29.629	61.36	56.95	65.0	56.7	68.0	.015	SE., E., NE.	0
	26	29.688	53.44	51.93	55.9	50.7	....	.605	NW., W., S.	0
	27	29.860	55.94	52.29	62.1	50.55	....	.055	W., SE., NE.	6
	28	29.960	58.84	54.63	65.0	52.2	99.9	....	W., calm, SW.	1
	29	30.000	57.91	54.39	61.2	51.8	83.7	....	SW., W., NW.	7
	30	29.891	58.23	54.61	62.8	50.9	86.4	....	SW., calm.	6
Means.		29.915	52.82	49.83	....	....	....	1.740		
July	1	29.777	58.75	54.95	62.8	53.4	88.7	....	SW., calm.	2
	2	29.896	56.54	53.37	59.9	50.5	77.0	....	SW., var.	3
	3	29.979	54.81	52.36	58.5	50.4	....	.040	W., calm.	0
	4	30.047	53.86	50.92	57.4	50.0	....	.010	W., SW.	0
	5	30.073	52.51	50.18	56.3	49.9	....	....	Calm.	0
	6	30.037	54.76	51.64	59.0	49.4	68.4	....	SW., W., calm.	0
	7	29.830	57.08	52.77	61.7	47.7	72.5	....	SW., calm.	2
	8	29.672	56.20	52.75	60.3	51.8	69.1	.010	NW., var.	0
	9	29.810	53.71	50.31	58.5	50.5	....	....	S., NE., var.	0
	10	29.692	53.89	51.78	57.0	51.8	....	.415	NW., SW., calm.	0
	11	29.735	53.31	51.64	55.8	50.1	....	.175	SW., calm.	0
	12	29.827	53.48	51.51	57.2	50.0	60.8	.070	SW., W., calm.	0
	13	29.827	54.25	51.08	58.5	46.4	....	....	SW., NE.	2
	14	29.683	55.17	51.37	59.2	50.0	59.0	.195	NE.	0
	15	29.865	57.13	52.32	62.4	47.7	65.7	....	SW., var.	5
	16	29.845	55.44	51.10	60.1	50.0	87.8	....	SW., NW., E.	5
	17	29.570	51.70	49.87	54.0	50.3	....	.240	SE., E., NE.	0
	18	29.681	54.40	51.30	58.3	50.3	....	.005	NE., calm, NW.	0
	19	29.692	55.78	51.16	63.9	45.5	69.8	....	E., calm.	6
	20	29.521	58.45	53.89	64.8	46.6	88.4	....	SW., var.	8
	21	29.675	54.42	53.22	60.8	50.4	79.0	.010	SW., S., SE.	1
	22	29.923	53.44	51.73	56.3	50.9	....	....	S., SW., calm.	0
	23	29.982	56.09	53.71	59.0	52.5	....	....	S., NW.	0
	24	29.909	56.26	54.07	60.8	50.5	77.0	....	SW., W.	1
	25	29.831	55.89	53.60	59.0	51.8	....	.005	SW., S., NW.	3
	26	29.920	55.04	53.48	57.6	51.6	....	....	Var., calm.	0
	27	29.896	54.36	52.83	58.3	51.8	....	.360	SW., calm.	0
	28	29.865	55.02	55.81	58.5	50.7	63.9	.580	Calm.	0
	29	29.818	56.99	54.34	60.8	53.8	71.1	.105	E., NW.	0
	30	29.876	54.76	53.80	56.3	53.4	....	1.570	Var.	0
	31	29.508	52.00	51.35	54.50	48.65	....	.335	SE. to NW.	1
Means.		29.815	55.02	52.72	....	....	....	4.125		
August	1	29.900	52.25	50.00	54.05	49.10	....	.235	SW., NE., E.	1
	2	29.722	52.92	49.77	55.17	50.00	....	.135	E., SE., var.	0
	3	29.731	51.80	49.10	55.62	47.97	....	.155	S., NE., E.	0
	4	29.752	51.12	49.55	54.50	46.62	....	.325	SW., NE., var.	2
	5	29.775	51.80	49.32	57.65	42.80	....	.010	Var.	5
	6	29.898	52.47	50.90	55.62	49.32	....	.345	SW., var.	0
	7	29.965	51.57	50.45	52.70	50.0	....	.335	SE., E., NE., var.	0
	8	29.827	52.47	51.57	55.85	51.35	....	.785	S., SE., SW.	0
	9	29.836	53.60	51.57	57.20	49.77	74.75	.000	SW., calm, NW.	1
	10	29.848	53.82	52.92	55.40	51.80	....	.885	Var., NW., SW.	0

Daily meteorological record at Sitka, Alaska—Continued.

Date.	Barom'r in inches, reduced to 62° Fahr.	Thermometer Fahr. Dry.	Wet.	Highest observed.	Lowest observed.	Black bulb exposed at noon.	Rain in inches.	Wind.	Sky clear in tenths.
1867. August 11	29.927	53.82	53.60	55.62	52.92	....	3.630	S., SW., NE., calm..	0
12	29.922	53.60	52.25	56.52	50.90	....	.785	Calm, SW., E., S....	0
13	29.768	51.35	50.67	54.05	45.50	....	.755	S., calm, E., N., W..	0
14	29.723	53.15	52.25	54.95	50.40	....	1.190	Var................	0
15	29.732	50.40	49.32	54.95	47.75	....	1.395	SW., calm, NE......	0
16	29.760	49.77	47.75	53.15	47.07	....	.310	S., SE., E., NE.....	1
17	29.567	50.67	48.20	53.37	47.75	....	.155	E., calm, N.........	0
18	29.666	51.57	50.67	53.60	48.87	....	.750	W., S., calm, E., SE.	0
19	29.847	51.12	49.55	53.15	48.42	....	.335	E., SE., NE., calm..	0
20	29.743	51.57	50.00	52.93	50.22	....	.050	S., NE., calm, E., SE.	0
21	29.557	51.12	48.87	54.50	47.75	....	.750	E., SW., SE., E.....	0
22	29.732	49.10	46.42	51.31	45.95	....	.270	E., var............	1
23	29.646	49.77	47.30	53.60	47.30	....	1.335	E., SE., NE.........	1
24	29.594	46.85	45.95	47.75	45.95	....	1.740	E., SE., NE.........	0
25	29.764	49.77	48.65	51.80	46.62	....	.605	S., SW., SE........	2
26	29.898	51.57	50.90	54.05	49.10	....	1.810	E., SE., NE.........	0
27	30.007	53.15	52.25	55.40	59.90	....	.370	E., SW., S., calm ..	1
28	29.944	55.40	54.95	55.85	51.80	....	.660	SW., calm, NW.....	0
29	29.936	54.95	54.50	57.20	52.70	....	.040	W., calm...........	0
30	30.064	53.60	53.15	58.55	50.22	....	.820	SW., calm, W.......	1
31	30.253	52.02	50.00	56.07	45.95	....	....	W., calm...........	4
Means.......	29.816	51.88	50.33	....	....	....	20.965		
September 1	30.212	52.92	52.02	55.40	50.45	....	.245	W., calm, NE., NW.	0
2	30.116	50.00	45.50	53.15	49.10	....	.005	Var................	3
3	30.077	48.87	46.85	55.62	42.57	64.80	....	W., NW., calm, NE.	5
4	29.822	46.85	44.60	54.50	40.55	....	.405	E., NW., NE.......	4
5	29.954	52.92	46.17	59.45	40.55	79.95	....	NW., N., calm	9
6	30.034	52.25	48.87	57.87	64.15	93.65	....	Var................	6
7	30.057	54.27	52.47	55.85	52.92	63.50	....	SW., calm, SE......	0
8	30.080	52.25	51.35	55.85	50.45	....	.705	E., SW.............	0
9	30.047	52.25	51.12	59.65	47.07	....	....	Var., W............	5
10	29.756	50.90	49.55	53.15	49.10	69.30	.215	SW., calm, var.....	1
11	29.497	51.12	49.10	52.70	46.85	....	1.040	E., NW.............	0
12	29.538	47.75	46.17	51.12	46.05	....	.450	E., NE., SE........	1
13	29.634	47.97	45.72	51.80	43.25	....	....	Var................	4
14	29.712	47.30	45.95	53.15	37.85	....	.010	SW., NE., NW......	5
15	29.918	49.77	46.85	53.60	45.50	72.90	....	SW., NW., W.......	3
16	29.880	51.12	49.55	53.60	47.75	....	1.690	E., SW.............	0
17	30.042	50.45	49.10	52.60	47.30	....	.215	Var................	0
18	29.941	52.47	50.00	57.75	48.20	....	2.115	E., SE., NE........	0
19	29.725	51.12	50.22	59.00	46.17	....	.760	Var................	0
20	29.613	52.25	50.22	54.50	48.65	....	1.040	Var................	0
21	29.588	52.70	51.67	54.50	50.45	....	.410	S., SE.............	0
22	29.679	49.77	48.65	51.57	46.40	....	.550	SW., S., E.........	0
23	29.420	51.12	48.87	54.05	49.35	....	.470	E., NE., SE........	0
24	29.604	51.31	50.45	53.60	46.17	....	.745	E., NW., calm......	1
25	29.866	49.10	48.20	51.80	46.17	....	3.545	Calm, E., var.......	0
26	29.952	49.55	48.87	52.25	46.17	....	.395	SW., E., calm......	1
27	29.972	47.97	47.57	50.9	46.27	....	.265	E., SE.............	0
28	29.472	48.20	46.85	50.00	46.85	....	1.025	E., NW.............	0
29	29.841	47.07	45.95	52.70	36.95	....	....	NW., calm, SW.....	6
30	....	....	....	....	....	....	.050	....	......
Means of 29 days.	29.793	50.40	48.57	....	....	....	16.350		

For the first eighteen days of October the amount of rain was 7.42 inches; observing then discontinued: heavy weather after that date to the end of the month; hurricane on the 28th.

APPENDIX L.

REPORT OF ALBERT KELLOGG, M. D., AID UNITED STATES COAST SURVEY, TO GEORGE DAVIDSON, ASSISTANT UNITED STATES COAST SURVEY, ON THE BOTANY OF ALASKA.

SAN FRANCISCO, CALIFORNIA, *November* 20, 1867.

DEAR SIR: In accordance with your instructions, I have drawn up this short preliminary account of the results obtained by me on the Coast Survey geographical reconnaissance to Alaska. The full report of the botany of the localities visited is being made up, and I hope to have it ready for mailing to you by the steamer of December 10.

The Russian-American expedition was hastily extemporized, and its labors crowded into a few months at the unpropitious season, with a climate offering scarcely a day of fair weather properly suited to botanical purposes. Add to this our cramped facilities, and only rare and incidental opportunities afforded, and we shall readily see why the field of thorough observations and collection must needs be very limited.

The steamer Lincoln, Captain White, under the direction of Captain W. A. Howard, United States revenue service, arrived off the western coast of Alaska before the middle of August, 1867.

The coast of Alaska, from Fort Simpson north to Sitka, like that of Oregon, is broken, but much more precipitous, and clad on all sides with a dense growth of timber.

At Fort Simpson, near the southern coast boundary, we find the western hemlock spruce, (*Abies mertensiana*, or—as most authorities regard it—a variety of *Abies canadensis*.) Its growth is much larger and freer, and it is considered somewhat more durable than the Eastern Canadian, and, like it, the bark is esteemed excellent for tanning. On the coasts and islands northward this tree greatly abounds. Here also we found the Sitka spruce, or pine,* as it is erroneously called, (*Abies sitchensis*.) With lumber dealers this is often styled white pine. This very spiry spruce and the hemlock, like the Douglass and Menzies spruces on the coasts below, mantle the rugged rocks and steeps, from tidewater to their tops, with a dark evergreen foliage. They cling to bare rocks, never leaning in the least, but climb the tall steeps, dripped or drenched in everlasting rains, toning down and softening the savage scenes with their somber shades.

We saw but one true species of pine, the Jersey or scrub pine, (*Pinus inops*, Ait.; *Pinus contorta*, Doug.) In this region it is always seen in sphagnous swamps or sources of retarded streamlets, and rarely of any available size. Near Sitka we found many of them from a foot to eighteen inches in diameter, and thirty to forty feet clean trunk, but such examples are probably rare; also the little juniper, (*Juniperus nana*, Wild.)

The best timber tree by far is the yellow cedar, (*Cupressus nutkatensis*, Hook.; *Chamoecipioris nutkatensis*, Spoch.) From this point more or less north and south it is said to abound, but our personal observations only verify its abundance northerly. At Fort Simpson it is now scarce, although we saw a sleeper thirty feet long, twenty-eight inches at the butt, eighteen inches at the extremity, eight inches thick, also unwrought knees, &c., used for boat building, for which purpose it is unsurpassed; in addition to its lightness, toughness, ease of working, and great durability, under constant exposure to rainy weather and water, it is neither liable to watersoak nor subject to the attacks of worms or tereds, at least for the first four or five years. The original constructors of Fort Simpson laid the ground timbers of *pine*, thinking it the best; an accidental piece of cedar being used, on recently replacing the rotten timbers it was found to be the only sound log left after twenty-one years' trial. Similar facts at Sitka verified by samples of an old hulk constructed of this cedar, still as sound as the day the vessel was built, though now thirty-two years since. Even the iron bolts or spikes show no signs of corrosion. This is the timber formerly exported to China, and often sent back to us, manufactured into cabinet wares for excluding moths, &c. The timber is sought after by the Indians, and the choicest canoes are made of it; much of it is destroyed annually by belting and peeling the bark as far as they can reach, working it into baskets and wearing apparel, and covering for their huts or packed in canoes as portable shelters for camping

* Spruces, in common parlance, are steeple-topped trees; pines, mostly flat-topped, with long tufted foliage, and, more closely noted, of two to five needle-shaped leaves in a common boot. To make confusion worse confounded, hemlock spruce is often designated Sitka pine.

purposes. At Noguarshinsky Bay, standing in our tracks without moving, we counted twenty-three trees killed in this manner. This practice is no doubt general, and has served greatly to diminish its abundance along the coasts, together with other demands made upon it. The grain indicates a rapid growth, and there is no doubt of its desirableness for forest culture.

The whole coast to Sitka and far northward exhibits one uniform topography and similar climatic conditions—being rainy and foggy—and the growth is nearly the same throughout. Unfortunately the vast region of islands and cultivated coast is not bordered at the bases of these lofty timbered ranges with sloping or level bottoms; but is gashed with sharp, precipitous and inaccessible gorges, the peaks for the most part being capped with snow, which melting in summer, together with the continued rains, make every rockless footstep a sphagnous miry morass. Altitude passes for naught here; even the mountains are mostly miry to their tops. The climatic conditions of the coast of Alaska appear to be governed in a great degree by those laws which govern the currents of the air and ocean, as well as the general law of latitude. Thus this North Pacific climate is very moist and much milder relatively than the same latitudes on the Atlantic. Hence the wood limit extends about seven degrees nearer the pole on the Pacific side. As these coast ranges precipitate the excess of moisture, and thus furnish a temperate supply of rain to the interior, we should expect a drier and more varied climate, with a corresponding sylva and flora.

On the southern boundary at Fort Simpson we found as fine herd's-grass (*Phleum pratense*) as any country can boast; it had escaped and was growing wild in thick lodged masses without care or culture. At Sitka we found also the common white clover, (*Trifolium repens*,) and Medick or Burr clover, (*Medicago denticulata*,) recently introduced by California trade. They seem to flourish and bloom well; hence the use of these and similar grasses as green fodder appears quite practicable; but no reliance can be placed on any of them for hay and winter feeding, for in such a climate no haying is possible. Turnips, beets, carrots, parsnips, potatoes, and root crops, together with cabbages and the like, are here the main resource.

Along alluvial bottoms, (if they can be said to exist in any mentionable sense,) the balsam poplar is seen, (*Populus balsamifera*, var. *candicans*.) This tree is often of sufficient size for canoes. At Barlowe Cove, Chilkaht, Globoko Lake, &c., we saw large trees, some in groves. This timber, though scarce on the lower bays and coasts, the drift shows to be sufficiently abundant in the interior.

The red alder, so styled on account of the sap or fresh-cut wood turning cherry-red and retaining that color, (*Alnus rubra*, Bong.; *Alnus oregona*, Nutt.,) grows to quite a tree—forty to fifty feet high, but in general much smaller. The shrubby white alder, (*Alnus fruticosa*, Ledeb.,) on the contrary, retains the white color of the wood, and burns well in the green state.

The Sitka willow (*Salix brachystachys*, Berth., or *Salix sitchensis*, Sanson) is a common shrub, seldom more than eight inches in diameter, and ten to thirty feet high. A few minor shrubs, such as menzies (*Menziesia ferruginea*, Smith,) and the horrible ginseng, (*Panax horridum*, Smith,) horrent with spines, are found throughout the Alaskan Territory, the roots formerly the food of the betrothed. Under-shrubs—plants bearing berries—are highly esteemed, serving the useful purpose of purifying the blood and preventing scurvy and the effects of a long-continued gross animal diet.

The stump currant (*Ribes laxiflorum*, Pursh., *Ribes affim*, Doug.) has good-flavored fruit. It has been spoken of as *Ribes prostatum*, Le Hert, and designated as fœtid. If this should prove to be the same, we can only say it varies, or tastes (about which there is no disputing) will differ. Its autumn foliage is most charmingly crimsoned.

The monster leaf-bracted currant, (*Ribes bracteosum*, Doug.,) though large-fruited, has a strong terebinthinate odor, and is truly unpalatable.

The spreading gooseberry (*Ribes divaricatum*, Doug.) is a tart and good fruit late into winter, found investing old deserted Indian lodges, as well as woody marsh borders, and, further south, river bottoms.

The best of the black glaucous-bloom whortleberries here is the little dwarf bilberry, (*Vaccinium cespitosum*; Mich.; *Vaccinium chamissonis*, Bong.) We found it of very good quality at Unalaska, but at Sitka of inferior flavor. The shrub is at the former place one to two feet, and at Sitka larger. The large oval-leaf bilberry has an indifferent black fruit. The bog bilberry (*Vac-*

cinium uliginosum, L.,) has large berries black with bloom, juicy but not very wholesome. The cowberry, (*Vaccinium vitis-idea*, L.,) has a stem a span high, box-leafed, with beautiful pale pink flower on the tips; berries bright red and blushing at the sun; acid and but little inferior to cranberries, and often growing together with the small species (*Vaccinium oxycoccus.*) Both of these make an excellent jelly, as brilliantly beautiful as the purest carmine. If they were largely cultivated in otherwise worthless peaty bogs, and sphagnous morasses, an unlimited market and good fortunes could be realized. The Russians make an exceedingly palatable jelly by mashing the berries and straining out the juice from the pulp, which is thrown aside, and cooking with a little water, adding "potato flour" or starch and the like to thicken. No dish can be more delicious for a sauce to mutton or game, or eaten alone with sugar and cream.

Several species of raspberries and blackberries are great favorites. The large salmon berry of two varieties (*Rubus spectabilis*, Pursh.) has large ornamental flowers, white and rose colored, found throughout Alaska along the sea coasts, but finest flavored in Unalaska. The great thimbleberry of the west (*Rubus nutkanus*, Mocius.) has a flagrant vinous odor and fine flavor. The northern Arctic blackberry (*Rubus arcticus*, L.) has delicious amber berries; the cloudberry, (*Rubus chamœmorus*, L.,) fruit of large grains, very rich, and in Unalaska often almost black—the finest flavor of any met with. The bird-foot bramble (*Rubus pedatus*, Smith) has few fruit grains, too small, pulpy and red; found in shady woods, creeping over mosses and rotten logs.

The red fruited whortleberry, (*Vaccinium parvifolium*, Smith,) everywhere found, we had well-nigh forgotten to note. This is the one most universally sought after, and is the finest for tarts, jellies, pies, &c. No native in the season would be without them.

Red elderberries (*Sambucus pubens*, Mich.) are boiled, besides various roots, with which they flavor their fish-soups, or chowders, or thus contribute to their nutriment. Even the hips of the early wild rose (*Rosa blanda*, Ait.) are used; also the Scotch loverage, (*Ligusticum scoticum.*) The Kamtschatkan lily we found both nutritious and of a pleasant, sweetish, anylaceous and mucilaginous quality. This has by some authors been considered a true lily, the little bulboidlet scales surrounding the main stem being considered as true scales, and the flower lacking nectaries, &c. Others of later authority consider it a species of checkered lily, (*Frittillaria chamtschatcensis*, Fiscf.) The roots look remarkably neat and white, quite inviting to the eye as well as the palate. This plant could undoubtedly be cultivated to advantage amid mossbogs and incessant rains, regardless of snows and storms. It is the "edible lily" of northern travelers and historians.

The roots of grasses, land and swamp, polygonums, &c., we must forego. The roots of the arrow grass (*Menyanthes trifoliata*) might be greatly improved in quality, when in a state of nature they serve so well for needful culinary purposes. Many of these water-plants we saw but could not procure at Kadiak and other places. The island of Kadiak is mostly bare of trees, but not of shrubs, grasses, and various herbs, for these clothe the mountains to their summits, among which the alder, willow, elder, Menzies' shrubs, rose, &c., with here and there a narrow leafed poplar.

All that is worthy the name of timber here is the Sitka spruce, (*Abies sitchensis.*) This tree resembles in form and foliage our silver firs. The largest we saw were three feet in diameter, ninety to one hundred feet high, and they are relatively of low growth and rapid taper, apt to be knotty, and in open exposures branching to their bases. In the governor's yard were some masts and spars over a hundred feet long, scarcely tapering two inches in thirty or forty feet; yet these were from Kadiak Island, so that good timber of this spruce may be obtained, although we had no opportunity of seeing noteworthy specimens in a growing state. Many masts and spars are from Spruce Island, ten to fifteen miles distant, from which they are floated in rafts.

The mountains here are in general more abrupt towards the sea and sloping inland; yet on the sea-sides we find a few foot-hills and rolling ridges on which only are distributed this forest growth, which is by no means continuous, but marked with beautiful verdant openings like planted lawns. The somber green of their foliage is slightly relieved by a silvery tint, but one unvaried form, too precisely conic, with a stiff and rigid horizontal spray, renders the scene somewhat monotonous, unaccompanied as it is by any other forest trees. There is at Sitka a variety of this spruce with finer pinules and pendant waving branchlets, we think more beautiful, though less regular. This timber growth is confined to the eastern valleys and declivities, indicating that the currents of wind, like those of the ocean, are chiefly from the western quarter.

The lowland leas are limited to a few acres in extent, which are liable to be too wet. The summer climate here, unlike Sitka and the coast below, is, however, sufficiently fair for haying. We saw many mown valleys where a good supply of hay from the native grasses had been secured for winter use. The cattle were fat and milk abundant. We did not, however, relish the flavor of the butter, although it looked yellow and remarkably rich. Whether this was owing to the mode of making, we could not determine. In the villages we visited—two on "Ulova" or Spruce Island—most of the inhabitants were far away in search of berries. To their credit be it noted, the floors were well scoured, and many rude indications of neatness were observed. It is therefore fair to presume that the coarse weeds and wild grasses were accountable for the flavor of the butter. On this island we saw many cozy and sheltered valleys under very indifferent and partial cultivation, only here and there a valley shorn by the scythe, but everywhere abounding in grass or sociable circles of Sitka spruce, alders, willows, elders, and Menzie's shrub of humble proportions, and a few small poplars. At one of these settlements the only person at home was a venerable, gray-haired Russian. Before his hut were hundreds of salmon hanging on poles, drying, exposed to the weather; cured without a particle of salt! Our host, with native hospitality and true politeness, brought forth a kit, or large bucket, wellnigh filled with the choicest luxury of the village, to wit, pickled mushrooms, which he assured us had been gathered only three days previous to our visit. I tested them, and pronounced them good in point of flavor; but as I recognized them as the *Agaricus mutabalis*, which, in the uncured state, were known to be exceedingly nauseous, affecting very disagreeably the *fauces* and throat—even causing sickness by simply holding them for a few moments in the palm of the hand—I dared not *eat* them. These are a part of the market resources of the settlement, doubtless designed for the governor or some notable personage at Paul's Bay, as Mr. McPherson, our interpreter, suggested.

Unalaska Bay, on the side visited by your party in the month of September, 1867, abounds in grasses, with a climate better adapted for haying than the coast of Oregon. The cattle we saw were remarkably fat, and the beef very tender and delicate, rarely surpassed by any well-fed stock. In this island we found much unmown grass. The available and good arable land which we saw lay chiefly near the coast formed by the meeting, mixing, and massing of the valley-washes with the high surf-sand of the sea, which forms a fine, rich, light, and genial soil, well suited to garden and root-crop culture. The turnips here were large and of excellent quality. Carrots, parsnips, and cabbage lacked careful attention, but were good. Potatoes were in bloom, which should never be allowed. They were scarcely half grown. They are cultivated in elevated beds about three or four feet across the flattened top. Our mode of planting by hilling or ridging we think would be preferable in a climate like this, too often drenching the earth with an excess of moisture, which requires to be readily shed, or beclouded by cold fogs, so that the crops require to make the most of the quickening sun and fair weather. It occurs to us that many choice sunny hillsides here would produce good crops under the thrifty hand of enterprise. They are already cleared and ready for the plow. Where grain-like grasses grow and mature well, it seems fair to infer that oats and barley would thrive, provided they were fall-sown like the native grasses, which are often in such haste to root that they even sprout in ear before reaching the soil. This is abundantly verified by reference to our collection.

Several of these grasses had already matured and cast their seed before we arrived, showing sufficient length of season. Indeed no grain will yield more than half a crop of poor quality, if they do not fail altogether, when spring-sown, whether north or south.

A. KELLOGG, M. D.,
Aid United States Coast Survey.

GEORGE DAVIDSON, Esq.,
Assistant United States Coast Survey.

APPENDIX M.

Plants collected by the United States Coast Survey on the geographical reconnaissance of Alaska, under the direction of George Davidson, assistant United States Coast Survey.—Collection by Albert Kellogg, M. D., aid United States Coast Survey; nomenclature by Elias Durand, esq., Academy of Natural Sciences, Philadelphia.

Durand's number.	Order, species, and habitat.	Kellogg's number.
	RANUNCULACEÆ.	
1	Anemone narcissaflora, L., Unalaska	305
2	Ranunculus eschscholtzii, Schl., Unalaska	26, 166
3	Ranunculus reptans, L., Vancouver Island	18
4	Ranunculus aquatilis, L., Unalaska	309
5	Coptis asplenifolia, Salisb., Alaska	128
6	Coptis trifoliata, Salisb., Sitka and Kadiak	175
7	Aquilegia formosa, Fischer, Sitka	366
8	Aconitum napellus, L., Spruce Island	226
9	Aconitum kamschaticum, Pall., Kadiak	150
10	Actæa spicata, var. rubra, Mich., Fort Simpson	92
11	*Thalictrum spariflorum, Turcy, Unalaska*	211
	NYMPHÆACEÆ.	
12	Nuphar advena, Ait.? capsules only, Sitka	104
	CRUCIFERÆ.	
13	Nasturtium palustre, Dc., Unalaska	319, 56
14	Barbarea vulgaris, var. stricta, R. Br., Sitka	317
15	Arabis ambigua, Dc., Sitka	243, 258
16	Arabis hirsuta, Scop., Alaska and Kadiak	255, 400
17	Cardamine hirsuta, L., Sitka	372, 258
18	Erysimum cheiranthoida, L., Kadiak	243, 273
19	Draba grandis, var. siliquosa, Roth., Kadiak	203
20	Draba off. borealis, Kadiak	203
21	Cochlearia oblongifolia, Tour., Sitka and Spruce Isl'd.	347, 255
22	Lepidium ruderale, L., Victoria, B. C	....
23	Capiella bursa-pastoris, L., Alaska	169
	VIOLACEÆ.	
24	Viola Langsdorffii, Fisch., Unalaska, Kadiak	237
25	Viola Langsdorffii, no flowers	59
26	Viola Langsdorffii, no flowers, Vancouver, B. C	....
27	Viola tricolor, L., Kadiak	326
	DROSERACEÆ.	
28	*Drosera rotundifolia, L., Fort Simpson*	123
29	Parnassia palustris, L., Kadiak	226
	HYPERICACEÆ.	
30	Hypericum scouleri, Hook., Victoria, Vancouver Isl'd.	12
	CARYOPHYLLACEÆ.	
31	Sagina procumbens, L., Sitka	402
32	Moehringia lateriflora, L., Kadiak	227
33	Stellaria media, Smith	....
34	Stellaria crispa, Cham., Alaska	86
35	Stellaria longifolia, Nutt., Fort Simpson	125
36	Stellaria borealis, Bigel., Sitka	260
36 *bis*	Montia fontana, var., Sitka	386
	PORTULACCACEÆ.	
37	Claytonia ulsinoides, Sims., Alaska	1
	GERANIACEÆ.	
38	Geranium erianthum, Dc., Kadiak, Unalaska	228, 220
	ACERACEÆ.	
39	Acer macrophyllum, Doug., Vancouver	36
	LEGUMINOSÆ.	
40	*Lupinus nootkatensis, Dou.*, Kadiak, Unalaska	245
41	Trifolium repens, L., Sitka	168
42	Meddeago denticulata, Willd.? Sitka	388
43	Vicia gigantea, Hook, var. sitchensis, Sitka	258
44	Lathyrus palustris, L., Kadiak	228, 197
45	Lathyrus maritimus, Big., (Pisum L.,) Kadiak, &c	197
	ROSACEÆ.	
46	Spiræa douglasii, Hook, Vancouver	15
47	Spiræa aruncus, L., Sitka	182
48	Spiræa pectinacea, Tou and Gr., Sitka	193
49	Geum calthæfolium, Smith, var. dilatatum, Unalaska	267
50	Sanguisorba canadensis, L., Sitka, Kadiak	133
51	Sanguisorba officinalis, L., Kadiak	133
52	Fragaria canadensis, Mx., Kadiak	376
53	Potentilla norwegica, L., Alaska	34
54	Potentilla gracilis, var., Alaska	269
55	Potentilla villosa, Pursh., Alaska	389
56	Potentilla anserina, L., Alaska	190
57	Potentilla palustris, Scop., (comarum, L.,) Alaska	247
58	Rubus arcticus, L., Alaska	254
59	Rubus nutkanus, Moc., Alaska	392
60	Rubus chamœmorus, L., Alaska	157
61	Rubus leucodermis, Dougl., Vancouver	31
62	*Rubus spectabilis, Pursh., Kadiak*	234
63	Rubus pedatus, Smith, Sitka	158
64	Rosa fraxinifolia, Bark, Vancouver	390
65	Rosa blanda, Ait., Kadiak	213
66	Pyrus rivularis, Dougl., Alaska	16, 26
67	Pyrus sambucifolia, Cham	....
68	Cerasus mollis, Dougl., Washington Territory	39
	ONAGRACEÆ.	
69	Epilobium latifolium, L., Unalaska	264
70	Epilobium angustifolium, 3 diff. forms, Spruce Island	131
71	Epibolium roseum, Schr.? Hope Island	33
72	Epibolium alpinum, Wahl., Unalaska	296
73	Epibolium coloratum, Muhl., Vancouver	180
74	Epibolium lateum, Pursh., Unalaska	306
75	Circæa alpina, Tourn., Sitka	375
76	Hippuris vulgaris, L., Unalaska	310
	CRASSULACEÆ.	
77	Sedum rhodiola, Dc., Kadiak	244
	GROSSULACEÆ.	
78	Ribes laxiflorum, Pursh., Sitka	161
79	Ribes bracteosum, Dougl., Sitka	166
80	Ribes divaricatum, Dougl.? Bellabella Island	57
81	Ribes lacustre, Poir, Chilkaht	338, 236
	SAXIFRAGACEÆ.	
82	Saxifraga seleniflora, Sterb., Sitka	112
83	Saxifraga punctata, L., æstivalis, Fisch., Sitka	403
84	Saxifraga off., S. Eschscholtzii serpyllifolia, Kellogg, Kadiak???	271
85	Tiarella trifoliata, L., Sitka	53

Plants collected by the United States Coast Survey, &c.—Continued.

Durand's number.	Order, species, and habitat.	Kellogg's number.
86	Telima grandiflora, Dougl., Sitka	404
87	Leptarrhena pyrifolia, R. Br., Unalaska	291
88	Philadelphus gordonianus, Lindl., Vanc. Island	2
89	Variety No. 97	
	UMBELLIFERÆ.	
90	Œnanthe sarmentosa, Nutt., Sitka	374
91	Archangelica Gmelini, Dc., Sitka	170, 104
92	Ligusticum scoticum, L., Sitka	181
93	Conioselinum fischeri, Wim and Gray? (not the original Gray,) Sitka.	107, 209
94	Heracleum lanatum, L., Sitka	182
95	Osmorrhiza brevistylis, Dc., Sitka	172
	ARALIACEÆ.	
96	Aralia (Panax) horrida, Hook, Alaska	50
	CORNACEÆ.	
97	Cornus canadensis, L	
	CAPRIFOLIACEÆ.	
98	Linnæa borealis, Gron., Kadiak	84
99	Lonicera involucrata, Banks, Vancouver	25
100	Sambucus pubens, Mich., Alaska, &c	93
101	Viburnum pauciflorum, Pilaie, Alaska, &c	
	RUBIACEÆ.	
102	Galium boreale, L., Kadiak	223
103	Galium trifolium, L., Alaska and Sitka	379
104	Galium trifolium, var. pusillum, Gr., Sitka	381
105	Galium triflorum, Mich., Sitka, Kadiak	380, 377
	COMPOSITÆ.	
106	Aster; A. mutatus T. and Gr., Unalaskensis, var. major, Hook, Unalaska.	118
107	Aster foliaceus, Lindl.; A. peregrinus, Less, Kadiak	194, 368
108	Aster peregrinus, Pursh	194
109	Aster alpinus, L., Unalaska	173
110	Aster saluginosus, Lindl	167, 238
111	Aster saluginosus, Lindl	7
112	Erigeron philadelphicum, L., Vancouver	3
113	Solidago confertiflora, Dc., Kadiak	232
114	Solidago virga-aurea, L., var. arctica, Kadiak	232
115	Nardosmia corymbosa, Hook, Unalaska	189
116	Achillea millefolium, var. floribus purpureis, Unalaska.	261
117	Artemisia filesii, Lindl., Unalaska	285
118	Artemisia vulgaris, L., Unalaska	284
119	Artemisia richardsoniana, Bess., Kadiak	285, 101
120	Gnaphaleum alpinum, Nutt., Unalaska	58
121	Antennaria margaritacea, R. Br	277
122	Senecio pseudo-arnica, Kadiak	266
123	Arnica chamissonis, Less., Kadiak	231
124	Arnica montana, var. unalaskensis, Less., Kadiak	290
125	Arnica montana, var. unalaskensis alpina, 3,000 ft. alt.	290
126	Arnica latifolia, Bong	370
127	Matricaria dioscordea, Dc., Sitka	165
128	Leontodon palustre, L., Unalaska	301
129	Hieracium scouleri, Hook? Vancouver	299
130	Hieracium triste, Willd., 2,000 ft. alt., Sitka	298
131	Souchus asper, Willd., Sitka	55
132	Nabalus alatus, Hook, Kadiak	106
	CAMPANULACÆ.	
133	Campanula rotundifolia, L., Kadiak	204
134	Campanula rotundifolia, var. linifolia, Gr., Kadiak	204
135	Dasyantha, Bieb., Unalaska	302
	ERICACEÆ.	
136	Vaccinium vitis-idæa, Alaska	152
137	Vaccinium oxycoccus, L., Fort Simpson?	121
138	Vaccinium ovalifolium, Smith, Carter's Bay?	55, 286
139	Vaccinium parvifolium, Soms., Alaska	150
140	Vaccinium myrtyllus, L., V. chamissonis, Bong., Sitka	185
141	Vaccinium cœspitosum, Mich., Unalaska	286, 367
142	Vaccinium uliginosum, L., Sitka	286
143	Arctostaphyllos alpina, Spreng., Unalaska	275
144	Menziesia ferruginea, Smith, Alaska	29
145	Andromeda polyfolia, L., Sitka	365
146	Kalmia glauca, Ait., Alaska	127
147	Rododendron kamtschaticum, Pall., Unalaska	282
148	Gaultheria shall., Pursh., Vancouver Island	32
149	Phyllidoce aleutice, Fisch., Alaska	277
150	Ledum latifolium, Ait., Sitka and Alaska	141
151	Pyrola rotundifolia, L., Kadiak	219
152	Pyrola secunda, L., Kadiak	192
153	Moneses uniflora, Salisb., Kadiak	152
	PLANTAGINACEÆ.	
154	Plantago maritima, L., Sitka	388
155	Plantago major, L., Sitka	387
156	Plantago, no flowers	
	PRIMULACEÆ.	
157	Dodecatheon frigidum, Cham., D. meadia, L., Kadiak.	205
158	Trientalis europæa, Ph., Alaska	191
159	Glaux maritima, L., Alaska	49
	OROBANCHACEÆ.	
160	Boschiakia glabra, Hook, Sitka	68
	SCROPHULARIACEÆ.	
161	Mimulus luteus, L., Sitka	199
162	Castilleia pallida, Kunth, Kadiak	218
163	Orthocarpus bracteosus, Benth, Vancouver	9
164	Orthocarpus castelleiodes, Benth, Vancouver	9
165	Euphrasia alpina, L., Unalaska	245
166	Phinanthus crista-galli, L., Kadiak	215
167	Pedicularis chamissonis, Stev., Unalaska	144, 248
168	Pedicularis langsdorffii, Fisch., Unalaska	334
169	Pedicularis verticillata, L., Unalaska	248
170	Pedicularis	
171	Veronica alpina, L., Unalaska	295
172	Veronica americana, Schu.? Sitka	407
173	Veronica scutellata, L., Sitka	20
174	Veronica serpyllifolia, L., Sitka	408
	LABIATÆ.	
175	Mentha canadensis, L., Vancouver	19
176	Galeopsis tetrahit, L., Sitka	164
177	Brunella vulgaris, L., Alaska	294
	BORRAGINACEÆ.	
178	Mertensia maritima, Dou., Kadiak	270
	HYDROLEACEÆ.	
179	Romanzoffia sitkensis, Cham., Sitka	335
	POLEMONIACEÆ.	
180	Polemonium micranthum, Dc., Spruce Island	249
181	Polemonium cœruleum, Dc., Kadiak	225
182	Polemonium cœruleum, var. sibericum, Kadiak	

Plants collected by the United States Coast Survey, &c.—Continued.

Durand's number.	Order, species, and habitat.	Kellogg's number.
	GENTIANACEÆ.	
183	Suertia perennis, L., Kadiak	214
184	Gentiana douglasii, Bong., Lawson's Bay, B. C.	168
185	Gentiana acuta, Mich., Spruce Island, &c.	246, 329
186	Villarsia crista galli, Gris., Alaska	124
	CHENOPODIACEÆ.	
187	Chenopodium album, L., Sitka	35
188	Atriplex littoralis, var. hastata, L., Barlowe Cove	176
	POLYGONACEÆ.	
189	Oxyria reniformis, Hook, Sitka	281
190	Rumex acetosella, L., Sitka	393
191	Rumex domesticus, Hook, Spruce Island	250
192	Polygonum viviparum, L., Unalaska	304
193	Polygonum sagittatum, L.?	118
	CALLITRICHACEÆ.	
194	Callitriche verna, L., Sitka	371
	EMPETRACEÆ.	
195	Empetrum nigrum, L., Unalaska	65
	CUPULIFERÆ.	
196	Quercus douglasii, Hook and Arn.? Vancouver	23
	BETULACEÆ.	
197	Betula glandulosa, Mich.? B. nana, var. kell, Kadiak.	216
198	Alnus viridis, Dc., Fort Simpson	126, 184
199	Alnus rubra, Bong., A. tomentosa, Reg., Sitka	....
	SALICACEÆ.	
200	Salix sitchensis, Anders., Kadiak	175
201	Salix richardsonii, Hook, Kadiak	221
202	Salix reticulata, L	....
203	Salix brachystachys, Benth., Vancouver	22
204	Salix ovalifolia, Trautr., Unalaska	275
205	Salix cordata, Muhl.? Kadiak	175
205 *bis*	Salix speciosa, Bong	....
206	Populus balsamifera, L., Kadiak	259, 272
207	Populus tremuloides, Mich., Vancouver	13
	CONIFERÆ.	
208	Pinus inops, Ait., P. contorta, Bong., Alaska, Lawson's Bay.	338
209	Abies grandis, Lindl., A. amabilis, Dougl., Vancouver.	....
210	Abies mertensiana, Bong.. Alaska	....
211	Abies sitchensis, Bong., A. menziesii, Hope Island	42
212	Thuja gigantea, Nutt., Bellabella Island	21
213	Cupressus nutkatensis, Hook, (Yellow Cedar,) Sitka.	155
214	Juniperus nana, Willd., Alaska	134
	ARACEÆ.	
215	Symplocarpus kamtschaticus, Bong., Alaska	62
	ALISMACEÆ.	
216	Triglochin maritimum, L., Sitka	403
	ORCHIDACEÆ.	
217	Microstylis diphyllos, Lindl., Sitka	162
218	Platanthera hyperborea, Lindl., Lawson's Bay	132
219	Listera cordata, R. Br., Kadiak	229
220	Listera convallarioides, Hook, Kadiak	229

Durand's number.	Order, species, and habitat.	Kellogg's number.
	AMARYLLIDACEÆ.	
221	Sisyrinchium bermudianum, var. anceps, Sitka	382
	IRIDACEÆ.	
222	Iris siberica, Willd., Unalaska	307
	LILIACEÆ.	
223	Smilacina bifolia, Ker., S. dilatata. Nutt., Alaska	212
224	Clintonia uniflora, Menz., Alaska	....
225	Hespericordium maritimum, Torr., Vancouver	14
226	Fritillaria kamtschatica, Fisch., Alaska	108
	MELANTHACEÆ.	
227	Streptopus amplexifolius, Dc., Alaska	74
228	Streptopus roseus, Mich., Sitka	413
229	Veratrum viride, Ait., Kadiak	71
230	Tofieldia glutinosa, Prest., Alaska	409
231	Tofieldia borealis, Vahl., Nequashinski Inlet	87
	JUNCACEÆ.	
232	Luzula campestris, Dc., Sitka	196
233	Luzula parviflora, Sitka	384
234	Juncus arcticus, Willd., Sitka	383
	GRAMINEÆ.	
235	Phleum pratense, L., Alaska	43
236	Phleum alpinum, L., Unalaska	129
237	Agrostis exarata, Trin., Kadiak	119
238	Agrostis canina, L., Unalaska	119
239	Agrostis vulgaris, With., Vancouver	114
240	Agrostis scabra, Will., A. laxiflora, Rich., Alaska	113, 103
241	Calamagrostis langsdorffii, Trin., Alaska	110
242	Calamagrostis aleutica, Bong., Alaska	111
243	Calamagrostis lapponica, Trin., Alaska	154
244	Aira elongata, Hook, Alaska	146
245	Aira cœspitosa, L., Unalaska	99
246	Aira atropurpurea, (sub-alpine,) Waht.	99
247	Poa nemoralis, L., Unalaska	97
248	Poa bulbosa, var. vivipara, Bess., Unalaska	95
249	Poa pratensis, L., Unalaska	96
250	Poa laxa, Mœnch., Spruce Island	239
251	Hierochloa borealis, Roem. and Sch., Alaska	89
252	Trisetum cernuum, Hook, Lawson's Bay	90
253	Glyceria distans, Wahl., Bellabella Island	147
254	Glyceria nervata, Torr., Lawson's Bay	83
255	Bromus secalinus, L., Vancouver	153
256	Bromus purgans, L., Unalaska	142
257	Bromus virens, Nutt., Hope Island	143
258	Bromus ciliatus, L., Alaska	145
259	Festuca ovina, L., Carter's Bay	146
260	Elymus mollis, Trin., Unalaska	140
261	Elymus sibericus, L., Hope Island	139
262	Hordeum pratense, L., Hope Island	138
263	Hordeum distichum, L., Unalaska	137
	EQUISETACEÆ.	
264	Equisetum eburneum, Sck.? Kadiak	328
265	Equisetum variegatum, Sck., Unalaska	316
	FILICES.	
266	Polypodium vulgare, var. occidentale, Hook, Unalaska.	44
267	Polypodium dryopteris, Gr., Sitka	69
268	Blechnum boreale, Swartz, Alaska	51
269	Cryptogamme acrostichoides, R. Br., Kadiak	252
270	Aspidium spinulosum, Swartz, Alaska	70, 205

In transmitting the preceding list, Mr. Durand says: "The greatest part of these plants is common to our northeastern region; but I remark that those of Alaska are, generally, of a larger size than the same species in Labrador, Greenland, &c."

APPENDIX N.

Comparative Vocabulary, upon the plan adopted by the Smithsonian Institution.

[NOTE.—Country: northwest coast of America, Buccleugh Sound, Fort Simpson, latitude 54° 35′. Tribe: Spuch′-æ-lotz″ tribe of the Tchim′-chæ-an′ people. Recorded by George Davidson, Assistant, United States Coast Survey. Date of record: August 6 and 7, 1867.—From "Clah," of the tribe mentioned, recommended by Mr. Horn, of the Hudson Bay Company, as a good man, and speaking, reading, and writing English.]

Number.	English.	Spanish.	French.	Latin.	Alaskan.
1	Man	Hombre	Homme	Vir, homo	U′-et.
2	Woman	Mujer	Femme	Mulier	Han″-nach″.
3	Boy	Muchacho	Garçon	Puer	Sku″-wamsk′.
4	Girl	Muchacha	Fille	Puella	Squah″-a-nah′.
5	Infant	Niño ó niña	Enfant	Infans	Ke-na es.
6	My father, (said by son)	Mi padre, dice el hijo	Mon père, dit le fils	Pater meus, dicit filius	No′-yo nah-qui′-a-duk.
7	My father, (said by daughter)	Mi padre, dice la hija	Mon père, dit la fille	Pater meus, dicit filia	Do.
8	My mother, (said by son)	Mi madre, dice el hijo	Ma mère, dit le fils	Mater mea, dicit filius	No′-yo nan′-dit.
9	My mother, (said by daughter)	Mi madre, dice la hija	Ma mère, dit la fille	Mater mea, dicit filia	Do.
10	My husband	Mi marido	Mon mari	Sponsus meus	No-yo nux-u-et.
11	My wife	Mi esposa	Mon épouse	Uxor mea	Do.
12	My son, (said by father)	Mi hijo, dice el padre	Mon fils, dit le père	Filius meus, dicit pater	
13	My son, (said by mother)	Mi hijo, dice la madre	Mon fils, dit la mère	Filius meus, dicit mater	No-yo skœ̄l-kut-it.
14	My daughter, (said by father)	Mi hija, dice el padre	Ma fille, dit le père	Filia mea, dicit pater	
15	My daughter, (said by mother)	Mi hija, dice la madre	Ma fille, dit la mère	Filia mea, dicit mater	No-yo skœ̄l-skum-han-nach.
16	My elder brother	Mi hermano mayor	Mon frère ainé	Frater meus natu major	No-yo sheel-æ-git-wykh.
17	My younger brother	Mi hermano menor	Mon frère cadet	Frater meus natu minor.	No-yo tswan-æ-git-wykh.
18	My elder sister	Mi hermana mayor	Ma sœur ainée	Soror mea natu major	No-yo sheel-æ-git klink-tee.
19	My younger sister	Mi hermana menor	Ma sœur cadette	Soror mea natu minor	No-yo tswan-æ-git klinktee.
20	An Indian	Indio	Sauvage	Indus	Tchim′-shæ-an.
21	People	Gente	Peuple	Populus	Ket.
22	Head	Cabeza	Tête	Caput	Tan″-kaus′.
23	Hair	Pelo	Cheveux	Crinis	Kaus.*
24	Face	Cara	Figure	Facies	Tchal.
25	Forehead	Frente	Front	Frons	Waup'h.
26	Ear	Oreja	Oreille	Auris	Mob.
27	Eye	Ojo	Œil	Oculus	Wil-leel.
28	Nose	Nariz	Nez	Nasus	Chah.
29	Mouth	Boca	Bouche	Os	Aah.
30	Tongue	Lengua	Langue	Lingua	Too′-lah.
31	Teeth	Dientes	Dents	Dentes	Wan.
32	Beard	Barba	Barbe	Barba	Imch.
33	Neck	Cuello	Cou	Collis	T'um′-lan-ee.
34	Arm	Brazo	Bras	Brachium	An-non′.
35	Hand	Mano	Main	Manus	Lach-sneel′.
36	Fingers	Dedos	Doigts	Digiti	T'sweld.
37	Thumb	Dedo pulgar	Pouce	Digitus pollex	Mōsh.
38	Nails	Uñas	Ongles	Ungues	Clach'sh.
39	Body	Cuerpo	Corps	Corpus	Tam′-magh.
40	Chest	Pecho	Poitrine	Sternum	'Ki′-ik.
41	Belly	Barriga	Ventre	Venter	Pēn.
42	Female breasts	Pechos de mujer	Mammelles	Ubera	Meshugh.
43	Leg	Pierna	Jambe	Crus	Tum-bæb′.
44	Foot	Pié	Pied	Pes	Ak-shee.
45	Toes	Dedos del pié	Doigts du pied	Digiti pedis	Tchum″-ma-shee.
46	Bone	Hueso	Os	Os	Shy′-ip.
47	Heart	Corazon	Cœur	Cor	Kor′.t.†
48	Blood	Sangre	Sang	Sanguis	Ichlæ′.
49	Town, village	Pueblo, villa, aldea	Bourg, village	Oppidum, pagus	Kul′ chup.
50	Chief	Jefe	Capitaine	Dux	Schmah′ eet.
51	Warrior	Guerrero	Guerrier	Miles	Will-do-eet.
52	Fights				Tull.
53	Friend	Amigo	Ami	Amicus	Dam-aghl.

* Lēēh for fur, feathers, &c. † has same sound as the obscure *e* in people.

Comparative Vocabulary, &c.—Continued.

Number.	English.	Spanish.	French.	Latin.	Alaskan.
54	My friend				Dam-ughl-cụt.
55	House	Casa	Maison	*Domus*	Wēlp.
56	Skin-lodge	Casa de cueros	Loge de peaux	Tentorium e pellibus	Wēlp an-ass.
57	Kettle	Caldera	Chaudière	Lebes	Kigh' lum-'dotchk.
58	Bow	Arco	Arc	Arcus	Howk'-tuk.
59	Arrow	Flecha	Flèche	Sagitta	How'-wel.
60	Ax, hatchet	Hacha	Hache	Ascia	Kee-yōl-tụk.
61	Knife	Cuchillo	Couteau	Culter	Hot-le-he-sk.
62	Canoe	Canoa	Canot	Scapha Indica	Agh-sho'.
63	Moccasins	Zapatos Indios	Souliers de sauvage	Calceamenta Indica	Chōch'-see-tragh''.
64	Pipe	Pipa	Pipe	Tubus nicotianus	Agh-pe-an.
65	Tobacco	Tabaco	Tabac	Nicotianum	Wun-tŏ-cum-she-whæ.*
66	Sky	Cielo	Ciel	Cœlum	L'ghi'.
67	Sun	Sol	Soliel	Sol	Kem'kum tchee'-us.
68	Moon	Luna	Lune	Luna	Kem' 'kum hu-pụl.
69	Star	Estrella	Étoile	Stella	Pee'-ells''.
70	Day	Dia	Jour	Dies	Tchee-us.
71	Night	Noche	Nuit	Nox	Hu-p.l.
72	Morning	Mañana	Matin	Tempus matutinum	Kun-klah-gh.
73	Evening	Tarde	Soir	Vesper	Kla' tum hu-pụl.
74	Spring	Primavera	Printemps	Ver	Koy'-yum.
75	Summer	Verano	Été	Æstas	Shu'-unt.
76	Autumn	Otoño	Automne	Autumnus	Ku-shu'-it.
77	Winter	Invierno	Hiver	Hibernus	Kom-shum.
78	Wind	Viento	Vent	Ventus	Pash'k.
79	Thunder	Trueno	Tonnerre	Tonitru	Kulp-leeb'.
80	Thunder in sky				Kullup leeb'-in lachigh', (? l'ghi.)
81	Lightning	Relámpago	Éclair	Fulgur	Tcham'-tee.
82	Rain	Lluvia	Pluie	Pluvium	Wæ'-sh.
83	Snow	Nieve	Neige	Nix	Mah'-dum.
84	Fire	Fuego	Feu	Ignis	Lụk.
85	Water	Agua	Eau	Aqua	Ụks.
86	Ice	Hielo	Glace	Glacies	Tough, (*ough* as in bough.)
87	Earth, land	Tierra	Terre	Terra	You'p.
88	Great extent of land				Lụch you'p.
89	Sea	Mar	Mer	Mar	Lụch ụks, (a great extent of water.)
90	River	Rio	Fleuve, rivière	Flumen	Tchim mówit-chụ.†
91	Lake	Lago	Lac	Lacus	Lụch' tagh.
92	Valley	Valle	Vallée	Vallis	Skụt-tēn'.
93	Prairie	Llano	Prairie	Pratum	Lụch''-lụp-pa'.
94	Hill, mountain	Cerro, montaña	Côte, montagne	Collis, mons	Tĕ, s'kun nisht'.
95	Island	Isla	Île	Insula	Lụch'' stah'.
96	Stone, rock	Piedra, roca	Pierre, roche	Lapis, saxum	Lau' ụp.
97	Salt	Sal	Sel	Sal	Mawn.
98	Salt water				Maw-un ụks.
99	Iron	Hierro	Fer	Ferrum	Tu'-.stk.
100	Forest	Bosque, selva	Forêt	Sylva	Kun'-kun'.
101	Tree	Árbol	Arbre	Arbor	Kun.
102	Wood	Madera	Bois	Lignum	Kun.
103	Leaf	Hoja	Feuille	Folium	Of a tree, lachs; of a bush, yûnsh.
104	Bark	Corteza	Écorce	Cortex	Mããs.
105	Grass	Yerba	Herbe	Herba	Ke''-och''.
106	Pine	Pino	Pin	Pinus	Hawks.
107	Yellow cedar				Kul''-lụl' or kul''-læl'.
108	Maize	Maïs	Maïs	Zea maiz	
109	Squash	Calabaza	Citrouille	Cucurbitus	
110	Flesh, meat	Carne	Chair	Caro	Shụm'-me.
111	Dog	Perro	Chien	Canis	Hããs.
112	Buffalo	Bisonte, búfalo	Buffle	Bison, bos americanus	
113	Bear	Oso	Ours	Ursus	Ōl.
114	Wolf	Lobo	Loup	Lupus	'Ku-bah'-o.

* Indians call all whites *cum-she-wah*. Traders bring here tobacco to chew and not to smoke; they call it *win-de-gh*.
† *Mow* as English mow.

Comparative Vocabulary, &c.—Continued.

Number.	English.	Spanish.	French.	Latin.	Alaskan.
115	Fox	Zorra	Renard	Vulpis	Na kutch chæ′.
116	Deer	Ciervo	Cerf	Cervus	Wun.
117	Elk	Alco	Élan	Cervus canadensis	Chle-on′.
118	Beaver	Castor	Castor	Castor	S'tchol.
119	Rabbit, hare	Conejo	Lapin, lièvre	Lepus	'Tụk-klen′.
120	Tortoise	Tortuga	Tortue	Testudo	
121	Horse	Caballo	Cheval	Equus	
122	Fly	Mosca	Mouche	Musca	Kee-. k.
123	Sand fly				Tach-tach.
124	Mosquito	Mosquito	Maringouin	Culex	Kee-. k.
125	Snake	Culebra, serpiente	Serpent	Serpens	Mit″tel-læ′lt.
126	Rattlesnake	Culebra de cascabel	Serpent à sonnettes	Crotalus	
127	Bird	Ave	Oiseau	Avis	Tchootsh.
128	Egg	Huevo	Œuf	Ovum	Ghụl-com-met′.
129	Feathers	Plumas	Plumes	Plumæ	Lēē-h.
130	Wings	Alas	Ailes	Alæ	'Kụ'k-i.
131	Goose	Ganso	Oie	Anser	ghHa′gh.
132	Duck, (mallard)	Pato	Canard	Anas boschas	
133	Swan				'Kụ'k.
134	Crane				Ku tel'ch.
135	Turkey	Pavo, guanajo	Dindon	Pavo	
136	Pigeon	Pichon	Tourte	Columba	Kah-bǣ′.
137	Fish	Pez	Poisson	Piscis	No general name.
138	Salmon	Salmon	Saumon	Salmo	Hawn.
139	Sturgeon	Esturion	Esturgeon	Sturio	
140	Name	Nombre	Nom	Nomen	Wah.
141	White	Blanco	Blanc	Albus	Maw′-s'k.
142	Black	Negro	Noir	Niger	'Tu-sk, and 'K sham′-isk.
143	Red	Colorado	Rouge	Rubrum	Mesh'k.
144	Light blue	Azul celeste	Bleu	Cœruleum	Kwish-kwy′sh'k.
145	Yellow	Amarillo	Jaune	Amarillis	
146	Light green	Verde	Vert	Viridis	M. t lee′. t'gh.
147	Great, large	Grande	Grand	Magnus	Wil-tēks′.
148	Small, little	Pequeño	Petit	Parvus	T'choos'hk′.
149	Strong	Fuerte	Fort	Fortis	Kot′-ket′.
150	Old	Viejo	Vieux	Vetus	Clah.*
151	Young	Joven	Jeune	Juvenis	Shu-pesh.
152	Good	Bueno	Bon	Bonus	Am.
153	Bad	Malo	Mauvais	Malus	H. t″-tach′.
154	Dead	Muerto	Mort	Mortuus	Tchu′k.
155	Alive	Vivo	Vivant	Vivus	T-'d u′-lis.
156	Cold	Frio	Froid	Frigidus	Kw. t-t'k.
157	Warm, hot	Caliente	Chaud	Calidus	Kem-'k.
158	I	Yo	Je	Ego	'No it.†
159	Thou	Tú	Tu	Tu	No′-en or nụ-en.
160	He	Él	Il	Ille	
161	We	Nosotros	Nous	Nos	Nugh′-um.‡
162	Ye	Vosotros	Vous	Vos	
163	They	Ellos	Ils	Illi	
164	This	Este	Ceci	Iste	Qui-it.‡
165	That	Aquel	Cela	Ille	Quah.
166	All	Todo, todos	Tout, tous	Omnis, totus	Tah′-næd′.
167	Many, much	Mucho, muchos	Beaucoup	Multus	We′-heldt.
168	Who	Quien	Qui	Qui	'Gnụh.
169	Far	Lejos	Loin	Longe	Whi′-toh.
170	Near	Cerca de	Près	Prope	Ki-im-qŭah′.
171	Here	Aqui	Ici	Hic	Qu'sh 'ku.
172	There	Allá	Là	Illuc	Qui-id.§
173	To-day	Hoy	Aujourd'hui	Hodie	Shæh.
174	Yesterday	Ayer	Hier	Heri	*As-tæ-'kits-ǣbt″.*

* As *clah u′-et*, old man.
† 'Tum tough . 'tl no it, I am going away; in this expression I understand *'no it* to represent I.
‡ First syllable soft.
§ Both syllables soft.
See conjugation of a verb at end.

Comparative Vocabulary, &c.—Continued.

Number.	English.	Spanish.	French.	Latin.	Alaskan.
175	To-morrow	Mañana, (el dia de)	Demain	Cras	Tche'-kits æbt.
176	Yes	Sí	Oui	Ita	Yĕh.
177	No	No	Non	Minime	Ine.*
178	One	Uno	Un	Unus	'Kṳ̄ll.
179	Two	Dos	Deux	Duo	Kṳ̄'pl.
180	Three	Tres	Trois	Tres	Kwṳ lee'.†
181	Four	Cuatro	Quatre	Quatuor	T'halb.
182	Five	Cinco	Cinq	Quinque	Sh-k'tūns'.
183	Six	Sies	Six	Sex	Kald't.
184	Seven	Siete	Sept	Septem	Tṳp pawlt.
185	Eight	Ocho	Huit	Octo	Kṳn dawlt.
186	Nine	Nueve	Neuf	Novem	Sh-tim-mowes.
187	Ten	Diez	Dix	Decem	'Kep.
188	Eleven	Once	Onze	Undecim	Kep''-ti-kṳ̄ll'.
189	Twelve	Doce	Douze	Duodecim	Kep''-ti-kṳp . l, &c., up to 19, inclu.
190	Twenty	Viente	Vingt	Viginti	Kṳ-deel'.
191	Twenty-one				Kṳ-deel-ti kṳ̄ll, &c.‡
192	Thirty	Treinte	Trente	Triginta	Kwæ-lee' wel-kep''.
193	Forty	Cuarenta	Quarante	Quadraginta	'Ta'l-fṳl-kep'.
194	Fifty	Cincuenta	Cinquante	Quinquaginta	Kstuns''-wil-kep''.
195	Sixty	Sesenta	Soixante	Sexaginta	Kald''-wil-kep''.
196	Seventy	Setenta	Soixante-dix	Septuaginta	Tṳ-pawldt-wil-kep''.
197	Eighty	Ochenta	Quatre-vingts	Octoginta	Kṳn-dawldt-wil-kep''.
198	Ninety	Noventa	Quatre-vingt-dix	Nonaginta	Sh-tim-mas'-wil-kep.
199	One hundred	Ciento	Cent	Centum	Sk tun-shawl.
200	Two hundred				Kṳ-pawl.
201	Three hundred				Kṳ-pawl tuk-tun-shawl.
202	Four hundred				Kṳ-dawl'.
203	Five hundred				Kṳ dawl tuk-stun, (? shawl.)
204	One thousand	Mil	Mi le	Mille	Does not remember.
205	To eat	Comer	Manger	Edere	'Tum yauchk, and kŭp.§
206	To drink	Beber	Boire	Bibere	Aks, (same as water.)
207	I am going to drink				'Tum-aks-æ-no-it.
208	To run	Correr	Courir	Currere	'Tum ban-ŏt.
209	To run quickly				'Tum-al̄-l̄o-ban-o't.
210	To dance	Bailer	Danser	Saltare	'Tum-mil'k'.
211	To sing	Cantar	Chanter	Cantare	'Tum-li'-mi.‖
212	To sleep	Dormir	Dormir	Dormire	'Tum-stoch.§
213	To speak	Hablar	Parler	Loqui	'Tum-al yoch.
214	To see	Ver	Voir	Videre	'Tum-nīd'g.¶
215	To love	Amar	Aimer	Amare	'Tum-shi'-pen.‖
216	To kill	Matar	Tuer	Cædere	'Tum-kel . 'k.
217	To sit	Sentarse	S'asseoir	Sedere	'Tum-'ti-a'h.
218	To stand	Estar en pie, parar	Se tenir debout	Stare	'Tum hi-adt'k.
219	To go	Ir	Aller	Ire	'Tum tough itl.**
220	To come	Venir	Venir	Venire	'Tum-coi-ṳtux, also kṳ̆l.
221	To walk	Andar	Marcher	Ambulare	'Tum-yǣh'b.
222	To work	Trabajar	Travailler	Operari	'Tum-ghṳt-lels, and 'tum-chep.
223	Carpenter work				Nūk-chep.
224	To steal	Robar	Voler	Furare	'Tum-kalch.§
225	To lie	Mentir	Mentir	Mentiri	
226	One tells another he lies				Shṳ bīks.
227	Lying all the time				*Ouk*-bīk.
228	To give	Dar	Donner	Dare	'Tum-kæ-num.
229	To laugh	Reir	Rire	Ridere	'Tum-shṳ-shack.
230	To cry	Gritar	Crier	Clamare	'Tum wi-on-it.

* As in fine.
† Soft *e*.
‡ Sometimes kṳ deel tṳ' kṳp . l.
§ *Ch* as in *ich*.
‖ *I* soft.
¶ *I* long and soft.
** *Ough* as in bough, and *itl* soft.

Comparative Vocabulary, &c.—Continued.

English.	Alaskan.
To hunt by canoe	'Tum-wah.
To hunt by simply walking through the woods	'Tum wil-la-chep.
To fish for salmon	'Tum shæ-hon.
To fish for halibut	'Tum shit-trow, (here *trow* means halibut.)
To fish for cod	'Tum shĕ-komtz.*
To barter	'Tum shit″-i-agh′.
To buy	'Tum ki-uk.
I love	Shee′ pụ 'no″ it.
You love	Shee′ pụn ne.
He loves	*Shee′ pụnt* 'kụh.
We love	Shee-pụ n . mpt.
You love	Shee-pụntsh . mpt.
They love	Ta-shee′pụnt-'kuk.
All love	Shite-shee-pụnt-kụh.
I fight	Tụll-'no it.
You fight	Tụll-ne.
He fights	Tụll-'kuh.
We fight	Tụll n. mpt.
You fight	Tụll sh. mpt.
They fight	Ta-tụll-. g . h.
All fight	Shite-tụll-. g . h.
I did fight	Tum-tan-no it.
You did fight	Tum-tan-i.
He did fight	Nụ-tụll't.
We did fight	Tum-tan-n. mpt.
You did fight	Tum tun-shụm-i.
They or all did fight	Tum-tull′ co-oyt.

* The women who have the small bone or stick through the under lip are called *she-komtz.*

APPENDIX No. 19.

OBITUARY ON ALEXANDER DALLAS BACHE.

Alexander Dallas Bache was born at Philadelphia on the 19th of July, 1806, and died at Newport on the 17th of February, 1867. His was a life devoted to the service of his friends, his country, and science; it was inspired by high aims, and always true to its inspiration. It was rooted in deep wisdom, it developed into an expanded growth of beneficial influence, and it ripened a full harvest of rich results. Rarely has there been such a complete and continuous unity of purpose, such a freedom from waste of intellectual power, and so successful an accomplishment of varied but connected plans. Organization and administration were his natural tasks, and his education and opportunities developed his nature. He filled many important offices, and undertook an extraordinary variety of difficult duty; but his clear perception and strong will combined them into a consistent whole. He was the center of many powers; the bond of union of diverse, and, except through him, contradictory energies; profound science and high philanthropy rejoiced to trust their dearest interests to him; men of all politics and of every art and doctrine had faith in him, and he justified their faith. All the influences to which he was subject conspired to build him up into a great and good man.

When he was graduated at West Point, at the head of his class, great expectations were entertained of him, which were not disappointed. He was conspicuous for the noble traits of character which peculiarly distinguish the illustrious graduates of that admirable institution. Sincere and manly speech, conscientious and unflinching performance of duty, unquestioning self-sacrifice, intense and grateful love of the country to which they owe their education, honest recognition of other men's rights and merits, freedom from jealousy, fertility in adapting means to ends, and practical good sense and sound judgment, all these qualities were eminently his, and he was the finest exponent of the possibilities of a military education for civil service. It was here, and in performance of his duty as a military engineer, that he learned the principles and practice of administering affairs and directing men, and that methods of organization first germinated in his mind. For eight years he devoted himself to physical science in his professorship in the University of Pennsylvania. His clear teaching and his valuable investigations contributed as much to the reputation of that city for science as any one of the greatest names by which Philadelphia has been adorned. As president of Girard College, he studied all the educational institutions of Europe. Circumstances which even his influence could not control deprived the college of the full benefits of his accumulated stores of knowledge. But the opportunity was given him to develop his studies upon education in the High School of Philadelphia. His organization of this institution was a marvellous adaptation of the best systems of academic education known in Europe, to American wants; and it has been the model upon which, consciously or unconsciously, the leading high schools of the country have been constructed.

In 1843 Professor Bache was appointed to be Superintendent of the Coast Survey. What it is now, he made it. It is his true and lasting monument. It will never cease to be the admiration of the scientific world. His name needs not to be carved by the hand of a sculptor. It is inscribed on the entablature of the survey by his own greatness. It is written upon the flood of the Gulf Stream; upon the pulse of the ocean's tide; upon the oscillation of the earth's magnetism. It is written on the bases of verification, on the great triangles with which these bases were brought into comparison, and on the hill-tops which he occupied for his stations; it is written on every shoal and rock and danger to navigation, and every channel discovered by the survey, and on the beautiful charts in which they are used by the grateful sailors; and it is written on all the investigations in geology, astronomy, and terrestrial physics, which have been conducted by the strongest intellect of the country combined under his control. No other name can replace his, or stand by its side. To whatever place and at whatever time the knowledge of the Coast Survey of the United States shall penetrate, it must carry with it the name of Bache. He is gone; but he is not forgotten. While he lived he was the acknowledged head of the science of his country; and he still lives, a glorious example and a cheering inspiration to us in the service of our country, of science, and of mankind.

APPENDIX No. 20.

TRIBUTE TO THE MEMORY OF A. D. BACHE, LL.D., LATE SUPERINTENDENT OF THE COAST SURVEY.

Professor Bache died at Newport, Rhode Island, on the 17th of February, 1867, after a lingering illness, the origin of which was a paralytic attack in the year 1864.

The decease was thus officially announced by the honorable Secretary of the Treasury:

"TREASURY DEPARTMENT, *February* 18, 1867.

"In the death of the Superintendent of the Coast Survey, Professor Bache, the department mourns the loss of one of its most valuable and most highly cherished officers. His decease occurred at Newport, Rhode Island, on the 17th instant, in his sixty-first year.

"No man within the present generation was more widely known in the walks of practical science; none has been so closely identified with collateral service in the various public departments.

"Alexander Dallas Bache was born at Philadelphia, July 19, 1806. He graduated at the Military Academy in 1825, and there remained a year as Assistant Professor. Subsequently, having resigned from the Corps of Engineers, he filled, at intervals, until the year 1843, an important chair in the University of Pennsylvania.

"Within the same period he was, during five years, President of Girard College, and matured the system of education adopted for the Philadelphia High School, yielding to that object time for examining the principles of systematic education in Europe.

"His devotion to practical science and his abilities as an administrative officer being well known, Professor Bache was appointed in December, 1843, to the vacant post of Superintendent of the Coast Survey. Under his direction that great national work has been eminent no less for its abundant results than for its high scientific character, which has won the approbation of the leading learned bodies of the world, among whom his name has long been held in honor. He possessed by nature the qualities most conducive to success in the management of widely-extended public interests. Invariably mild and forbearing towards those serving under his direction, his unremitting energies and his untiring patience were as invariably given to the accomplishment of the service in view.

"His sympathy with the efforts of others, and readiness to give credit for their exertions, secured a cordial spirit of co-operation. Sagacity, perfect freedom from bias, and constant activity within the sphere of his public duties, strongly marked his relations with this department.

"He was a member of the Light-house Board, and participated in its organization; a Regent of the Smithsonian Institution; and ever the valued associate of leading men to whom are committed questions in regard to matters of public utility. His advice was eagerly sought in the determination of many local and general facilities to further the interests of commerce and navigation.

"That the deceased Superintendent had become illustrious in America and in Europe, is due to the steady devotion of his great talents to the service of the people.

"His genial disposition attracted the love of associates and of subordinates; his wisdom commanded their respect. He leaves us a name of unsullied purity, and a memory that adds luster to the many public records upon which it is borne.

"As a tribute to his memory, the Coast Survey Office will be draped in black, and will be closed on the day of the funeral.

"HUGH McCULLOCH,
"*Secretary of the Treasury.*"

Several of the Field Assistants, then incidentally in Washington, convened with other persons employed in the service, at 2 o'clock p. m., on Monday, February 18, at the Coast Survey Office, on New Jersey Avenue.

On motion of Assistant Richard D. Cutts, the assistant in charge of the office was called to the chair. Mr. W. W. Cooper was designated to act as secretary.

Assistant Hilgard stated the object of the meeting in the following remarks:

"The sad occasion which brings us together is known to you all. Our honored and beloved chief passed beyond the bounds of earthly existence yesterday about nine o'clock in the morning, at Newport, where, since his return from Europe, he had awaited the termination of his sufferings. Although long looked for, the end strikes upon our feelings scarcely less severe than if he had been taken away suddenly, and without warning.

"We meet to give expression to our deep sense of the loss we have thus sustained; to our appreciation of his admirable character and eminent public services; and to tender our sympathies to the bereaved family.

"In a certain degree most of us belong to his family, for such was his sympathy with all, that the members of the Coast Survey have stood to him rather in such relation than as official subordinates; and each one present doubtless feels a sense of personal loss.

"Professor Bache had, more than most men of his day, won the close regard of his fellow-workers in the field of science; the confidence of the nation in his wisdom and integrity; and the love of those with whom he was personally associated. What he has done for the Coast Survey, the great work of his life, is familiar to us all. He infused into it life and vigor, inspired the public confidence, enlarged the scope of the work, and increased its scale more than fivefold. He has made it the trust of the mariner, and the admiration of the scientific world.

"In all departments in which the efforts of Professor Bache were exercised, his peculiar powers for organization became conspicuous. A great part of his success in this respect was due to discriminative sagacity; to the ready ear which he gave to the suggestions of others, and his sense of justice in according credit for such as were adopted.

"Of my own feelings I cannot trust myself to speak. Like yourselves, I have lost in him a friend and guide—a second father. Under the shadow of his great name I have loved to live, and have prospered. The future seems bereft of its best hope—that of enjoying his approbation."

Assistant Cutts spoke as follows:

"It is not my intention, nor is it the occasion, to refer to the eminent services of our late Superintendent, or to the distinguished consideration accorded to them both at home and abroad. The career of Professor Bache is interwoven with the history of American progress during the last thirty years. As a man ever foremost in the advancement of science; of rare learning, sound judgment, and of intense labor; as a gentleman of varied accomplishments, and of stern integrity of character, devoting all alike, and at all times, to the interests and honor of the government, the entire country will mourn his loss.

"To us, the assistants in the Coast Survey, the occasion is one suggestive of deeper feeling than an estimate or even admiration of his labors, or of the valuable and wide-spread results that rewarded them. He was not only our chief with whom we were connected by official ties, but a personal friend, bound to us by intimate and even pleasant association for many years. Kind and considerate in every act and word, he attracted us, as it were, to the earnest performance of duty, as well by a desire to secure his approval as from a strict sense of official responsibility. We have known him in the field and in the office, a partaker in our labors, and the most incessant worker of all. We have consulted with him in regard to details of the survey, and always with the feeling that we were co-operating with a friend who, while ready to adopt any suggested expedient that might facilitate progress or increase efficiency, never failed to give credit where credit was due.

"There is perhaps no one now present who cannot and who does not on this sad occasion recall to mind some incident connected with Professor Bache, full of pleasant memories, either illustrative of his genial disposition, or of his thoughtful kindness, or of some other of the many eminent qualities for which he was justly distinguished, and by which he had secured our respect, our regard, and our personal attachment. It is with such feelings that we meet to-day to commune in regard to his memory, and to express our sympathy with the afflicted family and relatives. I feel assured that, although most of our associates are absent, some on duty on the Atlantic and Gulf coasts, and others on the distant shores of the Pacific, every word that has been uttered to-day, of regard and respect for the memory of Professor Bache, will find an echo in their hearts and sentiments.

"I now move that a committee of three, of the assistants now present, be appointed to draft resolutions expressive of the sense of this meeting."

The chairman named Assistant C. O. Boutelle, Captain C. P. Patterson, and Assistant Henry Mitchell, as the committee on resolutions.

In accordance with the direction of the honorable Secretary of the Treasury, the Coast Survey Office had been draped in black. During the absence of the committee, Assistant Hilgard announced the general order of proceedings for the funeral.

On the return of the committee, the following preamble and resolutions were read by Assistant Boutelle and unanimously adopted, after which the meeting adjourned.

"Whereas, in the providence of God, our beloved Superintendent and chief has been removed from us by death: We, the officers and employés of the United States Coast Survey, now in Washton, desire, on behalf of ourselves and our absent associates, to express our sorrow at the great and irreparable loss we have sustained by his death; to unite in a tribute of affectionate respect to his memory; to give expression to our sense of his high qualities, the great services he has rendered to his country and to science; and to offer our respectful sympathies and condolence to his sorrowing family.

"Whatever of excellence there may be in the extended system of operations now carried on by the Coast Survey on every portion of our coast is due to Professor Bache. He came to the charge of the work at a time when its operations were conducted upon a small scale and restricted to a limited portion of the coast. In a wonderfully short space of time he succeeded in winning the confidence of his official superior, and in securing the consent of Congress to a gradual enlargement of the work to its present scale. He called to his assistance men of thought and men of action from civil life, and from the army and navy, and, with a rare felicity, discerning and applying the special aptitudes of each individual, he wrought out from discordant material a harmonious whole.

"He combined high administrative ability with vigor and energy in execution. While allowing and inviting free criticism of his plans during their inception, he exacted a rigorous accountability from the officers intrusted with their execution. Discipline under his administration was none the less real that it was not apparent.

"Professor Bache was eminently just. The Coast Survey reports—those monuments of his fame—are full of evidence of the scrupulous care with which every officer serving under him received proper credit for his labors. His quick and ready appreciation of merit in every department of scientific inquiry and action, whether theoretic or practical, has been felt through the entire country, and has been of lasting benefit. To his fostering care and aid we owe the present perfection of the telegraphic method of obtaining longitude, which has recently achieved its crowning triumph in the determination by the Coast Survey of the precise difference of longitude between any two points in Europe and America, through the Atlantic cable.

"Of those great intellectual qualities, aided by the highest culture, which made Professor Bache the foremost scientific man of America, this is not the time or place to speak. Other and more eloquent tongues and pens will record his eulogy, but none with greater love and veneration.

"At the breaking out of the great rebellion new duties and responsibilities were devolved upon him, and he met them all. In the midst of these onerous duties he found time to be an earnest worker in the organization of the Sanitary Commission. As the war grew in proportion, so did the demand upon his energies. In the construction of defenses around his native city of Philadelphia, when menaced by invasion in 1863, his powers of endurance were strained beyond bearing, and in the succeeding year he was seized with the malady which has now terminated in his death. He has given his life to his country, in its great struggle for national existence, as truly as did any of those heroes who laid down their lives upon the field of battle.

"While we honor and respect the memory of our chief for his great abilities and untiring industry, for his wisdom and forethought, his scientific skill and administrative power, we also feel that he was more to us than is implied in all these high qualities. We feel that we have each lost a personal friend whom we dearly loved, and to whom, aside from all official relations, each felt a personal tie of warm affection. We remember him as the genial, cordial companion in social intercourse, as the wise and friendly counsellor in difficulty, as the kind and sympathizing consoler in sorrow and distress, ever ready to do a kind act, to seek out and to bring forward modest merit and true worth, and never wearying in well-doing.

"Such has been to us the man whose death we this day deplore, and as a tribute to the memory of our respected and honored chief, and our beloved and valued friend, be it, therefore, "*Resolved*, That in the death of Professor Alexander Dallas Bache, Superintendent of the United States Coast Survey, the country has lost an eminent and faithful public servant, science its highest representative in America, and the Coast Survey its wise, prudent, and energetic chief, under whose careful administration and guardianship it has attained and maintained its present vigorous existence and extended scale of operations.

"*Resolved*, That as a token of our love for him personally, our respect and veneration for him as our official head, and our admiration for his public and private character, we will wear a badge of mourning for the term of six months.

"*Resolved*, That a committee of five persons be appointed to take measures for erecting a monument to the memory of our beloved chief.

"*Resolved*, That the chairman of this meeting be requested to tender our respectful sympathy and condolence to his family, suffering under the great loss they have sustained, and to transmit to them a copy of these resolutions."

LIST OF CHARTS AND SKETCHES.

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

Please Note:

This project currently includes the imaging of the full text of each volume up to the "List of Sketches" (maps) at the end. Future online links, by the National Ocean Service, located on the Historical Map and Chart Project webpage (http://historicals.ncd.noaa.gov/historicals/histmap.asp) will includes these images.